

VR, AI AND DATA ANALYSIS IN ACADEMIC RESEARCH AND APPLICATION

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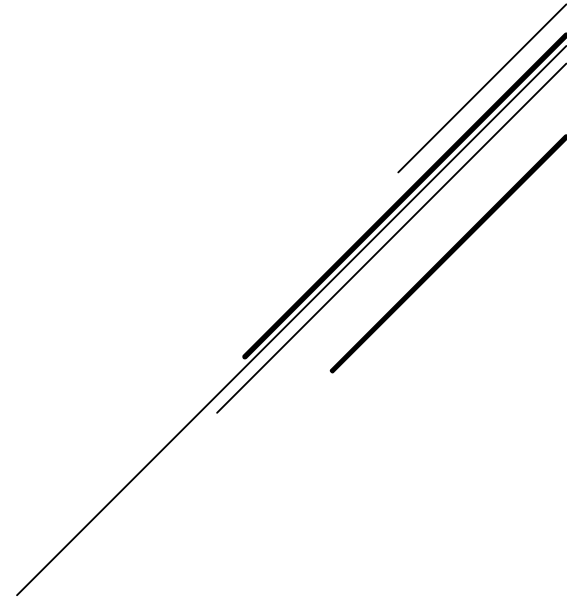
The Department of Computing

The Hong Kong Polytechnic University

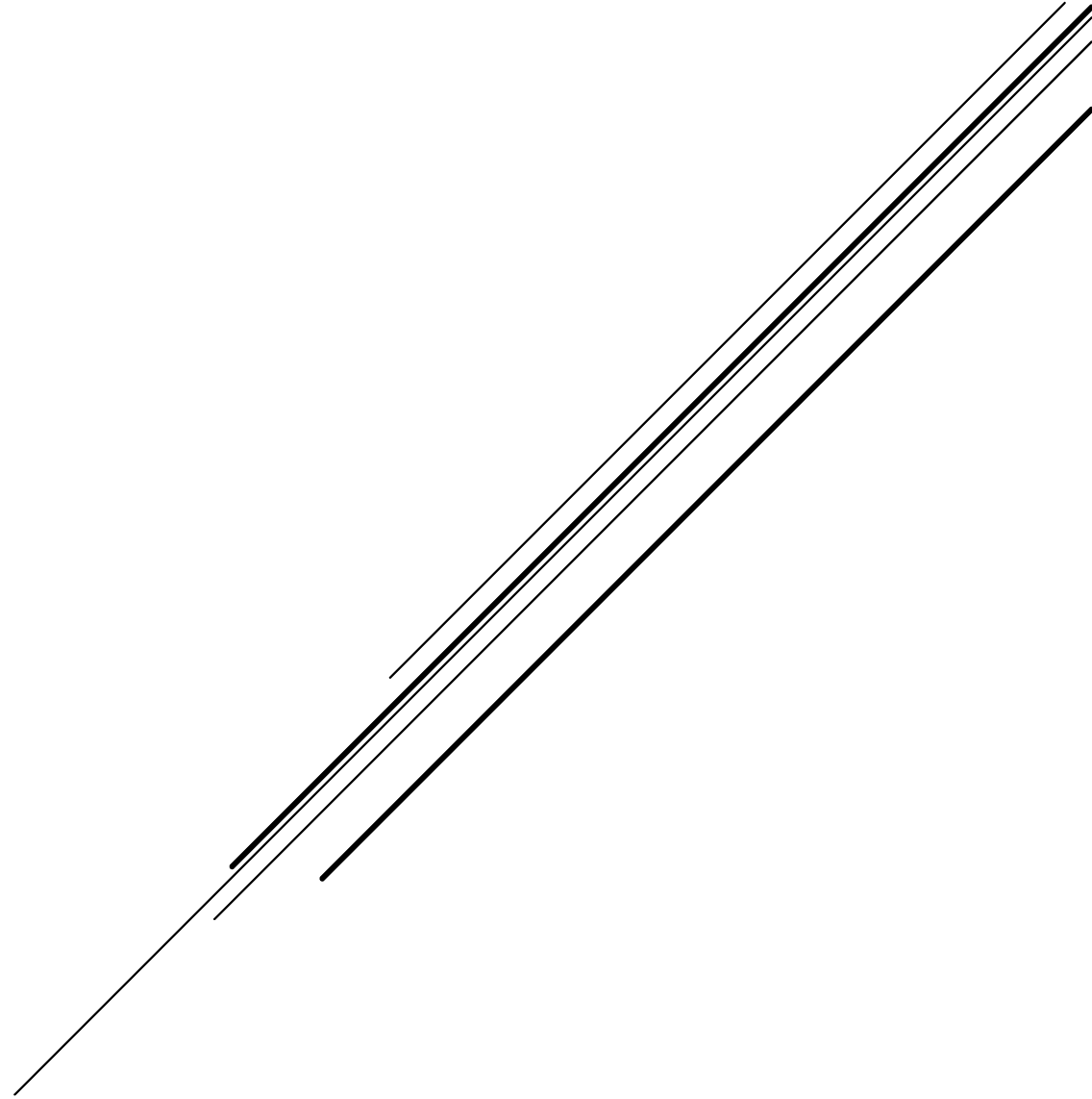
A decorative graphic consisting of several parallel diagonal lines of varying thicknesses, extending from the bottom left towards the top right, located on the right side of the slide.

- ▶ Our Project
- ▶ Game Market
- ▶ Virtual Reality
 - ▶ Topic in VR
 - ▶ Hardware in VR
 - ▶ Software in VR
 - ▶ Data Collection in VR
 - ▶ Data analysis by using AI approach
- ▶ Augmented Reality
 - ▶ Hardware in AR
 - ▶ Software in AR
- ▶ Demo

FLOW OF PRESENTATION



GAME MARKET





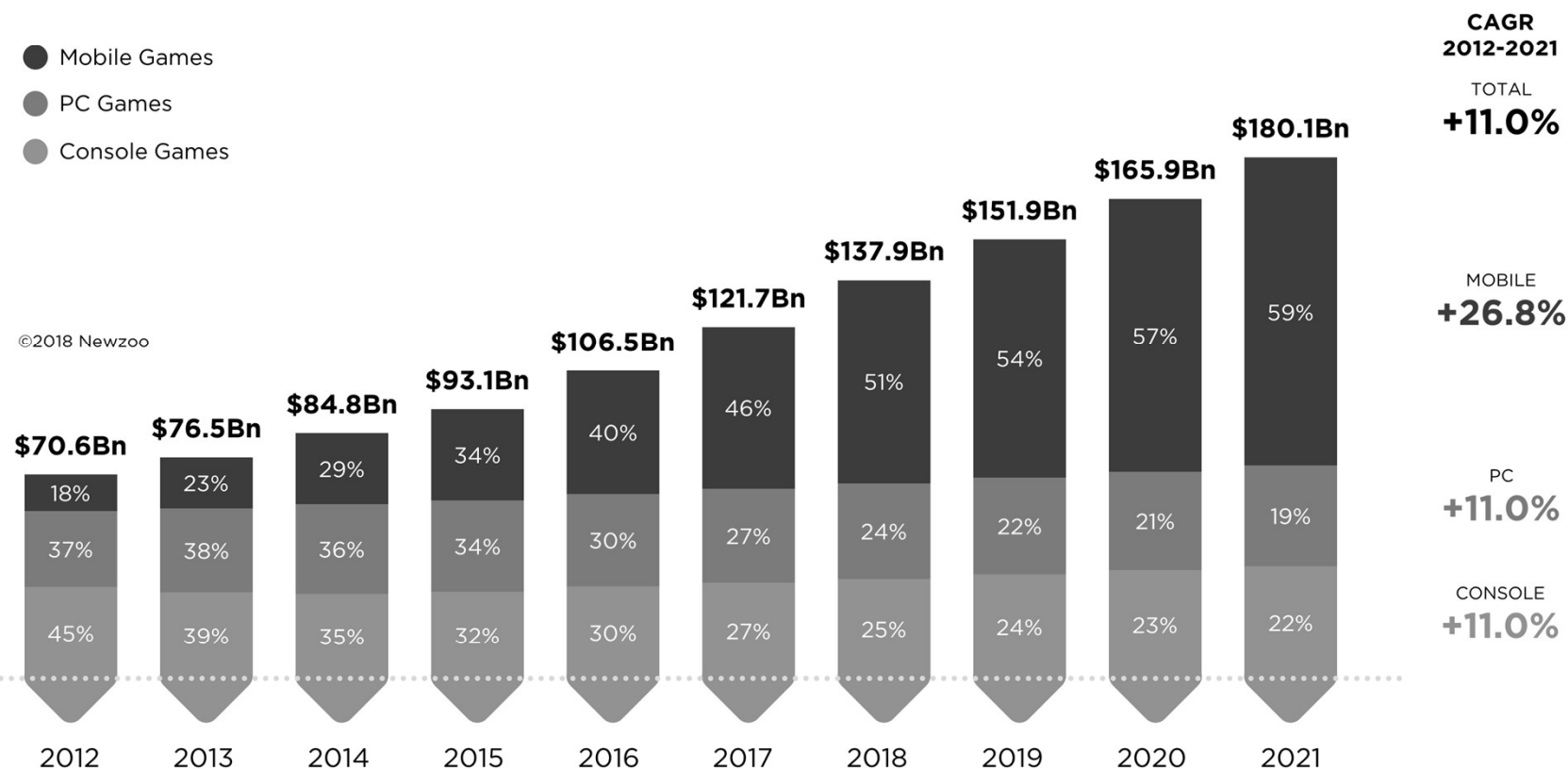
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2012-2021 GLOBAL GAMES MARKET

REVENUES PER SEGMENT 2012-2021 WITH COMPOUND ANNUAL GROWTH RATES

- Mobile Games
- PC Games
- Console Games

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Source: ©Newzoo | April 2018 Quarterly Update | Global Games Market Report
newzoo.com/globalgamesreport

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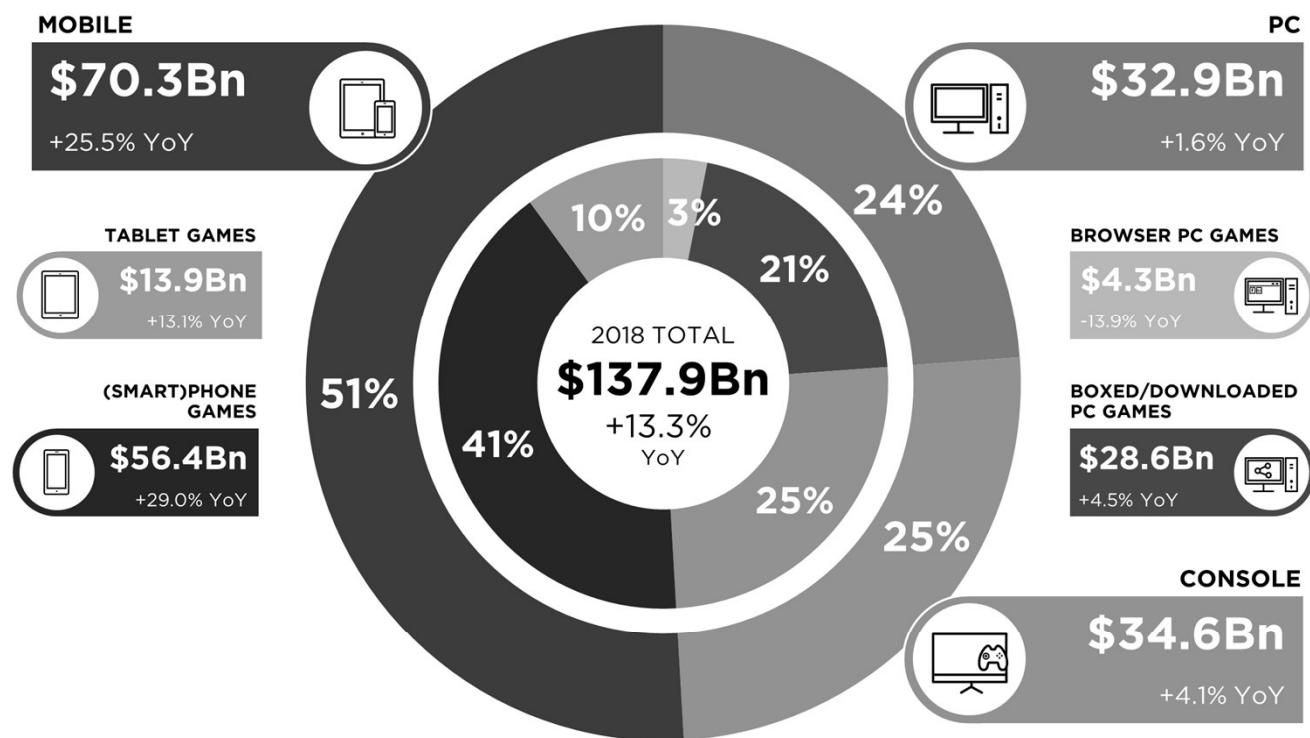


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2018 GLOBAL GAMES MARKET

PER DEVICE & SEGMENT WITH YEAR-ON-YEAR GROWTH RATES

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In 2018, mobile games
will generate

\$70.3Bn

or **51%** of the global
market.

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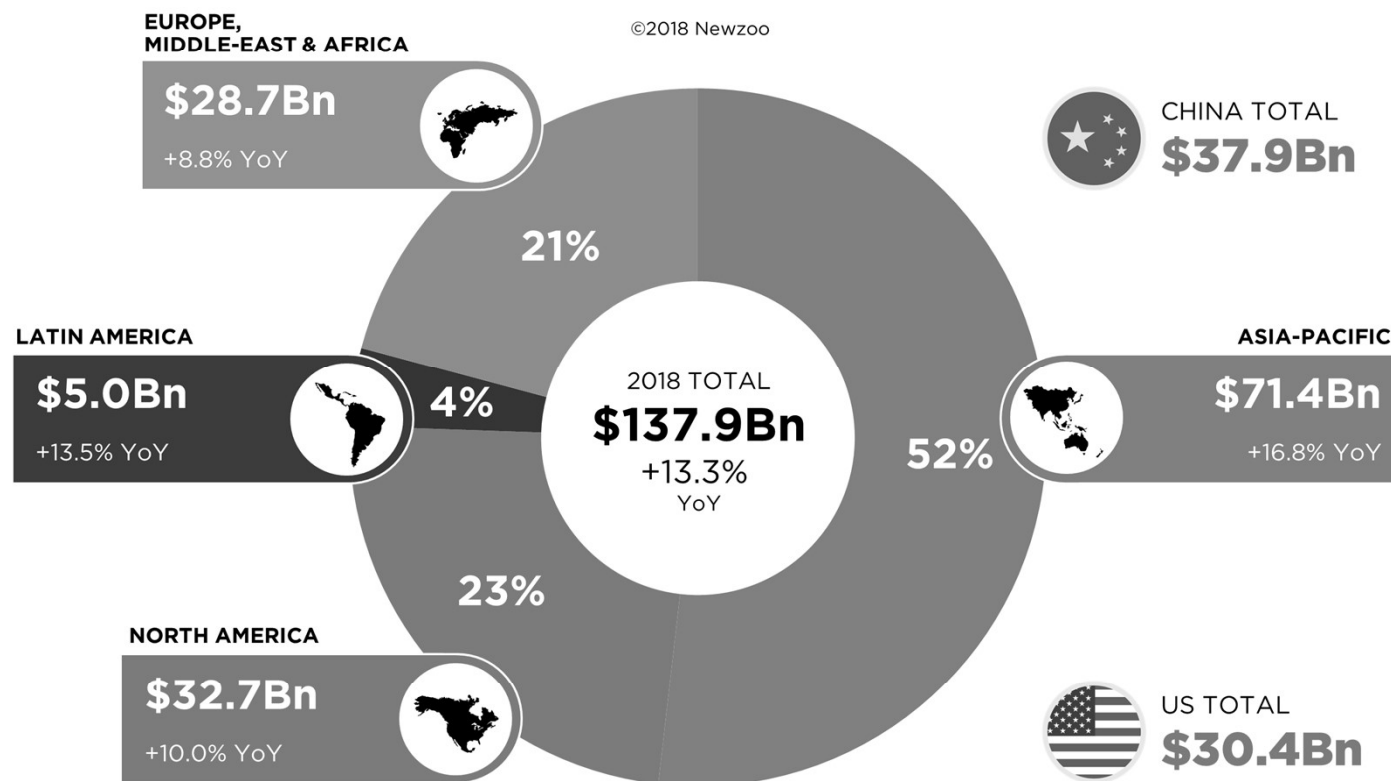


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2018 GLOBAL GAMES MARKET

PER REGION WITH YEAR-ON-YEAR GROWTH RATES

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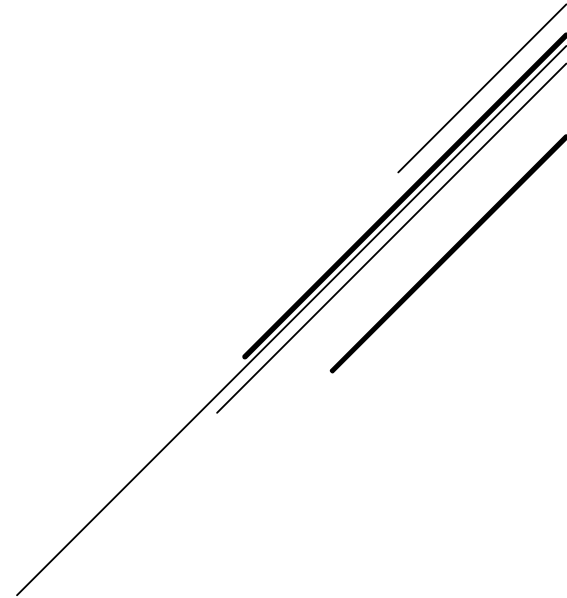
In 2018, almost

