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Geo Immersive Reality (GIR)

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Abstract. Maps are a reference to real-world objects. They help us navigate and make sense of the world by providing a list and locations of places and objects and a drawing to understand the attributes of objects invisible to our eyes. The height and contours of a mountain, the dimensions of a property, all relevant to help understand the environment. However, if this geospatial information is to help the user with situational awareness and operational intelligence in their current location, real benefits will be gained to deliver this data as a digital overlay on a smartphone or ultimately smart glasses for a heads up access. Apart from accessibility improvements, Immersive environments have also been proved to increase information retention after six months by 20%.

Keywords. GIS, geospatial, maps, education

1 GIS data

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

2 Augmented Reality and GIS usecases

Augmented reality (AR) and virtual reality (VR) have for years been main players on the gaming world stage. But there are exciting possibilities in the health and emergency response sectors too.

VR offers a 3D artificial environment ideal for gaming which immerses the player by simulating as many senses as possible, including vision, hearing, touch, even smell. And now its cousin, AR, has come along, which overlays computer-generated graphics or animation on top of real-world environments. Think of games such as Pokemon Go, where AR brings together physical locations and virtual worlds. Now players can interact with virtual targets.

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At Ordnance Survey, our adoption of the concept of Augmented Reality predates the new wave of the technology as Andrew Radburn, a long standing senior Research Scientist at OS published an early work in year 2006 on the concept of hand-held AR overlaying master map data onto the real world using very early hardware such as Toshiba tough books and external camera and GPS antennas and accelerometer. This however was very revolutionary at its time as smart phones were still in their infancy.

2.1 Location-based Augmented Reality

This is where the location of the object in real world becomes the key to unlock the digital data attributed to it. This data and attribution in this case is usually not visible to the naked eye but is then reavealed by augmented reality technology in a smart phone/tablet or headwear such as Hololens or Magic Leap.
This type of AR has many use cases and applicatiosn with geospatial data. One of the historical parallels to this is where stars were used for navigation. This is also a very good example of a rising computer science paradigm called Spatial Computing where information and data exists in all three dimensions rather than just on the monitor. It has been proved that this method icreases data consumption by 30% as it engages humans‘ peripheral vision which is highly sensitive as it is to be alerted where a dangerous even is approaching and is still not in our full view.

Indoor navigation.
During 2017, We carried out a case study for navigation in Southampton General Hospital which revealed that 57% of visitors find it ‘difficult’ and 21% ‘extremely difficult’ to find their way around hospitals. This is contributing to many missed appointments not just in this south coast hospital but right across the country. According to an NHS report, around 6.9 million outpatient hospital appointments are missed each year in the UK, costing an average of £108 per appointment.

An augmented reality arrow overlaid on a live camera view on a phone – together with a thumbnail of where you are in a building – could not just help the millions of hospital visitors each year but staff in emergency situations too. Even 60% of hospital staff find navigation ‘difficult’ which could add delay to a life or death situation.

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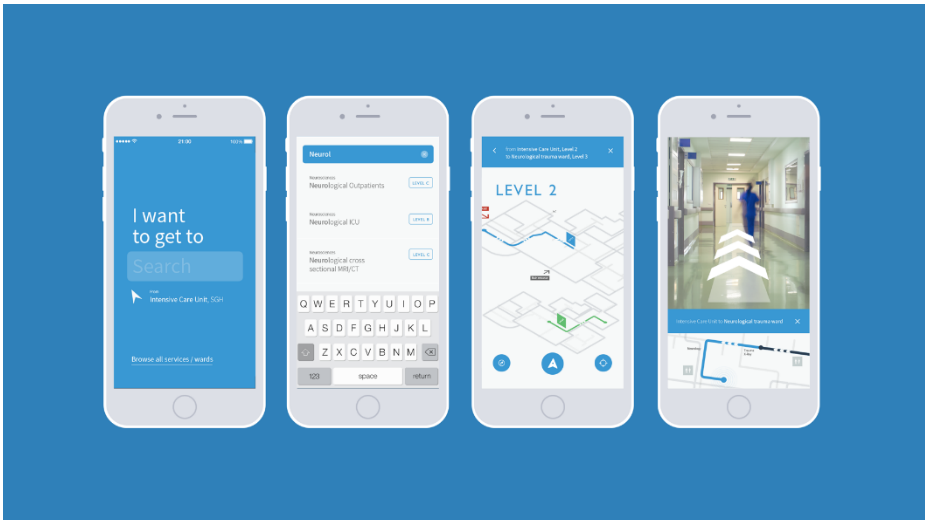

