Spatial Modelling for GPS Replication in Natural and Urban Canyons

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Overview

Global Navigation Satellite System (GNSS) data has become a stable of modern life, whether delivered through a smartphone, vehicle, or as part of an industrial dataset. The expectation of reliable position and time information, irrespective of the environment, becomes challenging in tunnels and canyons with significant multipath, whether natural or urban.
An initial look at an open dataset of LIDAR, Computer Vision, and GNSS data is presented, combined with a channel model produced from this dataset, comparing the expected and measured line of sight and multipath contributions from GPS sources while moving around Bristol, from unobstructed surroundings to deep natural and urban canyons.

Method

In collaboration with the University of Cardiff and Spirent, a series of seven multisensor recordings were carried out on the 29th of September 2023, combining coherent recording of L1 band GNSS, LIDAR, Camera, and IMU data.

Recording Setup

- Ouster OS0-128 Lidar
- Microstrain 3dm-gx-45 IMU
- Ublox evk-m8c GPS
- Spirent GSS6450 GNSS Signal Recorder : 1575.42MHz, 10MHz Bandwidth, 8 Bit resolution
- Survey Grade GPS Receiver (Novatel GNSS-850)
- Luxonis S2 W OAK Cameras, arranged at -30°,0°,30° in azimuth with respect to the direction of travel

Ground truth satellite availability data shows occlusions, position and heading information, which can be used as a reference for autonomous navigation and GNSS disruption research, key considering the potential for RF cyber attack on GNSS and reliant assets.

Figure 1 : Measurement Setup

Clifton Gorge (Southbound)