28%

of all consumer spend
on games will come
from China

newzoo

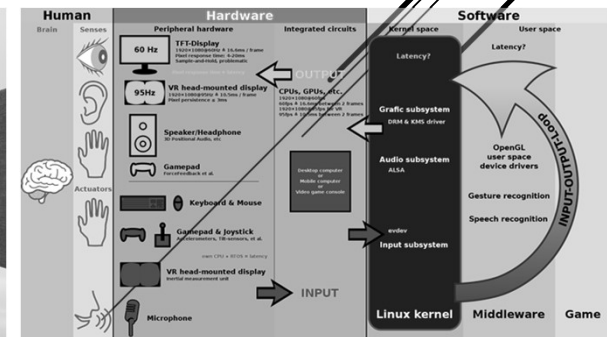
VIRTUAL REALITY



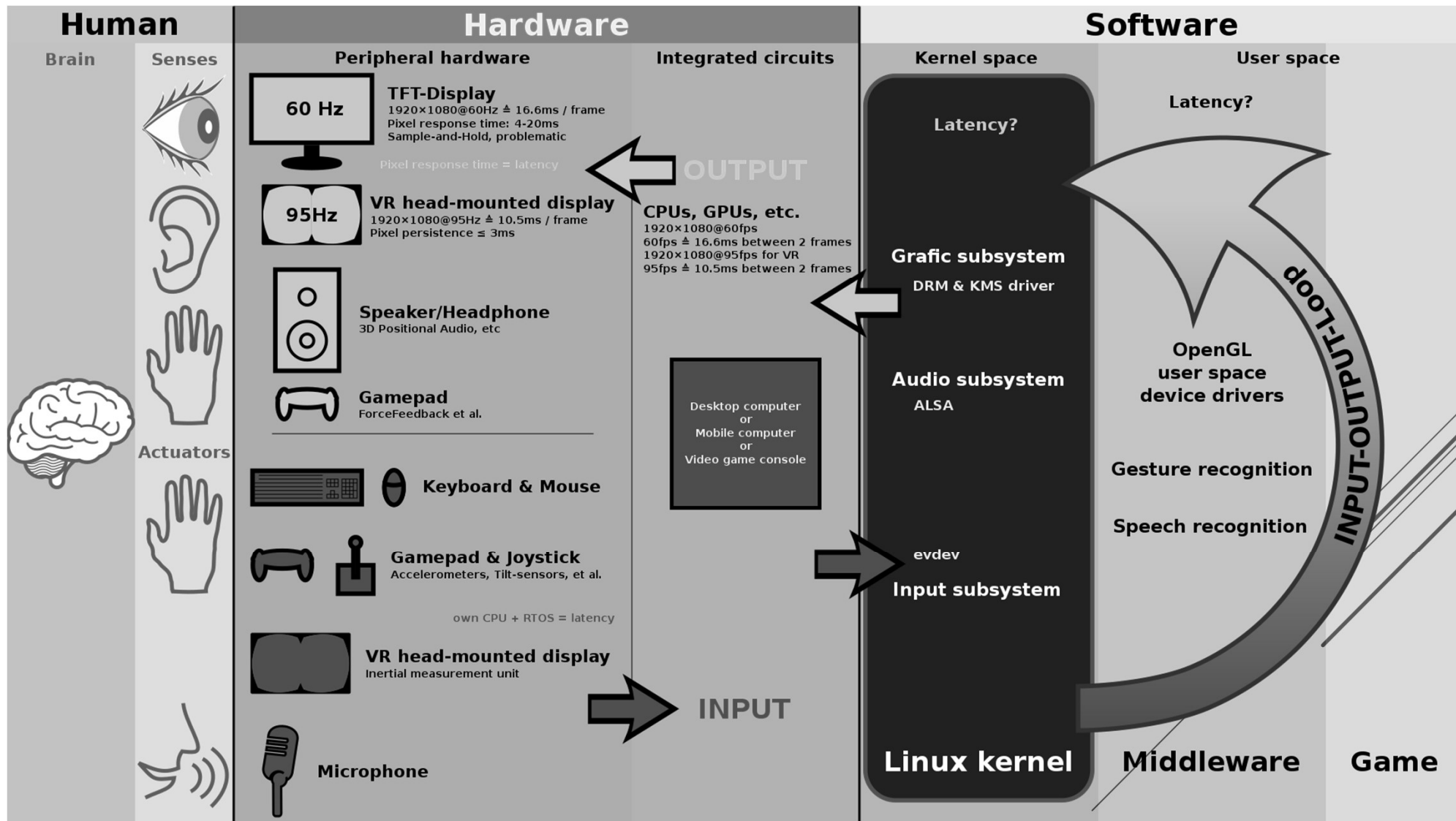
- ▶ Put the user into a virtual world
- ▶ **Realistic and Immersive simulation**
- ▶ Displayed either on
 - ▶ A computer monitor,
 - ▶ A projector screen, or with
 - ▶ A virtual reality headset (also called head-mounted display or HMD). HMDs typically take the form of head-mounted goggles with a screen in front of the eyes.

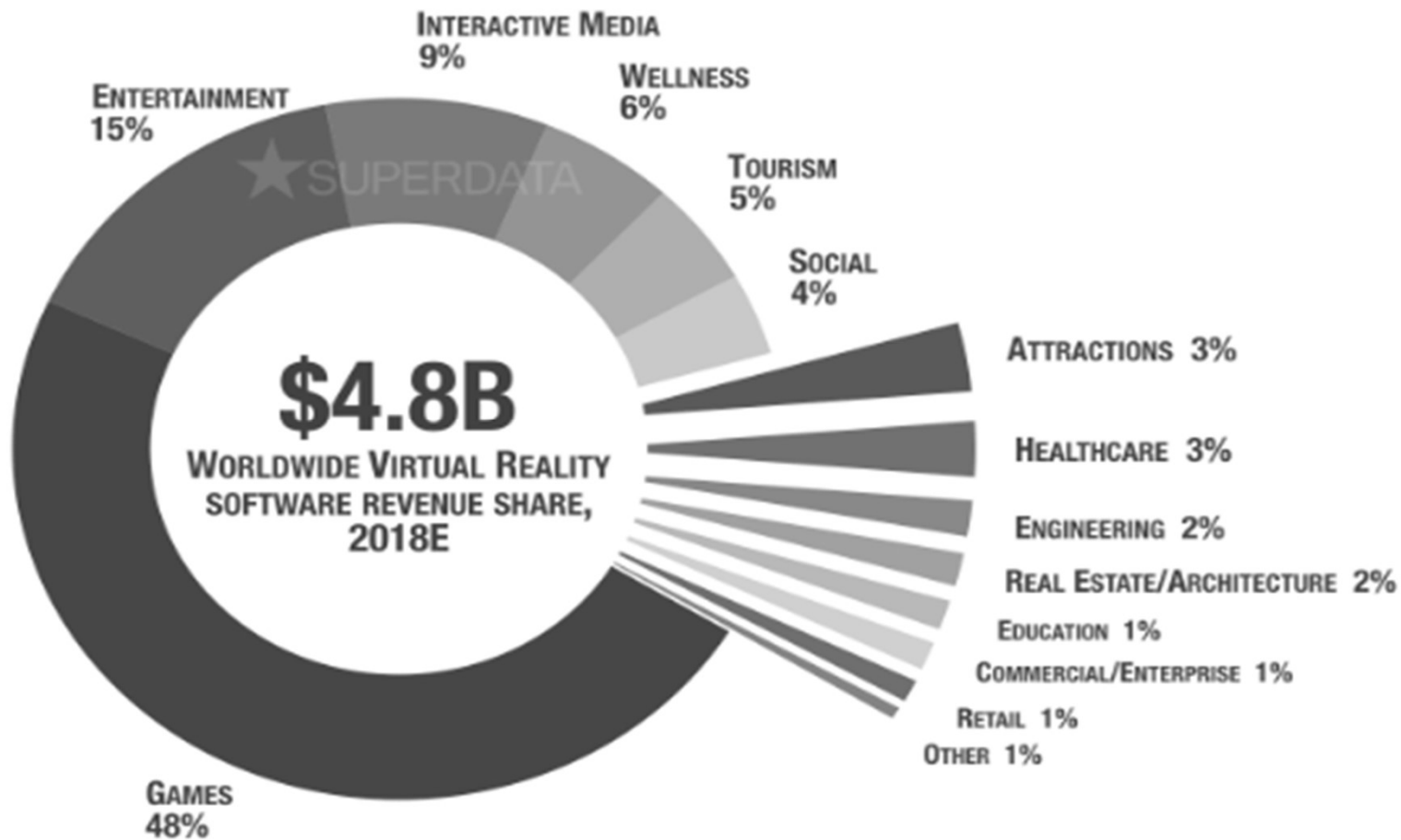


The Sensorama in the 1950s.



VIRTUAL REALITY





TOPIC IN
VIRTUAL
REALITY



TOPIC IN VIRTUAL REALITY GAME

- IEEE VR Conference & Journal

Hardware

◦ Tracking and sensing ◦ Input devices for VR/AR/MR ◦ Advanced display technology ◦ Immersive projection technology ◦ Haptics, audio, and other non-visual interfaces

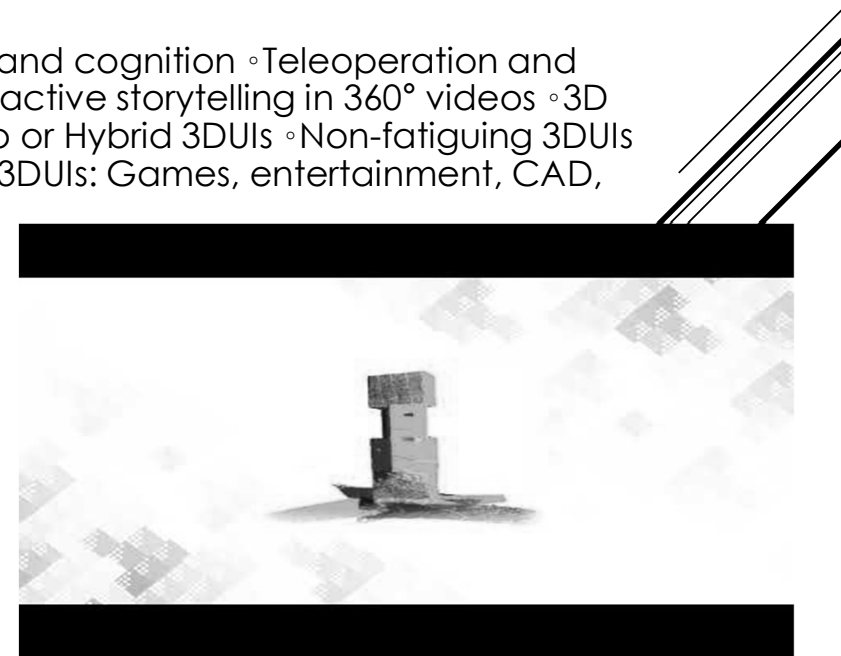
Software

◦ Modeling and simulation ◦ Computer graphics techniques for VR/AR/MR ◦ Virtual humans and avatars ◦ Multi-user and distributed VR/AR/MR ◦ VR systems and toolkits ◦ Locomotion and navigation in virtual environments

Application

◦ User studies and evaluation ◦ Perception, presence, virtual embodiment, and cognition ◦ Teleoperation and telepresence ◦ Applications of VR/AR/MR ◦ Ethical issues in VR/AR/MR ◦ Interactive storytelling in 360° videos ◦ 3D interaction for VR/AR/MR ◦ 3DUI metaphors for VR/AR/MR ◦ Mobile, Desktop or Hybrid 3DUIs ◦ Non-fatiguing 3DUIs ◦ Evaluation methods for 3DUIs ◦ Empirical studies of 3DUIs ◦ Applications of 3DUIs: Games, entertainment, CAD, education, etc.

TOPICS IN VIRTUAL REALITY RESEARCH



- ▶ Virtual Reality

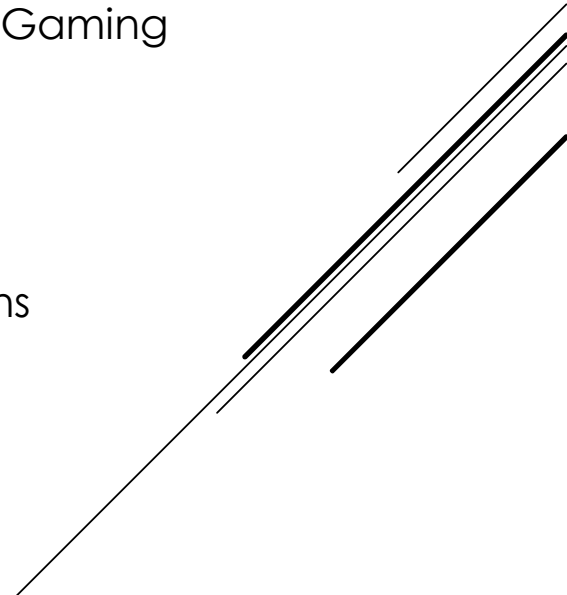
ISSN: 1359-4338 (print version)

ISSN: 1434-9957 (electronic version)

- ▶ Virtual Reality Technology and Software Systems
- ▶ Design of VR systems and VEs
- ▶ Human Factors
- ▶ Virtual Reality Applications
- ▶ Assessment of Virtual Reality Systems
- ▶ Philosophical and Ethical Issues
- ▶ Advances Relevant to Virtual Reality

- ▶ Business and Commerce
- ▶ Defence and Military
- ▶ Education and Training
- ▶ Entertainment and Gaming
- ▶ Fashion,
- ▶ Heritage
- ▶ Medicine
- ▶ Telecommunications
- ▶ Visualisation

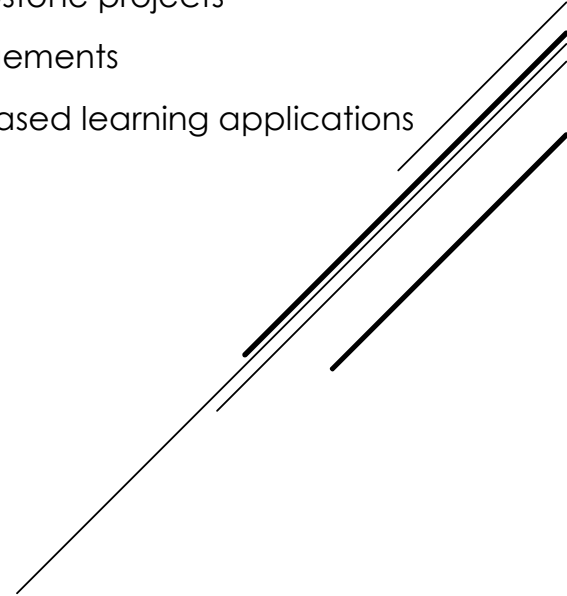
TOPICS IN VIRTUAL REALITY RESEARCH



- ▶ EDUCON – IEEE Global Engineering Education Conference
- ▶ Call for Papers – Special Session "Applications of Game-Based Learning EDUCON 2018"

- ▶ Applications of game-based learning
- ▶ industry oriented game learning
- ▶ games engineering
- ▶ serious games
- ▶ trends of game-based learning
- ▶ storytelling
- ▶ development of non-technical skills / meta-cognitive skills
- ▶ simulation
- ▶ learning scenarios based on virtual worlds
- ▶ project based learning – capstone projects
- ▶ game-based learning arrangements
- ▶ tools for developing game-based learning applications
- ▶ experience reports

TOPICS IN VIRTUAL REALITY RESEARCH



- ▶ Strategy 1 – Renew the Curricula of Science, Technology and Mathematics Education KLAS
- ▶ **Strategy 2 – Enrich Learning Activities for Students**
- ▶ **Strategy 3 – Provide Learning and Teaching Resources**
- ▶ Strategy 4 – Enhance Professional Development of Schools and Teachers
- ▶ Strategy 5 – Strengthen Partnerships with Community Key Players
- ▶ Strategy 6 – Conduct Review and Disseminate Good Practices

http://www.edb.gov.hk/attachment/en/curriculum-development/renewal/STEM%20Education%20Report_Eng.pdf

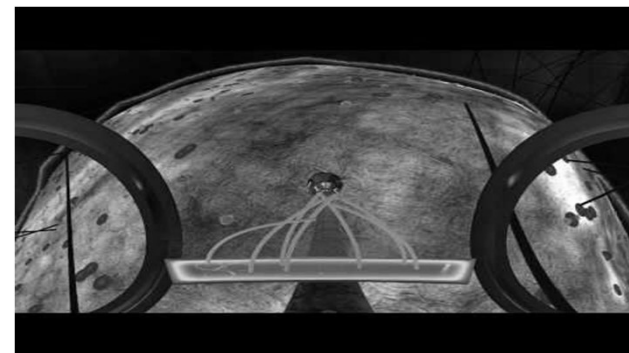
COMMUNITY PARTICIPATION IN FORMULATING THE
STRATEGIES FOR PROMOTING **STEM EDUCATION** IN SCHOOLS