Fig. 1. UI prototype of an indoor navigation app powered by iBeacons for patients, visitors and staff

It doesn't help that complex buildings such as these are harder to navigate under stressful conditions. Stress and its associated hormones are known to influence the function of the hippocampus, a brain structure critical for cognitive-map-based, allocentric spatial navigation, backed up by a 2015 study at the Department of Psychology in Canada's University of Victoria.

Therefore, what we propose is a turn-by-turn navigation for patients and staff to improve the wayfinding.

This technology along with iBeacon based indoor positioning was used in producing an app for an event Ordnance Survey sponsored in 2017 called Digital Shoreditch. Event visitors used the app for navigating in the venue and also networking and getting live alerts from the talks delivered to the app.

Another example of a complex building with stressed users is an Airport. Despite the open plan of the building and therefore less complexity we are still facing the reduction of navigation skills discussed above. Ordnance Survey has produced proof of concept apps using iBeacons and AR as demos to showcase the benefits of this type of application in three different areas:

Airport utility/asset managers staff.

Here the fixed and moveable assets can be located and visualized by airport utility staff. In case of items such as defibrillators where due to price of the unit can be shared by nearby buildings or even misplaced, it is very important to be able to locate them as quickly as possible to respond to a medical emergency.

Again, fire hydrant cabinet as displayed below can be highlighted for rapid access.

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Fig. 2. Concept design for a prototype location-based AR asset management app in an airport for utility managers

- Passengers

  Here as seen below, the app of the airport or airline will help the passengers navigate to the gate via shops or via the quickest route. The app will also show alerts from the flight information system to help inform the passenger as they make their way to the departures lounge.

  The arrow is again used for reasons of user experience simplicity and an easy to follow methodology. This technique has long been in practice with many years ago where hospital corridors were painted with various colors to follow to get to a certain destination. In this case the painting is done digitally to deliver a custom route for the individual using the app considering their destination and even accessibility limitations such as need the avoid the steps, etc.

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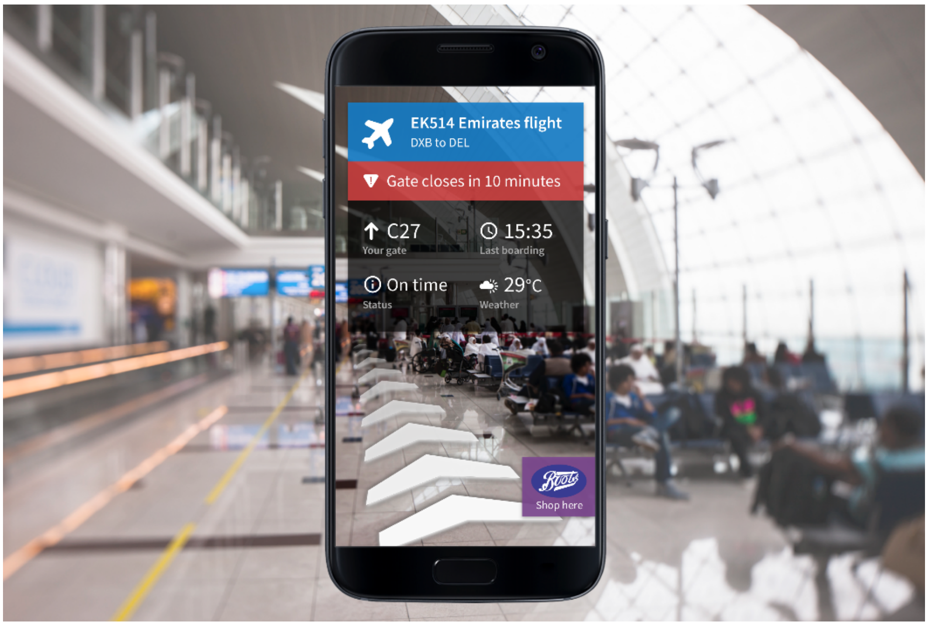

