Advanced Automobile Recognition Through the Use of Image Processing Techniques

Andrew W. Stebbins
TJHSST
Alexandria, Virginia

April 8, 2008

Abstract

Many law enforcement agencies have recently shown interest in automated automobile recognition and tracking technologies such as license plate reading or GPS tracking. However, some criminals may drive vehicles that have false license plates or are not equipped with GPS tracking devices, making the pursuit of such vehicles difficult. This project aims to create a computer vision system capable of taking real-time input from a static camera and identifying passing cars by make and model in order to assist law enforcement agencies in the tracking of suspect or stolen vehicles. Vehicle identification is accomplished using a combination of old and new algorithmic image processing techniques.

Keywords: Canny edge detector, Hough transform, Gaussian smoothing, Scale Invariant Feature Transform

1 Introduction

Many law enforcement agencies, especially those in large metropolitan areas, are faced with difficulties when tasked with finding one type car in a city of thousands. For example, a police officer may receive breaking news of a robbery underway, arrive late at the scene, and then have to chase the getaway car provided only with a witness's visual description of the vehicle.

Existing car-tracking technologies such as License Plate Recognition (LPR) would fail in this case, as the officer does not know the license plate number of the vehicle driven by the suspects who he is attempting to apprehend. It is in cases like these that an automatic visual automobile recognition system may prove useful. Thus, this project is primarily aimed towards enabling law enforcement agencies to more easily chase down criminals or recover stolen cars.

2 Background

Several computer systems currently exist for the tracking of military and civilian automobiles via License Plate Recognition (LPR) or GPS technology. Such systems are in use by law enforcement entities such as US Customs and Border Protection[1] and UK police[2], and have proved very effective in catching criminals. However, these systems fail when an automobile has fake or no plates, and no GPS tracking device, and is able to avoid recognition. The system outlined in this paper, on the other hand, is able to alert law enforcement officers of the presence of any specific type of vehicle regardless of whether or not it is equipped with GPS or the proper license plates, assisting in situations such as when an all-points bulletin is put out for a certain vehicle based only on a visual description. In addition, some systems already exist[3] that can automatically recognize military vehicles such as tanks by their color, size, geometric description. However, in the course of my research I found few existing systems capable of the advanced (ie make and model) recognition of everyday civilian vehicles such as cars, small trucks, semis, etc.

Much research has been done on the general topic of computer-based object recognition, resulting in the development of such techniques as the Viola-Jones face recognition algorithm and David Lowe's Scale Invariant Feature Transform (SIFT) keypoint matching object classification method. Dlagnekov and Belongie, at the University of California, San Diego, have made an attempt at a car recognition system based off of region of interest (ROI) identification through the use of LPR and actual object recognition through the use of SIFT keypoint matching. They recorded a successful recognition rate of 89.5% on their query set of 38 images using a database of 790 images of known make and model.

3 Region of Interest Identification

The purpose of identifying the region of interest in an image that contains a car is to remove background clutter and make it easier for the object classification algorithm to correctly recognize key features. My program only analyzes cars from a side profile perspective, so centering the ROI around the license plate as Dlagnekov et al.[5] did is not an option. Instead, my program uses a Hough transform-based circle detector to locate the front and back wheels of the car, and then uses those coordinates to center the ROI around the body of the car. Movement tracking is also a commonly used and reasonably accurate method for obtaining such a region of interest[5], and I may combine this method of ROI detection with my wheel detector if I have time at the end of the fourth quarter.

4 Object Recognition

I intend to use David Lowe's SIFT keypoint matching method to correctly identify the cars located inside the detected ROI in a given input image. SIFT keypoint detection consist of scale space extrema detection, keypoint localization, orientation assignment, and creation of a keypoint descriptor[6]. Currently, my program is able to locate all SIFT keypoint candidates through the use of Gaussian smoothing and the difference-of-Gaussian function. Scale space extrema are detected by comparing the difference in the value of a pixel at one scale to the value of the pixel in the same place at another scale to that same value at all of the locations adjacent to that pixel in all current and neighboring scales. Once my program is able to locate and describe SIFT keypoints, it will make a best guess as to the make and model of the car in the input image based on the number of matching SIFT keypoints between the input image and each image in the database of cars of known make and model.

I have developed a separate program to receive and process real-time input from a USB webcam attached to a Linux computer. Once I have completed my implementation of the SIFT keypoint matching algorithm, I intend to combine it with this program to produce a program with a GUI that allows the user to freeze any given frame and detect the model and make of each car located within the camera's view at that particular moment.

I have also looked into neural networks as an intuitive, learning-based method of automobile classification. My conclusion was that they would not be appropriate for an object categorization task of such complexity. The set of training example images would need to be immense for a neural network-based automobile recognition program to attain any acceptable level of accuracy.

5 Results and Discussion

Unfortunately, my project does not yet exist in the form of a single program able to be tested on its ability to detect and recognize automobiles in still images or streaming video feeds. I have yet to complete my implementation of the SIFT keypoint identification and matching algorithm, though I am confident that this will be achieved within the next few weeks. The frame rate of my streaming input viewer is somewhat low, a problem which will have to be addressed before motion detection can be considered as a possible method of ROI location in addition to wheel detection. I hope to be able to test an assembled version of my final program on a database of testing images composed of pictures of cars from the TJ student parking lot by the end of the fourth quarter.

References

[1] "LPR technology makes recording license plates a snap." U.S. Customs Today. 27 October 2007
http://cbp.dhs.gov/xp/CustomsToday/2001/December/custoday_lpr.xml

[2] "Number plate scanners hit crime." BBC News. 27 October 2007
http://news.bbc.co.uk/2/hi/uk_news/england/berkshire/4553469.stm

[3] Dalley, Gerald. "Vehicle Recognition in Cluttered Environments.", 2002.
http://people.csail.mit.edu/dalleyg/presentations/MSThesisPresentation.ppt (October 27, 2007)

[4] Ferencz, A. et al., "Learning Hyper-Features for Visual Identification", 2004.
http://www.eecs.berkeley.edu/Research/Projects/CS/vision/shape/papers/ferencz-nips04.pdf (October 27, 2007)

[5] Dlagnekov, L. et al., "Recognizing Cars", 2004.
http://www.cse.ucsd.edu/classes/fa05/cse252c/dlagnekov_belongie.pdf
(January 2, 2007)

[6] Lowe, David. "Distinctive Image Features from Scale-Invariant Keypoints", 2004.
http://www.cs.ubc.ca/ lowe/papers/ijcv04.pdf (January 2, 2007)