

Traffic Sign Detection and Extraction with GIS, GPS, and Machine Learning

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Abstract

Traffic signs play an important role in driving safety. Building and maintaining traffic sign inventories are essential to ensure normal functioning of traffic systems. Existing management systems for traffic signs usually rely on labor-intensive inventory. For instance, approaches have been developed to integrate GPS data and vehicle-based imageries to detect location-based signs. However, such process is hindered by moderate accuracy. This study provides an innovative way to detect traffic signs based on geotagged photos from Google Street View and geotagged videos from GoPro. We used the Single Shot Multi-Box Detector with a TensorFlow framework to train the recognition model to deal with the Google Street images. Besides, this research utilized YOLO to extract traffic signs from GoPro videos with GPS stamps. Google Street View provides tremendous data volume with street view. And GoPro videos enriched the accuracy and temporal update frequency of traffic sign. Combination of these two approaches unleashed the power of traffic sign extraction in both spatial and temporal dimension. Street spatial network were integrated to improve the accuracy of traffic signs location. The whole process is implemented on a graphic card with CUDA acceleration to speed up the training and detecting process. Results showed that stop signs and traffic lights can be accurately detected and extracted. This research helps to reduce workload for traditional traffic signs inventory. Our workflow can be used to detect other traffic signs and applied to other cities.

Background

Most traffic signs are digitized with geospatial related attributes [1], which contributes to the urban planning system. Some traffic signs management systems have been developed in the past a few decades. Existing traffic signs management systems usually rely on labor-intensive site inventory. And road traffic signs should be constantly and automatically maintained and updated. With a fast development of machine learning and big data techniques, such tasks could be accomplished based on automatic image recognition [2] with deep learning. This research employs innovative artificial intelligence techniques and geographic information sciences to automatically detect traffic signs based on images. Our model was trained and fine-tuned to achieve a robust and reliable result. Specifically, this research mainly focuses on traffic signs and then transfers them on digital maps.

Method

This research provides an innovative way to detect traffic signs based on geotagged photos from Google Street View (Fig. 1) and geotagged videos from GoPro (Fig. 2). This research used Google Street View Application Programming Interface (API) to download street view images. We used the objection detection API within TensorFlow framework to train the model and try to find features with useful information expected among images.

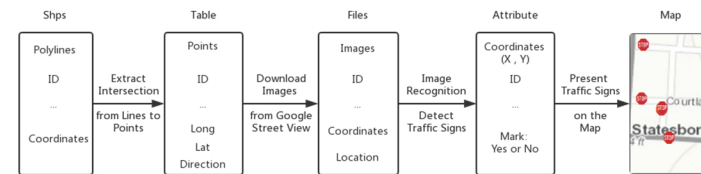


Fig. 1 Workflow from Google Street View

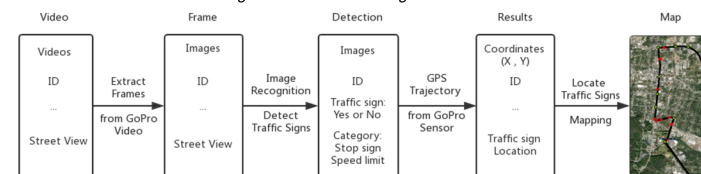


Fig. 2 Workflow from GoPro Video

This research utilized the Single Shot Multi-Box Detector [3] with a TensorFlow framework to train the recognition model to deal with the Google Street images. Figure 1 illustrated the pattern of traffic sign detection and extraction in a systematic and automatic way with an innovative method to acquire street sign information from Google Street View [4]. Besides, this research utilized pre-trained model to extract traffic signs from GoPro videos with GPS stamps. First, we used GoPro to record a video in the downtown area of Statesboro. Then, frames extracted from videos are linked with GoPro sensor data at same time to acquire GPS information, which can contribute to locate traffic signs. With many traffic sign possibility areas because of frames captured by GoPro, it is necessary to create an algorithm to clear traffic signs redundancy and sort them out. Before presenting the results on the map, we evaluate the detection results with confusion matrix.

Results

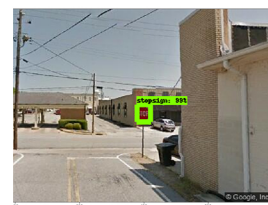


Fig. 3 Detection of stop sign



Fig. 4 Detection of speed limit



Fig. 5 Detection of traffic light

Google Street View provides tremendous data volume with street view. And GoPro videos enriched the accuracy and temporal update frequency of traffic sign. Combination of these two approaches unleashed the power of traffic sign extraction (Fig. 3-5) in both spatial and temporal dimension. Results showed that stop signs and traffic lights can be accurately detected and extracted (Fig. 6).

