

利用混合實境技術展示BIM 工程模型與開放地理資料之 現況與挑戰

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計畫主持人: 國立高雄科技大學營建系 盧之偉 教授



2018.11.06

@行政院農委會水土保持局 技術研究發展小組

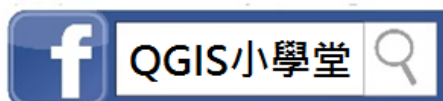
導讀者是誰?

我名片上的 (假的,暫時的....)

- ▶ 應用地質技師
- ▶ 高雄應用地質公會理事
- ▶ 應用地質公會全聯會監事
- ▶ 嘉南藥理大學兼任講師
- ▶ 聚禾工程顧問有限公司負責人

我覺得可以的(這才是真的!)

- ▶ 高中一年級(1986)開始寫程式
- ▶ 工作中接觸**地理資訊系統(GIS)**
- ▶ 寫了兩本GIS書
- ▶ 撰寫GIS工具,超過萬人下載
- ▶ FaceBook QGIS小學堂版主



除了 VR....

澎湖南方四島
這輩子一定要
去一次!

西吉嶼藍洞



東吉嶼，王爺廟

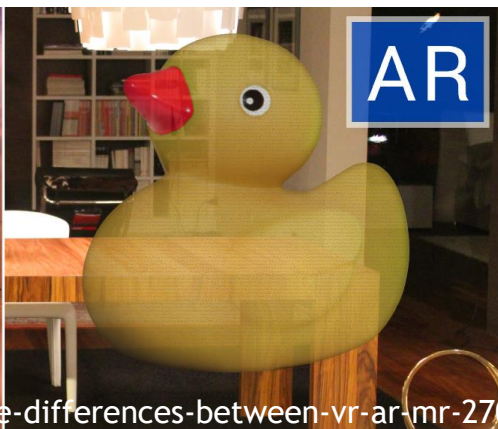
穿戴裝置上的VR,AR,MR



What is Mixed Reality?



虛擬環境



虛擬物件與真實環境套疊



虛擬物件與真實環境融合



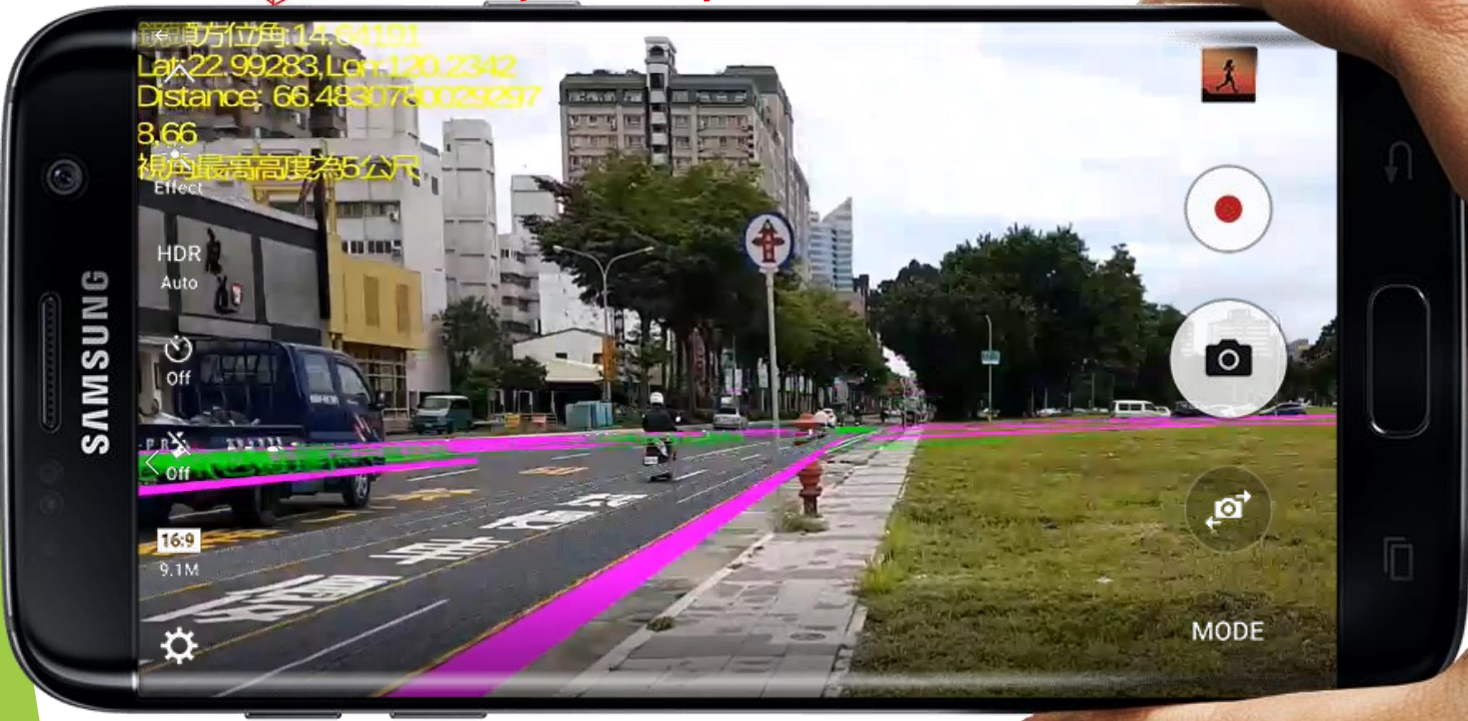
圖片來源:<https://read01.com/o3n0JM.html#.W2ljXIElPY>



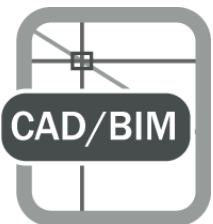
具備地理
資訊概念

- ◆ 虛擬實境 (Virtual Reality, VR)
- ◆ 擴增實境 (Augmented Reality, AR)
- ◆ 混合實境 (Mixed Reality, MR)

穿戴裝置虛擬物件(BIM)與真實環境融合



OpenStreetMap
OSM XML



BIM



Camera

利用擴增實境技術展現 開放地理資料

以 開放街圖(OpenStreetMap)為例

OSM XML Elements



The screenshot shows the OpenStreetMap Wiki page for 'Elements'. The browser address bar displays 'https://wiki.openstreetmap.org/wiki/Elements'. The page features a sidebar with navigation links: 首頁, The map, Map Features, Contributors, 說明, Blogs, Shop, Donations, 近期變更, and 工具. The main content area has tabs for '頁面' and '討論', and buttons for '閱讀', '檢視原始碼', '檢視歷史', and '搜尋'. The title 'Elements' is prominently displayed. Below it, a section titled 'Available languages — Elements' lists various language options including English, Spanish, French, Italian, etc. Another section titled 'Other languages — Help us translate this wiki' is also present. The main text explains that 'Elements' are the basic components of OpenStreetMap's conceptual data model of the physical world, consisting of nodes, ways, and relations. It also mentions that all these elements can have associated tags.

首頁
The map
Map Features
Contributors
說明
Blogs
Shop
Donations
近期變更
工具

頁面 討論

閱讀 檢視原始碼 檢視歷史 搜尋

Elements

Available languages — *Elements*

• čeština • Deutsch • **English** • español • français • italiano • magyar • Nederlands • polski • português • slovenčina • suomi • svenska • 한국어 • 日本語 • 中文 (简体) • فارسی

Other languages — Help us translate this wiki

Elements are the basic components of OpenStreetMap's *conceptual data model of the physical world*. They consist of

- **nodes** (defining points in space),
- **ways** (defining linear features and area boundaries), and
- **relations** (which are sometimes used to explain how other elements work together).

All of the above can have one or more associated **tags** (which describe the meaning of a particular element).

Elements are the basic components of OpenStreetMap's *conceptual data model of the physical world*. They consist of

- **nodes** (defining points in space),
- **ways** (defining linear features and area boundaries), and
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All of the above can have one or more associated **tags** (which describe the meaning of a particular element).

