

2016 中国显示产业研讨会 2016 China Display Conference

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中英同声传译 English-Chinese Simultaneous Interpretation

Virtual Reality / Augmented Reality Devices and PC Cooperation

“See” your future by AR / VR

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Part 1 : What's AR / VR

What's AR / VR



Image credit: credencys



Image credit: Samsung

- > With AR, users continue to be in touch with the real world while interacting with virtual objects around them.
- > With VR, the user is isolated from the real world while immersed in a world that is completely fabricated.

Augmented Reality (AR)

Augmented reality combines digital information with actual surroundings.

It enhances our visual and hearing by adding graphics and sound onto actual surroundings in real time.

Example: Google Glass, Pokémon Go Mobile Application

Mixed Reality (MR)

Mixed reality merges the with the real world to create a connected environment. AR objects are more static, whereas MR is able to create spatial experience. For instance when you lean forward, the virtual object would appear closer.

Example: Microsoft HoloLens

Virtual Reality (VR)

Virtual reality is a technology that creates the entire environment and allows the user to interact with the artificial world. Along with sensors, 3D graphics and surround sound, the content is able to make users feel as though the fabricated object or environment is real.

Example: Oculus Rift / HTC Vive

Product Categories of AR / VR

Virtual

Real

Hand-Held VR

(Smartphone Adaptor Headsets)



Cardboard



Image credit: Google

Gear VR



Image credit: Samsung

Hand-Free VR

(Integrated display headsets)



Oculus Rift



Image credit: Oculus

HTC Vive



Image credit: HTC

Sony PS4 VR



Image credit: Sony

Hand-Held AR



Image credit: credencys



Image credit: credencys

Hand-Free AR



Microsoft HoloLens



Image credit: Microsoft

Google Glass



Image credit: androidcommunity

Hand-Held

Hand-Free

Part 2 : VR Product Development Trend Update

Why Virtual Reality's Commercial Impact is Coming

Evolution of Virtual Reality

Past (1962)

**Worldwide 1st Virtual Reality Device
by Morton Heilig**

Image Source:
[http://www.avadirect.com//](http://www.avadirect.com/)

Now (2016)

