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Intelligent Driver Assistance System using Image Processing

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Abstract: ***Road safety is an imperative issue to be considered towards the aim of decreasing road accidents and fatalities thereof. The nature of traffic in India is identified to be highly heterogenic. Considering this an Intelligent Driver Assistance System is proposed in this paper. The said system, comprising of three phases: Image Acquisition, Image Processing and Reporting, employs a sequence of efficient image processing algorithms. The three modules of the Image Processing Phase work towards different aims to provide complete driver assistance in totality. These modules are: Prediction of crash; Least Congestion Route Suggestion and Lane Departure Detection. The proposed system makes use of onboard sensors for image acquisition. Canny edge detection algorithm is employed on the greyscale converted images to yield better results than other first order derivative filters. In the Crash prediction module, the system engages Kalman filters for trajectory analysis of the equipped vehicle and the surrounding vehicles in defined proximity. The proposed system is superior to its counterparts by virtue of its integrated modules providing comprehensive driver assistance.***

Keywords: Road safety, Crash prediction, Lane departure, Kalman filters, Driver assistance

1. Introduction

Road safety has become the utmost concern in the country in view of the rising numbers of road accidents and fatalities thereof. A report by WHO states that-

'The *Global status report on road safety 2013* estimates that more than 231 000 people are killed in road traffic crashes in India every year. Approximately half of all deaths on the country's roads are among vulnerable road users - motorcyclists, pedestrians and cyclists. A heterogeneous traffic mix that includes high-speed vehicles sharing the road space with vulnerable road users as well as unsafe road infrastructure and vehicles that are in poor condition all contribute to the high fatality rates seen on India's roads.'[5]

Road accidents can be prevented by using driver assistance systems. Such systems are currently employed for suggesting routes using GPS or in the form of alarming systems in which the alarm is set off when proximity of another vehicle is below a certain threshold. Individual systems have their own advantages but an integrated system would provide to be much more effective.

This paper proposes an Intelligent Driver Assistance System that uses Digital Image Processing algorithms. It is superior to existing technologies by virtue of its integrated modules and use of trajectory analysis and prediction by employing Kalman filters.

2. System Architecture

The proposed system primarily consists of three phases, namely:

- Image Acquisition phase
- Image Processing phase
- Reporting phase

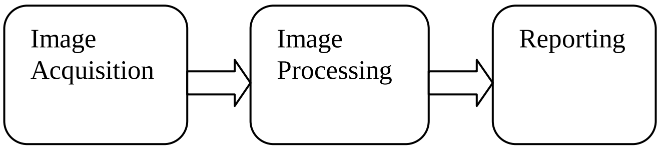

Fig1: Phases of the system

3. System Description

3.1 Image Acquisition Phase

In this phase, the images are acquired using sensors mounted on the vehicle. Images can be obtained as still frames from a continuous video captured by the onboard camera. Frames will be captured at predetermined interval so as to avoid processing of unnecessary or similar frames. A quick detection and elimination of similar frames when the vehicle is still or there is no significant change in the successive images can be employed using the following steps:

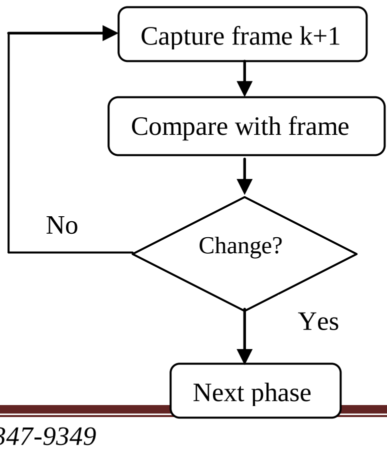

Fig 2: Image Acquisition steps

3.2 Image Processing Phase

This phase is the actual heart of the system. It is responsible for implementing the following sequence of Image Processing algorithms to get the desired outputs.

