VR

EMmotion

TRACKING SENSORS

& APPLICATIONS

PREMO

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VR
EM MOTION TRACKING SENSORS & APPLICATIONS

Innovative Magnetics have a significant role in sensing and tracking position and motion in immersive Virtual and Augmented Reality systems. **Premo** is committed to contribute with World Class Innovative components to the Key Enabling Technologies of the 4th Industrial Generation. 4 patents have been filed for VR Tracking sensors in less than 6 months. With this book we start a series of publications on our contribution to a coming better world from our experience, vision and value proposition. This is a recognition and tribute to our team of Innovators and our Ecosystem. We hope you can enjoy and contribute online in our **Blog 3dcoil.grupopremo.com** if you, as we expect, want to enlarge this knowledge and technology Ecosystem.

CONTENTS

01

10 KEY CRITERIA FOR CHOOSING TRACKING SENSORS

By Ezequiel Navarro Pérez

01

10 Key criteria for **choosing tracking sensors**

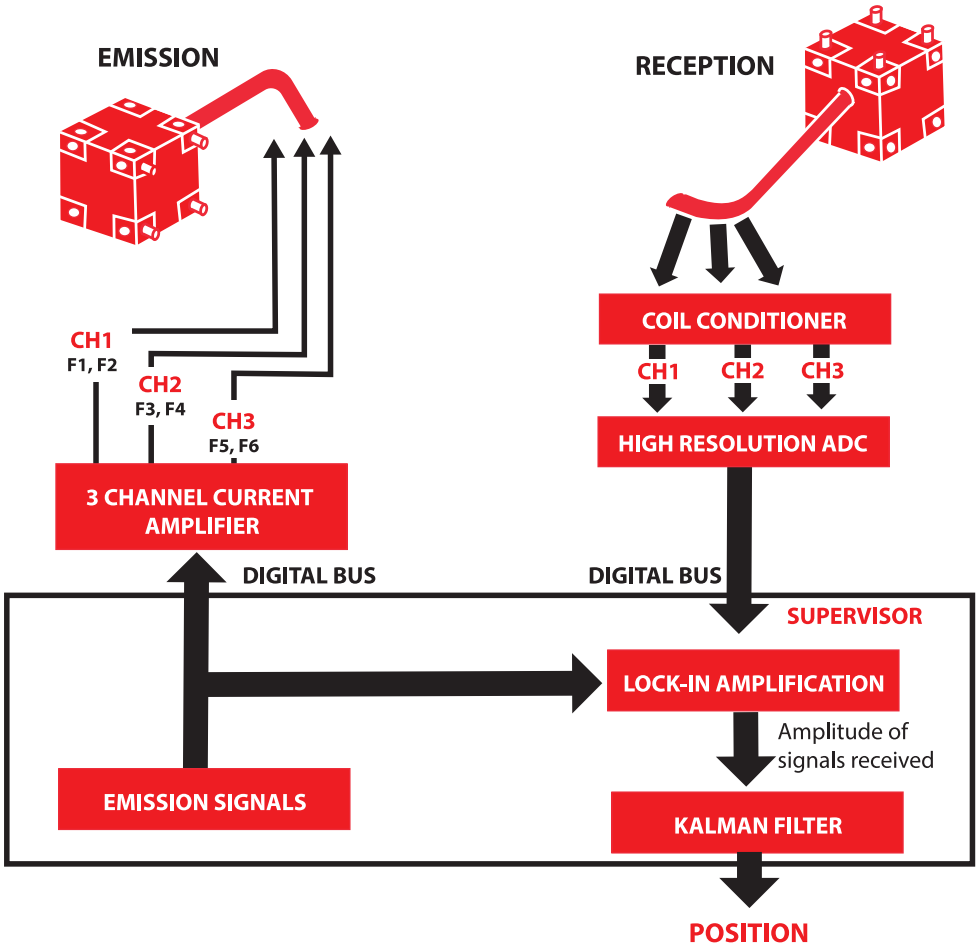
ABSTRACT

Hardware designers have to confront a very wide array of quick decisions when setting and freezing a design. Choosing state-of-the-art standard components that are commodities like capacitors, resistors, Op Amps or drivers is relatively fast, as there are plenty of compatible options, of similar performance and cost.

However, when it comes to DSP (digital signal processors) and microcontrollers, a joint decision is made usually between the hardware engineer and the system architect, taking into consideration software/firmware designers, computing capacity, memory, A/D D/A resolution and the capacity for real-time error compensation and correction.

Choosing the right digital hardware in virtual reality and augmented reality systems is one of the most important important decisions you will make, and it's trickier than it seems.

Every aspect of the future product, from cost to performance, flexibility and marketing strategies will depend on those decisions for the duration of the product lifetime.



That being said, the performance of a virtual and augmented reality motion tracking system also lies in the selection of the right tracking technology:

- **Visual/ Optical**
- **IMU** (Inertial Measurement Units)
- **Electromagnetic**, within which we can point out two types:
    - DC permanent or pulsed magnets
    - AC Electromagnetic sensing

TECHNOLOGY	COST	LATENCY	PRECISION	RANGE	LINE OF SIGHT
3Dcoilcube	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓
IMU*	✓ ✗	✗	✓	✓	✓
Visual / Optical	✗	✓ ✗	✓	✓	✗ ✗ ✗

* IMU Inertial Measurement Unit (Sensor array with Gyroscope, Accelerometer & Magnetometer)

3DCOILS, THE PRISTINE 3D EM TRACKER FOR VIRTUAL AND AUGMENTED REALITY

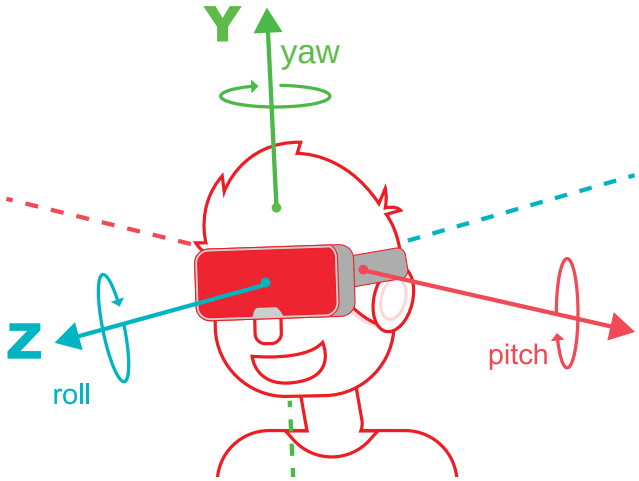
Introducing 3DCoils, the pristine 3D EM tracker for virtual and augmented reality. Among its many **advantages,** it boasts:

- Lower Latency: real-time data output provide immediate feedback without post-processing of position and orientation data.
- No line of sight needed: LF Magnetic Fields can reach antennae through solid objects.
- Sensors are never occluded.
- No fixed referenced emitter or multiple fixed calibration elements.
- Can deliver longer range tracking than competing technologies.
- Operates at lower power levels.
- Offers the best signal-to-noise ratios.
- Multiple tracking systems can be used in the same environment, without any cross-talk interference.
- Can be embedded inside any kind of enclosure or housing, except for ferromagnetic materials.
- Even completely covered, they still track position and orientation seamlessly, due to the long wavelength and low field attenuation in paramagnetic and diamagnetic environments.
- No Drift.
- Unmatched precision of 0,01m, with reliable & repeatable tracking results.

3DCoilCubes™ and 3DCoils™ are extremely flexible 3D EM trackers for VR, entirely customizable and easy to setup. It is possible to fine-tune the settings to meet application needs or environment changes.

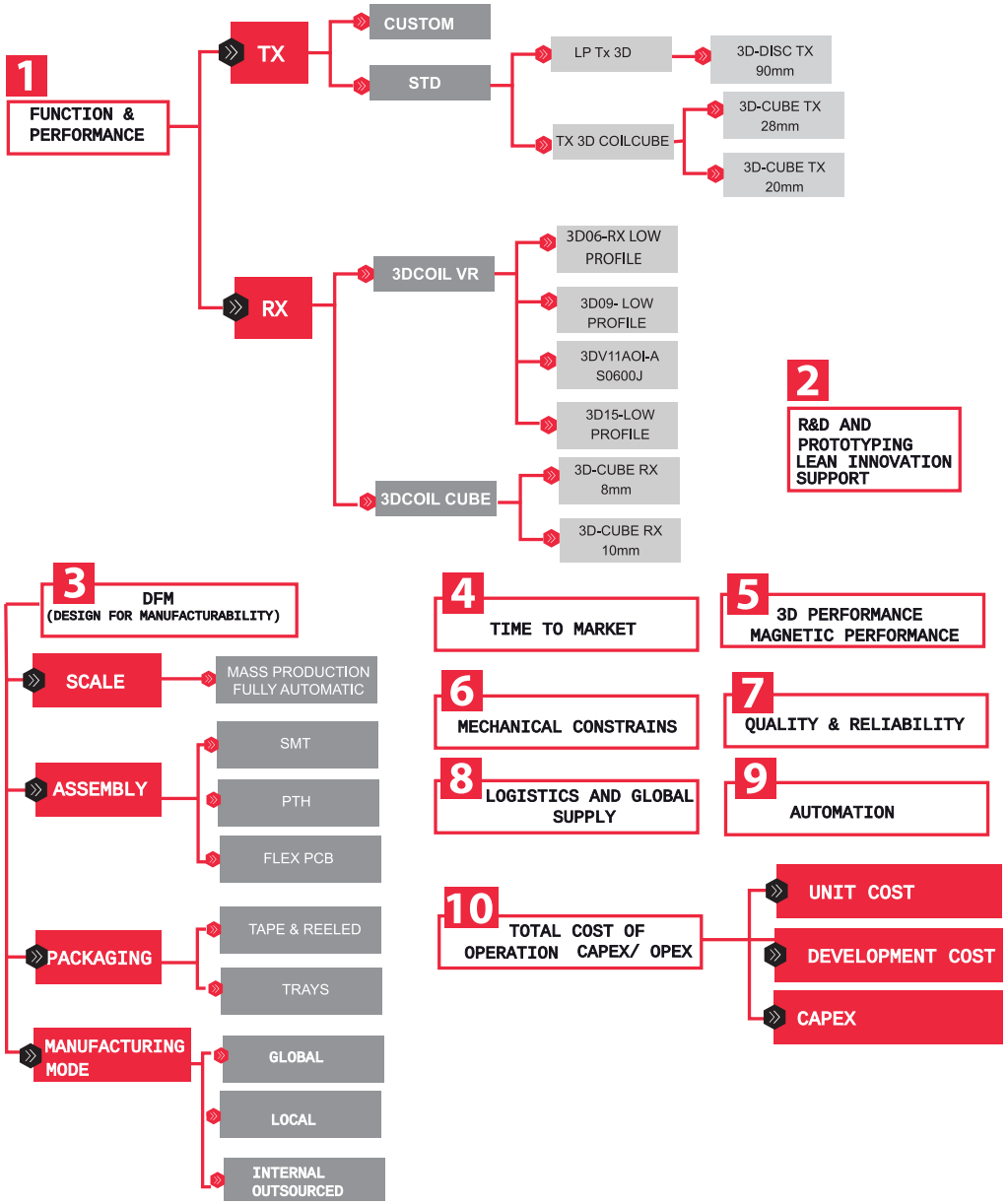
So, what key parameters should you look at to choose a TX emitter coil or a specific RX receiving sensor coil? The present article is a quick guide for HW and System Architects:

Choosing the right product in TX/RX 3D tracking sensor for VR



We have created a short-list of recommended parameters to look into:

1. **Function & performance**
2. **R&D and prototyping Lean Innovation Support**
3. **DFM (Design For Manufacturability)**
   - › Scale
   - › Assembly
   - › Packaging
   - › Manufacturing mode
4. **Time-to-Market**
5. **3D magnetic performance**
6. **Mechanical constraints**
7. **Quality & reliability**
8. **Logistics and global supply**
9. **Automation**
10. **Total cost of operation : Capex / Opex**


1
FUNCTION & PERFORMANCE
TX
CUSTOM
STD
LP Tx 3D
3D-DISC TX 90mm
TX 3D COILCUBE
3D-CUBE TX 28mm
3D-CUBE TX 20mm
RX
3DCOIL VR
3D06-RX LOW PROFILE
3D09- LOW PROFILE
3DV11AOI-A S0600J
3D15-LOW PROFILE
3DCOIL CUBE
3D-CUBE RX 8mm
3D-CUBE RX 10mm
2
R&D AND PROTOTYPING LEAN INNOVATION SUPPORT
3
DFM (DESIGN FOR MANUFACTURABILITY)
SCALE
MASS PRODUCTION FULLY AUTOMATIC
ASSEMBLY
SMT
PTH
FLEX PCB
PACKAGING
TAPE & REELED
TRAYS
MANUFACTURING MODE
GLOBAL
LOCAL
INTERNAL OUTSOURCED
4
TIME TO MARKET
5
3D PERFORMANCE MAGNETIC PERFORMANCE
6
MECHANICAL CONSTRAINS
7
QUALITY & RELIABILITY
8
LOGISTICS AND GLOBAL SUPPLY
9
AUTOMATION
10
TOTAL COST OF OPERATION CAPEX/ OPEX
UNIT COST
DEVELOPMENT COST
CAPEX

Let´s look into **these recommended factors** one by one:

1

FUNCTION & PERFORMANCE

The maximum available power, i.e. the maximum TX Current, will determine the max H field intensity. The constraints of the systems will be related to material magnetic saturation as a function of N x I product in the TX emitter antennas (N being the number of turns and I the electric current).

TX emitter antennae's maximum capabilities are determined by soft magnetic material induction saturation (if a ferrite or any equivalent soft magnetic material is used), and by max output current, as a consequence of the output equivalent impedance if the TX emitter coil is a 3D Air coil. In that case there would be no magnetic saturation as the core is the air. However, the impedance of the coils would limit the factors, mostly composed of the DC and AC resistance (in the real part) and the inductance (in the imaginary part).

Once you have chosen the performance needed, comes the time to chose:

- **The right size for your product.**
- **The core material composition**: ferrite, nanocristallyne, amorphous, mpp cores or air cores.
- **The maximum size:** this directly impacts the magnetic induction generated, as it is proportional to the cross sectional area of the core.

In Premo's line of TX 3D motion tracking electromagnetic transmission coils, we recommend **3DCoilCubes™,** a low profile 3D TX antenna built with soft magnetic materials to minimize volume and size and maximize the generated magnetic field as a multiple of the effective magnetic permeability.

Air coils do have less THD than soft magnetic material coils, however you should take into account that they are bulky and their generated fields are usually weaker and less directional.

Premo uses high frequency, high permeability MnZn ferrite cores, or PBM, or Alma cores in its **3DCoilCubes™** and Lp 3D TX emitter antennas for VR.

2 R&D AND PROTOTYPING

When choosing the physical shape of the EM tracker for VR, most non-experts select the simpler geometry forms like spheres and cubes. This is logical when looking for the simplest way to generate equal fields in all 3 orthogonal axis.

Nonetheless, the search for isotropy can also be respected and enhanced with asymmetric core shapes, making for isotropic TX electromagnetic motion tracking emitter antennas that generate identical Bx, By, Bz magnetic induction orthogonal vectors that are identical, all the while every axis can present different geometries as the induction vector B is a function of I (current), N (number of turns of the winding), u (effective magnetic permeability of the core, f (frequency), l (length of the magnetic circuit) and A (the cross sectional area of the core).

There are infinite combinations of the parameters that give identical values of B with different shapes. Therefore, there is no need to seek geometric symmetry in the quest for isotropy.

3
DFM | DESIGN FOR MANUFACTURABILITY

Winding a few turns around a bobbin, a coil-former or directly over a piece of magnetic core is a very simple operation that can lead to confusion. This simple process may be good for a mockup sample but, when you need to produce millions, the most important factors to take into account are high repeatability, isotropy and a high merit figure of MTBF that assures not only 0ppm in field failures, but most importantly, 0ppm during the product lifetime.

When choosing an EM tracking sensor for your project, you not only have to consider the early stage of design, it's also vital to look into cost per milion, quality, performance, reliability and automatic mass production with reasonable low capex per unit.

Premo **3DCoilCubes™ and 3DCoils™** for VR/AR EMTS are designed for mass production. 3Dcoil technology is already used in wearables, M2M systems, robotics, general IoT applications, RFID access control and for multiple LF wake-up functions to other HF and UHF systems. They are massively produced and have been for over 20 years, providing over 50% of the global automotive production of Passive Keyless Entry Systems for automobiles. Furthermore, **we guarantee:**

> Scale: very high volumes make investments in automation highly profitable and achievable as well as competitive sourcing of the best possible materials.

> Assembly: DFM assures that the assembly of **3DCoilCubes™** and **3DCoils™** for Electromagnetic Motion Tracking Sensors in VR/AR and RFID can be done fully and automatically at high speed. Typical SMT machines can assemble over 90,000 components per hour, thus requiring very strict packaging and connection standards. SMT with AOI in standard Tape & Reel of our components makes assembly fast, inexpensive and reliable.

> Packaging: Jedec standard compatible trays allows components to occupy minimum warehouse space, to travel safely, to be preserved from humidity and oxidation and to be assembled automatically.

> Manufacturing mode: Premo has a very long relationship with contract manufacturers in most of their locations. Our customer service, account management, logistics, consignment stocks and follow-up of quality and service is state-of-the-art and well defined with most manufacturers around the world.

4
TIME TO MARKET

When you need to ramp up your product from 0 to millions in a few months, you need a supplier able to set up mass-scale, fully-automatic production in record time. Premo's in-house automation and the Business Model Innovation that re-engineered our business processes is key to offering the highest quality to our clients.

We changed our R&D and merged with our factory to create the first fully integrated FabLab for magnetics which can design and create any new idea in 24 hours. The key in attaining short time-to-market is not only lean innovation and lean prototyping, but the integration of multiple engineering skills working towards a common goal of generating new processes, creating automatic lines instead of merely products.

Sending automatic lines to our plants for the start is what gives us the competitive advantage of setting up innovative products and processes from 0 to several million pieces in a very short time (just a few weeks).

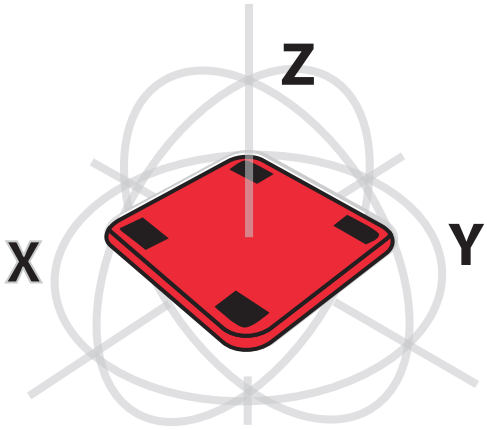
THE KEY IN ATTAINING SHORT TIME-TO-MARKET IS NOT ONLY LEAN INNOVATION AND LEAN PROTOTYPING, BUT THE NTEGRATION OF MULTIPLE ENGINEERING SKILLS WORKING TOWARDS A COMMON GOAL OF GENERATING NEW PROCESSES, CREATING AUTOMATIC LINES INSTEAD OF MERELY PRODUCTS

5
3D PERFORMANCE MAGNETIC PERFORMANCE

Premo invented **3DCoils™** and developed their industrial applications to several fields globally for the last 20 years. This experience allowed us to file for several patents, and fine-tune the portfolio of solutions for our customers' best interests.

Products have been engineered to maximize performance in different applications. Depending on the system requirements (frequency, minimum sensitivity in mV/A/m or mV/uT, circuit selectivity, Q factor, self-resonance, THD, cross talk, capacitive coupling, temperature stability , mechanical constraints, drop and vibration resistance, humidity resistance and IP protection, etc.) we guarantee a very wide range of available solutions to ensure your product will be efficiently produced and highly customized for your needs.

A deep understanding of the effective combination of materials and shapes, as well as its impact on effective magnetic permeability, has led us to always choose either the best L/D ratio or the best materials to keep the induced voltage for a given magnetic induction at a maximum.



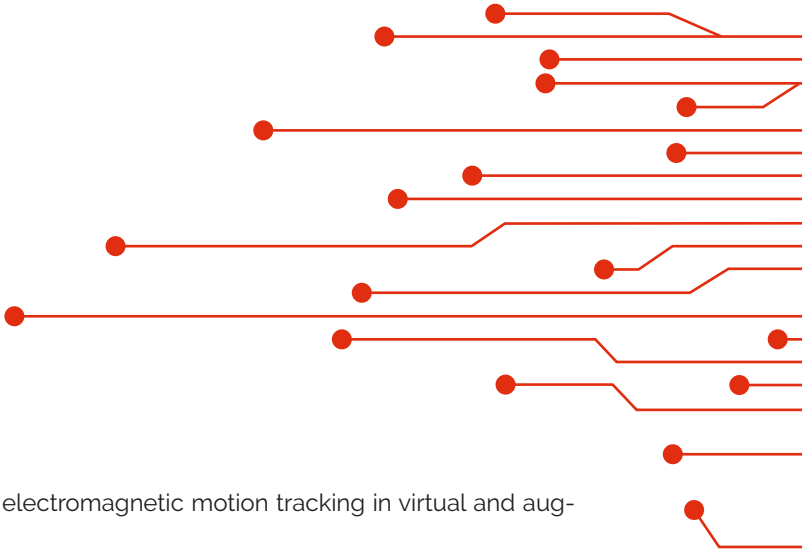
Magnetic performance of 3DCoilCubes™ and 3DCoils™, (both TX and RX) have the following characteristics:

- Magnetic permeability of the core (real and imaginary)
- Shape and size of the core
- High frequency losses of the core (eddy currents and hysteresis losses)
- Losses in the winding (DC, AC and capacitive losses related to interwinding capacitances.
- Windings configuration.

6
MECHANICAL CONSTRAINTS

No VR/AR system has unlimited space, or an ideal way to incorporate the device into the mechanism. Resistance to impacts, vibrations and drops, as well as the IPXX index of protection against humidity or solvents, our some of the advantages of choosing 3DCoils.

EMTS sensors for VR/AR typically need to work reliably within a range of 1.5 to 4 meters and we excel at designing the right TX for its RX (larger TX antennas require smaller RX sensors and vice versa).



7
QUALITY & RELIABILITY

When choosing a TX and RX set of 3D emitter coil for electromagnetic motion tracking in virtual and augmented reality, quality is a major factor:

› **Parts with 0ppm field failures** must necessarily be produced automatically and fully tested in all key electromagnetic and mechanic parameters.

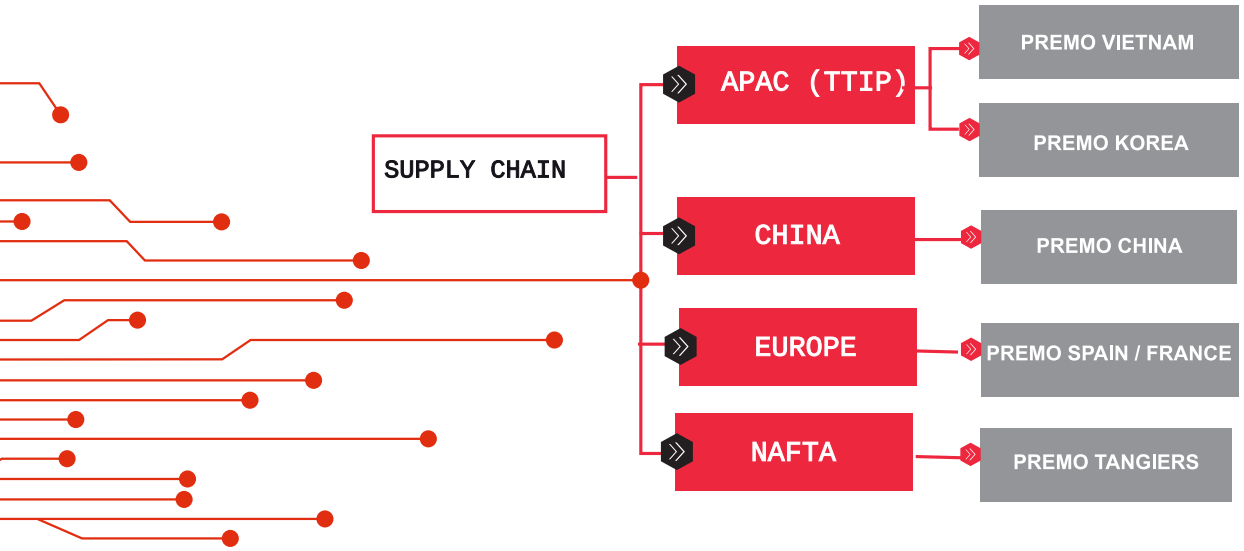
› **Expected lifetime of the products** should be consistent with the reliability of the parts in the systems and their MTBF.

3DCoilCubes™ and **3DCoils™** have been engineered to meet quality requirements and beat lifetime expectations. Over 180Mpcs are already in present in cars, robots, access systems and IoT devices globally.

8

LOGISTICS AND GLOBAL SUPPLY

Premo has its own sales and logistics offices, as well as exclusive partners in 57 countries and covers the main trading areas of the world from its 3 main plants.



9

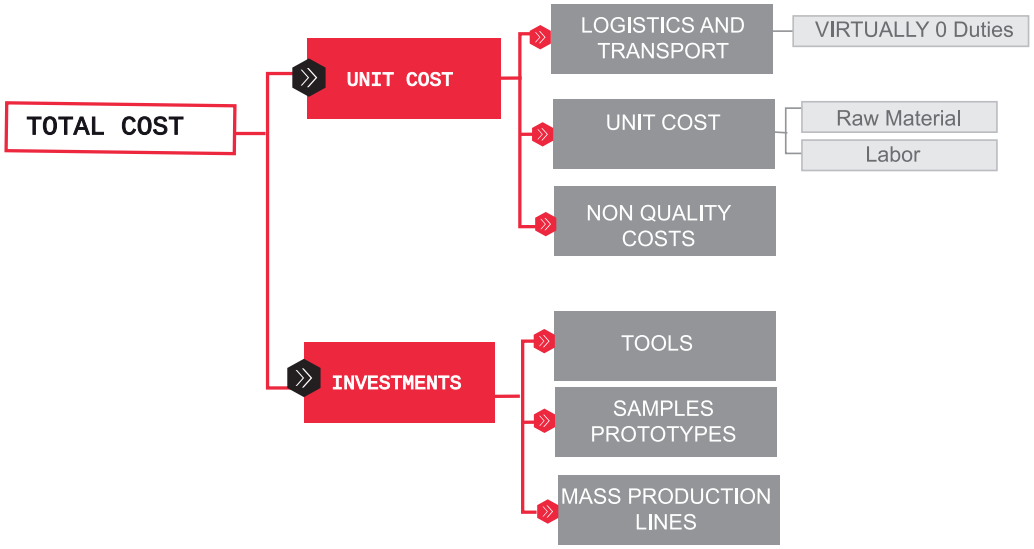
AUTOMATION

The degree of automation of our plants is very high, regardless the cost of local labor in each country we invest in. We believe it important to have the best automatic processes for the sake of quality, reliability and capacity.

10

TOTAL COST OF OPERATION: CAPEX / OPEX

Premo 3DCoilCubes™ and 3DCoils™ are designed as the output of a process. This means that the total cost to the customer goes beyond unit cost:



PREMO'S UNIQUE VALUE PROPOSITION IS GUARANTEEING THE BEST POSSIBLE PERFORMANCE, AT THE LOWEST OVERALL COSTS. AFTER ALL, LOWER UNIT COSTS DOES NOT MEAN THAT PRICES WON'T EXPLODE ONCE PRODUCTION MULTIPLIES.

Choosing an electromagnetic tracking sensor for your VR/AR device is an important and complicated endeavor. It may change the direction the project takes from then on, after all. It's crucial for you and your team to take into account all those aspects when discussing which EM tracker works best for your product. If you're interested in 3DCoilCube and wish to receive more information, don't hesitate to get in touch with us.

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Cross-talk: http://searchnetworking.techtarget.com/definition/crosstalk

Ferromagnetic materials: http://www.ieeemagnetics.org/index.php?option=com_content&view=article&id=190:ferromagnetism&catid=50:general-magnetism&Itemid=156

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Paramagnetic: https://en.wikipedia.org/wiki/Paramagnetism

Diamagnetic: https://en.wikipedia.org/wiki/Diamagnetism

3DCoilCubes™: https://twitter.com/search?q=%233DCoilCube

3DCoils™: https://www.grupopremo.com/314-3-axes-transponders-3dcoils

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Material magnetic saturation: material magnetic saturation

Ferrite: https://www.britannica.com/science/ferrite-iron-oxide-compound

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Effective magnetic permeability: http://www.encyclopedia-magnetica.com/doku.php/effective_magnetic_permeability

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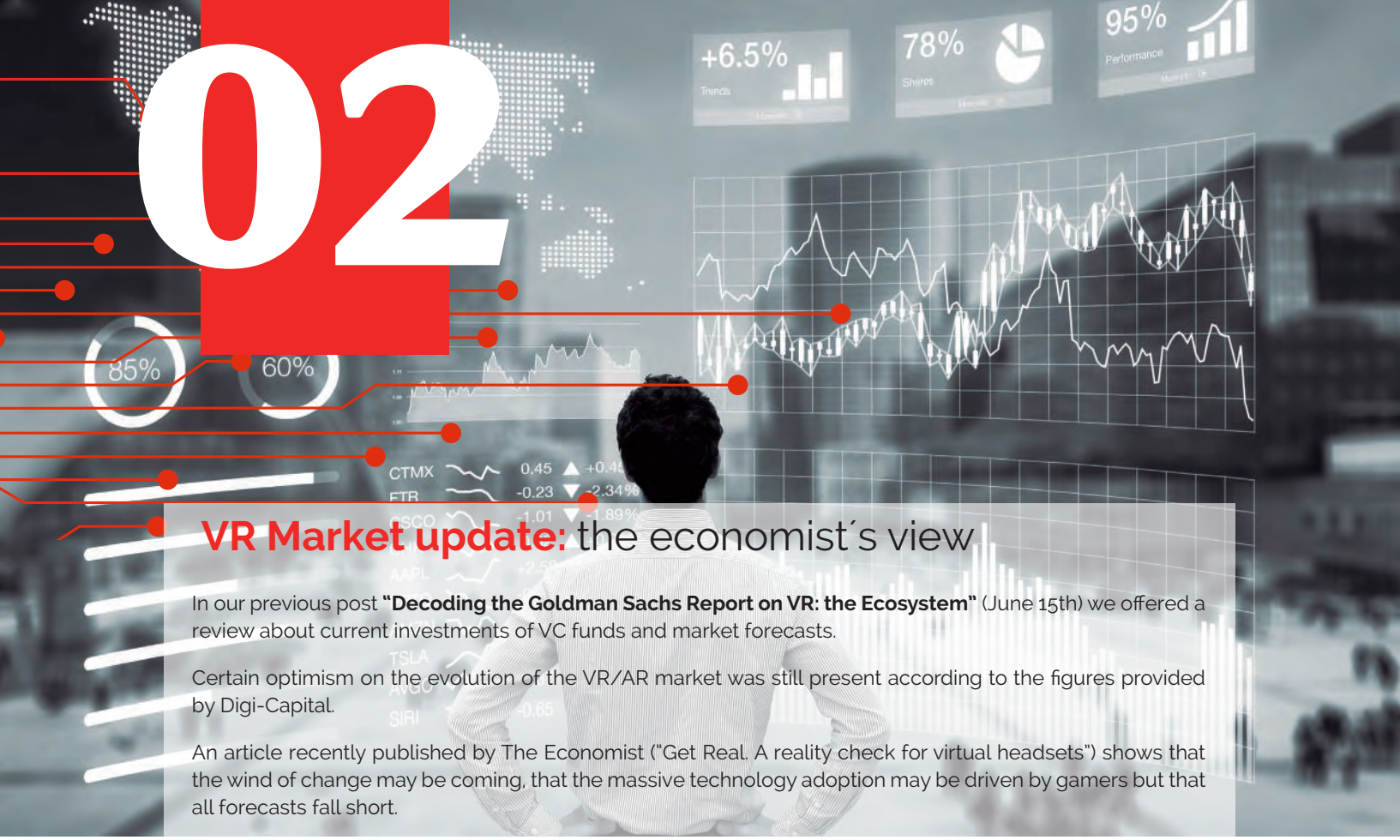
Flex: https://flex.com/

02

VR MARKET UPDATE:

THE ECONOMIST´S VIEW

By Ezequiel Navarro Pérez et Al



VR Market update: the economist´s view

In our previous post **"Decoding the Goldman Sachs Report on VR: the Ecosystem"** (June 15th) we offered a review about current investments of VC funds and market forecasts.

Certain optimism on the evolution of the VR/AR market was still present according to the figures provided by Digi-Capital.

An article recently published by The Economist ("Get Real. A reality check for virtual headsets") shows that the wind of change may be coming, that the massive technology adoption may be driven by gamers but that all forecasts fall short.

This e-paper is intended to update the scenario.

Virtual Reality (VR) has been identified by top investment funds, and by corporate and investment banks, as more than a hype: it is the next big thing to happen. There are plenty of opportunities to invest and make a significant return. There have been unicorns but also many bad experiences with significant losses.

Which is the market forecast? Many sources state that the market will experience a huge growth. But again there are bears and bulls. In general terms, even the most cautious agree on the growth of the VR market, considering that the VR world includes Augmented Reality (AR) and Mixed Reality.

This post is intended to help on this with a marketing vision:

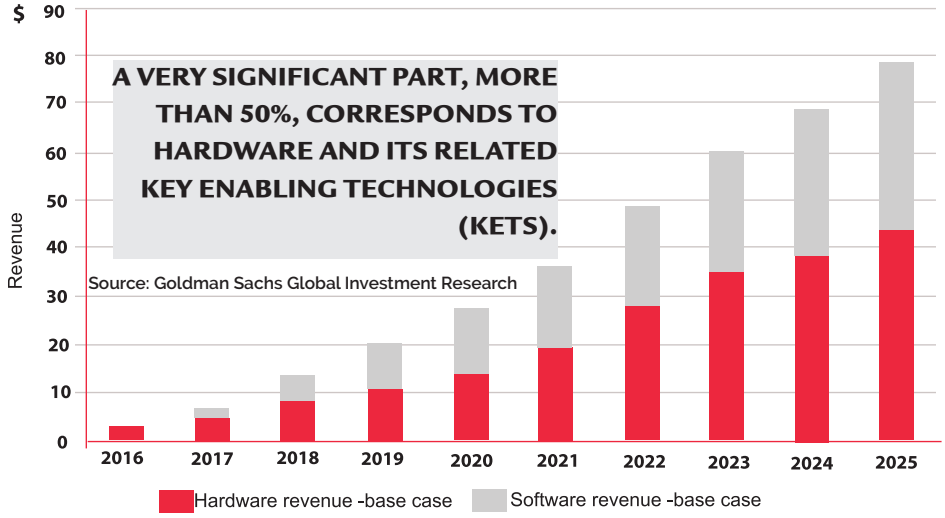
1. **What is the market?**
2. **Who are the players?**
3. **What are the forecasts?**
4. **With special attention to WiiFM (stay tuned to WiiFM)**

The VR/AR market: is there a hype?

The acquisition of the VR startup Oculus in 2014 by Mark Zuckerberg's Facebook opens the era of serious investments in the VR arena. Many statistics still remark the disturbing effect that this visionary decision had in the market dynamics. But Zuckerberg described the VR technology as "incredible" and made an early movement that caught definitively the attention of other investors. Facebook recently hired Hugo Barra, a leading executive coming from Google and the Chinese fast growing success Xiaomi. Barra is leading the VR division and has started to offer "Spaces", an innovative application were friends can socialize by means of VR meetings.

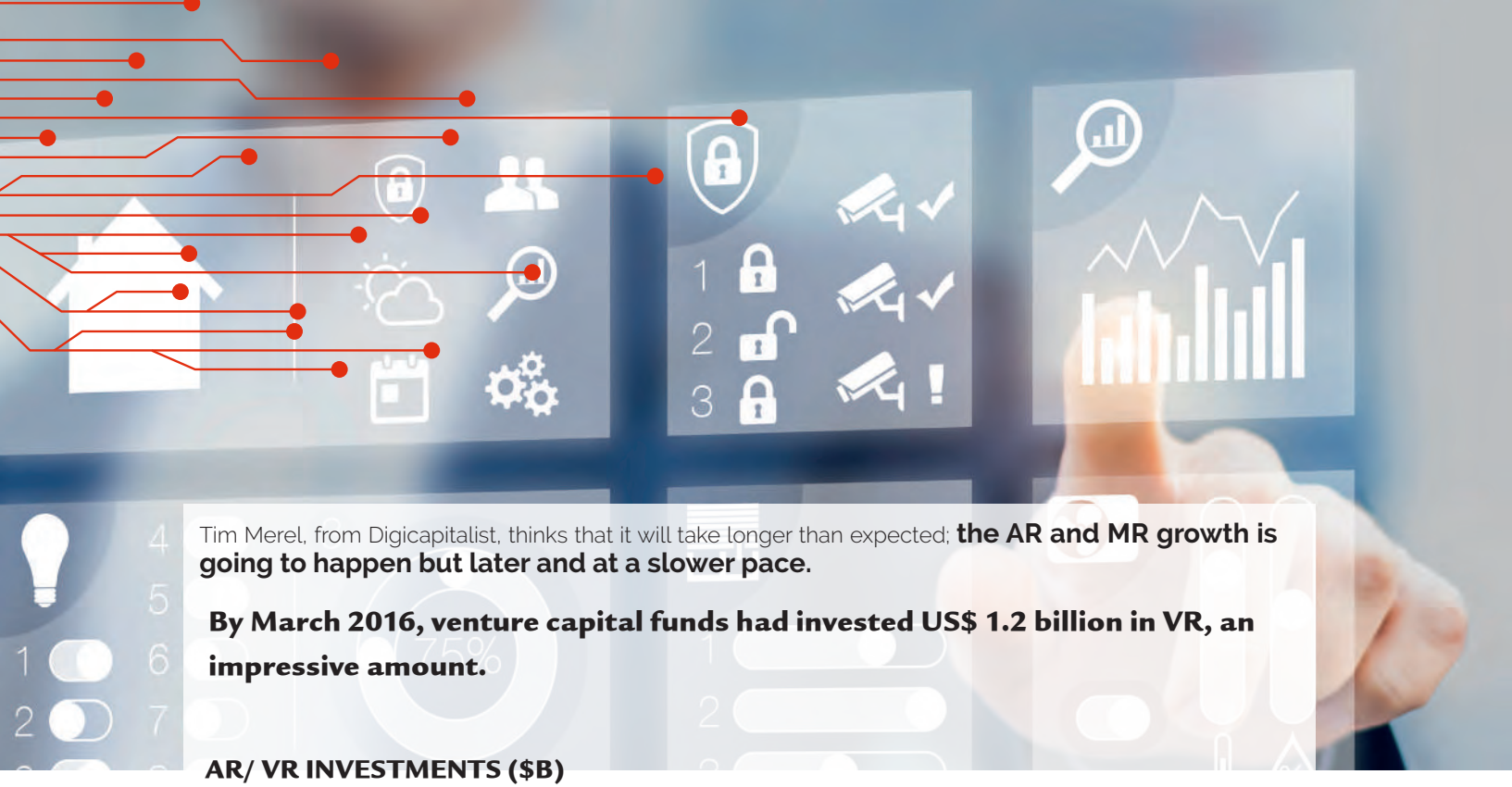
The forecast made by Goldman & Sachs in January 2016 envisions US$80 billion by 2025:

THE PROGRESSION PF OUR BASE CASE HARDWARE AND SOFTWARE FORECAST



"The race for the next computing platform may be over. Heather Bellini of Goldman Sachs Research expects virtual and augmented reality to become an $80 billion market by 2025, roughly the size of the desktop PC market today. In this video, Bellini discusses how the technology has improved since earlier launch attempts and how it's already transforming sectors like real estate, healthcare and education".

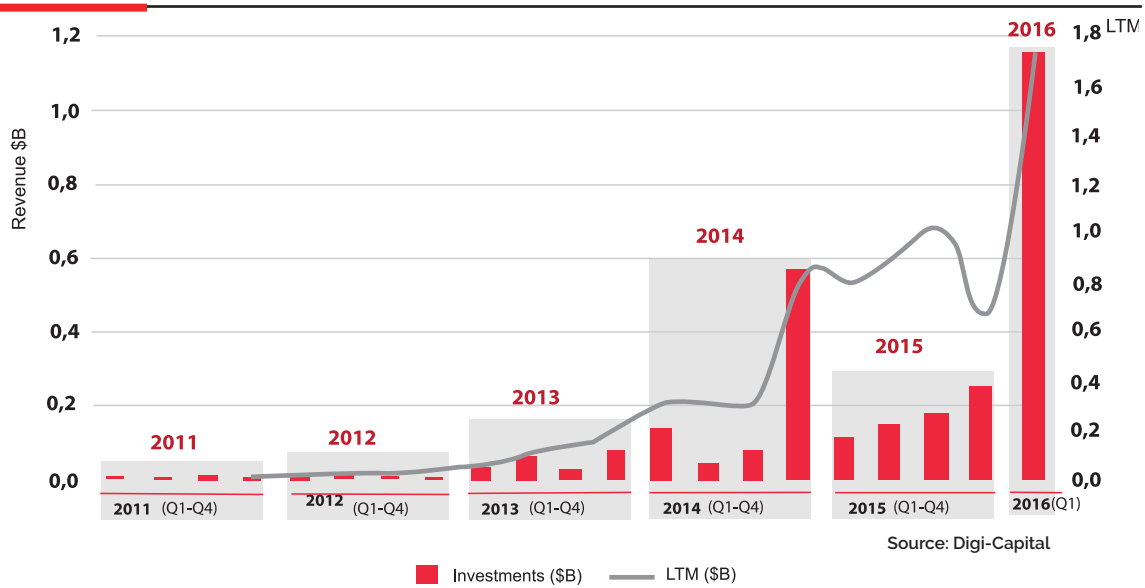
Source: Heather Bellini



Tim Merel, from Digicapitalist, thinks that it will take longer than expected; **the AR and MR growth is going to happen but later and at a slower pace.**

By March 2016, venture capital funds had invested US$ 1.2 billion in VR, an impressive amount.

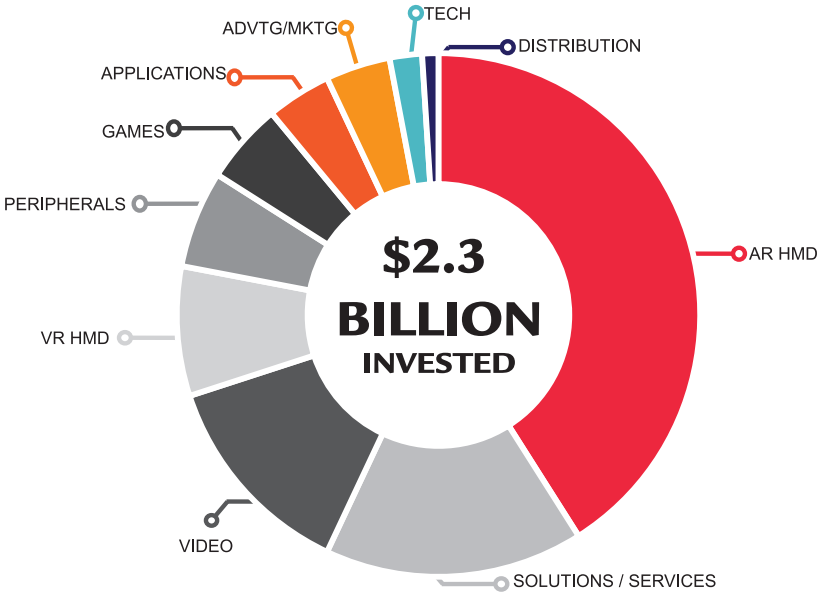
AR/ VR INVESTMENTS ($B)



Source: Digi-Capital

The information published by the same source (Digi-Capital) shows a total investment at that time (March 2016) of US$ 2.6 billion.

Source: Digi-Capital

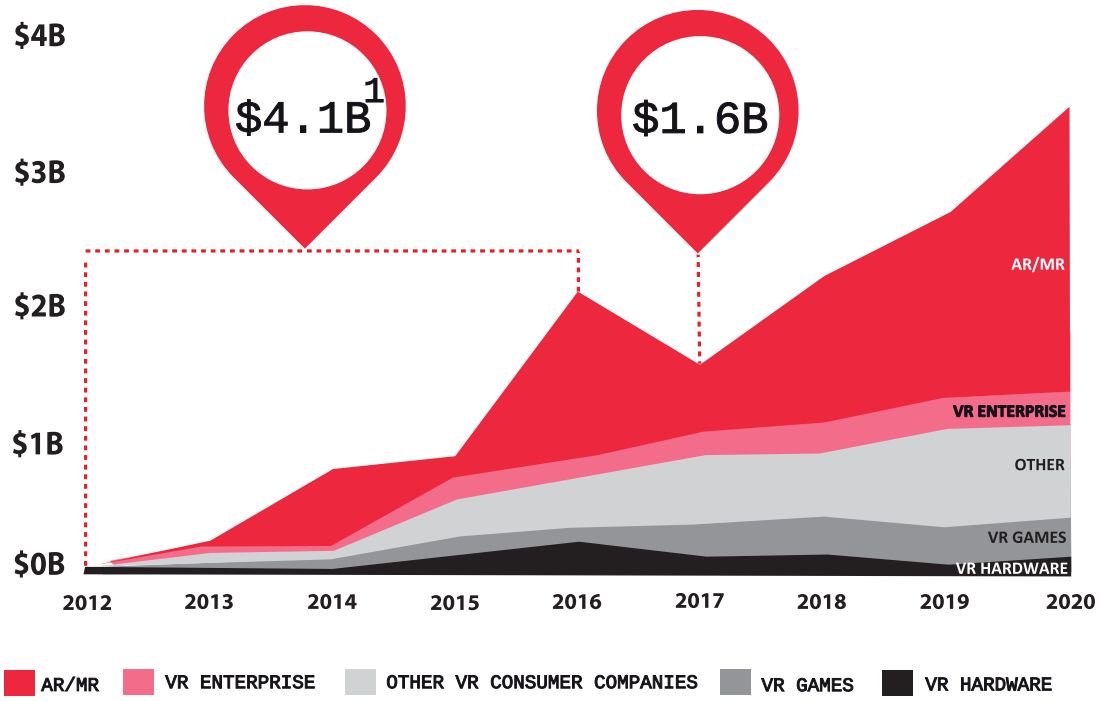


Finally, the same source indicates that the installed base of VR/AR/MR devices will grow to 300 billion units by 2020, including PC and consoles (10%), mobile VR (20%), standalone AR/MR (35%), and smartphones & tablets (35%).

