Intelligent Assistive Navigation

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Current digital mapping systems do not dynamically collect indoor navigation data due to their reliance on satellite-dependent technologies. Consequently, digital maps tend to only offer outdoor navigation services. The purpose of my project was to establish a new technique for automating the construction of indoor maps. By systematically accessing sensors from mobile devices to create, collect, and parse user navigation data, I attempted to make indoor digital mapping satellite-free, automatic, dynamic, and controlled. This solution may benefit services requiring prior knowledge of private urban structures such as firefighting and law enforcement, and provide navigation support for visually impaired individuals.

To achieve this goal, I implemented a system that detects and registers small scale navigation without reliance on Global Positioning System (GPS). Instead, my system relies on the user device's accelerometer, gyroscope, and magnetometer to dynamically construct virtual trajectories. Distances and directions are set from the behavior of the sensors, and for each collection session, these navigation data collapse into a path; geometrically, a floating line on a metric-based cartesian grid. Path construction is only activated when, using Google services, the system detects a change in user location from outdoor to indoor. This ensures that each created path is satellite-free and can be assigned to its satellite-dependent host building.

To reinforce the validity of the final data, the system uses crowdsourcing to improve its accuracy. Therefore, each building is connected to a pool of paths incrementally filled from different users. Path collections either create new or complementary lines. The path is sent to its associated pool (which is linked to the specific building via digital mapping, e.g. mapping from Google Maps APIs), and if a similar path is already saved in the pool, the probability that the building contains a hall or a corridor as that path is increased. Otherwise, the new path is added to the pool with a low probability of existence in the building.

Cloud storage services and automated permission management are used for securing user data. With an asynchronous upload service constantly waiting to migrate newly collected paths onto a cloud-based database, and an indoor map distribution limited to reading owned constructions, the system delegates security to third-party groups while ensuring that endpoint devices are unable to access restricted data or compromise accessed information.

Although the system is currently unable to group paths within pools and link itself to cloud-based platforms for increased security, all other settings are harmonized and project tolerable performance upon fully equipping the system. A major issue is the need to hold the mobile device vertically (portrait), due to the technical assumption that the device heading does not deviate from the user heading. This issue prevents individuals from using the system hand-free. A solution would require the use of machine learning to automatically harmonize the user heading with the device heading.