OSM XML Example

座標系統WGS84
(EPSG 4326)

```
<node id="3993164342" visible="true" version="1" changeset="37054881" timestamp="2016-02-07T07:59:38Z" user="Supaplex" uid="120.2443000">
  lon="120.2443000">
    <tag k="addr:city" v="臺南市"/>
    <tag k="addr:district" v="永康區"/>
    <tag k="addr:full" v="復國路53巷1號"/>
    <tag k="addr:village" v="光復里"/>
    <tag k="amenity" v="community_centre"/>
    <tag k="emergency:amenity" v="social_facility"/>
    <tag k="emergency:description" v="光復里、建國里、周邊居民"/>
    <tag k="emergency:shelter_type" v="水災"/>
    <tag k="emergency:social_facility:capacity" v="146"/>
    <tag k="emergency:social_facility:code" v="SD710-0003"/>
    <tag k="emergency:social_facility:id" v="4869"/>
    <tag k="isIndoor" v="yes"/>
    <tag k="isOutdoor" v="no"/>
    <tag k="name" v="臺南市永康區光復里活動中心"/>
  </node>
```

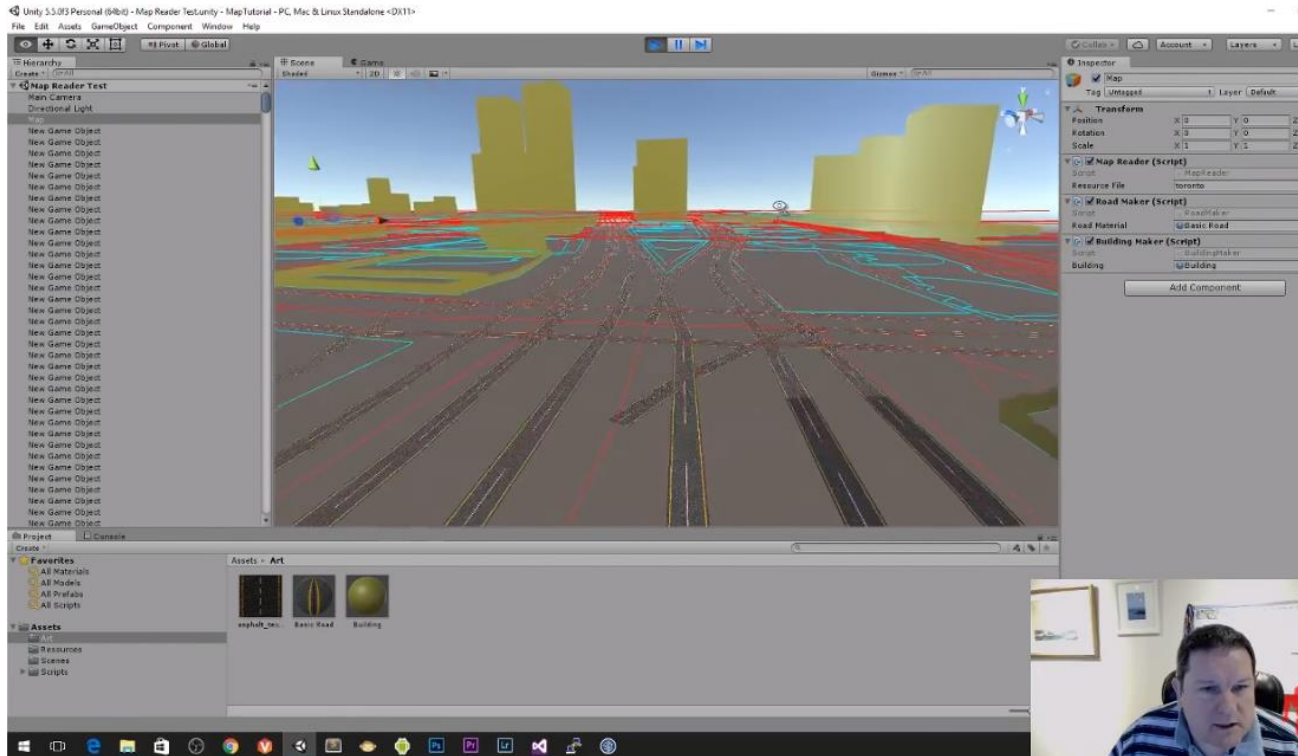
<<點>>

```
<way id="317035628" visible="true" version="2" changeset="37288200" timestamp="2016-02-18T13:48:08Z" user="Kagami" uid="189328">
  <nd ref="3232607317"/>
  <nd ref="3232607318"/>
  <tag k="highway" v="service"/>
  <tag k="lanes" v="1"/>
  <tag k="name" v="建東街63巷"/>
  <tag k="service" v="alley"/>
  <tag k="surface" v="asphalt"/>
</way>
```

<<線>>

```
<relation id="3392763" visible="true" version="1" changeset="19577616" timestamp="2013-12-22T08:24:30Z" user="Kagami" uid="189328">
  <member type="way" ref="253004076" role="outer"/>
  <member type="way" ref="253004065" role="outer"/>
  <tag k="admin_level" v="9"/>
  <tag k="boundary" v="administrative"/>
  <tag k="is_in" v="臺南市永康區"/>
  <tag k="name" v="光復里"/>
  <tag k="type" v="boundary"/>
</relation>
```

<<面>>



Parsing OSM XML by Sloan Kelly

CODE

<https://bitbucket.org/sloankelly/youtube-source-repository>

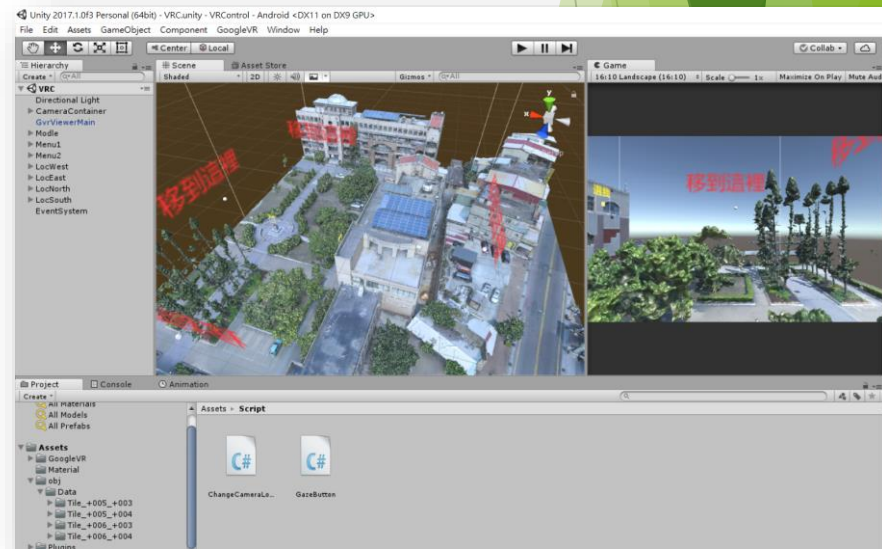
Tutorial

<https://www.youtube.com/watch?v=780la5e8LHQ>



Why use

- ◆ 一次開發跨平台發布
- ◆ 支援VR,AR,MR虛擬眼鏡
- ◆ 豐富第三方資源
- ◆ 強大的遊戲引擎
- ◆ 易於開發



OSM data → Unity

- ✓ Mercator projection
- ✓ Axis Translation

座標投影(球面座標→平面座標)



