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厦门大学

硕 士 学 位 论 文

基于激光扫描点云的交通标志牌可见性评估研究

Research on Visibility Estimation of Traffic Signs based on Laser Scanning Point Cloud Data

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摘　要

交通标志牌是基础交通设施，它为司机和行人提供道路指示信息，这些指示信息能帮助促进交通顺畅、保障交通安全。交通标志牌作为一种重要的道路附属设施，应该具有良好的视觉可见性。但在实际应用中，存在着诸多制约其可见性的因素，如因标志牌安装位置及安装高度不恰当引起的周围建筑遮挡，绿化树的标志牌遮挡。交通指示牌被遮挡，司机不能提前看到指示信息，极易走错路线或因减速寻找指示信息而造成不必要的拥堵与追尾事故。因此亟需一种可直观、准确地评估交通标志牌可见性的方法。传统的交通标志牌可见性研究主要是基于计算机视觉的方法。这些方法未考虑三维空间中距离、视角和障碍物遮挡等因素对交通标志牌可见性的影响。鉴于此，本文提出了一种基于激光雷达扫描系统的交通标志牌空间可见性评估研究方法。该方法的优点是可以精确的衡量空间特征信息对交通标志牌可见性的影响。本文主要研究工作如下：

第一，提出了有效的交通标志牌提取算法。交通标志牌具有平面特性，在点云数据中，结合反射强度和主成分分析（(Principal Component Analysis)方法来检测交通标志牌。其中 PCA 方法检测点云中呈面状特征的点云簇，并从这些点云簇中提取具有高反射强度特征的点云。

第二，提出了空间可视场和空间可视场强度的基本概念，同时提出了在三维点云中，衡量物体空间可见性的可见度的定义，即在空间可视场的某一视点处交通标志牌投射到视网膜上的有效成像面积，并以可见度值作为交通标志牌在不同观测位置的空间可见性评估标准。

第三，提出了交通标志牌空间可见性评估框架。根据从激光点云数据中提取出的交通标志牌，计算其与视点之间的距离、视角以及标志牌尺寸，然后利用四元数方法、alpha-shape 算法和视网膜成像原理计算该视点处标志牌的可视场强度；通过射线透射法计算遮挡度；并利用空间可视场强度和遮挡度计算某视点位置的标志牌的可见度。

本文通过一系列相关实验，对所提出的交通标志牌空间可见性的评估框架进

行了分析与验证。使用车载激光点云扫描系统 VMX-450 对厦门岛道路进行实地数据采集，并利用该数据进行实验与验证。结果表明，本文提出的交通标志牌空间可见性的评估框架可以用于交通标志牌空间可见性评估，具有重要的应用价值。

关键词：激光扫描点云；交通标志牌；目标检测；空间可见性

Abstract

Traffic signs, with different types and locations, are an integral part of transportation infrastructure, which are designed for giving traffic information for drivers and pedestrians and guiding traffic participants' behavior, resulting in smooth and safe traffic. As part of intelligent transportation system, the visibility of traffic signs is playing a significant role in road safety. Therefore, directive traffic signs should be salient and eye-catching. Nevertheless, there exists a number of factors that hinder its visibility in reality, among which obstacles of buildings and green belt caused by improper installation spot or height are the biggest. Drivers might go wrong if traffic signs were blocked, and traffic congestion and accidents might be caused because of drivers' slowing down to find direction. As a consequence, some are overly trimmed while others are ignored, which is neither efficient nor satisfactory. Thus, what is badly needed is an intuitive and accurate method that can evaluate the visibility of traffic signs. Nevertheless, traditional methods for the study of visibility of traffic signs were all based on computer vision, in which visibility of traffic signs were measured by features like contrast and texture between traffic signs and their surroundings in images and videos. These approaches don't take into consideration impacts exerted on traffic signs by factors like distance, visual angle, obstacles, etc, in three-dimensional space. Consequently, the thesis proposes a Laser-scanning-system-based method for the research on spatial visibility estimation of traffic signs. We can accurately measure the influence space feature can have on traffic signs, which is exactly the characteristic of this method. The research work explored in this dissertation are as follows:

Firstly, we propose an effective algorithm for the extraction of traffic signs, we accomplish the detection task by making a combination of Reflected Intensity and Principal Component Analysis(PCA) to detect traffic signs in point clouds. To be

specific, we first detect planar Point Clouds Cluster in the Point Clouds based on PCA, and then extract traffic signs in the Point Clouds Cluster using its high Reflected Intensity Feature.

Secondly we propose spatial visibility field, intensity of spatial visibility field and visibility that measure objects' spatial visibility in 3D point clouds, and we define visibility as the effective image area of traffic sign in the retina. We make visibility as the standard of spatial visibility of traffic signs from different observing locations.

Thirdly, we propose a framework of assessing spatial visibility of traffic signs. According to extracted traffic signs, we can calculate the distance between traffic signs, the visual angle and the size of the signs; and then we figure out the spatial visibility of the signs in question by adopting the quaternion method, alpha-shape algorithm and retina image formation principle；after that the shade is calculated by using X-ray transmission method and the viewpoint is figured out by spatial visibility field and shade。

In this dissertation, we analyze and verify the proposed framework of spatial visibility of traffic signs through a series of related experiments, for instance, we collect Xiamen Island's road data by using Vehicle-Borne Laser Scanning System VMX-450 for experiment and validation. The results show that this framework of spatial visibility proposed in the paper can resolve the problem and achieve the research goal, it has important application value.

Key words：Laser Scanning Point Cloud; Traffic Sign；Object Detection；Spatial Visibility

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