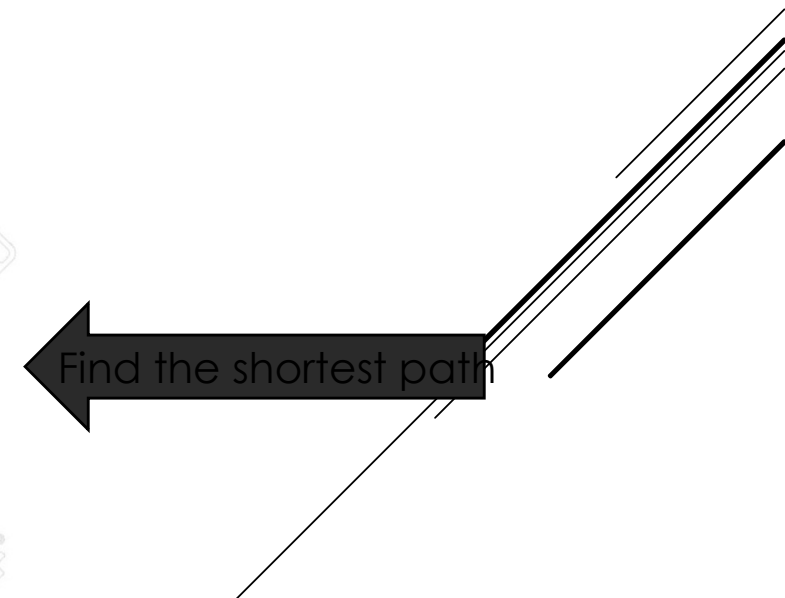
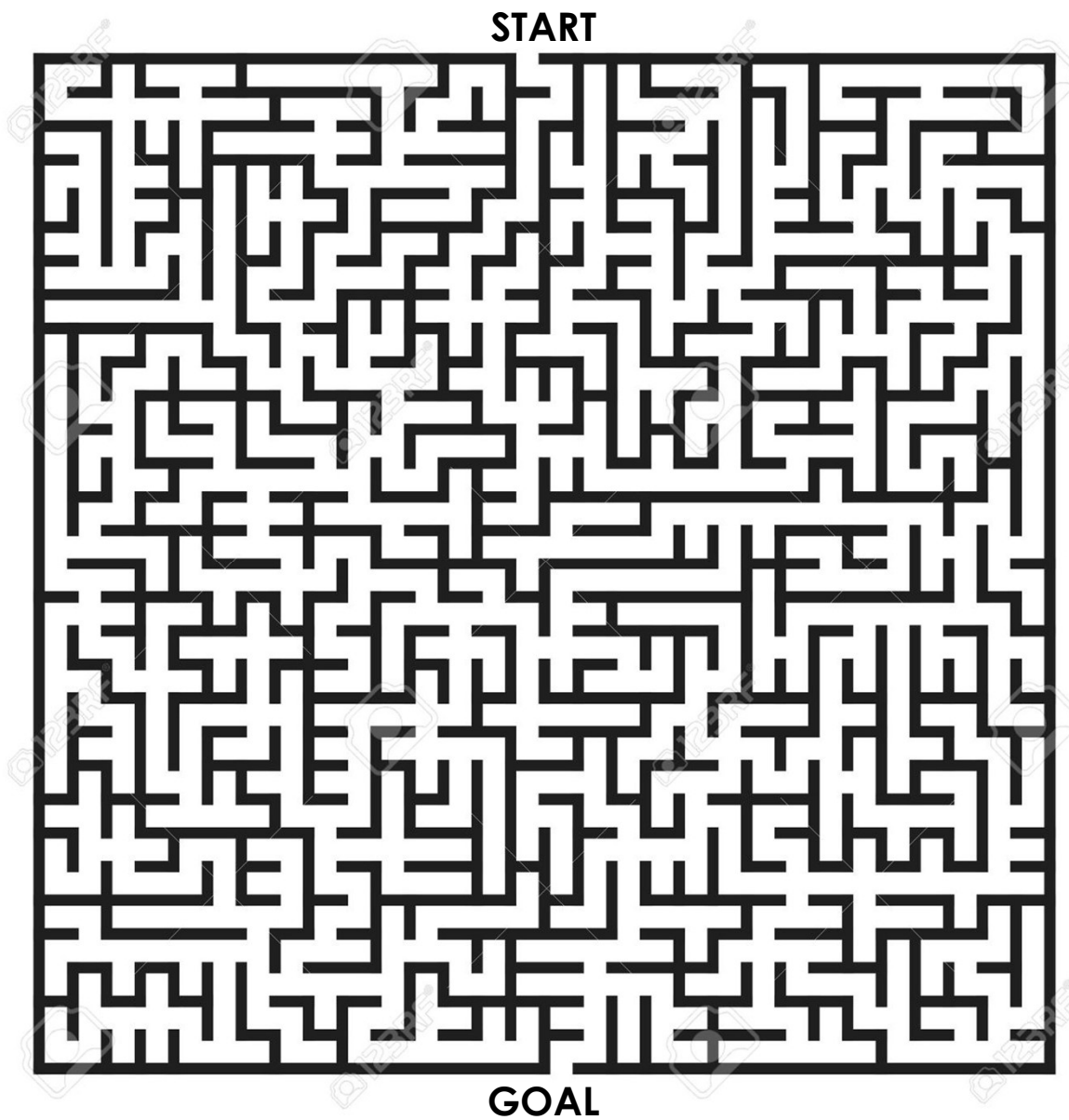




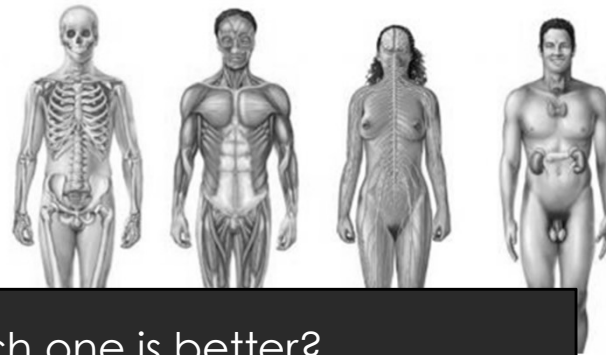
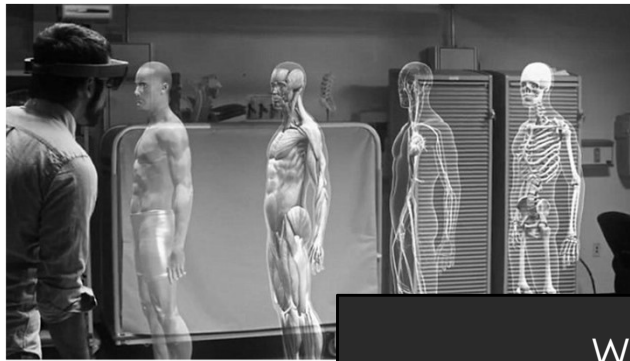
- ▶ 70 VR education games/applications in STEAM
 - ▶ Science 29
 - ▶ History 17
 - ▶ Art 6
 - ▶ Physical Education 4
 - ▶ Abstract thinking 3
 - ▶ Social 3
 - ▶ Music 2
 - ▶ Language 1

VR EDUCATION GAMES/APPLICATIONS IN STEAM

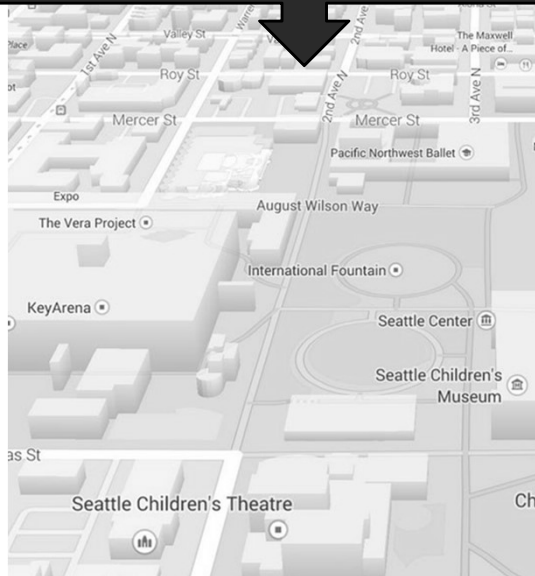




- Visualization in three dimensions allows more easily the humans to see patterns, relationships, trends

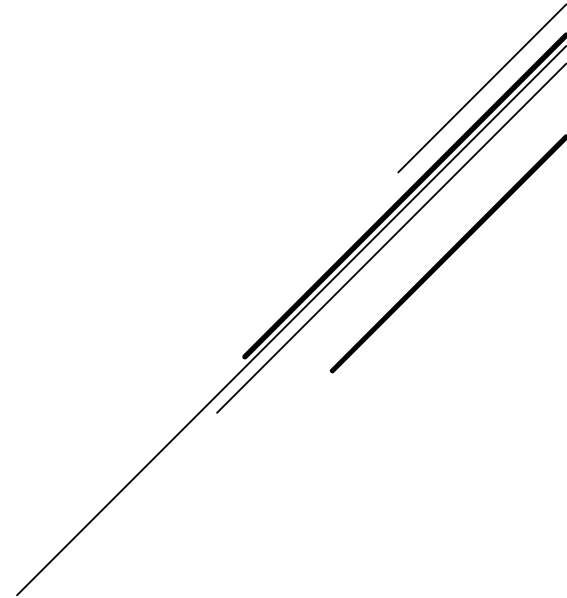


Which one is better?



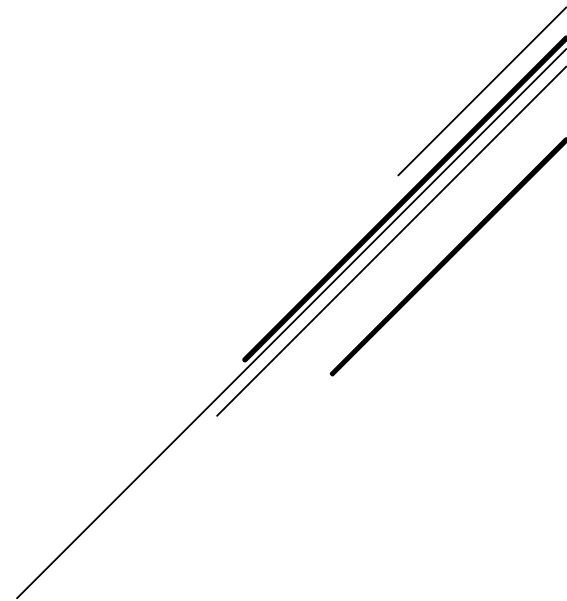
- ▶ User comfort,
- ▶ Amount of data to process,
- ▶ Image realism,
- ▶ Deal with real objects as well with as graphical models
 - ▶ Visualization of a scenario helps to understand the dynamic behaviour of a system

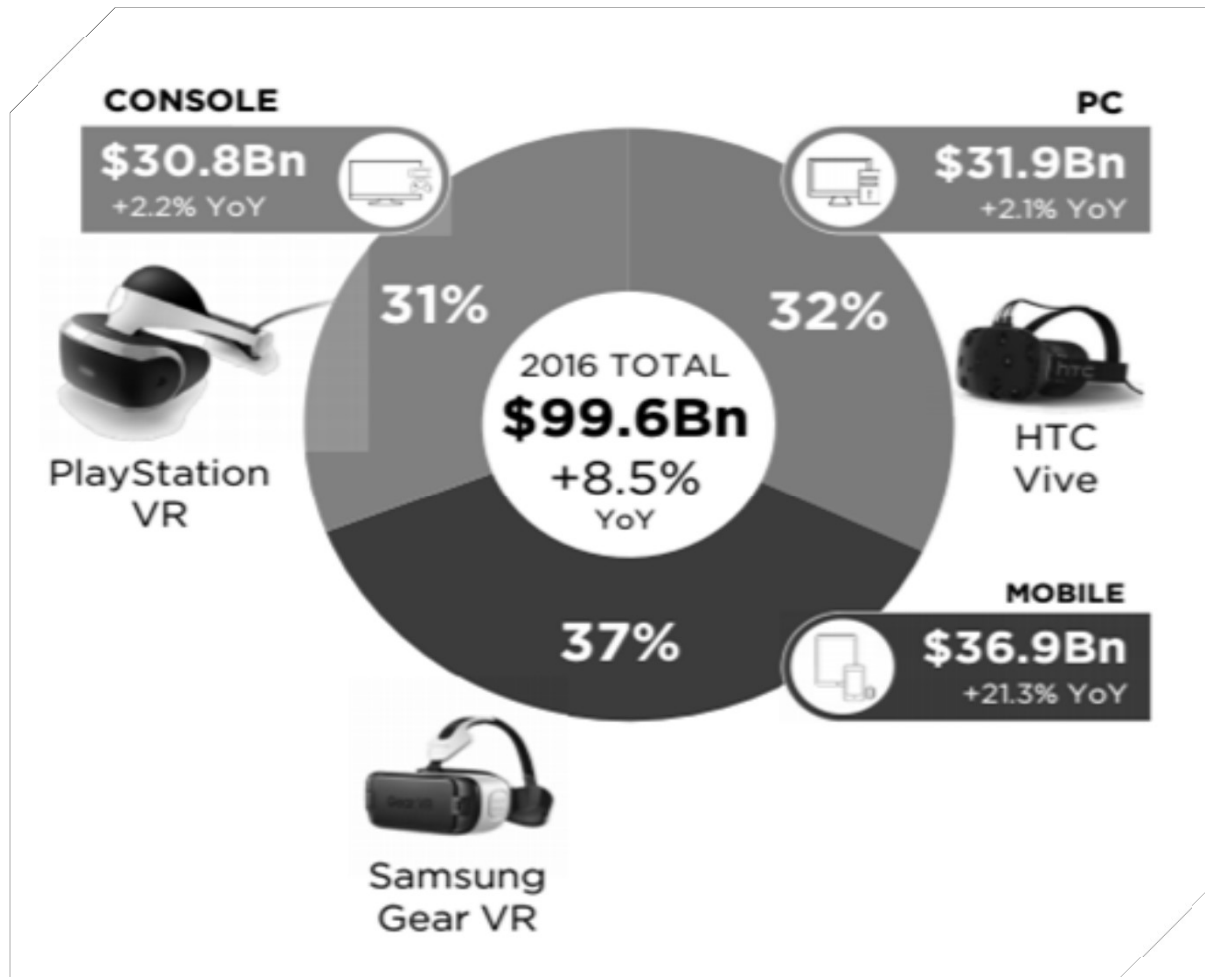
CRITERIA OF HCI IN MIXED REALITY



- ▶ Why do people need the 3D working space in this application?
- ▶ Why do people need the immersive environment in this application?
- ▶ Why do people need the motion sensing in this application?
- ▶ Why doesn't this exist already?
- ▶ Why us?

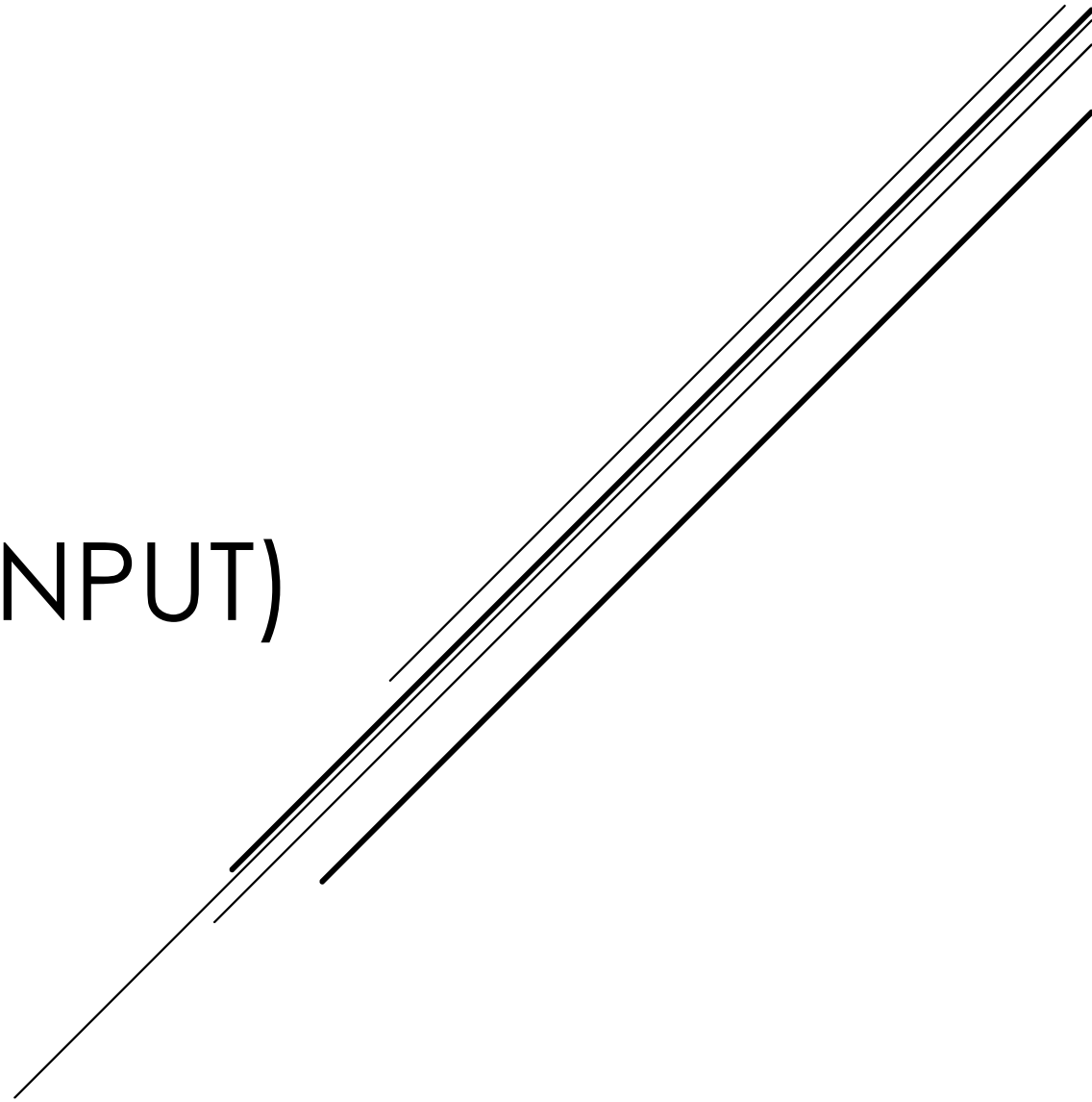
5 “WHY” GUIDING PRINCIPLES IN VR



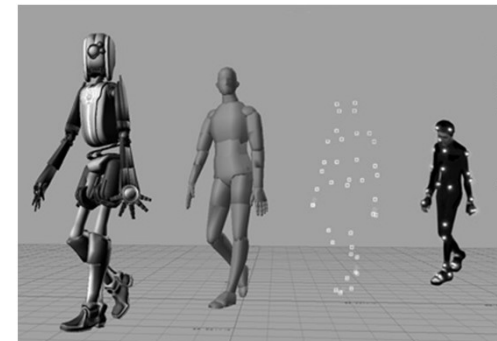


HARDWARE IN VIRTUAL REALITY

HARDWARE IN VIRTUAL REALITY (INPUT)



- ▶ Images from multiple cameras to calculate 3D positions, often the purpose of motion capture is to record only the movements of the actor, not his or her visual appearance.
- ▶ This animation data is mapped to a 3D model so that the model performs the same actions as the actor.
- ▶ Optical Motion Capture is using reflective markers and multiple infra red cameras to digitize different views.

