Research on Lining Carts Pose Estimation Method Driven by High-Precision Point Clouds in Construction Tunnel

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SUMMARY

To address the demand for intelligent construction of tunnel linings in complex environments, this paper proposes a method for estimating the position and orientation of lining carts driven by high-precision point clouds. Centered on high-precision tunnel point cloud data, this method integrates 3D tunnel reconstruction with design model constraints of the lining carts to achieve high-precision identification and optimization of the carts' posture. The method first registers point clouds from multiple survey stations, extracts key structural features of the tunnel's primary lining, and establishes a 3D tunnel model reflecting the actual construction scene. Next, it integrates geometric and semantic constraints from the lining carts design model to establish a robust pose solution framework, enhancing the stability and accuracy of pose estimation. Furthermore, for multi-cart collaborative construction, a path planning and posture optimization strategy based on spatial relationship constraints is proposed to effectively reduce path conflicts and error accumulation. This research method forms a digital construction chain integrating point cloud reconstruction, cart pose estimation, and path optimization, providing technical support for intelligent calibration of tunnel construction equipment and digital twin construction. It holds significant theoretical research significance and engineering application value.

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