手機GPS

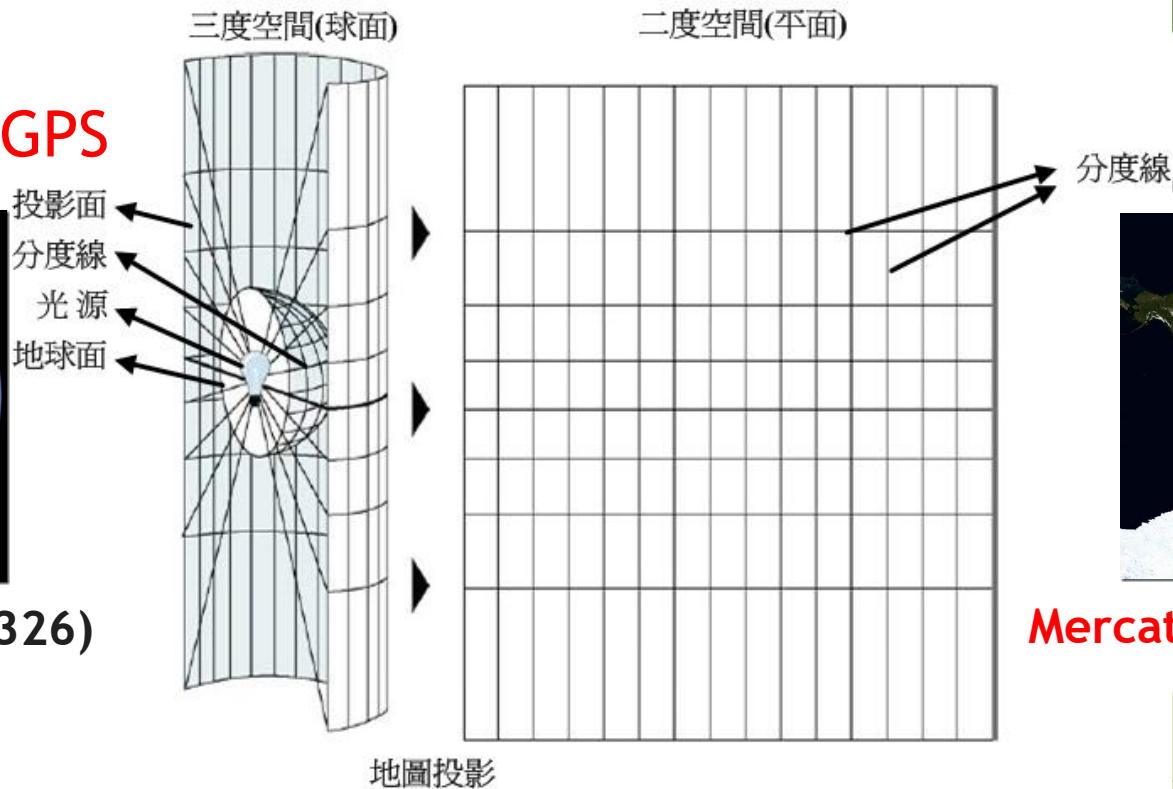


WGS84 (EPSG 4326)
Lon, Lat



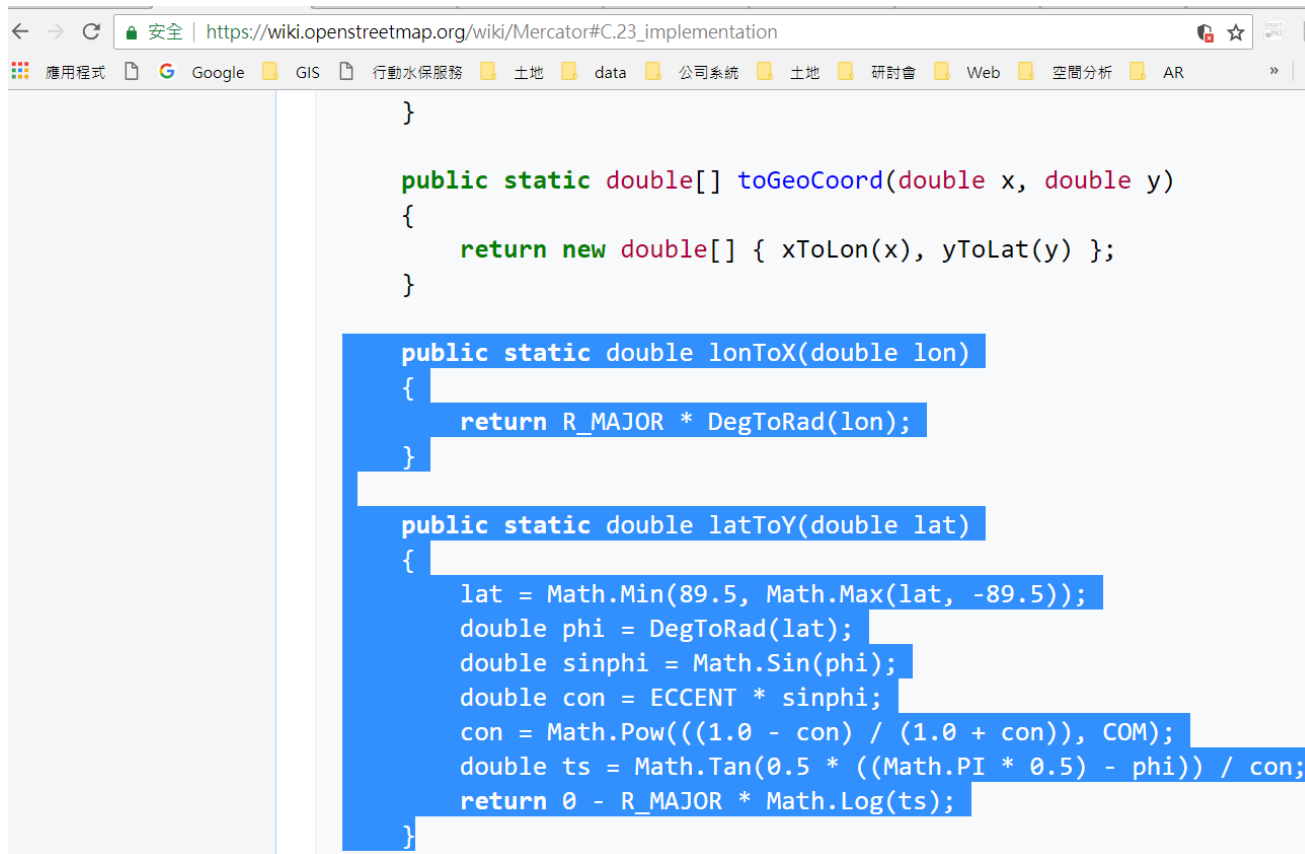
OSM XML

OpenStreetMap



Mercator (EPSG 3857)
X, Y

於unity中 使用 **OSM** Mercator projection

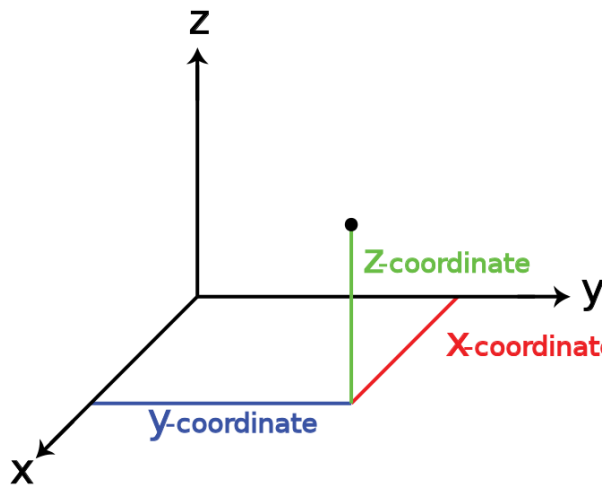
A screenshot of a web browser window displaying the OpenStreetMap Wiki page for the Mercator projection implementation. The browser's address bar shows the URL 'https://wiki.openstreetmap.org/wiki/Mercator#C.23_implementation'. The page content shows C# code for the projection. The code includes a 'toGeoCoord' method and two other methods, 'lonToX' and 'latToY', which are highlighted with a blue background. The 'lonToX' method converts longitude to a planar coordinate, and the 'latToY' method converts latitude to a planar coordinate, taking into account the Earth's eccentricity and the Mercator projection's properties.

```
}  
  
public static double[] toGeoCoord(double x, double y)  
{  
    return new double[] { xToLon(x), yToLat(y) };  
}  
  
public static double lonToX(double lon)  
{  
    return R_MAJOR * DegToRad(lon);  
}  
  
public static double latToY(double lat)  
{  
    lat = Math.Min(89.5, Math.Max(lat, -89.5));  
    double phi = DegToRad(lat);  
    double sinphi = Math.Sin(phi);  
    double con = ECCENT * sinphi;  
    con = Math.Pow(((1.0 - con) / (1.0 + con)), COM);  
    double ts = Math.Tan(0.5 * ((Math.PI * 0.5) - phi)) / con;  
    return 0 - R_MAJOR * Math.Log(ts);  
}
```

