Joint Transportation Research Program

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Integration of Lane-Specific Traffic Data Generated from Real-Time CCTV Videos into INDOT's Traffic Management System

Introduction

The Indiana Department of Transportation (INDOT) uses about 600 digital cameras along highways in populated areas of Indiana to monitor highway traffic conditions. The videos from these cameras are currently observed by human operators looking for traffic conditions and incidents. However, it is time-consuming for the operators to scan through all the video data from all the cameras in real-time. The main objective of this research was to develop and implement an automatic and real-time system at INDOT to monitor traffic conditions and detect incidents automatically.

Findings

The Transportation and Autonomous Systems Institute (TASI) of the Purdue School of Engineering and Technology at Indiana University-Purdue University Indianapolis (IUPUI) and the Traffic Management Center of INDOT have worked together to conduct research and develop a system that monitors traffic conditions based on the INDOT CCTV video feeds. The proposed system performs traffic flow estimation, incident detection, and classification of vehicles involved in an incident. The goal was to develop a system and prepare for future implementation.

The research team designed the new system, including the hardware and software components, the currently existing INDOT CCTV system, the database structure for traffic data extracted from the videos, and a user-friendly web-based server for showing the incident locations automatically.

Implementation

The preliminary prototype of some system components was implemented in the 2018–2019 JTRP projects, which provided the feasibility and structure of the automatic traffic status extraction from the video feeds. The 2019–2021 JTRP project focused on developing and improving the functionality and computation speed of features to make the program run in real-time. The specific work in this 2021–2022 JTRP project is to improve the system further and implement it on INDOT's premises. The system implemented at INDOT has the following features.

Vehicle-Detection

Automatic detection of vehicles is an essential part of this project. The artificial intelligence object detection method, YOLOv4, has been used and further improved for vehicle detection in various lighting and traffic conditions. As a result, vehicle detection performance in an automatically selected region of interest can reach over 90% accuracy.

Road Boundary Detection

Since the aiming direction of each camera can change, it is impossible to specify, a priori, the road and lane locations on the video image. Therefore, the team used the tracking information of detected moving vehicles to determine road boundaries. This way only the vehicles detected on the road are considered for traffic condition checking. The knowledge of road location helps to eliminate vehicle detection errors.

Lane Detection

Since the aiming direction of each camera can

change, the lane locations on the video image must also adapt to the camera angle. The lanes are statistically determined by tracing the vehicle motion at the reference lines on the road, since the majority of vehicles remain in the same lane for their duration in the region(s) of interest.

Vehicle Count and Flowrate Detection

There are horizontal region(s) on the video frames where the vehicle can be detected most accurately. The vehicles in each lane are counted and the frames have timestamps. Each lane's flow rate (cars/hour) is derived based on vehicle counting and the camera frame timestamps.

Traffic Condition Detection

The traffic flow status is derived from the availability of the real-time flow rate on each detected lane. The traffic flow status is categorized as normal, slow, and congested. The conditions for each camera-observed road segment are reported to the central database and displayed on the webpage for traffic operators.

Database Development

This project uses a database as a central place to gather and distribute the information generated from all camera videos and the incident detection results derived from sensory information. In addition, the database also provides information for the user interface. The database has been successfully implemented in MySQL.

Web-Based Graphical User Interface (GUI)

A web-based graphical user interface (GUI) was developed with input and suggestions from INDOT. The GUI automatically reads data from the database and displays information on the output webpage. The GUI displays four types of information—(1) the location of all installed cameras on the Google Map, (2) all traffic incident locations (shown in red color) on the Google Map, (3) the real-time video of the focused incident location, and (4) all traffic information at the focused incident location. In addition, this GUI supports the selection of a focused traffic incident location among all incident locations.

Hardware Specification Study

In addition to developing and testing on Linux PCs with powerful NVidia GPUs, the research team also tailored the system to enable it to run on Linux PC with relatively low-end GPU and CPU (e.g., a $1,500 PC is sufficient to process one camera data in real-time).

The research team has installed the system on one computer at INDOT for daily road traffic monitoring operations.

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