Appetite for AR & VR

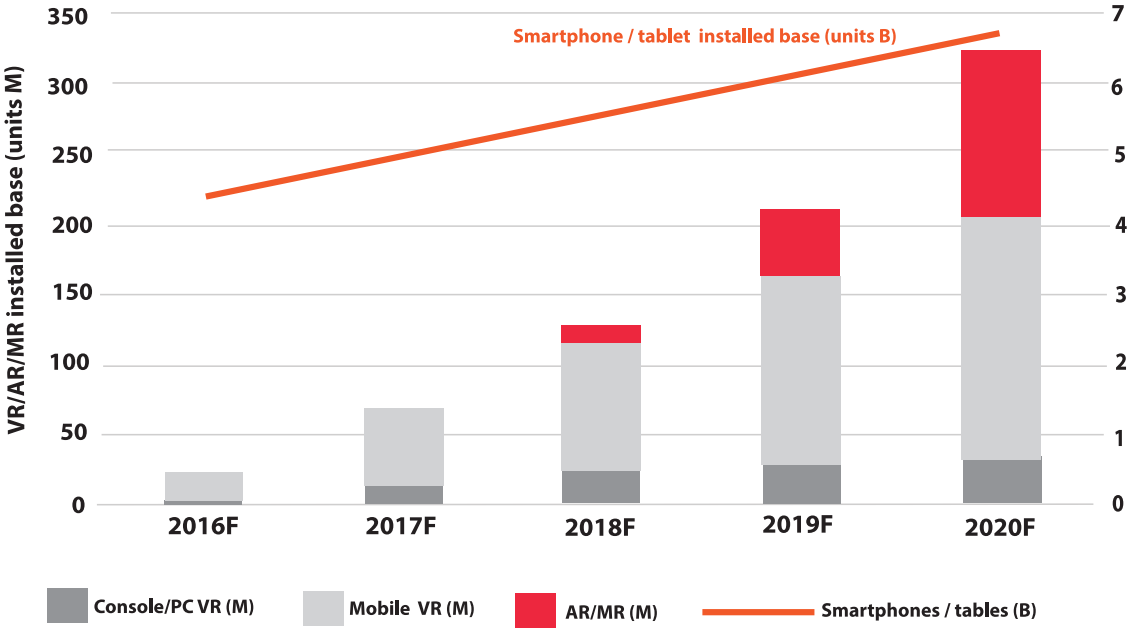
The market research company Superdata Research disclosed recently that VR funding is decreasing but that there is still plenty of appetite for Artificial Reality (AR) and Mixed Reality (MR):

INVESTMENT IN VR/AR/MR COMPANIES



Media content giants like HBO, Lionsgate or Disney (i.e., the Jaunt VR acquisition or the Disney Accelerator startups) are investing heavily or co-working with VR video content companies.

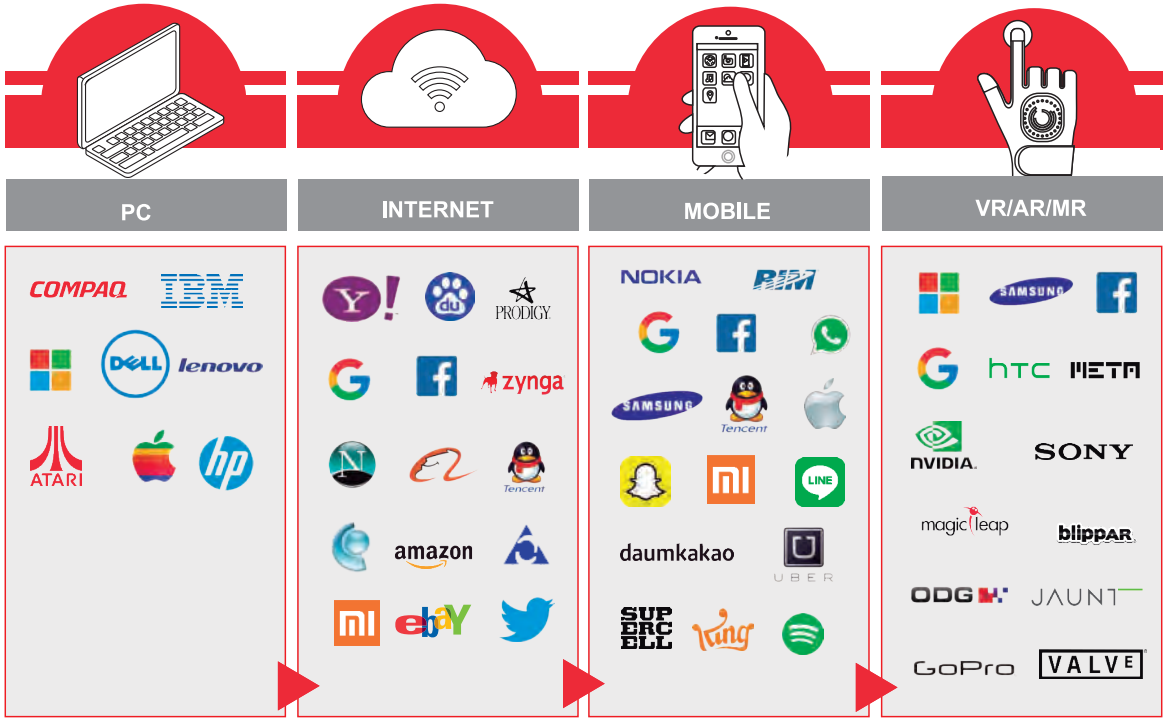
AR/ VR / MR INSTALLED BASE (units, not sales)



Considering that Digi-Capital specializes in digital companies, with their work more focused than a generalist company such as G&S, we think that their analysis should be mentioned here. Digi-Capital describes several waves for the VR market, and states that in H2 2016 the new wave was the 4th one and had just started with huge players now investing heavily and assuming a leading role.

For further information we recommend you to visit their blog.

PLATFORM WAVES



Source: Digi-Capital

In brief, this company advises their investors that VR/AR/MR is the next thing to happen after the PC, Internet and mobile waves. For those more deeply interested we recommend their full report. The new platform wave is VR/AR/MR, but who are the players? These are mentioned: HTC, NVidia, Google, Magic Leap, Facebook/Oculus Rift, Sony, Blippar, Valve, Jaunt, and Go-Pro.

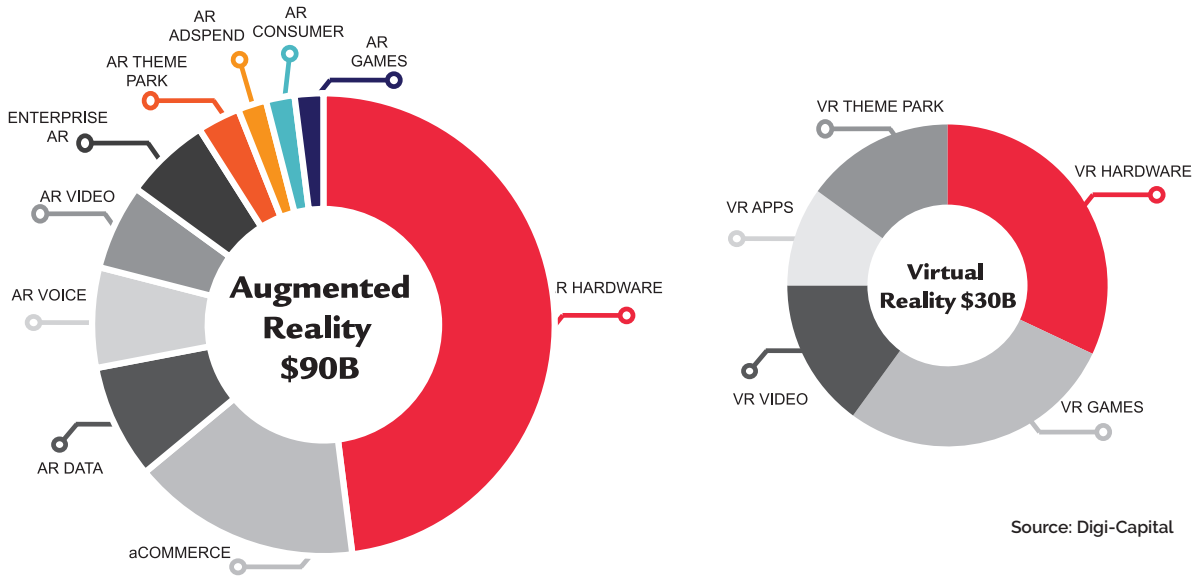
We miss many key players here: some enablers and other key players like Microsoft, NDI, Ascension, Polhemus, Mediatek, Nokia Technologies, Sixsense, and Nintendo, among others.

They warn literally that the tsunami and the waves are more like tides that can really destroy some business to bring new models to others. What side of the tsunami is yours?

"There are different ways you can pick a wave wrong. If the wave is smaller than you expect, you just bob up and down a bit. If the wave is much bigger than you think, you get dumped head first into the sand. Not fun. But platform changes are more like tidal waves, and are much more dangerous for incumbents than regular waves. When did you last use your Nokia?" (Source: Digi-Capital)

The big difference between our two mentioned sources is that AR is expected to be a market at least 3 times larger:

AUGMENTED / VIRTUAL REALITY REVENUE SHARE 2020F

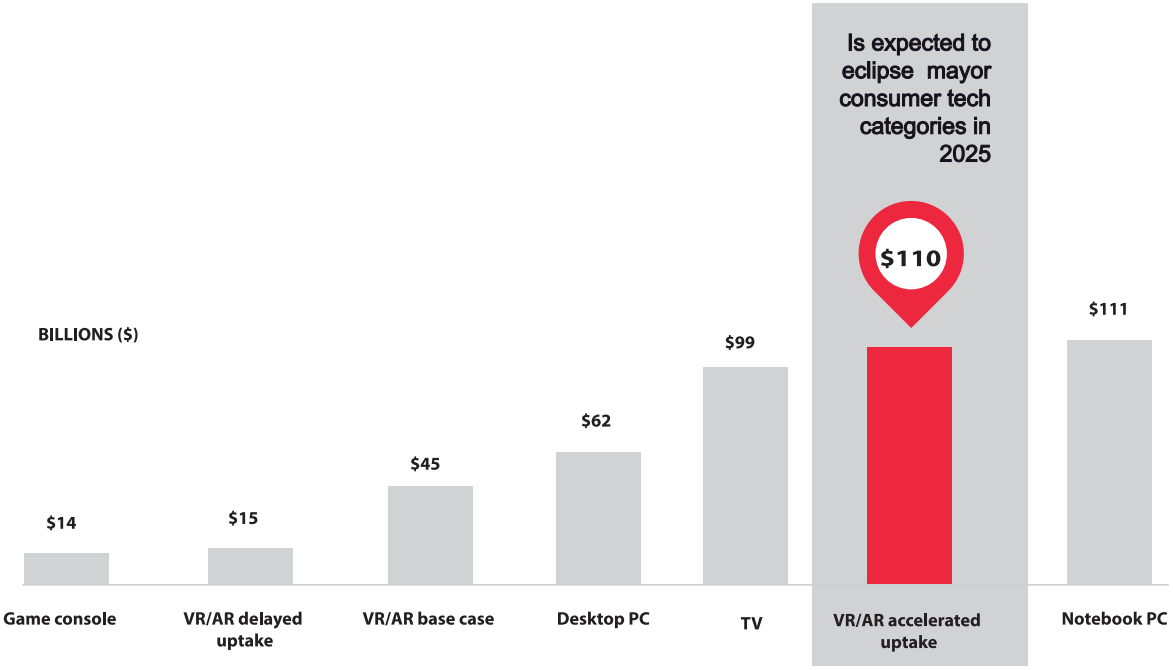


Source: Digi-Capital


Smartphone-powered headsets
PC-powered headsets
Game console-powered headsets
60
50
40
30
20
10
Millions
2015
2016
2017
2018
2019
2020
2021
2022

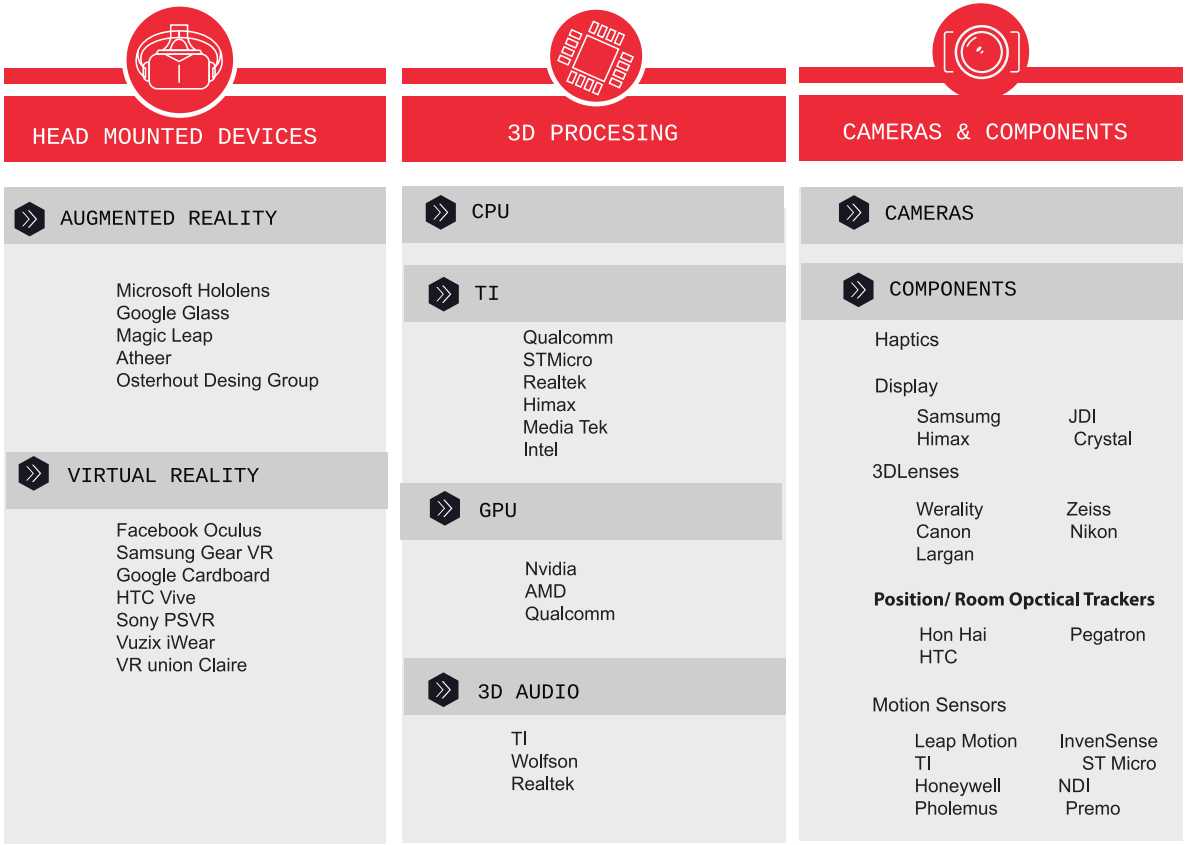
Business Insider has just published the last forecast made by G&S and has updated the figure under the "accelerated update" tag, which shows US$ 110 billion by 2025. In just one year the revised figure exceeds US$ 30 billion.

THE GLOBAL AR/VR MARKET



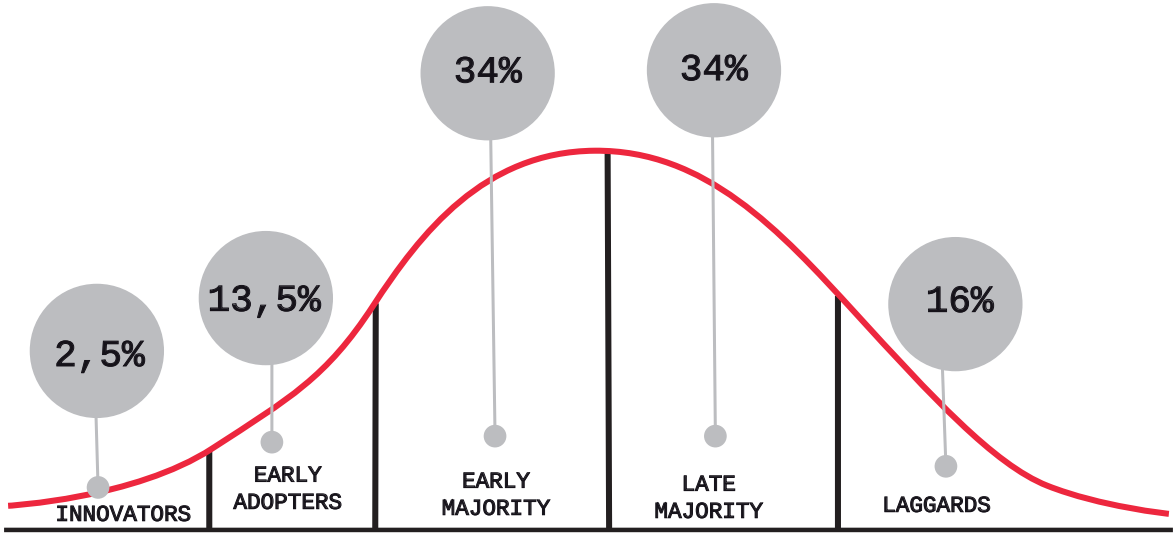
Source: Goldman Sachs

In terms of the current amount of technology adopters, it is significant that they are not any more just early adopters. In any case, there is a gap between users and business forecasts, so the adoption rate should be much higher. Another source, eMarketer, states that "... asking its first look at the augmented reality (AR) and virtual reality (VR) video markets, research company eMarketer sees strong growth ahead in the U.S. In 2016, 30.7 million people used AR monthly, a number that will grow to 40.0 million in 2017 for a 30.2 percent increase. The company predicts 48.1 million users in 2018 and 54.4 million in 2019..."



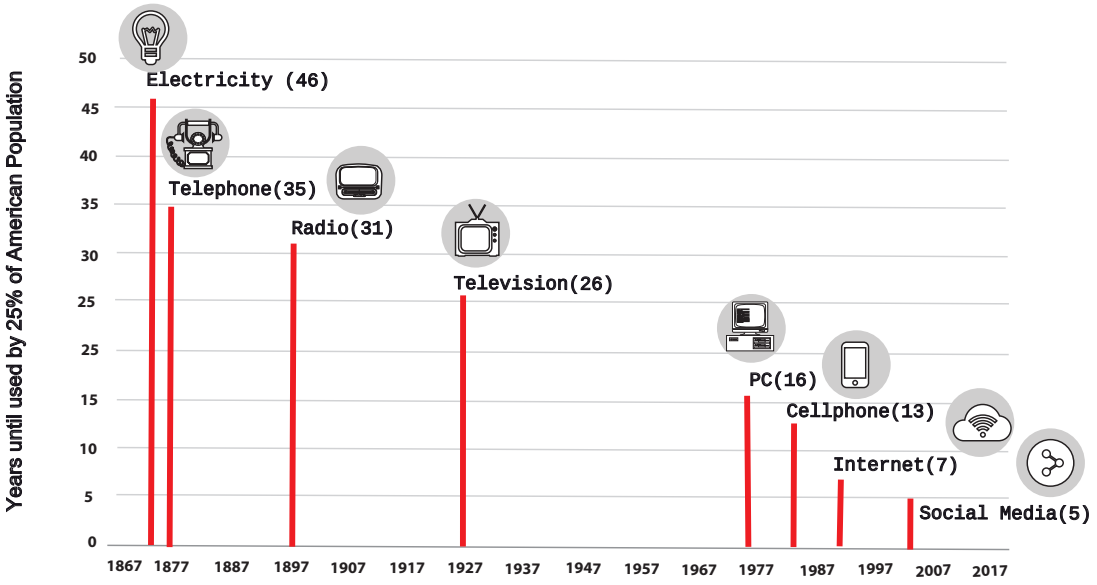
Immersive experience is the key for adoption

The technology adoption cycle is well-know:



We need to know whether we are addressing now the first 2.5% of innovators or entering a larger volume phase of the cycle. Early and Late Majorities probably will be the cash cows and the consolidation for the platforms, but as technology companies, we know that standards and definitions are created in the first two steps. While the adoption chart is known, we also know that the adoption speed is increasing dramatically due to economies of scale in an ultra-connected and globalized world.

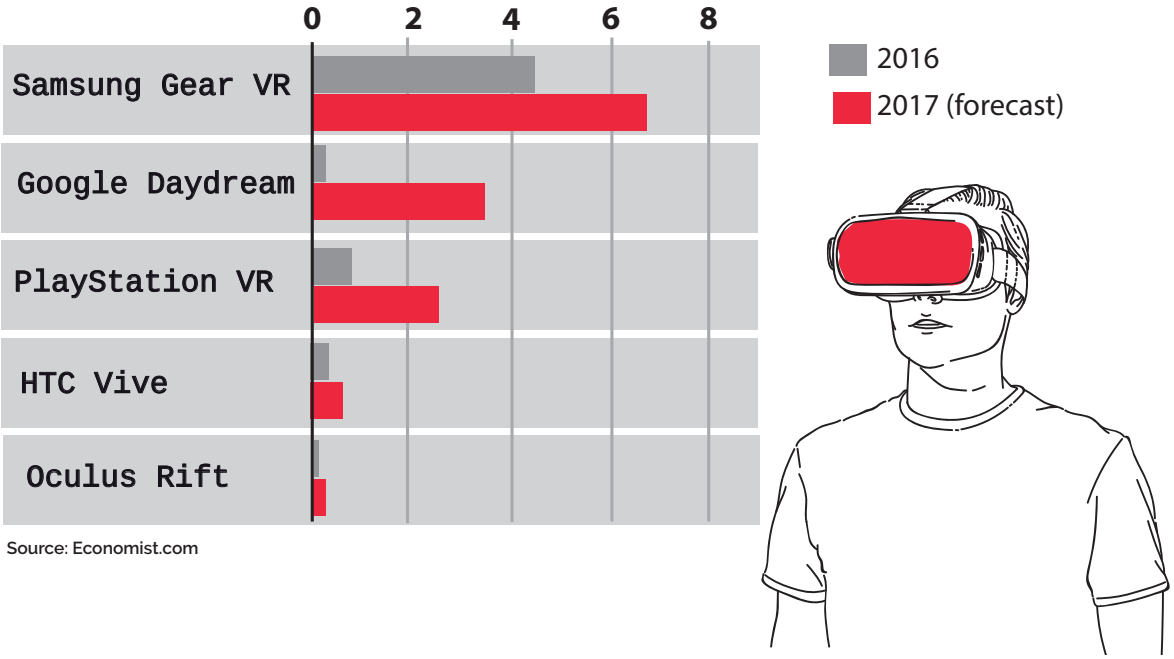
Acceleration of technological adoption curves 1867-2017



If telephone adoption by the first early majority took 35 years in the US, TV took 26 years, and Internet 7 and social media (Facebook, Twitter, Instagram…) just 5 years, make your bet. How long will it take for VR/AR to be adopted by 25% of the US population? It seems than it will take less than 5 years, probably 3, provided that HW, as a first bottleneck, is widely available, affordable, simple, and compatible.

And what about the rest of the world? Will the developing Asian countries just look? We rather doubt it; HTC , Sony, Nintendo, Samsung, LG, Lenovo are already big players but the second largest world economy has a lot to say about this technology. Chinese firms have been quick to research and invest in systems that are smaller, cheaper and wireless, and its industry is churning out new products. Most importantly, the Chinese Government is supporting this development as mentioned by Xi Jinping as they envision VR as an important vector for economic growth. Chinese tech giants are getting ready like Lenovo, Huawei , Xiaomi, ZTE…

VIRTUAL REALITY HEADSET SHIPMENTS, WORLDWIDE, M



Source: Economist.com

The evolution shown by The Economist mentioning SuperData Reseach sources is promising. Most companies grew from 2016 to 2017 and the average market growth will roughly double to 106%. Nevertheless, analysts mention that supply constraints in headsets and lack of availability of devices like Oculus Rift in 2016 delayed both HW and SW revenues. However, as far as we now, those issues have been overcome and big players are focus in developing more user-friendly, wireless HW platforms. 2016 was considered the VR year, but the true reality is that just 6.3 million headsets were shipped, most of them simple and low-cost devices, like the Samsung Gear VR used by smartphone as the screen. In the high-end market, i.e., Oculos Rift, only supplied 200,000 devices globally. A big success but still far from the early majority adoption group. Most of last year forecasts have been updated to a lower adoption pace. For example, SuperData reviewed its January 2016 data and cut the total HW and SW revenue down to US$ 3.6 billion from US$ 5.1 billion.

Experts mention several hurdles to mass adoption:

Gear is expensive and awkwardly heavy or clumsy.

SOLUTION: New HW developments coming to market in the following quarters are lightweight, stylish, and wireless.

A powerful computer or gaming console is required.

SOLUTION: Standalone systems are being developed worldwide.

Consumers do not spend on a HW without many available applications/games.

SOLUTION: Big players are setting platforms to coders and developers and strengthening their ecosystems as announced by Facebook in F8 2017 ,Google I/O 2017 and Microsoft Build 2017 Developers Conferences.

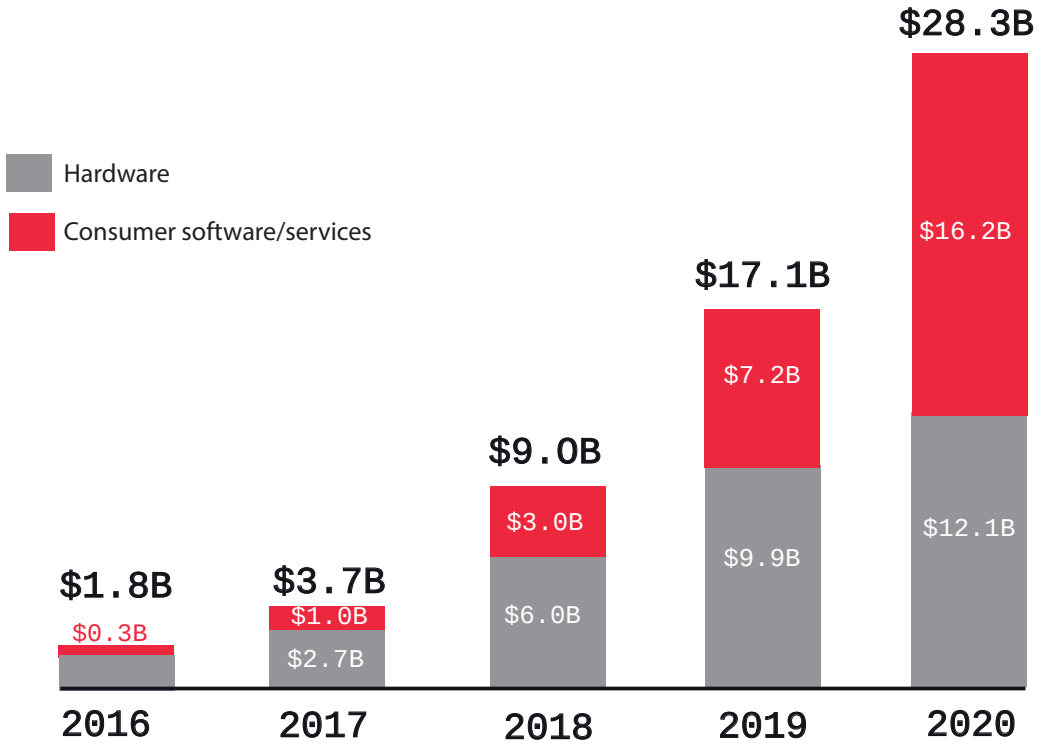
Developers don't invest in a small and fragmented market of different not compatible headsets that require a lot of repeated coding efforts.

SOLUTION: See above.

The way users have to wave around handheld controllers to input movements falls short of VR promises.

SOLUTION: Electromagnetic Tracking, Electromagnetic Motion Capture and Wireless IMUs turn haptics, immersion and presence experiences into reality.

WORLDWIDE VIRTUAL REALITY REVENUE BY SEGMENT



We researched the sources and news are good, especially for us, HW developers and manufacturers, as there is a clear need for high quality reliable, wireless and affordable hardware to run applications over. Nevertheless, HW, as usually, will be surpassed by SW by 2020. We have seen this in other platforms (PC's, smartphones, ICT's and smart vehicles.)

Barriers are being removed

Our own experience tells us that most of the barriers described above are being seriously addressed and most of them solved. Especially the need for haptics, sensors, and the feeling of real presence. The full immersive experience will be a key issue, and this will change completely the way users interact with the VR environment. The massive use of Electromagnetic Motion trackers for MOCAP (Motion Capture) makes HW simple, affordable and wireless.

Last month in Los Angeles E3, a month earlier in Seoul during the World IT Show WIS 2017, later in July on the occasion of VAARWorld in London, a few weeks earlier in Madrid DES2017, and also in June in AWE2017, in Santa Clara we have seen a revolution in the offer and whole new set of companies addressing the issues of immersion and presence and a clear vision of large players like Microsoft, Google and Facebook, to develop platforms and coders easier in order to accelerate their adoption.

Gamers have a first and important voice and Augmented and Mixed Reality, which allows users to overlay the digital world onto the real one, has more and more everyday applications. Apple, Google and Microsoft, with its Hololens and its definition of MR, believe that AR MR will become a bigger phenomenon than VR.

These are our findings from the shows. For more information please check our posts:

VR & AR World as a starting point

Observatory of VR/AR Motion Tracking

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03

DESIGN FOR EMTS MANUFACTURING

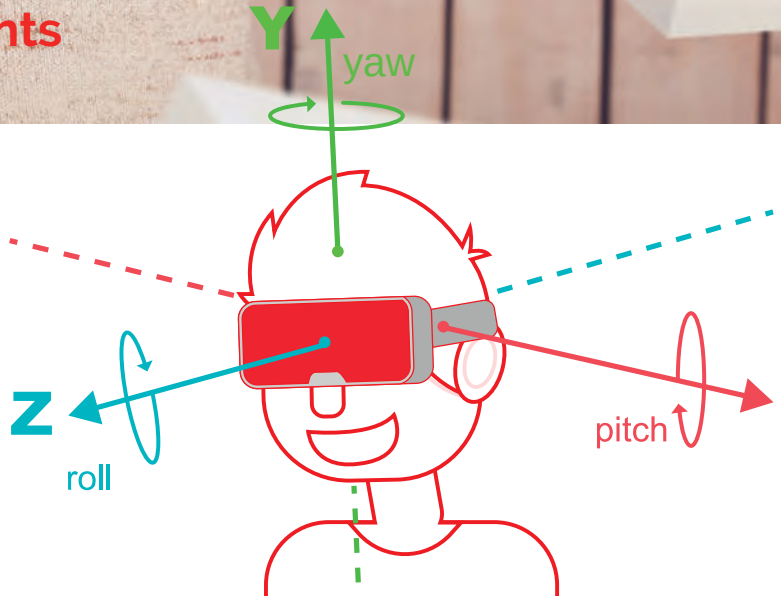
VR/AR COMPONENTS

By Andrés García Morilla

03

Design for EMTS Manufacturing
VR/AR Components

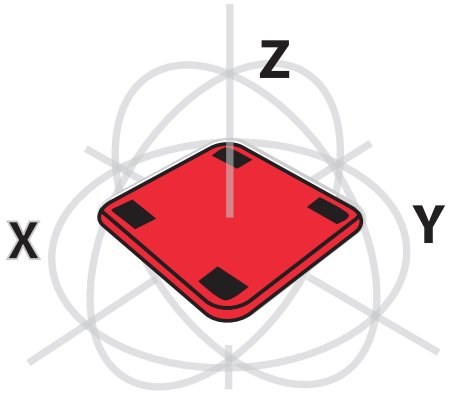
In our ebook 10 Key Criteria for Choosing Electromagnetic Tracking Sensors we recommend VR/AR immersive technologies hardware developers to consider a short list of key aspects related to the whole value chain.



If you've read the ebook (which we hope you did), you know that one of the criteria for choosing electromagnetic tracking sensors is DFM (Design for manufacture).

DFM has been described with 4 basic general components: **scale, assembly, packaging, and manufacturing mode.**

This post adds specific quality, materials, performance, and reliability requirements for the **3DCoilCubes™** EMTS (Electro-magnetic Tracking Sensors) manufactured by **PREMO**, a leading provider of **good quality components** with 55 years of experience.



Design to achieve quality first

Production is bound to design, as well as design is bound to manufacture. Therefore, it's very logical that neither a design is valid if it can't lead to manufacture.

Highly qualified team

To achieve that, PREMO takes the requirements of accepted international standars, and as recognition of the effort of all employees to all our customers, PREMO certifies its management systems according these standard.

	ISO 9001	ISO TS 16949
TANGLER	✓	✓
CHINA	✓	✓
VIETNAM	✓	✓

So there is always a trade-off between manufacturability and quality/design. The point is to keep in mind that the design

3DCoilCube™ Process and Components

PBM Core SMT

High Precision base

X Winding Pitch

Sensor Coil

Y Winding Yaw

Sensor Coil

Z Winding Roll

Sensor Coil

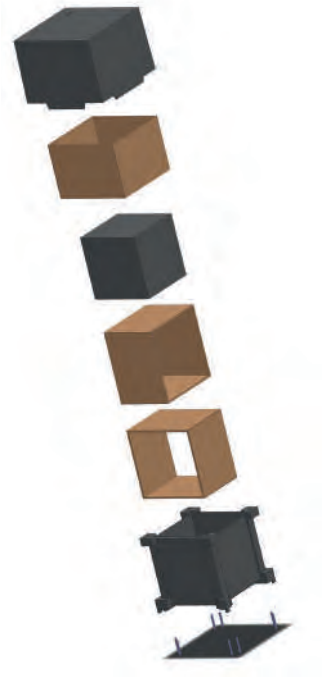
X winding Pitch

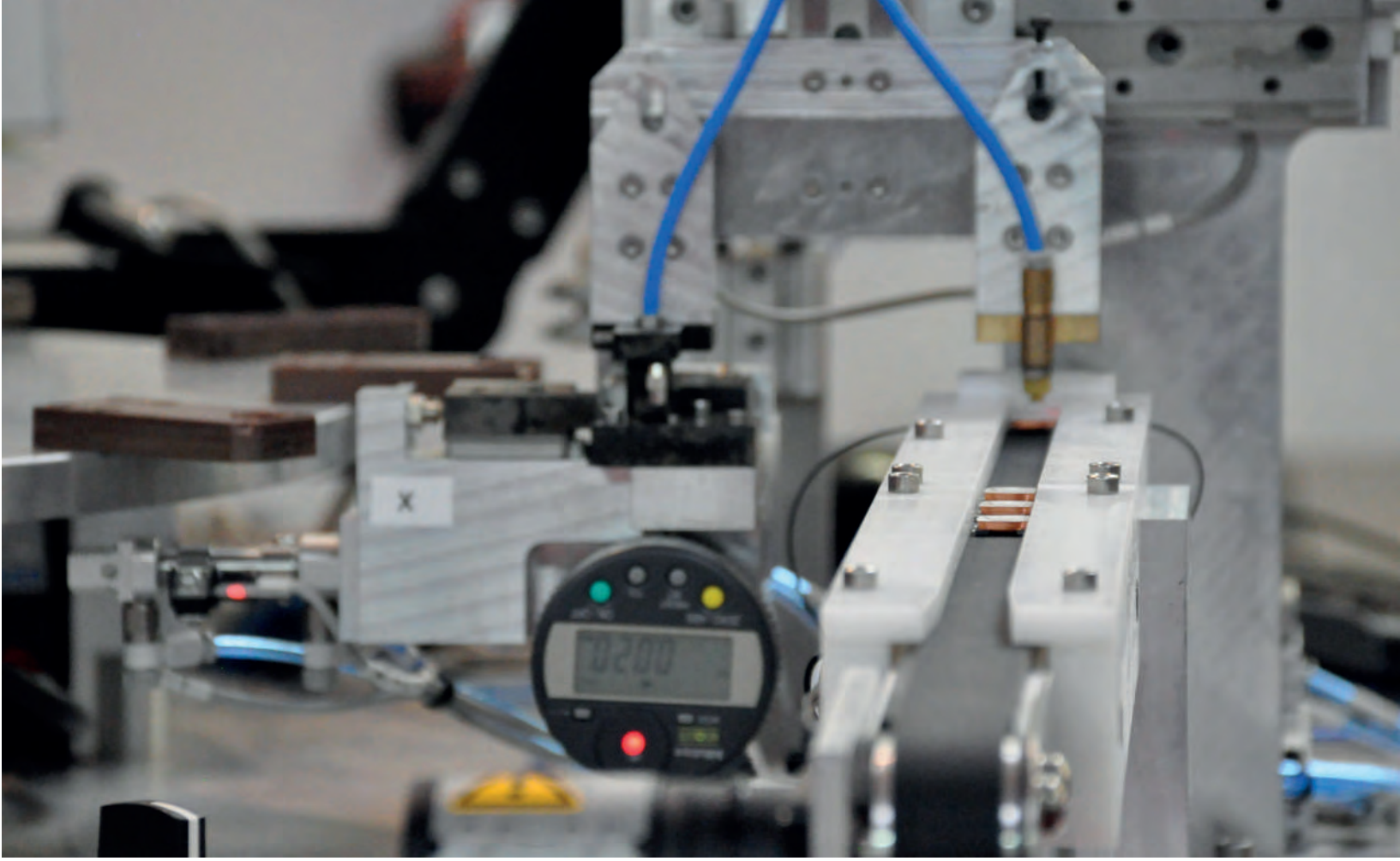
3DCoilCube

The best starting point not to forget about simplicity is a design based on strictly necessary materials. Manufacturing coils has been always a challenging task since the competition in the passive components market is very fierce. PREMO has always tried and accomplish the simplicity target being able to manufacture simple coils using three core components: core, base and wire.

As the market evolves, its requirements do also grow and change, ant this set of three core components may run obsolete and need the addition of new components. PREMO has overcome all these challenges to keep the simplicity to use of only these three components by improving the assembling, winding, soldering, testing & packagingautomatic manufacturing processes.

Simple parts should also be simple to manufacture. PREMO has also brought this concept to its plants in order to achieve the above mentioned goal.





Is it always possible to avoid any complexity to design/new components and still match the requirements?

Well, that's a real challenge. When it's time to add a new element to secure the requirements, add it. But again, try to come up with some simple addition.

Depending on the requirements, the proven flexibility of PREMO will fulfill the expectations for any design. The addition of a cap to some designs is a proof of simplicity in terms of winding protection and assembling expertise.

The requirements of EMTS

The foundations of the design are well known by this name. Requirements are the target to be matched by production. Mass production must be reliable. Again, the key is simplicity. How to match requirements while keeping simplicity? Well, first, let's have a look at the requirements of an EMTS sensor.

- **Isotropic** magnetic field (functionality)
- **Size (**integration)
- **Coplanarity** (connection and solderability)
- **Durability** under extreme operation conditions (reliability)
- **Mechanical resistance** (reliability)

It can be assumed these are the general requirements to be matched by any EMTS device today. While bringing simplicity to design is a matter of components and their interrelation, as we have seen before, bringing simplicity to mass production is a matter of choosing the right materials (also during the design phase) that can be easily handled and assembled in the production phase by drawing simple shapes, trying to always provide an easy way to route, wind and solder cap and base.

How to make a good decision then? What is the best for mass production? Some hints will be provided for each component.

Core

Core material will determine the EM properties of our sensor. Regarding production, the core should be as robust as possible and should have a size enough to be easily handled: not too big or too small. The handling of ferrite cores – which are fragile – during the manufacturing process – assembling – has been one of the best skills proven by PREMO. The core shape can ease the assembly and winding process, so this may be designed taking this into consideration, as the winding process can be adapted to match requirements of isotropy as needed.

SMT Base

Regarding the SMT base, three special concerns have to be taken into consideration.

1. The SMT base, normally plastic injected, should feature a simple pad drawing in order to ensure its coplanarity and solderability easily.

2. The SMT base should have a simple surface drawing in order to ease the ferrite core assembling over it. Glue dispensation processes will be much simplified if a good decision is made here.

3. Plastic material should match all the mechanical specifications and constraints in temperature in order not to be damaged by any curing/soldering process.

4. SMD

> Leadframe-based
> Thermoplastic with inserts
> Injected thermoplastics
> Laser plated LDS
> AOI

5. PTH

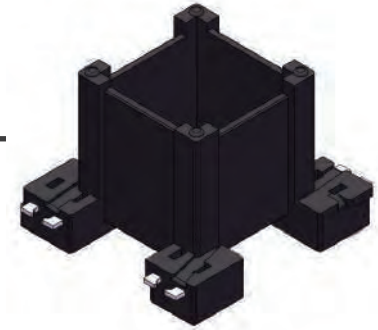
> Gull-wing
> L-insertedn
> L-injected
> Squared/rounded

6. DFM techniques

7. With/without snap-in

> With/without stand-offs
> With routing and wire guides
> Single/double multisection
> Capped/molded/open

8. Thermostable/phenolic



Adhesive blonder

Regarding the assembly processes, the bonder to be used is a key issue. While some technical adhesives will bring complexity to the assembly process because of their difficult handling and clean dispensing, they can provide ruggedness and improved pull-off strength.

The wire

The wire is the coil. The wire, normally coated with enamel, must be properly selected because of several reasons concerning the winding process. Ideally, the risk of a broken wire should be avoided. When the diameter of the wire decreases, this risk is increased, resulting in more complicated and delicate winding and post-winding handling processes. Wire diameter should then be selected also thinking about this.

1. Insulation
- a. Simple
- b. Double
- c. Triple

2. Thermal
- a. B/F/H

3. Bonding
- a. Self-bonding heat
- b. Self-bonding alcohol
- c. Not self-bonding

4. Solderability
- a. Solderable
- b. Not solderable
- c. Strippable

5. Strands
- a. Monofilar
- b. Bi-Multifilar
- c. Litz

What about the enamel coating? This decision is also important, because of the soldering and winding processes. A poor coating can lead to unintentionally short-circuited turns, resulting in magnetic field sinks, and a thick coating will bring uncertainty and dirty to the soldering process.

More about the wire: should the winding be performed directly over the core or over some other plastic surface with some supports to ease the routing and secure the winding shape? The ferrite core is a hard material. Winding processes expose the wire to a high voltage when a high winding speed is reached. This can modify the winding shape, adapting it to the form of the core, thus generating quality losses.

Tin

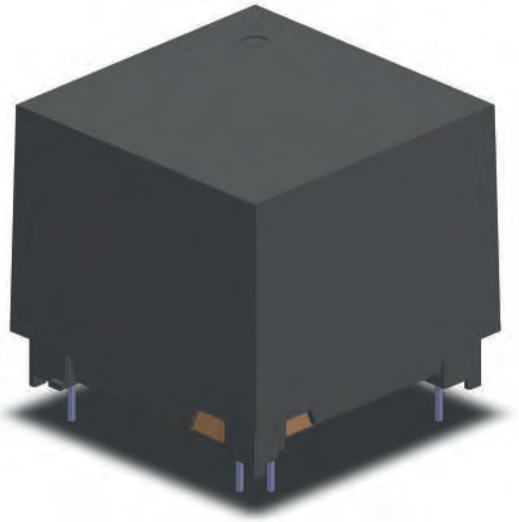
Tin is also an important material and its melting point should definitely be considered. It will affect the results of the soldering process by compromising success rate and quality. So it is important to make a good decision here – choose the right alloy – according to the implemented soldering process.

Another way to simplify the connection process is to remove the tin. Many methods can accomplish the electrical connection in absence of tin, such as point-to-point soldering using electrodes, laser soldering, and mechanical connection without soldering, among others.

Cap

The cap is an element meant to protect the part. It can be assembled – glued – to the part and also soldered. These two different procedures may have different advantages/disadvantages. On the one hand, while assembling is simpler than soldering, since cap gluing and assembling is a low-risk process; however, it can trigger also some quality issues over almost finished products because of the effect of applying adhesive over the winding. On the other hand, soldering is a more complex process with higher scrap rates, but will guarantee the stability of inductance.

This is also an important fact in order to design the cap in order to simplify the assembly and soldering processes. Drawing of the cap should take into account soldering process limitations and provide an open soldering surface as well as a defined space to dispense the glue and let it be distributed without altering the winding shape.