Fig. 3. Concept design of a prototype augmented reality app for navigation in a smart airport

- Autonomous baggage handling systems

Another use case for this type of AR in the airport is for baggage handling staff in a smart city airport which has autonomous pods for loading and offloading of the passengers' baggage into and from aircrafts. Like any other IOT system, there will be a cloud service to feed data to an augmented reality platform to be visualized in an app. To detect which baggage QR codes can be placed on the platform to identify the load. Below pictures shows a dashboard in AR view to help the staff with offloading of the baggage from the conveyor belt.
[1]

[1] All images are sole property of Ordnance Survey and produced by internal staff apart from where indicated

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Fig. 4. AR dashboard for the baggage handler staff connected to an autonomous baggage handling system

Points of interest discovery.

When planning to explore a place you have never been to, we always look at a map. This shows us the places and information we need to plan our trip. But once we are there, although we will carry on using the map to see the big picture of where everything is, the other way we can engage with those ‘interest’ points is to be alerted about them and being able to click and see more information about them as we walk around and one is in our ‘view point’.

An example of this is an already released AR feature within the OS Maps `app` which is used by walkers in their discover of nature trails. The `algorithm` was developed in house by me in OS Labs and therefore there is no reliance on external SDK’s for the augmented reality technology.

This feature won the Yahoo Sports Technology award of year 2018 for best use of AR technology and it continues to benefit walkers with their discoveries of points of interests in outdoor trails.

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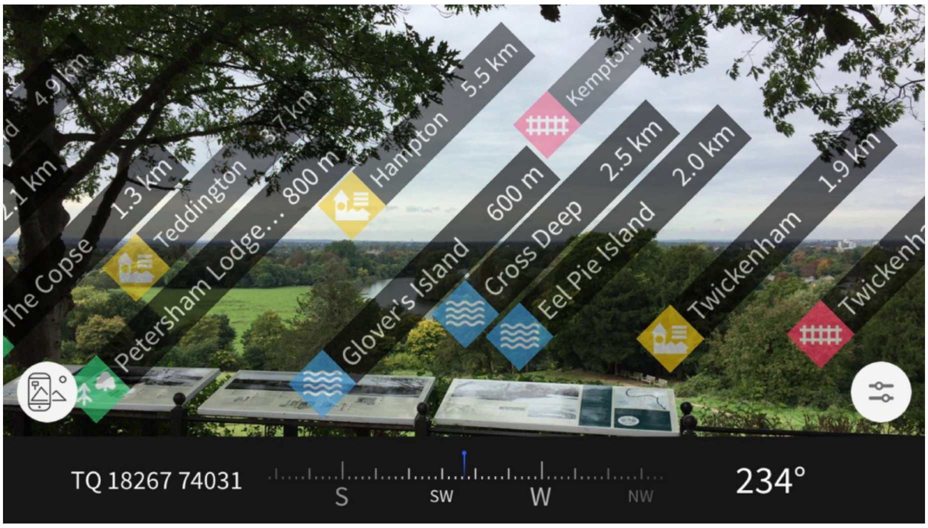

Fig. 5. Snapshot of Ordnance Survey Leisure OS Maps app AR view

There is also the scenario of city navigation and health routes. This scenario has the potential to benefit from IOT sensors and connected information with the use of Artificial Intelligence for data discovery and delivery. Imagine a scenario where a person with a health condition such as asthma is taking a walk through a large polluted city center. The sensors within the city are constantly monitoring the pollution levels in the busy parts of the center. Since this is an IOT scenario, there will be APIs and cloud services available for accessing the live readings from the sensors and perhaps predicted values too.