The phase obtains the images from the previous phase. These images are full-color images. Processing full-color images is computationally complex and also requires more memory. Hence, in the first step in this phase, the full-color images are converted to greyscale for ease of applying the image processing algorithms thereafter.

The second step in this phase is edge detection. Now, edge detection can be done using first as well as second derivative filters. But, the second derivative is more responsive to noise and also produces double edge. On the other hand, the first derivative, though produces thicker edges, is less affected by noise. First derivative filtering involves using Prewitt or Sobel filters. Using Gaussian filtering to smooth the image i.e. removing the noise before applying first derivative yields above average results. This concept is used in Canny edge detection algorithm. The following figures show comparison between edge detection using Prewitt filter and Canny edge detection algorithm.

Fig 3: Grey scale image

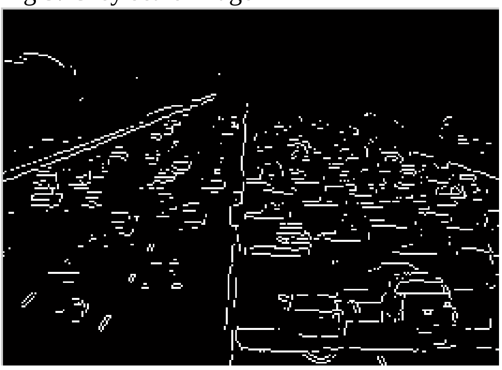

Fig 4: Edge detection using Prewitt Filter

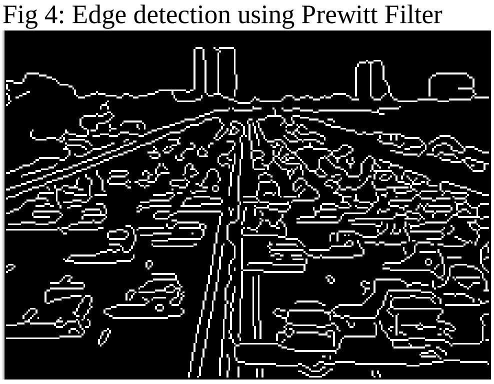

Fig 5 : Canny edge detection

The figures show that Canny edge detection gives better results. However, a lot of details are highlighted. Unnecessary details can be omitted by applying thresholding after edge detection.

After the detection of edges, morphological operation of closing is used to obtain the vehicles. Detection of each vehicle is done and the type of the vehicle is identified by feature extraction.

The next step in the image processing phase will depend on the modules as follows:

- Module 1: Prediction of crash or accident.
- Module 2: Least congestion route suggestion.
- Module 3: Lane departure detection.

Each module works towards a different goal by employing different algorithms on the so-far processed image. These modules are described in the following sections.

3.2.1 Module 1: Prediction of crash

The vehicle on which the said system is mounted is referred to as the equipped vehicle. This module makes use of trajectory analysis of the equipped vehicle as well as other vehicles in defined proximity of the equipped vehicle.

An efficient tool for this purpose is ‘Kalman filter’. Kalman filter basically uses the knowledge of previous state and some control inputs to predict the current state, without measurements for the current state. This step is the prediction step. In the update step, the Kalman filter takes measurement of control inputs for current state and compares with the predicted state to obtain the error. These two phases alternate each other. The prediction advances the state until the next scheduled observation and the update incorporates the observation. However, the update may be skipped and multiple prediction steps may be performed. The update step helps in reducing the error between the predicted and measured output. Once this error is reduced to an acceptable level, training is accomplished. Thus using the Kalman filters, trajectories of the equipped vehicle and the surrounding vehicles can be sketched. These trajectories are then used to predict a possible crash.