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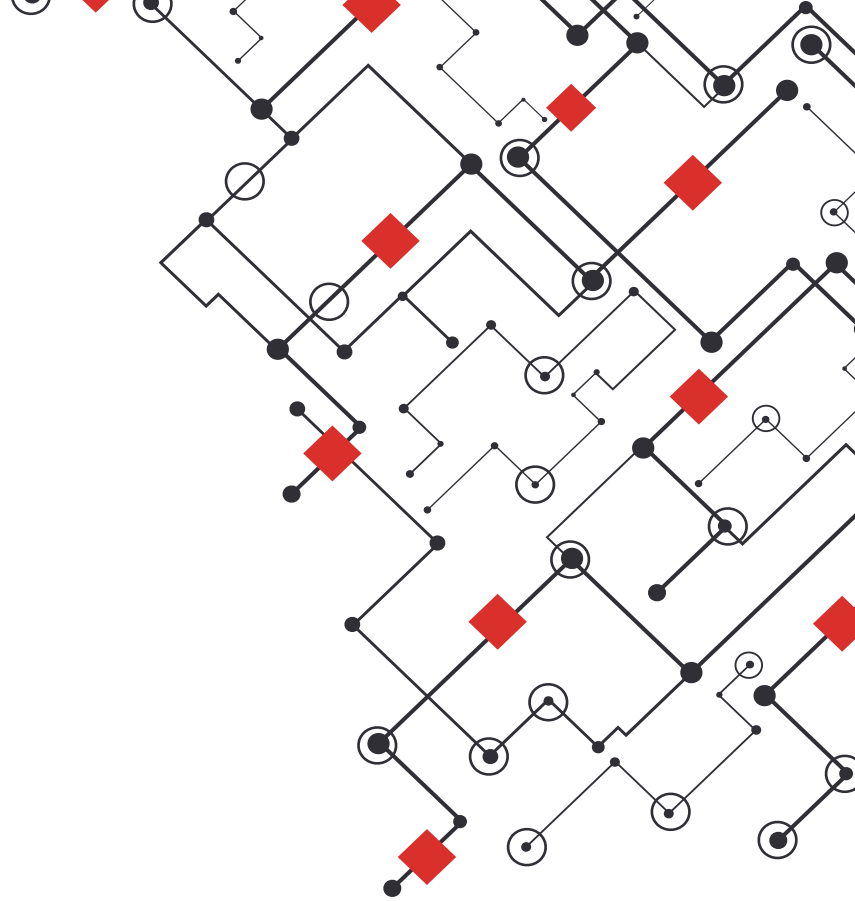


04

AR / VR TECHNOLOGY WILL IT CHANGE THE WORLD?

By Antonio Rojas Cuevas

04

AR/VR technology – **Will it change the world?**

Augmented reality and virtual reality (AR/VR technology) alter our perception of the world and of the things surrounding us.

What is the difference between virtual reality and augmented reality?

It's simply the degree to which you interact with this new reality. Within virtual reality, you feel as if you are fully immersed in a virtual world. You no longer see the "real world" but rather a new version of it, which can vary depending on the software you are using. If you believe your eyes, you are no longer in your living room but rather in a roller coaster (for example!). When you move your head, walk through the environment or interact with the animation, the image moves accordingly.

Augmented reality is more of a mix between the "real world" and the "new reality". You indeed see the real world around you, meaning you can actually see yourself in your living room, but you can follow a new image or new reality in front of you, and more recently even interact with 3D objects.

There is no limit to the possibilities of these technologies, now applied in the military (flight simulation, managing a weapon in battle, etc.), medicine (imaging, radiology, diagnostics, surgery, etc.), industry (effective training for dangerous tasks, object design in real-time), education (from primary school to graduate school), games, travel (travelling across country, across the world and even in outer-space), customer experience, and more. The human consciousness is exploring new and unknown worlds thanks to virtual and augmented reality.

AR/VR technology is changing our perception of the world

Can AR/VR technology lead to vertigo?

Possibly, but the limits and corrections will be established by the market and the leading players.

Even if there are many ways to make AR/VR work properly, the final target/application tracking system will be different, depending on accuracy, range, latency, line of sight, environmental impact, etc.

Optical, infrared and EM are the most popular tracking systems used in AR/VR; the choice of the solution depends upon the ultimate advantage or disadvantage taking into account many technical variables, cost as well as environmental conditions.

In a cost vs. accuracy vs. environmental impact, electromagnetic tracking is the selected technology in more than 80% of the cases.

Electromagnetic tracking used as a motion sensor is the oldest technology in this field and has driven large innovations in sensors technology, specifically sensitivity and size.

A wide variety of EM sensors can be designed to meet AR/VR technology requirements. From cube to low-profile configurations, and from lower to higher sensitivities, the range of possibilities is very wide.

A good, technical advantage for these sensors offered to the AR/VR market include more than six degrees of freedom (6DOF): 3 positions and 3 orientations generated by 3 transmitter coils and 3 receiver coils.

The number of applications using EM tracking will be exponential in the mid-term. The development of miniaturized electromagnetic sensors, even in 3D configurations with sizes less than 6mm square and the availability of larger tracking volumes with an improved accuracy, have opened the door for EM tracking systems for augmented reality applications such as medial environments applications.

These small coils can easily fit into a "virtual hand" glove. A single TX 3D coil and several receiver sensors on each finger can provide a realistic sensation of hand and finger movements in a working environment.

The latest and most recent algorithms improved the accuracy of EM tracking systems and allow computations of the receiver alignment with variable system parameters, including different numbers of turns and overall coil areas. The control unit of the EM tracking system determines the current position and orientation in tracking spaceautomatically (no latency, it takes into account the real time signal induced in the coils) by applying such an algorithm and forwards the results to a computerized managing circuit.

Tracking data is usually provided by the systems as translation vectors (x, y, z) for positional measurements and the orientation alternatively as rotation matrices.

This kind of system requires some kind of power measurement in a cycle, in DC, to sometimes compensate for the magnetic field coming from the earth and also the eddy current induced in metals near working volume.

Advantages and disadvantages of EM tracking for AR/VR technology:

ADVANTAGES

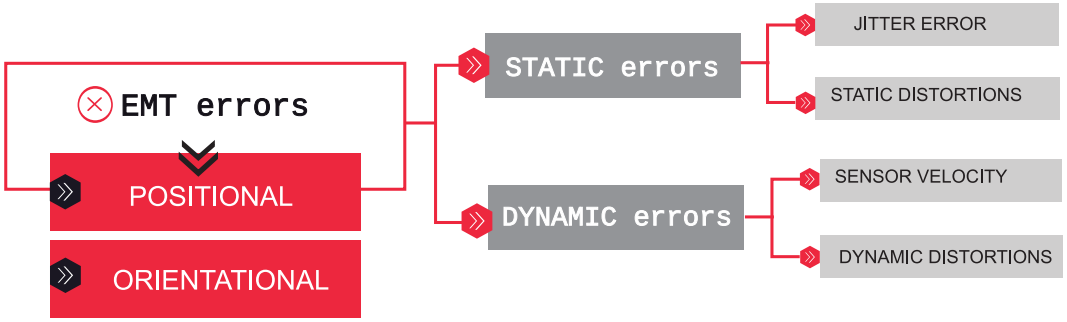
- No line of sight between transmitter and receiver is necessary
- Relatively inexpensive in comparison with other systems (optical)
- Convenient to use

DISADVANTAGES

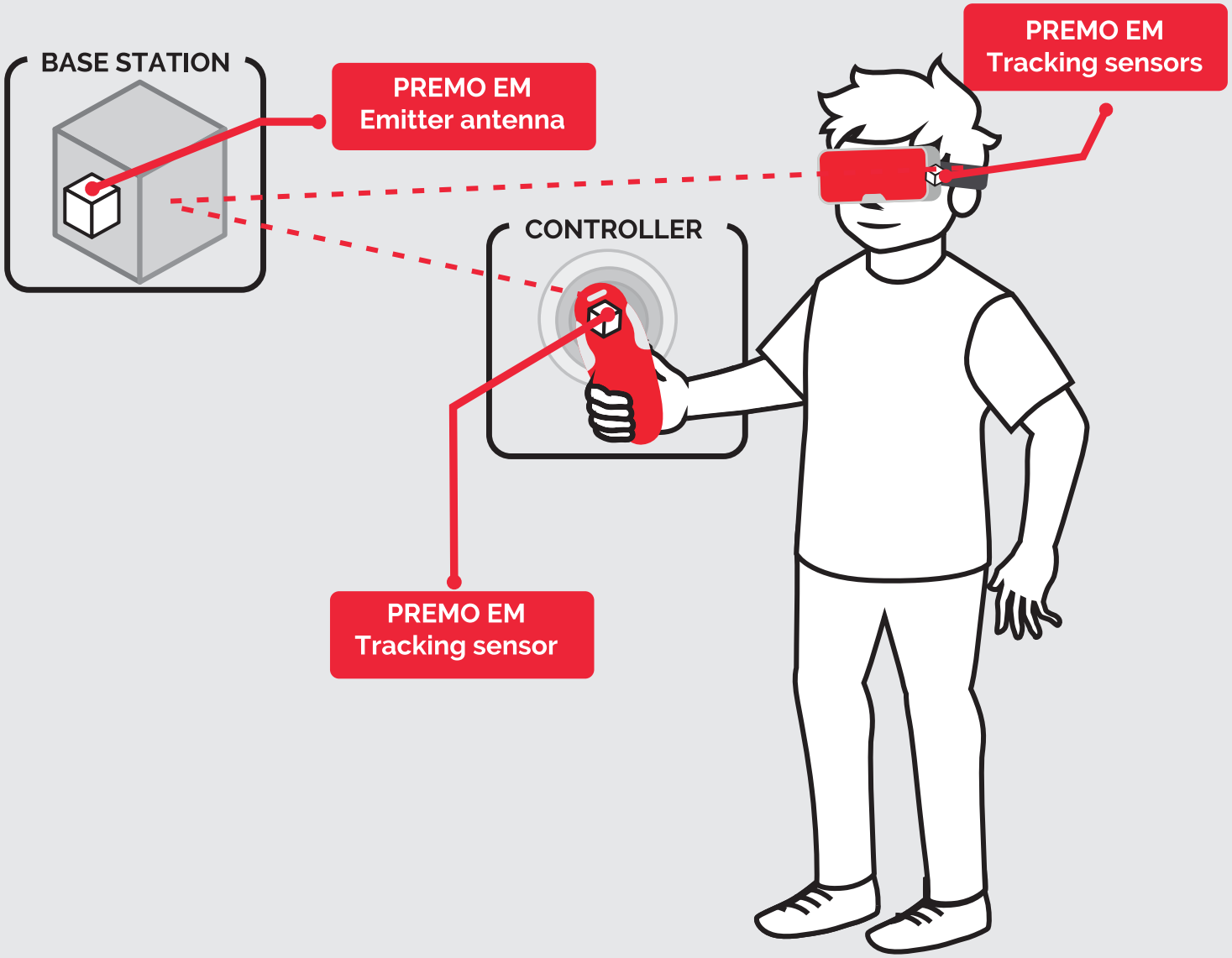
- Distortion caused by conductive ferromagnetic material and electrical appliance
- Limited working volume Tx-Rx distance (depending of Tx-power Rx-sensitivity)
- Low accuracy, one order of magnitude (in comparison with optical)

According to "Error Classification and Propagation for Electromagnetic Tracking" ("Fehlerklassifizierung und Fortpflanzung für elektromagnetisches Tracking") written by Julian Much, from Technische Universität München, some of the EM Tracking errors classification.

All disadvantages can be overcome by system design, using different techniques.



All of these can be addressed and compensated for by proper design, calculation techniques and calibration of the system in a real world environment.


BASE STATION
PREMO EM
Emitter antenna
PREMO EM
Tracking sensors
CONTROLLER
PREMO EM
Tracking sensor

05

GEOMETRIC SYMMETRY IN VR/AR ELECTROMAGNETIC MOTION TRACKING SENSORS

By Ezequiel Navarro Pérez et Al

05

Geometric Symmetry in VR/AR **Electromagnetic Motion** Tracking Sensors

Most VR /AR /MR hardware available and supporting literature in the form of papers, research docuements, PhD Thesis' and technical articles and contributions in books describe 3D TX Coils as Spheres of Cubes. Why?

Is magnetic Isotropy linked to Geometric Symmetry?

Circuit and components are typically built onto PCB's that are low profile. Can a low profile 3D TX emitter antennas work as a Cubic or as a Spherical one?

Most existing cases use Air Coils in 3D TX emitter coils. Why? Can we use high permeability soft magnetic materials to multiply the magnetic induction? What are the pros and cons'? How a proper soft magnetic material selection can mitigate the drawbacks while boosting performance and minimizing size?

Why are most existing HW solutions for 3D Tx emitter coils for motion tracking in VR/AR custom? Are there any of- the-shelf systems ready to take solution on the market?

Understanding the basics of EM tracking

Magnetism is substantially based in a very small number of principles and equations.

The Biot-Savart Law can be used to determine the magnetic field strength from a current segment. For the simple case of an infinite straight current-carrying wire it is reduced to the form:

$$\vec{B} = \frac{\mu_0}{2\pi r}\vec{I}$$

A more fundamental law than the Biot-Savart Law is Ampere's Law, which relates magnetic field and current in a general way.

NAME	INTEGRAL EQUATIONS	DIFFERENTIAL EQUATIONS	MEANING
GAUSS´S LAW	$\oiint_{\partial\Omega} \mathbf{E}\cdot d\mathbf{S} = \frac{1}{\varepsilon_0}\iiint_{\Omega}\rho\, dV$	$\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$	The electric flux leaving a volumen is proportional to the charge inside.
GAUSS´S LAW FOR MAGNETISM	$\oiint_{\partial\Omega} \mathbf{B}\cdot d\mathbf{S} = 0$	$\nabla\cdot\mathbf{B} = 0$	there are no magnetic monopoles; the total magnetic flux through a closed surface is zero.
MAXWELL-FARADAY EQUATION (Faraday´s law of induction)	$\oint_{\partial\Omega}\mathbf{E}\cdot d\boldsymbol{\ell} = -\frac{d}{dt}\iint_{\Sigma}\mathbf{B}\cdot d\mathbf{S}$	$\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$	The voltage induced in a closed circuit is proportional to the rate of change of the magnetic flux it encloses.
AMPÈRE´S CIRCUITAL LAW (with Maxwell´s addition)	$\oint_{\partial\Sigma}\mathbf{B}\ d\boldsymbol{\ell} = \mu_0\iint_{\Sigma}\mathbf{J}\cdot d\mathbf{S} + \mu_0\varepsilon_0\frac{d}{dt}\iint_{\Sigma}\mathbf{E}\cdot d\mathbf{S}$	$\nabla\times\mathbf{B} = \mu_0\left(\mathbf{J} + \varepsilon_0\frac{\partial\mathbf{E}}{\partial t}\right)$	The magnetic field induced around a closed loop is proportional to the electric current plus displacement current (rate of change of electric field) it encloses.

Electromagnetism describes the interaction between magnetic fields and electricity.

AN EXPANDED VIEW OF GAUSS´LAW MAGNETISM

Reminder that the magnetic field is a vector

Dot product tells you to find the part of $\vec{B}$ parallel to $\hat{n}$ (perpendicular to the surface)

The unit vector normal to the surface

$$\oint_S \vec{B} \circ \hat{n} \, da = 0$$

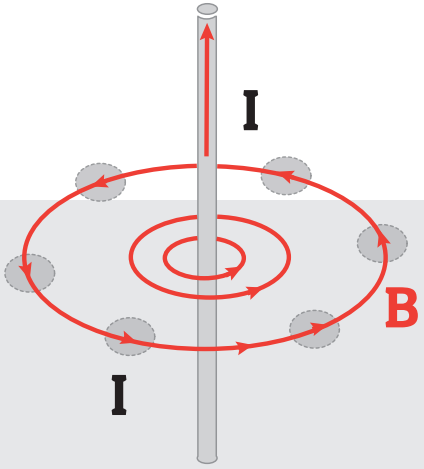
The magnetic field in Teslas

An increment of surface area in m^2

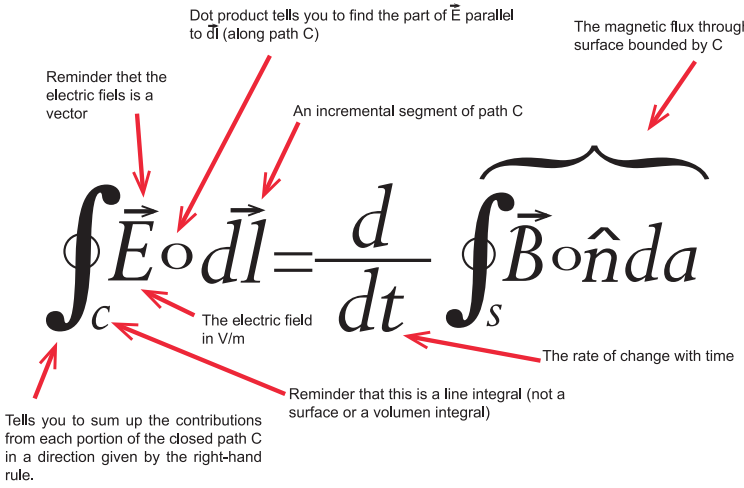
Reminder that this is a surface integral (not a volume or a line integral)

Tells you to sum up the contributions from each portion of the surface

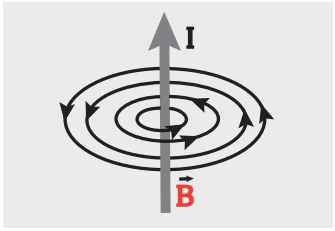
Very basically, any current flow generated by a voltage drop across a conductor generates a magnetic field.



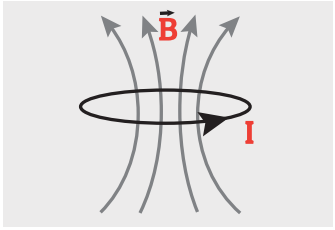
AN EXPANDED VIEW OF THE STANDARD FORM OF FARADAY´S LAW



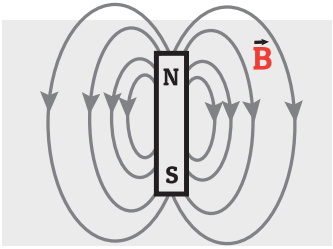
CURRENT -CARRYING STRAIGHT WIRE



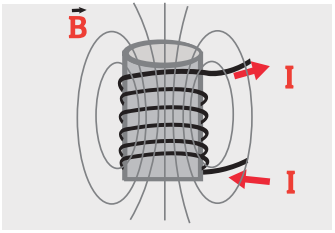
CURRENT LOOP



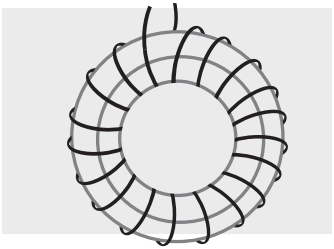
BAR MAGNET



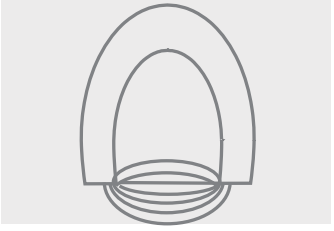
SOLENOID



TORUS



HORSESHOE MAGNET

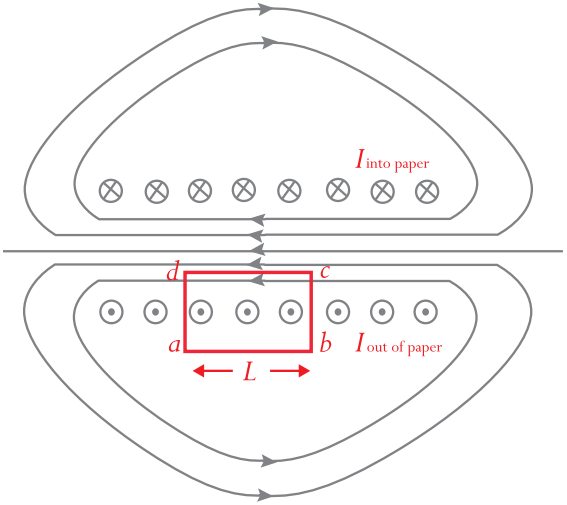


As all the mentioned equations present a clear geometry impact, the differential cross sectional area $\vec{dS}$ is a vector that is multiplied (vector product) by $\vec{dB}$ .This means that in complex geometries the cross sectional area at every point has to be calculated and will not always be as simple as a circle or a square. Nevertheless, for the sake of simplicity and to avoid complex integral calculus, most cases present either a cube (cross sectional is a constant square of side l), or a sphere (cross sectional areas is a circle with radius r), or a solenoid (an infinite cylinder), or a torus (a revolution shape); last 3 shapes have a constant cross sectional area equal to $A = \pi r^2$ which makes calculation easy.

A simple example is the solenoid.

Magnetic Fiels of a Solenoid

A solenoid is a tightly wound helical coil of wire whose diameter is small compared to its length. The magnetic field generated in the center or core of a current carrying solenoid is essentially uniform and is directed along the axis of the solenoid. Outside the solenoid, the magnetic field is far weaker. The figure below shows (rather schematically) the magnetic field generated by a typical solenoid. The solenoid is wound from a single helical wire which carries a current ***I.***



The winding is sufficiently tight that each turn of the solenoid is well approximated as a circular wire loop, laying in the plane perpendicular to the axis of the solenoid, which carries a current, ***I***. Suppose that there are N such turns per unit axial length of the solenoid. What is the magnitude of the magnetic field in the core of the solenoid?

In order to answer this question, let us apply Ampere's circuital law to the rectangular loop ***abcd*** . We must first find the line integral of the magnetic field around ***abcd*** . Along ***bc*** and ***da*** the magnetic field is essentially perpendicular to the loop, so there is no contribution to the line integral from these sections of the loop.

Along ***cd***, the magnetic field is approximately uniform, of magnitude ***B***, say, and is directed parallel to the loop. Thus, the contribution to the line integral from this section of the loop is ***BL*** , where ***L*** is the length of ***cd*** . Along ***ab*** the magnetic field-strength is essentially negligible, so this section of the loop makes no contribution to the line integral. It follows that the line integral of the magnetic field around ***abcd*** is simply:

w= BL.

By Ampere's circuital law, this line integral is equal to μ_0 times the algebraic sum of the currents which flow through the loop ***abcd***.

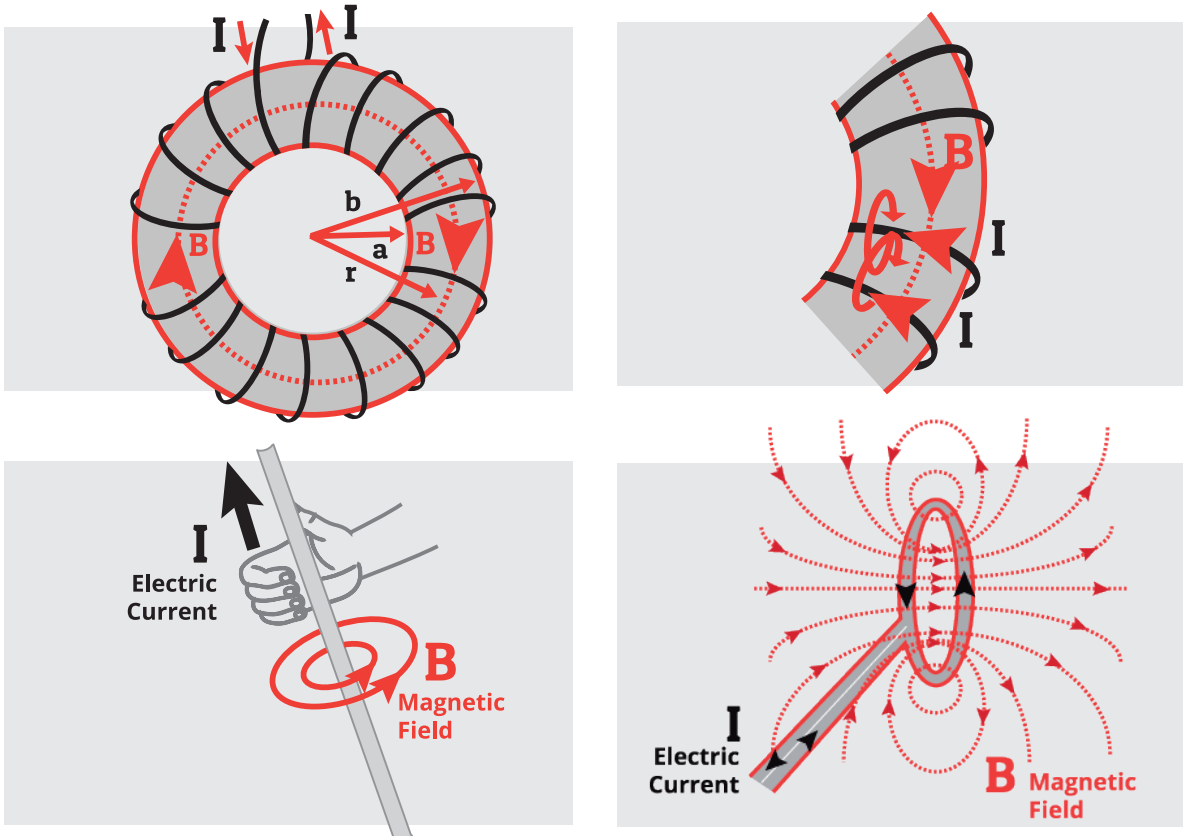
Since the length of the loop along the axis of the solenoid is ***L***, the loop intersects ***n L*** turns of the solenoid, each carrying a current ***I***. Thus, the total current which flows through the loop is ***n L I***. . This current counts as a positive current since if we look against the direction of the currents flowing in each turn (i.e. into the page in the figure), the loop ***abcd*** circulates these currents in a counterclockwise direction. Ampere's circuital law yields:

$$\vec{B}\vec{l} = \mu_0 N\vec{l}\vec{I} \quad \text{Wich reduces to:} \quad \vec{B} = \mu_0 N\vec{I}$$

When the core is not air but a soft magnetic material with a magnetic permeability magnetic permeability, $\mu_r \mu_r$ and final effective permeability being final effective permeability:$\mu_e \mu_e$

$$|\vec{B}| = |\mu_0 \mu_r NI| = \mu_e N|\vec{I}|$$

Magnetic Fiels of a Torus



Finding the magnetic field inside a torus is another good example of the use of Ampere's Lawin simple shapes. The current enclosed by the dashed line is just the number of loops times the current in each loop. Ampere's Law then gives the magnetic field by :

$$|\vec{B}|2\pi r = |\mu_0 \mu_r N\vec{I}| = \mu_e N|\vec{I}| \qquad |\vec{B}| = \frac{\mu_e N|\vec{I}|}{2\pi r}$$

All of the loops of wire that make up a torus contribute magnetic field in the same direction inside the torus. The sense of the magnetic field is that given by the right hand rule, and a more detailed visualization of the field of each loop can be obtained by examining the field of a single current loop.

MAGNETIC FIELD EQUATIONS FOR SIMPLE OBJECTS

Infinite straight wire carrying current I (at distance r)	$\vec{B} = \frac{\mu_0 I}{2\pi r}\hat{\varphi}$
Segment of straight wire carrying current I (at distance r)	$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}\times\hat{r}}{r^2}$
Circular loop of radius R carrying current I (loop in yz plane, at distance x along x-axis)	$\vec{B} = \frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}\hat{x}$
Solenoid with N turns and length l carrying current I	$\vec{B} = \frac{\mu_0 NI}{l}\hat{x}\,(\text{inside})$
Torus with N turns and radius r carrying current I	$\vec{B} = \frac{\mu_0 NI}{2\pi r}\hat{\varphi}\ (\text{inside})$

Topies, Myths and mistakes

Most primitive VR 3D Tx emitter and Rx receiver motion tracking coils are made by directly winding 3 orthogonal coils around the 3 axis' of a cube.

There are 2 fundamental disadvantages and 2 conceptual mistakes:

DISADVANTAGES / DRAWBACKS:

01

The concept is ideally good but in industrial practice fundamentally wrong as it is impossible to achieve high volume automatic production.

Solution 1: In order to assemble more than 90.000 components per hour; a full SMT solution is needed. The use of a coil former and a SMT mount base is a must. Multiple solutions are possible but the combination of SMT assembly, AOI , automatic winding and housing for a soft magnetic core that can preferably be a ferromagnetic fluid like Magment of PBM is part of Premo 3DcoilCube key innovations.

02

It is impossible to decouple the geometric imperfections of the core from the windings

Solution 2: When windings are directly wound on the cubic core, there are risks of damaging the enamel isolation of the magnetic wires and also a risk of short circuit when the copper windings touch each other (a short circuited turn is a magnetic field sink) or that through the conductivity of the core the whole winding has low resistance parallel impedance that minimizes performance. There are two common practices and both are wrong for VR applications. One solution is winding directly over the cubic core using high resistivity ferrites like NiZn spinal ferrites. The second solution is using the widely available MnZn high permeability ferrites but isolated by insulating tape (polyester or kapton tapes are common). Both solutions forget that when you wind onto the core, the windings adopt the shapes and imperfections of the core and, therefore, the perfect symmetry and orthogonality needed to generate an isotropic symmetric orthogonal field is compromised.

Ferrites are produced by high temperature sintering after a very high pressure forming of the so called green, fresh form of wet combination of Fe oxides and binders. The process is very aggressive and there is a significant change of volume by 20% to 40% which is known as shrinkage. Shrinkage is not always symmetric as the density of the green ferrite after pressing is not homogeneous and therefore the only way to obtain perfect and symmetric ferrites is by grinding one or two faces after the core has been fired in a furnace. This is obviously a slow and expensive process. Premo 3DcoilCubes assure that the windings are perfectly equal and symmetric and orthogonal by the design of a high precision injection mold for high stability technical plastics that is the container of a magnetic fluid (Magment or PBM) that fills into the perfect cubic shape and that is mechanically decoupled from the coils that are wound around the cubic plastic thus avoiding translating the core imperfections to the copper windings. Alternatively, any ferrite (NiZn for its good high frequency person or MnZn for its higher permeability and lower cost) can also be fitted into the coil former.

CONCEPTUAL MISTAKES

"Only simple symmetric geometries can assure an isotropic magnetic field."

It is true that a symmetric geometry can be simpler to analyze but we cannot sacrifice performance or manufacturability (DFM) or cost for the sake of simplicity. We must think twice about the challenge to decompose it and prove that there are multiple variables that can help us obtain symmetrical identical orthogonal B vectors in our TX and Rx sensors.

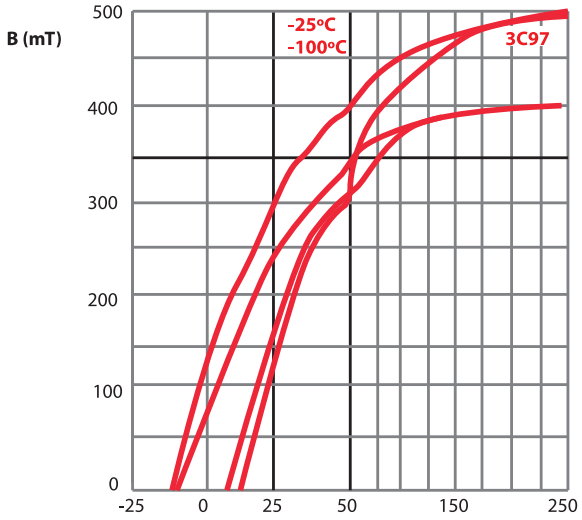
"Ferromagnetic cores introduce imperfections."

We have proved that introducing a high permeability soft magnetic material lets us increase $\mu_e \mu_e$ times the magnetic field generated. This is true provided the core is not in saturation so $B < B_{sat}$ is a minimum condition of operation being B_{sat} the value in the BH Hysteresis loop where higher H do not produce larger B. After this Bsat point of the loop, the magnetic domains of the material are all aligned when the magnetic fields spin in the same direction.

There is a part of the B-H loop where the function is linear and differential increments of H produce proportional differential increments of B. The derivative of the function is the effective permeability in this infinitely small point. Provided the magnetizing current in the winding does not produce oscillations that gets the operation out of the linear part of the loop, the Total Harmonic Distortion (THD) is negligible.

A typical B-H loop courtesy of Ferroxcube is shown below for a common MnZn ferrite at two different operating temperatures. Both loops show that the material is very linear in the range 50-250 mT.

TYPICAL B-H LOOPS



A simple example: The Sphere

Most pre-industrial systems have a **3D TX** emitter coil based on a sphere with 3 identical orthogonal windings with N turns of the identical wire. For the sake of simplicity, we will consider that the sphere has a radius **R** and that the three orthogonal windings have identical number of turns **N** with the same radius **R.**

Each winding will generate a magnetic field B having a total resulting field $\vec{B}=\vec{B}_x+\vec{B}_y+\vec{B}_z$ being all identical in modulus ; $|\vec{B}_x|=|\vec{B}_y|=|\vec{B}_z|$; $0{,}0|\vec{B}_z|$

As per the summary table below, the field at a given point (x,y,z) from the center would have the following identical components:

$$\vec{B}_x=\frac{\mu_0 I R^2}{2(x^2+R^2)^{3/2}}\hat{x} \quad \vec{B}_y=\frac{\mu_0 I R^2}{2(y^2+R^2)^{3/2}}\hat{y} \quad \vec{B}_z=\frac{\mu_0 I R^2}{2(z^2+R^2)^{3/2}}\hat{z}$$

What happens when we introduce a high permeability soft magnetic material like a **MnZn** ferrite that may have an initial magnetic permeability μ_i**>10000?** Just by introducing this factor we could have a much higher effective permeability $\mu_e = \mu_0\ \mu_r$ The generated field in every axis is μ_r folds bigger than with an air coil.

$$|\vec{B}_x| = |\vec{B}_y| = |\vec{B}_z| = \left| \frac{\mu_e I \vec{R}^2}{2(x^2 + R^2)^{3/2}}\ \hat{x} \right|$$

Here you can see that keeping the shape the same you can play with virtual infinite different multiples $\mu_e N$ that keeps vector identical.

When we change the shape to a low profile solution like in the picture below, the free variables are **Nx,Ny,Nx,** μ_e and dimensions that provides enough freedom to generate infinite combinations that produce identical B vectors.

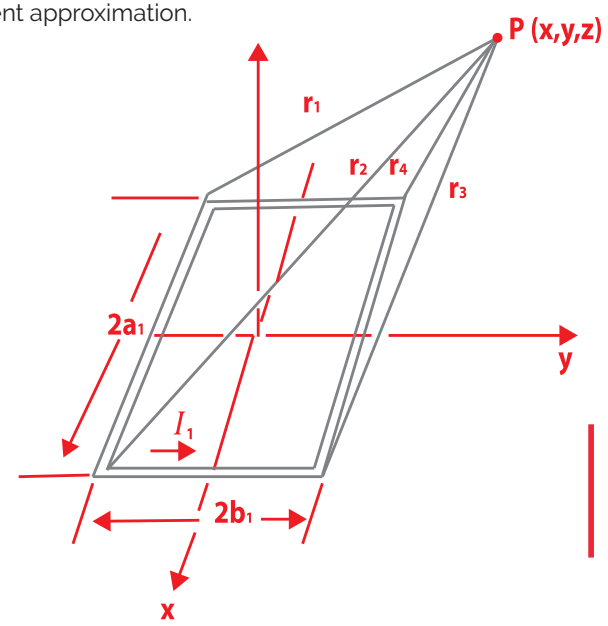
The **3D Tx** emitter antenna shown below can generate identical **Bx, By** and **Bz** fields to the above spherical solution.

Bx and **By** can be assimilated to two identical perpendicular solenoids or two identical orthogonal rectangular windings (dimension of each rectangular turn 2a1 x 2b1) with magnetic permeability $\mu_{ec} = \mu_{ex} = \mu_{ey}$ and number of turns **Nx =Ny ; Bz** is generated by a circular winding with a circular core as represented under item #4 in figure below that has effective magnetic permeability μ_{ez} radius **Rz** and **Nz.**

This will lead to:

$$\vec{B}_z = \frac{\mu_0 I R^2}{2(z^2 + R^2)^{3/2}}\ \hat{z}$$

Let's determine the field of a rectangular loop and then extend it to Nx times and μ_{ec} times the value as a sufficient approximation.



Geometry for a single rectangular loop of wire in the x-y plane.
The magnetic flux density is evaluated at point P (x,y,z)

$$\vec{B}_x = -\frac{\partial A_y}{\partial z} \quad \vec{B}_y = -\frac{\partial A_x}{\partial z} \quad \vec{B}_z = -\frac{\partial A_y}{\partial x} - \frac{\partial A_x}{\partial y}$$

$$A_{x1} = \frac{\mu_0 I_1}{4\pi} 1n \left[\frac{(r_1 + a_1 + x)}{(r_2 - a_1 + x)} \cdot \frac{(r_3 + a_1 + x)}{(r_4 - a_1 + x)} \right]$$

$$A_{y1} = \frac{\mu_0 I_1}{4\pi} 1n \left[\frac{(r_2 + b_1 + y)}{(r_3 - b_1 + y)} \cdot \frac{(r_4 - b_1 + y)}{(r_1 - b_1 + y)} \right]$$

$$B_{z1} = \frac{\mu_0 I_1}{4\pi} \sum_{a=1}^{4} \left[\frac{(-1)^{\alpha} d_\alpha}{r_\alpha [r_\alpha + (-1)^{\alpha+1} C_\alpha]} - \frac{C_\alpha}{r_\alpha [r_\alpha + d_\alpha]} \right]$$

$$C_1 = -C_4 = a_1 + x \quad d_1 = d_2 = y + b_1$$
$$C_2 = -C_3 = a_1 + x \quad d_3 = d_4 = y - b_1$$

$$r_1 = \sqrt{(a_1+x)^2 + (y+b_1)^2 + z^2}$$

$$r_2 = \sqrt{(a_1-x)^2 + (y+b_1)^2 + z^2}$$

$$r_3 = \sqrt{(a_1-x)^2 + (y-b_1)^2 + z^2}$$

$$r_4 = \sqrt{(a_1+x)^2 + (y-b_1)^2 + z^2}$$

$$r = r_1 = r_2 = r_3 = r_4 = \sqrt{a_1^2 + b_1^2 + z^2}$$

Then the field in the z axis for the figure would be: b_1

$$B_{z1} = \frac{\mu_0 I_1 a}{\pi} \frac{b_1}{r^2 - b_1^2}$$

For a given number of turns Nx=Nz and same effective permeability and considering that our 3D Low Profile TX emitter coil as per the figure configuration this applies to the X and Y axis, we would obtain:

$$B_x = B_y = \frac{\mu_0 \mu_{ec} N_x I_x}{\pi} \frac{ab_1}{r^2 - b_1^2} = \frac{\mu_0 \mu_{ec} N_y I_y}{\pi} \frac{ab_1}{r^2 - b_1^2}$$

If we consider a form factor that is constant for this given geometry of rectangular winding $klp = \frac{ab_1}{r^2 - b_1^2}$ **equation 9** then we can have a simple:

$$B_x = B_y = \frac{\mu_0 \mu_{ec} N_y I_y}{\pi} klp$$

Again, there are infinite combinations of N, μ_{ec} **equation11** that satisfy the equation to obtain equal symmetric values of B with an open air winding than in the low profile 3D emitter antenna with high permeability core.

$$B_x \ low\ profile = B_x\, sphere;$$

$$\frac{\mu_0 \mu_{ec} N_y l_p I_y}{\pi} klp = \frac{\mu_0 N_{ys} I R^2}{2\,(x^2 + R^2)^{3/2}}$$

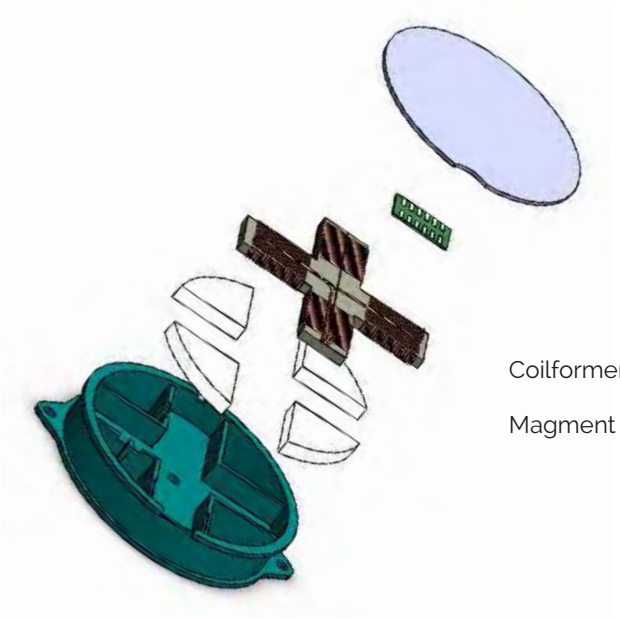
Considering the constant form factor of the sphere K_{sphere}

$$K_{sphere} = \frac{R^2}{2\,(x^2 + R^2)^{3/2}}$$

$$\frac{\mu_0 \mu_{ec} N_y l_p I_y}{\pi} k_{lp} = \mu_0 N_{ys} I\, k_{sphere}$$

The equal B is obtained as long as the product

$$\mu_{sc} N_{ylp} = \frac{N_{ys} I_s\, k_{sphere}}{I_y\, \pi k_{lp}}$$



There are infinite solutions > Myth Killed

Coilformer for liquid core: innovation

Magment or PBM: innovation

The Cube and the 3DCoilcube

As already explained, the detection principle is based on the magnetic formulas that in radial (radial and tangential) coordinates are:

$$B_\theta = \mu_0\mu_e \frac{NIl^2}{4\pi d^2} sin(\theta)\,;\; B_r = \mu_0\mu_e \frac{NIl^2}{2\pi d^2} cos(\theta)\,;$$

Where:

N= Number of turns of every winding

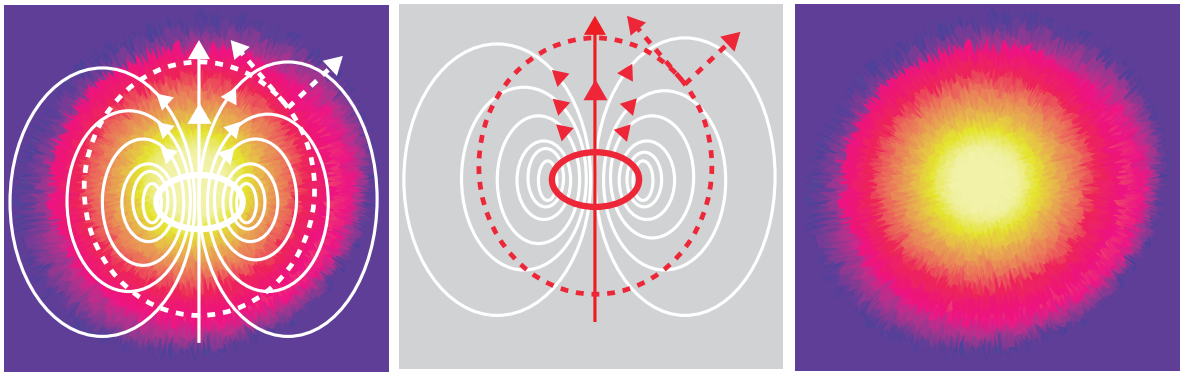
I= Current

l= side of the cube

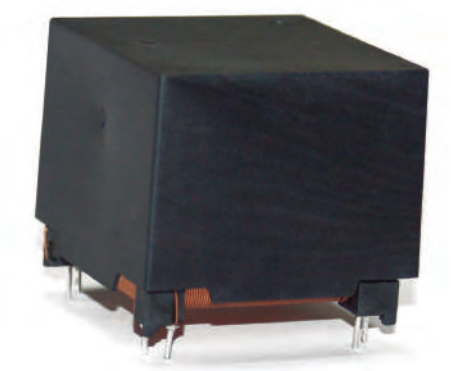
d= distance to the center

θ= the angle of reception

The following figure shows the dipole generated simulation:



This next figure shows an industrial finished **3DCoilCube™** with a protective cover cap.



The following figure shows the cubic **3DCoilCube™** with high permeability soft magnetic core and mechanical decoupling of the winding from the core.

Sensor to generate and receive the magnetic field signals

One-of-a-kind 3D magnetic coils are placed in both ends of the EM system to generate and receive the agnetic field signals. With 50 years of experience under our belt, we are the world leaders in designing and manufacturing this kind of coils, producing more than 30 million 3DCoils per year.

System works by using a low frequency

3DCoilCube´s electromagnetic motion tracking system works in low frequency isotropic magnetic field generator (3D emitter) and one or several isotropic 3D magnetic sensor.

The manufacturing process starts with a PBM core into the SMT mechanicak polymeric structure

PBM Core SMT
High Precision base

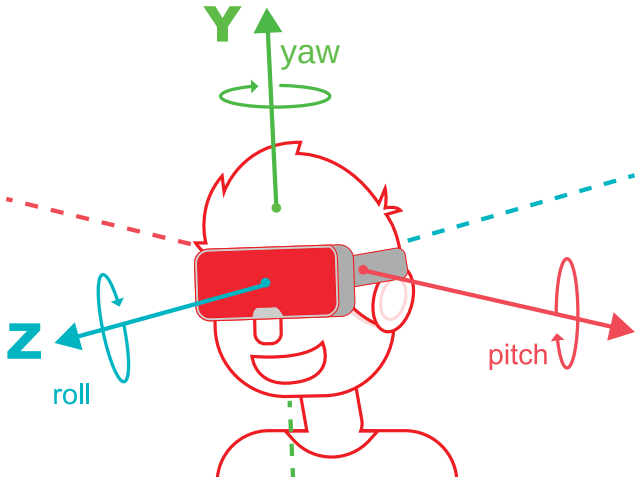
X Winding Pitch
Sensor Coil

Y Winding Yaw
Sensor Coil

Z Winding Roll
Sensor Coil

X winding Pitch
3DCoilCube

The X, Y and Z windings determine Pitch, Yaw and Roll.