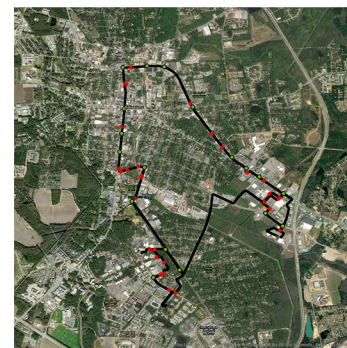


Fig. 6 Extraction of stop signs and traffic lights from GoPro Video (Red: stop signs, Green: traffic lights)

And all the stop signs can be present on the digital map (Fig. 7).

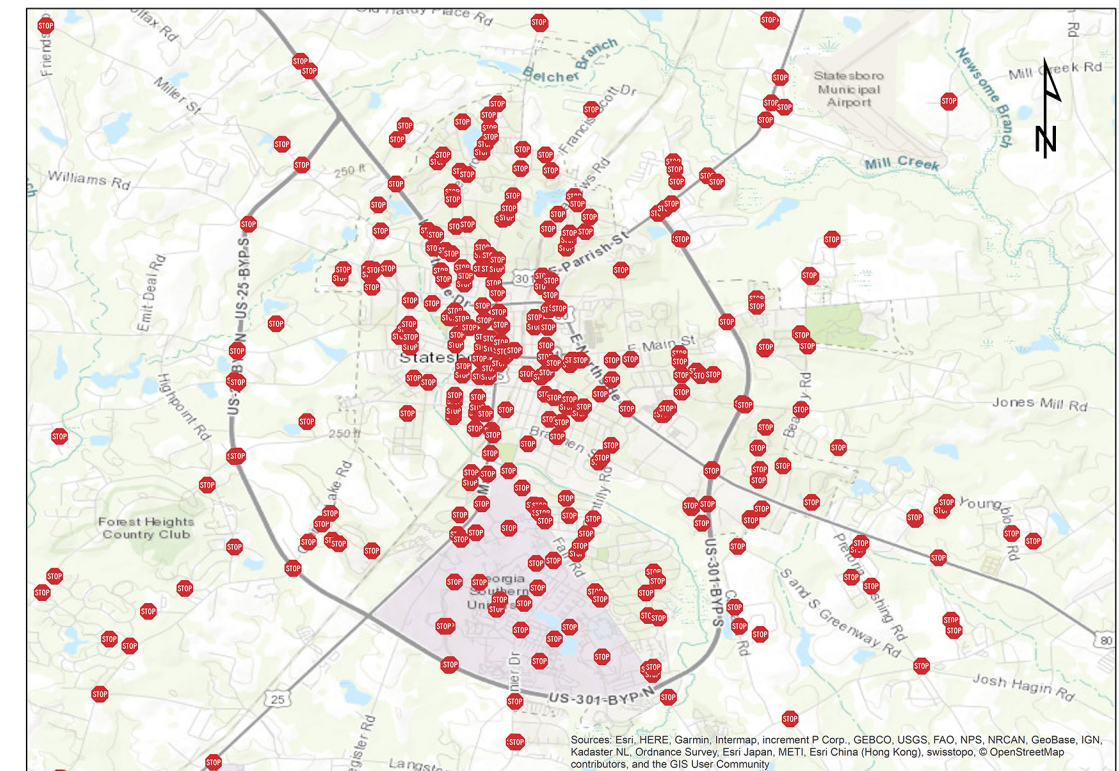


Fig. 7 Automatically detected stop signs overlaid on the Statesboro street map

Discussion and conclusion

This research analyzes traffic sign information in the city of Statesboro and has significance in traffic sign management. This method illustrates the principle of traffic sign recognition and road assets extraction. This research takes traffic lights, road signs, speed limit signs, and other general traffic signs into account. It helps to reduce workload for traditional traffic signs inventory. The whole toolkit can be used by transportation and related departments. This method can be widely used in traffic sign management to improve efficiency and reduce cost and workload for traditional traffic inventory. It can provide some innovative thoughts to help them to create auto deliver system (from warehouse to consumers) in an urban area.

Acknowledgements

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Reference

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