Sony PlayStation4 VR



Image credit: Sony

Oculus Rift



Image credit: Oculus

HTC Vive

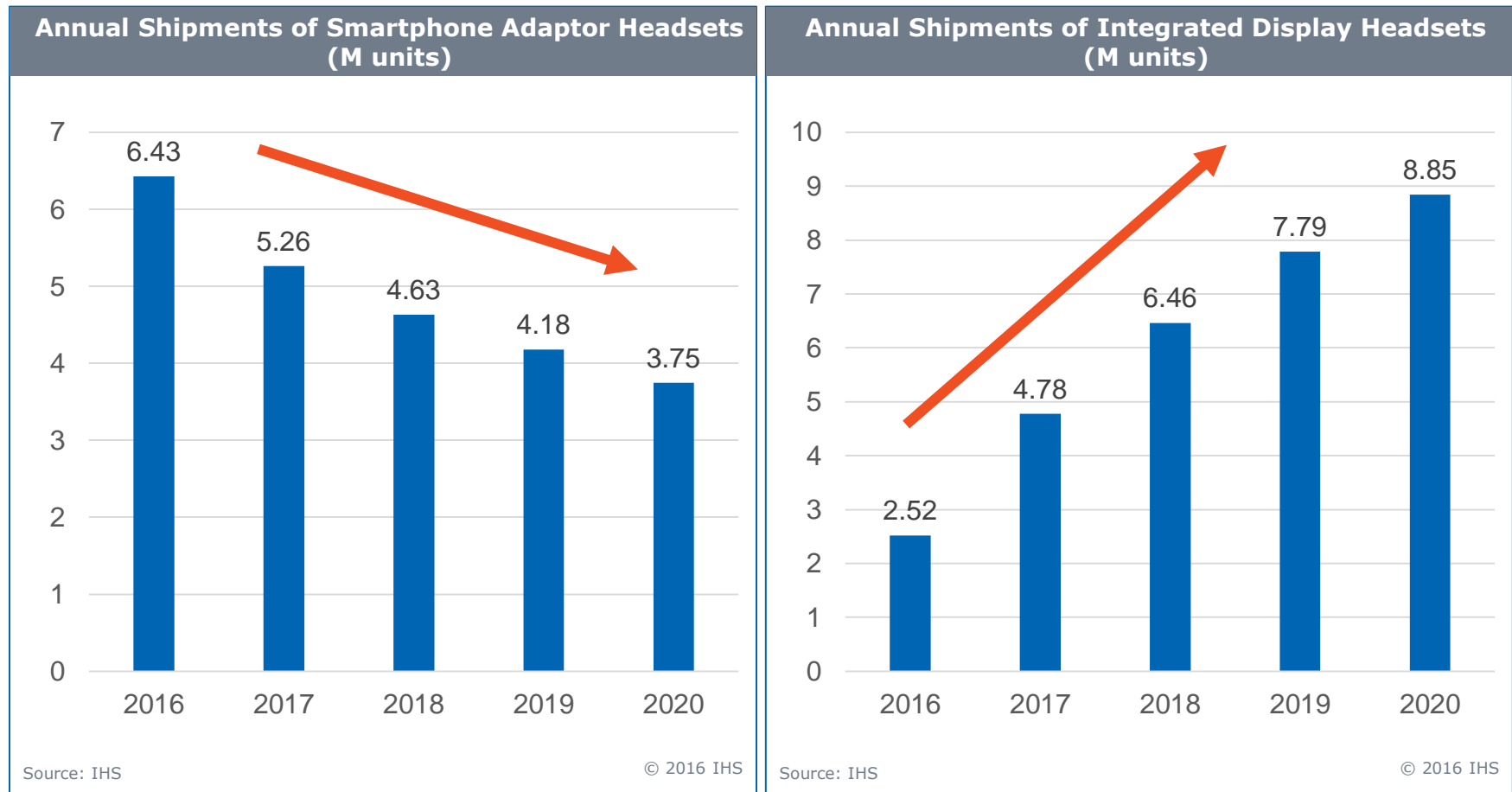


Image credit: HTC

- Following technological advancements allow virtual reality to be commercialized
GPU, OLED display, Motion Sensor, Battery, Game Engine

Worldwide Virtual Reality Device Shipment Forecast

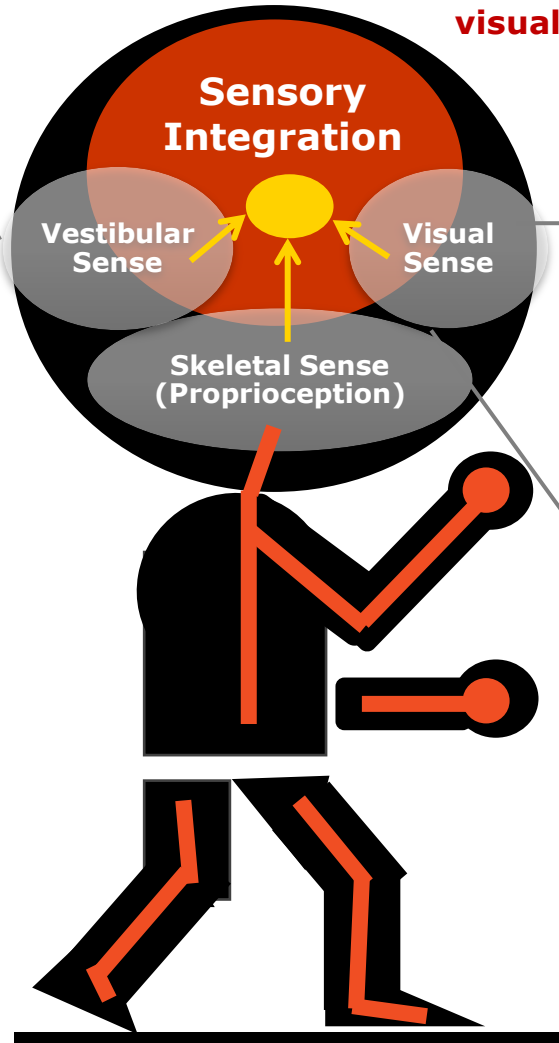
Without head tracking function, VR device is just a personal 3D display device, so we remain conservative on the demand for smartphone adaptor headsets.



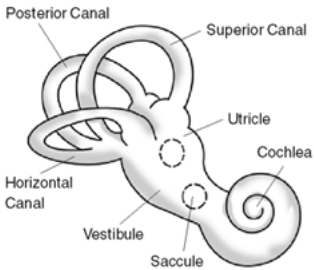
Sensory Integration Introduction

Motion Sickness – Conflicting inputs from visual sense, vestibular sense, and proprioception.

- Children under **16** whose vestibular system have not attain maturity completely.
- Ears are very sensitive on **audio performance** (surround-sound).



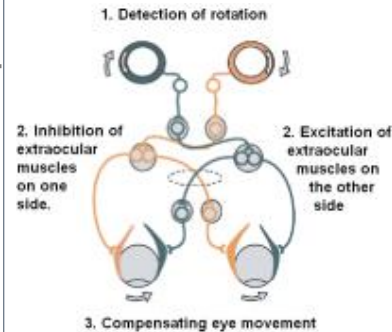
Vestibular System



The vestibular system consists of three semicircular canals and the vestibule, and the three semicircular canals are responsible for detecting rotational movements while the otolithic organs in the vestibule detect linear acceleration (movement in a straight line).