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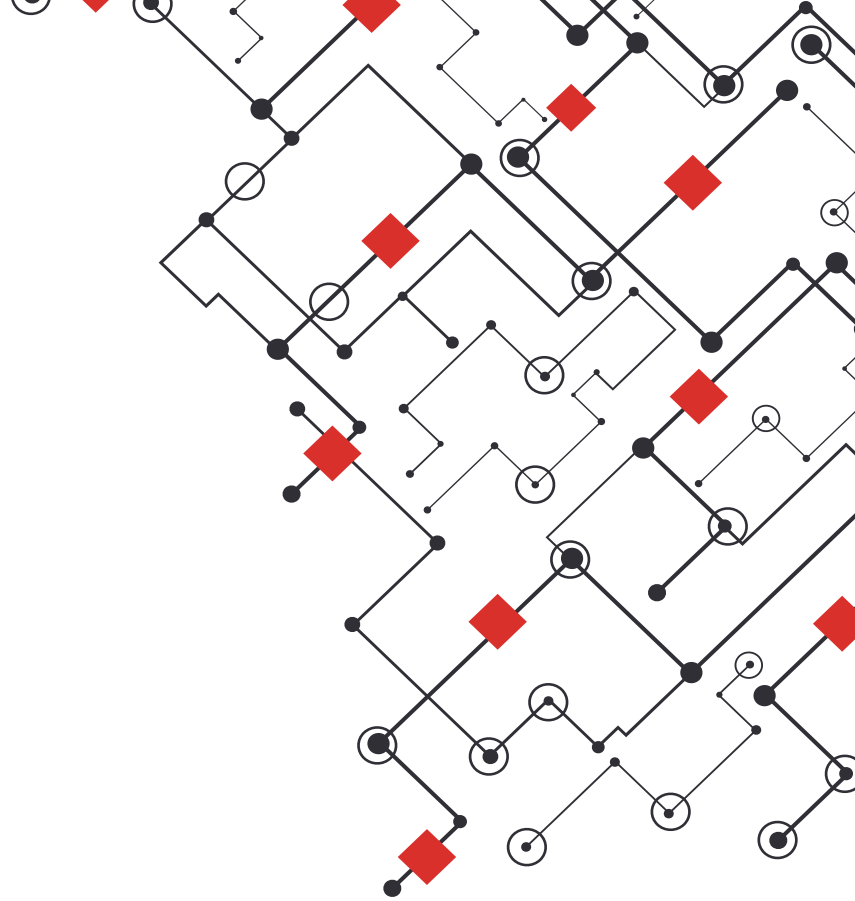
Magnetic Field of Current Loop: http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/curloo.html#c1



06

WHAT ARE ELECTROMAGNETIC TRACKING SYSTEMS?

By Ezequiel Navarro Pérez et Al

06

What are electromagnetic **tracking systems?**

What are the challenges that most engineers face after they decide that ELECTROMAGNETIC Tracking is the best choice?

What is the Structure of a typical Tracking System?

As a closed loop control system, what are the time-domain challenges such as Stability and Error in EMTS?

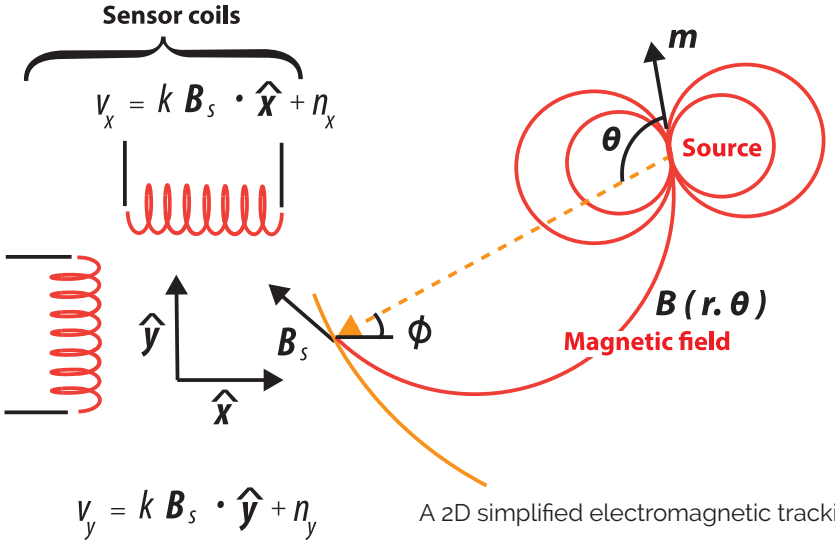
What EMTS sensors are optimal for a given design?

With this post we try to help fellow VR designers to understand the first 2 questions. Keep visiting our Blog for next Post on the next two questions in a series intended to assist with the fundamentals or AC EM tracking and the best possible emitter and sensors.

first taste of virtual reality

The tools of state of the art media are excellent at portraying human experience- a clear evidence is computer generated special effects in movies or a better example the big success of James Cameron movie Avatar (2009) with its amazing combination of technology and the first large introduction to mass public of the possibilities of Virtual Reality. VR is the next step in man-made verisimilitude. A face covering display (or at least goggles) takes over a user's sense of sight, while sensors mimic the body's subconscious mechanisms responsible for balance. The result is being someplace when you are not. VR proponents go further into Augmented Reality and say that liberating computers, tablets and smart phones from the confines of glass rectangles will change the ways in whichpeople interact with information . Alex Kipman, the inventor of Microsoft HoloLens and Kinect, as recently as 5 days ago said in an interview with Bloomberg that this is going to end with the smart phones as we know them today .

According to Faradays Law, when a receiver sensor moves in the space inside an alternating (AC) magnetic field B (T), a voltage, proportional to the vectorial or cross product of the cross sectional winding area and the intensity of the magnetic field, is induced in every winding this producing N times the total voltage across the coils (being N the number of turns of the winding). This induced voltage immediately gives the measurement of rotation (θ) vs the reference emitter coils and the position (as the modulus of the resulting vector) in relation with the modulus of the emitting vector (r) .



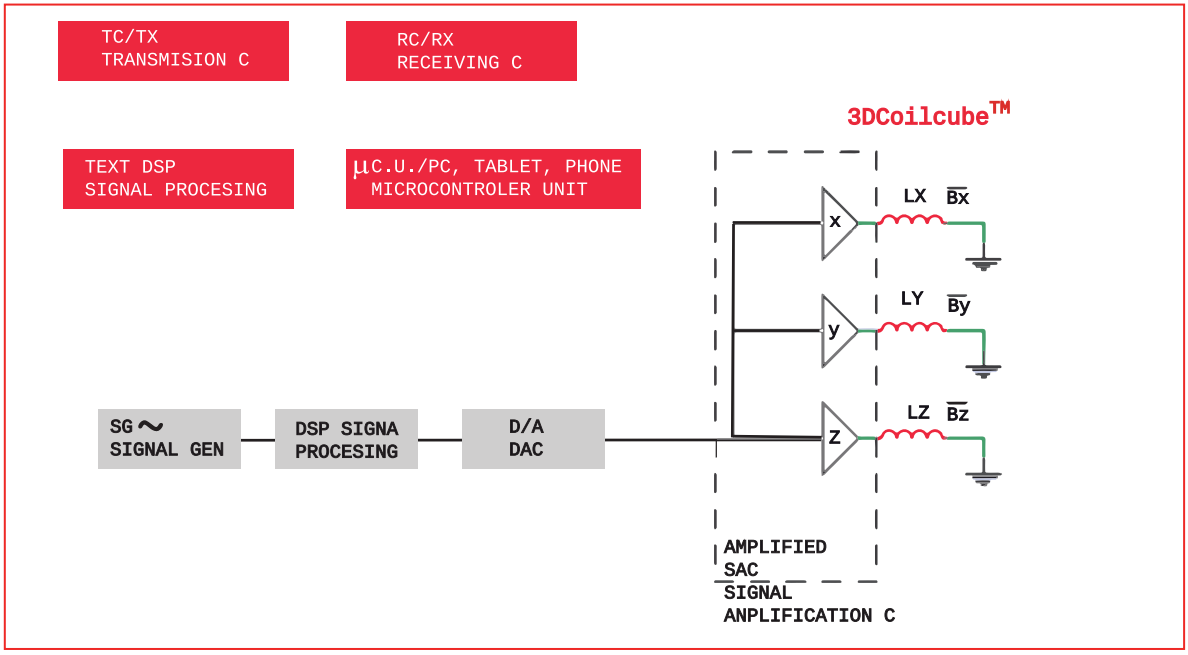
A 2D simplified electromagnetic tracking system 1

Therefore, EMTS ElectroMagnetic Tracking Systems can accurately calculate position and orientation as described in above figure for a 2D system. In a 3D system the process is identical but in R3 and can provide dynamic, real-time measuring position and orientation angle. This system is mainly used in Digital fields such as navigation, ballistic tracking, biomechanics, contruction, robotics, biomechanics, advance education, and above all Virtual Reality and Augmented reality systems to represent in the Digital (Virtual) World the exact position and movements of physical objects or people, making their avatar move identically as their original physical characters.

A tracking system case for anaysis

Electromagnetic tracking systems are composed of 4 functional moduli:

1. **TX** circuit.
2. **RX** circuit.
3. **DSP** (Digital Signal Processing).
4. **MCU (Micro-Controller Unit)** based on a PC, a Gaming Set Top Box, a Smart portable device like a Tablet or Smartphone able to run software defined algorithms



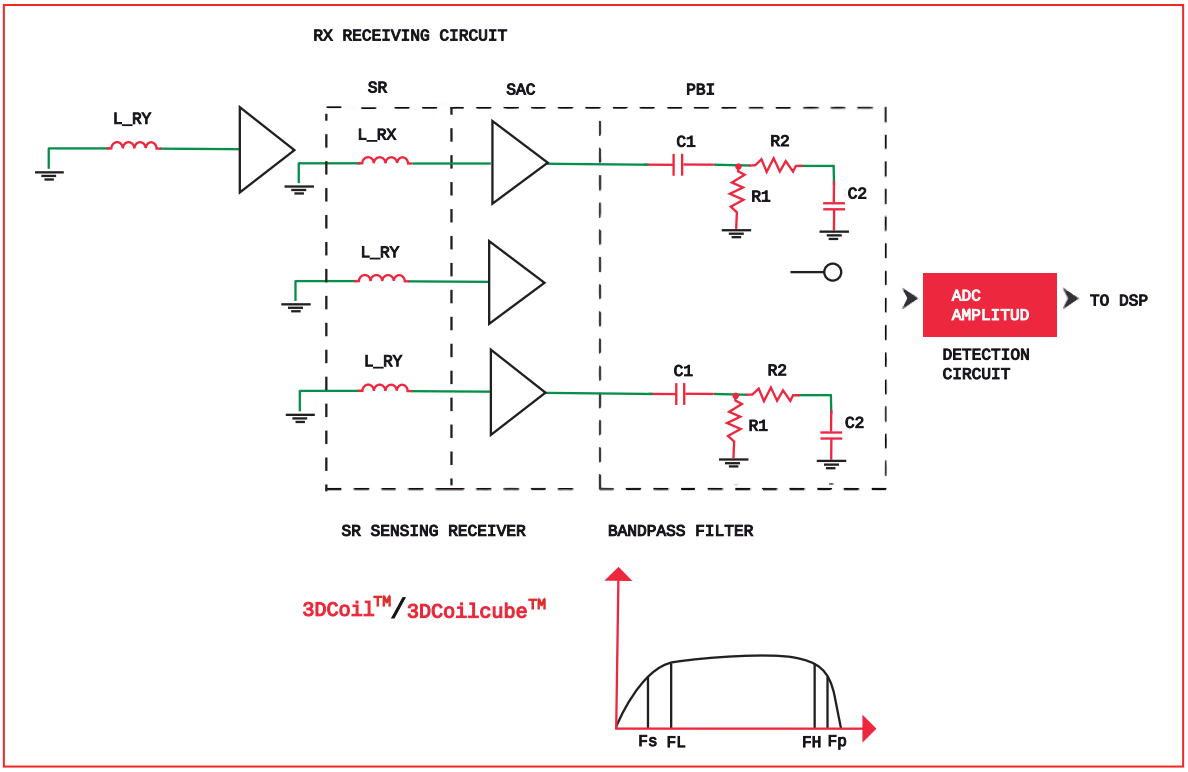
The TX Circuit contains:

› SGC or Signal Generator typically an oscillator and by frequency division a generator of LF (10KHz to 60 KHz) signal (we will cover in another post the key topic of choosing the right operating frequency).

› A simple DSP or Signal processing.

› A DAC or Digital to Analog Converter.

› An Amplifying unit or SAC to generate the 3 identical signals (?) with same amplitude, frequency, shape and shift signals that generate the 3 orthogonal magnetic fields Bx, By and Bz in the 3D TX Emitter Antenna **3DCoilcube™.**



The RX receiving Circuit is basically composed by :

› **The EM Sensing Receiver coils**

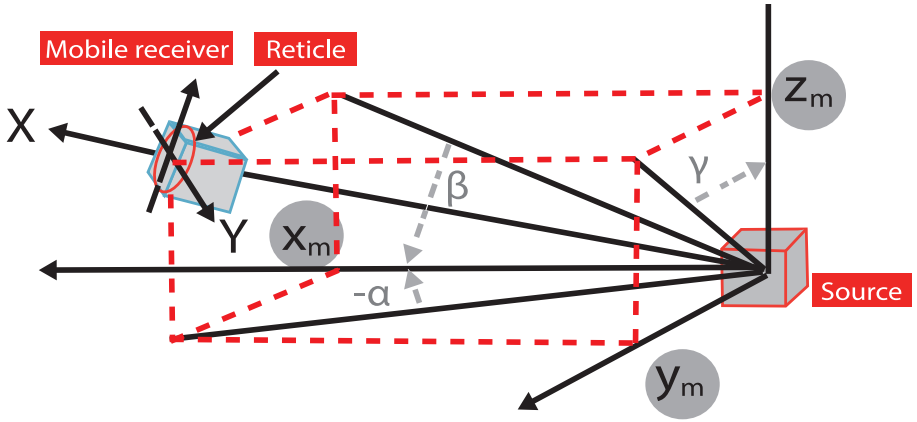
› **The 3 orthogonal coils wound on a cubic core** (a **Premo 3dCoilCube™**) **or on a low profile core** (**Premo 3DCoil™**) would receive voltages that are vectors with 3 orthogonal components :

$$Vx = k\,BBs + nx = k\,Bs \cdot \hat{x} + nx$$

$$Vy = k\,Bs \cdot \hat{y} + n$$

$$Vz = k\,Bs \cdot \hat{z} + nz$$

As an example : a detailed 3D Vectorial schematic for an application in a VR Cockpit Flight Simulator can be seen below:

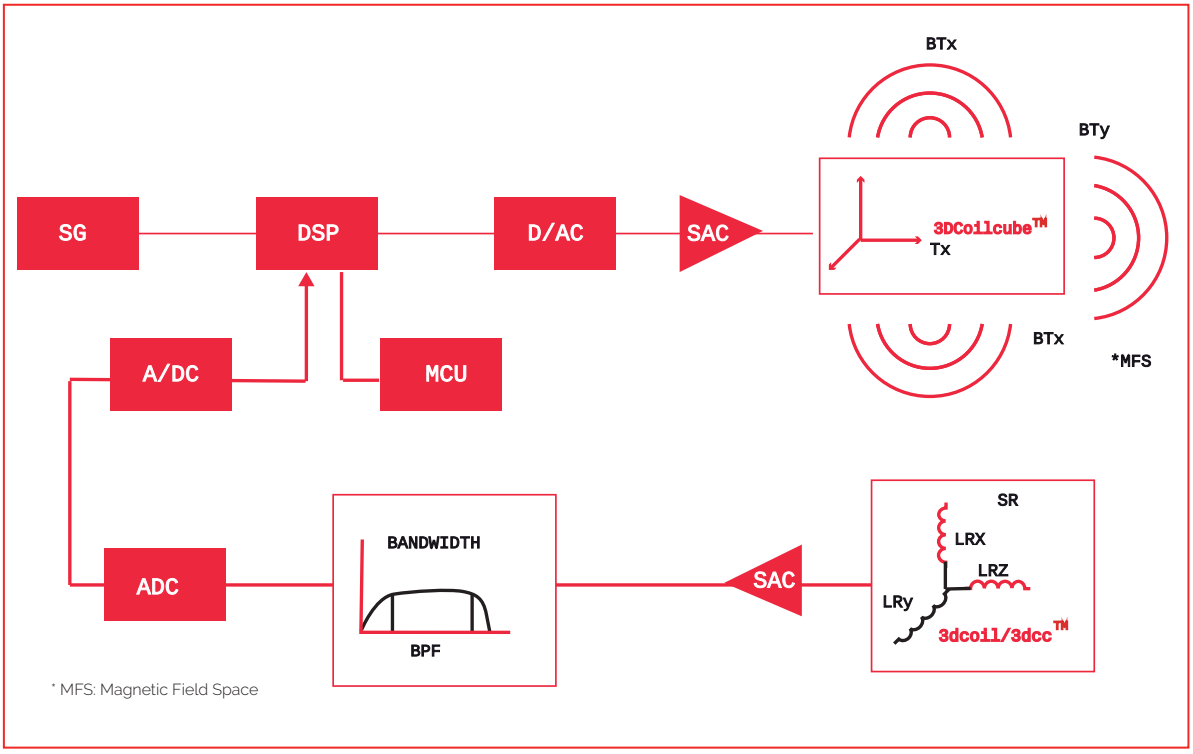


› **SAC** (Signal Amplifier Circuit).

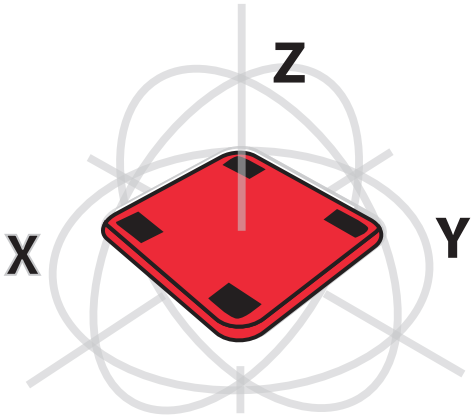
› **BPF** (Band Pass Filter).

› **ACD** (Amplitude Detection Circuit) to give us the signal amplitude that we need. The signal can be managed by the DSP, which can be embedded in the microcontroller or in a peripheral in most MCUs.

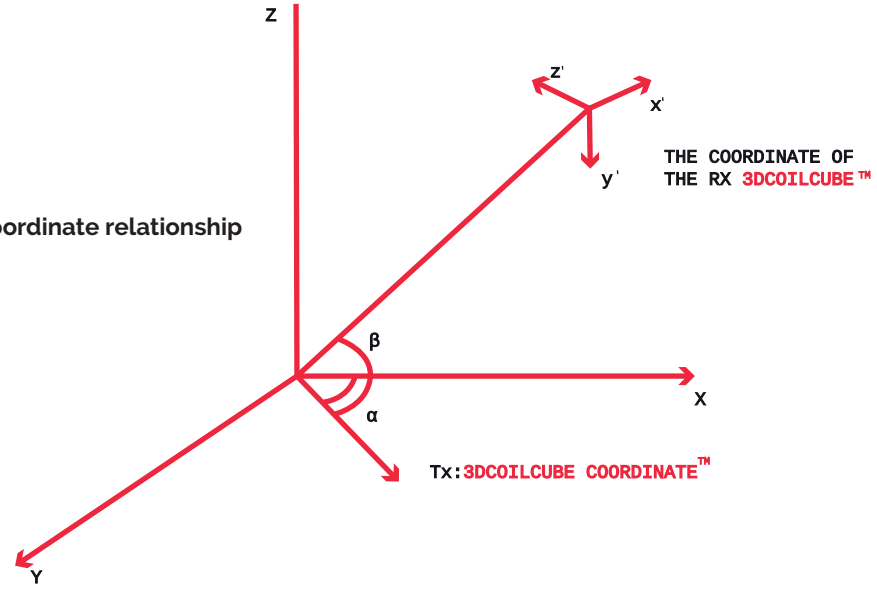
The complete system would look as follows:



The electromagnetic emitter coil may be a spherical, a low profile or a cube. In another Post we will cover how to choose the right configuration for the Tx Electromagnetic Emitter Antennas.



EM Tracking RX 3Dcoil Sensor



The coordinate relationship

The Mathematics of a 6-DOF EMTS

This example of application of 3DCoilCube and 3DCoil technology of electromagnetic tracking systems is based on a six-degree-of-freedom (6-DOF) electromagnetic algorithm. We describe the main variables and mathematics relations between them for reference.

The problem is a typical vectorial configuration of two coordinates reference systems that are related (the Tx and the Rx 3DCoilcubes represent two orthogonal related systems that, as long as they are sharing the same magnetic field **B**, they can be linked by the spherical coordinates expressed as a 3 dimension vector (ρ, α, β) with the radius ρ and and 2 angles, α, β The rotational angles of sensing Rx 3Dcoils or 3DCoilCubes relative to the Tx Electromagnetic Emission 3Dcoilcube can be expressed as (ω, ξ, ψ) The definition is: first round x´makes ω degrees of horizontal rotation; then, round y´make ξ degrees of pitching rotation; at last round z´makes ψ degrees of roll rotation. After a series of matrix transformations we can get the output formulae of $\varphi, \alpha, \beta, \omega, \xi, \psi$ hence the three important definitions of F,W & A :

EQUATION 1

$$F = \frac{c}{\rho^2} \begin{vmatrix} \cos\alpha\cos\beta & \sin\alpha\sin\beta & -\sin\beta \\ \frac{1}{2}\sin\alpha & \frac{-1}{2}\cos\alpha & 0 \\ \frac{-1}{2}\cos\alpha\sin\beta & \frac{-1}{2}\sin\alpha\sin\beta & \frac{-1}{2}\cos\beta \end{vmatrix}$$

EQUATION 2

$$W: 1/4\ c^{\uparrow}2/\rho^{\uparrow}6 \blacksquare (1+3[\cos]^{\uparrow}2\alpha[\cos]^{\uparrow}2\beta\&3\sin\alpha\cos\alpha\ [\cos]^{\uparrow}2\beta\&-\cos\alpha\sin\beta\cos\beta@3\sin\alpha$$
$$\cos\alpha\ [\cos]^{\uparrow}2\beta\&1+3[\sin]^{\uparrow}2\alpha\ [\cos]\ 2\beta\&\ -3\sin\alpha\sin\beta\cos\beta@-3\cos\alpha\sin\beta\cos\beta\&-3\sin$$

EQUATION 3

$$A=\begin{vmatrix} \cos\varphi\cos\omega & \cos\varphi\sin\omega & -\sin\varphi \\ \sin\varepsilon\ \sin\varphi\ \cos\omega - \cos\varepsilon\ \sin\omega & \sin\varphi s\ \sin\varepsilon\ \sin\omega & \sin\varepsilon\ \cos\varphi \\ \cos\varepsilon\ \sin\varphi\ \cos\omega & \cos\varepsilon\ \sin\varphi\ \sin\omega + \sin\varepsilon\ \cos\omega & \cos\varepsilon\ \cos\varphi \end{vmatrix}$$

EQUATION 4

P(z) in F matrix is the modulus square of Rx vector of z axis and G is the unit matrix.

$$P(z)=\frac{c^2}{\rho^6}\left[\sin^2\beta+\frac{1}{4}\cos^2\beta\right]$$

EQUATION 5

Using F we can calculate the formula of ɵSimplifying W:

$$W=\frac{1}{4}\frac{c^2}{\rho^6}F$$

Using equation 2 we can get the calculation formulae of ɑand ɵ

EQUATION 6

$$\alpha=\arctan\left(\frac{F_{23}}{F_{13}}\right)$$

EQUATION 7

$$\beta=\sqrt{}\ ([\arctan((F_{\downarrow}23/F_{\downarrow}13)/3])$$

Using equation 3 we can get the calculation formulae of ω ε and ψ

EQUATION 8

$$\varepsilon = \arctan\left(\frac{A_{23}}{A_{33}}\right)$$

EQUATION 9

$$\omega = \arctan\left(\frac{A_{12}}{A_{11}}\right)$$

EQUATION 10

$$\varphi = \arctan\left(-\frac{A_{13}\cos\omega}{A_{11}}\right)$$

Based on these formulas the DSP coding can be done to complete the operation of software.

The relationships between coordinates can be illustrated by the above figure and the coordinate conversion formula is as follows:

EQUATION 11

$$\begin{vmatrix} x' \\ y' \\ z' \end{vmatrix} = R \begin{vmatrix} X \\ Y \\ Z \end{vmatrix} + T = \begin{vmatrix} r_{11} & r_{12} & r_{22} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{32} \end{vmatrix} \begin{vmatrix} X \\ Y \\ Z \end{vmatrix} + \begin{vmatrix} t_x & t_y & t_z \end{vmatrix}^T$$

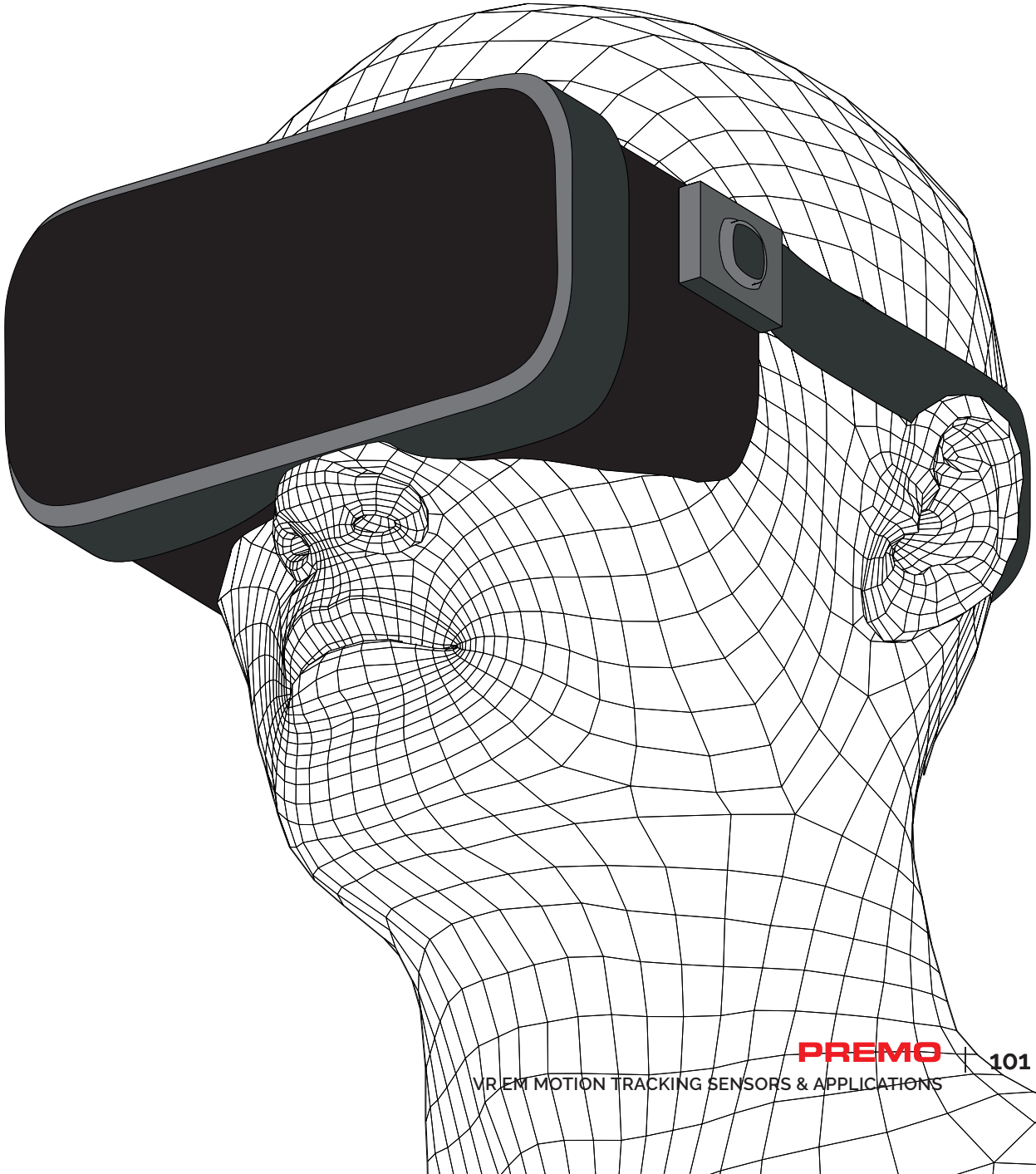
Being R the rotation matrix and T the translation matrix.

Translation

1. Moving forward and backward on the X-axis. (Surging)
2. Moving left and right on the Y-axis. (Swaying)
3. Moving up and down on the Z-axis. (Heaving)

Rotation

1. Tilting side to side on the X-axis. (Rolling)
2. Tilting forward and backward on the Y-axis. (Pitching)
3. Turning left and right on the Z-axis. (Yawing)



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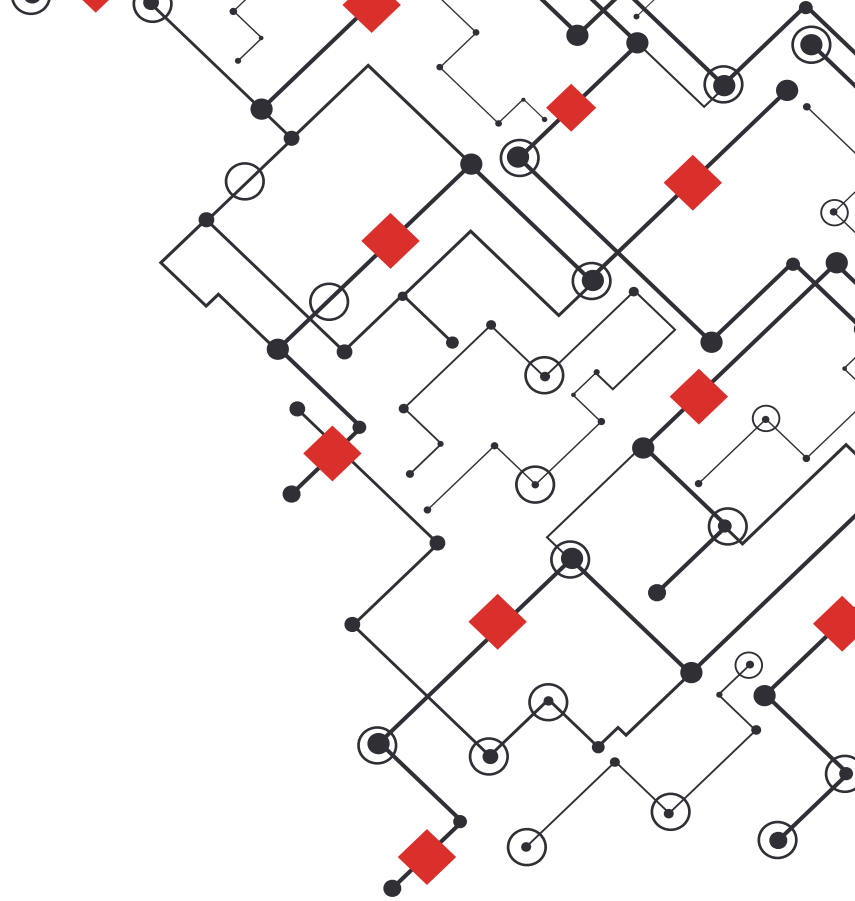


07

DECODING THE GOLDMAN SACHS REPORT ON VIRTUAL REALITY

By Ezequiel Navarro et Al

07

Decoding the Goldman Sachs Report on virtual reality

Virtual Reality (VR) has been identified by top investment funds, and by corporate and investment banks, as more than a hype: it is the next big thing to happen. There are plenty of opportunities to invest and make a significant return. There have been unicorns but also many bad experiences with significant losses.

Which is the market forecast? Many sources state that the market will experience a huge growth. But again there are bears and bulls. In general terms, even the most cautious agree on the growth of the VR market, considering that the VR world includes Augmented Reality (AR) and Mixed Reality.

This post is intended to help on this with a marketing vision:

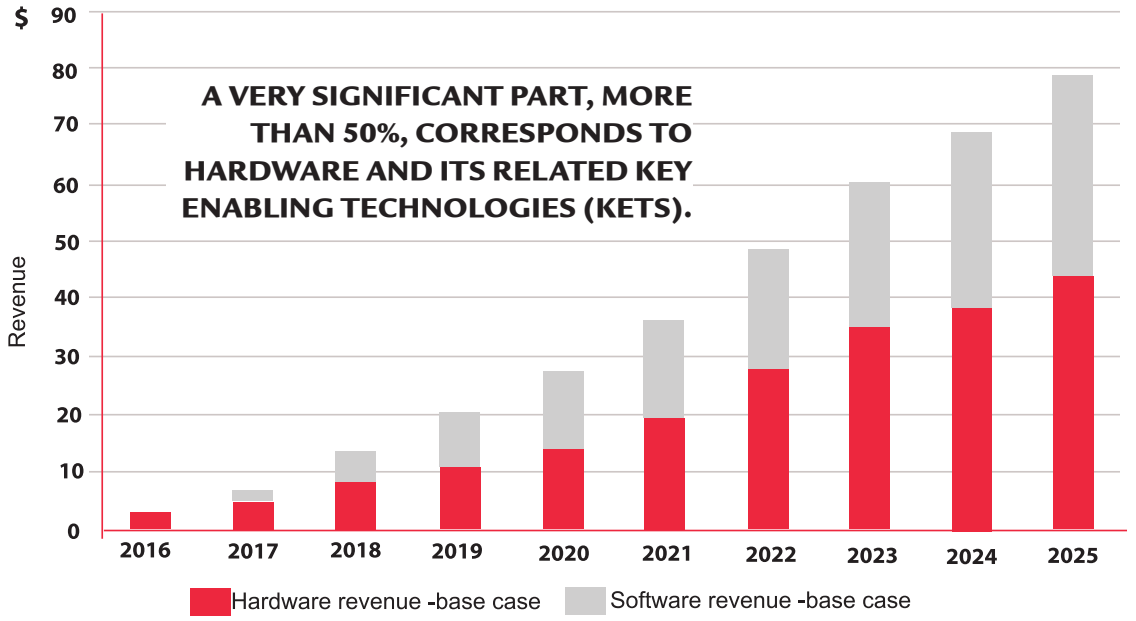
1. What is the market?
2. Who are the players?
3. What are the forecasts?
4. With special attention to WiiFM (stay tuned to WiiFM)

VR/AR market: is there a hype?

The forecast made by Goldman & Sachs in January 2016 envisions

US$80 billion by 2025:

THE PROGRESSION PF OUR BASE CASE HARDWARE AND SOFTWARE FORECAST



Source: Goldman Sachs Global Investment Research

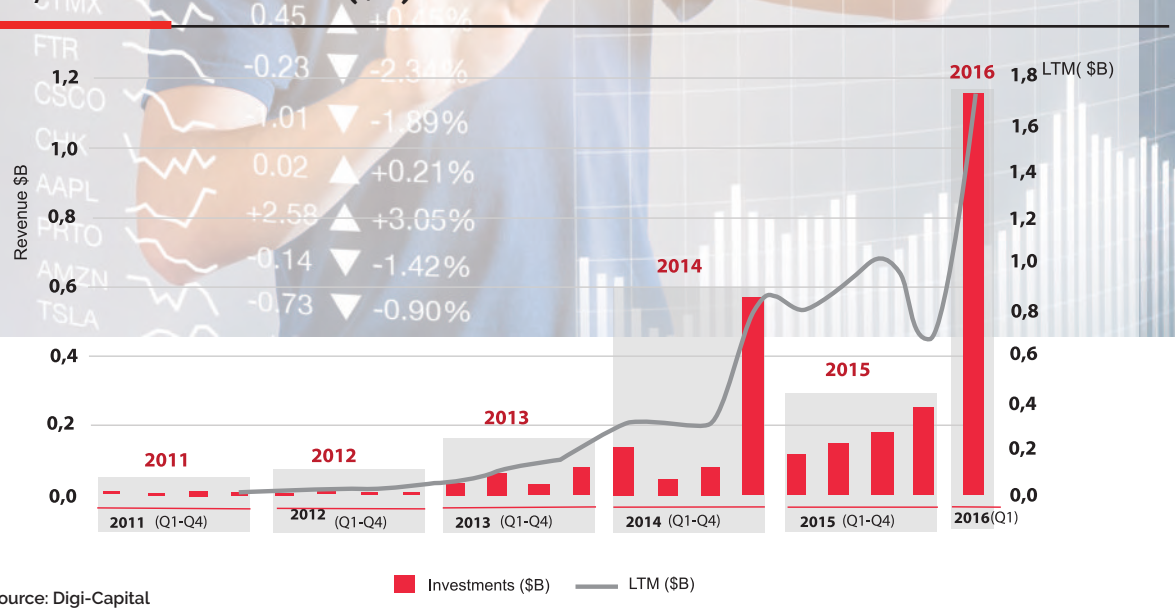
"The race for the next computing platform may be over. Heather Bellini of Goldman Sachs Research expects virtual and augmented reality to become an $80 billion market by 2025, roughly the size of the desktop PC market today. In this video, Bellini discusses how the technology has improved since earlier launch attempts and how it's already transforming sectors like real estate, healthcare and education".

Source: Heather Bellini

Tim Merel, from Digicapitalist, thinks that it will take longer than expected; the AR and MR growth is going to happen but later and at a slower pace.

By March 2016, venture capital funds had invested US$ 1.2 billion in VR, an impressive amount.

AR/ VR INVESTMENTS ($B)

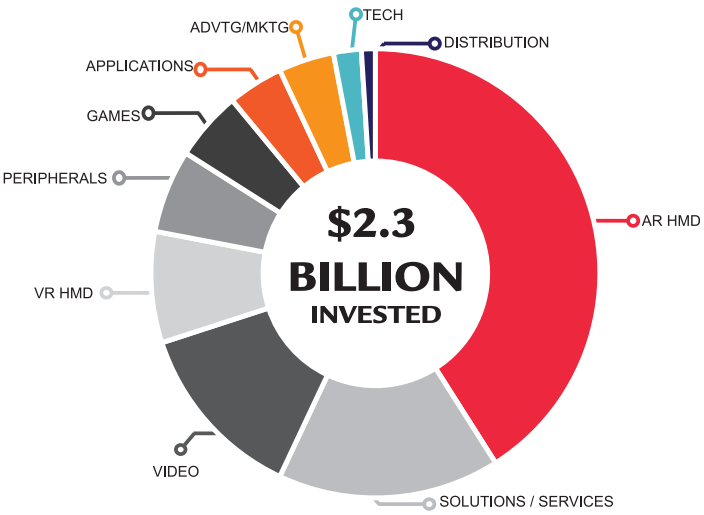


Source: Digi-Capital

AR/ VR INVESTMENTS 2016

Information published by the same source (Digi-Capital) shows a total investment at that time (March 2016) of US$ 2.6 billion.

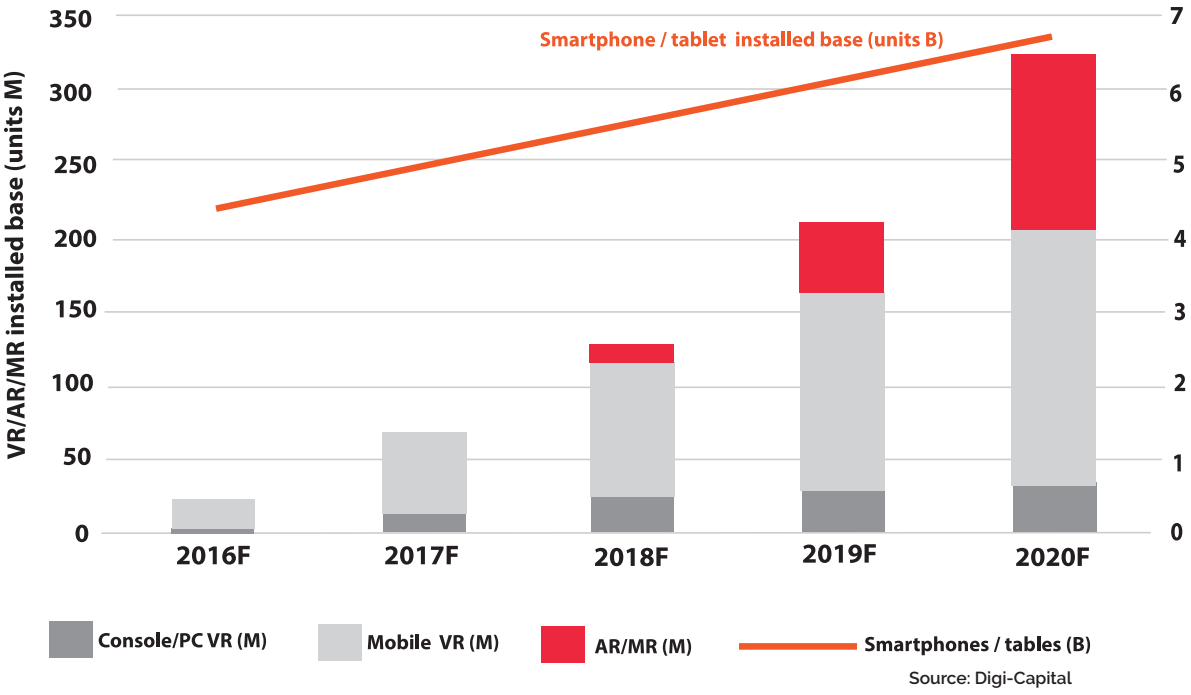
Source: Digi-Capital



Finally, the same source shows that the installed base of VR/AR/MR devices will grow to 300 billion units by 2020, including:

1. PC and consoles (10%)
2. Mobile VR (20%)
3. Standalone AR/MR (35%)
4. Smartphones and tablets (35%)

AR/ VR / MR INSTALLED BASE (units, not sales)

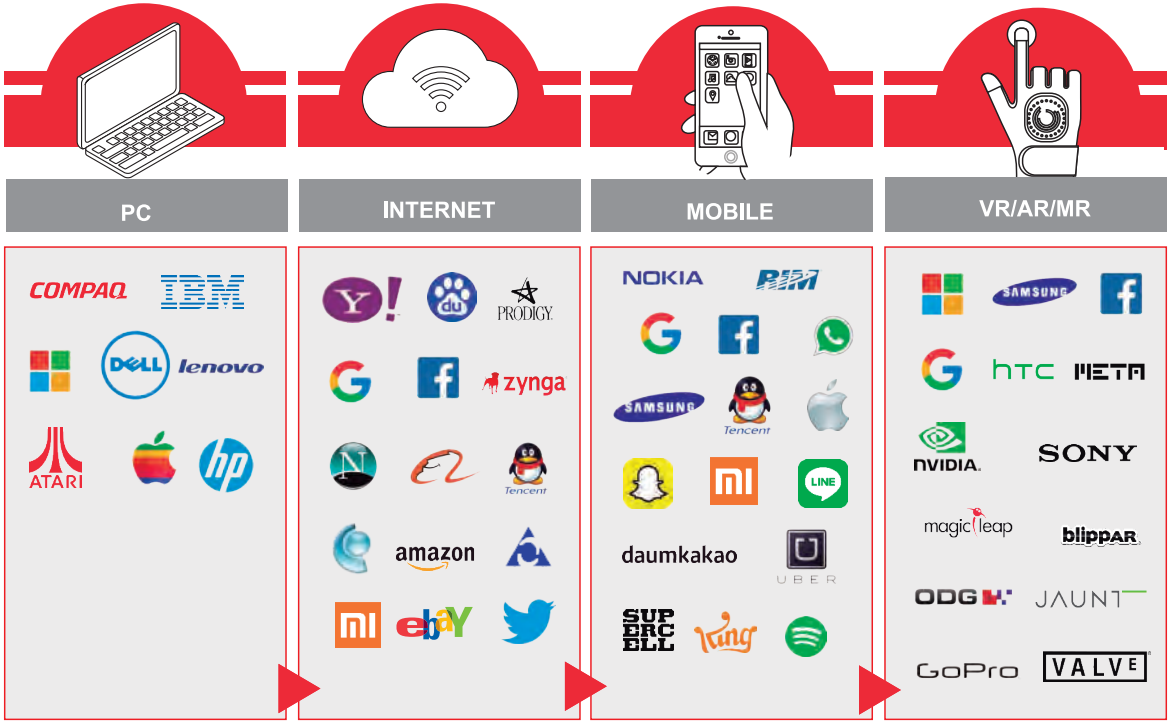


Source: Digi-Capital

Considering that Digi-Capital specializes in digital companies, with their work more focused than a generalist company such as G&S, we think that their analysis should be mentioned here. Digi-Capital describes several waves for the VR market, and states that in H2 2016 the new wave was the 4th one and had just started with huge players now investing heavily and assuming a leading role.

For further information we recommend you to visit their blog.