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Fig. 6. Concept prototype of a urban ride sharing and health optimized routing app for smart cities citizens

The smart navigation app will combine the user's health conditions with the real time values to deliver a visualization of location-based points of interest to help with finding the least polluted route for the user to take.

This will all be powered by AI and IOT in a smart city.

Connected vehicles can also play a part in this scenario, where lift available in real time from a friend or a ride sharing service such as Uber or Lift.

Most large cities are currently suffering from increased pollution due to large number of single passenger commutes. The simplest remedy for this would be to use ride sharing apps to reduce the number of cars for work journeys as one geographical destination is shared by many users. However, one of the barriers for their lack of widespread use lies in the population's perception of lack of flexibility in these services. Many people work patterns includes shifts and irregularities hence the reluctance to make fixed arrangements for ride sharing with work colleagues. Other factors that are in play include the lack of reliability by families in case of emergencies with illnesses of young kids.

Augmented reality and real time ride sharing can remedy this by enabling an on-demand service where people can just 'e-hail' a ride on the spot.

Emergency services incidence management.

This is another group of users who are again under stress, the navigation can also be hampered by poor vision due to smoke, helmets or low lighting. AR has the capability

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to make buildings smarter by highlighting fire safety routes, electricity junctions, wiring, exits, and even who's attending which function in what room. This helps with collaboration between different fire crews by showing them where everyone else is in real time.

In future where heads up displays can be mounted on the safety helmets the information above will be added to the HUD to for example show where a vulnerable person is in a particular floor of a high rise as the crew approach whilst still outdoors without the need to take out a map which speeds up the rescue response time.

Fig. 7. Concept design of a location-based AR app used indoors to reveal the 'beyond the wall' features of the building that the human eye can not normally see. The positional accuracy of 2-3 meters is achieved by using over 30 iBeacons installed in the underground of Shoreditch Townhall basement

It can also be used for alerting the emergency services about any hazards such as chemical spillages and help visualize this data in relation to real world buildings and roads.

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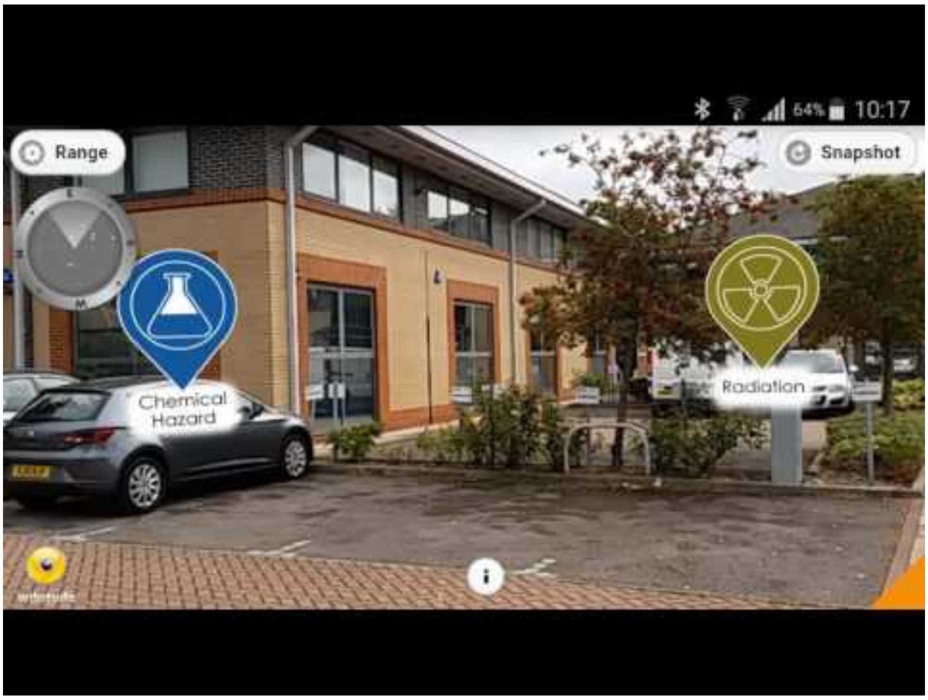