Image and Data Source: <http://www.web-books.com/eLibrary/Medicine/Physiology/Ear/Ear.htm>

Vestibulo-ocular reflex (VOR)

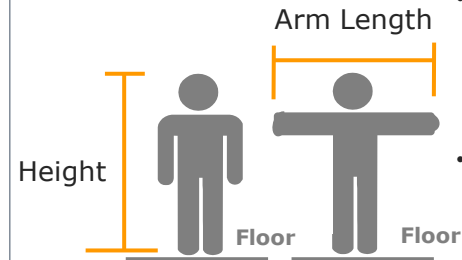


[Vestibulo-ocular reflex]
A rotation of the head is detected, which triggers an inhibitory signal to the extraocular muscles on one side and an excitatory signal to the muscles on the other side. The result is a compensatory movement of the eyes

Image and Data source: Wikipedia

How to have a perfect match between head track and eyes movement is very important for VR device.

Immersion - 3 Dimensional Sense of Space

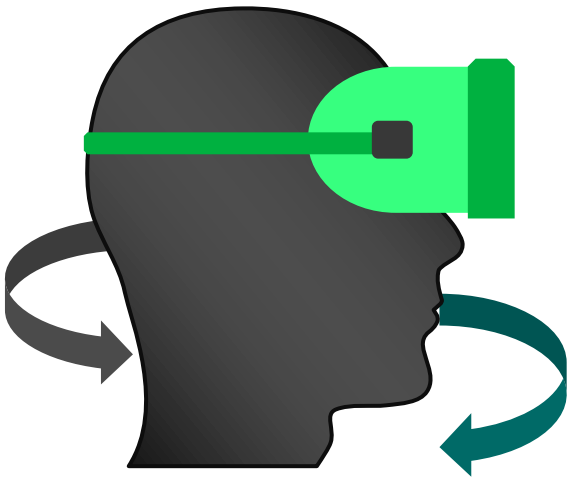


- **Not only ears (vestibular sense), 3 dimensional sense of space is also constructed by proprioception.**
- **Immersion performance of VR device depends on**

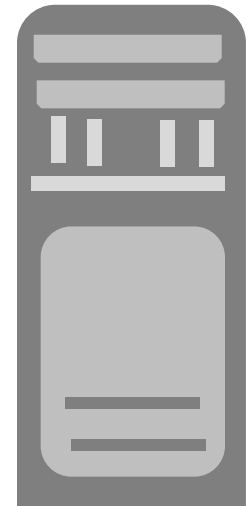
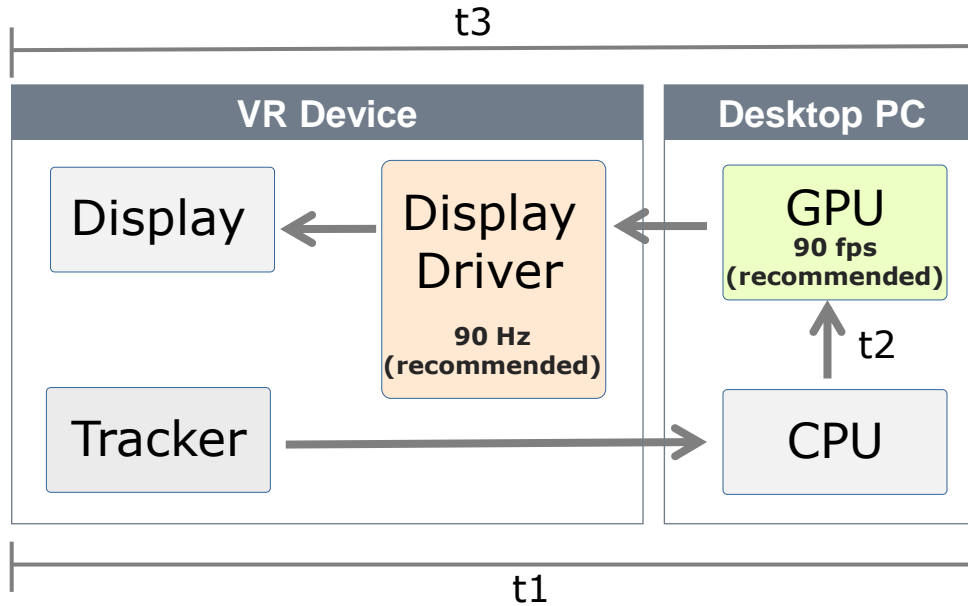
floors

Why VR Device Adopts OLED Display

Latency Time: $t_1 + t_2 + t_3$



VR Device



Desktop PC

Why VR device adopts OLED display

- Reason 1 : No blue light issue
- Reason 2 : Quick response time
- Reason 3 : No display persistence issue
- Reason 4 : Wider color gamut range
- Reason 5 : Slim and light

OLED display's potential issue

- Issue 1: Limit on PPI upgrade
- Issue 2 : Limit on OLED supply capacity
- Issue 3 : Limit on qualified OLED driver vendor

[Note] PPI : Pixels Per Inch ; GPU: Graphics Processing Unit ; CPU : Central Processing Unit ; OLED : Organic Light-Emitting Diode