PLATFORM WAVES



Source: Digi-Capital

In brief, this company advises their investors that VR/AR/MR is the next thing to happen after the PC, Internet and mobile waves. For those more deeply interested we recommend their full report. The new platform wave is VR/AR/MR, but who are the players? **These are mentioned: HTC, NVidia, Google, Magic Leap, Facebook/Oculus Rift, Sony, Blippar, Valve, Jaunt, and Go-Pro.**

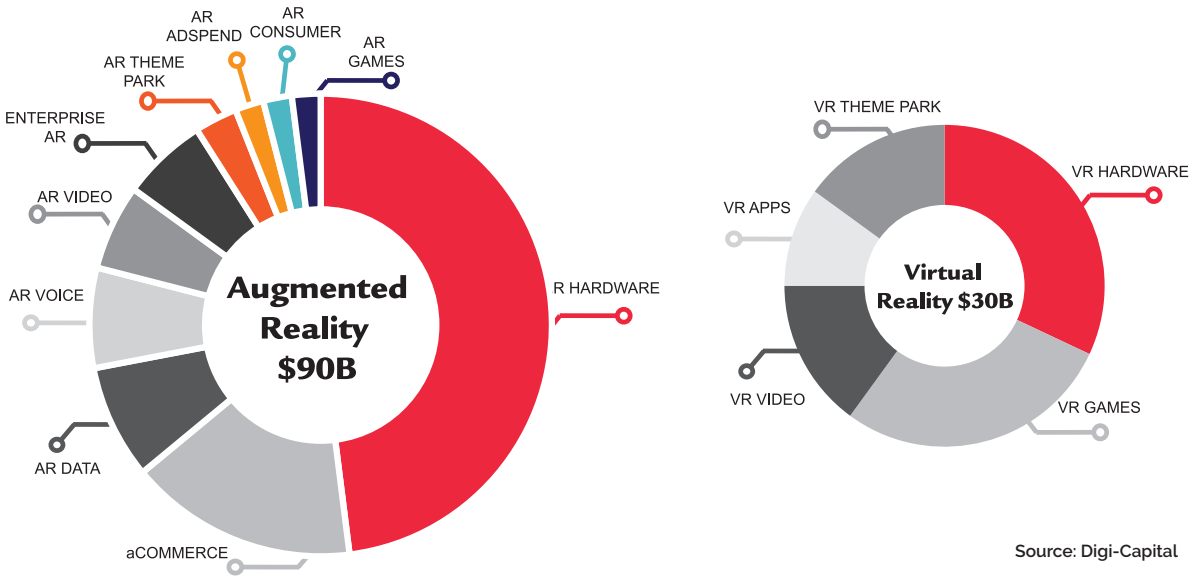
We miss many key players here: some enablers and other key players like Microsoft, NDI, Ascension, Polhemus, Mediatek, Nokia Technologies, Sixsense, and Nintendo, among others.

They warn literally that the tsunami and the waves are more like tides that can really destroy some business to bring new models to others. What side of the tsunami is yours?

"There are different ways you can pick a wave wrong. If the wave is smaller than you expect, you just bob up and down a bit. If the wave is much bigger than you think, you get dumped head first into the sand. Not fun. But platform changes are more like tidal waves, and are much more dangerous for incumbents than regular waves. When did you last use your Nokia?" (Source: Digi-Capital)

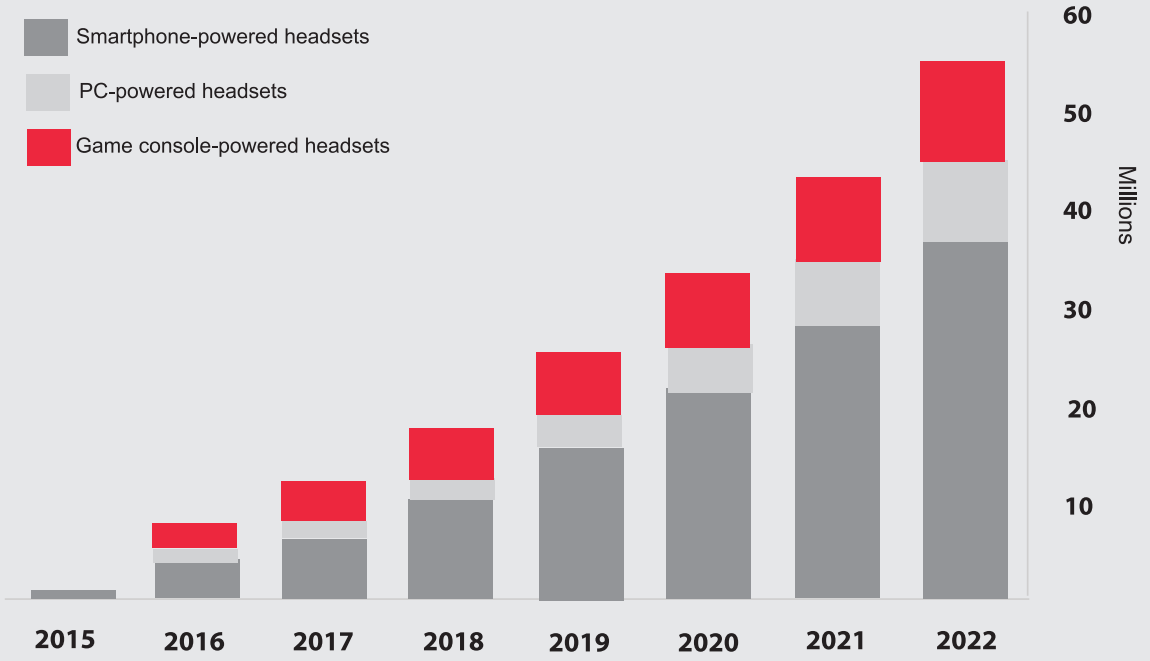
The big difference between our two mentioned sources is that AR is expected to be a market at least 3 times larger:

AUGMENTED / VIRTUAL REALITY REVENUE SHARE 2020F



Source: Digi-Capital

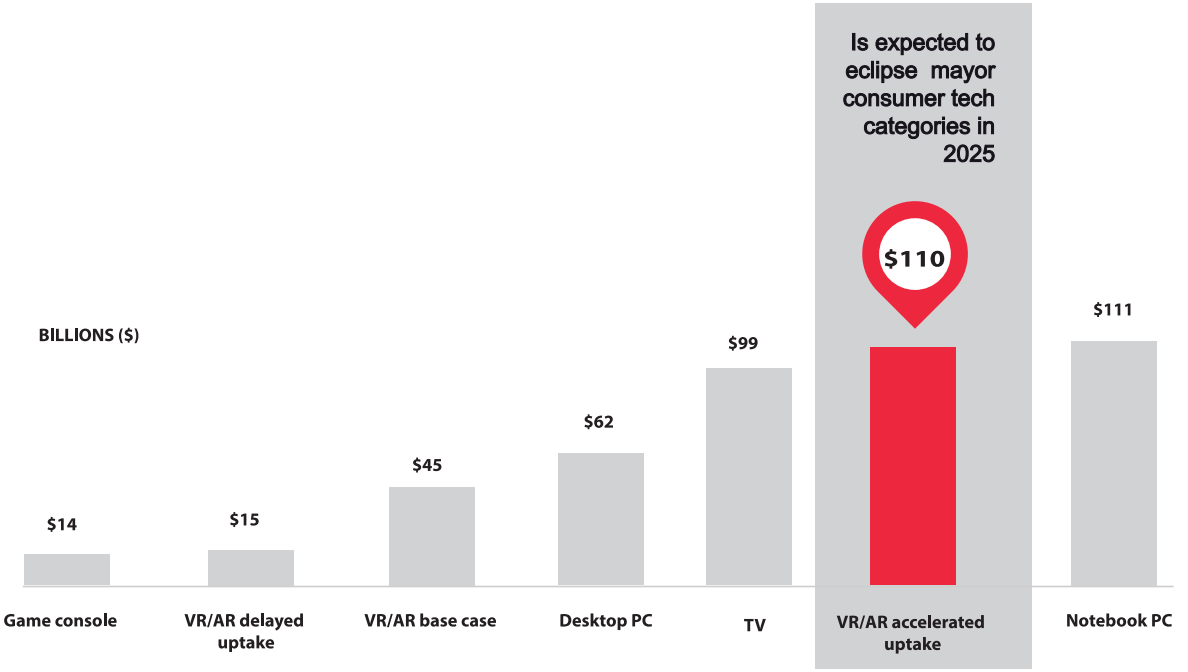
A first obvious finding is that AR or VR hardware will account for the lion's share of the cake. This is why tech giants are turning their strategies into KETs. Anyone interested in this matter knows that VR/AR has infinite applications but the challenge is getting enough processing power (from GPUs and CPUs) with high precision, low energy consumption and low cost. At the end hardware is, once more the key with a share of more than US$ 30 billion by 2020. Another KET corresponds to immersive technologies.



Source: Goldman Sachs Global Investment Research

Business Insider has just published the last forecast made by G&S and has just updated the figure under the "accelerated update" tag, which shows **US$ 110 billion by 2025. In just one year the revised figure exceeds US$ 30 billion.**

THE GLOBAL AR/VR MARKET



Source: Goldman Sachs

In terms of the current amount of technology adopters, it is significant that they are not any more just early adopters. In any case, there is a gap between users and business forecasts, so the adoption rate should be much higher. Another source, eMarketer, states that "... asking its first look at the augmented reality (AR) and virtual reality (VR) video markets, research company eMarketer sees strong growth ahead in the U.S. In 2016, 30.7 million people used AR monthly, a number that will grow to 40.0 million in 2017 for a 30.2 percent increase. The company predicts 48.1 million users in 2018 and 54.4 million in 2019..."

HEAD MOUNTED DEVICES

AUGMENTED REALITY

Microsoft Hololens
Google Glass
Magic Leap
Atheer
Osterhout Desing Group

VIRTUAL REALITY

Facebook Oculus
Samsung Gear VR
Google Cardboard
HTC Vive
Sony PSVR
Vuzix iWear
VR union Claire

3D PROCESING

CPU

TI

Qualcomm
STMicro
Realtek
Himax
Media Tek
Intel

GPU

Nvidia
AMD
Qualcomm

3D AUDIO

TI
Wolfson
Realtek

CAMERAS & COMPONENTS

CAMERAS

COMPONENTS

Haptics

Display

Samsumg
Himax

JDI
Crystal

3DLenses

Werality
Canon
Largan

Zeiss
Nikon

Position/ Room Opctical Trackers

Hon Hai
HTC

Pegatron

Motion Sensors

Leap Motion
TI
Honeywell
Pholemus

InvenSense
ST Micro
NDI
Premo

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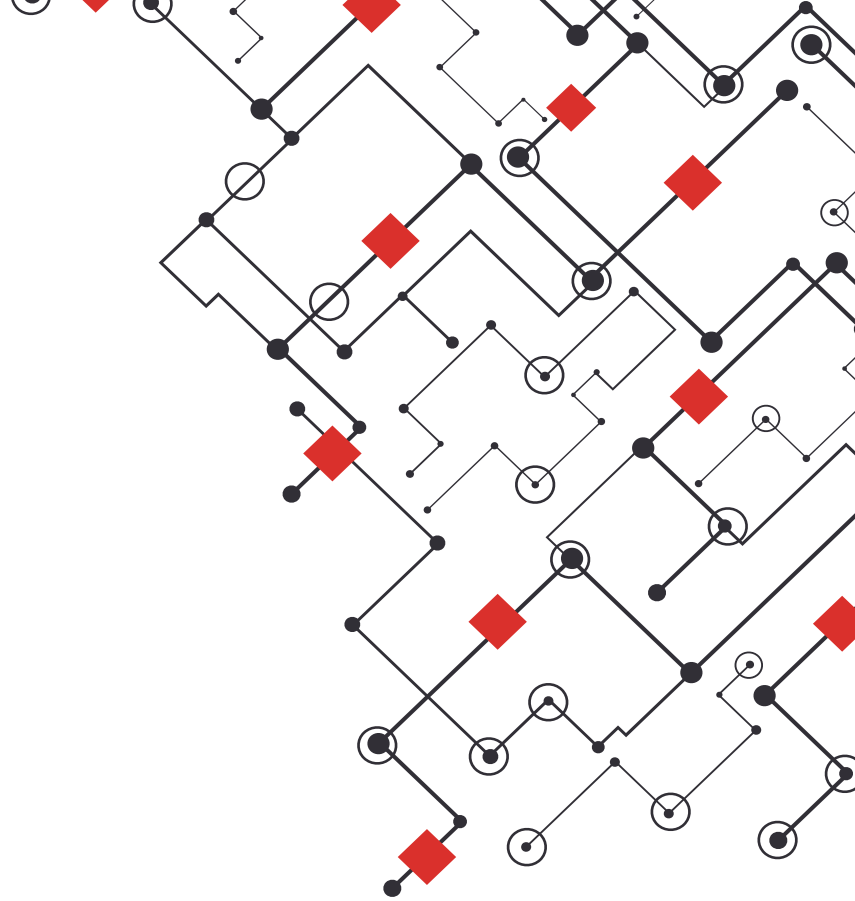
The Biggest Challenges Left In Virtual Reality, According To Oculus: https://techcrunch.com/2015/03/26/the-biggest-challenges-left-in-virtual-reality-according-to-oculus/



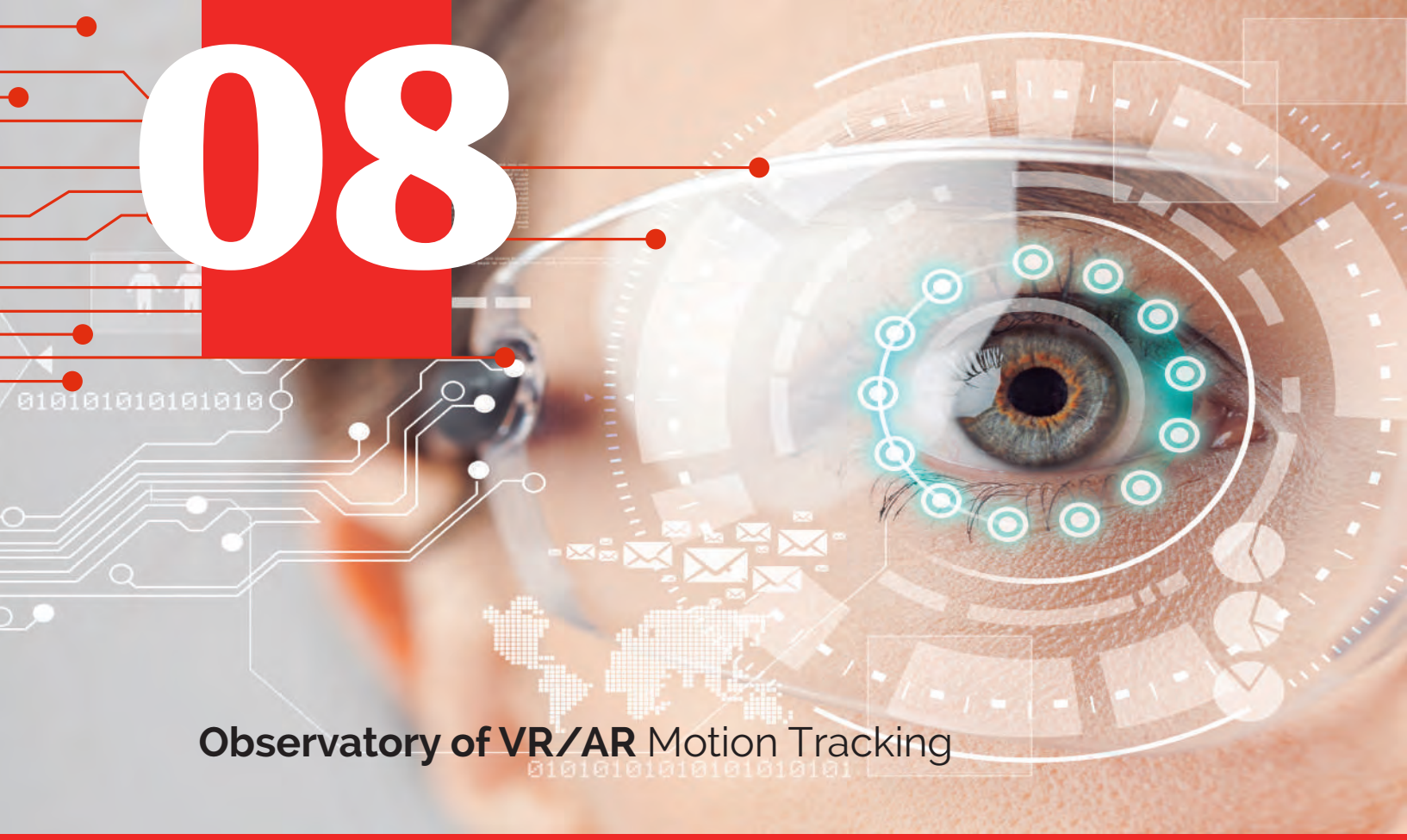
08

OBSERVATORY

OF VR/AR MOTION TRACKING

By Ezequiel Navarro Pérez

08



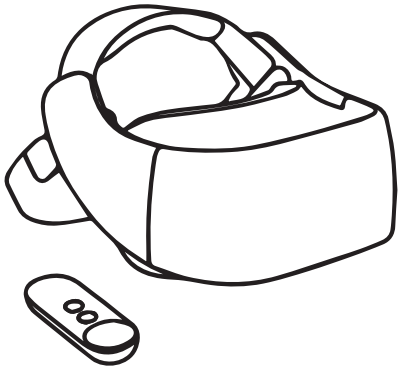
Observatory of VR/AR Motion Tracking

This week we had several global technology events with news, product releases and tech trends. Our Electromagnetic Motion Tracking Sensors web went online this week and presented to our shortlist of VR Immersive Technology global experts.

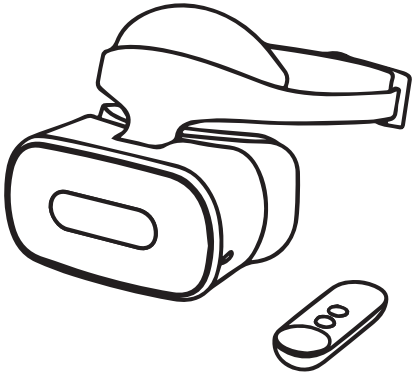
TheWhat's new in VR / AR / Mixed Reality Immersive technology?

Five years in technology is a long time and only in August of 2012, Palmer Luckey's Oculus Virtual Reality launched with a crowd funding campaign for his VR technology venture: the first prototype of desktop grade VR Headset.

Five years later we are at the forefront of the next big step : Immersive experience in VR. The era of motion tracking and haptics for VR



VIVE sandalone headset with **DayDream**



Lenovo standalone headset with **DayDream**

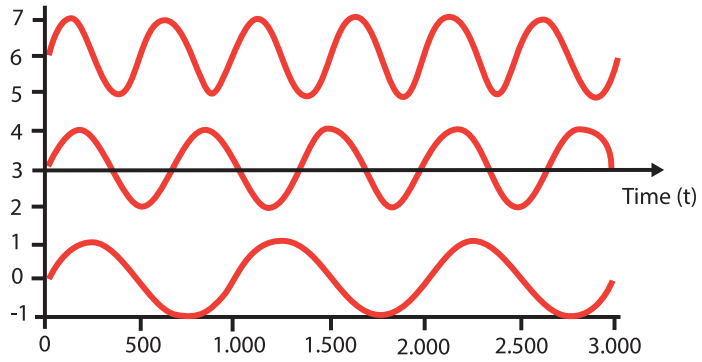
Last week we had a full package of information coming from Google I/O 2017#GoogleIO2017, **a blow of fresh air into the future of VR.** They take VR very seriously and, after having sold millions of cardboard goggles, they announced they are now betting on the fully immersive experience by boosting Daydream with new hardware. They also announced a collaboration with HTC Vibe for new stand-alone headsets. Every component of VR, the CPU and the GPU is built directly in the headset. **These innovations give the user several grades of freedom:**

1. No need for High End expensive PC's
2. Wireless → You can move
3. No need for a mobile phone → No dependency on the manufacturers or mobile devices.
4. Standardization in VR apps may boom. Now it is painful for so many players
5. Inside out tracking -> No need for cameras or sensors for hand tracking
6. True to scale positional tracking
7. Precise 6DoF
8. Sensors integrated into standalone VR thus reducing the floating point imprecision and increase precise tracking.

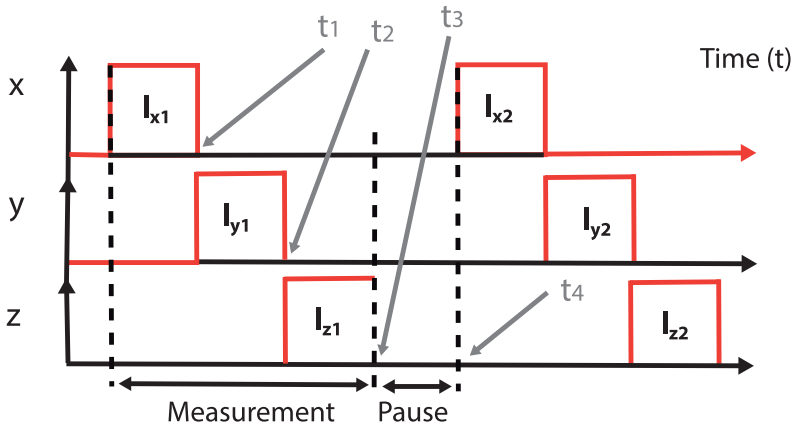
EM Tracking Basics

There emitter side coil generates the magnetic field by different type of low frequency signals, depending system design:

› Low frequency AC full sinusoidal low frequency waves, one different frequency for each axis



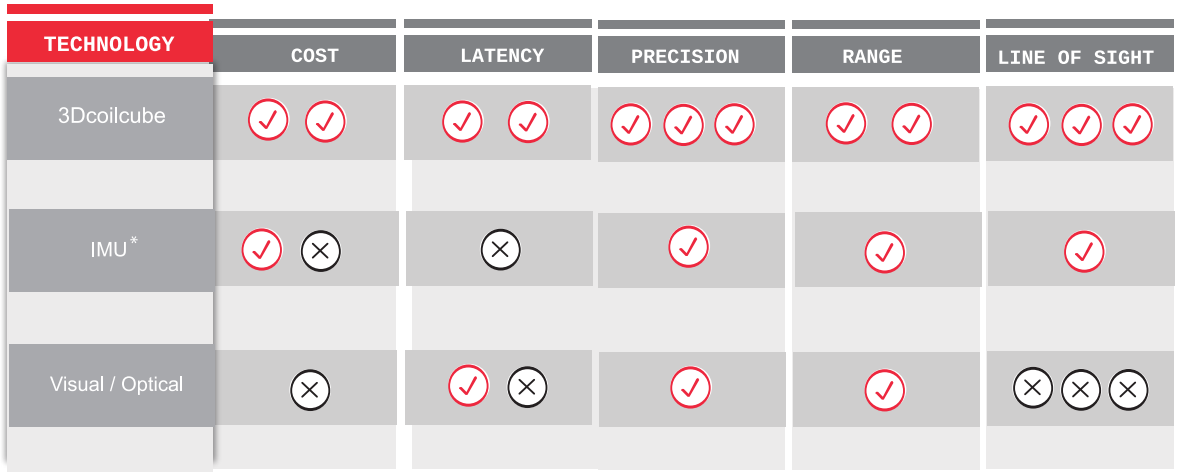
› DC Pulses triggering system, straggered in time by axis



› Resonant mode (L+C resonant tanks)

Another boost to 3D Tracking and immersive VR technology was announced this week , this time by Oculus Rift that has confirmed that they officially support the HTC Vive's Touch Motion controllers. HTC's Touch Motion Controllers went on sale in December of 2016 but some users could not get **guaranteed performance when they added additional sensors for greater immersion.** The company announced their latest software release and assured users that "tracking with 3 sensors is now fully supported".

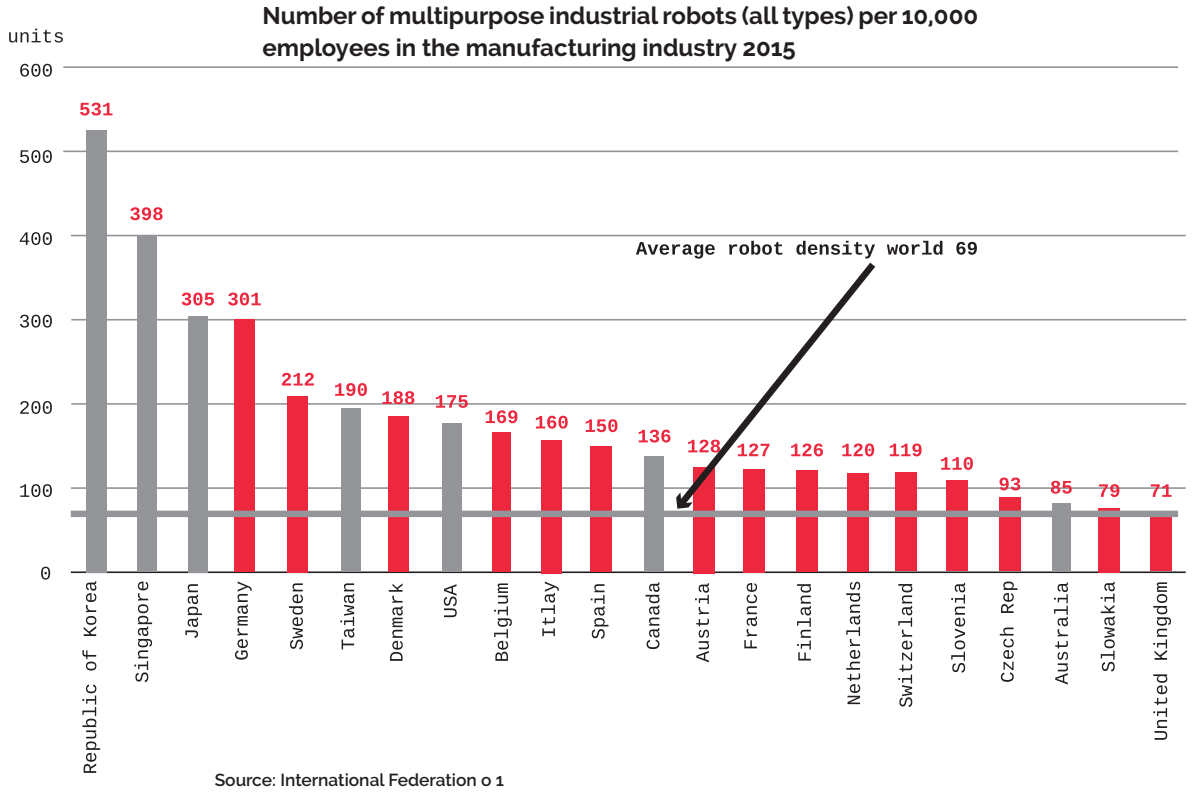
ADVANTAGES OF EM TRACKING IN VR/AR



* IMU Inertial Measurement Unit (Sensor array with Gyroscope, Accelerometer & Magnetometer)

South Korea & World IT show 2017 Seoul this week.

Let´s start with the Seoul World IT Show. South Korea is leading in several technologies and it has been made public that they also lead in robotics with the highest concentration of robots in the world according the International Federation of Robotics. This "miracle country" is second to none in many technologies and innovation. The figure of robots concentration followed by Singapore, Japan and Germany shows how technology and productivity join forces in South Korea.



Source: International Federation o 1

The World Robotics Report also have good news for the European Union that, as a trading block, is leading in the global automation race. Our Korean colleaguesexhibited our motion tracking sensors at the Seoul World IT Show and reported that the VR/AR related technologies are gaining momentum in Korea and that is seriously competing but still not leading in the VR Ecosystem where US companies like Facebook/Oculus, Microsoft and Google and top technology suppliers like QUALCOMM are taking the technology lead, especially in Immersive technologies where motion tracking is a key technology. According to Goldman Sachs, VR Ecosystem has a significant presence of US players but HTC is also very actively leading and growing in the Immersive Virtual Reality experience with their Vibe product and its motion tracking solutions. The extraordinary boom in the VR/AR and Mixed reality markets is a boost for the extraordinarily performing Korean Ecosystem of large Chaebol Industrialconglomerates and thousands of extremely good startups that are already delivering results beyond Samsung and LG and that made the World IT Show the place to be this year in Korea. Good luck to our Premo Korea team and our Alwox joint venture.

Madrid Digital Business World Congress #DES2017

Our headquarters home country,Spain, organized this show that we attended. The Tech series, Digital Demos and Industry programs were the more interesting for an Innovative Technology Global Company like Premo. While Industry 4.0 is in everybody's mouth, we still believe that there is no clear common understanding and that messages we received in Hanover Messe a few weeks ago is different here and that GE has a completely different vision than Microsoft or than Airbus.

Meanwhile we continue equipping our plants with our self-designed machinery fully automatic, robotized, with multi IP access with mass data recording to manage later in our data warehouse in our cloud and with the possibility to manage, supervise and control from the cloud or in remote all our robots, lines and test equipment in Vietnam, Tangiers and Wuxi. Flexibility, productivity, co-working human–bots and AI applied to lessons learned to build faster, with more flexibility and lower Capex is our Industry 4.0 goal inPremo. For this our Fablab Innovation center in Málaga has a complete different mission than our competitors.

Meet the 3dCoil family

The best EM tracker sensor for your virtual reality systems.

Our TX/RX electromagnetic tracking sensors are entirely customizable for you and deliverable within 4 weeks, we are equipped to produce over 50 million 3DCoilCubes per year. Just say the world.

We do not develop Electromagnetic Motion Trackers for VR but processes and production lines that can produce them massively , quickly and inexpensively with reliability. The output of our Innovation center is a machine or a line and not a product. Again in DES2017, we heard about the rise of bots and the need to make them cognitive and again, Watson from IBM everywhere. Is it real? Yes. Is it so good and ready as presented this week and by IBM? We still believe that there is some hype to this but also that IBM is investing and taking a good position in the race but Watson will need to evolve to be easily accessible to technology SME's .

We missed in the congress more specific applications for VR /AR and Mixed reality. Being that eHealth is a challenge in the world and a priority targeted in Europe and Edtech is a clear way to educate better and more efficiently our doctors and surgeons and the extraordinary role that Augmented Reality plays in the surgery room with the latest generations of precision position and motion trackers for AR, this field of the Digital Transformation is going to change the way we are treated in hospitals and the ways our doctors learn, experience and act was quite missing. Nevertheless the congress left some clear lessons:

- There is no scaling up without a great product.
- Rosa Garcia (CEO of Siemens) :
- " La empresa que no se digitalice tendrá serios problemas para competir"
- " Customers want fully customised products"
- Dioni Nespral (Everys) "The most important asset in Digital Transformation is Talent"

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09

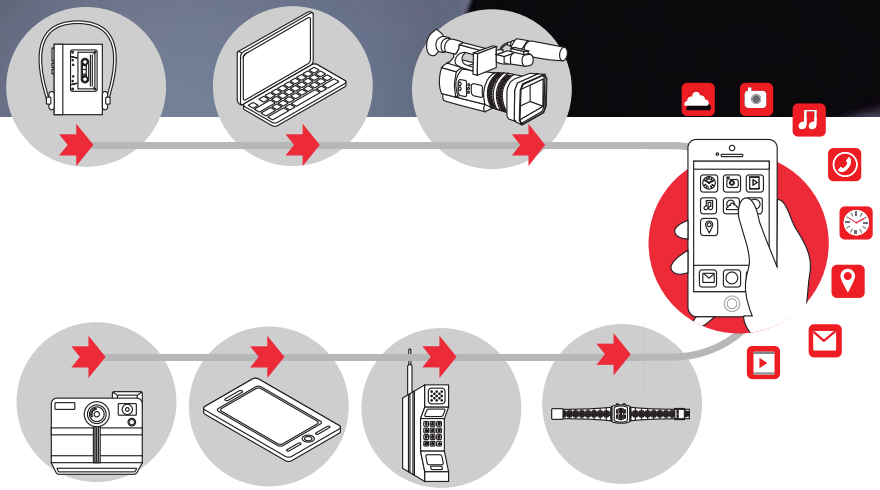
VIRTUAL REALITY AND NEW TECHNOLOGY TRENDS: WHAT'S NEXT?

By Claudio Cañete Cabeza

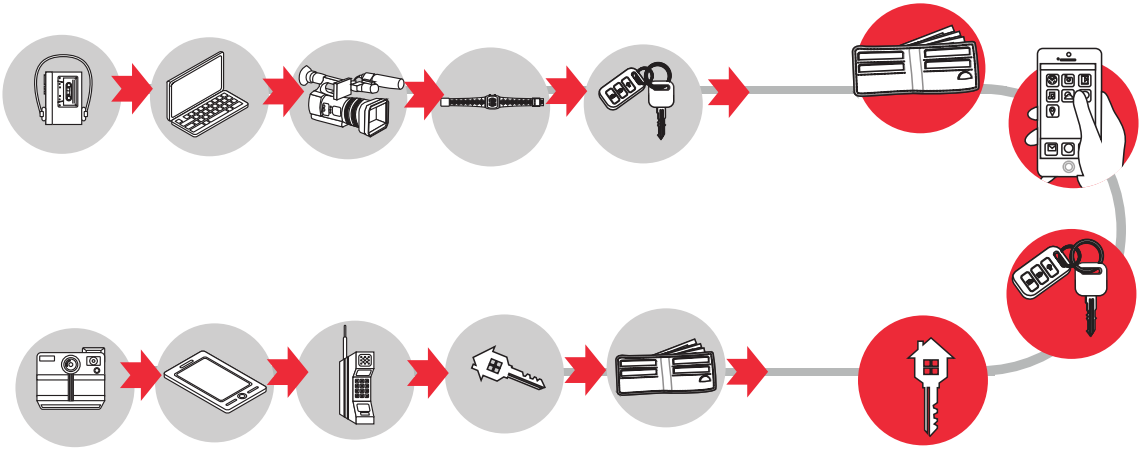
09

Virtual Reality and New Technology Trends:
What's Next?

The picture below became viral recently and shows the effect of Moore's law since the 90s. Walkman, watches, cameras, GSM phones, laptops, camcorders, pagers and PDAs are today integrated in one single device carried by everyone: the smartphone.



Besides experiencing an impressive evolution and improvement on semiconductor integration, the creators of this picture chose old portable devices on purpose to achieve a better "wow effect" over the audience. The cold reality looks more like this:



This second picture reflects much better what's happening. Our pockets contain four objects that are still usually in our pockets: the smartphone, our home keys, the car keys, and the wallet.

In addition to the efforts made by many innovative mobile companies worldwide, we still carry three more items with us because they are not fully integrated in the smartphone yet.

The integration of the wallet is almost a fact. Apple and Samsung have already developed their payment systems with relative success, and their market penetration is due to grow in the coming years. Coins and paper money will be useless in the medium term.

Individual IDs and passports are electronic in many countries. Passive ICs have been integrated into these, so the transition to smartphone integration is much easier. This doesn't require a technology challenge; it's a matter of population, government and companies embracing the change.

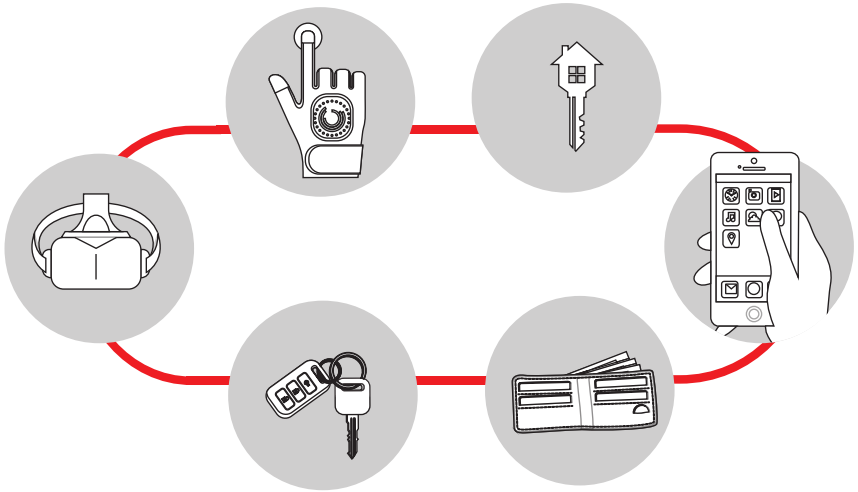
A different story

House and car keys are a different story. High-end passive entry systems used in latest luxury car models set a high technology standard. There are two big barriers to overcome. First, current drivers don't want to sacrifice the performance when the smartphone integrates car access solutions. Second, passive entry technology is based on LF positioning and communication between car and key fob. Smartphones still lack LF radio front-ends, and their integration is a must to achieve a seamless comparative access and operation performance to achieve that of advanced key fobs.

The LF front-end is based on a custom IC semiconductor and a 3DCoilTM antenna, and these two elements must be integrated into the phone successfully. The 3DCoilTM integration is a huge challenge due to the low-profile constraint of PCB mounted components in smartphones.

On top of those additional elements we carry on with us, new gadgets and technologies are being developed and reaching the consumer market. Virtual Reality and Augmented Reality devices are among them. 3D headsets and controllers are poised to be part of our lives in the near future.

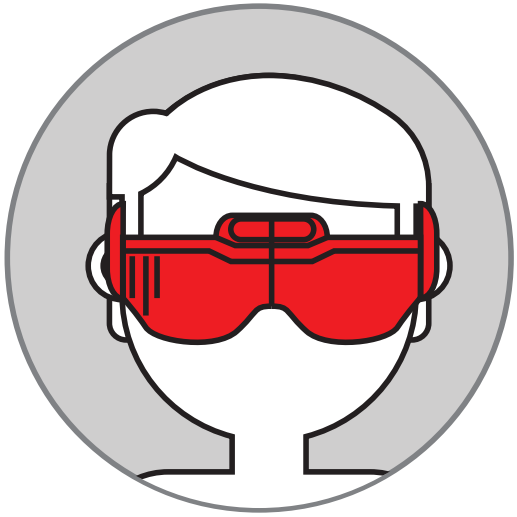
So, if we look forward to the future and try to guess what's going to happen next, the previous should be updated with the following:

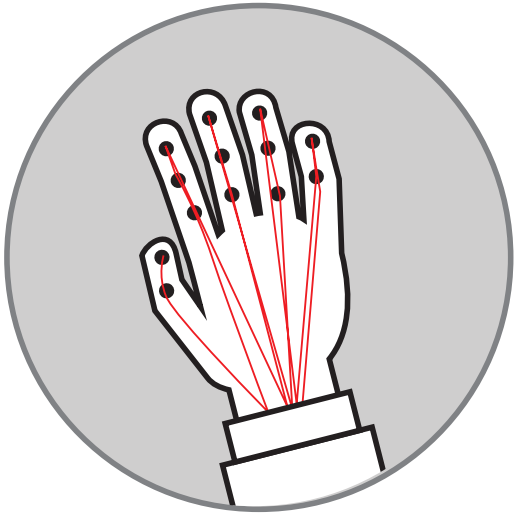


Yes, those are a pair of augmented reality glove controllers and glasses. If we move forward several years, AR/VR tech gadgets will be living with us in the same way as smartphones are today. The potential applications for these devices are far beyond the current smartphones. We will be able to receive information directly to our eyes, without screens or touch devices. Our hand gestures, by using motion tracking controllers, will be the interface to cloud hardware that will process big data for us.

AR/VR will come to stay with us. In parallel, Moore's law will continue evolving, making all devices smaller and integrating them ever more. There is one particularly relevant point about this integration. The LF front-end currently available in car access systems is common to the motion tracking EM systems. In fact, today's cars with passive entry systems have the capability to sense the key fob in 3D around them within a range of 3 to 4 m, depending on the kind of antennas used. This technology is exactly the same needed for EM motion tracking in AR/VR devices. The integration of a LF front-end in a smartphone will drive the chance of using the phone as 3D emitter or receiver EM device. This opens the application to the use of the phone with AR/VR motion controlling features integrated. With the increase of processing power in smartphones, they will be able to act like 3D glasses in our headset and EM 3D motion controller's receivers/emitters at the same time.

The future is promising, as we will see more and more features in our gadgets, along with more integration efforts. We can think what will happen next. Maybe something like this:





Just 3D glasses and ultra-miniature wireless motion tracking sensors. Or maybe not glasses and just the smartphone without a screen, and projecting images directly to our eyes. Sensing our movements will be a must, and the miniaturization of EM sensors and other technologies will be more relevant. One thing is clear: electronics will continue shrinking and new devices with multiple features will be developed with the aim of carrying fewer devices in our pockets. No more mechanical keys, no coins, no wallet. They will disappear in the same way as the walkman. We will not miss them.

Looking far beyond the future in the long term, we can imagine a scenario where no devices will be carried at all. Everything will be in the cloud. Individuals will be recognized by DNA automatically when entering buildings or vehicles. Sound and video will be projected to our eyes and ears automatically, using ultrasound and laser interference, without noticing other people around us. And the whole processing power and big data will be shared from the cloud, with no hardware in our pockets.

This may sound like a technology big brother, possibly scary, but challenging and exciting too!

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10

VR & AR WORLD WE WENT, WE SAW, WE'RE TELLING YOU ABOUT IT

By Juan Esteo García

VR & AR World – We went, we saw, we're telling you about it

VR & AR World as a starting point

VR & AR World advocates itself as the annual meeting place in Europe for the enterprise-focused Virtual and Augmented Reality community. In its recent 2017 edition – that took place in London, as usual – aimed not only at unlocking the market potential of VR & AR, but also to position itself as one of the most influential events included in the TechXLR8, London Tech Week's flagship show.

Its vision included cutting-edge keynote presentations, demos and discussions by a wide range of leading industry speakers, as the event tried to engage the whole VR and AR ecosystem to meet, connect and do business under one roof.

However, vision and reality didn't seem to match in this case. As the PREMO Group team verified upon attending the event, despite its strong sponsorship, partnership, and a dynamic agenda, less than 30 companies participated in the event as exhibitors. Small firms with modest stands occupied just a limited total exhibition surface, which may indicate that even if the technology is mature enough, its market applications and generalization among end users still remain underdeveloped – in Europe at least.

This event was participated by companies whose main focus was content or software development, most of them on 360° experience. There was an additional underlying trend also, since many of these developers purchase hardware solutions such as headsets or helmets from 3rd parties.

Naturally, hardware solutions, even if not self-developed, were represented in the event by a majority of the exhibitors. However, major companies that integrate and develop most of the hardware available did not attend. As the industry is currently shaped, it seems that a few major manufacturers provide physical devices to content/software developers in order to integrate and run their solutions. Hardware solutions, for which PREMO can offer a wide range of motion tracking sensors, were not customized or adapted in most of the cases; each set came with the original manufacturer logo, such as HTC Vive, Oculus Rift or Samsung Gear VR, and no external modifications whatsoever.

Market expectations of VR/AR

Unlike the high attendance of content and software developers, there were just a few exhibitors that develop their own hardware, such as StarVr. In these cases, there were still prototypes in their advanced stage, which means that the market expects smaller companies or labs to come up with new hardware solutions, but still with a long way to go. These were found both for VR and AR applications.

Considering the scarce number of exhibitors, there was a fairly wide range of applications displayed: automotive, gaming, industrial, and security, and even more oriented to the medical and health industry, etc. It is worth mentioning that in exhibitor stands from related sectors such as 5G or IoT (Industry of Things) there were some displayed prototypes for applications that were clearly oriented to virtual reality, such as home appliances, automotive industry, wearables, M2M, robotics, or drone related apps. There was clear evidence that VR and AR will be closely related to these previous fields of activity in the near future, while PREMO keeps innovating one step ahead of the industry. As a result of this effort, the company has developed a wide range of AR/VR EM Motion tracking sensors.

AR/VR EM MOTION TRACKING SENSORS

	Code	Type	Feature	Sensitivity @20kHz (mVpp/App/m)	Dimensions (mm)	Inductance Range	Mount tech
	3DV06	Rx	Smallest 3D magnetic Rx sensor for VR tracking systems	6	7x7x2,3	1-4 mH	SMD
	3DV09	Rx	Low profile 3D magnetic Rx sensor for VR tracking systems	11	9,5x9,5x3,1	2-9mH	SMD
	3DV11AOI	Rx	Low profile 3D magnetic Rx sensor for VR tracking systems	18	13x11,6x3,5	2-10mH	SMD
	3DV15	Rx	Low profile 3D magnetic Rx sensor for VR tracking systems	16-18	17x15,6x3,7	2-10mH	SMD
	3DCC08	Rx	3D Coil Cube magnetic Rx sensor for VR tracking systems	4,5-18	16,5x14,8x11,8	300-600uH / 2-10mH	SMD
	3DCC10	Rx	3D Coil Cube magnetic Rx sensor for VR tracking systems	8,5-25	17,4x15,2x13,9	600-800uH / 2-10mH	SMD
	3DCC20	Tx	3D Coil Cube magnetic emitter for VR tracking systems	18-31	30,7x30,7x30,2	300-600uH - 1-1,5mH	THT
	3DCC28	Tx	3D Coil Cube magnetic emitter for VR tracking systems	30-60	39,5x39,5x38,6	350-600uH - 1,5-3mH	THT

Our conclusion after attending VR & AR World is that far from unlocking the commercial potential of the virtual and augmented reality in Europe, this event served merely as a starting point, a dynamic platform where one can nowadays get insights of the potential and direction in which this market is going, while its true form rests veiled. The feedback obtained from several attendants and experts is consistent, for now the VR & AR market is thriving mainly in the US, where most of the integrators and hardware developers are based.

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Oculus Rift: https://www.oculus.com/rift/

Samsung Gear VR: http://www.samsung.com/es/wearables/gear-vr-sm-r325nzvaphe/

Applications Of Virtual Reality: https://www.vrs.org.uk/virtual-reality-applications/

AR/VR EM Motion tracking sensors: https://3dcoil.grupopremo.com/

Virtual Reality and New Technology Trends: What's Next? : https://3dcoil.grupopremo.com/blog/virtual-reality-and-new-technology-trends-whats-next/

11

AR/VR INNOVATIONS IN SURGERY AND HEALTHCARE

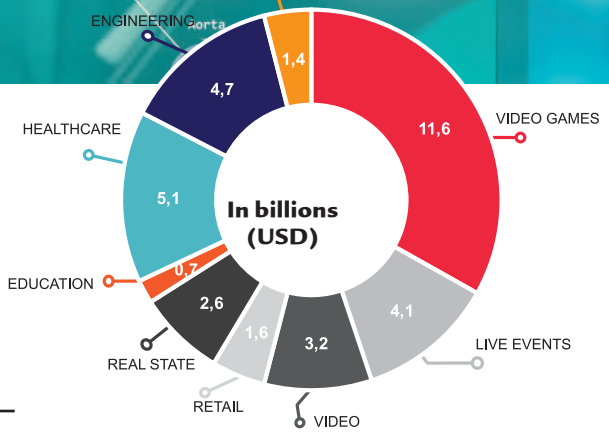
By Sergio Cobos Reyes

11

AR/VR innovations **in surgery and healthcare**

Virtual Reality in the healthcare market is expected to reach $3,8bn by 2020, demand is far from slow down in healthcare system, and day by day new company and research centers are offering AR/VR based solutions for the healthcare market. According Goldman Sachs Global Investment Research estimations becomes $5,1bn by 2025.