https://wiki.openstreetmap.org/wiki/Mercator#C.23_implementation

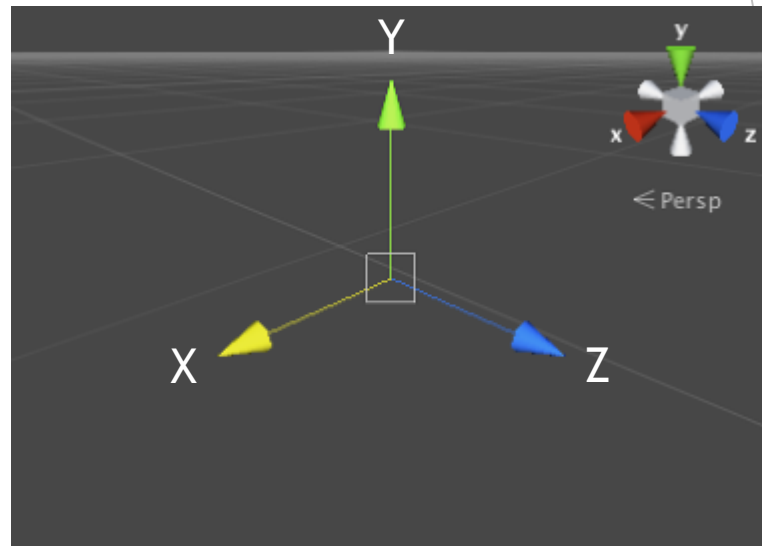
Axis Translation of Geospatial Data

► $(X, Y, Z) \rightarrow (X, Z, Y)$



https://en.wikipedia.org/wiki/Three-dimensional_space#/media/File:Coord_planes_color.svg

Geospatial Data



Unity environment

Code example

```
Vector3 PT = new Vector3();
float dx = (float)node.X - map.orgx;
float dy = (float)node.Y - map.orgy;
PT = new Vector3(dx, 0.0f, dy);
Vector3 ROT = new Vector3(180f, 0f, 0f);
Pointer.transform.Rotate(ROT);
Instantiate(Pointer, PT, transform.rotation);
// GameObject sphere = GameObject.CreatePrimitive(PrimitiveType.Sphere);
// sphere.transform.position = new Vector3(dx, 0.0f, dy);
// sphere.transform.localScale = new Vector3(5.0f, 5.0f, 5.0f);
Debug.Log("Point:" + dx + "," + dy);

GameObject gotext = new GameObject(V);
TextMesh BulidingName = gotext.AddComponent<TextMesh>();
MeshRenderer mrName = gotext.AddComponent<MeshRenderer>();
BulidingName.text = V;
Font ArialFont = (Font)Resources.GetBuiltinResource(typeof(Font), "Arial.ttf");
ArialFont.material.color = Color.green;
BulidingName.font = ArialFont;

BulidingName.characterSize = 8;
// gotext.transform.parent = Pointer.transform;
gotext.transform.position = new Vector3(dx, 2f, dy);
// Vector3 TextRotate = new Vector3(90,0,0);
Vector3 TextRotate = new Vector3(0, 0, 0);
gotext.transform.Rotate(TextRotate);
```

(x,y,z)

MR → Unity

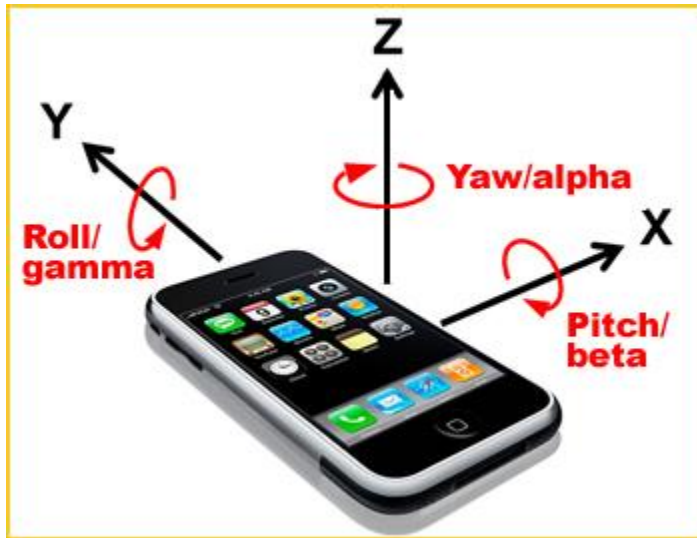
- ✓ Mercator projection
- ✓ Axis Translation

Control Main Camera in unity using Gyroscope

Camera Render Depth

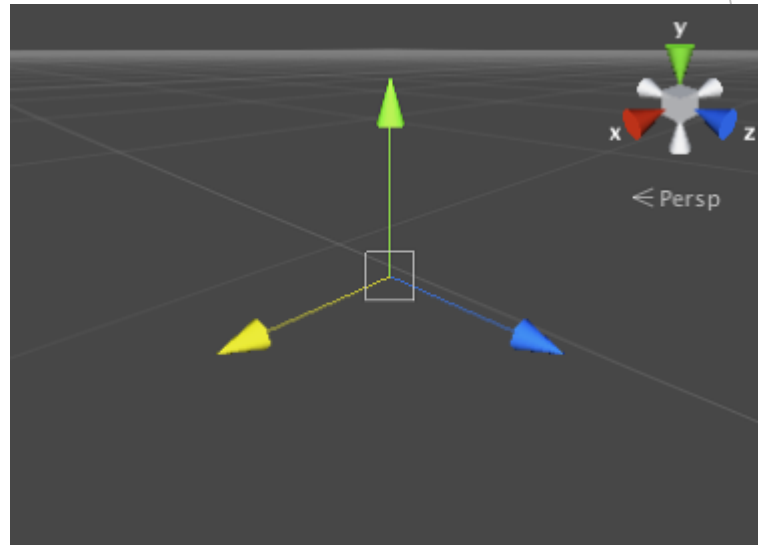
Axis Translation of Gyroscope

► $(X, Y, Z) \rightarrow (X, Z, Y)$



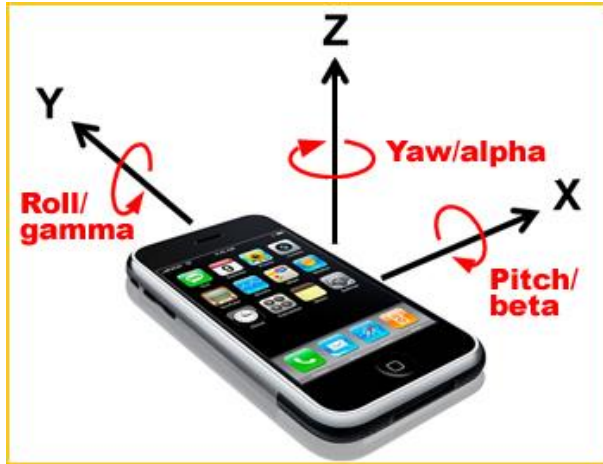
http://www.sentiance.com/wp-content/uploads/2016/02/javascript_sensors_yaw.jpg