Viewing Quality Loss – Barrel Distortion

Display (Barrel Distortion)

Warped image required to match optics – enlarged in the center and compressed in the periphery

Optics

Transforms light from display to a wide field of view focused on the eye

User's View

User sees correctly proportioned scene with wide field of view

Image & Data source: <http://www.tomshardware.com/news/nvidia-gameworks-vr,29197.html>

Why VR devices need higher PPI display

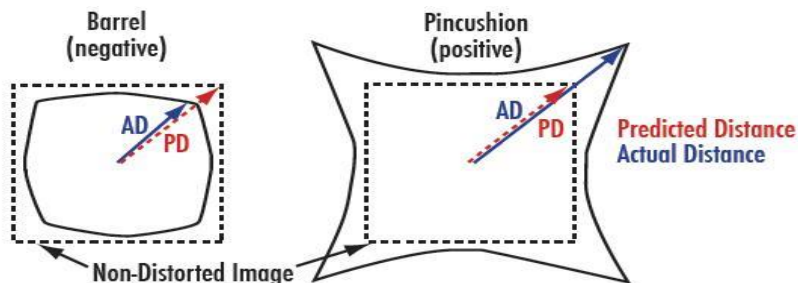


Image Source: <http://www.edmundoptics.eu/>

$$Distortion (\%) = \frac{AD - PD}{PD} \times 100$$

Barrel distortion causes loss of viewing quality, affecting approx. 30%~50% of the overall PPI loss. Therefore, VR display requires at least 600 PPI to account for the loss.

OLED Display's PPI Limit Issue

VR OLED Display List				
Panel Spec	VR OLED Display			
Size	3.58 inch	3.61 inch	3.64 inch	3.72 inch
Resolution	1920 (RG/BG) x 2160	1080 (RG/BG) x 1200	1440 (RG/BG) x 1280	1440 (RG/BG) x 1600
PPI	806 ppi	447 ppi	530 ppi	575 ppi
Frame Rate	90 Hz	90 Hz	90 Hz	90 Hz
Response Time	< 1ms	< 1 ms	< 2 ms	< 1 ms
MP schedule	TBD	MP Ready	TBD	TBD

Source: IHS

© 2016 IHS

Display Requirements
<ul style="list-style-type: none"> • Frame Rate: 90 Hz above • Resolution : 1080P (Per Eye) • Low Persistence : < 3ms • FOV : 80 degree above

Solution of OLED Display's PPI Limit Issue : Eye Tracking Technology

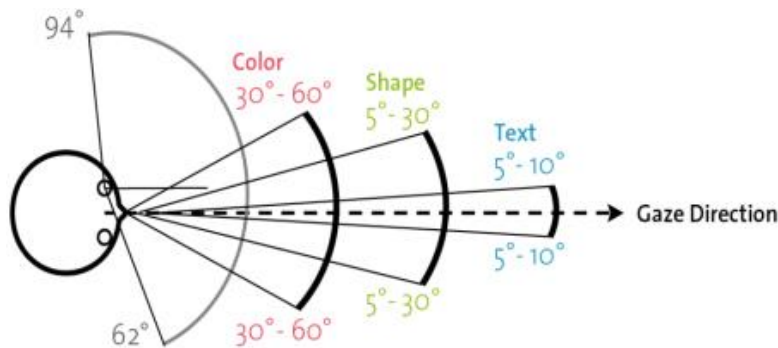


Image Source: <http://www.wikiwand.com/>

- **The human eye's vision field for eye-focus is 5 to 10 degree.**
- **With eye tracking technology and image upscaling technology, VR headset designers can overcome OLED display's PPI limitation issue. Also, they don't need to use expensive high PPI OLED display.**

PC Development Trend : Backpack PC vs. Desktop PC

MSI Backpack VR PC Specification



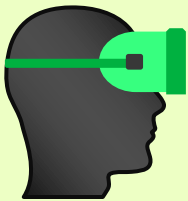
Image credit: MSI

- **CPU : Intel Skylake Core i7 Processor**
- **GPU : Nvidia GTX 980**
- **Weight : around 5kg**
- **Battery Life time : around 2 hours**

Not only heavy (5 kg) and short battery life time (2 hours) issues, Backpack PC also have thermal issue which is caused by GPU.

However, NVidia doesn't have any improvement proposal for VR backpack because NVidia thinks backpack VR PC is an infeasible product concept, so NVidia prefers to invest more GPU development resources on automotive application.

Without NVidia's support , VR GPU will not applied for portable device in short term.