The algorithm for tracking the vehicles can be implemented using the following steps:

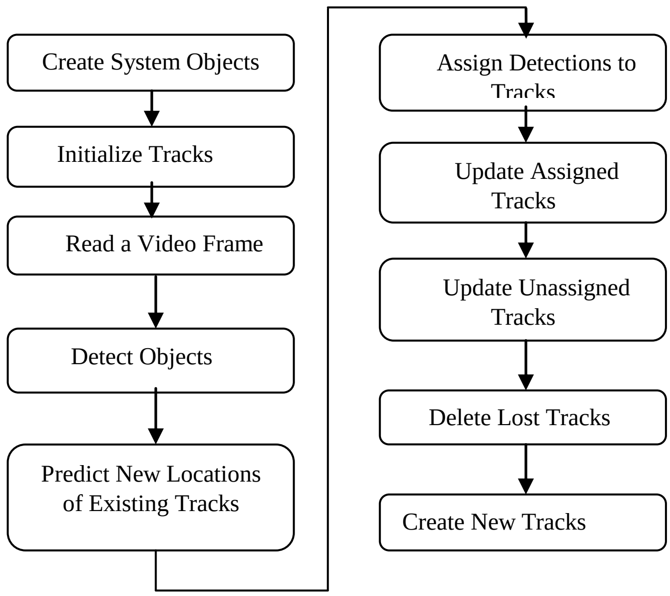

Fig 6: Steps for tracking vehicles.

3.2.2 Module 2: Least congestion route suggestion.

This module suggests congestion free routes to be taken by the driver. For this, the equipped vehicle must communicate with a remote system to obtain satellite based images of different roads.

Once the desired destination is fed into the system, the system will come up with different routes that the driver may take to the desired destination. Using the satellite images of these paths, the system on the equipped vehicle computes the traffic density on each path. For this it requires traffic density computation algorithm. On the pre-processed images, the system applies this density computation algorithm. Different routes are compared on this density value and the least congested path is suggested to the driver.

3.2.3 Module 3: Lane Departure Detection

This module warns the driver about lane departure. Lane departures may be necessary, like in the case of making a turn to the right or left or unnecessary. In case of frequent unnecessary lane departures, the risk of a crash increases and is identified as one of the primary causes for road accidents in India. Lane departures can be notified to the driver using this module, posterior to which the driver may decide to either override the notification in case of necessary lane departure or be warned in case of unnecessary ones. The module works in the following manner.

When the equipped vehicle starts its travel on any road, the system detects the paint lines on either side of the vehicle. These lines may be the broken white lines or the continuous dividers. The system identifies the lanes through these paint markings. The system continuously monitors these paint lines. If the regular pattern of these lines is broken by the equipped vehicle at any instance, a lane departure is detected and the driver is notified.

3.3 Reporting Phase

Reporting phase involves giving notifications to the driver. In this phase, whenever any of the modules has some result or error, the driver is notified. The notification may be in the form of an LCD display or better still, a voiced notification. The driver’s acknowledgement to the notification will turn it off. Priorities are defined in case of multiple notifications occurring at the same time. Highest priority is given to the crash prediction module followed by lane departure detection module. The least congestion route suggestion module is activated by the users command.

4. Conclusions and Future Scope

The proposed Intelligent Driver Assistance System integrated three modules to provide complete driver assistance. This system makes use of Kalman filters to produce efficient and accurate outputs. Moreover, the various algorithms used by different phases and modules in this system are compared with their counterparts and deduced to be more effective. Hence, the system as a whole can efficiently work towards the goal of reducing traffic problems on the roads.

However, certain drawbacks of the system can certainly be improved as part of the future scope. Firstly, considering the heterogeneity of traffic on Indian roads, the vehicle detection algorithm must contain a rich database to detect every kind of vehicle. Secondly, the edge detection and vehicle identification algorithm must account for shadows. Shadows of vehicles should not be considered while computing traffic congestion, else it will yield erroneous results. Thirdly, an attempt to reduce the response time of each module must be made in order to predict crashes well in advance so as to give enough time for the driver to react and also to increase the speed of the overall system.

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