JOINT TRANSPORTATION RESEARCH PROGRAM

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Road Condition Detection and Classification from Existing CCTV Feed

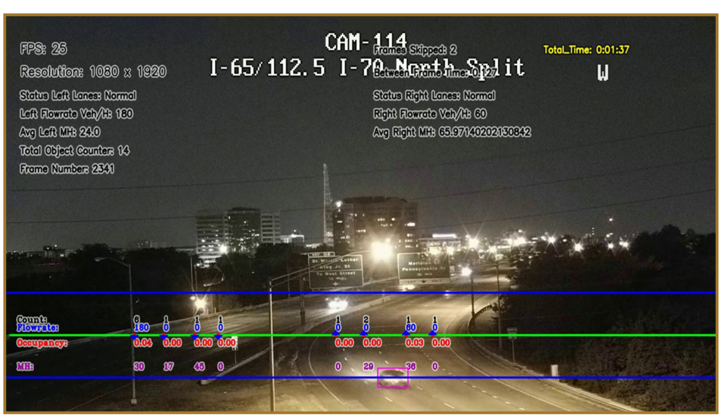
Introduction

The Indiana Department of Transportation (INDOT) has approximately 500 digital cameras along highways in populated areas of Indiana. These cameras are used to monitor traffic conditions around the clock, all year round. Currently, the videos from these cameras are observed one by one by human operators looking for traffic conditions and incidents. It is time-consuming for the operators to scan through all the video data coming from all the cameras in real-time. The main objective of this research was to develop an automatic and real-time system 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 this 2-year research project to develop a system that monitors the 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 system, which included the hardware and software components additions to the currently existing INDOT CCTV system; the relationship between the added system and the existing INDOT system; the database structure for traffic data extracted from the videos; and a user-friendly web-based server for showing the incident locations automatically.



Detection of multiple lanes.

Implementation

The preliminary prototype of some system components were implemented in *Development of Automated Incident Detection System Using Existing ATMS CCT* (SPR-4305). This 2-year project focuses on improving feature functionality and computation speed to make the program run in real-time. The specific work in this project included the following.

1. *Vehicle Detection*

Automatic detection of vehicles is an essential part of this project. Various methods were tried and compared to improve the computation speed. The artificial intelligence method in YOLOv4 for vehicle detection currently generates the best results for daytime and lit conditions. Vehicle detection performance in an automatically selected region of interest reaches over 90% accuracy by YOLOv4.

2. Road Boundary Detection

Since the aiming direction of each camera can change, it is not possible to specify, a priori, the road and lane locations on the video image. Therefore, the team used the tracking information of moving vehicles to determine road boundaries. Then only the vehicle detected on the road is considered for traffic condition checking. This helps to eliminate vehicle detection errors.

3. Lane Detection

Since the aiming direction of each camera can change, it is not possible to specify, a priori, the lane locations on the video image. However, because most vehicles stay in their current lanes, the team developed lane detection and direction detection methods.

4. Vehicle Count over Time and Low-rate Detection

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

5. 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 fast, 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.

6. Database Development

This project uses a database as a central place to gather and distribute the information generated from camera videos and the incident detection results derived from sensory information in the database. The database also provides the information for the user interface. The database tables and their relationships have been redesigned and augmented. The database has been successfully implemented in MySQL and can be converted to PostgreSQL if needed.

7. Web-based Graphical User Interface (GUI)

A web-based Graphical User Interface (GUI) was developed with input and suggestions from INDOT. The GUI reads data from the database and generates user-interested information on the output display. The GUI displays four types of information: (1) 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.

8. Hardware Specification Study

After implementing various system components, the research team performed experiments to run the system in different computer hardware and software environments. As a result, it is concluded that a mid-range GPU is sufficient for the real-time implementation of the system. On the other hand, the CPU power and the memory size are important factors (e.g., a $2,500 PC is sufficient to process one camera data in real-time).

The research team is currently testing the integrated systems for various camera and lighting conditions. In addition, the system is put into daily road traffic monitoring operation to identify the situations that need to be considered.

Recommended Citation for Report

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