Desktop PC

Nvidia Geforce GTX VR-Ready - Desktop Requirements

- **GPU:** NVIDIA GeForce GTX 970 or greater
- **CPU:** Intel Core i5- 4590 equivalent or greater
- **Memory / RAM :** 8GB+ RAM
- **Video Output :** 1x HDMI 1.3
- **Ports:** 3x USB 3.0
- **OS:** Windows 7 SP1 (64bit) or higher
- **Driver:** GeForce 359 or newer



Notebook

Nvidia Geforce GTX VR-Ready - Notebook Requirements

- **GPU :** NVIDIA GeForce GTX 980*
- **CPU :** Intel Core i7- 6700HQ or greater
- **Memory / RAM :** 8GB+ RAM
- **Video Output :** 1x HDMI 1.3
- **Ports :** 3x USB 3.0
- **OS:** Windows 7 SP1 (64bit) or higher
- **Driver :** GeForce 359 or newer

Google VR Strategy Analysis : Cardboard vs. Daydream

Forward View

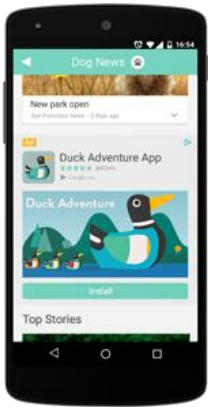


Image credit:: Google

x 5
Advertising Amount



Forward / Up / Down / Left / Right View



Image credit:: Google

Cardboard vs. Daydream

Platform	Cardboard	Daydream
Type	Entry Level of Smartphone VR Platform	Advanced Level of Smartphone VR Platform
Smartphone Requirement Recommend	For All Smartphones	For High Performance Smartphones (ex: Smartphone : Nexus 6P / Controller : Nexus 5X)
VR Experience Time	Short VR Viewing Experience	Longer VR Viewing Experience by Abundant VR contents
Headset Accessory Requirement	Low Cost (ex: Cardboard)	Higher Quality of Headset Accessory

Google Strategy:
Increase advertising amount by VR application

Google Action:
Offer more free or attractive VR contents by 360 degree camera

Potential Issue:
Motion sickness issue

Part 3 : AR Product Development Trend Update

Head-Mounted AR Device Overview

Microsoft HoloLens



Image credit: Microsoft

Price of Development Edition : \$3,000

Microsoft HoloLens embraces virtual reality and augmented reality to create a new reality: mixed reality

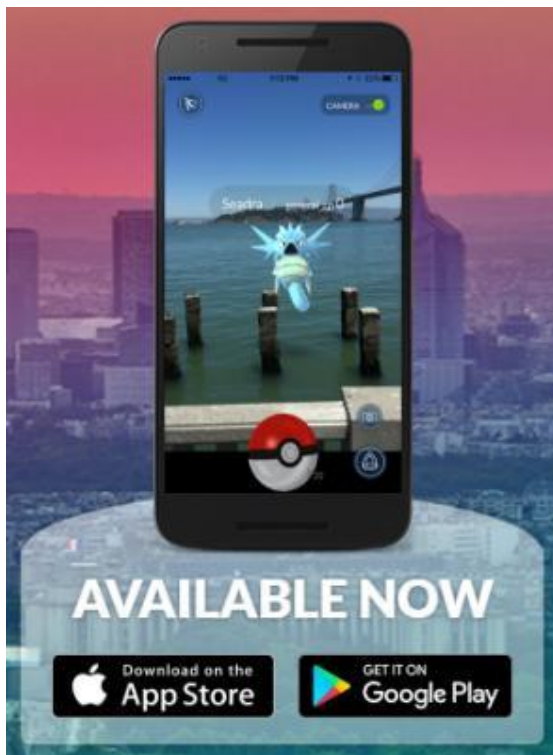
Hardware List of Microsoft HoloLens	
OS and Apps	Windows 10 Windows Store
Processors	Intel 32 bit architecture Custom-built Microsoft Holographic Processing Unit (HPU 1.0)
Memory	64GB Flash 2GB RAM (2GB CPU and 1GB HPU)
Optics	See-through holographic lenses (waveguides) 2 HD 16:9 light engines Automatic pupillary distance calibration Holographic Resolution: 2.3M total light points Holographic Density: > 2.5K radians (light points per radian)
Sensors	1 IMU 4 environment understanding cameras 1 depth camera 1 2MP photo / HD video camera Mixed reality capture 4 microphones 1 ambient light sensor
Human understanding	Spatial sound Gaze tracking Gesture input Voice support
Input / Output / Connectivity	Built-in speakers Audio 3.5 mm jack Volume up/down Brightness up/down Power button Battery status LEDs Wi-Fi 802.11ac Micro-USB 2.0 cable
Power	Battery life (2-3 hours of active use / Up to 2 weeks of standby time) Full functional when charging Passively cooled (no fans)
Weight	579 g
Memory	64GB Flash 2GB RAM (2GB CPU and 1GB HPU)

Data Source : Microsoft

Augment Reality (AR) : AR Apps on Portable Devices

Pokémon GO : AR App + Camera + GPS + Map + Mobile Payment

Potential issue on outdoor AR Apps : Pokémon GO could not capture outdoor objects by camera easily because of Infrared (IR) interference.