Results

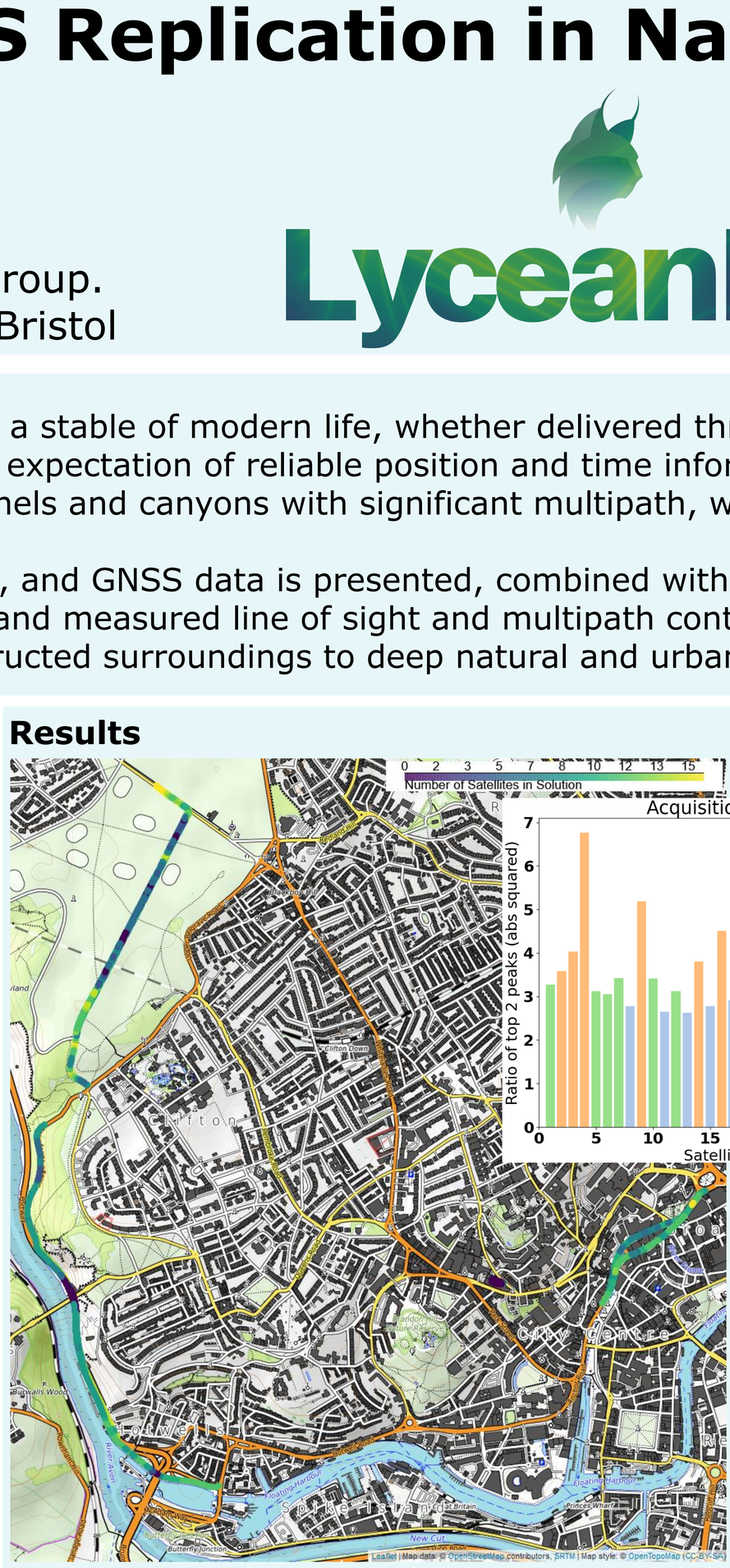

Figure 2 : Track Data with Satellite Availability

Figure 3 : Beamformed GPS Detection

Figure 4/5 : Clifton Gorge (Google Earth, and LIDAR/GPS Map)

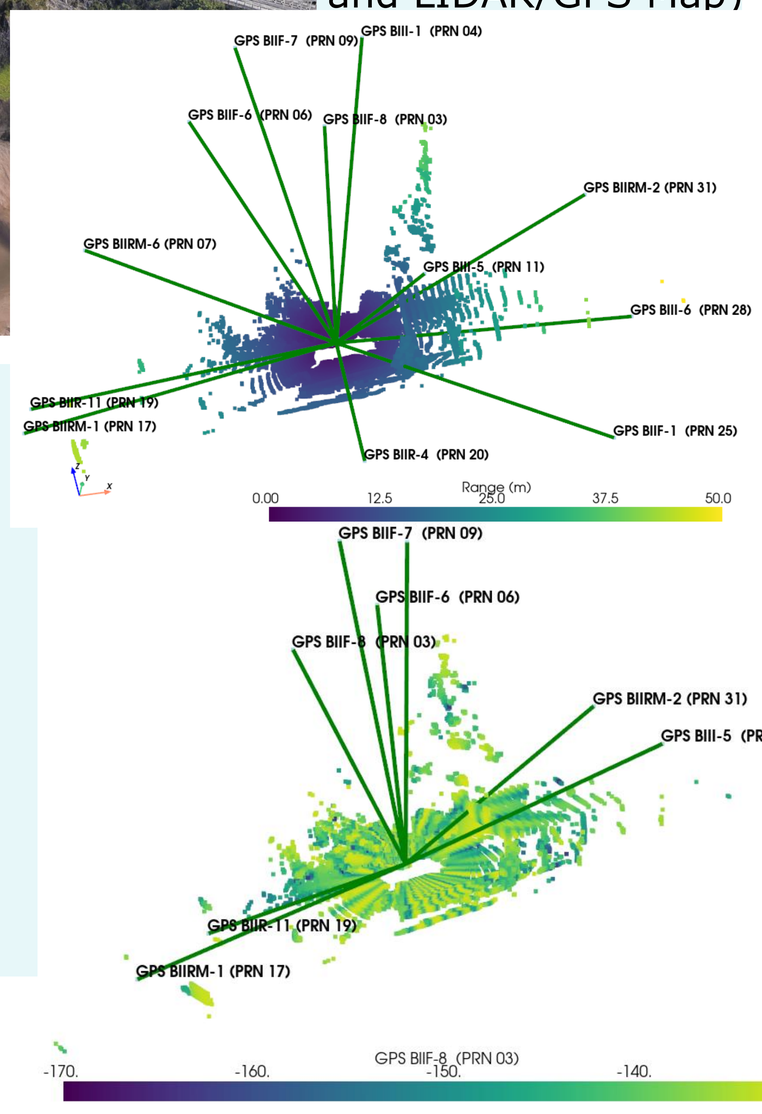

Figure 6 : Spatial Map with LyceanEM

Conclusions and Further Work

Initial analysis of the dataset reveals both expected major GPS disruptions in tunnels, and underground carparks, as well as minor disruptions between high rise buildings and dense foliage. Initial Spatial Mapping using LyceanEM [1], has allowed projection of the received power of individual GPS PRN codes onto the surrounding environment, identifying scattering trajectories.
The open dataset will be published by the end of 2023.

Future Applications

- Spatial Sensing
- Model in the Loop
- Atmospheric Channel Measurements
- Passive Radar Research
- Computer Vision
- GNSS Discrimination/Accuracy

[1] Pelham, T. G., (2023). LyceanEM: A python package for virtual prototyping of antenna arrays, time and frequency domain channel modelling. Journal of Open Source Software, 8(86), 5234, https://doi.org/10.21105/joss.05234

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This research was supported by SWAN: Secure Wireless Agile Networks, and the Royal Academy of Engineering and the Office of the Chief Science Adviser for National Security under the UK Intelligence Community Postdoctoral Research Fellowship programme.

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