Fig. 8. Snapshot of Ordnance Survey partner Aligned Assets Symphony AR app for local authorities[2]

Underground utility asset management.

This is where the augmented technology can be the holy grail of field workers and utility inspectors. It is a scenario where AR is giving 'X-ray' vision to the utility staff for visualizing buried assets and a dashboard of readings from wireless IOT sensors that are inside the pipes and junctions.

In this scenario AR is increasing operational intelligence and also safety and therefore adding value and saving money and lives.

Hazards can be detected quickly and accurately by this 'X-ray' vision capabilities and it also remedies the difficult task of correlating the information displayed usually on a map of the assets which are normally not even in the same scale as real world to real world scales.

There are already off the shelf apps such as Augview that deliver this type of AR technology specifically for utility services, but this of course relies on accurate geospatial data being available from the assets and the device needs to be capable of centimeter accuracy positioning. Capturing the buried assets data can be achieved by using ground penetrating radar. Satellite positioning systems and the use of surveying grade antennas and differential GPS can also provide centimeter accurate position of the user in x, y and z.

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2 Sourced from the website of Aligned Assets

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Fig. 9. Concept design of a prototype app for AR visualization of buried assets and the attribution of each individual physical item

2.2 Marker based Augmented Reality

In this type of augmented reality, a symbol, a pattern, a barcode such as QR code or even a three dimensional shape of a physical object is used as a target to trigger an AR event and visualise the data that the user can not normally see. This technique can enhance/augment the shape of an object, present a three dimensional represenation, reveal a digital dashboard or show meta data and attribution related to the real worl object. Attribution can also be added to this AR view and edited to be shared to the community over the internet and synched in real life. Again this can have many many applications but in this paper we look at the GIS domain again to stay relevant to Ordnance Survey data and its customers.

Enhanced paper maps.

Printed maps as we know them are a merged view of many layers of topographical data about the land. Cartography is a technique to present this data using shapes, different line thicknesses colors. Map reading is a skill to be able to isolate all these layers and interpret the information. and even patterns.

Paper due to its convenience, versatility, security, cost and also the scale and reliability is still the favorited medium for presenting mapping information for large areas.

However, AR can be used to ‘de-clutter’ maps as it can show you only the information that you are interested in and hide the information that is not required.

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The other use case is where pattern of the map due to its' uniqueness is used as an AT target to reveal extra information that is not printed on the map such as weather, traffic or even temporal events such as concerts and groups activities.

This was developed and demonstrated in a collaborative project called Mapsnapper between the author and Southampton University computer vision research department which was featured in New Scientist in year 2006[3] and recently hailed by The Register in a featured article about Ordnance Survey during national map reading week October 2017.[4]

The methodology used computer vision algorithms such as SIFT features to create a geographically indexed dataset of map tiles with unique identifying vision signatures created by processing salient features in raster OS explorer maps. When the user takes a picture of the map, this is used for identifying the location and the points of interests are then returned and overlaid on the image of the map.