Gyroscope



scene in unity

Control Main Camera in unity using Gyroscope

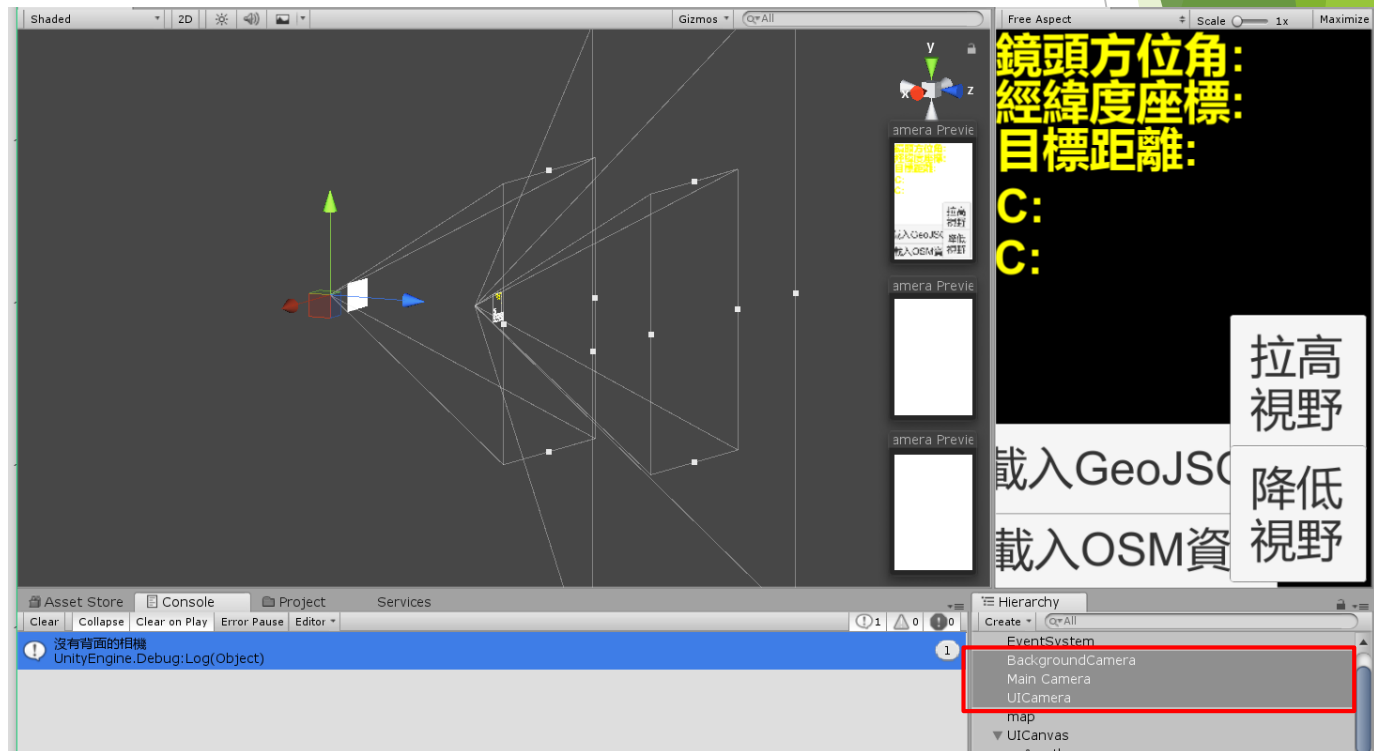
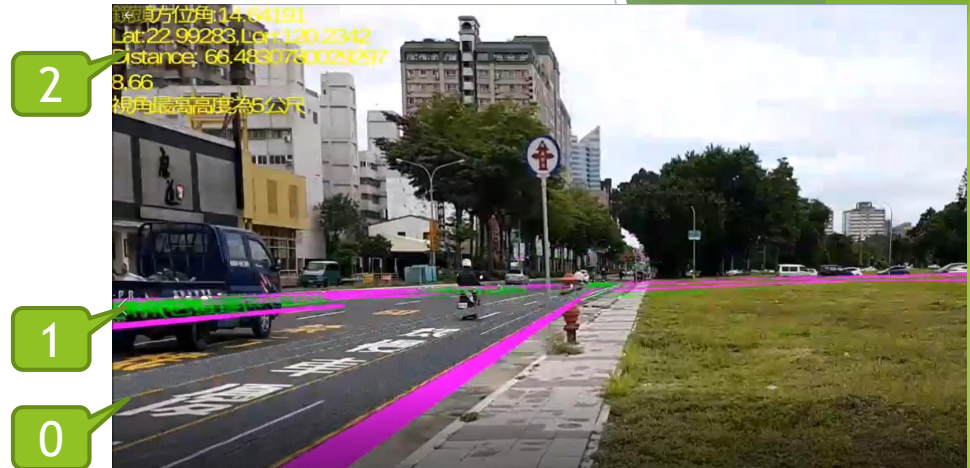


http://www.sentiance.com/wp-content/uploads/2016/02/javascript_sensors_yaw.jpg

```
private void ApplyGyroRotation()
{
    _rawGyroRotation.rotation = Input.gyro.attitude;
    // Swap "handedness" of quaternion from gyro.
    _rawGyroRotation.Rotate(0f, 0f, 180f, Space.Self);
    // Rotate to make sense as a camera pointing out the back of your device.
    rawGyroRotation.Rotate(90f, 180f, 0f, Space.World);
    // Save the angle around y axis for use in calibration.
    _appliedGyroYAngle = _rawGyroRotation.eulerAngles.y;
}
```

Camera Render Depth

- ▶ Camera,內容,Rendering depth
 - ▶ UICamera ,APP介面,2
 - ▶ MainCamera,OSM data,1
 - ▶ BackGroundCamera,手機影像,0