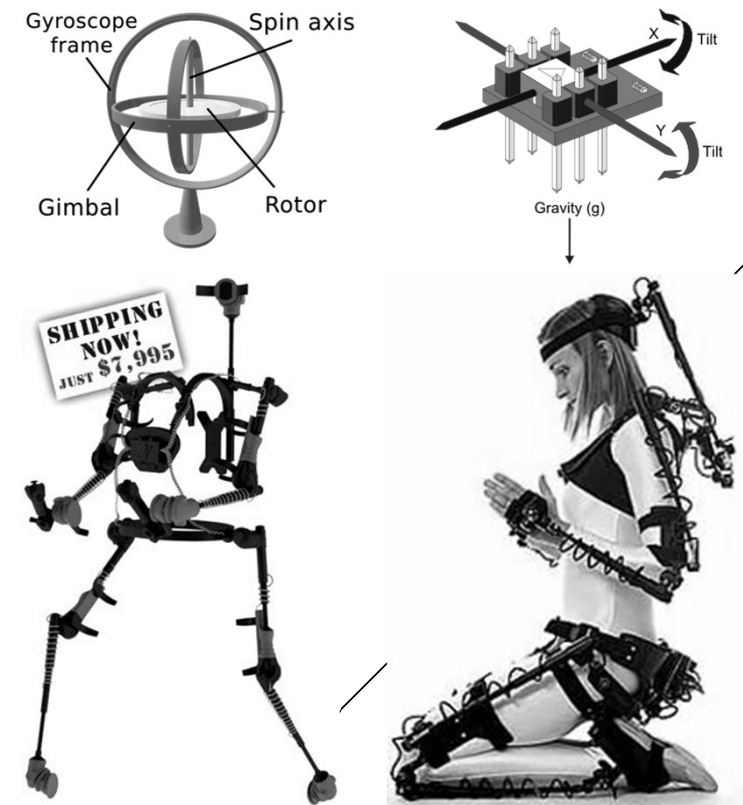


MOTION CAPTURE SYSTEM

<https://vrscout.com/projects/gear-vr-motion-capture/>

- ▶ Use Potentiometers to calculate the orientation and position
- ▶ Such as Gyroscope, Accelerometer
- ▶ Pros
 - ▶ No occlusion problems
 - ▶ No additional camera
 - ▶ Portable and outdoors capture
- ▶ Cons
 - ▶ Not as accurate as optical system

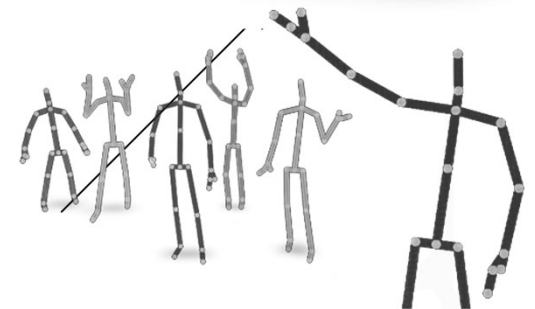
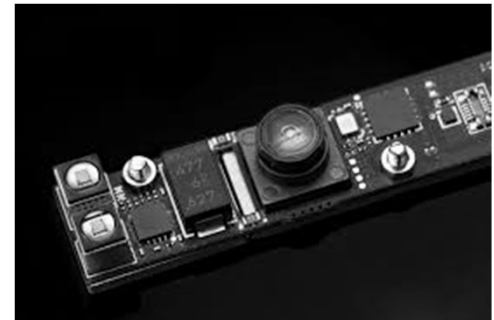
MOTION CAPTURE SYSTEM



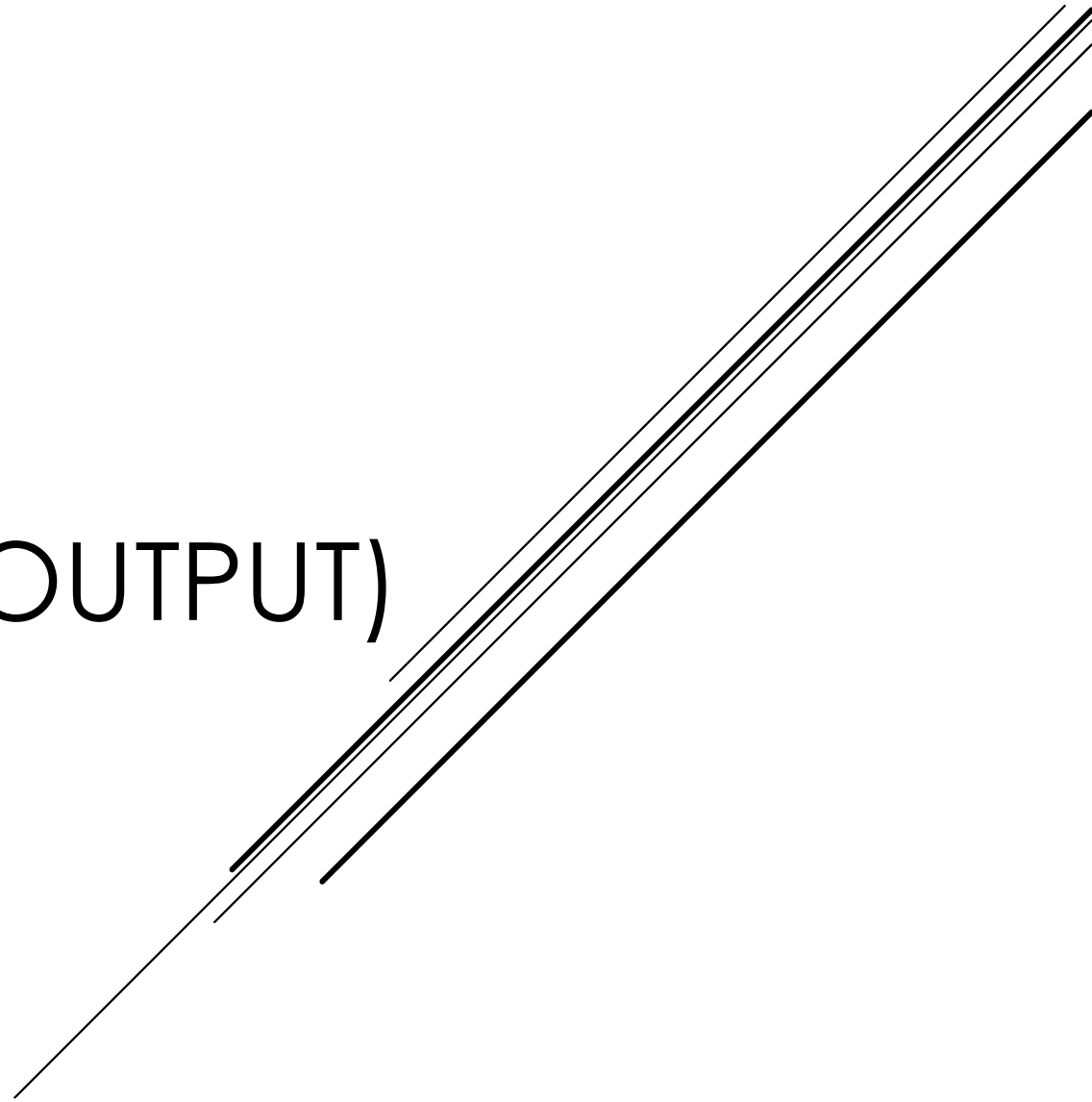
<http://stringvisions.ovationpress.com/wp-content/uploads/2014/10/mechanical-motion-capture-skeleton.jpg>

- ▶ Using Infra Red Camera to depth data
- ▶ Recognize a common and structural object (Human body, face, hand) by using the depth data and pattern recognition algorithm (extra computation power is needed)
- ▶ Kinect for Xbox One
 - ▶ Body, face and hand
 - ▶ Using wide-angle time-of-flight camera, and processes 2 gigabits of data per second to read its environment
 - ▶ Track up to 6 skeletons at once
- ▶ Leap Motion
 - ▶ Hands only
 - ▶ Using an active IR sensor

MOTION CAPTURE SYSTEM (MARKERLESS / NON- CONTACT)



HARDWARE IN
VIRTUAL REALITY (OUTPUT)

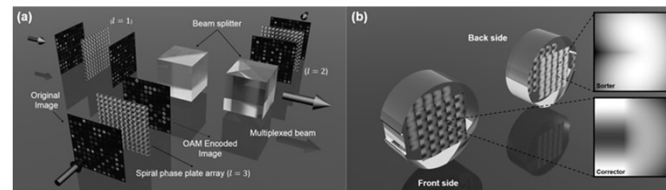
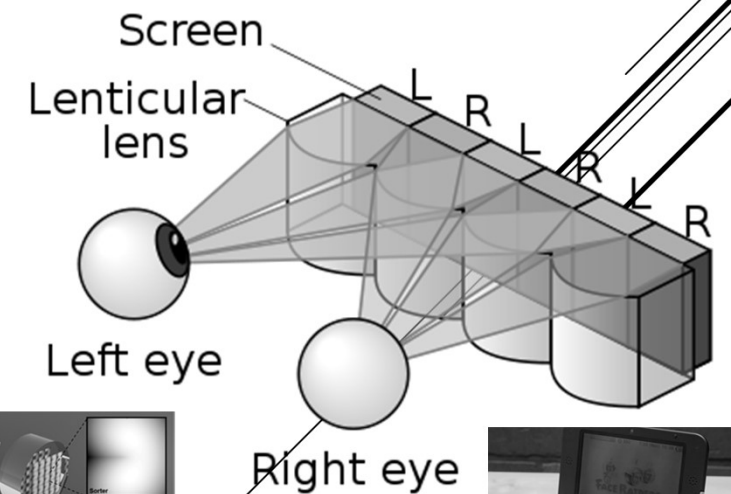
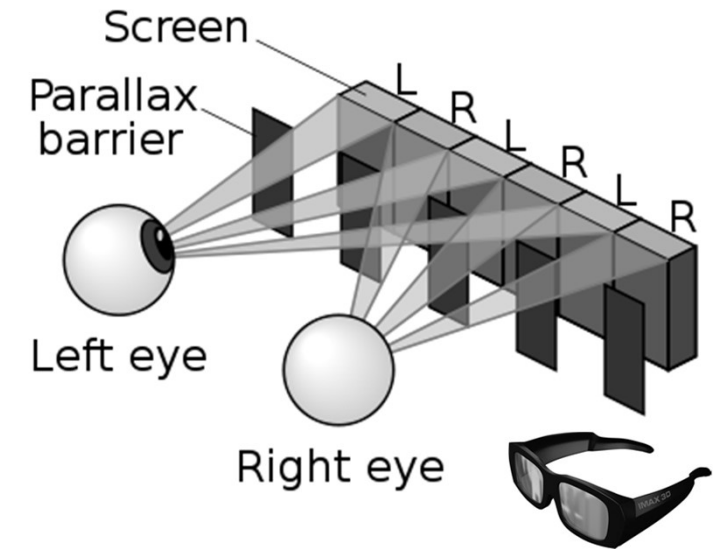


- ▶ Also known as Helmet Mounted Display
- ▶ “Standard” 3D representation
 - ▶ Two optical displays in correspondence of two eyes by two flat screens
- ▶ In 1968, computer science visionary Ivan Sutherland developed a HMD system that immersed the user in a virtual computer graphics world
- ▶ One of the first commercial HMD can be considered the Nintendo's Virtual Boy
- ▶ Advantage:
 - ▶ lightweight, compact, easy to program, 360° tracking, generally cheap
- ▶ Disadvantage:
 - ▶ Low resolution, low field of vision, mostly standalone
 - ▶ High latency between the time a user repositions of head and rendering
 - ▶ Effect of level-of-detail degradation in the periphery
 - ▶ The fact that the HMDs must be donned and adjusted, and that they are not recommended for people **15 years old and younger** because some experts believe overly stimulating imagery is not good for teenagers whose brains are still developing

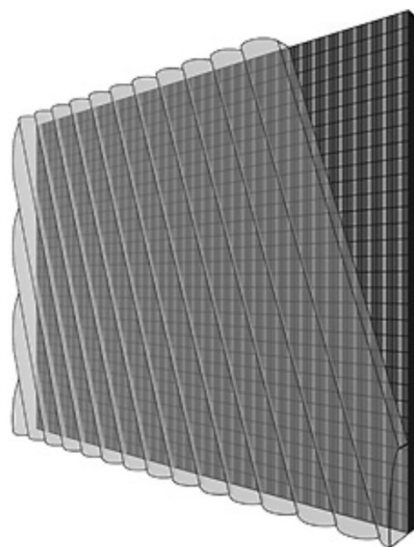


HEAD MOUNTED DISPLAYS (HMD)

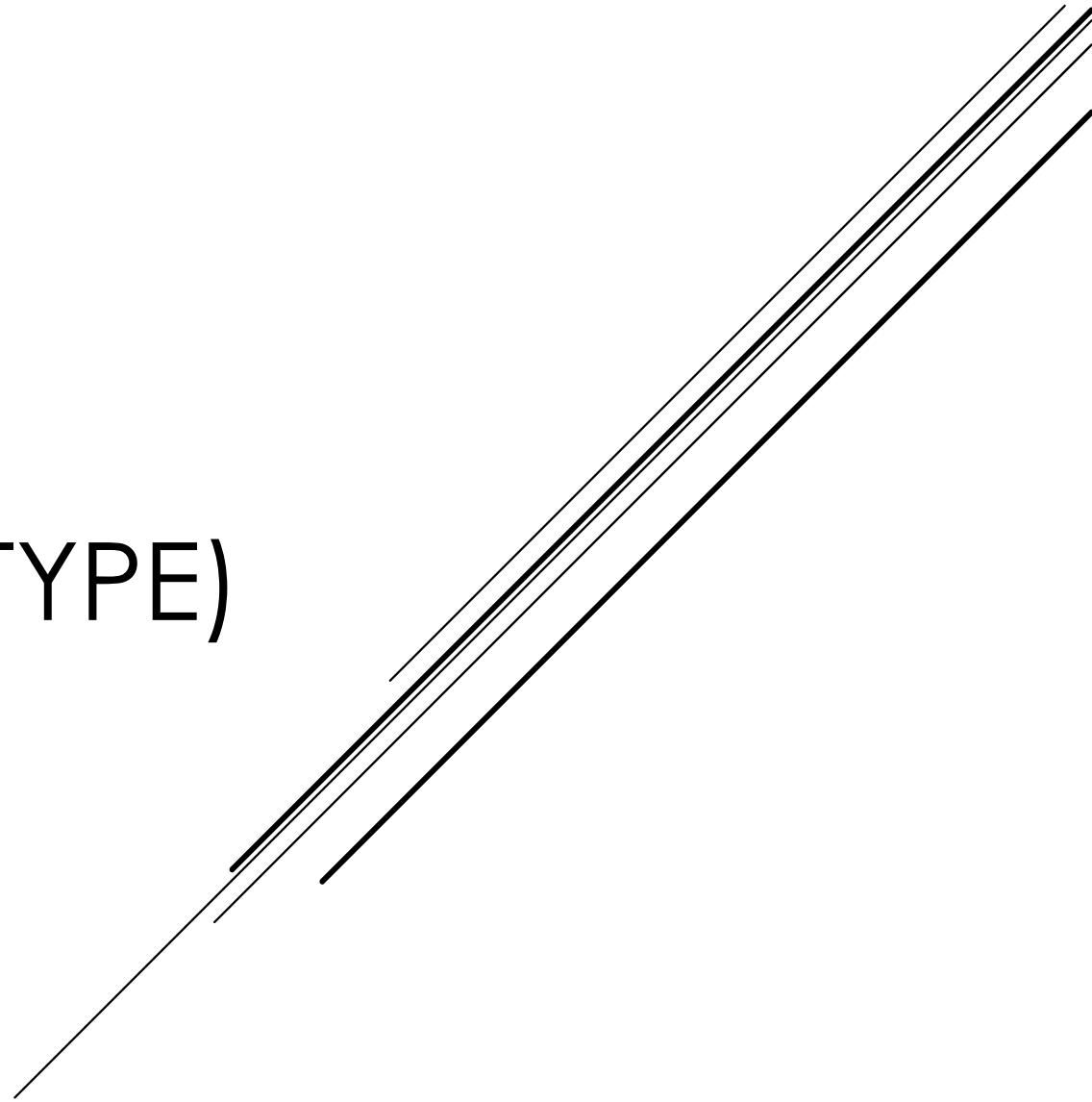
- ▶ Stereoscopy or 3D imaging
- ▶ Furnish the “illusion of depth” in an image by presenting two offset images separately to the left and right eye of the viewer
- ▶ AutoStereoscopy
 - ▶ the user wear eyeglasses to filter for each eye the two offset images from a single source (Upper)
 - ▶ the user's eyes receive a directionally splitted image from the same source (Lower)
- ▶ AutoMultiscopic
 - ▶ Has not only the “illusion of depth” but the “illusion to turn around” the visualized object just moving his/her head position with respect to the source
 - ▶ <https://www.disneyresearch.com/publication/auto-multiscopic-displays-based-on-orbital-angular-momentum-of-light/>



AUTO STEREOSCOPY



HARDWARE IN VIRTUAL REALITY (TYPE)



- ▶ Immersive Cave System with Motion tracking
- ▶ Without Head Mounted Display, not active glasses
- ▶ Allow multiple user to interact at the same time
- ▶ Allow to trace any part of body or tool
- ▶ 120Hz
- ▶ Warehouse-scale VR



PROJECTION VR



- ▶ Large tracking area (20M * 20M * 3M)
- ▶ High accuracy in motion tracing (0.25mm)
- ▶ Able to adopt to any HMD, such as HTC, Oculus, or PS VR)

WALKING VR



► Home Use VR System

► HTC Vive

- 70 infrared sensors
 - 32 on the headset
 - 19 for each controller
- Gyroscope
- Accelerometer