Another example prototype of a marker-based AR using cartographic features as a marker was a prototype iOS app made by the author to work with the Mars map published by Ordnance Survey. This was very successful in recognizing the map pattern and used Qualcomm's Vuforia technology. As the user points the camera of the device at the paper Mars map, an AR experience is triggered, and A 3D model of Mars is overlaid on top of the paper representation. The 3D model was produced by OS cartographic team using the elevation data from the MOLA instrument on MGS. Supplied by NASA/JPL/GSF. Resolution approximately 463 meters per pixel.

The original paper map sheet is a topographic base-map based largely on elevation data from satellite imagery and is printed at a scale of 1 to 4 million (1:4000000) and measures 980 by 840mm. It represents an area of Mars 3672 x 2721km which is similar in size to the United States of America (USA).

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[3] https://www.newscientist.com/article/dn10416-phone-creates-interactive-maps-from-snapshots/

[4] https://www.theregister.co.uk/2017/10/20/ordnance_survey_augmented_map_week/

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Fig. 10. An actual snapshot of the Ordnance Survey topographic Mars Augmented Reality app during a demo

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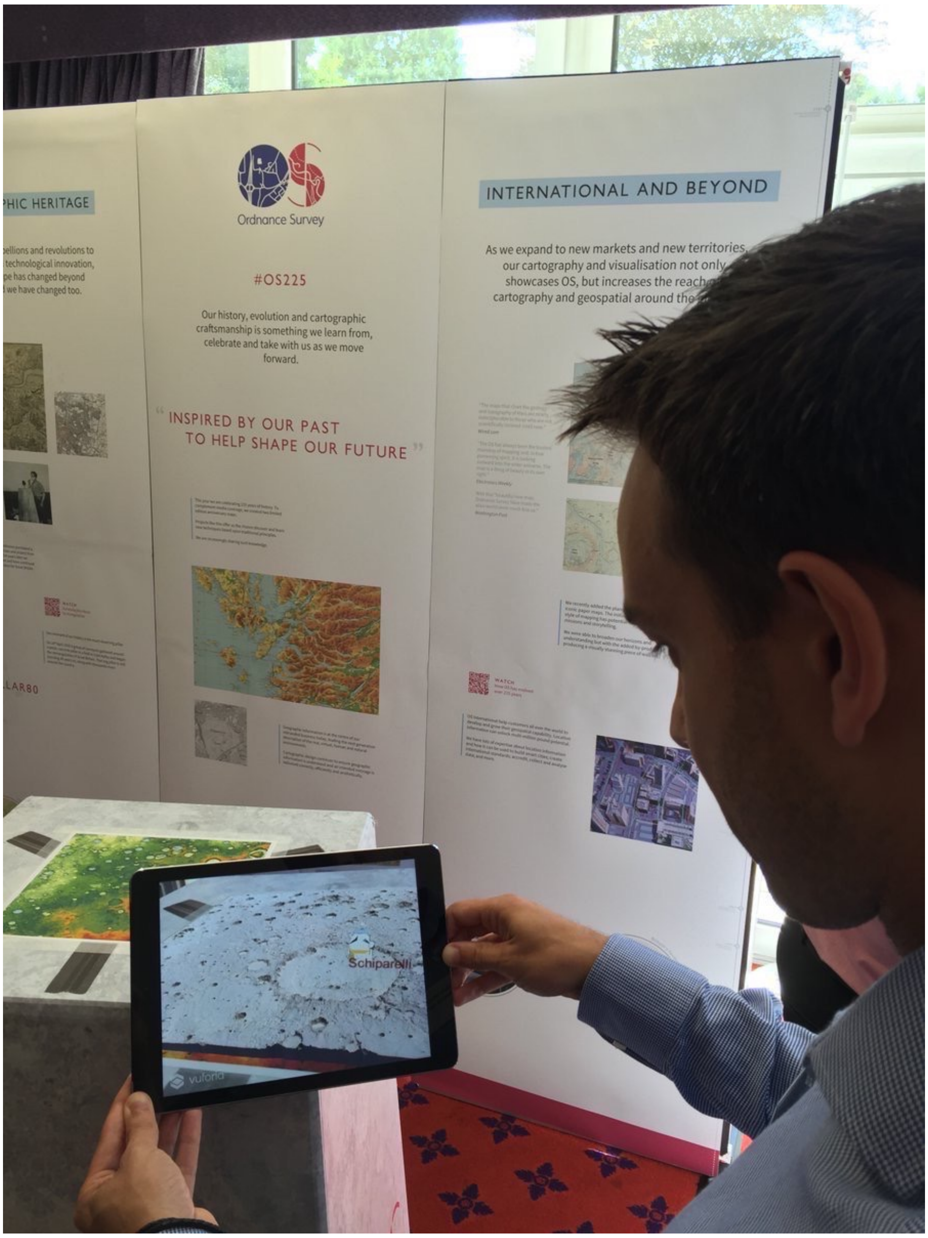