Pokémon GO is a free-to-play location-based augment reality mobile game released in July 2016 by Niantic. It allows players to capture, battle, and train virtual creatures between real world and the virtual world of Pokémon for iPhone and Android devices.

Introduction of Pokémon GO



Developer : Niantic

Game Engine : Unity

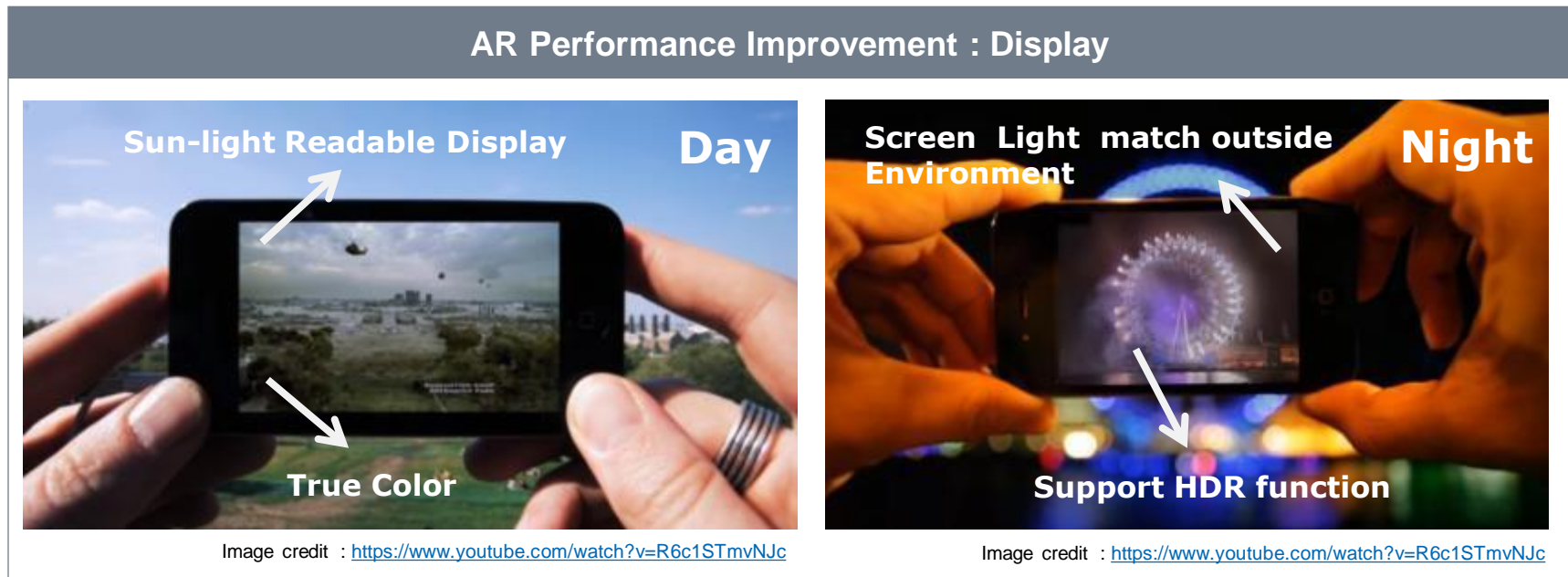
Platforms : iOS, Android

Release date : July 6th, 2016

Play Mode : Single-Play, Multiplayer

Image credit : <http://www.pokemon.com/>

AR : Display Performance Improvement



When users start to play AR Apps out of door, display quality will become first issue. Therefore, we foresee there're four potential issues on display design.

Issue 1 : Could display be sun-light readable ?

Issue 2 : Could display have true color performance?

Issue 3 : Could display support HDR function if using AR Apps late evening?

Issue 4 : Could display light switch to outside light quickly when turning on camera ?

AR : Camera Performance Improvement

AR Performance Improvement : Camera



Image credit : <https://www.youtube.com/watch?v=R6c1STmvNJc>



Image credit : <https://www.youtube.com/watch?v=R6c1STmvNJc>

If users want to have great experience of playing AR Apps, camera design will be 2nd issue when seeing virtual objects in real world. Therefore, we foresee two potential issues on camera design.

Issue 1 : How to have better view quality of depth and shallow of field at same time?

Issue 2 : How to assist AR software developers to detect the distance between camera and specified location of virtual object?