► Oculus Rift

► Sony VR

► Reasonable Price

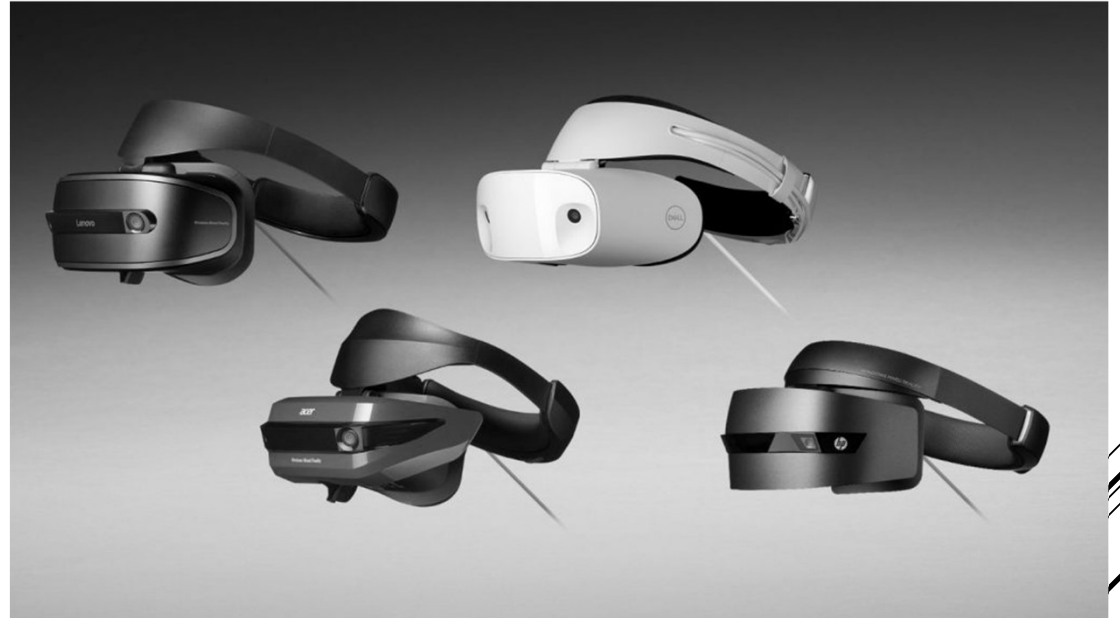
► Portable

STANDING VR





STANDING VR



- ▶ Mobile Use VR System
 - ▶ iOS
 - ▶ Android
- ▶ Type of Mobile VR
 - ▶ Cardboard
 - ▶ Daydream
 - ▶ Samsung Gear VR
- ▶ Cheapest Price
- ▶ Easiest to Deploy

MOBILE VR





6.6%
of mobile devices
are compatible with
Gear VR



SAMSUNG
Gear VR

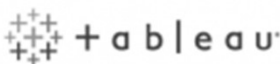


*Compatible with the Gear VR or Google Daydream

191.1
million devices
globally are VR-
ready*

NEWZOO GLOBAL SMARTPHONE & TABLET TRACKER | FEBRUARY 2017

POWERED BY



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**NEWZOO GLOBAL
SMARTPHONE &
TABLET TRACKER**

MONTHLY ACTIVE USE OF 3.1
BILLION MOBILE DEVICES

2.8BN
SMARTPHONES

280M
TABLETS

7000 DEVICE MODELS

10+
TECH SPECS

STARTING AT
\$19K/YR

IN COOPERATION WITH

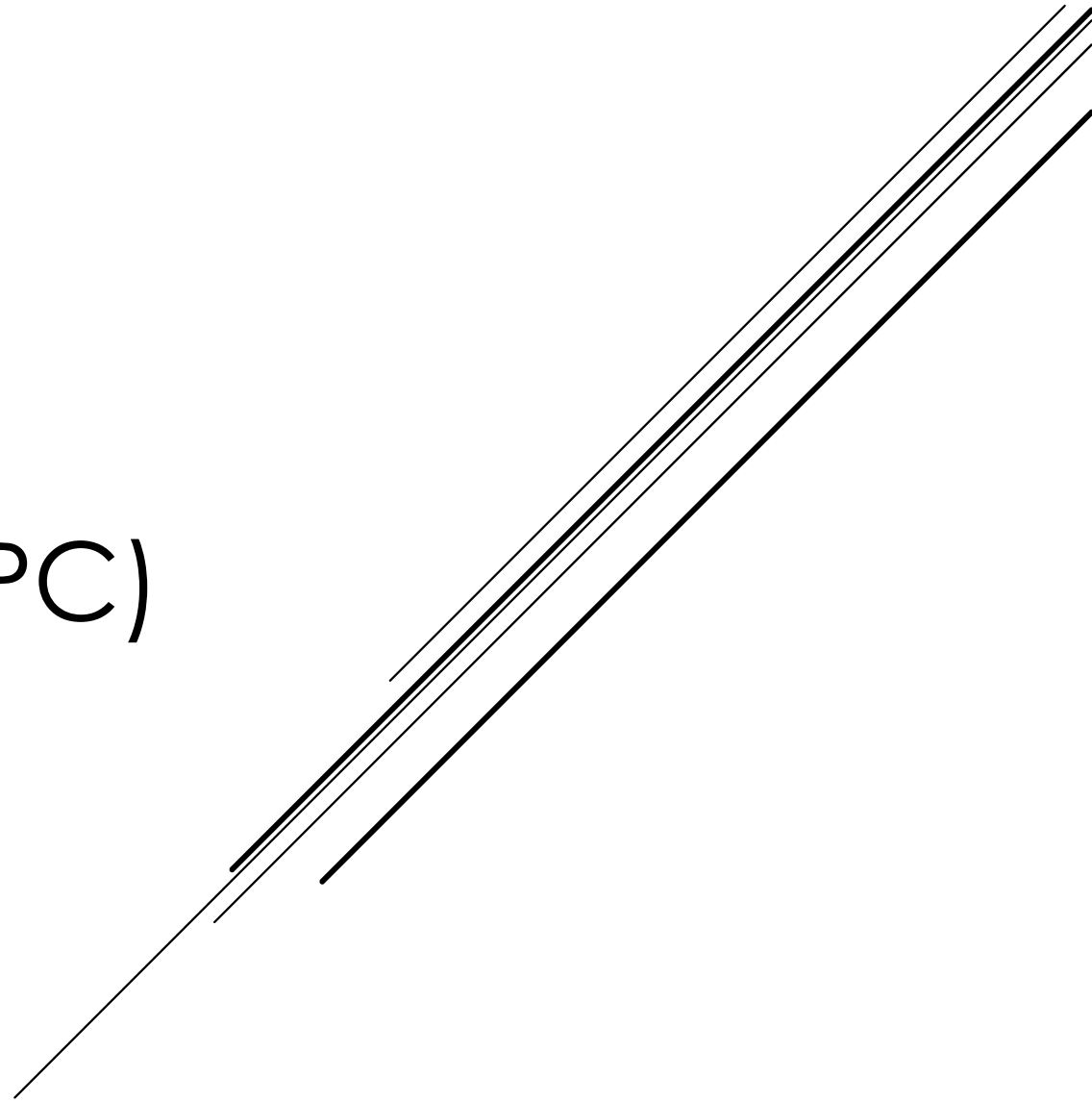


PUSHWOOSH



TalkingData

HARDWARE IN VIRTUAL REALITY (PC)





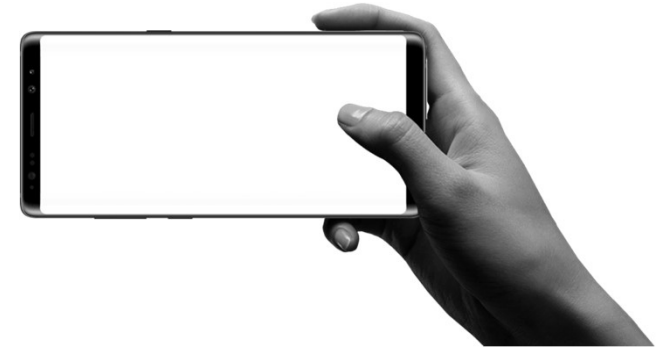
MSI Vortex VR One 7RD
HK\$ 19999

GeForce GTX 1060 6GB GDDR5



MSI GS73VR 7RF Stealth Pro
HK\$ 15499

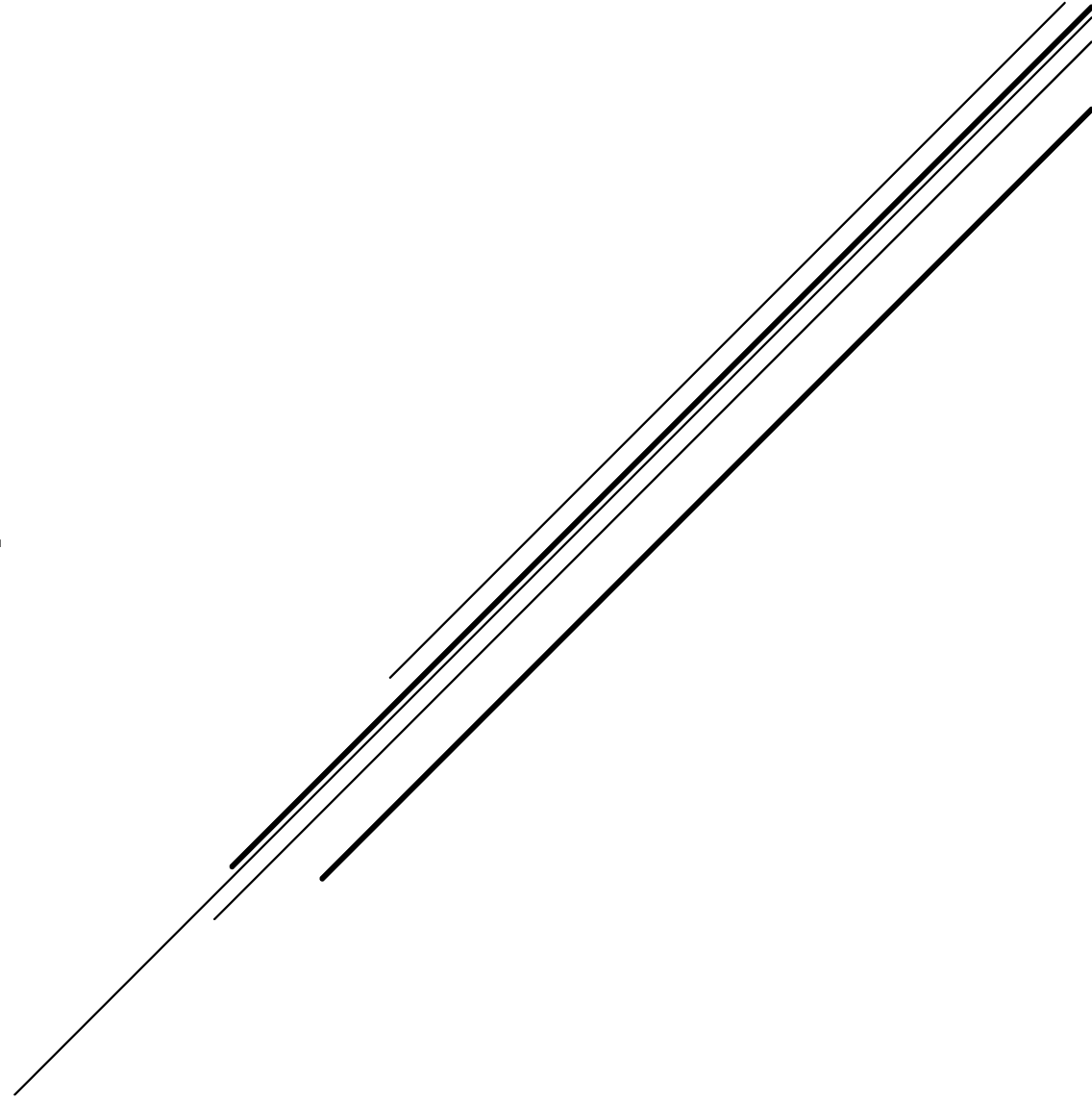
GeForce GTX 1060 6GB GDDR5



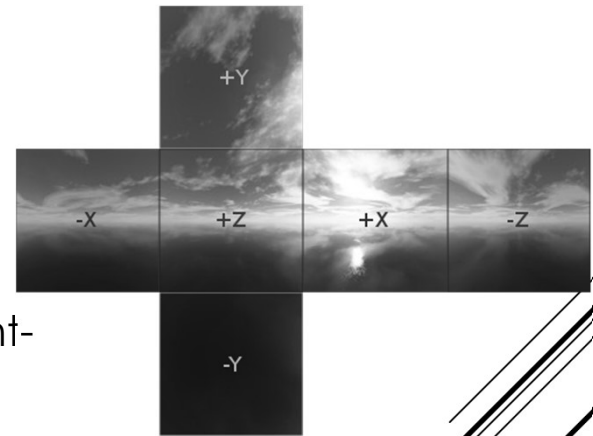
Samsung Galaxy Note8
HK\$ 7280

HARDWARE IN VIRTUAL REALITY (PC)

CONTENT IN VR ENVIRONMENT



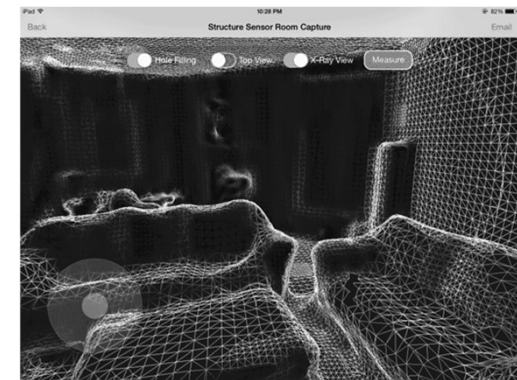
- ▶ Immersive Video (IV) technology stands for 360° video applications, such as the Full-Views Full-Circle 360° camera
- ▶ “Spherical camera”
- ▶ Youtube is supporting MP4(H.264) with 360 Video Metadata
- ▶ Apple Inc. developed the QuickTime Virtual Reality (QuickTime VR or QTVR), also as a plugin for the QuickTime Web browser plugin
- ▶ Computed by Environment Mapping algorithm
 - ▶ <https://cglearn.codelight.eu/pub/computer-graphics/environment-mapping>



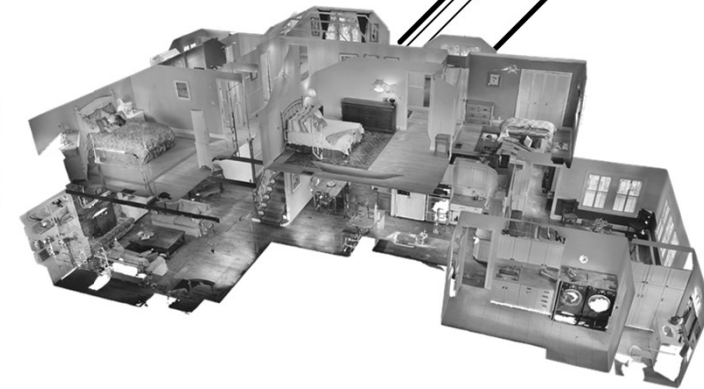
IMMERSIVE VIDEO



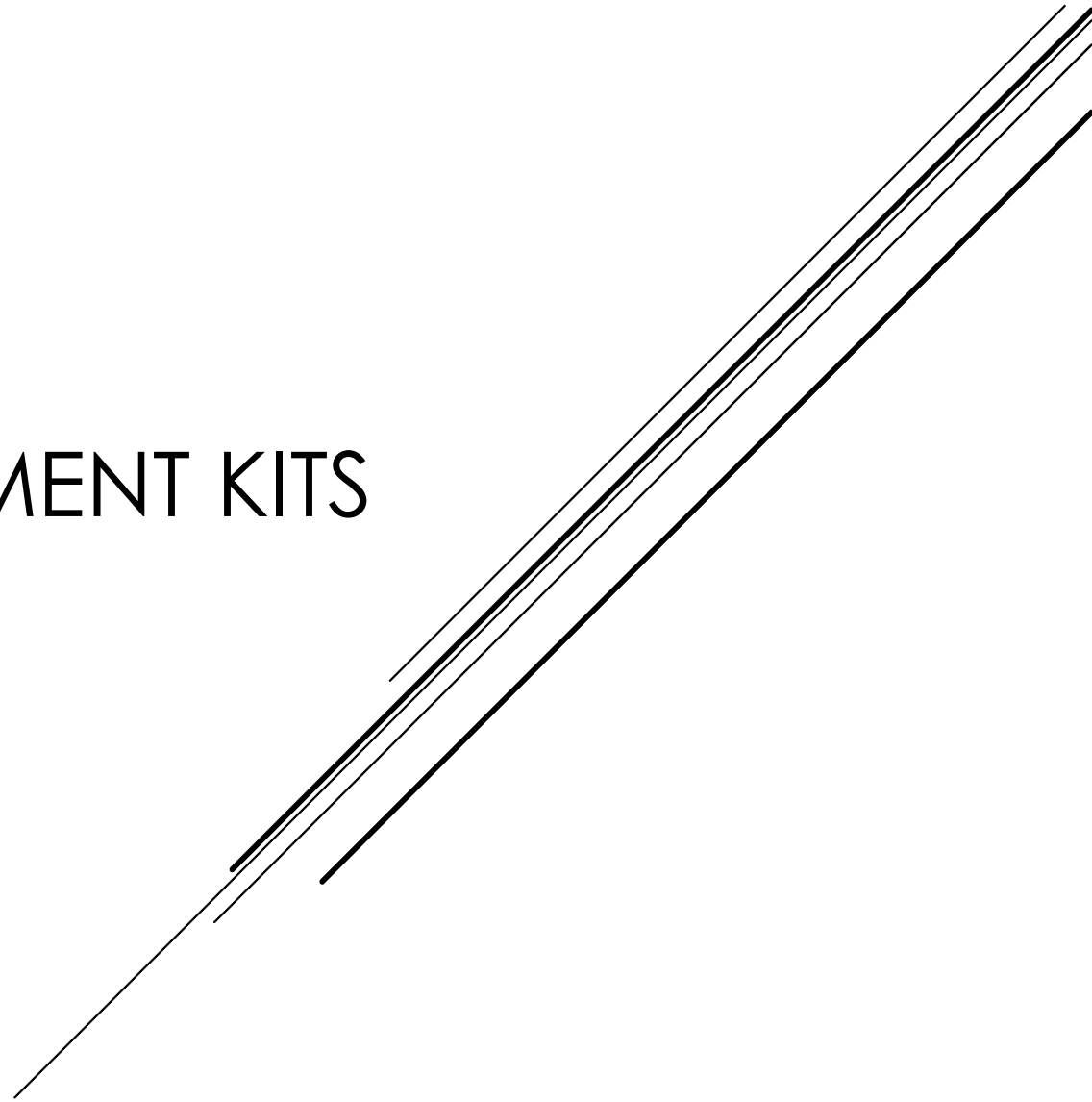
- ▶ Object scanned in a beam are turned into dedicated projection surfaces and tangible interaction devices
- ▶ The approach is based on a RGBD sensor
 - ▶ D stands for Depth. InfraRed sensor, such as Kinect, Structure sensor, Matterport
- ▶ Can be manipulated within a limited 3D space and the projected image will reorient itself