Demonstrations

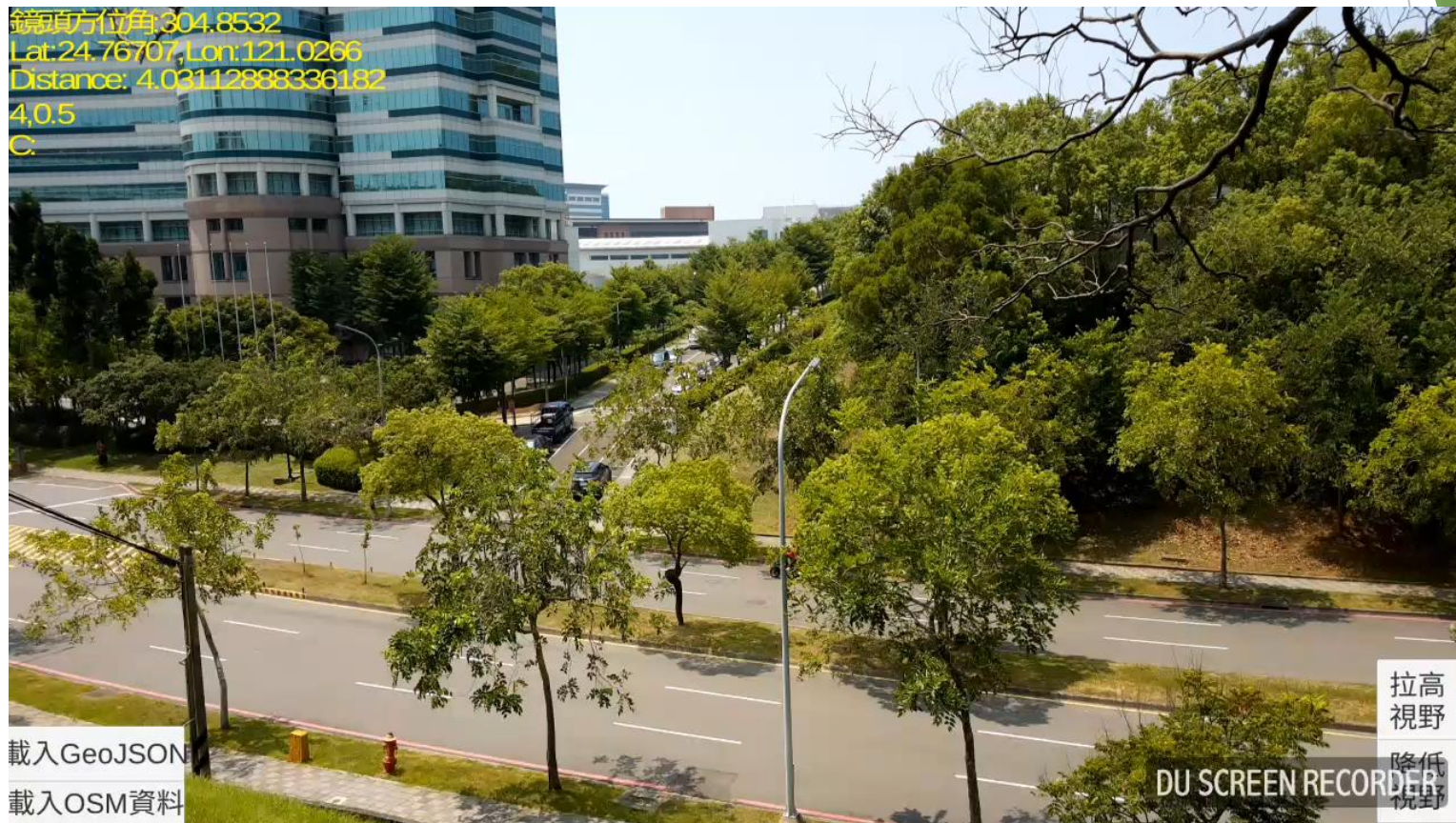
Building

Road

台南市南紡夢時代



新竹科學園區



台灣科技大學

利用擴增實境技術展現 BIM資料 - 虛擬放樣

以 水保工程為例

擬解決問題

過去



2D設計圖
修改費時
設計不符現況

現在



3D模型
擬真受限
室內展示

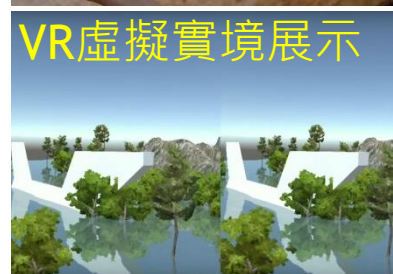
未來



AR擴增實境展示



MR混和實境虛擬放



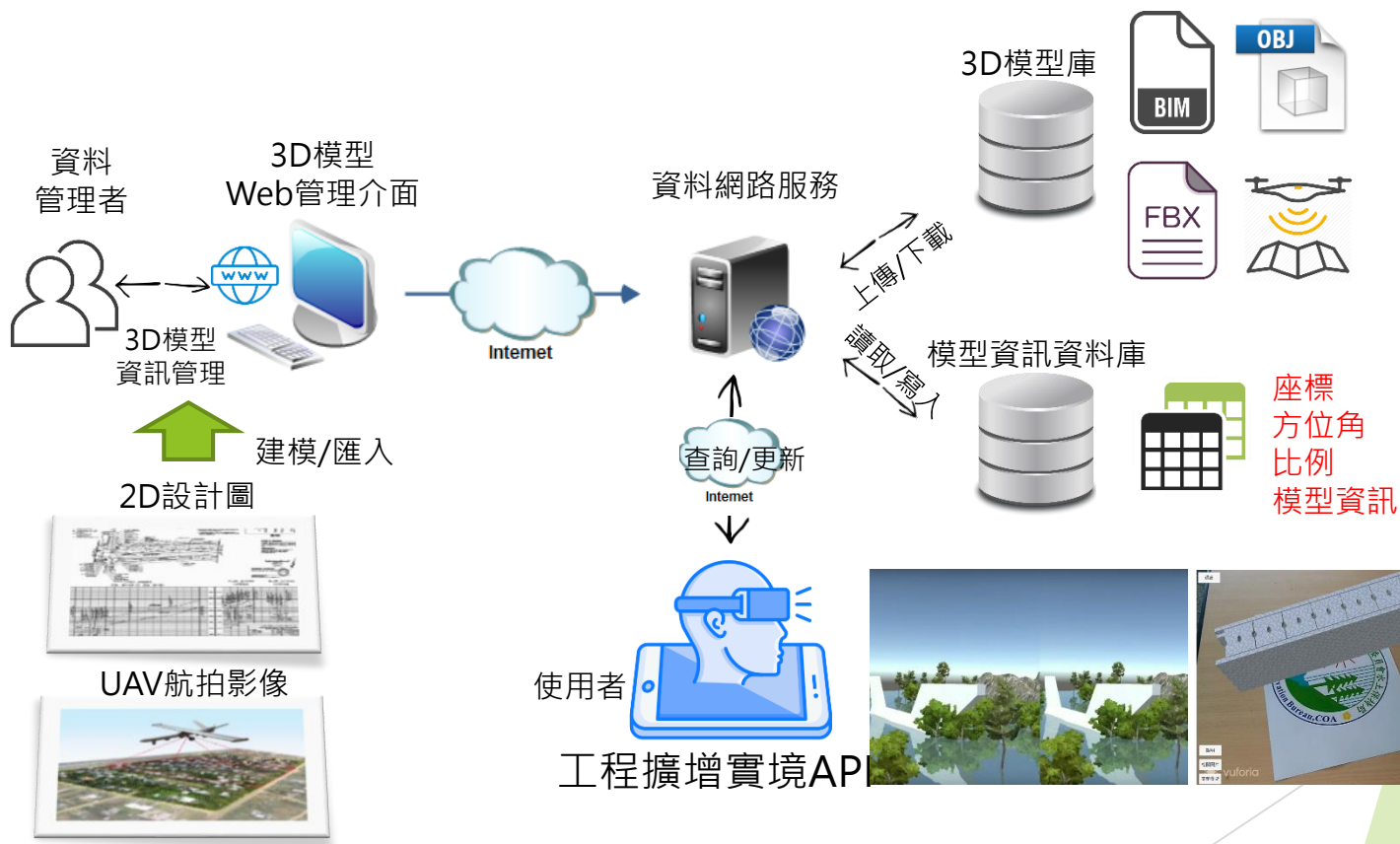
VR虛擬實境展示

3D模型庫+擴增實境
虛擬放樣
行動展示

擬解決問題

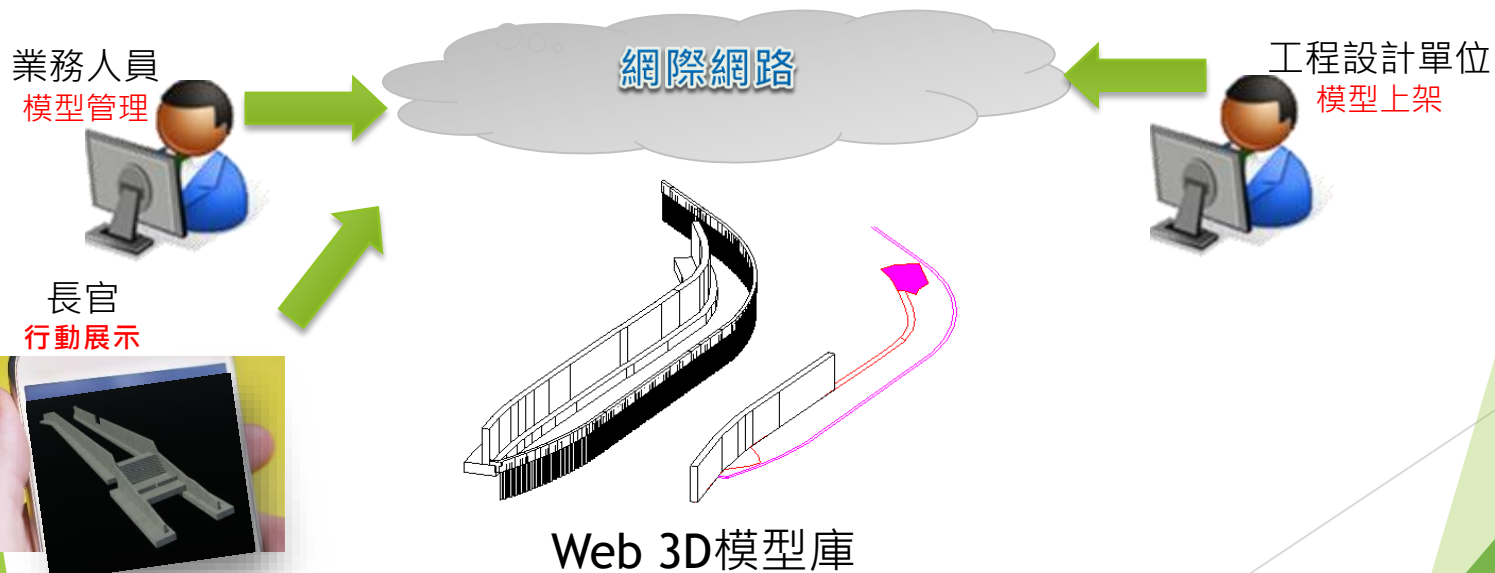
- ▶ 工程施作前-合宜適地的設計
 - ▶ 降低變更設計風險
 - ▶ BIM即時材料及費用估算
 - ▶ 虛擬放樣
- ▶ 工程施作中-符合設計的施工
 - ▶ 數位監工
- ▶ 工程施作後-工程效益的精進
 - ▶ 工程管理
 - ▶ 工程效益評估

工程擴增實境管理系統架構設計



3D模型Web管理介面

- ▶ 使用技術
 - ▶ 網頁技術及three.js套件
- ▶ 功能設計