Fig. 11. A variation of Mars Augmented Reality app in action at an ESRI conference stand, where the maps creator cartographer Christopher Wesson pictured demos the app to the visitors

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Walking trails unlocking geospatial data with smart symbols.

Another concept the author is currently exploring with one of the OS sponsored startups is an interactive walking trail augmented reality app for kids and families exploring the wildlife of England and learning about the animals they reveal with the app. Unlike the location-based AR, the physical posters with pictures in woodlands are used as targets to unlock the digital content in this case the 3D animated cartoon animal and overlay them on top of the real-world sign. The app allows the kids to take a photo and currently features four animals with fact sheets included in the app.

Fig. 12. An actual snapshot of Pocket Pals Trail app running on iPhone showing an animated digital butterfly and the tree trunk hiding the physical sign behind it

2.3 Tabletop mixed reality (Hololens)

In this scenario, headwear is used for a hands-free AR experience where the user will see the digital content overlaid on real world through the clear lenses as holograms.

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OS has developed two prototype app for Microsoft HoloLens for tabletop placements of detailed 3D models as holograms. One is of Manchester University captured by high precision drone acquired aerial imagery on a tabletop. The use case for this is smart city dashboards where real time data can be overlaid on the model and incidents can be discussed in a disaster management scenario. An actual footage of the app can be seen YouTube channel `Here.`

The other demo features a 3D model generated using the digital elevation model based on OS Terrain 5 datasets of mount Snowden. An actual footage recorded on Hololens headset can be viewed `Here.`

One use case for the example above can be flood visualization and management in a multi-agency scenario where all users some in the room and some not all wearing Hololens can collaborate in a common mixed reality session to visualize and have a discussion around natural disaster management.

Another type of mixed reality prototype has also been developed for visualizing the buried assets in real world scale overlaid on real roads and surfaces. This would allow utility inspectors to asses where the current pipes are in the ground underneath if planning new assets or repairing existing ones. It allows them to dig the correct place and avoid damage to neighboring pipes and assets.

This would offer utility companies a new level of operational intelligence which can drive efficiencies and increase safety.

3 Virtual Reality and GIS usecases

Due to its closenss to a real life experience, Virtual Reality can be a very powerful medim for simulation and education.

Research has proved that VR certainly enhances learning. The brain absorbs information 33 per cent more effectively when in the immersive environments of AR and VR, according to Stansford University Virtual Human Interaction Lab researcher Jeremy Bailenson.

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3.1 OS Virtual Map Room

This Oculus Rift app has been developed with purely education in mind. The idea is based around gamifying a GIS task of interacting with geospatial data in an escape room scenario. The app was demoed to visiting school students on a GIS education day, where they were required to collaboratively solve a GIS task and find the key to exit the map room. The maps themselves are two-dimensional raster Ordnance Survey maps and points of interests and polygons are overlaid on the virtual tabletop.

Fig. 13. Actual snapshot of OS Virtual Map Room app on Oculus Rift

We continue to collect feedback from students to assess how they find the VR map interaction versus non-VR. Certainly, the level of engagement and participation of students has been witnessed to have been higher compared to previous years where VR was not used.