Global 2025 VR/AR Market Share by use case



Source: Goldman Sachs Global Investment Research

Current and future healthcare solutions include a wide range of applications, from educational purposes, training of future physicians, guided surgery, tele-medicine, physical therapy and treatments of phobias and mental diseases phobias.

Focusing in surgery, involving not just the training of surgeons, VR visualizers for anatomy studies, pre-planning of surgeries, AR/VR guided and assistant at the operation theater, robotic and tele-surgery.

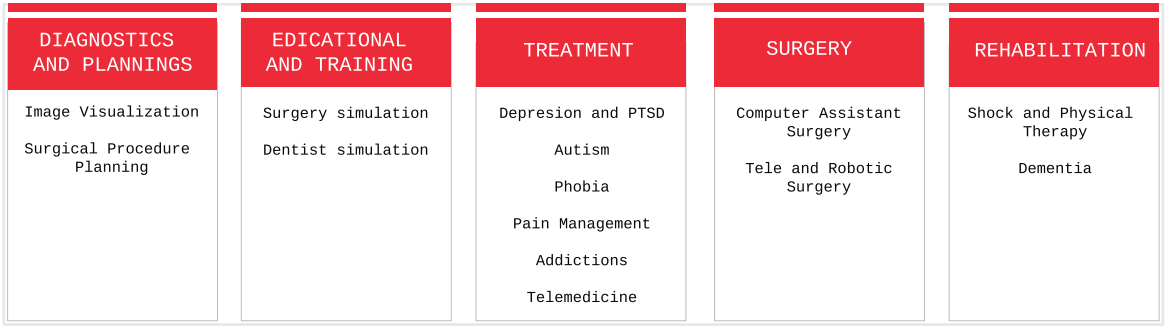
According to recent studies, 18% of U.S. physicians in 2016 had used VR for professional purposes, and 3/5 are interested in using VR for medical training and assistance. More than a half were interested in the use of VR in new medical treatments and conditions. The healthcare sector is receptive to this revolutionary technology, and surgery is one of the most active fields.

AR / VR APPLICATIONS IN HEALTHCARE

Most of us are familiar with impressive videos of VR immersive 3D videos showing human body anatomy but applications in healthcare of this amazing technology are pushing several cases that includes a wide range of medical disciplines.

HEALTHCARE VR/AR USE CASES

In billions (USD)



Classification of some VR/AR use cases and some companies

AR/VR can revolutionize future medicine providing advanced applications that covers different fields of applicatio, involving:

- Educational projects
- Visualization of 3D data from diagnosis (CT, MRI and ultrasonic imaging)
- Teaching and Training of future physicians
- Radiotherapy treatments planning
- Computer assisted surgery in all their stages from planning using 3D diagnoses up to the assistant during surgery.
- Plastic surgery and dentistry (from previous visualization of the results up to assistant during operation)
- Orthopedic surgery (from planning/prosthesis analysis to guided assistance during operation)
- Telemedicine (from diagnosis and remote assistance up to the most impressive tele/robotic surgery)
- Rehabilitation and physical therapy
- Phobias and mental diseases treatments

Advantages of AR/VR technology in all of these scenarios are numerous and some of them are:

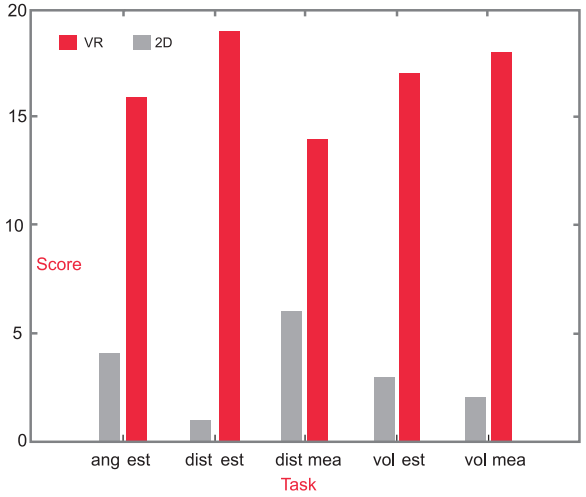
- Time and cost reduction in the training of future doctors and surgeons.
- Surgeon skill level analysis without patient injuries.
- Reduction of cadaver needs in physician training.
- Safe environment for both doctors and patients.
- Real-time feedback of the data during surgery planning.
- The medical assistance in remote locations.
- Most comprehensive diagnosis for patients.
- Immersive treatment of difficult diseases (phobias, etc.).
- Time reduction in rehabilitation and physical therapy.

A great discovery: VR/AR for medical data visualization

Several of 3D images are managed by surgeons and other medical disciplines including Computer Tomography (CT), Magnetic Resonance Imaging (MRI) and ultrasound images.

Surgeons often have to build the mental 3D model of a complex biological structure (brain, liver, spine, etc), and its demonstrated that a better spatial, distance and volume estimation is achieved by surgeons using VR environment rather on a 2D desktop based application. [5]

Qualitative results from surgeon experience using VR environments fitted with position trackers and head-tracked visualization devices show their preference for VR environments.



Qualitative surgeon preferences in angular, distance and volumes estimation and measurements during anatomical visualization [5]

Awesome hardware and software progress allow nowadays an excellent method for visualize the anatomic model of the human body, or the specific 3D anatomic data of the patient (internal organs, neuronal circulatory system, bones, etc.). An exhaustive planning of the surgical operation to increase the success rate of the surgery.

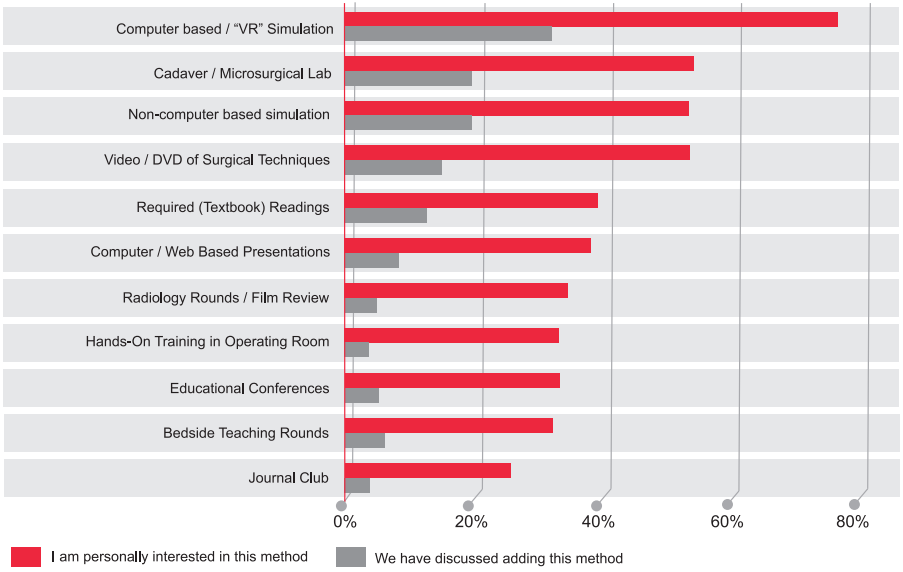
And for a patient, after image recording procedure like MRI the doctor could check the position inside the patient of the organ allowing an immediate feedback that no other technology provide.

Surgical training and surgical simulators, VR “upper hand”

VR simulation as training tool has been deeply integrated nowadays in several medical residency programs. Several studies demonstrate improvements in surgical residents trained on VR simulators. Trained residents were almost 30% faster in surgical dissections and made 1/6 of the errors of their non-simulator trained counterparts. [1][2]

There are two main groups of surgeries: Open Surgery and Minimally Invasive Surgery (MIS). First one requires for simulation a more complex computation due to less restrictive scenario, and its flexibility in the interaction between surgeon and patient. Second restrict the procedure and interaction, but requires that surgeon get enough skill by training, and in this point is where the simulators, and most recently VR simulators reach a big success in terms of safety and cost effectiveness.

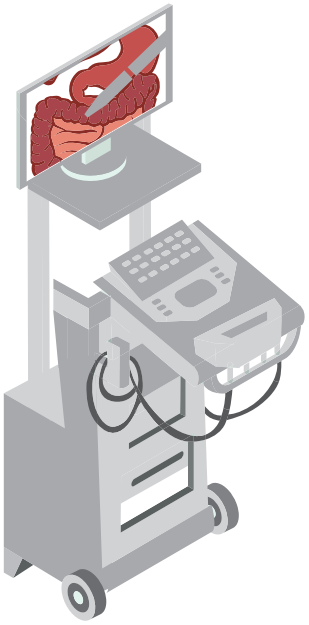
WHICH OF THE FOLLOWING METHODS MAY BE USEFUL FOR EDUCATION AND SURGICAL SKILLS TRAINING?



CSNS survey results to assess desired use of simulation by NS residents and educators [6]

Several surgery domains and clinical applications are currently using VR/AR surgical planning or surgical training tools, including:

- **Laparoscopy** (VR training/simulators, AR assistance surgery)
- **Ocular surgery** (VR training/simulators)
- **Liver surgery** (VR training/simulators, AR assistance surgery)
- **Neurosurgery** (VR training/simulators, AR assistance surgery)
- **Spine surgery** (VR training/simulators, AR assistance surgery)
- **Maxillofacial surgery** (VR training/simulators, AR assistance surgery)
- **Breast surgery** (VR training/simulators, AR assistance surgery)
- **Plastic surgery** (VR training/simulators)
- **Orthopedic surgery** (VR training/simulators, AR assistance surgery)

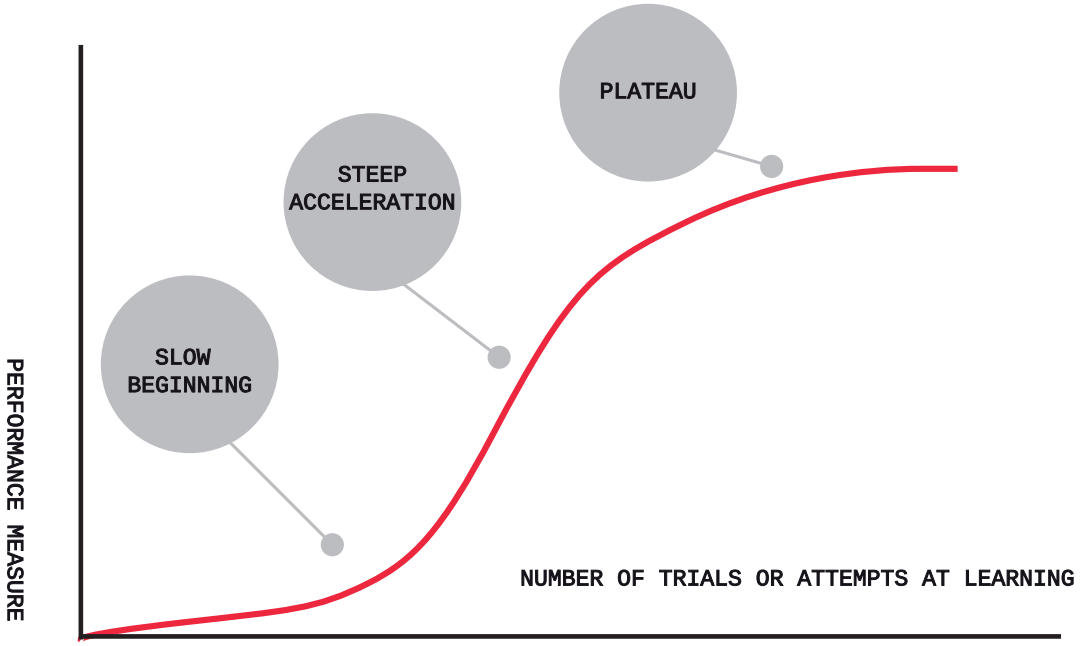


Laparoscopy conventional simulator

Main advantages of the use of VR/AR simulators and assistance during surgery:

Improve learning curve and reduce the errors during the learning stage of future surgeons

- There is a shortage of cadavers for medical research
- More realistic imitation of a human body inside VR environment
- Helps to visualize complex anatomic structures (for example: neurosurgery)
- Increases speed and accuracy of surgical procedures
- Reduces patients trauma and risk
- Assist surgeons during surgical procedures



Graphical representation of the learning curve [9]

Regarding first point the retention level a year after VR training session can be as much as 80%, compared to 20% retention after a week with traditional training.

Initially this kind of simulators were very expensive, but progress of VR/AR industry is providing this technology to much more users. For example Osso VR provide cost effective VR orthopedic surgery simulation that teaches surgeons how to use medical devices in the operating theater, guiding through different steps of the surgical procedure and improving their skills without putting patients at risk.

Before diagnosis and/or surgery doctors and specialists peer at MRI and CT scans. This amount of data is difficult to visualize as a 3D image, companies like Bioflight VR build a solution that takes these data to display in VR/AR environment. Using this kind of platforms medical professionals can analyze, interact and identify conditions, viewing details that 2D static images rarely reveal.

VR/AR surgical simulators, a brief approach

VR/AR surgical simulators should have following characteristics:

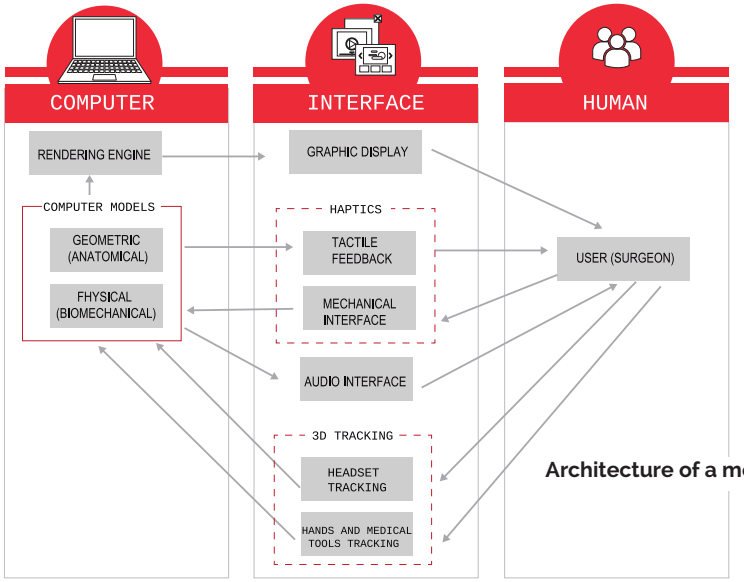
- Visual fidelity
- Interactivity
- Force feedback

Visual fidelity means that need to generate convincing visual information for the surgeon. Nowadays AR/VR hardware and software progress achieve this target.

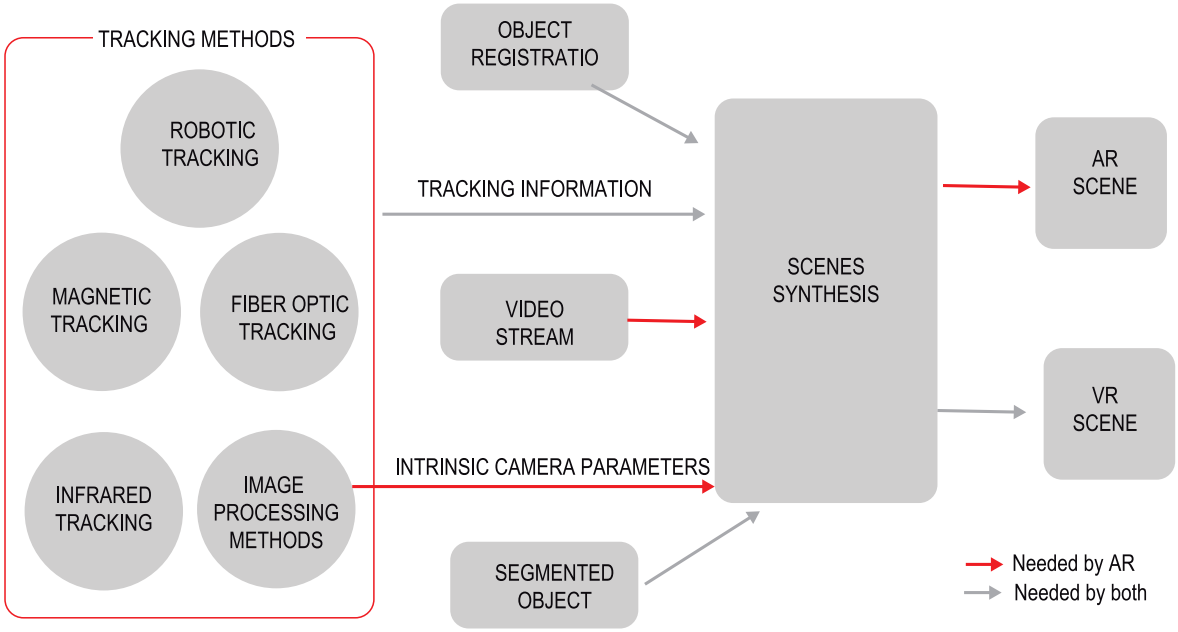
Interactivity to react to surgeon visualization areas and position change, and manage (mainly in AR systems) collision between real and virtual objects.

Force feedback typically with the use of haptic devices. Allow the surgeon react feeling the applied force and movement applied during the simulation.

ARCHITECTURE OF A MEDICAL VR SYSTEM



Architecture of a medical VR system



Needed components for the generation of an AR and VR scene [8]

3D TRACKING FOR AR/VR APPLICATIONS

Tracking systems measures the three dimensional position (x,y,z) and the orientation (defined by three angles: pitch, roll, yaw) of an object with respect a reference coordinate systems. Combining this information a full description of the six degrees of Freedom (6DoF) allow full spacial and motion tracking of the object.

Five categories are used to rank a tracking device:

1. **Accuracy** (degree of with the measured data match the true values)
2. **Robustness** (respect corrupted or missing measurement)
3. **Range and degrees of Freedom.**
4. **Update rate**. The speed of the system is going to be determined by the update rate (data/second) and latency (delay between the capture of the object pose and the display in the VR/AR world)
5. **Hardware** (how complex is the system and also its size and weight)

Tracking technologies include magnetic, acoustic, mechanical inertial and optical trackers.

› **Magnetic trackers** are based on generated magnetic field and discrete sensors (three coils placed perpendicular to each other defining a spacial reference). Measuring the field variation of the sensor coils allow a tracking sensor with 6DoF.

› **AC and DC magnetic systems** could be used and second one is more robust against distortion fields created by metallic elements (usually in surgical operation theater there are several metallic elements that can affect the magnetic field).

› **Main advantages of magnetic trackers is low latency and no line of sight is needed.** Another advantage is the small size that could be achieved using small coil sensors. And one of the most important is that several position trackers should be managed using just one magnetic field emitter.

› **Acoustic trackers are based on ultrasonic waves to determine the position and orientation of the object.** Its main disadvantages are low response rate and that can be affected by the temperature and humidity. Also suffer an accumulative error due to the phase difference measured of the acoustic signal.

› **Mechanical trackers** include sophisticated encoders or potentiometers, but requires complex mechanical section and joints so have constraints of movement.

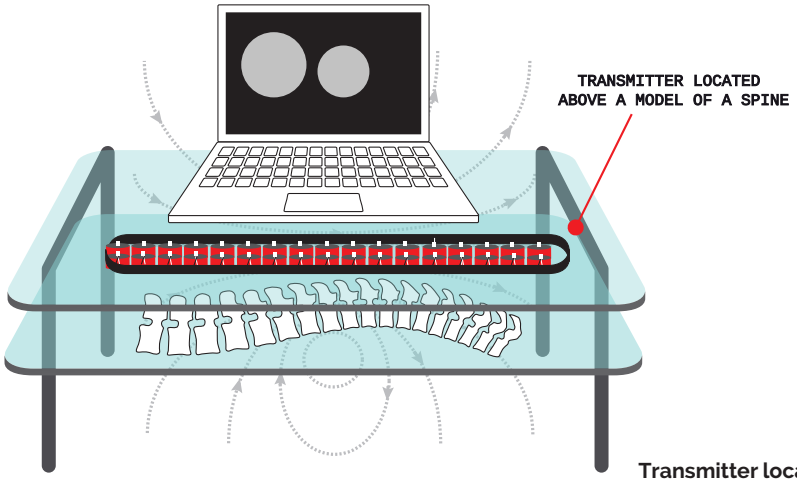
› **Inertial sensors are based on gyroscopes and accelerometers,** as position and movement is achieved from a double integration of acceleration, that produces an accumulative error over time.

› **Optical trackers** provide maximum accuracy, but has the main disadvantage of need a line of sight between the led or tracked by a camera object.

Summary table of the specifications of the tracking technologies [4]

	MAGNETIC	ACOUSTIC (TOF)	OPTICAL (Outside -in)	INERTICAL	MECHANICAL
DOF	6	6	6	6	6
ACCURACY POSITION (mm) ORIENTATION (degree)	0.8-25 0.15-3	0.5-6.0 0.1-0-6	0.1-0.45 <0.5	- <0.5	1.1-2.5 -
RESOLUTION POSITION (mm) ORIENTATION (degree)	0.04-0.8 0.025-0.1	0.1-0.5 0.02-0.5	0.1-0.1 <0.1	- <0.1	0.05-1.5 0.15-1
UPDATE RATE (Hz)	15-120	25-200	50-400	100-1200	300
LATENCY (ms)	4-20	40	10	6	3
RANGE (m)	Up to 1.5	Up to 4.5	Up to 6	-	1.8

In other cases 3D tracking is needed to control the position of elements of the human body during the surgical procedure like in the Computer-Assisted Orthopedic Surgery (CAOS). This discipline that we can name Intra-Operative Position Sensing are usually made by optical systems, that are very awkward, and always need a line of sight. **Several researches are been made to replace them with electromagnetic tracking systems.**



Transmitter located above a model of a spine

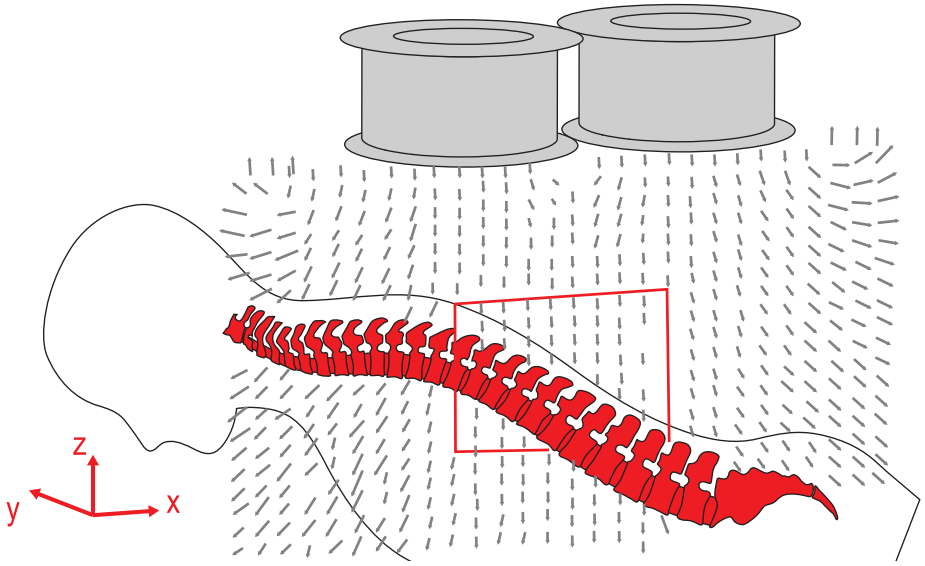


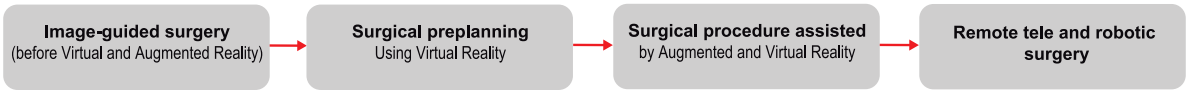
Illustration of the magnetic field created by the transmitter [10]

	MECHANICAL	OPTICAL	MAGNETIC	ACOUSTIC
ACCURACY	0.1-2.5 mm	0.1-2.5 mm	~5 mm	~1 mm
RESOLUTION		best ~0.01 mm		~0.01 mm
BANDWIDTH	>3000Hz	>100-2500Hz	20-100Hz	500-1000Hz
INTERFERENCES SOURCES	Physical Occlusion	Heat Occlusion	Ferrous objects Magnetic fields	Temp, Humidity Occlusion
EXAMPLES	Faro Arm Neuro Navigator	Orpotrak 3020 Flashpoint	Polhemus Flock of birds	Sonic Wand
CONTACT / NON CONTACT	Direct Contact	Contact w targets	Contact w targets	Contact w targets
PASSIVE/ACTIVE	Passive	Active	Active	Active

Comparison of position/ orientation sensing modalties [7]

In contrast with Virtual Reality (VR) systems that immerse the surgeon in immersive full computer generated world, Augmented Reality (AR) generates a composite view of virtual and real objects to the surgeon. Target of added virtual objects is to enhance or add information displayed to the surgeon, in the operation theater or before, during the planning stage of the surgery.

These differences means that 1) in AR need to create just the virtual data, but should mesh them properly with real user view and 2) Latency and display lag of the system should be minimal, the overlaid virtual objects movement should be noticed in correct position. Electromagnetic 3D tracking sensors that can help to this purpose.



This AR technology is been tested in surgical procedures for complex structures like neurosurgery, maxillofacial and spine surgery. In all of them, a comprehensive 3D visualization of the body structures of the patient is needed by the surgeon.

Future and beyond: Tele and remote surgery

One of the biggest challenge for VR in surgery is to face telesurgery, procedures where surgeons and patient are at different locations. **Physicians should have a VR produced copy of a remote environment including the patient at their physical location.** Combination of advanced technologies for precisely tracking of surgeon movement, a realistic and real time VR environment display for the physicians and codification and telecomunication techniques to transmit the data between two remote locations is needed to accomplish successful these applications.

Main advantages of this promising technology includes [3]:

- In some cases, injured in accidents require immediate surgery in the scene of accident to have better chances of survival
- Patients could be operated by an expertise surgeon who can be located everywhere
- Patients too ill or injured to be transported to a hospital may be operated remotely

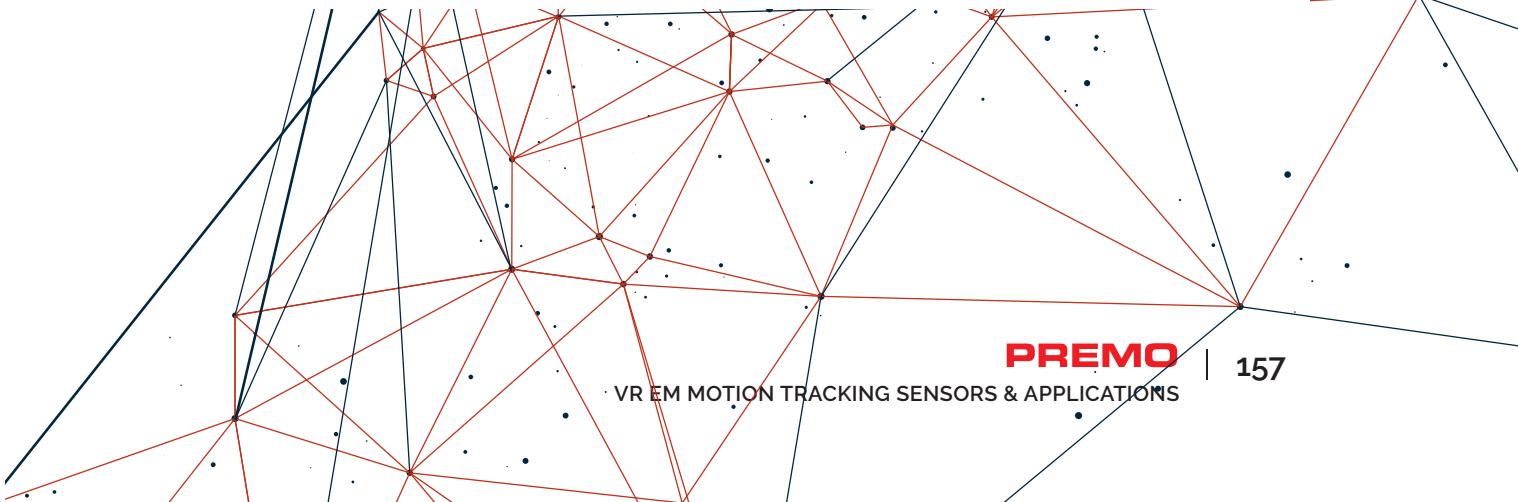
Robotic surgery guided by a remote surgeon is a field that is not new, but has boosted recently with the addition of VR technology.

Surgery procedures have been benefit from VR/AR technology, but there are many other medical treatments that can benefit from this revolutionary technology:

Palliative treatments focused in provide a better condition of patients with painful treatments like chemotherapy or for patients that suffer anxiety during other medical procedures.

Phobias or treatments for mental diseases like autism. Several clinics are applying VR immersive experience to help patients get over fear of heights, flight, animals, etc. Regarding autism, there are several projects to allow that kids with autism learn some basic social skills.

Physical therapy or rehabilitation after an accident or orthopedic intervention surgery requires a long time with repetitive routines that can be more pleasant with inside an immersive VR environment, besides the fact that VR 3D tracking of movements allow correct them and evaluate the progress of the treatment.



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CT: https://www.nibib.nih.gov/science-education/science-topics/computed-tomography-ct

Educational projects: https://www.cnet.com/news/use-kinect-to-teach-anatomy-its-a-mirracle/

Plastic surgery: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5447526/

MRI: https://www.nibib.nih.gov/science-education/science-topics/magnetic-resonance-imaging-mri

Physical therapy: http://www.pivotphysicaltherapy.com/blog/future-virtual-reality-physical-therapy/

Video Human Augmented Anatomy Mirro: https://www.youtube.com/watch?time_continue=2&v=YCAFATrbTSc Video

Human Augmented Anatomy Mirro: https://www.youtube.com/watch?time_continue=2&v=YCAFATrbTSc

Video Virtual Reality of Human Anatomy: https://www.youtube.com/watch?time_continue=3&v=RgGJqqYAS54

Position trackers: https://3dcoil.grupopremo.com/blog/observatory-of-vrar-motion-tracking/

Anatomic model: http://thebodyvr.com/anatomy-viewer/

Video INSIGHT HEART on HoloLens: https://www.youtube.com/watch?v=c9O7L1Wtqqc

Video IRCAD-IHU Augmented Reality using Microsoft Hololens: https://www.youtube.com/watch?v=kFQulgeYh7w

Laparoscopy: https://www.nhs.uk/conditions/laparoscopy/what-happens/

Virtual Reality Based Surgery Simulation: https://www.youtube.com/watch?v=oYMXHIafoBY

Learning curve: https://en.wikipedia.org/wiki/Learning_curve

Retention level a year after VR training session: http://fortune.com/2015/08/17/virtual-reality-hospitals/

Osso VR: http://ossovr.com/

Osso VR Mixed Reality Promo: https://www.youtube.com/watch?time_continue=4&v=yes_GEtIa6o

Acoustic Tracking: https://en.wikipedia.org/wiki/Positional_tracking#Acoustic_Tracking

Mechanical trackers: http://www.davychiu.com/projects/praxim-3d-curvilinear-surgical-robot.html

Inertial sensors: https://www.mdtmag.com/article/2012/01/inertial-measurement-sensing-technology-enables-surgical-precision

Computer-Assisted Orthopedic Surgery: http://knowcas.com/knee

Video HoloEyes Sharing Mixed Reality for surgical navigation: https://www.youtube.com/watch?v=vi3Q3K0DAqw

Spine Surgery Simplified with HoloLens: https://www.youtube.com/watch?v=H0Igr-6nhzo

Robotic surgery: https://www.uclahealth.org/robotic-surgery/

Video World's 1st VR navigation for robot surgery with Oculus Rift and OsiriX stereo-3D in daVinci surgery: https://www.youtube.com/watch?v=pGdeWdO5Efc

Painful treatments: http://kindvr.com/

Physical therapy or rehabilitation : http://www.abc.net.au/news/2017-03-30/reimagining-rehabilitation-with-help-of-virtual-reality/8397276

12

INSIGHTS INTO VR & AR: FACTS AND PROSPECTS

By Juan Esteo García

12

Insights into VR & AR: **facts and prospects**

In line with PREMO's strategy of raising awareness, spreading knowledge and contributing to the development and spreading of augmented and virtual reality (AR & VR), we recently made available an e-paper written by Ezequiel Navarro, CEO of PREMO, discussing his insights into AR & VR.

This e-paper takes its basic ideas from an article posted on June 15th, entitled "Decoding the Goldman Sachs Report on Virtual Reality", in which we reviewed the current investments of VC funds and market forecasts. If something could be extracted then, after analyzing the figures provided by Digi-Capital, it was that globally there is a certain feeling of optimism regarding the evolution of the VR/AR market.

Furthermore, a recent article published by The Economist on July 8th, under the title "Get Real. A reality check for virtual headsets", announces that the wind of change may be finally blowing after a period of low performance, due to the gap between early forecasts and actual figures in the industry. The new publication of Navarro has included not only information from this second article, but it has merged also both scenarios in a marketwise and dynamic approach that helps to create a structured view of the industry both for specialists and newcomers.

As mentioned earlier, in our previous post we made clear that virtual reality (VR) has been identified by top investment funds and even by corporate and investment banks as more than a hype. In fact, it is the next big thing to happen. Plenty of investment opportunities have arisen, and consequently, many ways to obtain significant returns. It is a process with unicorns and also several bad and loud experiences.

How does the market forecast really look? What are our experts' insights into VR & AR? According to many reliable and renowned sources, the market will experience a huge growth. But again, there are bears and bulls. When exactly? At what speed? To what extent? Considering the most recent information from several sources and publishers, the mentioned e-paper is intended to update the scenario, while bringing some insights related to the definition and size of the market, who the main players are and will be, and "What's In It" for those who wish to operate in this market.

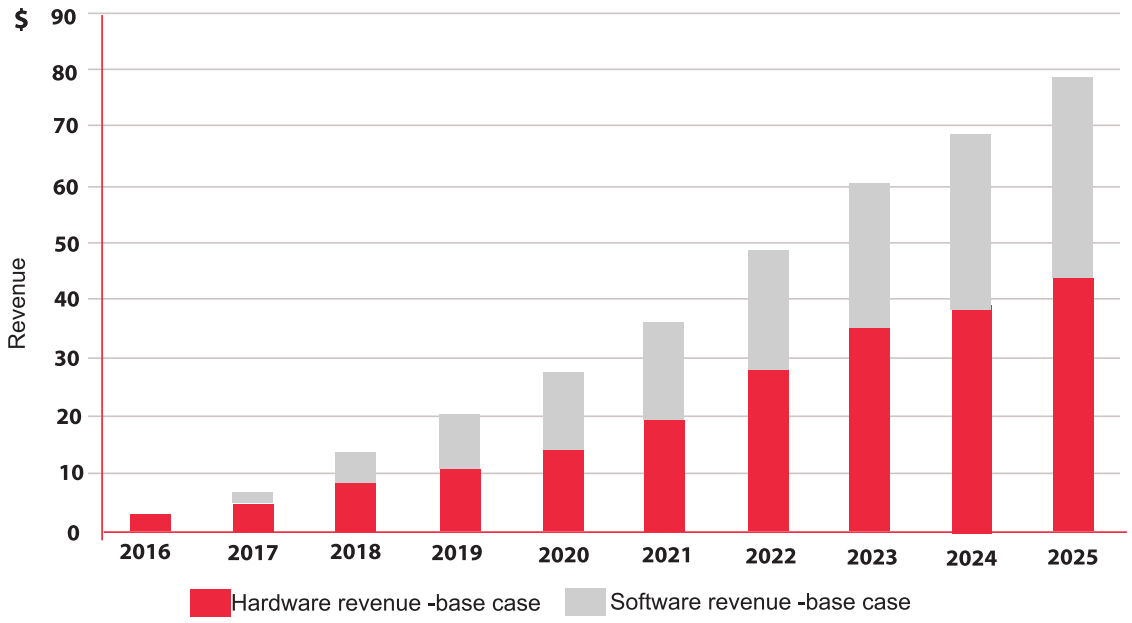
We have only just begun

VR dates back to Ivan Sutherland's Sword of Damocles in 1968, and yet almost half a century later, we've only just started down the long road to what VR will ultimately be. The acquisition of Oculus, a startup in 2014, by Mark Zuckerberg's Facebook opened the era of serious investments in VR. Plenty of statistics still remark today the disrupting effect that this visionary decision had in the market dynamics. Indeed, Zuckerberg described the VR technology as "incredible" and executed an early move that caught the attention of other investors.

In line with its strategy, Facebook recently hired Hugo Barra, a leading executive from Google and previously Xiaomi, consolidated nowadays as one of the fastest growing technology firms. Barra leads Facebook's VR division and the first results have been displayed, since the firm has already presented "Spaces", an innovative application were friends can socialize by VR meetings.

Why such a strong support to VR? Let's not forget the forecast made by Goldman & Sachs in January 2016, envisioning total revenues of $80 billion by 2025, of which a very significant part of more than 50%, corresponds to hardware and its related key enabling technologies (KETs):

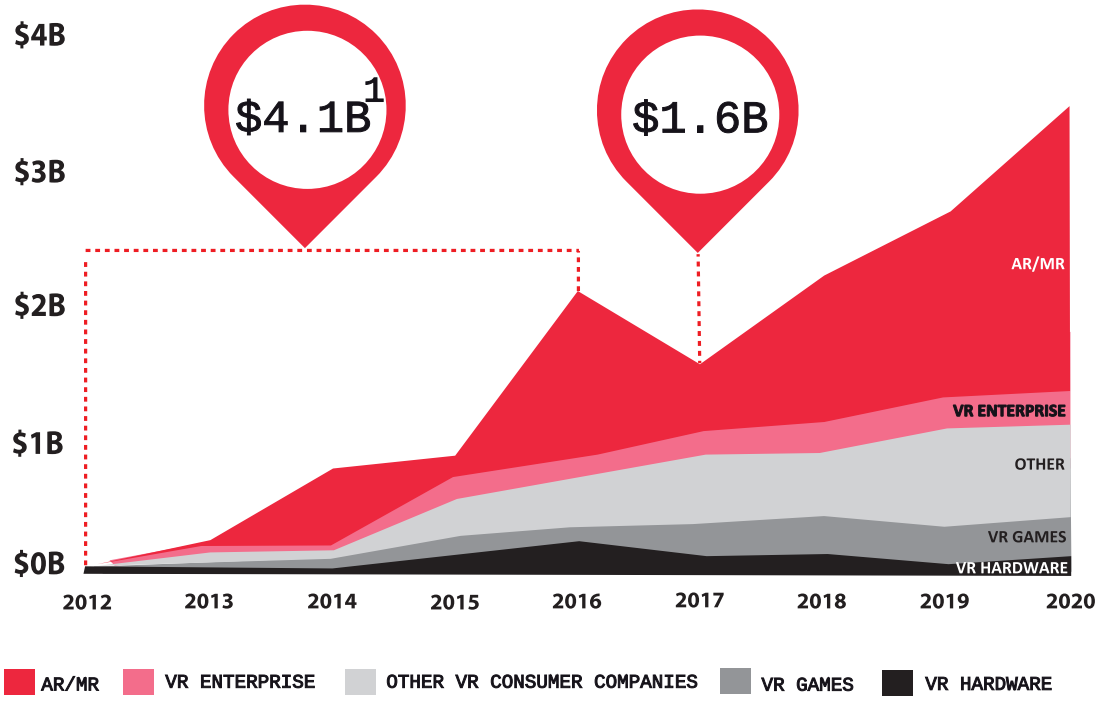
THE PROGRESSION PF OUR BASE CASE HARDWARE AND SOFTWARE FORECAST



Source: Goldman Sachs Global Investment Research

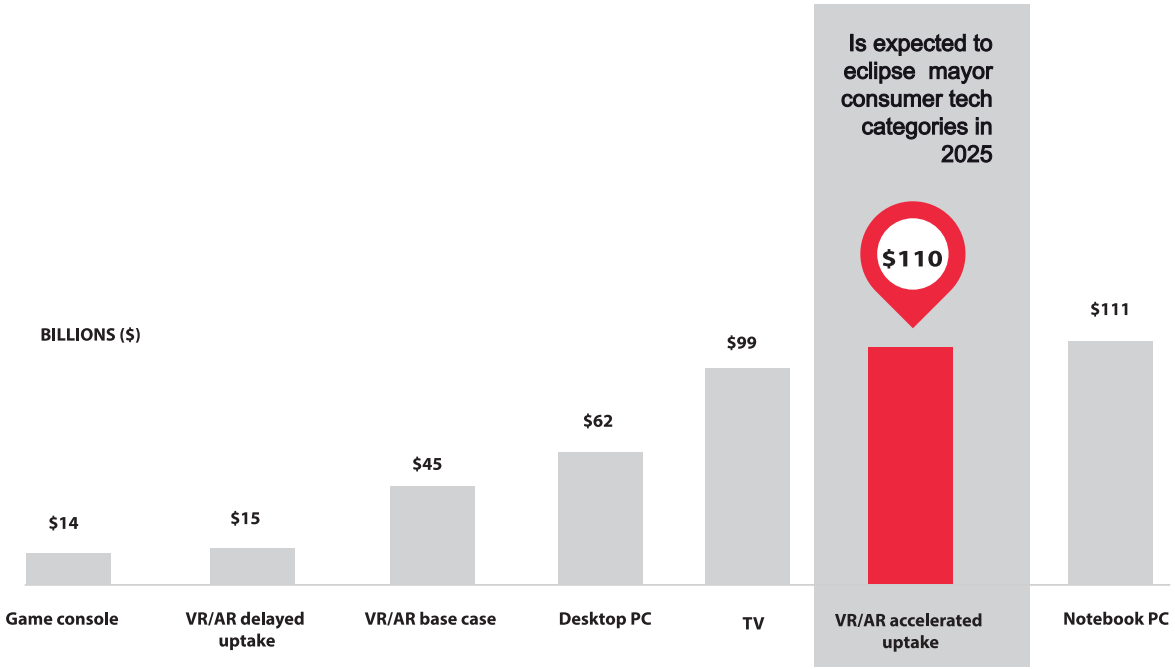
Shortly after, in March 2016, Digi-Capital announced a total investment of US$ 2.6 billion in the VR market, of which US$ 1.2 billion had been provided by VC funds. Finally, the same source anticipated that the installed base of VR/AR/MR devices will grow to 300 billion units by 2020, including PC and consoles (10%), mobile VR (20%), standalone AR/MR (35%) and smartphones & tablets.

INVESTMENT IN VR/AR/MR COMPANIES



A first obvious conclusion is that AR & VR hardware will account for the lion's share of the cake. This is why tech giants are turning their strategies into KETs. Anyone interested in this matter knows that VR & AR have countless applications, but the challenge is getting enough processing power (from GPUs and CPUs) along with high precision, low energy consumption and low cost. Ultimately, hardware is once more the key, with an expected share of more than US$ 30 billion by 2020. It is worth mentioning that another notable KET corresponds to immersive technologies.

THE GLOBAL AR/VR MARKET



Source: Goldman Sachs Global Investment Research

While experts like Tim Merel, from Digi-Capital, think that the true boost of this market will take longer than announced and that its growth will happen later and at a slower pace, there is no question about its growth in general terms. However, looking more into detail, possibly not the whole market will expand simultaneously.

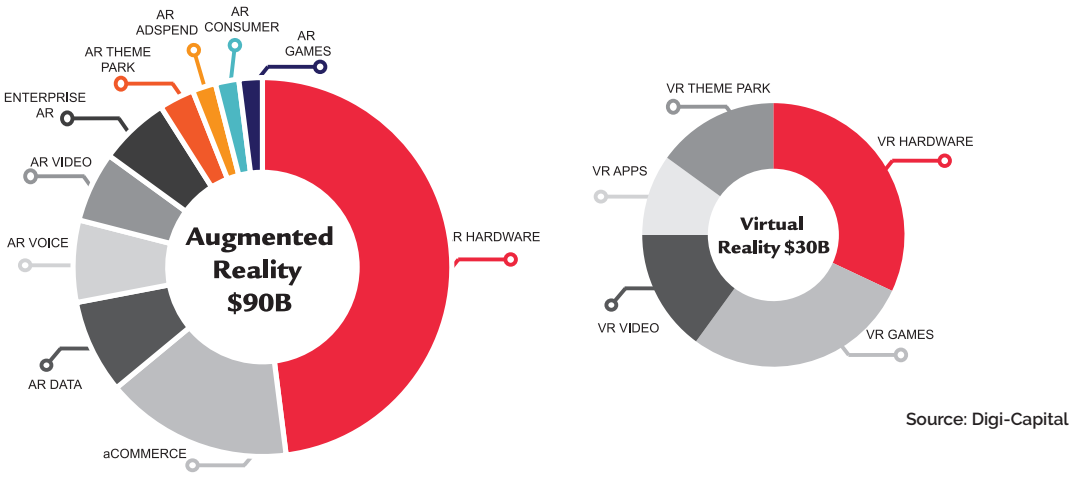
Apetite for AR & MR

The market analyst Superdata Research recently made public that the funding of VR is drying out but that there is still plenty of appetite amongst investors for augmented reality (AR) and mixed reality (MR). Among the 6.3m headsets shipped last year, most were cheap, unsophisticated devices, such as the Samsung Gear VR, that rely on smartphones to act as their screens.

