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Railway Ballast Volumes Automated Estimation Based on LiDAR Data

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Abstract : The ballast layer plays a key role in railroad maintenance and the geometry of the track structure. Ballast also holds the track in place as the trains roll over it. Track ballast is packed between the sleepers and on the sides of railway tracks. An imbalance in ballast volume on the tracks can lead to safety issues as well as a quick degradation of the overall quality of the railway segment. If there is a lack of ballast in the track bed during the summer, there is a risk that the rails will expand and buckle slightly due to the high temperatures. Furthermore, the knowledge of the ballast quantities that will be excavated during renewal works is important for efficient ballast management. The volume of excavated ballast per meter of track can be calculated based on excavation depth, excavation width, volume of track skeleton (sleeper and rail) and sleeper spacing. Since 2012, SNCF has been collecting 3D points cloud data covering its entire railway network by using 3D laser scanning technology (LiDAR). This vast amount of data represents a modelization of the entire railway infrastructure, allowing to conduct various simulations for maintenance purposes. This paper aims to present an automated method for ballast volume estimation based on the processing of LiDAR data. The estimation of abnormal volumes in ballast on the tracks is performed by analyzing the cross-section of the track. Further, since the amount of ballast required varies depending on the track configuration, the knowledge of the ballast profile is required. Prior to track rehabilitation, excess ballast is often present in the ballast shoulders. Based on 3D laser scans, a Digital Terrain Model (DTM) was generated and automatic extraction of the ballast profiles from this data is carried out. The surplus in ballast is then estimated by performing a comparison between this ballast profile obtained empirically, and a geometric modelization of the theoretical ballast profile thresholds as dictated by maintenance standards. Ideally, this excess should be removed prior to renewal works and recycled to optimize the output of the ballast renewal machine. Based on these parameters, an application has been developed to allow the automatic measurement of ballast profiles. We evaluated the method on a 108 kilometers segment of railroad LiDAR scans, and the results show that the proposed algorithm detects ballast surplus that amounts to values close to the total quantities of spoil ballast excavated.

Keywords : ballast, railroad, LiDAR , cloud point, track ballast, 3D point
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