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3.2 Virtual Explorer House

In thsi example, the team created a virtual reality app that poulates the assets dynamically at run time by connecting to a live data set of in this case desk locations held by utilities at Ordnance Survey and places the virtual desk the locations they really are in the building and with the information about the desk number viewable in virtual reality. The aim of this demonstrator was to asses the methods in which geospatial data in this case desk with locations can be obtained from external sources and with unity creating assets in real time and placing them in a correct location. This is the basis for a dynamic virtual reality experience as opposed to fixed data. With a future in 5G networks becomign mainstream, the concept of untethered dynamic VR would be more than achieveable.

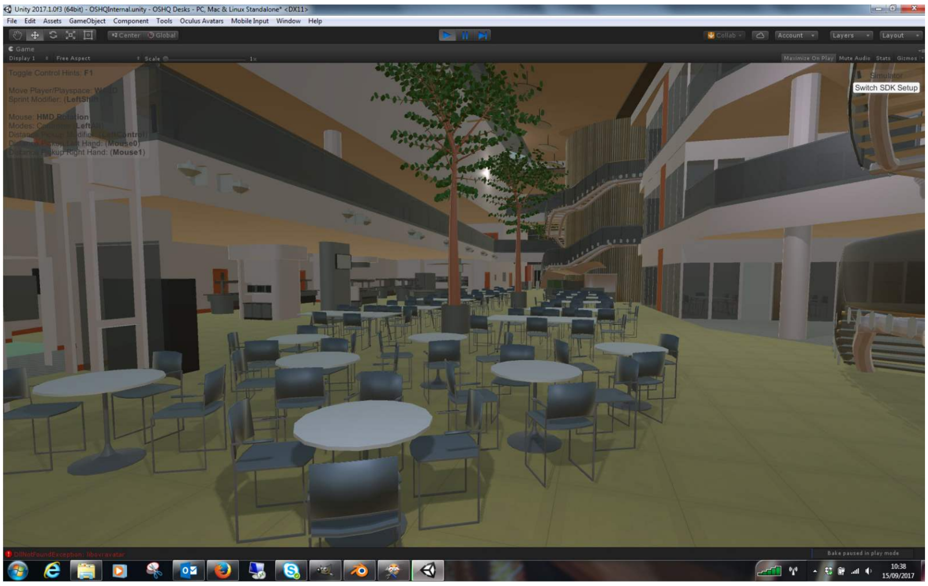

Fig. 14. Virtual Explorer House snapshot

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Fig. 15. A virtual tabletop experience featuring 3D mode of the Ordnance Survey headquarters

3.3 Digital Twins: Bournemouth VR for 5G planning

The aim of this demo was to use virtual reality for remote asset management and planning of a 5G network visualising the street assets and locations of the building. The powerful medim of immersive placement in a remote location adds an enhanced information retention, situational awareness and also a greater data consumption from peripheral vision. Overall the experience should be as if the user was directly flown in real life atop the city of Bournemouth to plan the network. Of course, virtual reality provides a more convenient, cheaper and repeatble alternative to a flight. It is also weather independant as aerial flights sometimes need to be cancelled due to poor visibility. The education angle could be that the task of planning the 5G network can be turned into a set of steps in a VR enviornment and trainee GIS analysts can use it as a learning tool and improve their skills.

In order to add a fun element to learning and also to showcase the detailed elevation model, OS branded beachballs are featured in the app where the user can pick up and throw them into the city. The app has been part of the VIP visits by ministers and geospatial commission to the building and received many good feedback for an interactive enviroment and the quality of the automatically generated 3D model jusst using oblique standard aerial imagery.

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Fig. 16. An snapshot of Bournemouth VR playing on Oculus Rift

This type of scenario assesses the role VR can play in immersive 360 visualisation of digital twins of cities for urban incident managament, urban planning and also remote asset planing and management.

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