AR : Feedback Engine Performance Improvement

AR Performance Improvement : Feedback Engine

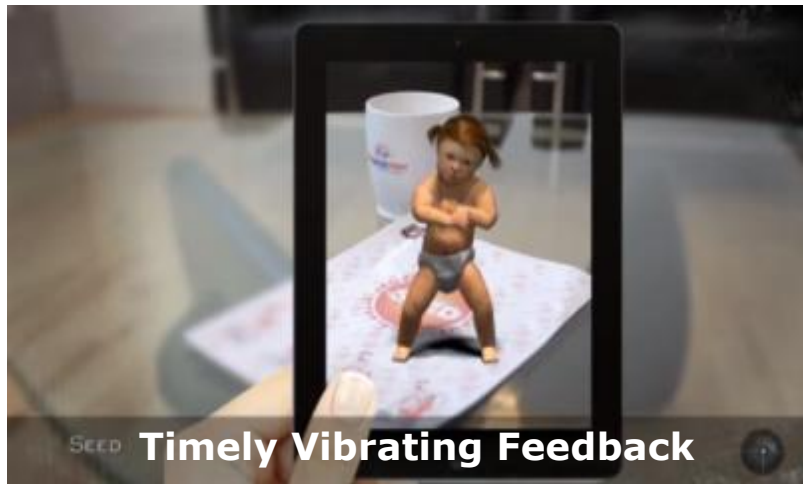


Image credit : <https://www.youtube.com/watch?v=R6c1STmvNJc>



Image credit : <https://www.youtube.com/watch?v=R6c1STmvNJc>

When viewing quality of playing AR Apps improved (display & camera), feedback engine design will be the next issue. Therefore, we foresee three potential issues on feedback engine design.

Issue 1 : Will it be easy to pop out the info you want while peeking at the one you see?

Issue 2 : Will it have timely vibrating feedback design when playing AR Apps?

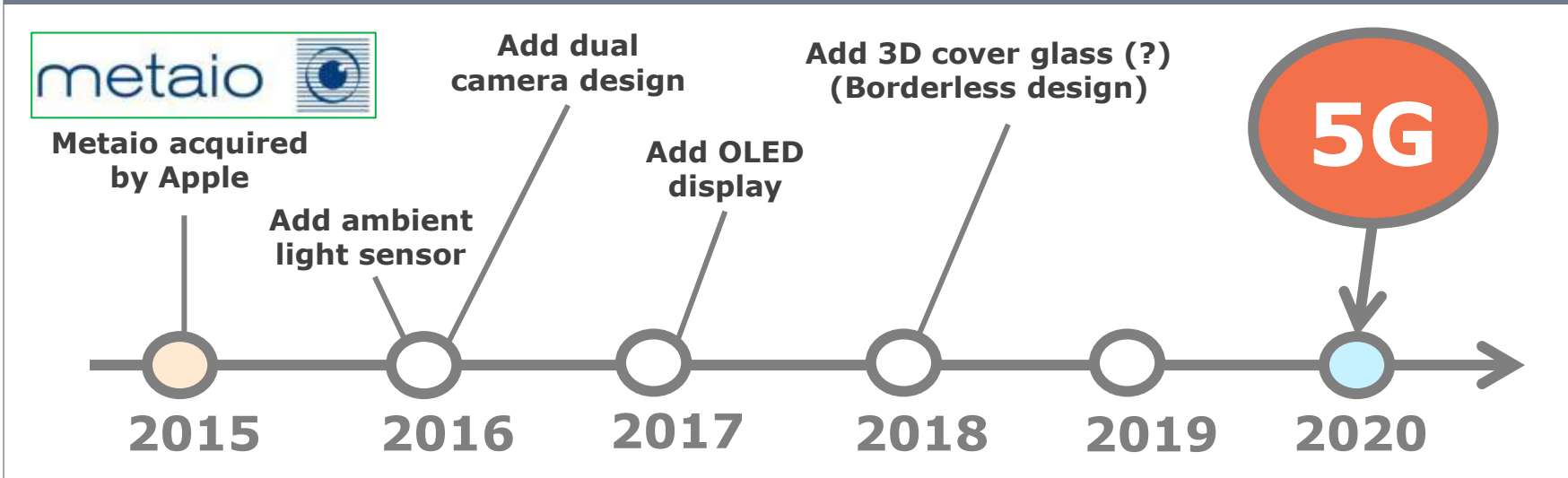
AR : New Business Model (AR Apps + Mobile Payment)