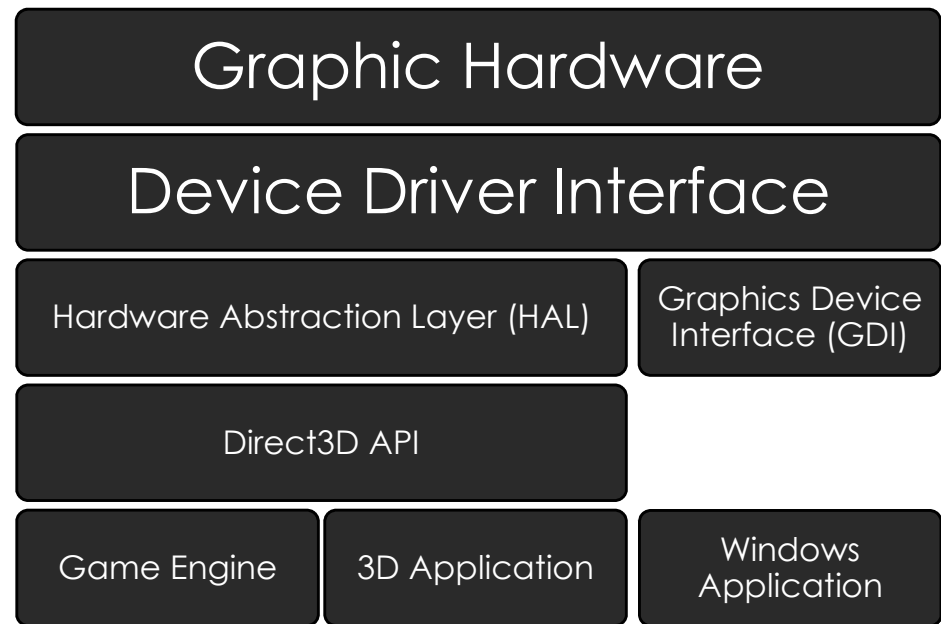
NOMADIC VIDEO



SOFTWARE DEVELOPMENT KITS IN VIRTUAL REALITY



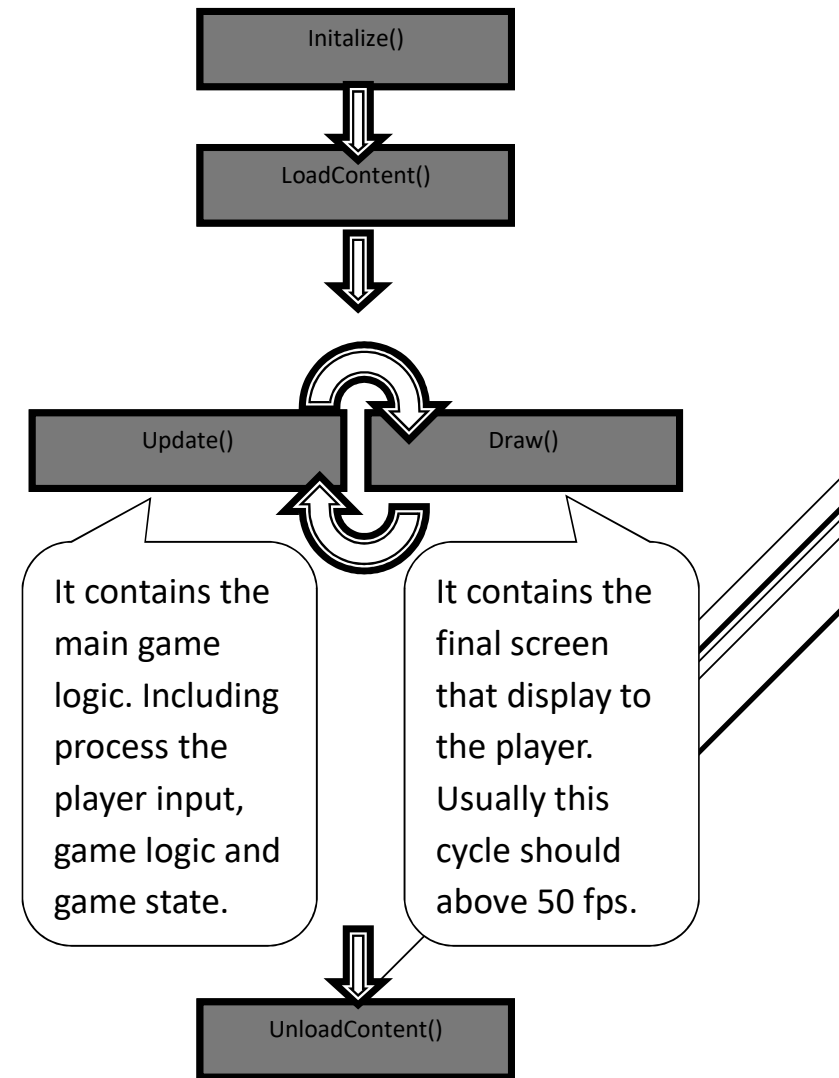
- ▶ DirectX is HAL (Hardware Abstraction Layer) interface. It centralizes and provides a common interface for different 3D card. Another common HAL is OpenGL.
- ▶ Unity 3D, Unreal, Virtual GL is game engine. A game engine is a software framework designed for the creation and development of video games by using scripting.



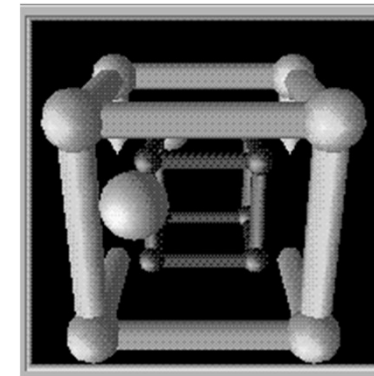
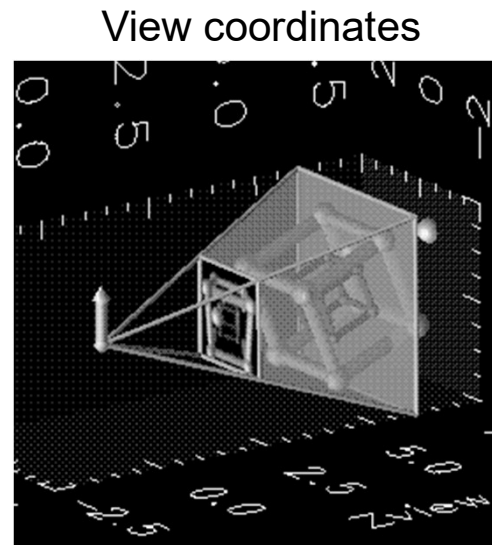
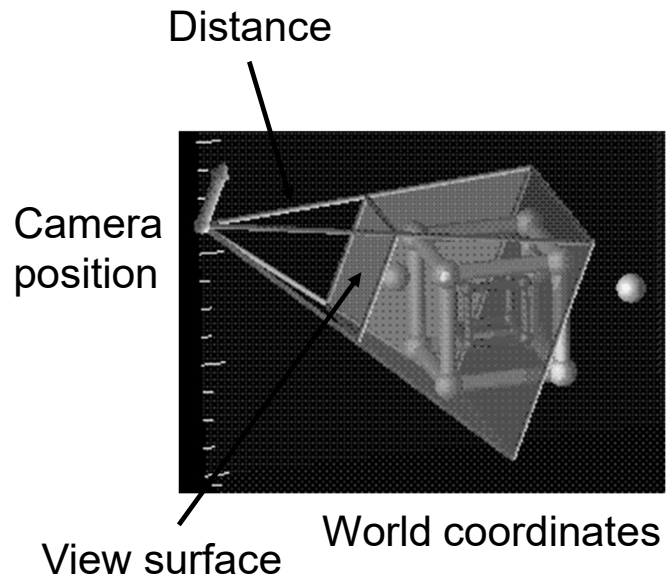
SYSTEM STRUCTURE OF 3D APPLICATION

- Game Loop
- Deploy the screen shoot of 3D application according to the game time, user input and processor speed

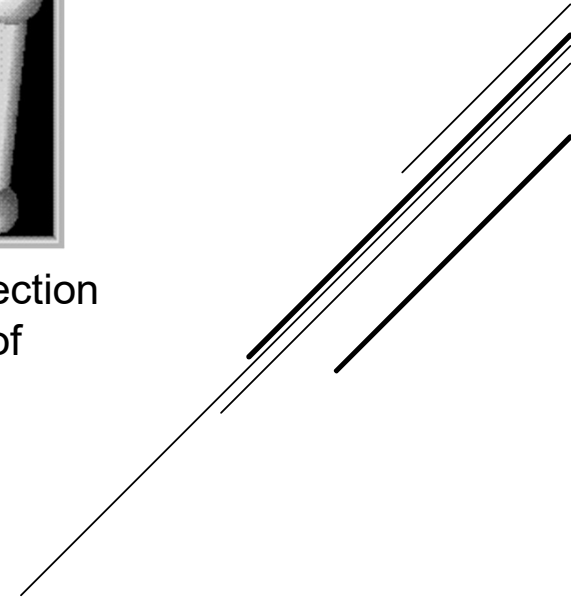
SYSTEM FLOW OF 3D APPLICATION

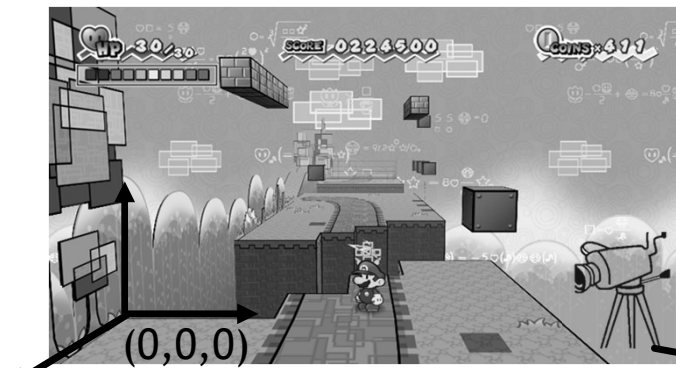


- Distance calculation and Transformation among object coordinates, view coordinates and world coordinates.

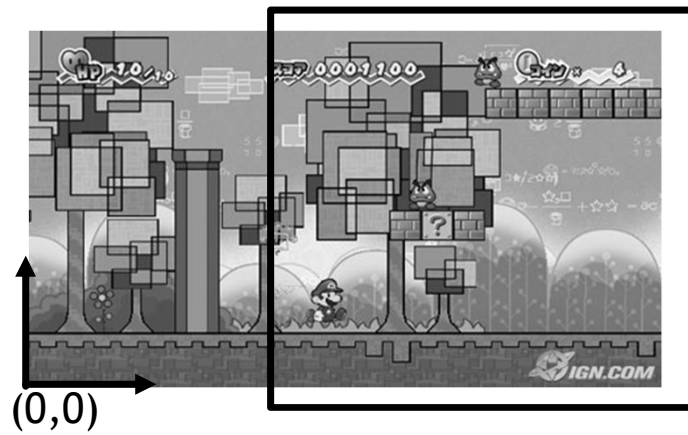


3D Screen Projection
The simulation of
“depth”

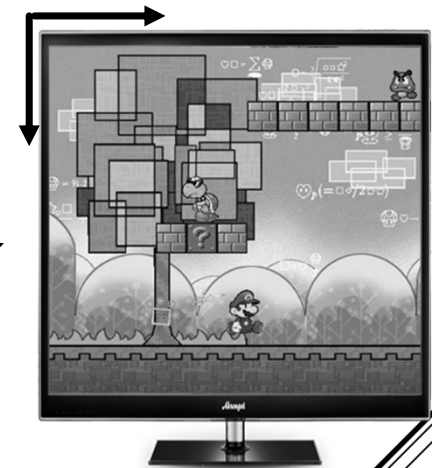




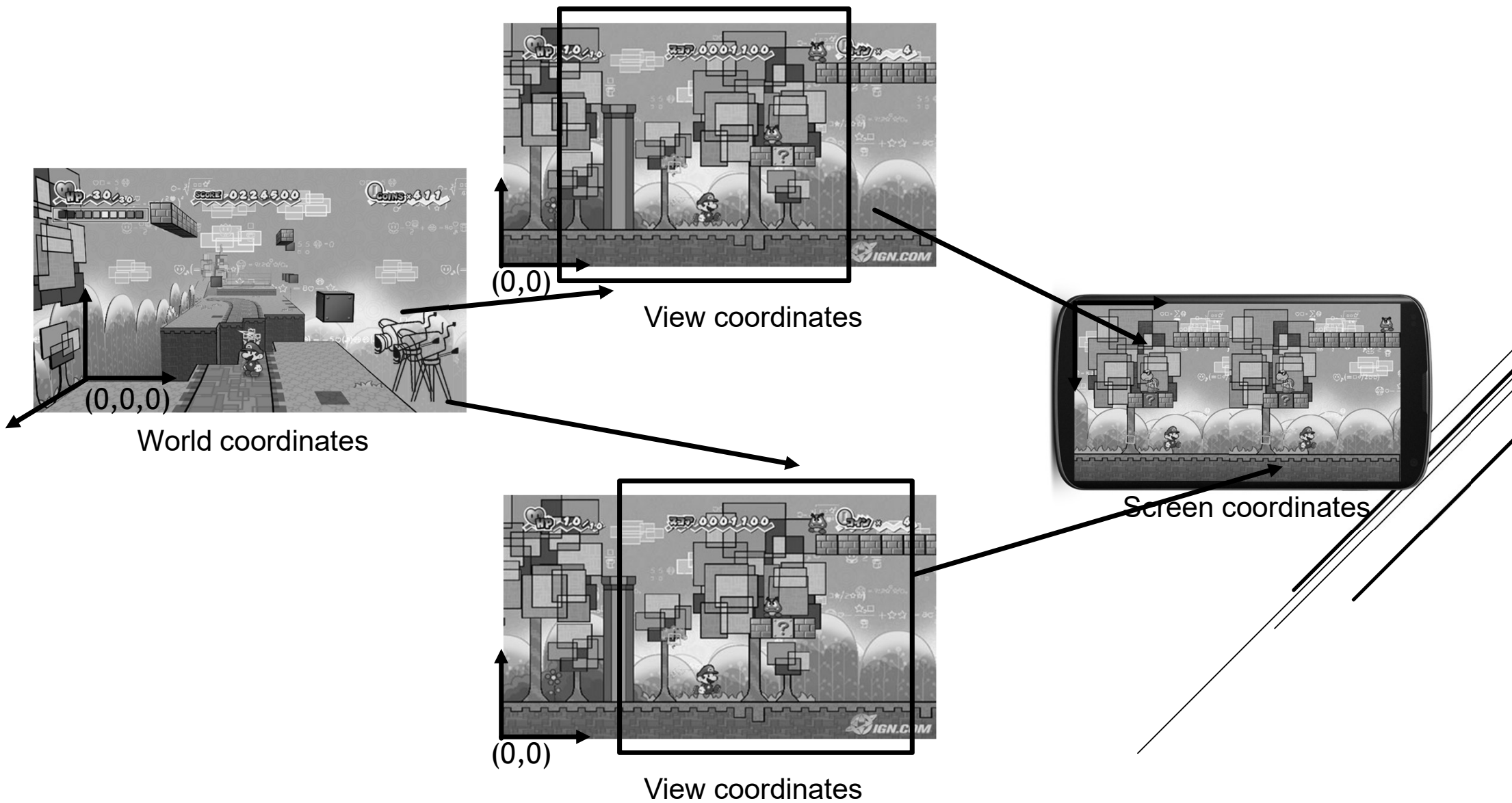
World coordinates



View coordinates

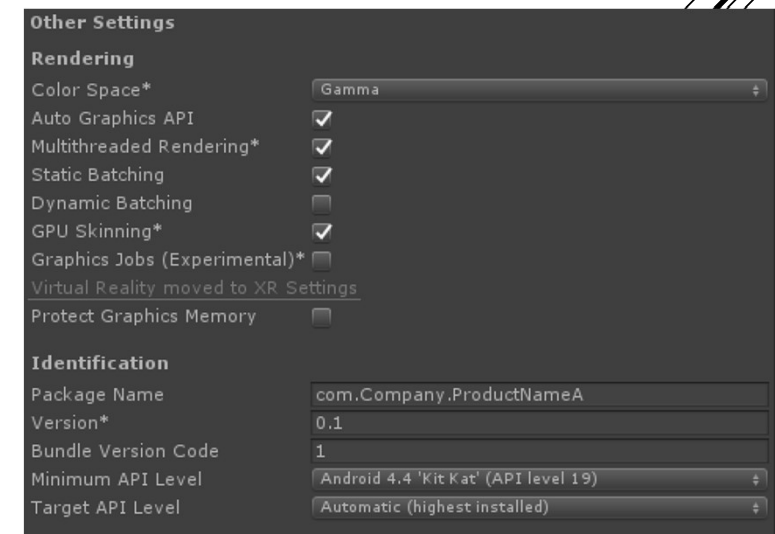
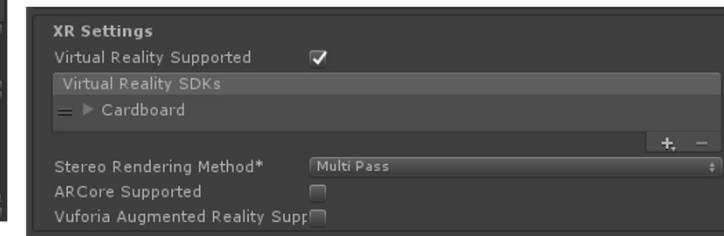
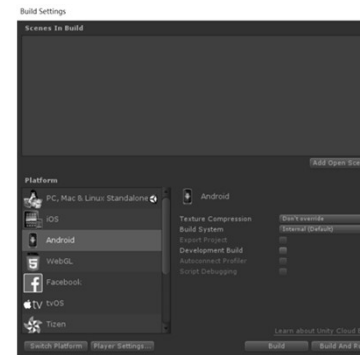
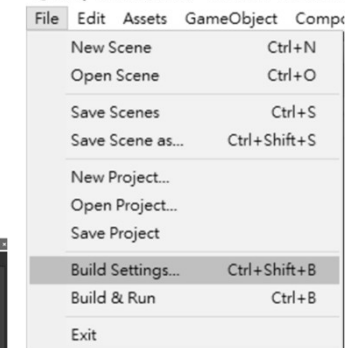


