INFINITY

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Technical Brief

Geospatial Data Visualisation

DISSEMINATION LEVEL PUBLIC

PARTNER

VTT

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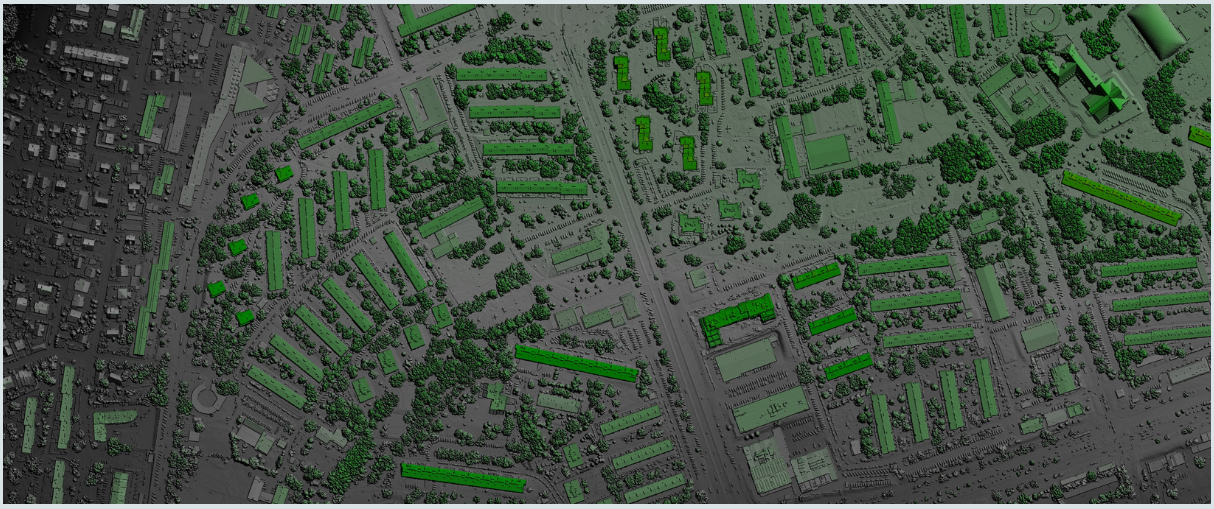


1. Introduction[1]

The U.S. Code Title 10, §467 describes geospatial intelligence as:

The term "geospatial intelligence" means the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the earth. Geospatial intelligence consists of imagery, imagery intelligence and geospatial information.[2]

Research on terrorist activity patterns is still an ongoing subject with unknown variables, which makes improving on geospatial intelligence gathering and visualisation methods important. Visualising geospatial data is a non-trivial task, which may fail to display adequate of information or on the other hand induce an information overload for the user. The data presentation and user interfaces can also be unintuitive if done incorrectly.[3]

Additional benefits in geospatial data gathering and visualisation can be achieved with light detection and ranging (LiDAR) equipment and point cloud visualisation. LiDAR equipment can be used to scan a physical environment, which can later be visualised in a digital environment as a point cloud. This can also be complemented with 360-panoramic pictures and videos or traditional 2D pictures and videos.

Virtual Reality (VR) technology has evolved very quickly in recent years and the head-mounted display (HMD) has emerged as a common way to experience VR. This evolution in conjunction with geospatial data and point clouds allows visualisation of geospatial data in a novel and intuitive way.[4]

2. State-of-the-art

This chapter briefly covers the current state of the art of virtual reality, geospatial visualisation as well as LiDAR and point clouds.

2.1 Virtual Reality

Virtual reality can visualise various data in three dimensions, has access to unlimited amount of virtual working area, unlimited availability of virtual displays, user interfaces and other virtual gadgets as well as functional shortcuts unavailable in the real world, such as teleportation, flight, digital data analysis and different easily switchable visualisation methods. As non-recreational utilisation of VR at the current readiness level is a novel research field, more research on effective geospatial and point cloud visualisation methods in VR is still required.[5]

Virtual reality applications are still very demanding on the computational hardware, especially when combined with other computation heavy functionalities, such as point clouds. The following figure effectively shows the infinite space and gadget availability in VR environments.

Figure 1: Example of unlimited amount of virtual space and displays

For law enforcement, handling large amounts of data might get easier with the introduction of VR-technology, because of the above mentioned freedom with gadgets and space. Also as more intuitive user interfaces get developed for VR, handling data can be done faster and more efficiently.

