A Low-cost Mobile Monitoring System for Enhanced Railway Track Safety and Facility Management

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The degradation of railway track geometry poses significant risks to ride quality and potentially leads to derailment incidents, necessitating continuous monitoring of track conditions and unobstructed pathways for ensuring transportation safety and efficient facility management. Therefore, this study proposes a low-cost mobile monitoring system to automatically investigate track geometry and clearance within the structure gauge along tracks. To this end, the proposed system integrates optical and depth camera sensors alongside a GPS antenna to facilitate the collection of spatiotemporal data. The downward-facing depth camera acquires depth maps at specific time intervals, enabling precise estimation of the track gauge. By contrast, the forward-facing optical camera, coherently integrated with the GPS antenna, applies visual Simultaneous Localization and Mapping (SLAM) to the collected sequential images to position the platform and estimate superelevation and 3D track curvature. Moreover, a learning-based object detection model is leveraged to identify obstructions within the structure gauge space automatically. The practical benefits of the proposed system lie in its remarkable cost efficiency, with automated functionalities reducing equipment and labor expenses, which make the system affordable and deployable across extensive rail networks, enhancing routine monitoring tasks and offering enhanced safety and operational efficiency.

Keywords: Railway track geometry, Visual SLAM, Mobile track monitoring, Obstruction detection