Mobile Payment



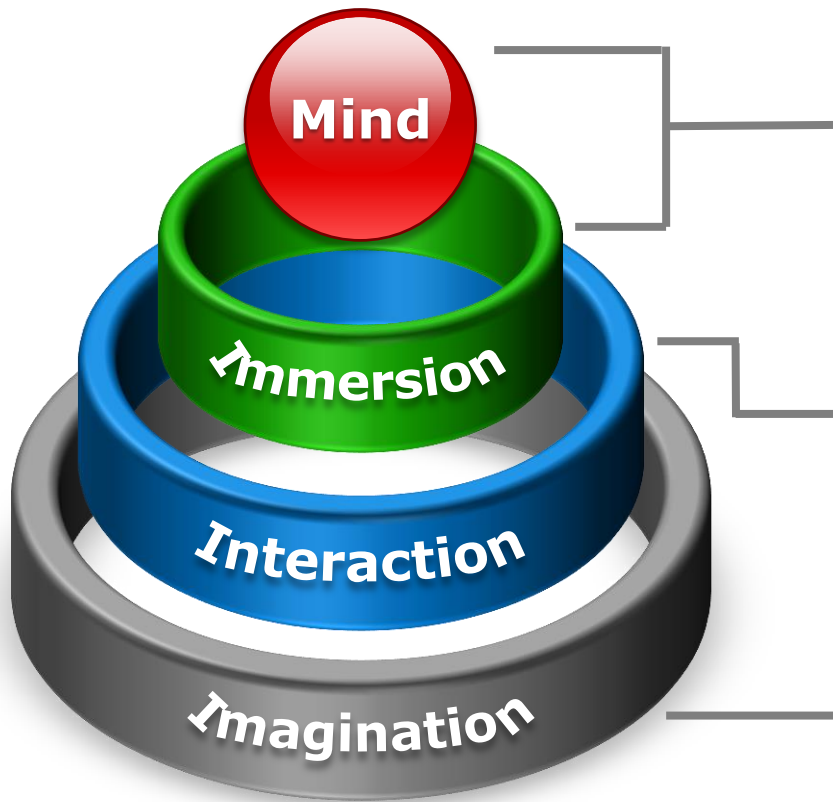
Apple Strategy Analysis : Hardware + AR Apps + Mobile Payment



[Note] AR : Augment Reality; Apps :Application Software; 5G: 5th generation mobile networks

Part 4 : AR/VR's Potential Market

AR / VR's Potential Market



VR / AR's Potential Market			
Level	Technology	Device	Potential Market
Mind Immersion	VR technology	Integrated Display Headsets	Medical / Education
	AR technology	Optical fiber by Light Field Image technology	Education / Office workplace / Television
Interaction	VR technology	Integrated Display Headsets	Education / Sports and entertainment / Television
	AR technology	Wearable Device (ex: Microsoft Holo Lens)	Gaming / Education / Navigation / Translation / Office workplace
Imagination	VR technology	Smartphone Adaptor Headsets	Television
	AR technology	Smartphone / Tablet	Gaming / Education / Advertisement / Navigation / Translation

Using VR from User Role : Medical (Mind Rehabilitation)

**Core Value of VR Application : Help end-user to see what they want to see.
For example : Physical therapy and rehabilitation combined with VR (mind rehabilitation)**

Physical Therapy and Rehabilitation

Replace monitor by VR device while doing rehabilitation



Image credit : www.trabzonmedicaltourism.com/

VR : Mind Rehabilitation



Image credit: Nike

See your future



Image credit: Oculus

Using VR from Outsider Role : Experienced Learning

Distance Learning : Joining and learning skills by VR devices, even though you're not there

Participatory Entertainment: Joining TV show by VR devices, even though you're at home

Distance Learning

Haircut Learning out of School /Hair Salon



Image credit : www.michaelanthonysalondc.com

Surgery Learning out of Emergency Room



Image credit : www.surgicalcenter.uci.edu

Seeing it
like you're
be there



Image credit: Oculus

Participatory Entertainment

Experienced Cooking While Watching TV



Image credit : www.foodgal.com

Experienced Traveling While Watching TV



Image credit : www.tourism.australia.com

VR Application on Education Market (Language Lab)

Return on the investment of VR hardware and software will be potential issues. VR application on education market (ex: Language Lab) will be a feasible solution.

Traditional Language Lab (w/o immersion)

The best English learning way is to live in the US or the UK, but the cost it too high for students.

Therefore, students only can learn English in language lab (ex: Classroom cubicles)



Image credit : <http://www.calstatela.edu/>

English Learning by VR (with immersion)

Shopping



Image credit: <http://www.coupons.com/>

Hotel Check-in / Check-out



Image credit: <http://www.hotelroomsearch.net/>

Seeing it like you're be there

If VR device with *sound receiver*?



VR with *Speech Recognition*

Image credit: Oculus

Conclusion

- **Motion sickness is caused by conflicting inputs from visual sense, vestibular sense, and proprioception.**
- **Children under 16 whose vestibular system have not attain maturity completely, so AR will be better option for children's education market.**
- **Without head tracking function, VR device is just a personal 3D display device, so we remain conservative on the demand for smartphone adaptor headsets.**
- **Controllers will replace keyboard and mouse while using VR devices, and track design will influence VR software development.**
- **Future VR hardware development will focus on display driver, audio receiver (ex: de-noise function), audio quality improvement component, and motion sensor (ex: gloves with haptic feedback function)**
- **Future AR hardware development will focus on display, camera, and haptic device.**
- **Education and medical market will be potential market for VR device because VR device can help end-users to see what they want to see.**

A microscopic view of numerous oil droplets of various sizes, appearing as bright yellow and orange spheres with dark outlines, set against a lighter, hazy background. The droplets are densely packed in some areas and more sparse in others, creating a complex, textured pattern.

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