Some tech giants still see VR as integral to their future. However, other tech firms reckon VR may be a stepping stone to a bigger prize: augmented reality (AR), which allows users to overlay the digital world onto the real one. AR has far more everyday applications than VR, which is expected to be used chiefly for leisure activities and in industry. For example, Apple believes that AR will become a bigger phenomenon than VR and is acting accordingly. Later this year, the US giant will start putting augmented reality software in as many as a billion mobile devices.

Whether it be VR, AR or MR, attending to an analysis for each industry, it is generally accepted that the biggest share of the market in the early stages will remain mostly for video games and healthcare, while there will be increasing opportunities in engineering, live events, retail and even military use. **Augmented reality (AR) is expected to be a market at least 3 times larger than that of VR:**

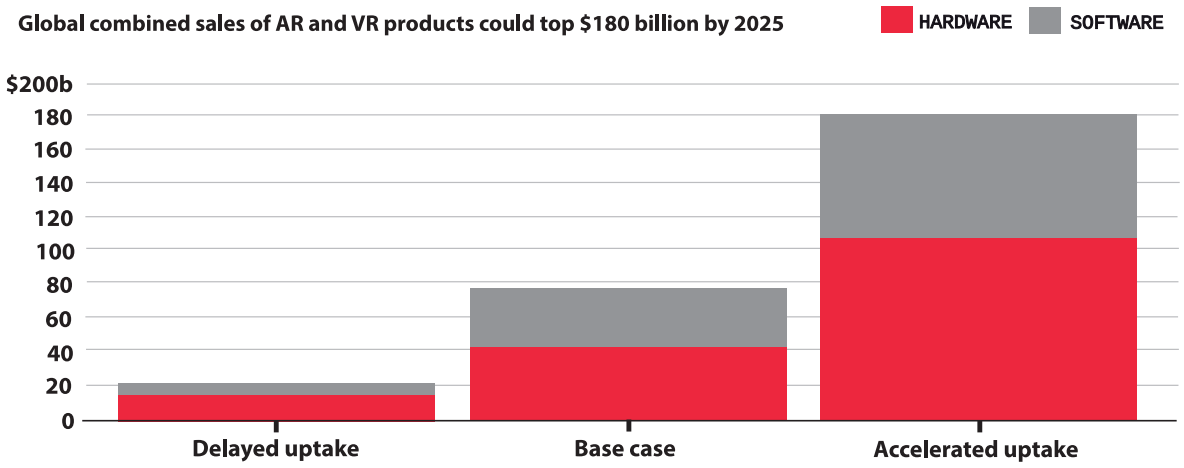
AUGMENTED / VIRTUAL REALITY REVENUE SHARE 2020F



Source: Digi-Capital

Anyway, there is a gap between users and business forecasts, so the adoption rate should eventually be much higher. Up until now the market has shown signs of a delayed uptake, but this could change swiftly anytime given the potential, if the current blocking factors, of which we will talk about later, can be solved.

AUGMENTING REVENUE



Source: Goldman Sachs Virtual and Augmented Reality Report, Jan 2016/ Forecast is for 2015

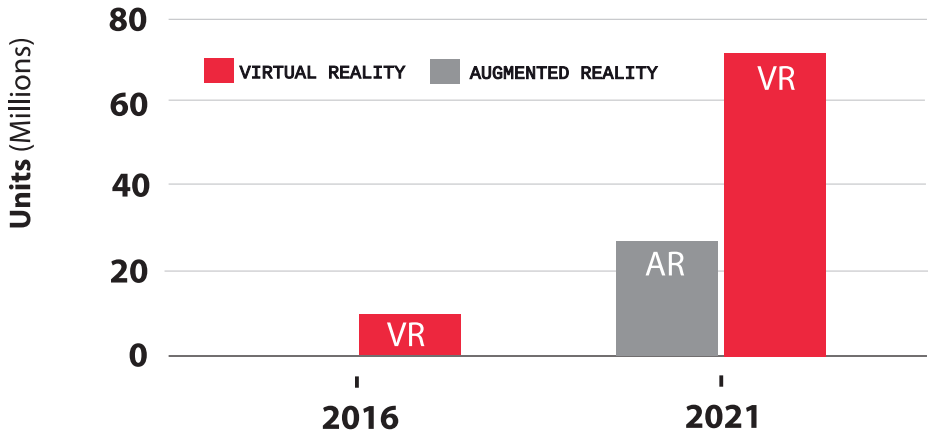
The overview of the market is good, especially for us hardware developers and manufacturers, as there is a clear need for high quality, reliable, wireless and affordable hardware to run applications. Hunger for wireless devices and a better immersion experience are a fantastic tailwind for everyone involved in Electro-magnetic Motion Capture Sensors and Systems. Nevertheless, HW – as usual – will be surpassed by SW by 2020. We have seen this in other platforms (PCs, smartphones, ICT and smart vehicles). Until that day comes, HW will play just as an important role as SW, or even more, due to its crucial potential impact into allowing mass adoption by end users.

In pursuit of the top positions

The players in this industry know it. New headsets from a variety of hardware firms—Acer, Asus, Dell, Lenovo and Hewlett-Packard—all running on Windows, are expected later this year. Many new games and entertainment products using VR are poised to go on sale. Better technology and more content will encourage gamers who were on the fence to join in. headsets will become smaller, cheaper and wireless, ultimately leading to the achievement of a sensation of complete immersion, called "presence". Boosters of VR say it is what will drive the technology's mass adoption, in time.

Currently, VR hardware comes in two flavors: cheap headsets that turn smartphones into virtual reality players (like Samsung's $130 Gear VR) and high-end gaming rigs (like Facebook's $400 Oculus Rift) that hook up to $1,000+ desktop computers. Facebook's new headset is designed to bridge that gap, a device that will sell for as little as $200 and need not be tethered to a PC or phone. It will ship next year and represent an entirely new category. According to IDC, once hardware becomes available for the majority of potential end users, annual shipments could amount to over 75 million units in just 5 years!

WORLDWIDE SHIPMENTS OF AR vs VR



Source: The Market Mogul | Data: IDC (2021 are estimates)

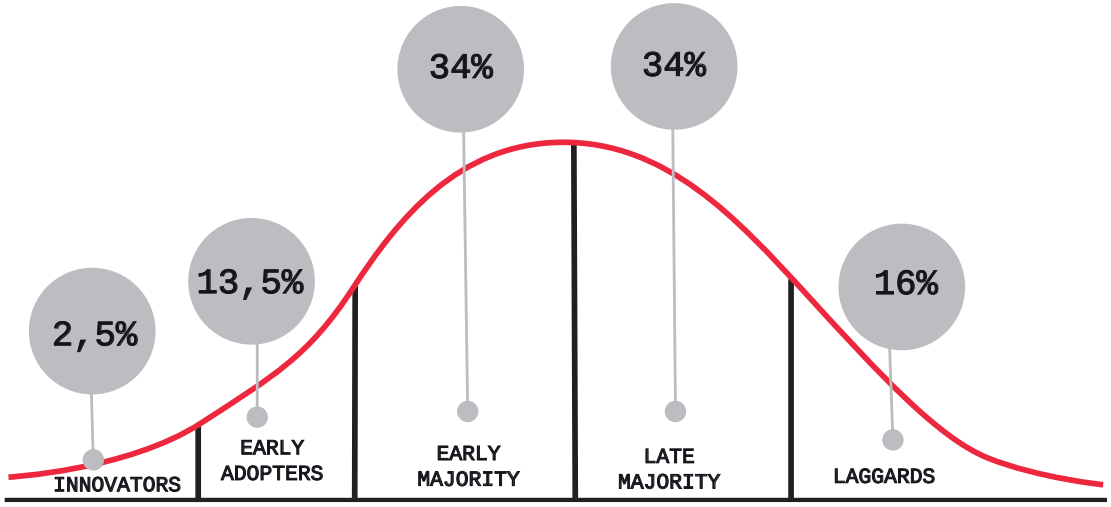
The massive potential of this industry is not secret at this point, and as stated, some key players are positioning themselves with strategic moves. In this sense, as published in the technology website VentureBeat, earlier this year HTC became an official partner with Google in producing a **Daydream-based standalone VR headset under the Vive brand.** Today, HTC announced it is producing a similar device for the Chinese market powered by Qualcomm's Snapdragon 835 chipset. It looks like it will access HTC's storefront, called Viveport, to get to virtual worlds rather than Google Play

These standalone systems are designed to be far more convenient than Rift and Vive because they don't require separate hardware like a phone, PC or dedicated external tracking systems to operate. It is unclear, however, how compelling the virtual worlds will be that you can visit with these standalones.

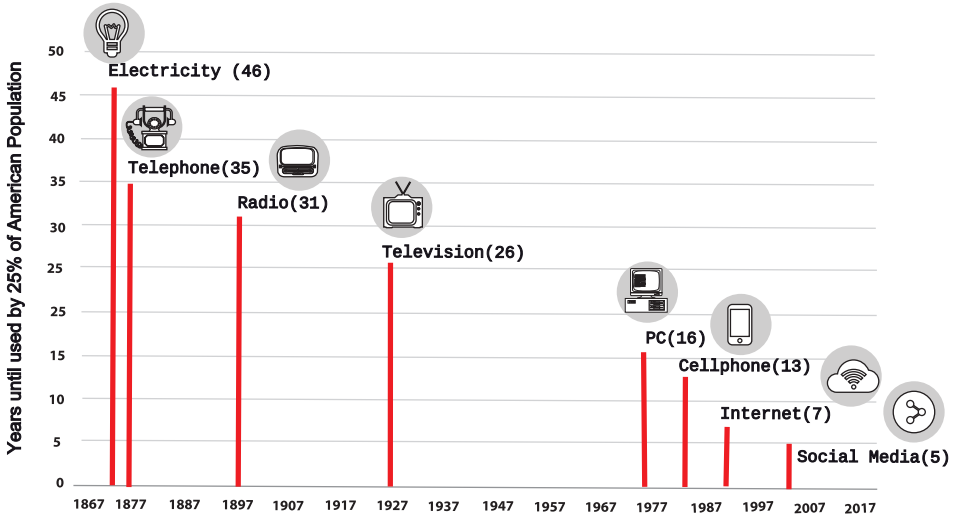
Key questions

With so many stakeholders of the virtual revolution scrutinizing the market and taking positions in order to obtain as much profit as possible from it when the boom finally comes, Navarro's e-paper accurately addresses one of the most important factors that remain hidden as of today. With a market that shows clear vital signs and a promising future, we as hardware manufacturing players that aim to lead not far from now, must ask ourselves: when will the pool of consumers be ready for mass adoption of our solutions? And what can we do to help them?

The social adoption cycle is a well-known classic:



We need to know now whether we are still addressing the first 2.5% of innovators or entering a larger volume phase of the curve. Early and Late Majorities probably will be the cash cows and the consolidation of the platforms but for us, technology companies, it is a fact that the standards and definitions for the whole life cycle are set in the first two stages. In addition to being familiar with the adoption graph, we are also aware that the speed of adoption is increasing dramatically, partly thanks to economies of scale in an increasingly connected and globalized market.



If phone adoption by the first early majority took 35 years in USA, TV took a span of 26, Internet a shorter period of 7 years and Social Media (Facebook, Twitter, Instagram) just 5 years, make your bet. How long will it take for VR and AR to be adopted by up to 25% of the American population? Only when the current biggest bottleneck, hardware, becomes widely available, affordable, simple and compatible with multiple systems, we will witness the real launch and mass adoption of VR.

What about the rest of the world? Will an increasingly competitive Asia just sit and look? Not likely; HTC, Sony, Nintendo, Samsung, LG, Lenovo are already big players and only naturally the second largest economy of the planet will have a lot to say about this technology. Chinese firms have been surprisingly quick to research and invest in systems that are smaller, cheaper and wireless, and as a result this industry is churning out new proposals. Most importantly, the Chinese government is supporting this development as mentioned by Xi Jinping, as they envision VR as an important vector for economic growth. Thanks to a favorable business climate, Chinese tech giants like are getting ready for when the VR wave finally arrives.

The market indicators shown by The Economist, mentioning SuperData Reseach, and processed in our published e-paper, are promising. Most companies grew from 2016 to 2017 and in average the market will roughly double itself by next year. Nevertheless, analysts mention that the supply constraints in headsets and lack of availability of devices, like Oculus Rift in 2016, delayed both HW and SW revenue, but, as far as we know, those issues have been solved and the big players are focusing now on developing HW platforms that are more user friendly, wireless and accessible in every respect.

The industry is aware that 2016 was presented as the VR year, but the reality falls short. Objectively, today the global market for VR headsets remains tiny. In the first quarter of 2017, hardware makers shipped 2.3 million of devices, according to IDC, compared with 347 million smartphones. As explained previously, mainly buggy hardware and pricey headsets apart from insufficient contents are holding back mass adoption. Right now Samsung leads the pack with about 22 percent of the global VR market, according to IDC. Facebook's Oculus Rift is in fourth place, behind Sony and HTC, with about 5 percent of the market, or less than 100,000 units sold.

On the long journey to mass adoption of augmented and virtual reality, experts mention several hurdles to mass adoption. Since VR is mostly about driving the perceptual system, mainly the following senses are crucial: vision, audio, haptics, etc. Others matter too, such as smell or taste, but that are far away from being mastered, so not in the industry's scope of action so far.

Concerning what we do at PREMO and what we are good at, haptics is particularly challenging. The haptics that will probably matter most, at least in the initial years, would be for the hands, which are our primary means of interaction with the world. Precisely, in order to interact with the world on a full scale at some point in the future, eye, hand, and face tracking will be crucial to provide a realistic experience. PREMO works actively on this field and associated challenges, through Electromagnetic Motion tracking coils, which provide superior performances than any other equivalent technologies.

A unique technology **for unique experience**

- No line of sight needed. LF Magnetic Fields can reach sensors through solid objects.
- No fixed referenced emitter or multiple fixed calibration elements.
- Longer range traking than competing technologies.
- Operate at lower power levels and offers the best signal-to-noise ratios.
- Multiple tracking systems can be used in the same environment.
- Entirely customizable for needs of your product. performances than any other equivalent technologies.

Challenges envisioned in virtual reality

When it comes to identifying or classifying the many challenges face nowadays, they could be boldly listed as below. The solution that PREMO envisions for each one of them can be found in the recently published e-paper, about which we already spoke and in which the author aims not only to inform, but also to promote critical thinking.

› **Gear is expensive** and awkwardly heavy or clumsy. With many new technologies, price influences consumer adoption, and a decrease may drive enterprise adoption as well. As prices fall, expect enterprise experimentation and deployment to increase. As lighter and sleeker devices become available, their adoption will grow.

› **A powerful computer or gaming console** is required. AR & VR require a substantial computing power to create high-quality graphics, reduce lag between a user's movement and the display's response, and increase the visual frame rate to more than 90 frames per second (FPS), a rate that won't induce motion sickness. The development of dedicated processing units that can increase computing power and speed, while reducing power consumption, will allow AR/VR hardware to do more.

› **Many guidance and collaboration applications** will remain impractical until the batteries in AR/VR headsets can last an entire work shift—at least eight to ten hours. Most devices on the market currently last less than half that time. As battery life increases, so will the appeal of these applications.

› **Consumers do not spend on HW** that has not many applications/games to run yet.

› **Developers don't invest in a small and fragmented market** of different not compatible headsets that require a lot of repeated coding efforts.

› **The way users have to wave around handheld controllers** to input movement falls short of the promises of VR. Also, the human field of view can extend to approximately 180 degrees, the middle 114 of which is considered to be binocular in which humans use both eyes and can perceive depth and distance. Although many devices have fields of view just higher than 100 degrees, increasing the field toward 180 degrees will expand a worker's observable environment and enable more immersive experiences.

Our own experience tells us that most of the blocking points described above are being seriously addressed and most of them already in the process of being solved. Especially the need for haptics, sensors and the feeling of real presence, which is no other than the sensation of complete immersion, who Boosters of VR say is what will drive the technology's mass adoption, in time. The massive use of Electromagnetic Motion tracking for MOCAP (Motion Capture) brings the exceptional opportunity of obtaining simple, affordable and wireless hardware that will enable a significant presence.

Having developed our first 3D coils more than 20 years ago, we are in an second-to-none position in terms of experience, time to market, customization capabilities and product range. With our series of highly efficient small sized receptor and emitter coils, we provide the possibility of reducing gear dimensions and weight, reducing latency while keeping the highest performance that can be found in the market, ultimately leading to a fully immersive and realistic experience.

Soon after improvement of the current bottlenecks, a great variety of sectors will merge in and adopt this technology. The VR industry has not yet fulfilled the hype, but the believers have not lost their faith. According to Deloitte, the industry could eventually have a free way to develop and market several applications with great benefits for several key fields of activity, still limited today:

ENTERPRISE CATEGORY	WHAT	WHERE	POTENTIAL RESULTS
Guidance and collaboration	Provide a worker with visual cues to help her perform tasks such as maintenance, repair, or assembly	Aerospace and defense, automotive, construction, health care providers, industrial products, oil and gas, power and utilities, technology	Improved productivity, streamlined work processes, reduced risk, cross-geographic collaboration
Immersive learning	Immerse the user in realistic training environments that are normally either high-cost or high-risk to personnel; variations include addressing PTSD, phobias, and other medical issues	Consumer products, health care providers, higher education, and industrial products	Stronger retention of material, reduced risk, cost savings, improved therapeutic outcomes
Enhanced consumer experience	Enhance customers´experience by providing customized or unique methods to interact with the company, brand, or its products	Automotive, banking and securities, consumer products, health care providers, industrial products, media and entertainment, and travel, hospitality, and services	Better customer engagement, increased marketing opportunities, increases sales, enhanced brand positioning
Design and analysis	Enable knowledge workers to assess design ideas virtually and/or analyze data in new formats	Aerospace and defense, automotive, construction, higher education, industrial products, real estate, and technology	Cost savings, increased efficiency, earlier detection of design flaws, new methods to analyze data and generate insights

Source: Deloitte

As we've seen, a good number of organizations are already exploring enterprise applications of AR/VR. As the technology continues to improve, the case for testing, adoption, and deployment will become stronger, but solving the current bottlenecks is just the gate that opens the achievement of real possibilities. The reality we experience is whatever our minds infer it to be based on perceptual inputs, regardless of the source. So if VR can provide the right perceptual inputs, we can have whatever experiences we want, and those experiences will feel real.

It will take time, possibly several years to fully solve each of the challenges listed above. In short, VR is a truly vast space waiting to be explored, and much more research attention needs to be focused on it. Without a doubt, decades of innovation lie ahead, as announced Oculus Chief Scientist Michael Abrash recently at the third Global Grand Challenges Summit. After all, we are talking about the second greatest leap of history technology wise after the creation of the computer. One day, instead of interacting with the digital world through flat screens, we'll be able to live in the digital space whenever we want.

VR is a grand challenge in the purest sense. Obviously, it's highly difficult, requiring research and development across dozens of technologies, but that's only half of the story. As Abrash claimed, "VR is the culmination of more than 70 years of the computer revolution and centuries of development of information technology. We're finally capable of building an interface that lets us interact with the digital world using a significant fraction of the full bandwidth and biological processing that we're evolved for."

At PREMO Group we want to be a part of this revolution, and while we work and learn day after day to solve part of the challenges, we also commit to share the knowledge we acquire on the way.

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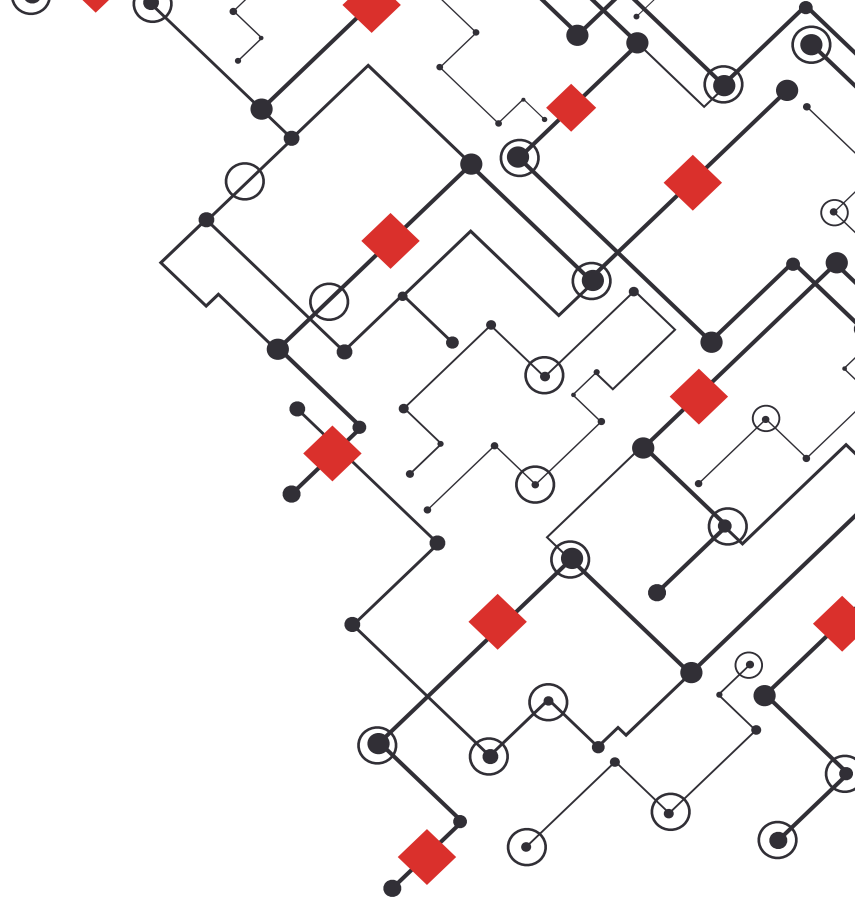


13

IMPROVING ENGAGEMENT BY TRUE IMMERSIVE EXPERIENCES IN SERIOUS GAMING USING VR & AR TECHNOLOGIES

By Lucía Vera Mahiques

13

Improving engagement by **true immersive experiences** in serious gaming using VR & AR Technologies

Currently, there is a common culture of innovation and technological advances. Technology is being incorporated into all sectors of our daily life. Also, many technical terms and words are starting to appear in our vocabulary although, many times, they describe concepts that have been in use for some time; such is the case of "Serious Games".

Many researchers talk about the future of Serious Games including the advantages of using them for training and learning purposes and, also, how we can improve the results obtained using Serious Games. A key point is that the experience is perceived as truly real and, to achieve this, truly immersive systems are needed.

But... **What are serious games?**

The term "Serious Game" is sometimes confused with other related terms such as "Simulator" or "Virtual Reality". Depending on the environment used, the difference between them can be very subtle, but it is important to clarify each one in this context.

On the one hand, a simulator is an application that replicates a certain situation, natural phenomenon, process, or experience. These kinds of developments can be very different types but the majority are computer-based simulations and normally have a very important visual component to represent the result of the simulated entity.

On the other hand, Virtual Reality (VR) creates a completely unusual experience, offering to the users a synthetic and alternative world so that users believe they are actually living this virtual experience. It is possible to consider VR as a specific kind of computer-based simulation because the main objective of this kind of application is to simulate, inside the virtual settings, the perception cues that a person would perceive in a real situation so as to make the users believe they are experiencing a real situation when they are inside a virtual one.

Between these kinds of applications we can find gaming. The principal objective of games is entertainment and for that they use several kinds of technologies and applications. Some games are simulators but most of them use virtual reality. So, where can we place the term Serious Games?. This term comes from the evolution of games and video games to cover some kind of learning or training necessities and the development of specific skills in a comfortable, enjoyable and relaxing environment.

In particular, one of the most popular definitions is:

"A mental contest, played with a computer in accordance with specific rules, that uses entertainment, to further government or corporate training, education, health, public policy and strategic communication objectives" given by Michael Zyda in 2005 in his paper "From visual simulation to virtual reality to games"

In other words, Serious Games (SGs) are computer-based games whose main mission is NOT ENTERTAINMENT and fun but are developed for training and learning purposes or for improving certain user skills. Other terms related with this concept include "educative games", "educational games" or "edutainment", which are less formal and technical than SGs but are used in a wide variety of fields.

These kinds of applications do not need to simulate a particular phenomenon, and if they do, the simulation's accuracy is normally less than in a simulator. For their development, different technologies can be used, among them Virtual Reality (VR) and Augmented Reality (AR) or a combination of both. These elements are more likely a component in an SG or an interaction paradigm used to accomplish the educational objectives of the game design.

SGs are considered a very successful environment to provide awareness about different aspects of life and improve learning skills. There are several researches suggesting that these applications have an important impact in generating public interest and an increase in awareness[1] and also the benefits and advantages of them for teaching concepts, addressing specific problems or training certain skills[2]. These capabilities are due to how attractive these applications are for all types of individuals: both appealing to young people due to its ludic nature, and to adults as they provide rigorous information about diverse issues in a relaxed environment.

But what about engagement?

In general, "engagement" is considered as a generic indicator of user involvement in the system or game used, so it can be an important indicator of how interesting and attractive that application may be. High levels of engagement can positively impact the user's attitude towards the learning tool, his/her emotional state while using it and the desire to play it again to continue learning. Here immersive technologies are proven to obtain a better engagement than non-immersive technologies.

The usage of virtual and augmented reality is well-known in today's gaming industry. They are very important interaction points and very useful in getting games successfully launched to a wide variety of the general public. The technology is more present in our lives and the gaming industry always tries to bring the latest technological trends to an audience eager to try and experience new things. VR and AR have a very important presence in the gaming and video areas, and their incorporation in non-entertainment uses are increasing every year.

For that reason, the inclusion of technological components that enhance 6DOF (six degrees of freedom) immersion by motion tracking in Serious Games could influence in a significant increase of its engagement. In this sense, the VR and AR are good candidates to achieve an engage serious game, where the user is learning, training or improving certain skills while he/she is playing and enjoying, using a very attractive technology.

Inmmersive Experience

Serious Games can only be a choice if the technology evolves into real immersive solutions. In June of 2017, we had a full package of information coming from Google I/O 2017 #GoogleIO2017, a breath of fresh air into the future of VR. Goggle takes VR very seriously and, after having sold millions of cardboard goggles, they announced they are now betting on the fully immersive experience by boosting Daydream with new hardware. They also announced a collaboration with HTC Vibe for new stand-alone headsets. Every component of VR, the CPU and the GPU is built directly in the headset. **These innovations give the user several grades of freedom:**

1. No need for High End expensive PC's
2. Wireless → You can move
3. No need for a mobile phone → No dependency on the manufacturers or mobile devices.
4. Standardization in VR apps may boom. Now it is painful for so many players
5. Inside out tracking -> No need for cameras or sensors for hand tracking
6. True to scale positional tracking
7. Precise 6DoF
8. Sensors integrated into standalone VR thus reducing the floating point imprecision and increase precise tracking.

According to **Deloitte's**, immersive learning is one of the four key applications of VR/AR and the learning experience is maximized when there is full and precise 6DOF motion tracking of the own body and instruments.

APPLICATIONS OF AR/VR TECHNOLOGIES

ENTERPRISE CATEGORY	WHAT	WHERE	POTENTIAL RESULTS
Guidance and collaboration	Provide a worker with visual cues to help her perform tasks such as maintenance, repair, or assembly	Aerospace and defense, automotive, construction, health care providers, industrial products, oil and gas, power and utilities, technology	Improved productivity, streamlined work processes, reduced risk, cross-geographic collaboration
Immersive learning	Immerse the user in realistic training environments that are normally either high-cost or high-risk to personnel; variations include addressing PTSD, phobias, and other medical issues	Consumer products, health care providers, higher education, and industrial products	Stronger retention of material, reduced risk, cost savings, improved therapeutic outcomes
Enhanced consumer experience	Enhance customers´experience by providing customized or unique methods to interact with the company, brand, or its products	Automotive, banking and securities, consumer products, health care providers, industrial products, media and entertainment, and travel, hospitality, and services	Better customer engagement, increased marketing opportunities, increases sales, enhanced brand positioning
Design and analysis	Enable knowledge workers to assess design ideas virtually and/or analyze data in new formats	Aerospace and defense, automotive, construction, higher education, industrial products, real estate, and technology	Cost savings, increased efficiency, earlier detection of design flaws, new methods to analyze data and generate insights

Source: Deloitte

Advantages of VR

Virtual Reality environments have been used in learning simulators for years. They were not exactly originally conceived as games and their usage was more oriented to the adult public. Its evolution and the appearance of new immersive technologies, such as the Samsung Gear VR or Oculus Rift (vincular a páginas?) and other low cost solutions make VR more accessible to the public in general. It also makes possible the development of a wide variety of applications based on VR and with many different purposes, from leisure to educational, and for all ages.

There are many advantages of using this technology in multiple applications but, in Serious Games, significant educational developments and advantages include the following:

It makes possible the adaptation of each environment to the specific needs and profile of the user or player. This aspect is very important in learning, because not all students have the same level of learning or the same learning speed.

It is highly interactive, making the applications more attractive, enjoyable and engaging.

Provides a very important capability to reproduce almost every kind of scenario using virtual models.

Has the possibility to simulate situations of any kind, increasing the learning areas where it can be utilized.

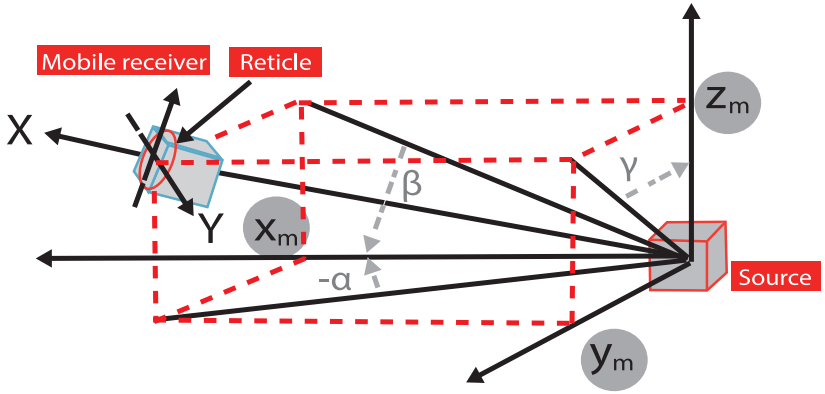
It is possible to control the learning process with user identification, score registration and evaluation of the individual's performance.

Allows the control of the stimulation level offered in each tool.

It is possible to create a predictable and repeatable environment where the situations can always happen in the same way. This is a very important key in learning: the possibility of repetition of the same situation or scenarios which are very difficult to completely reproduce in real life. This aspect can be very useful in cases of users with special needs.

Learning or training can be accomplished in a very safe environment so it will be a perfect technology in case of considerable risky training situation or learning concepts.

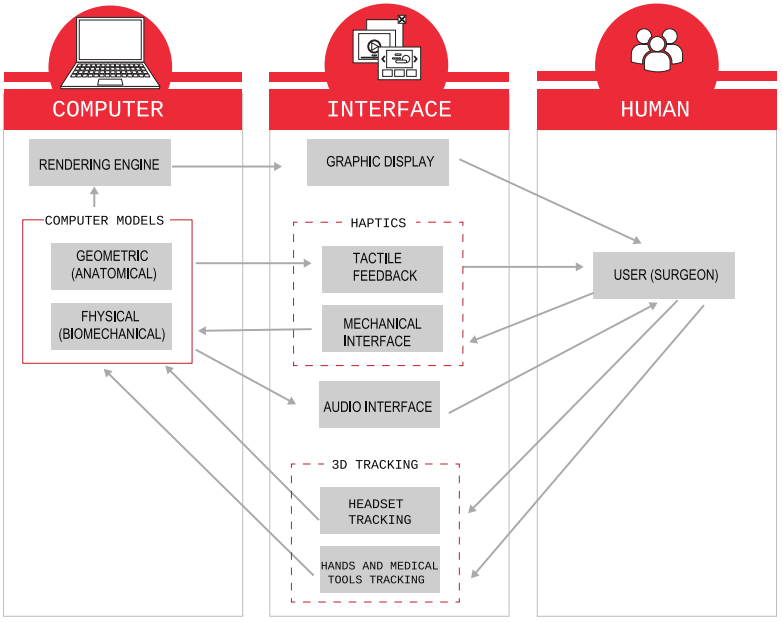
There are a wide variety of technological devices that can be incorporated to improve the user feelings, engagement and immersion in the application. For instance, the use of motion tracking sensors to control the position of user, his/her hands or specific elements which motion must be controlled to produce a very important sense of presence, are possible in this kind of applications.



Advantages of AR

If VR seems to be a powerful development tool for training or teaching, what happens if the information comes to you in a real world environment? The possibilities of Augmented Reality applications are incredible because the knowledge can be offered in the space where the learning or training needs occur.

The real environment is augmented with information which can help the user learn or train for specific skills. In this case, AR is supporting the real world rather than replacing it with virtual environments. Its everyday usage is more often in games, tourism, leisure, training and education. The main advantages of AR in educational environments or Serious Games are[3]:



Architecture of a medical VR system

It is possible to offer all the components needed to learn concepts or train for specific skills in the scenario where the person has to develop his/her work skills later.

Offers a safe environment of learning and training, avoiding the risk that a real world experiment may entail.

It is possible to break the limitations of space and time so students can observe the inner workings of simulated elements by entering inside them (particles, atoms, etc). Also, long experiments which can take extended periods of time can be simulated via AR in a substantially shorter amount of time.

Allows the virtualization of historical people, celebrities or scientists, bringing them to the real world around the student, and enabling interaction with them to understand their story, their experiments or their contribution to humanity.

It is possible to show works of art, monuments or other types of cultural heritage symbols directly to students, inside their current environment, allowing them to move around, investigate and to receive information about them and for analysis and discussion with other students and teachers.

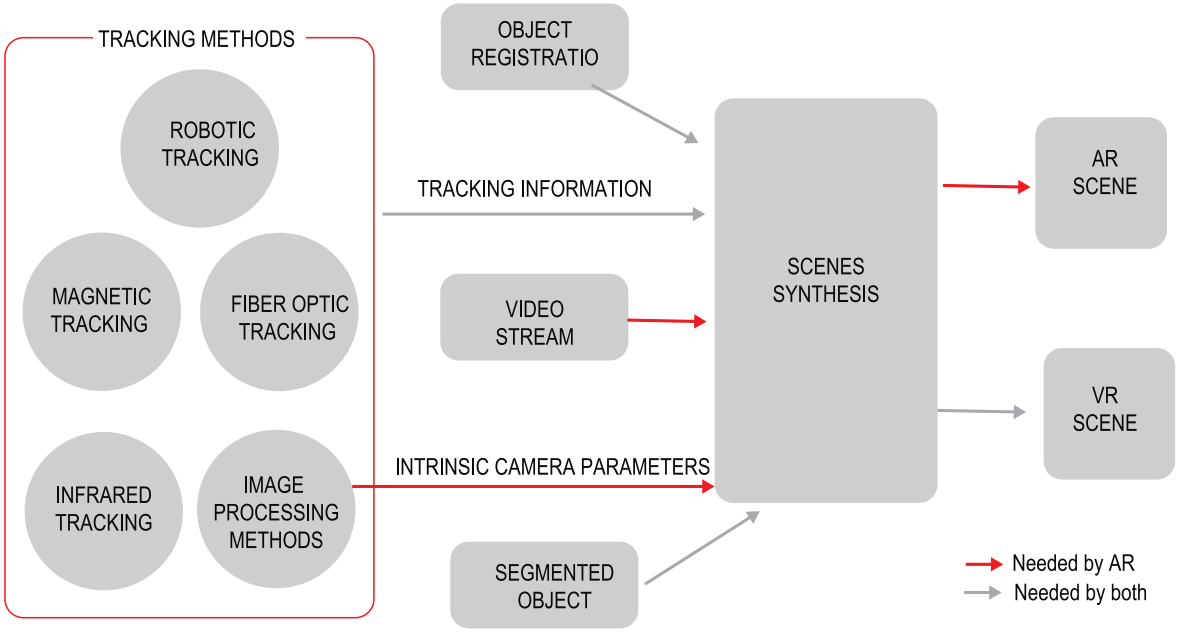
New technologies including tablets, smartphones or AR glasses make more accessible the usage of this kind of interaction and applications to every area of our daily life. See our post on VR and New Technology Trends for more details.

The engagements in AR development are quite high since they offer a very natural and intuitive method to acquire knowledge. See our post on applications on Surgery.

Allows the usage of motion tracking systems, similar to the ones used in VR, to control the user motion and the motion of complementary elements needed to interact with the augmented environment.

If engagement is related to immersive experience What's Next?

Multiple tracking methods are technologically available as highlighted in the next frame.

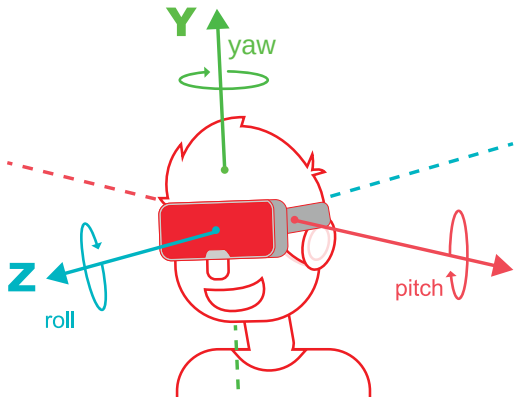


Nevertheless, Electromagnetic sensors have several clear advantages as per below figure:

TECHNOLOGY	COST	LATENCY	PRECISION	RANGE	LINE OF SIGHT
3Dcoilcube	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓
IMU*	✓ ✗	✗	✓	✓	✓
Visual / Optical	✗	✓ ✗	✓	✓	✗ ✗ ✗

* IMU Inertial Measurement Unit (Sensor array with Gyroscope, Accelerometer & Magnetometer)

All the advantages and opportunities provided by these technologies, specifically the full immersive experience, make Serious Games a very powerful area where the learning, training and knowledge can be acquired in a very engaged, enjoyable, attractive and highly interactive environment.



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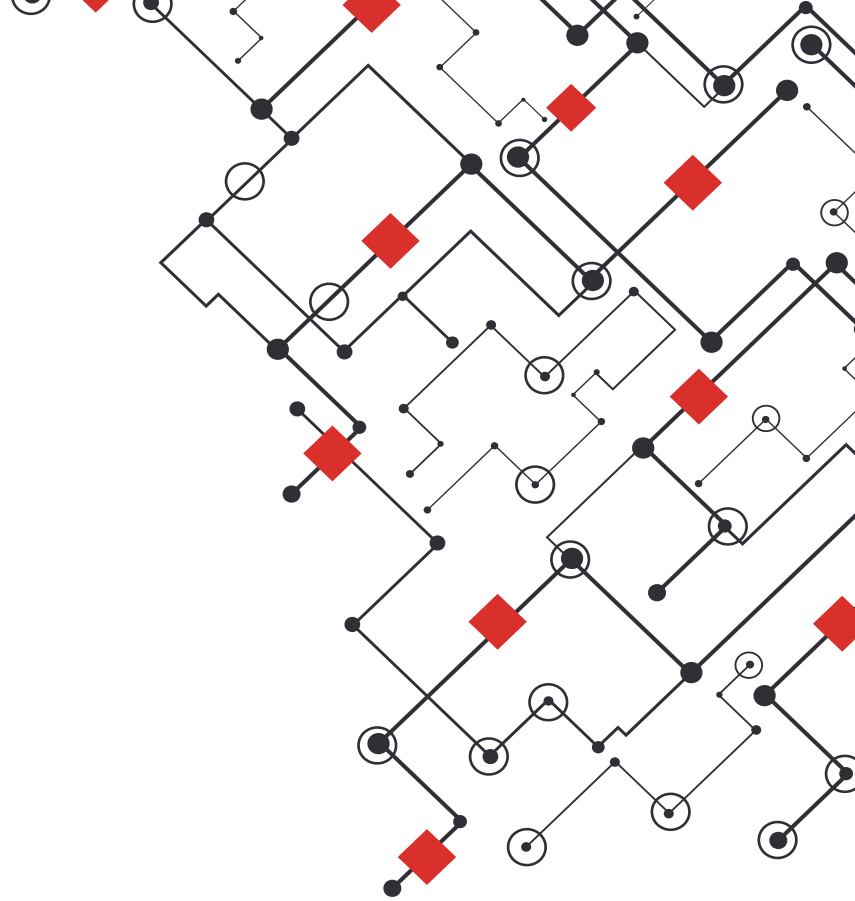


14

HOW IS ELECTROMAGNETIC MOTION TRACKING USED IN VR/AR?

By Antonio Serrano Sillero

14

How is Electromagnetic Motion Tracking used in VR/AR?

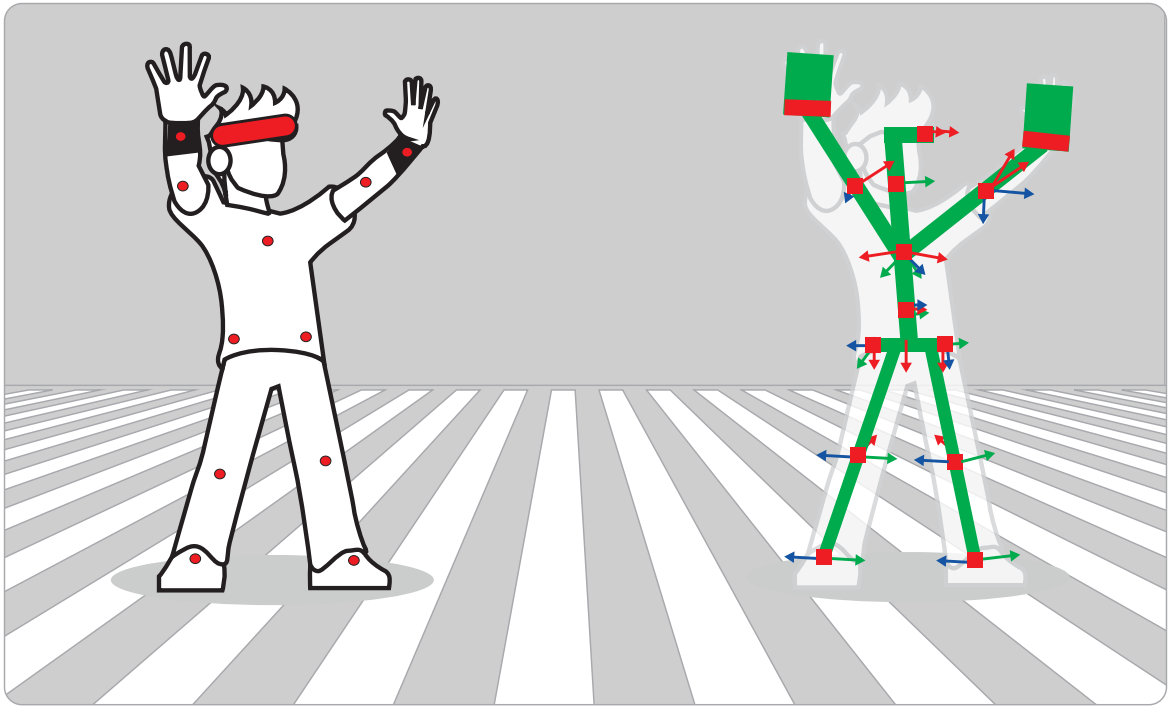
Immersive experiences driven by motion tracking systems for Virtual and Augmented Reality are becoming more popular, and due to this growing trend several kind of technologies to develop these systems are emerging, one of most popular of those are based on electromagnetism, which are called Electromagnetic Motion Tracking. But how does it work? What kind of tracking technologies exist? What are the advantages and drawbacks of every one? Where are motions tracking systems used? These questions are addressed in our blog and will be reviewed in this post.

What is electromagnetic motion tracking?

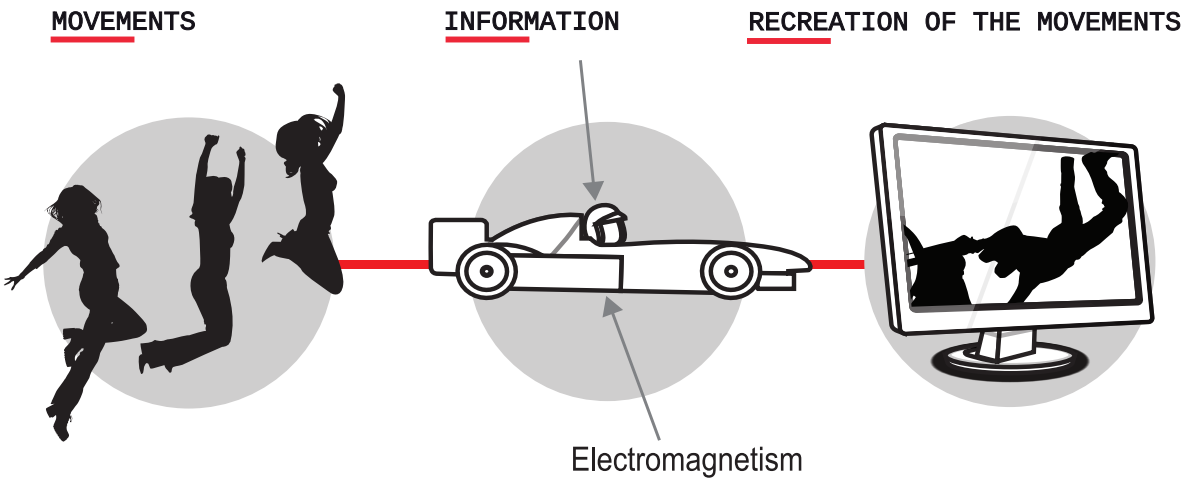
Electromagnetic motion tracking, as its name indicates, is an electromagnetism-based tracking technology.

Motion tracking is a technology which allows a moving object to be followed and after transfer the data gathered to be processed. For example, a digital avatar could render our movements.