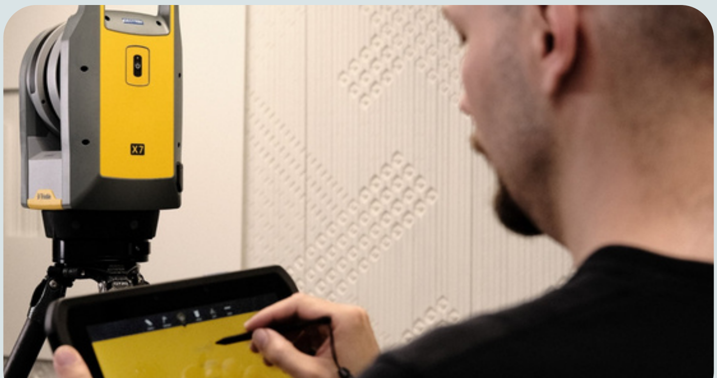
2.2 LiDAR and Point Clouds

A LiDAR scanner can create an accurate reconstruction of the environment around it by shooting rays of light around it and measuring the reflection. The end product is a digitised cloud of 3D points, which can be rendered on a digital scene to reconstruct the environment within the resolution of the LiDAR scanners capabilities. This has been widely used in the last two decades for earth surface research, building reconstruction, natural disaster monitoring and solar energy potential estimation as well as robot localisation and autonomous navigation.[6]

Point clouds are still very computational resource demanding, when the point cloud is thick or large, especially when combined with other resource demanding functionalities, such as VR. The following figure displays INFINITY point cloud environment of an apartment, with 2D pictures as well as separately activateable 360-pictures (the spheres).

Figure 2: Point cloud environment with picture annotations and 360-media

LiDAR technology has also evolved becoming more easily available in the recent years. There are multitude of LiDAR scanners available on the market, from handheld scanners to stationary terrestrial scanners. A noteworthy mention are also the Apple IPhones, which have had a LiDAR sensor from IPhone 12 onwards. The following figure displays an example of a LiDAR scanner.[7]



For law enforcement, LiDAR technology allows storing and digitising crime scenes and even public buildings for possible terrorist hostage scenarios. Point cloud technology on the other hand allows the digital reconstruction of the stored scene for investigative or tactical operative purposes.

Figure 3: Trimble X7 LiDAR scannera

2.3 Geospatial visualisation

Geospatial data often involves multiple layers of data. Visualising this can be done in various ways, for instance single multi-layered map versus multiple maps and how to represent various data on a map. This has been done by cartographers for centuries, but with the advancement of digital technology there are more effective ways to display and interact with maps, such as Google maps. This can still be complemented with additional layers of data with custom visualisation for specific use cases. Also the application can be run on mobile phones or computer screens, but running it in VR environment allows for novel ways to visualise and interact with a map. The following figure displays the INFINITY Geospatial map with various visualised data layers, such as map elevation (3D map), buildings and custom map pins with textual, picture and video annotations as well as point clouds.[8]

Figure 4: Map with elevation, building and pin data as well as text and picture annotations

For law enforcement, knowing the whereabouts and timing of events and actors in an investigation are important. Visualising a crime scenario on the INFINITY Geospatial map visualises positions as well as timing of events and actors in an intuitive way: animating the movements between known points and timings and showing events, such as explosions when they happen. The scenario playback can also be paused, fast forwarded or rewinded for closer inspection.

3. Conclusions / Future challenges and opportunities

The concurrent evolution of geospatial data visualisation, LiDARs, point cloud visualisation and VR has created new ways to combine and visualise digitised data, which in turn has created promising new ways for law enforcement agencies to do investigative or tactical operation planning. The user interfaces in VR for various geospatial information still require future research to find the most effective ways to visualise and interact with geospatial data, as well as the ineffective ways, which should be avoided. The computational requirements of point clouds and VR are still very high, compared to current technology level and as such, they bottleneck some of the applications of these technologies. As technology advances in the future, even more elaborate geospatial applications can be developed.

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4. Cf. J. Hautamäki (2021), "Interfacing extended reality and robotic operating system 2," Tampere University, at: https://urn.fi/URN:NBN:fi:tuni-202108206663.
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