Screen coordinates



- ▶ Install Java SDK
 - ▶ <http://www.oracle.com/technetwork/java/javase/downloads/jdk8-downloads-2133151.html>
- ▶ Install Android Studio
 - ▶ <https://developer.android.com/studio/index.html>
- ▶ Open [File] > [Build Setting]
- ▶ Select [Android] and [Player Setting]
- ▶ Select the Inspector
- ▶ Select XR setting
- ▶ Select [Virtual Reality Supported] > [Cardboard]
- ▶ Select Other setting
- ▶ Change the name of package the [Minimum API level] to [Android 4.4]
- ▶ Export to APK
- ▶ Test APK in Android

Unity 5.6.1f1 (64bit) - Untitled - New Uni

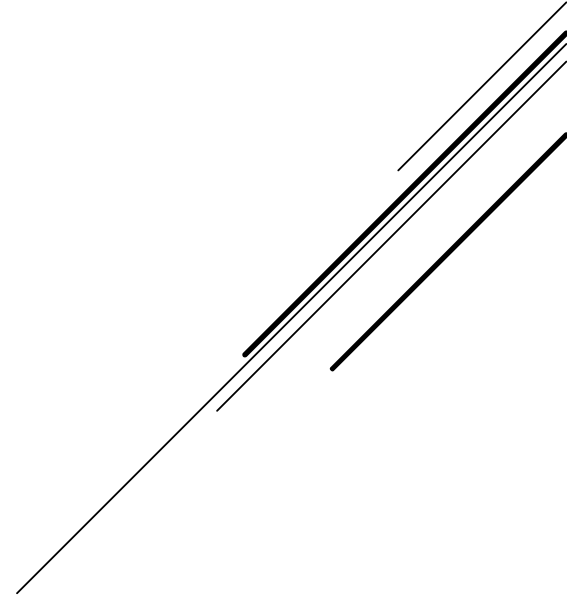


EXPORT TO GOOGLE CARDBOARD IN UNITY 3D



<https://www.assetstore.unity3d.com/en/#!/content/32647>

EXPORT TO HTC VIVE IN UNITY 3D



DATA CAPTURE IN VR DEVICES

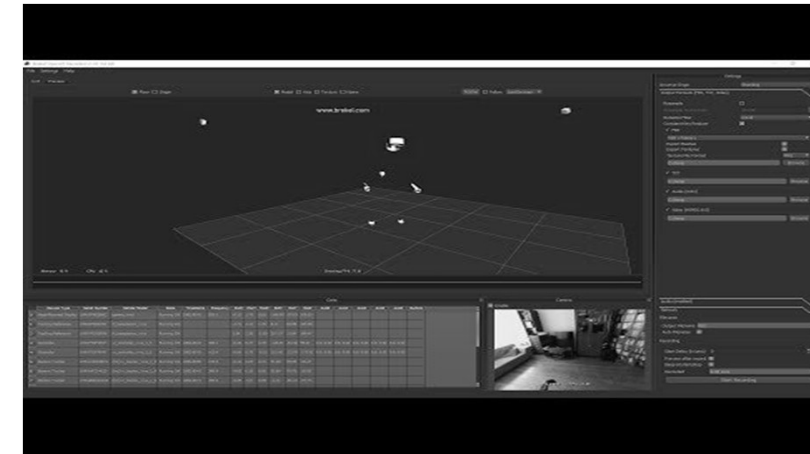
An abstract graphic consisting of several parallel diagonal lines of varying thicknesses, extending from the bottom right towards the top right, partially overlapping the text.

► Data in Physical Level

- ▶ Position and Orientation of VR HMD and controller
- ▶ Open VR recorder
 - ▶ <http://brekel.com/openvr-recorder/>

- Data in Logical Level

- ▶ Game condition (Action and Performance)
- ▶ Questionnaire (Pre and Post)
- ▶ Medical test
 - ▶ Dyslexia Test
 - ▶ Mini-Mental State Examination
 - ▶ Cambridge Neuropsychological Test Automated Battery
 - ▶ Patient Health Questionnaire (PHQ-9)

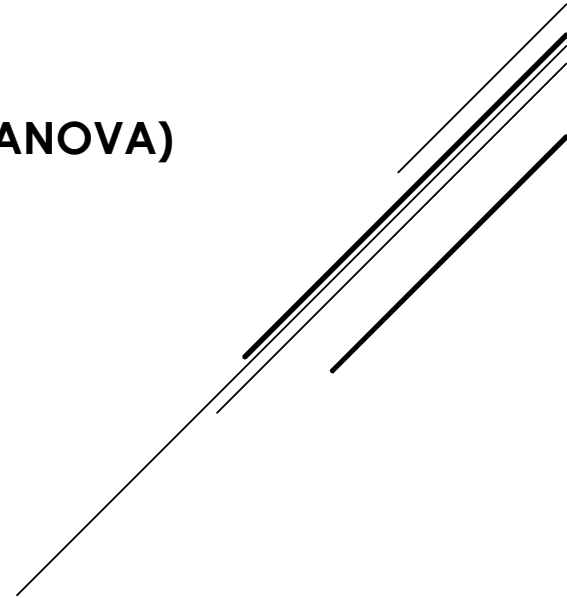


DATA CAPTURE IN VR DEVICES

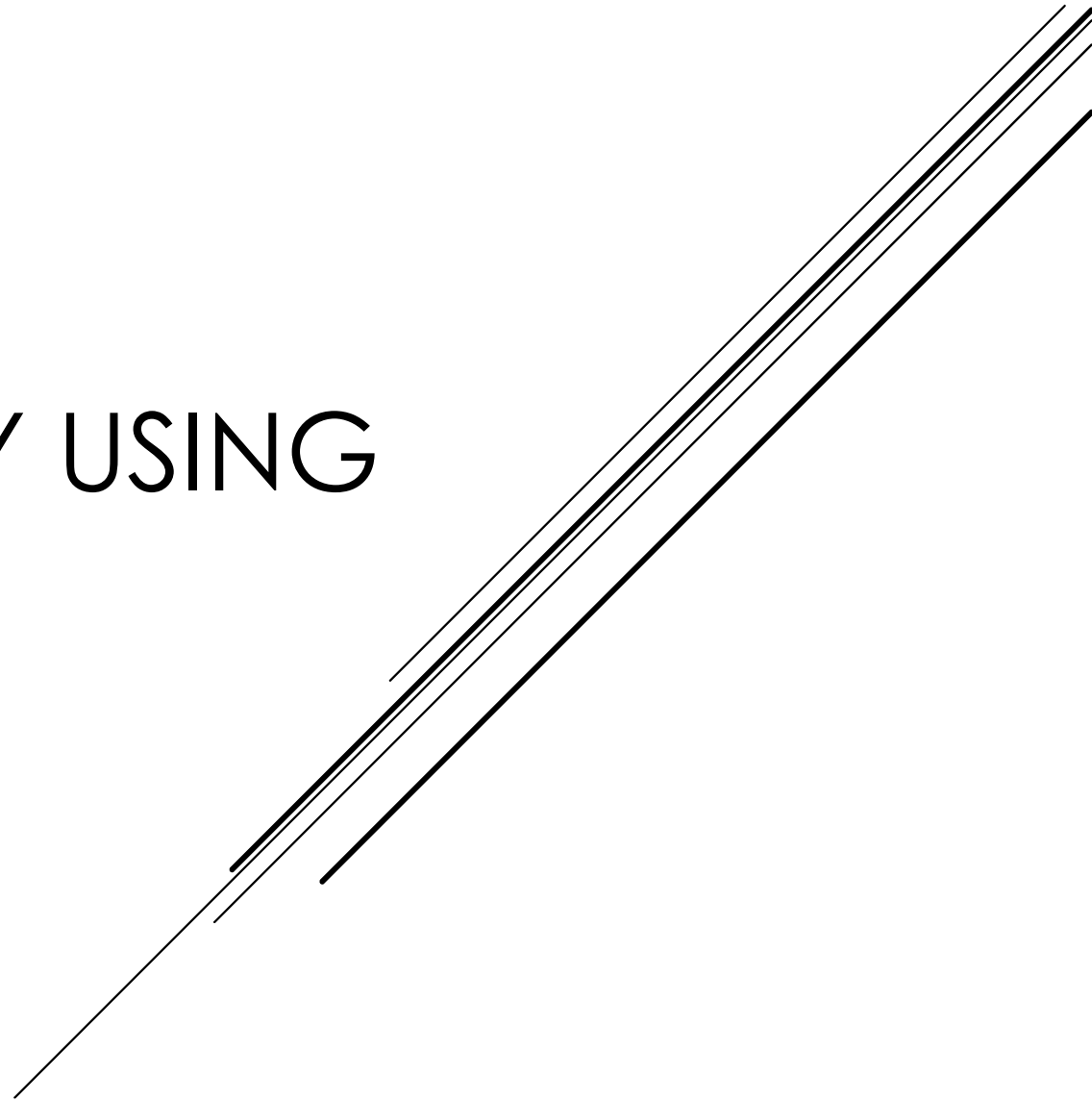
Evaluation of Students Motivation on STEM									
I-CLASS									
我認為「科學」是:									
To me, SCIENCE is:									
11	吸引人的 fascinating	1	2	3	4	5	6	7	平凡的 mundane
12	有魅力的 appealing	1	2	3	4	5	6	7	不吸引人的 unappealing
13	令人興奮的 exciting	1	2	3	4	5	6	7	不令人興奮的 unexciting
14	沒有意義的 means nothing	1	2	3	4	5	6	7	意義重大的 means a lot
15	無聊的 Boring	1	2	3	4	5	6	7	有趣的 interesting
我認為「數學」是:									
To me, MATH is:									
16	吸引人的 fascinating	1	2	3	4	5	6	7	平凡的 mundane
17	有魅力的 appealing	1	2	3	4	5	6	7	不吸引人的 unappealing
18	令人興奮的 exciting	1	2	3	4	5	6	7	不令人興奮的 unexciting
19	沒有意義的 means nothing	1	2	3	4	5	6	7	意義重大的 means a lot
110	無聊的 Boring	1	2	3	4	5	6	7	有趣的 interesting
我認為「工程學」是:									
To me, ENGINEERING is:									
111	吸引人的 fascinating	1	2	3	4	5	6	7	平凡的 mundane
112	有魅力的 appealing	1	2	3	4	5	6	7	不吸引人的 unappealing
113	令人興奮的 exciting	1	2	3	4	5	6	7	不令人興奮的 unexciting
114	沒有意義的 means nothing	1	2	3	4	5	6	7	意義重大的 means a lot
115	無聊的 Boring	1	2	3	4	5	6	7	有趣的 interesting
我認為「科技」是:									
To me, TECHNOLOGY is:									
116	吸引人的 fascinating	1	2	3	4	5	6	7	平凡的 mundane
117	有魅力的 appealing	1	2	3	4	5	6	7	不吸引人的 unappealing
118	令人興奮的 exciting	1	2	3	4	5	6	7	不令人興奮的 unexciting
119	沒有意義的 means nothing	1	2	3	4	5	6	7	意義重大的 means a lot
120	無聊的 Boring	1	2	3	4	5	6	7	有趣的 interesting
我認為「遊戲工程(開發遊戲)」是:									
To me, GAME ENGINEERING (The basis of developing a game) is:									
121	吸引人的 fascinating	1	2	3	4	5	6	7	平凡的 mundane
122	有魅力的 appealing	1	2	3	4	5	6	7	不吸引人的 unappealing
123	令人興奮的 exciting	1	2	3	4	5	6	7	不令人興奮的 unexciting
124	沒有意義的 means nothing	1	2	3	4	5	6	7	意義重大的 means a lot
125	無聊的 Boring	1	2	3	4	5	6	7	有趣的 interesting

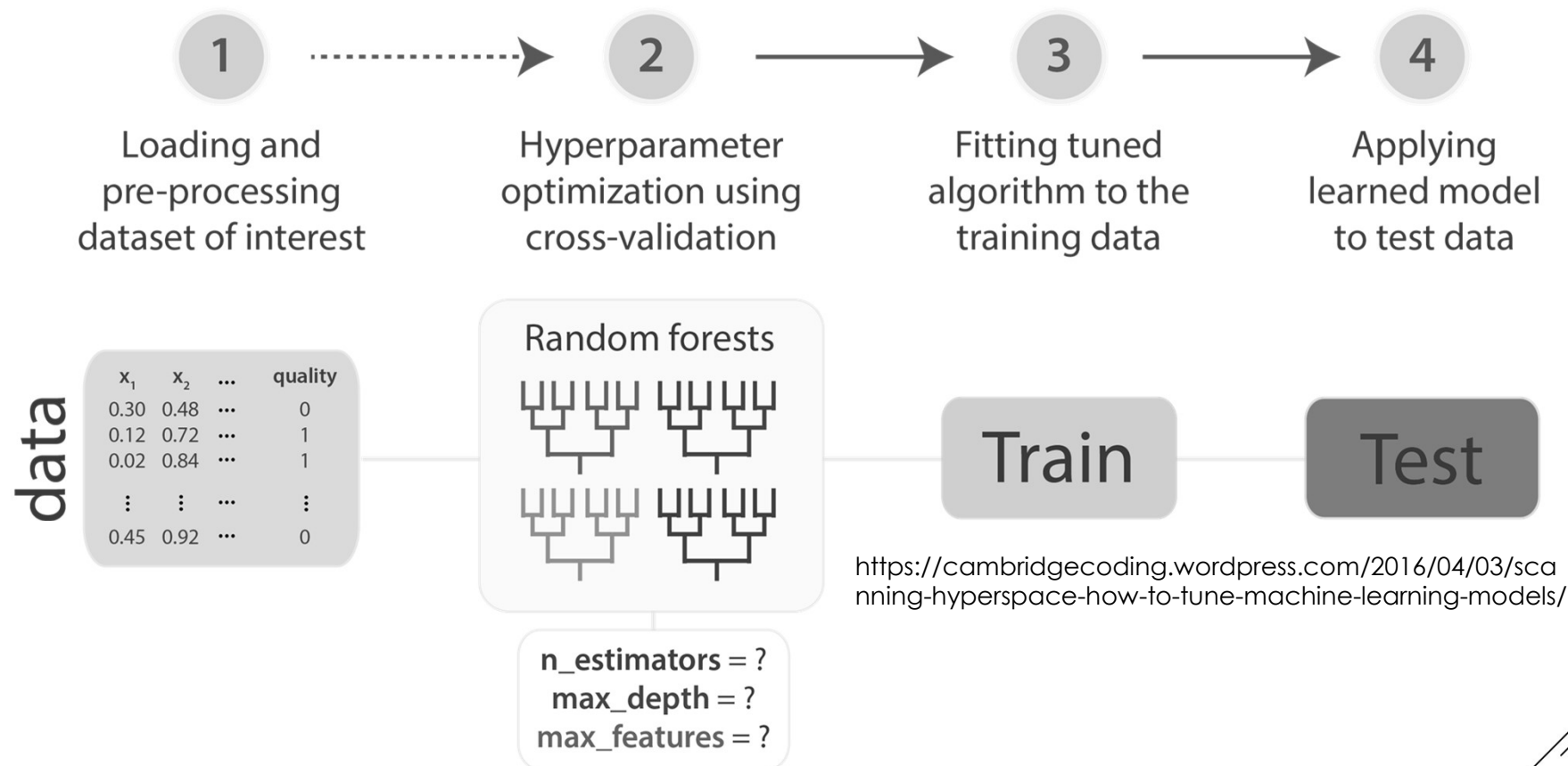
- ▶ Structured Data
 - ▶ In relational databases (RDBMS) / table structure
 - ▶ Field as data dimension
 - ▶ Row as data instance (As many as possible)
- ▶ Unstructured Data
 - ▶ Text, Opened question, images, animation, voice
- ▶ Data Filtering & Data Clustering
- ▶ **Prepare the data in Table Structure**
- ▶ **Retrieve the column data (Min, Max, Avg) and statistics data (P-test, ANOVA)**
- ▶ **Objective: Predict the new data instance**

