Transport Infrastructure Interactions: Digital Twin Simulation for Automated Accessibility Assessment

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SUMMARY

Melbourne's tram network – the most extensive in the world – consists of a highly heterogeneous transport infrastructure and rolling stock. To improve the accessibility of users with mobility restrictions to Melbourne's next generation trams, PTV is considering the deployment of Mobility Aid Lifts (MAL). MALs will allow wheelchair access to trams from street level. All current tram stops therefore need to be assessed for compatibility with MAL deployment in terms of physical obstacles, road gradient and camber within the deployment zone. This study develops and validates an end-to-end automated framework to perform public transport infrastructure accessibility assessment, based on physical movable asset simulation in a large-scale Digital Twin. To effectively acquire the data, we built a custom vehicle-mounted multi-sensor mapping system consisting of lidar, cameras, Global Navigation Satellite System (GNSS) and Inertial Navigation System (INS), integrated in the Robot Operating System (ROS) open-source data fusion framework. We collected comprehensive geospatial data along selected tram routes in Melbourne. Digital twin assets were then produced as co-registered Cloud Optimised Point Clouds (COPC) and stereo stree-view imagery. We trained a deep learning model to detect tram tracks and tram stop flags from the stereo image sequences, projected to the 3D space of the digital twin. MAL deployment zones of pre-defined dimensions were then simulated relative to the tracks. Temporary obstacles (parked vehicles and pedestrians) were filtered from the point clouds using a custom deep learning model. Cleaned MAL deployment zones could then be assessed for accessibility: physical obstacles preventing MAL deployment were identified within each deployment zone, platform planes of each tram stop were extracted and their ground gradient and camber identified. Benchmarked against visual inspections and manual measurements, the automated framework has shown an accuracy of around 90% in all of the assessment tasks, namely tram stop extraction, obstacle detection and ground gradient and camber estimation, while minimising human intervention. Moreover, the multi-sensor mapping system is demonstrated to be capable of

producing large-scale, multi-modal and accurately georeferenced digital twin of road environments at a fraction of the cost of its commercial counterparts.