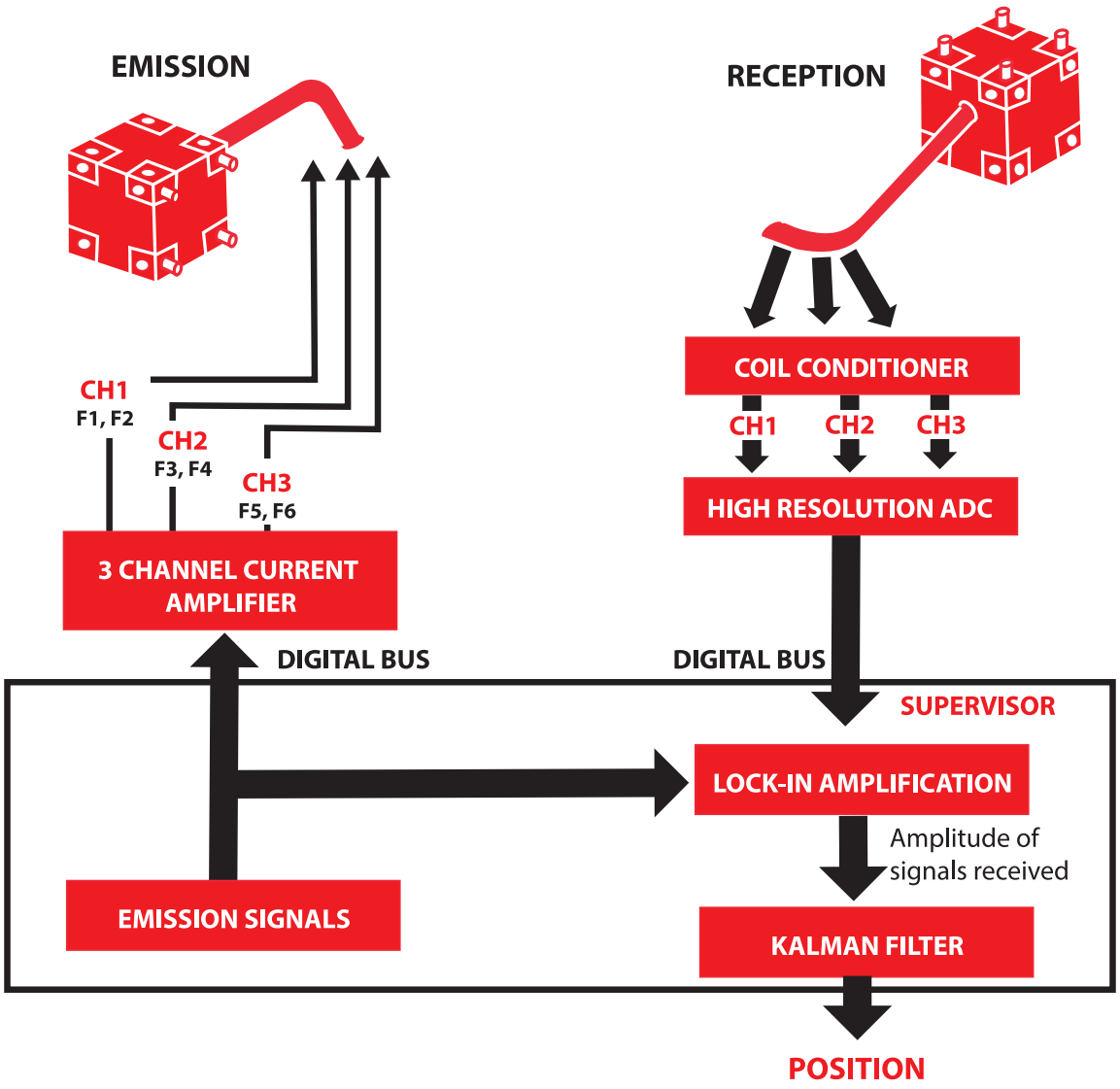
MOTION TRACKING



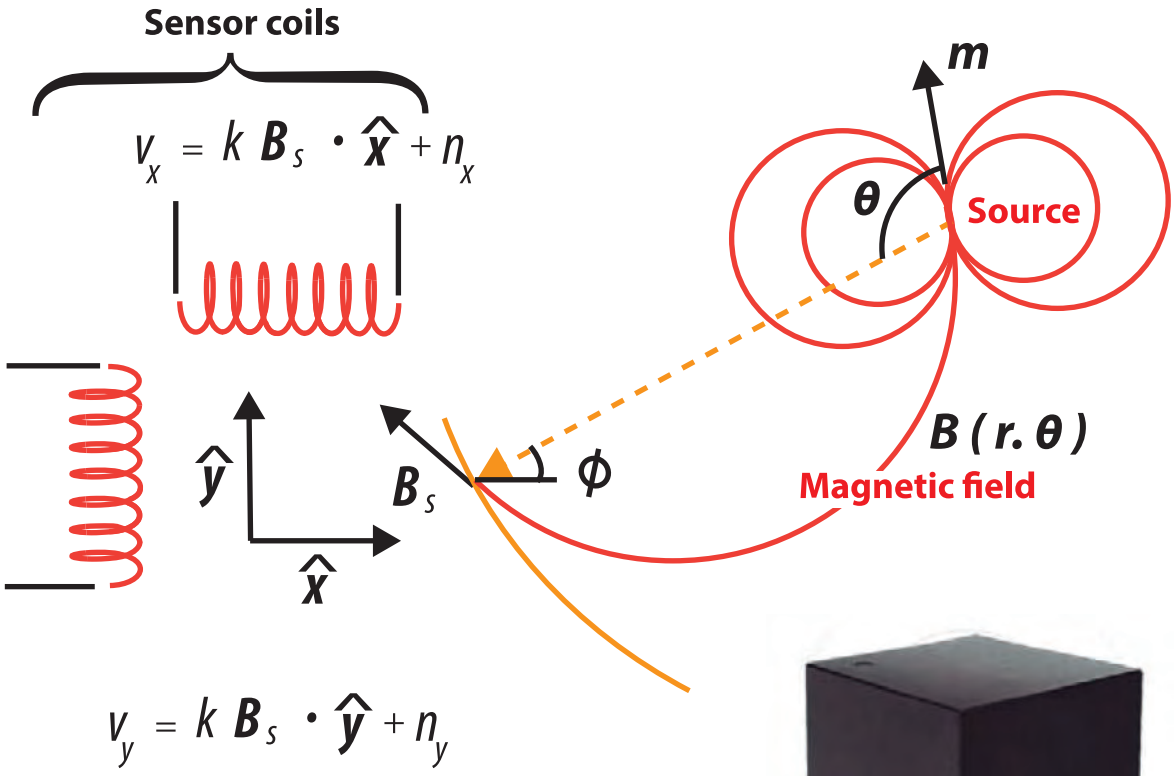
Following the example of the digital avatar, the role played by the electromagnetism here is a vehicle which drives the information from our body to the system that represents our avatar and move it depending on our body movement. You can read the full article here.



EM tracking systems are based on two main elements: transmitters and sensors.



The transmitter is an antenna, normally fixed in a position, in charge of generating a magnetic field in the three spatial directions. For this reason, manufacturers of transmitters typically use three antennas, one for each spatial direction.

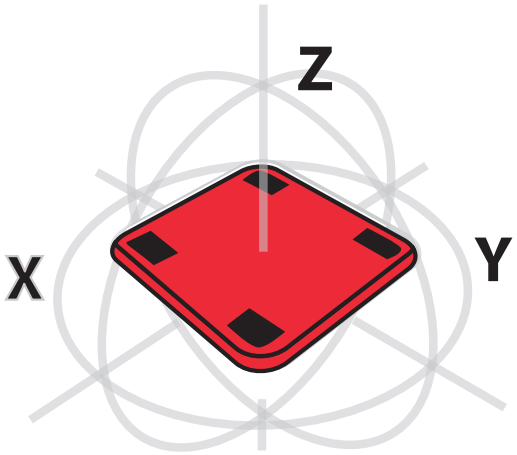


Instead, Premo has developed 3D emitter devices called **3DCoilCubes™** which can generate an isotropic magnetic field using only one of them.

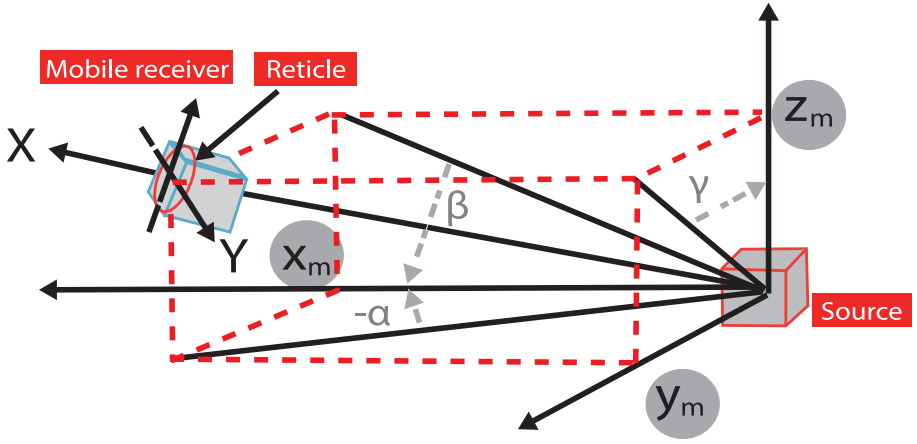
Sensor

Sensors are devices usually built-in in the device to be tracked, i.e., the device whose position we want to know. These sensors acquire the value of the magnetic field in the three spatial directions, so that, position and orientation can be known.

Premo **3DCoilCubes™** and **3DCoils™** are the perfect devices for this purpose, since they consist of windings in the three spatial directions to acquire data from the emitter antenna, allowing the position and orientation to be known with a good performance.



In other words, EM tracking systems use as spatial reference an electromagnetic field generated by an emitter antenna. Sensors measure the magnetic field strength by means of attenuation and level of the signal in each axis, so that orientation and movement can be known using a simple analytic method consist on getting the direction vector according to the voltage levels for each axis of the sensor.



Comparing EM, IMU and Visual Tracking Systems

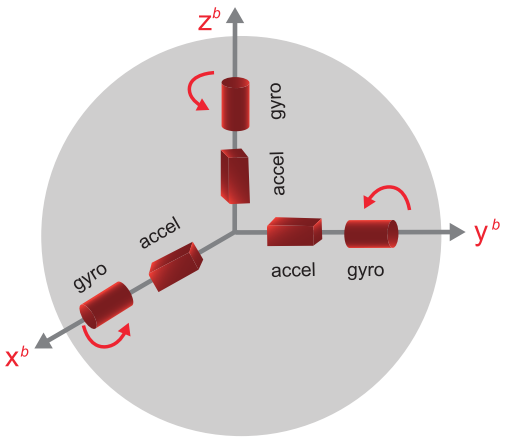
We talked about EM tracking systems and how these works, but there are other tracking technologies available in the market. This is good from the point of view of the designer, since they can compare and choose the solution that is best fits their requirements. Several tracking technologies are shown below and they are compared to EM to know their advantages and drawbacks.

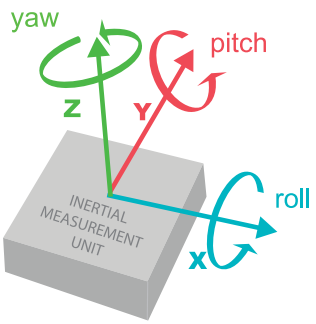
IMU (Inertial measurement unit)

The tracking technology based on IMU works using the current position and estimating the new one by mean of speed and acceleration data, i.e., in analytic way.

IMU is an electronic device that measures linear and angular motion by mean of a triad of accelerometers and a triad of gyroscopes, which are orthogonal between them, since each couple is composed of an accelerometer and a gyroscope, and is orthogonal to the other two couples.

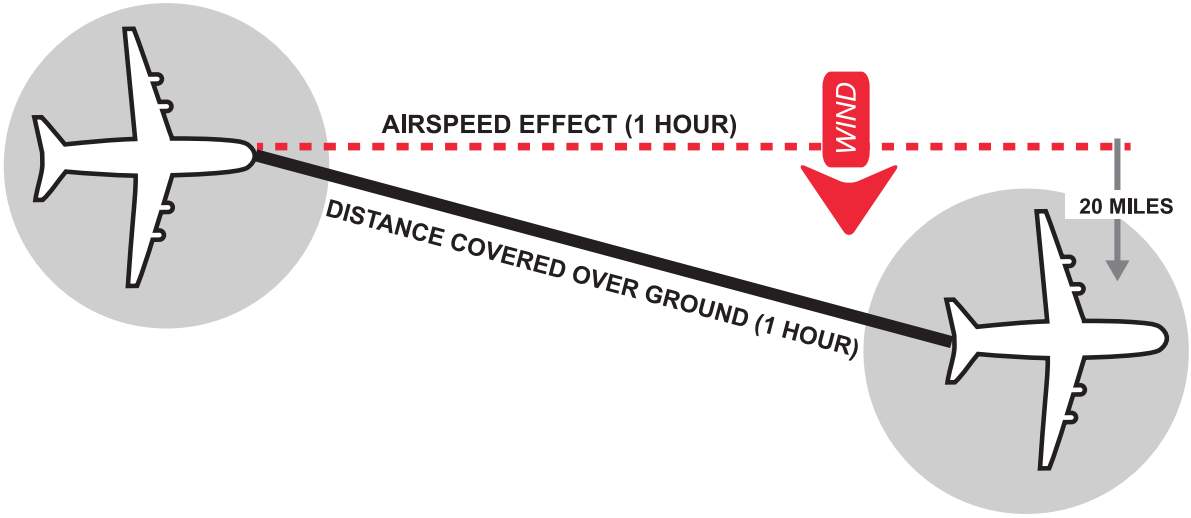
This technology allows acceleration and speed data to be gathered to be processed from accelerometers and gyroscopes.





Inertial Measurement unit
3 accelerometers, 3 gyroscopes

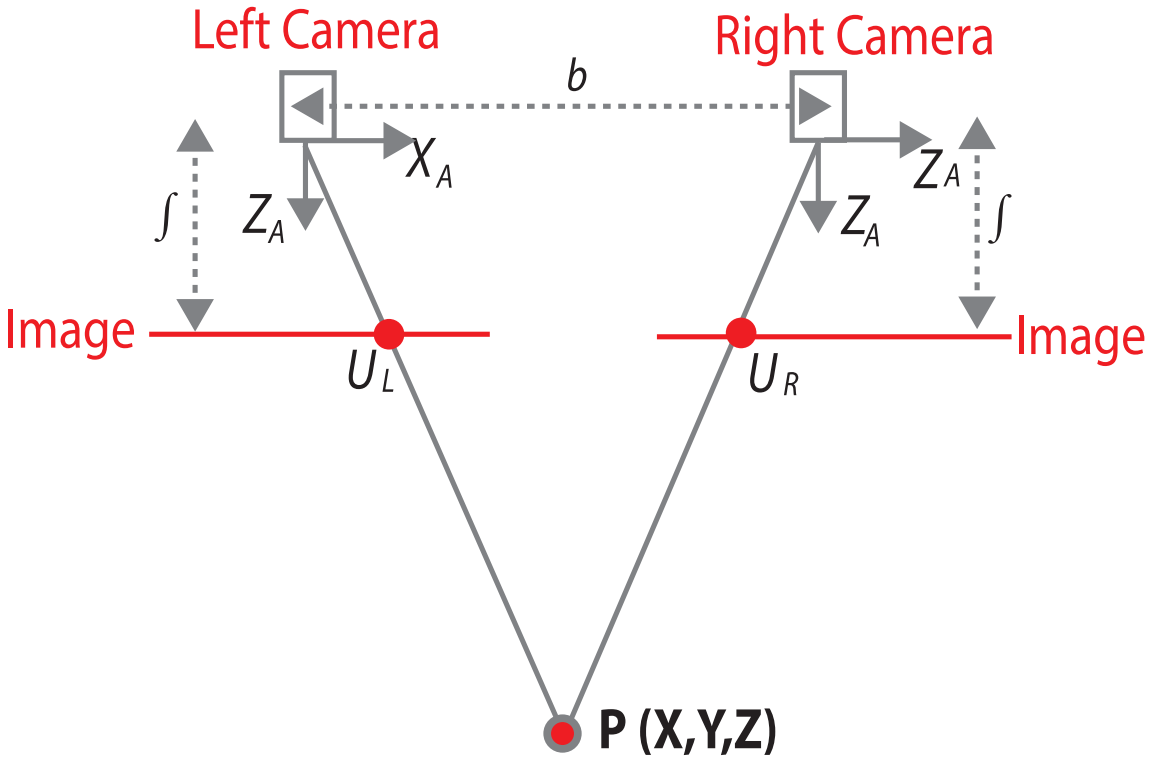
These devices are widely used in aircrafts, aerospace industry, guided missiles on board of ships, among others. The technique used to know the position and orientation in this kind of systems is called Dead Reckoning. This is a mathematic method which uses trigonometric to know the current position, but it should consider the accumulated error to be corrected.



Video/ Optical

Video tracking is typically defined as the process to locate the position of a target by means of cameras; cameras must take frames from the target continuously, so every frame is analyzed to detect the object to be tracked and to know its position.

We can find this king of system usually working with two or more cameras and/or different types of vision system, as infrared cameras to see in the darkness. These systems incorporate more than one camera and use the triangulation technique to locate the object to be tracked into the space.



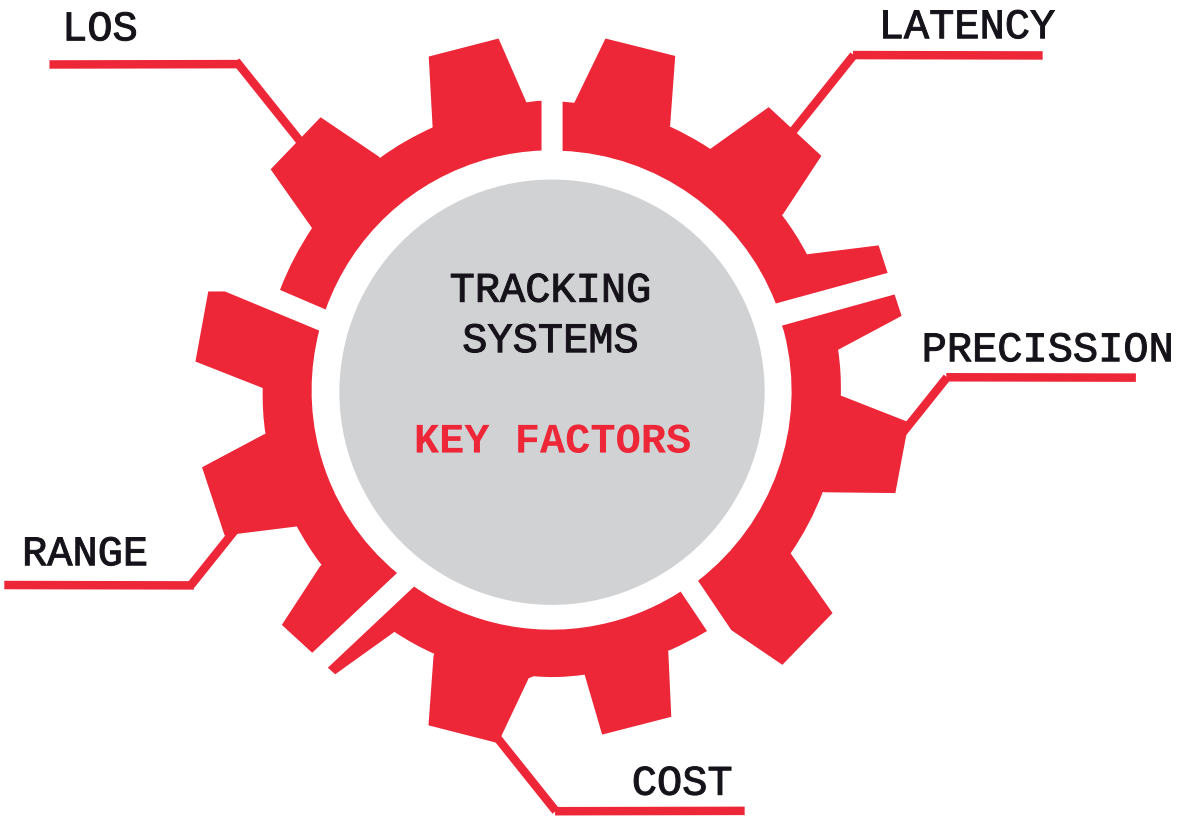
Since the system knows the object to be tracked, we can find three different methods to implement the tracking; from a pattern, additional identification system as a beacon and systems are able to learn what they must track.

Typical applications for these systems include videogames and video tracking in the AV industry.

Comparison with EM tracking systems

The quality of the motion tracking system is normally related to the tracking technology. For this reason, in this section we will compare Premo solutions, which are based on electromagnetic tracking, with the other tracking technologies explained above.

The main parameters to be considered in a tracking technology are:

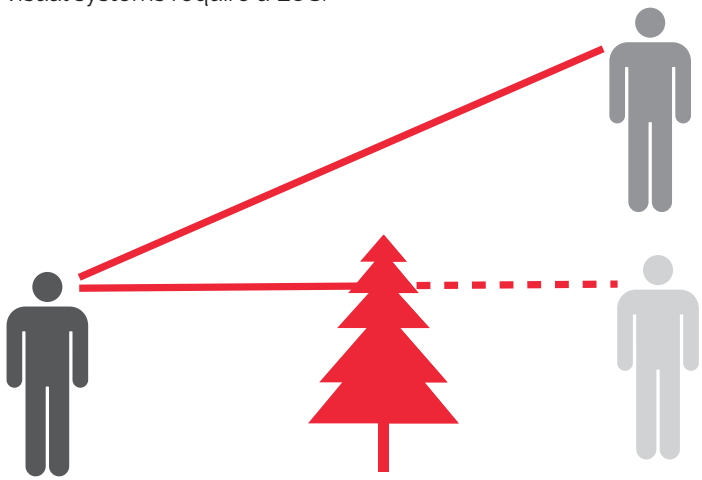


› **Latency:** It can be defined as the time required since the movement is performed until this change is transmitted and processed by the system. Ideally, this time should be instantaneous to offer a more realistic experience. Latency of EM tracking systems is very low because orientation and position are directly sent by the sensor in an analog signal that just needs to be converted into a digital value. By the other hand, a IMU needs more time to calculate the position and the orientation of the tracked unit. Also, visual systems require time due to the computational cost to manage images.

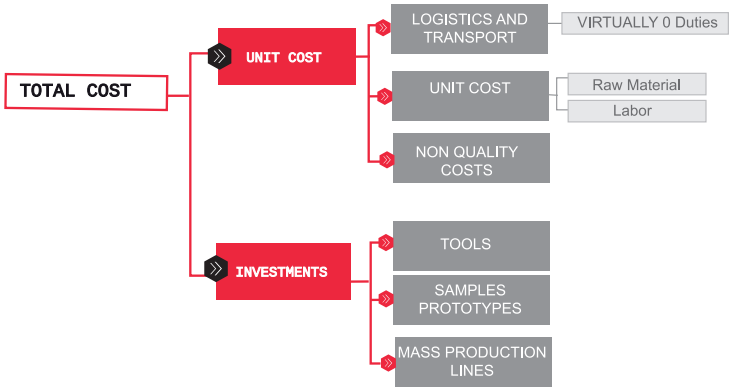
› **Accuracy**: This parameter shows how much reliable is the measure obtained by our system. Obviously the accuracy of the system should be very high for the feedback to show that our system matches the real movement performed by the user. Accuracy is very high in EM systems because the three axes of the transmitter and the sensors devices joined to the sensor provide very reliable spatial data. However, IMU systems require the accumulative error produced and visual systems to be corrected; this error results from reflections brightness and so on.

› **Range:** It indicates how far our system can work. Requirements for this factor depend on the application but a long range is always beneficial for the system and for the user experience, since a long-range system offers more freedom of movement to the user.

› **Line of sight (LOS)**: It shows the need of the system to have a direct line of sight between the tracked unit and the tracker. This requirement implies a limitation of the freedom for the user. For example if there's a wall between the tracked unit and tracker, the system will not detect the movement. Since the electromagnetic field can pass through the obstacles, a LOS is not required between the tracked unit and the tracker. By the other side, visual systems require a LOS.



› **Cost:** The price of the system depends heavily on the technology and, as usual, the best cost able to cover the needs of the application is also advisable. The product developed by Premo offers a competitive price because the manufacturing cost of the sensor and the transmitter is very low because Premo has mass production lines to produce these device with a very low price. By the other hand, optics and cameras are usually very expensive in visual systems. Also, IMU systems are more expensive than Premo solutions because the cost of sensors and processing units is higher than the ones used in EM tracking systems.



In the table below, a comparison between the different technologies explained is shown considering the key parameters described above:

TECHNOLOGY	COST	LATENCY	PRECISION	RANGE	LINE OF SIGHT
3Dcoilcube	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓
IMU*	✓ ✗	✗	✓	✓	✓
Visual / Optical	✗	✓ ✗	✓	✓	✗ ✗ ✗

* IMU Inertial Measurement Unit (Sensor array with Gyroscope, Accelerometer & Magnetometer)

EM Motion tracking applications

The most popular application fields for motion tracking systems are certainly virtual reality and augmented reality systems, which are becoming increasingly relevant.

Virtual reality and augmented reality applications are already using EM motion tracking systems incorporating a sensor in the glasses to detect the head movement and show those variations on the screen. These technologies can be applied to a wide range of applications.

Low latency, accuracy and independence of the line of vision provided by EM tracking technology give the user the chance to fully enjoy the virtual reality which with other technology would be more difficult. For this reason, video games companies are incorporating this system in their products, where performance requirements are very relevant.

Besides videogames industry, there are a lot of sectors benefiting from VR/AR systems, as medical, military and so on. Medical sector is implementing these systems to allow the surgeons practice with very real simulations, so the professional is better trained.

There are many more examples of VR/AR systems, but the way they work is very similar. Moreover, we have seen that their performance depend closely on the sensor, which define the accuracy and processing required.

Conclusions

Several motion tracking techniques that are widely applied in current systems from games, security and transport, among others, have been described. The kind of use is closely related to the sensor used because of the different advantages and drawbacks have been described and showed the primacy of motion tracking systems based on electromagnetism regarding the key features required for these systems.

The advantages offered by EM MT systems are being used for AV/RV technologies, which became a key application field for MT systems, so EM MT are gaining relevance since they have and outstanding performance compared with other solutions and are cheaper.

In conclusion, EM MT is becoming a disruptive technology in the MT. Therefore, it will be a key part for technologies using motion tracking, allowing better results and expanding the limits of these systems.

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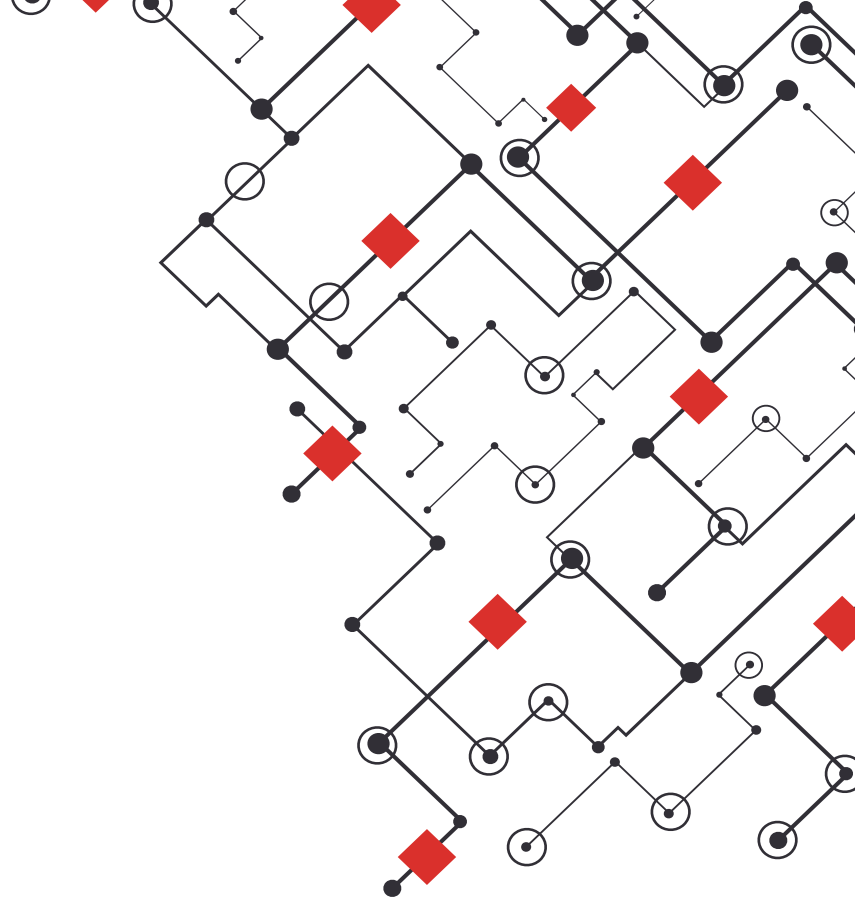
Virtual reality: https://en.wikipedia.org/wiki/Virtual_reality




15

THE MOST EXTREME EXAMPLES OF VIRTUAL REALITY: IMMERSIVE EXPERIENCE

By Lucía Vera Mahiques

15

The most extreme examples of Virtual Reality: **Immersive Experience**

Around Virtual Reality (VR) Technology exists a complex world of imagination, creativity, design, realism and impossibility. VR worlds allow users to live experiences of all kind, including those completely impossible. For example, if we think about flying, we associate this activity with certain elements or vehicles that allow us to fly. But with a VR headset, a computer and an application, it's possible to live an experience like flying, which can even become more realistic if we can try it in a facility with certain hardware that allows the user to feel the complete sensation of fly (air, movements, feet out of the floor, etc.).

For that reason, VR is used as an important tool to treat disorders, phobias and live extreme experiences that may be dangerous in real life. How about living an out-of-body experience only wearing a VR headset and headphones? This is one of the experiments developed by Frank Kolkman to treat "Existential Death Anxiety" disorder using his experiment called Outrespectre, whose main objective is to make users experience the sensation of been out of their body, viewing themselves in from of them and hearing as if they were not where their body is.

If experiencing this out-of-body sensation could be incredible, check the following VR developments and try to imagine how you will feel in each one.

The completion of a full human experience happens when we can see, and feel in a VR or AR context that parts of our own body and whatever we carry on our body, hands, feet or clothes, have an exact avatar and digital clone that we see and feel with their precise movements, positions, rotations. Making the experience fully immersive is keeping scientists and researchers all over the world busy by means of high-precision technology devices that must be tiny and cheap for their massive adoption. Premo Electromagnetic Tracking Sensors are intended for a secure, precise and wireless low-cost contribution to full immersive VR and AR technologies. Researches and progresses have been recently made in the field of ultra-low weight, high precision EM Trackers that face successfully the challenges of:

- Miniaturization
- Low-weight with new advanced alloys and topologies
- Low jittering and high noise immunity
- High-precision location
- High-speed precision
- Low-cost
- Massive availability

An increasing ecosystem of companies developing the VR and AR full technology value layers are addressing and solving the challenges with the soon coming announcement of the first world ever fully integrated monolithic semiconductor for standalone solutions in wireless Immersive VR.

This post describes some of the most eye-catching and impressive uses of the VR extreme experiences. Enjoy, comment or make contributions to the VR Ecosystem by making the knowledge of the technology broader and deeper.


Birdly
Birdly

Birdly – a realistic flying experience

This extreme experience of free flying was born in 2013 at the Zurich University of the Arts (ZHdK) in Switzerland as a Design Research project. After the work of several researchers, media artists and students, the first prototype was available in 2014, winning the Laval Virtual Award at Siggraph 2014 in Vancouver and nominated to be "the best and most exciting VR application existing today." Currently is SOMNIACS, in collaboration with ZHdK, responsible for the distribution and marketing of Birdly and other full-body VR experiences.

This technology is based on VR headset and headphones that the user wears and a platform based on a hydraulic mechanism controlled by the user, simulating "bird" wings. The movement inside the virtual environment is fully controlled by the user, who must change his/her posture and move his/her arms to move and fly inside the virtual world.

More videos at: https://vimeo.com/158664105 and https://www.youtube.com/watch?v=gWLHIusLWOc

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Kraken Unleashed extreme roller coaster

This is one of the attractions of the SeaWorld Theme Park in Orlando, called Kraken Unleashed, a real roller coaster combined with VR headset and earphones, offering some extreme experiences to the visitors. Along the movement of the roller coaster the visitor "race through underwater canyons and the deep, dark hunting grounds of the legendary sea monster."

The ride starts in a futuristic underwater laboratory and in the first steps seems a peaceful and nice dive inside a pod of dolphins (as you can see in the picture). Then the visitors enter a deep underwater canyon before the ride turns in a terrifying experience.

Are you enough brave to feel the physical sensation of one of the biggest roller coasters, combined with a virtual reality experience inside a dangerous and terrifying underwater experience?

A YouTube video can be seen at: https://www.youtube.com/watch?v=SIUsmYjpZ8Q

Virtual Sword Fight – Sword Master VR

This is an extreme game used as a kind of fitness training due to its high physical requirements. This game, called Sword Master VR, supports Oculus Touch and HTC Vive and offers an intense sword fighting gameplay never seen before in another video game.

The user must learn the use of the sword and fight in several combats in the 360 degrees of the virtual space, involving quick movements from all angles, quick reactions and defense from attacks coming from everywhere.

If you would like to feel this extreme experience of survival in a virtual world full of dangers, this will be your game.

A YouTube video can be seen at: https://www.youtube.com/watch?v=grUc75ELfvE

Virtual Mountain Biking

If you like mountain biking and want to live this kind of activity in another way, maybe you must try this amazing experience.

An indoor bike and a headset combined with earphones are enough to do some exercise while you can ride your bike in places where you have never been before. Speed, adrenaline, jumps and more could be present in this immersive experience.

VirZoom is one of the companies offering this kind of experience. You can buy a specific device to turn your indoor bike (among compatible models), an exciting experience, along with a VR headset and some games available. Also, they offer a specific model of indoor bike marketed by them, if you prefer to acquire the complete kit. The application supports several VR headsets, including HTC Vive and Oculus Rift.

ACTIVETAINMENT is another company that offers this kind of experiences. It consists of a specific indoor bike which offers real motion inside the games and user full control of the bike movement inside the environment. It enables a completely immersive experience of extreme mountain biking.

The idea of these applications is making the user feel completely immersed in a virtual world, exploring spaces never seen before, while pedaling with his real bike. The extreme experience will be given by the simulation of risk spaces, obstacles to get by and all kinds of elements that allow users to recall the most real and complex attitudes of a mountain biking expert.

NextVR – Live Events in VR

What about living live events in a more immersive and realistic way? NextVR is the leader distributor of this kind of experiences. With a Samsung Gear VR, it is possible to be immersed in different sports and music events by only connecting in real time to their specific channel. This company has partnered with the biggest leagues and broadcasters to deliver exclusive VR events, including NBA games, International Champions Cup soccer matches, and live concerts. Their technology allows the user to be courtside, behind the goal or center stage using their headset.

One example of this technology is the chance of living NBA games live on-demand. For that, you only need the Samsung Gear VR, a compatible mobile phone and a downloadable app, when you can connect to the live event following a specific schedule.

This new way of living the most relevant games sports using this technology could be amazing.

VR Surfing Experience

Specular Theory is a content studio located in Venice Beach. Due to their work developing immersive contents since 2013, they have been awarded on multiple occasions. Among its innovating creations you can find HTC Vive Interactive Experiences, Driving Simulation, Rift Park (Oculus Rift Experience) and more. One of the most exiting experiences offered by this studio is called Jeep@ brand VR Surfing Experience.

In this case, the user can feel in the first person the real experience of surfing the waves themselves. Using a Samsung Gear VR headset, the viewer gets a first-person point of view form the surfer's perspective, living the experience of catching waves in an iconic surf location in Malibu, CA. This VR development won the Best Live-Action Sports Experience at CES 2016 VR Fest Awards.

If you do not how to surf and you are really interested in feeling this extreme experience, this could be the best way of living it.

Virtual Reality Racing

When we talk about extreme experiences, we cannot miss those related to car driving. We all know the adrenaline and excitement of driving vehicles in real life, especially if we are talking about experiences related to races and speed. However, these activities are dangerous and can be only done by professionals.

For that reason, there are a lot of games and simulators trying to transmit all the feelings around cars, races and speed using virtual simulations. The use of headsets allows an immersive experience that can create a complete feeling of living a race.

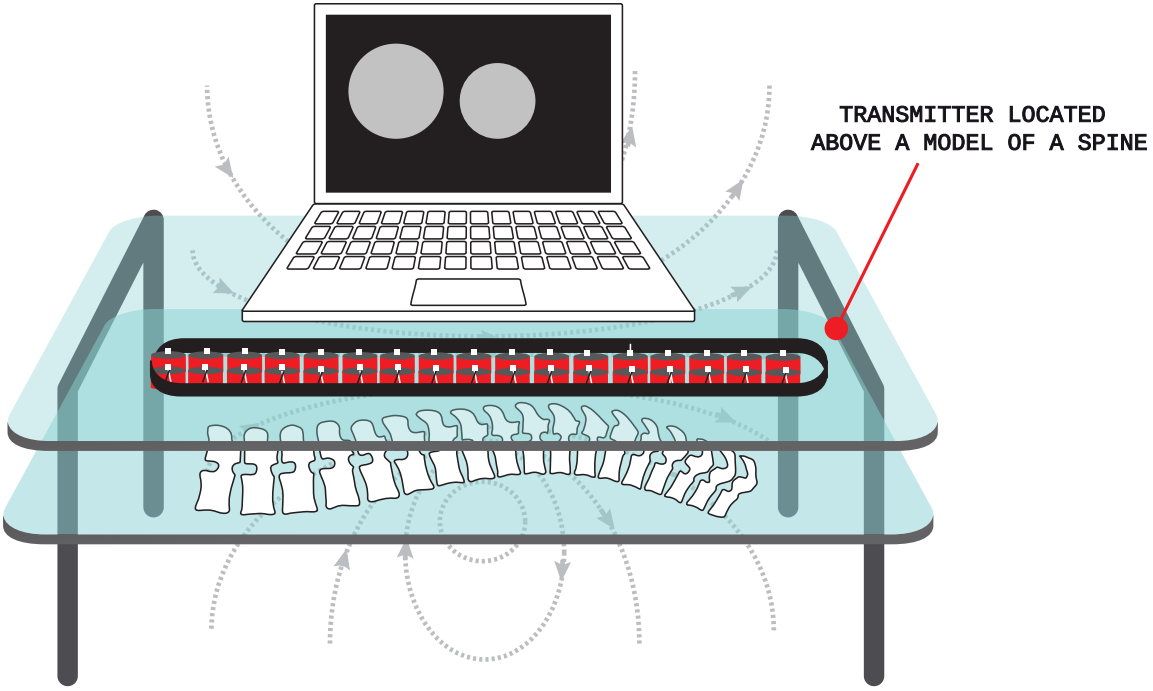
There are several racing applications and games that support VR simulation using HTC Vive and Oculus Rift. RaceRoom Racing Experience, Project CARS, Asseto Corsa, iRacing, Live for Speed. All of them try to immerse the user in a world of speed, races and skilled driving. It is possible to read a description and comparison in the article offered by Road-toVR.

Learn surgery in VR

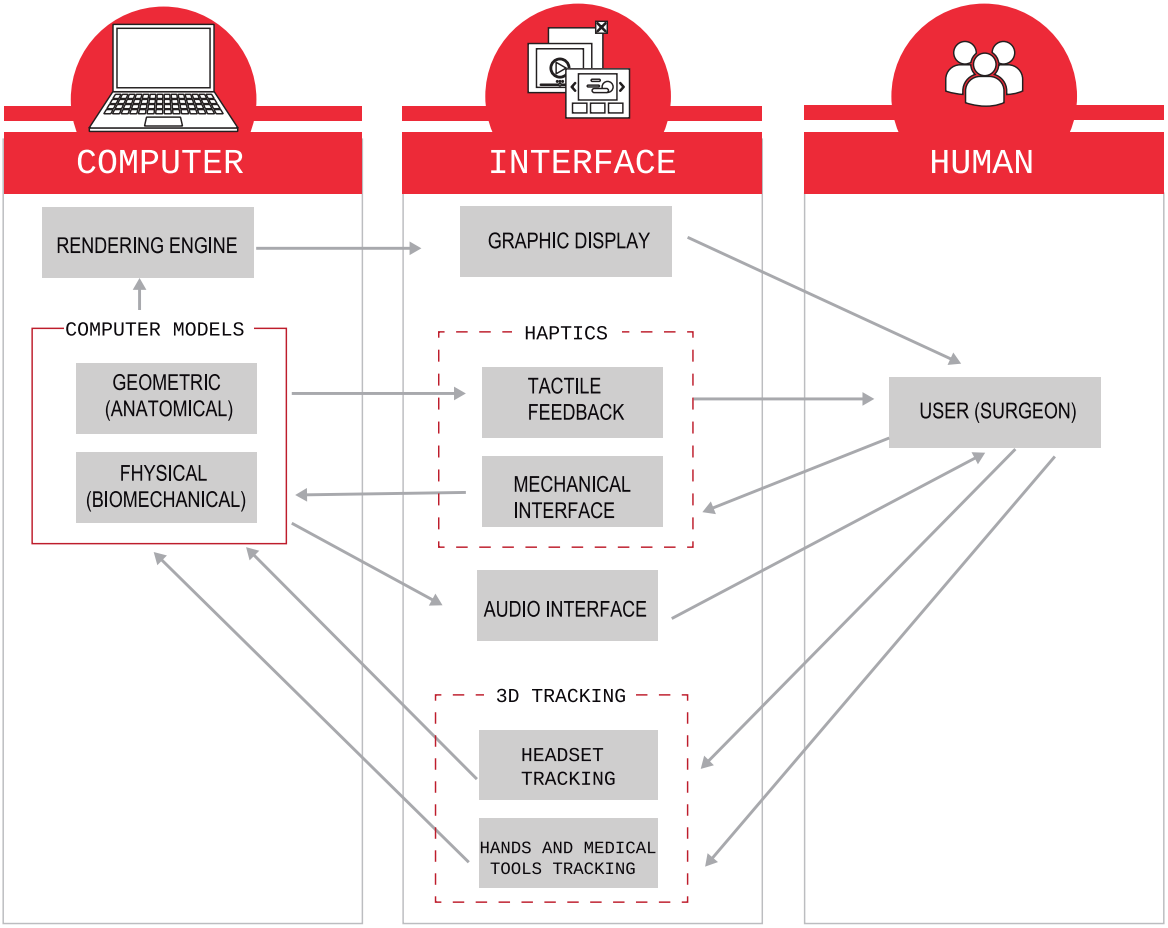
Medicine is another area where VR can offer a good environment to train professionals for dangerous interventions and situations. Medical Realities is a company offering a wide range of materials to train and teach in surgical procedures.

This platform is based on immersive video and is available for Gear VR, DayDream, Android and IOS (with Google CardBoard). In all of them, they provide a 4K 360° Video augmented with information about procedures, knowledge to transmit to the user and more. Also, they provide a complete VR anatomy representation, trying to deep more in the knowledge needed for each surgical procedure.

In this case, the application is not a real VR interactive platform, because they use 360° video technology to get a complete immersive view of each surgical procedure, but realism and the opportunity of learning using Immersive Video techniques are very high.



For the interested reader in this topic you can access the post written by Sergio Cobos, who offers an in-depth and excellent detailed view on AR/ VR Innovations in Surgery and Healthcare..



Architecture of a medical VR system

SkyDiving experience

Not everyone feels comfortable with the idea of wearing a parachute and launching themselves out of an airplane or similar. For that reason, it could be interesting to live the experience of Skydiving in a more comfortable environment – maybe to feel the sensation and then try the real experience, or to overcome phobias o fear of height.

This company, TwinWoods Adventure, offers the opportunity of living the experience of Skydiving in an indoor and controllable environment. They have a fully immersive VR 4D Skydive experience wearing a specific jumpsuit, harness, parachute and a full-face VR helmet, inside a powerful wind tunnel, which can generate wind speeds up to 180 mph. The user experience starts from the realistic jump form a plate and continue with the incredible skydiving above a sunny Californian environment. To complete the experience, users need 4 preparations flights without the complete equipment, inside the wind tunnel, and when they are ready, they can live the full experience wearing the complete set.

This company offers other interesting experiences (not all VR immersive), such as skydiving without VR environment simulation, indoor surfing, racing, shooting, climbing and archery.

Rollover simulators

Going through a rollover car accident is not a pleasant experience. However, if we think of a simulator that allow users to feel what can happened in a car accident, with the main objective of raising awareness of the importance of road safety and proper driving in the real life, could be an extreme experience. The University of Valencia in Spain has carried out a project for the Saudi Aramco company involving edge technologies to improve the behavior of people related to traffic and driving. The project includes several interactive applications in VR and AR, including a fully immersive rollover simulator.

This system involves a real setting with a car and some mechanism to simulate the real rollover in a safe and controlled environment. Also, users wear a headset to live the complete experience of an accident while they feel the extreme experience of spin around. The possibilities of this technology are important and the main objective in this case is not entertainment, but also education and awareness.

Links:https://thenextweb.com/virtual-reality/2017/09/22/body-vr-experience-changed-views-dying/undefined/virtual-reality/2017/09/22/body-vr-experience-changed-views-dying/#.tnw_FZjvIgB2

Conclusions

The real Maverick of our time, the great wave all surfers dream about in technology, is the combination of ultra-high computational capacities at very low cost, high power GDUs, a new revolution in sensors and hardware driven by the smartphone economies of scale. Immersive experiences in VR are coming to stay and make our digital dimension of life better. The above examples are just a few examples of what is coming and what is already possible.

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