DATA PRE-PROCESSING IN VR



DATA ANALYSIS BY USING AI APPROACH

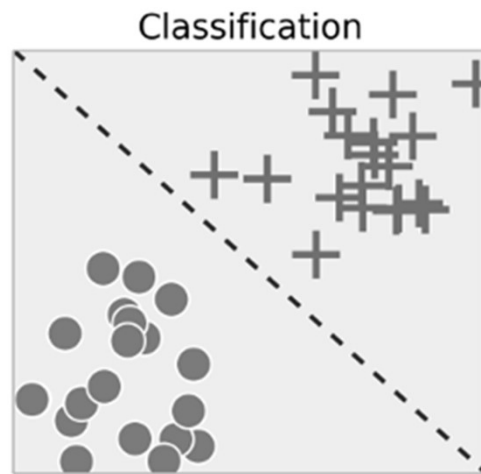




DATA ANALYSIS BY USING AI/MACHINE LEARNING APPROACH

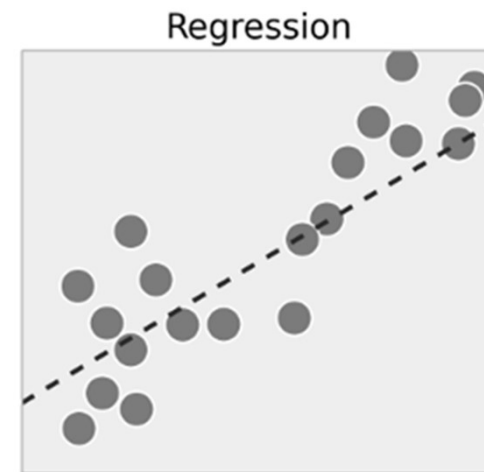
- Classification

- Predict discrete values

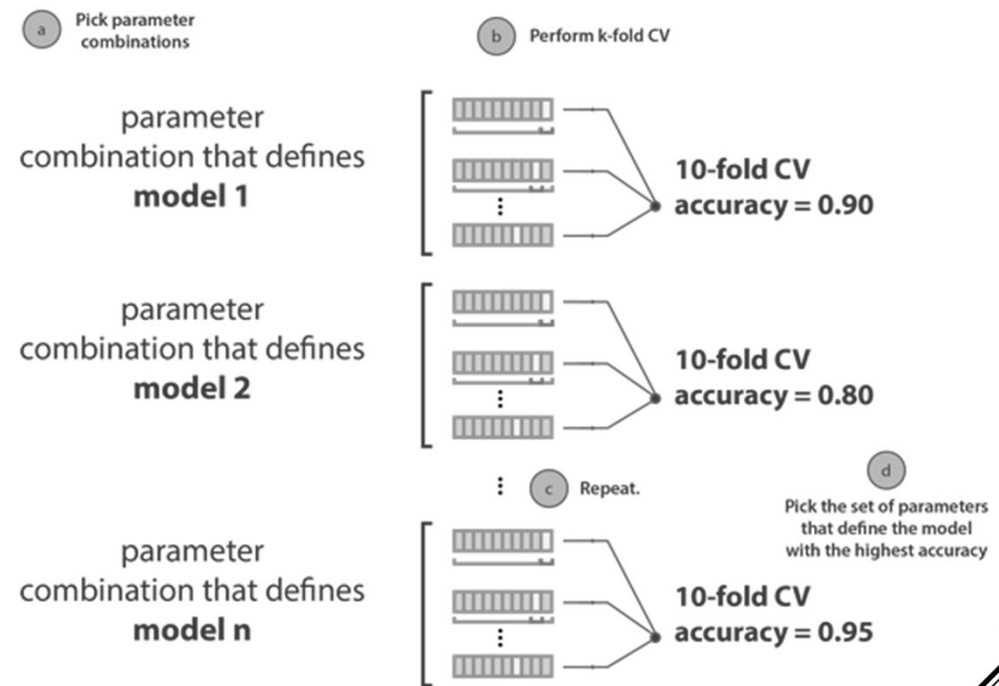
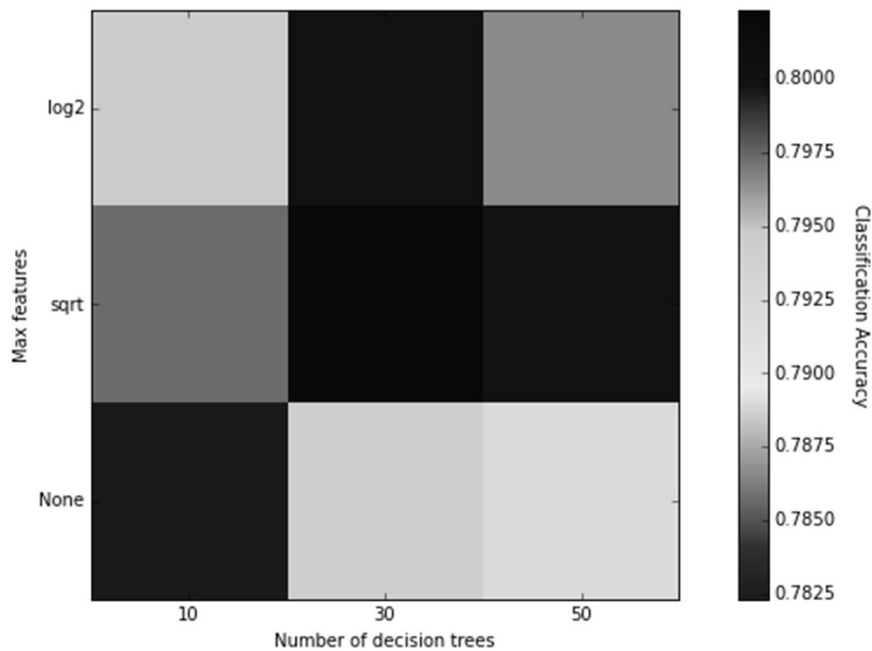


- Regression

- Predict continuous values



REGRESSION / CLASSIFICATION PROBLEM



<https://cambridgecoding.wordpress.com/2016/04/03/scanning-hyperspace-how-to-tune-machine-learning-models/>

DATA FILTERING , CLUSTERING & CHANGING PARAMETER / FIELD TO FIND THE BEST ACCURACY

- ▶ Linear Regression
- ▶ Logistic Regression
- ▶ Classification and Regression Trees
- ▶ K-means Clustering
- ▶ Naive Bayes
- ▶ Fuzzy inference machine
- ▶ Artificial Neural Network, ANN, CNN, RNN, etc

ALGORITHMS FOR MACHINE LEARNING



- ▶ Matlab
- ▶ TensorFlow
- ▶ Azure



TOOLS FOR MACHINE LEARNING

AUGMENTED REALITY HARDWARE (INPUT)

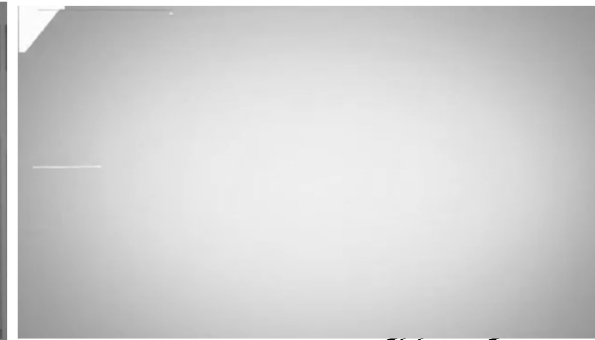


- ▶ Put a virtual object into the real world
- ▶ **Information about the environment or object**
- ▶ Sensory input
 - ▶ Video & graphics
 - ▶ GPS data & Orientation
 - ▶ Sound
 - ▶ RFID, Wifi

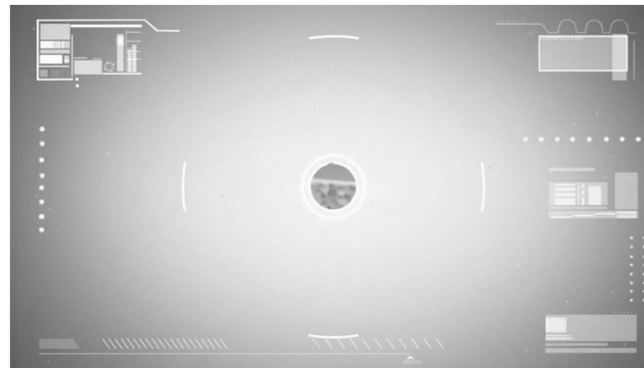
AUGMENTED REALITY



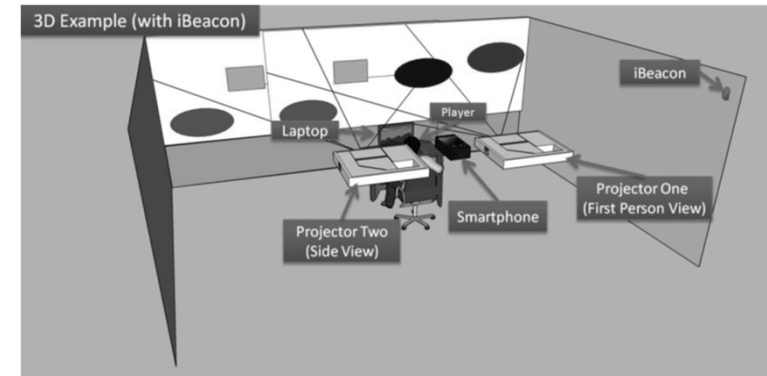
- ▶ QR codes
- ▶ 2D tags
- ▶ Popcode
- ▶ Artificial image
- ▶ Vector graphics



MARKER AR

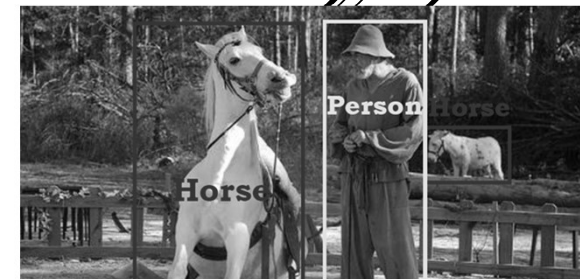


- ▶ RGBD Camera
 - ▶ Project Tango and Smart Terrain
- ▶ Positioning System
 - ▶ GPS, Wifi, iBeacon
- ▶ RGB Camera
 - ▶ Object segmentation
 - ▶ Object recognition
 - ▶ Color segmentation
- ▶ Accelerator



L Shape

MARKERLESS AR



Methods	DPM [1]	SS [2]	Regionlet [3]	R-CNN [4]	SPP [5]	Ours
mAP	33.7%	33.8%	41.7%	54.2%	55.1%	56.3%



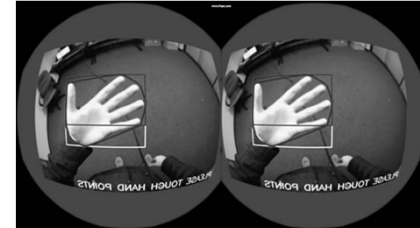
IOS ARKIT

- ▶ iOS 11 introduces ARKit,
- ▶ It allows you to create unparalleled augmented reality experiences
- ▶ RGBD Camera
 - ▶ iPhone X front camera
 - ▶ Detect the position, topology, and expression of the user's face
- ▶ Algorithm
 - ▶ Scene Understanding
 - ▶ Detect horizontal planes (Similar texture and using accelerometer)
 - ▶ Lighting Estimation
 - ▶ Estimate the total amount of light available in a scene and applies the correct amount of lighting to virtual objects

AUGMENTED REALITY
HARDWARE (OUTPUT)



- ▶ The panel therefore works as a device's screen which combine the image from camera and virtual object.
- ▶ Advantage. Cheap. Easy to implement. Limited physical computing.
- ▶ Disadvantage. High Latency



SCREEN OVERLAP



- ▶ The panel therefore works as a device's screen and a see-through glass at the same time.
- ▶ The transparent displays (TDs) have a wide range of use in all industry areas as an efficient tool for delivering information and communication.
- ▶ Latest innovation from the field is set to the transparent technology, which produces displays with a high transparency rate and without a full-size backlight unit
- ▶ Microsoft Applied Science and MIT Media Lab has been developed a unique sensor OLED (Organic Light Emitting Diode) transparent technology.

OPTICAL OVERLAP (TRANSPARENT DISPLAY)

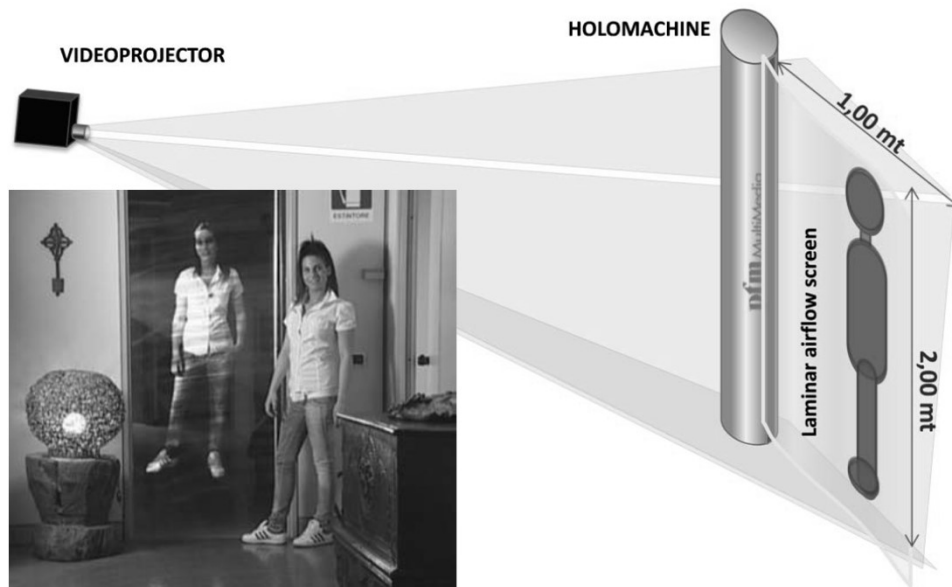


Kent Optronics Inc. (www.kentoptronics.com)

- ▶ Reproduction of a scene is realized with a *non-solid* support.
- ▶ Feeling as sensation of present. Feel the space
- ▶ Images appear to float
- ▶ It is recorded the light scattered from an object and later reconstructed by a beam which restores the high-grade volumetric image of that object
- ▶ Appears three-dimensional and changes as the position and orientation of the viewer changes
- ▶ Project through a dedicated commercially available video-projector

ALIOSCOPY/HOLOGRAPHICS/ VOLUMETRIC DISPLAYS





AUGMENTED REALITY SOFTWARE

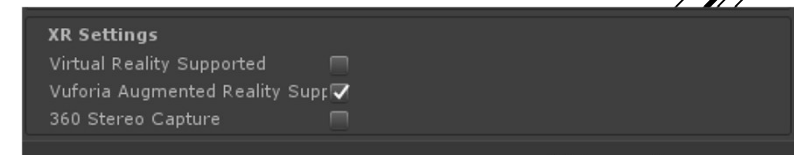
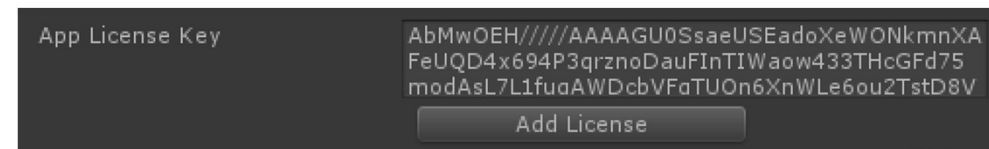
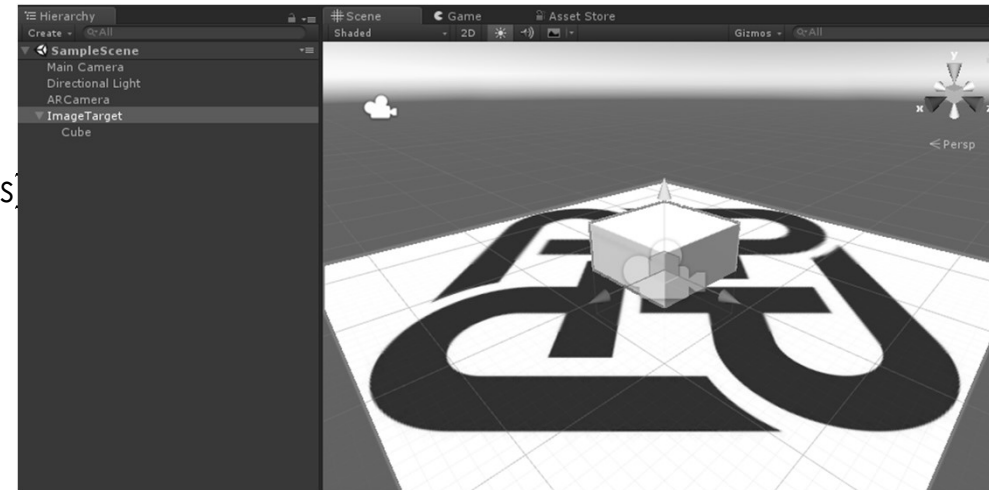


- ▶ Register a Vuforia developer account
 - ▶ <https://developer.vuforia.com/user/register>
- ▶ Download Vuforia SDK for Unity 3D
 - ▶ <https://developer.vuforia.com/downloads/sdk>
- ▶ Open the Unity Project
- ▶ Double click and import the Vuforia SDK
- ▶ Go to Vuforia Website > [Develop] > [License Manager] > [Add License Key]
- ▶ Copy the License Key
- ▶ Go to [Target Manager] > [Device]
- ▶ Select [Single Image] and upload the image
- ▶ State the length of image (pixel)
- ▶ Make sure the rating is 3 stars or above
- ▶ Download the Database
- ▶ Double click and import the Database

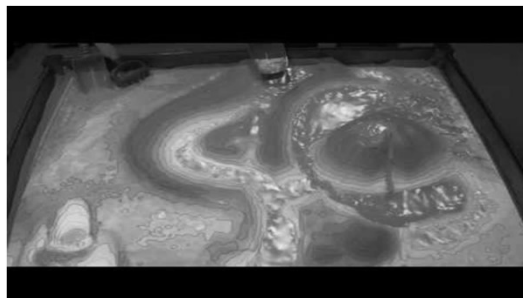
USING VUFORIA PLUGIN IN UNITY 3D

The screenshot displays the Vuforia Developer Portal interface. At the top, the navigation bar includes links for Home, Pricing, Downloads, Library, Develop, and Support. Below this, the 'License Manager' and 'Target Manager' tabs are visible. The 'License Manager' section prompts the user to 'Create a license key for your application' and features an 'Add License Key' button. The 'Target Manager' section is active, showing a 'Create Database' dialog box with fields for 'Name' and 'Type' (Device, Cloud, VuMark). Below the dialog, a table lists existing targets, including 'PolyU' which is selected. To the right, the 'License Key' is displayed as a long alphanumeric string, and the 'Usage' section shows the license type as 'Development', status as 'Active', and creation date as 'May 31, 2017 11:40'. The 'Add Target' section shows options for 'Single Image', 'Cuboid', 'Cylinder', and '3D Object', with 'Single Image' selected. A file upload section shows 'PolyU.jpg' being uploaded, with a width of 128 pixels specified.

- ▶ Install all the additional
- ▶ Import the [ImageTarget] & [ARCamera] from [All Prefabs] to the scene
- ▶ Select [ImageTarget]
 - ▶ Select the [Database]
 - ▶ Put the object on the Image Target
- ▶ Select [ARCamera]
 - ▶ Open the Vuforia Configuration
 - ▶ Add the APP License Key
 - ▶ Load and Activate the Database
- ▶ Enable Vuforia Augmented Reality Support in the player setting



USING VUFORIA PLUGIN IN UNITY 3D



MIXED REALITY