 - ▶ 3D工程模型及集水區實境場景上架、刪除、3D展示、下載、權限控管
- ▶ 使用者
 - ▶ 工程設計單位、業務人員、長官



BIM模型上架流程

登入系統

重大土砂災害集水區工程擴增實境管理系統

登入網頁

首先點選“登入系統”按鈕，
開啟登入系統畫面



模型清單

[新增模型]	項次	緯度	經度	方位角(0~360度)	縮放比	X軸轉向	Y軸轉向	Z軸轉向	下載模型	管理模型
	1	23.004024076661338	120.23639504825634	0	0.5	-270	90	0	FBX層	[編輯] [刪除]
	2	22.5262769306277	120.68529230490	0	1	0	0	0	來義-挑流工(zip)	[編輯] [刪除]
	3	22.54751300211919	120.71459711476857	0	1	0	0	0	來義-現有瑞士牆-鋼板樁	[編輯] [刪除]

座標系統:WGS84

新增模型頁面

登出

設定模型地理位置

管理模型

點選地圖即可設定新增模型之經緯度座標

選擇檔案 未選擇任何檔案

自訂名稱:

緯度:

經度:

方位角:

比例尺:

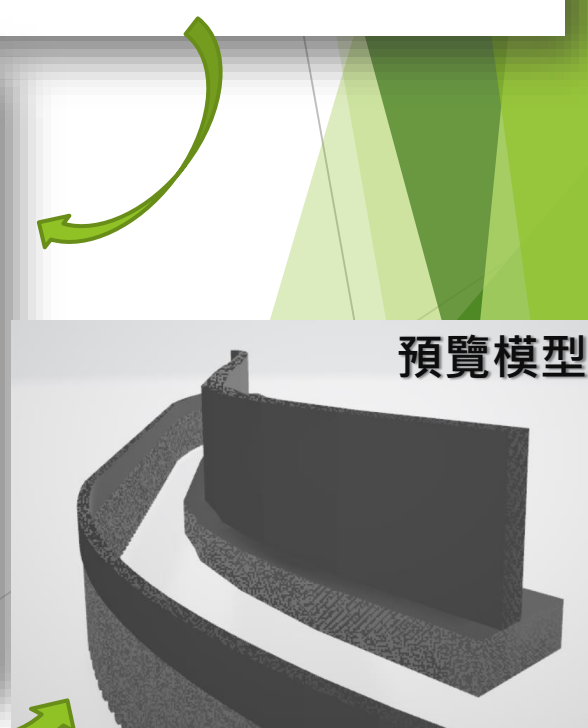
X軸轉向:

Y軸轉向:

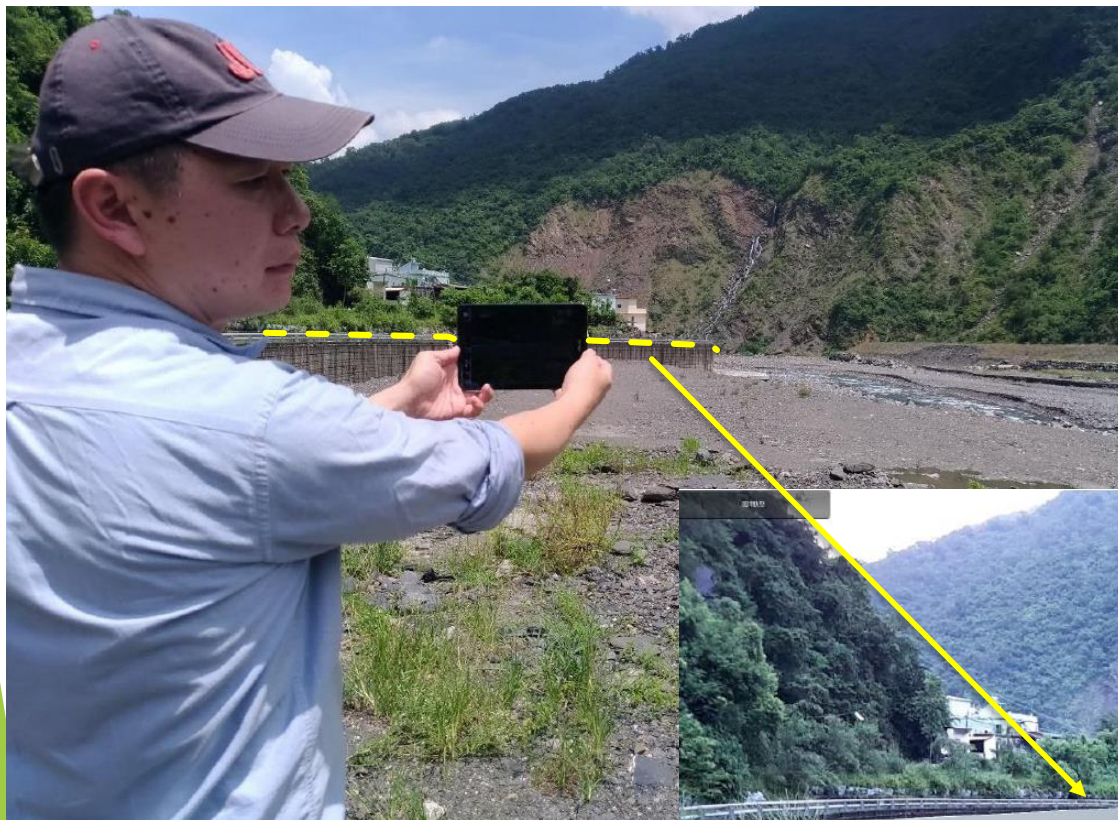
Z軸轉向:

說明:實際方位角及轉向的單位為°,
再輸入實際比例尺時,
只需輸入單一比例尺數值即可(例:輸入比例尺為1,將會換算為1:1:1)。

[\[點此上傳模型\]](#)
取消



工程擴增實境APP



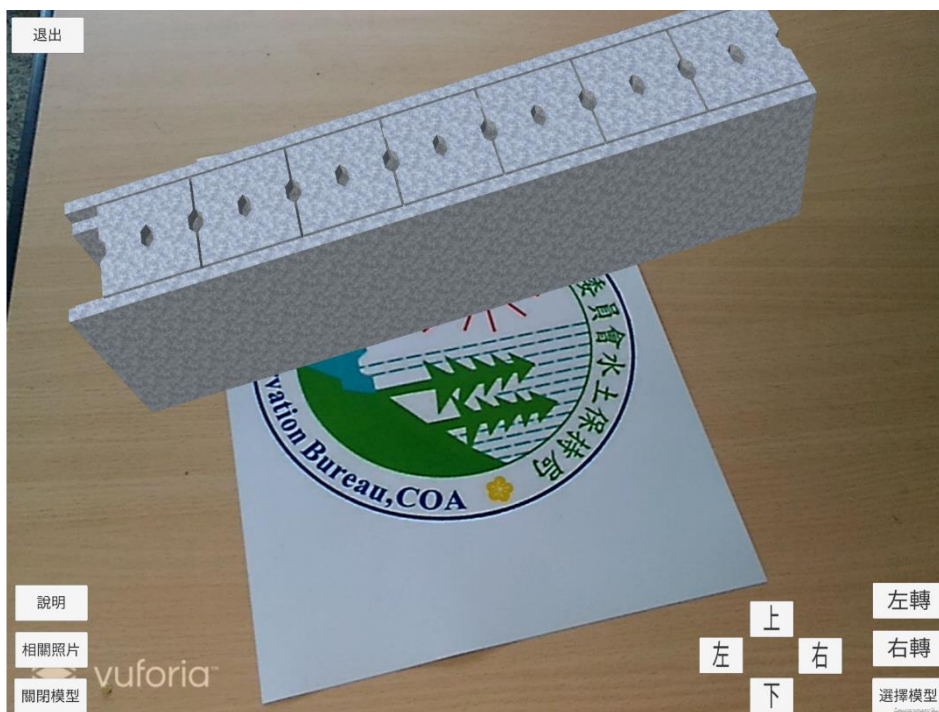
工程擴增實境APP開發

- ▶ 使用技術
 - ▶ UNITY遊戲開發引擎
 - ▶ 具備跨平台能力Windows、Android、iOS
- ▶ 室內虛擬實境
 - ▶ 以虛擬眼鏡為主要呈現方式
- ▶ 室外擴增實境
 - ▶ 手機方式可讓使用者於工程尚未施作前，於現地進行虛擬放樣



室內虛擬實境展示

- ▶ 使用者透過手機，可於室內展現**3D**實境場景模型及工程模型
- ▶ 透過內建之文字、動畫、影音等導覽解說內容與使用者互動
- ▶ 提供使用者與尚未到達集水區前，對於工程有一初步之認知與了解



室外擴增實境展示

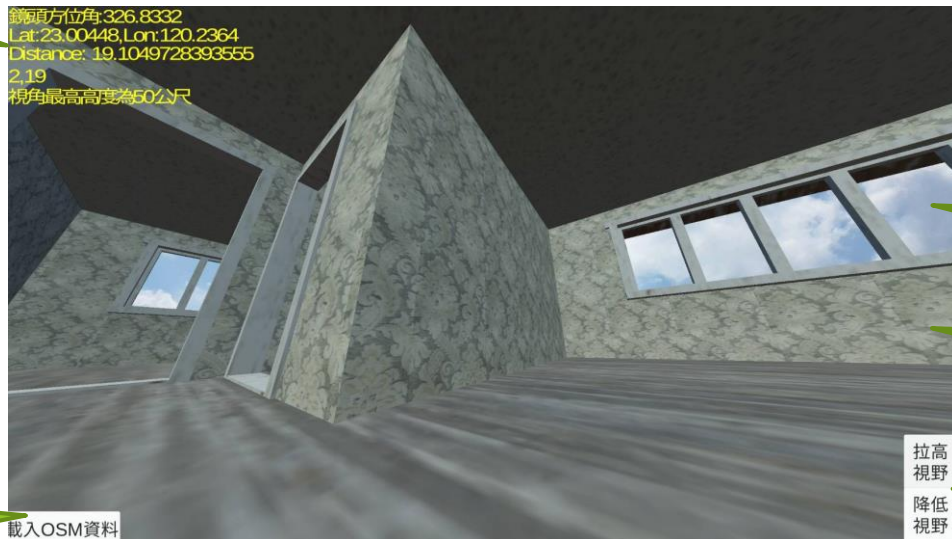
- ▶ 設計以手機方式可讓使用者於工程尚未施作前，於現地進行虛擬放樣
- ▶ 將預計施作之3D工程模型與現場實況影像疊合，模擬展現施工後之工程現況
- ▶ 提供工程設計修正與討論互動之有效互動平台

手持裝置
資訊

鏡頭方位角:326.8332
Lat:23.00448,Lon:120.2364
Distance: 19.1049728393555
2.19
視角最高高度為50公尺

載入背景
資訊

載入OSM資料



實境

虛擬放樣

視野控制

拉高
視野
降低
視野

國內發展現況

- ▶ <https://www.youtube.com/watch?v=f55OJtb6dzE&feature=youtu.be>
- ▶ 資料來源:日陞空間資訊股份有限公司

問題與挑戰

- ▶ OSM 編碼格式 → OSM資料標準
- ▶ 2D → 3D (ex. 山區的道路高程落差大)
- ▶ 手持裝置 / 穿戴裝置GPS及陀螺儀精度
- ▶ 使用同步定位與地圖構建? (SLAM或Simultaneous localization and mapping)



未來方向



► 2D→3D : 內政部地政司路線剖面分析

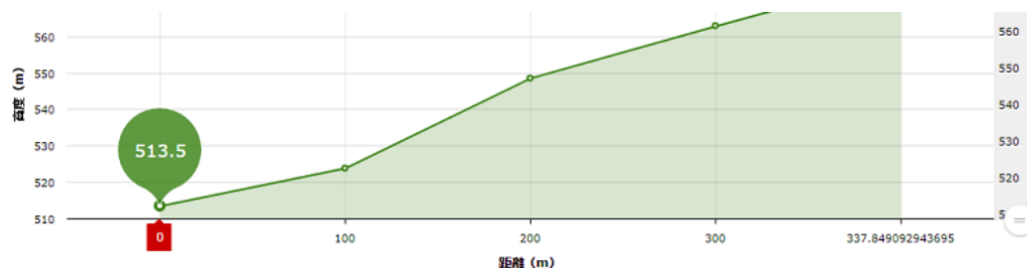
► <http://land.colife.org.tw/docs/pathprofile.aspx>



API說明網頁

數值地形模型加值應用服務

本服務採用WGS84坐標系統、
TWVD2001高程基準(正高系統)



取得路線剖面座標資訊 getLineProfile

► SLAM

► ORB-SLAM2 code載點

https://github.com/raulmur/ORB_SLAM2

► UI 設計

ORB-SLAM2

► <https://www.youtube.com/embed/ufvPS5wJAx0>

slam unity - Google 搜尋 x ORB-SLAM2: an Open-S

安全 | <https://www.youtube.com/embed/ufvPS5wJAx0>

應用程式 Google GIS 行動水保服務 土地 data 公司系統 土地 研討會 Web 空間分析 AR GitHub UNITY me <https://www.rstinstn.com/> HUA 其他書籤

ORB-SLAM2: an Open-Source SLAM for Monocular, Stereo and RGB-D Cameras

Show Points
Show Keyframes
Show Graph
Localization Mode
Reset

SLAM MODE | KFs: 441, MPs: 50456, Matches: 338

Speed x5

STEREO

0:47 / 2:32

YouTube

感謝聆聽,敬請指教!

選擇模型....

Thank you!

0446

Lon:121.2982

13.4000930786133

25

最高高度為50公尺

Lat:23.2701554655085,Lon:121.29848483