**Research Methodology**

**(IN 6910)**

**Assignment**

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**Analysis of the research paper “A real-time computer vision system for vehicle tracking and traffic surveillance (Coifman et al., 1998)” using scientific method.**

1. Observation

In recent years, traffic congestion has become a significant problem. Early solutions attempted to lay more pavement to avoid congestion, but adding more lanes is becoming less and less feasible. Contemporary solutions emphasize better information and control to use the existing infrastructure more efficiently.

The quest for better traffic information, and thus, an increasing reliance on traffic surveillance, has resulted in a need for better vehicle detection such as wide-area detectors; while the high costs and safety risks associated with lane closures has directed the search towards non-invasive detectors mounted beyond the edge of the pavement. One promising approach is vehicle tracking via video image processing, which can yield traditional traffic parameters such as flow and velocity, as well as new parameters such as lane changes and vehicle trajectories.

Increasing congestion on freeways and problems associated with existing detectors have spawned an interest in new vehicle detection technologies such as video image processing. Existing commercial image processing systems work well in free-flowing traffic, but the systems have difficulties with congestion, shadows and lighting transitions. These problems stem from vehicles partially occluding one another and the fact that vehicles appear differently under various lighting conditions.

1. Preliminary study

Most of the commercial VIPS available today are tripwire systems which mimic the operation of loop detectors, but they do not track vehicles. That is, they do not identify individual vehicles as unique targets and follow their movements in time distinct from other vehicles. The following detectors are examples of commercial tripwire systems: AUTOSCOPE, CCATS, TAS, IMPACTS and TraffiCam (Hockaday, 1991; Hoose, 1992; Chatziioanou et al., 1994; Klein and Kelley, 1996; MNDOT, 1997).

The systems typically allow a user to specify several detection regions in the video image and then the given system looks for image intensity changes in the detection regions to indicate vehicle presence/passage. The comparisons are not computationally intensive and can be implemented on Intel 386 based PC's. The primary advantage of these systems is the ease of placing/replacing detector zones and the fact that there is no need to cut the pavement. Some of these systems use a large number of detection zones to follow successive detector actuations through the image, (e.g. IMPACTS), but they do not track vehicles.

Some commercial systems do track vehicles, the so-called “third generation” VIPS, e.g. CMS Mobilizer, Eliop EVA, PEEK VideoTrak, Nestor TrafficVision, and Sumitomo IDET (Chat-ziioanou et al., 1994; Klein and Kelley, 1996; MNDOT, 1997; Nihan et al., 1995). Generally, these systems use region based tracking, i.e., vehicles are segmented based on movement. Unfortunately, if one moving target (including its shadow) occludes another, the two targets may become merged together by the tracking software.

Recent evaluations of commercial VIPS found the systems had problems with congestion, high flow, occlusion, camera vibration due to wind, lighting transitions between night/day and day/night, and long shadows linking vehicles together (Hockaday, 1991; Chatziioanou et al., 1994;

Nihan et al., 1995; Klein and Kelley, 1996; MNDOT, 1997). The need for traffic surveillance under ALL conditions has led to research in more advanced video-based vehicle detection. For example, Chao et al. (1996) have developed an algorithm to differentiate vehicles from shadows.

On a larger scale, the FHWA has sponsored a major research effort administered by the Jet Propulsion Laboratory (JPL) to advance wide-area traffic detector technology (Condos, 1996; JPL,1997). Five VIPS were funded by the JPL project, of which, three were existing commercial products (AUTOSCOPE, CMS Mobilizer, and Nestor TrafficVision). The two remaining systems were produced in university laboratories: Autocolor (Chachich et al., 1996; Zeng and Crisman, 1996), which uses color features to identify vehicles, segment them from the background image and track them through the camera's field of view; and Roadwatch, the subject of this report.

1. Problem definition

To be an effective traffic surveillance tool, whether by mimicking loop detectors or actually tracking vehicles, a video image processing system (VIPS) should meet several stringent requirements:

1. Automatic segmentation of each vehicle from the background and from other vehicles so that all vehicles are detected.
2. Correctly detect all types of road vehicles - motorcycles, passenger cars, buses, construction equipment, trucks, etc.
3. Function under a wide range of traffic conditions - light traffic, congestion, varying speeds in different lanes.
4. Function under a wide variety of lighting conditions - sunny, overcast, twilight, night, rainy, etc.
5. Operate in real-time.

Even though a number of commercial VIPS for monitoring traffic have been introduced to the market, many of these criteria still cannot be met.

1. Hypothesis development
2. Experimental design
3. Data Collection
4. Data Analysis
5. Conclusion

Recent evaluations of commercial VIPS found the existing systems have problems with congestion, occlusion, lighting transitions between night/day and day/night, camera vibration due to wind, and long shadows linking vehicles together. We have presented a vehicle detection and tracking system that is designed to operate under these challenging conditions. Instead of tracking entire vehicles, vehicle features are tracked, which makes the system less sensitive to the problem of partial occlusion. The same algorithm is used for tracking in daylight, twilight and nighttime conditions, it is self-regulating by selecting the most salient features for the given conditions. Common motion over entire feature tracks is used to group features from individual vehicles and reduce the probability that long shadows will link vehicles together. Finally, camera motion during high wind is accounted for by tracking a small number of fiducial points.

The resulting vehicle trajectories can be used to provide traditional traffic parameters as well as new metrics such as lane changes. The trajectories can be used as input to more sophisticated, automated surveillance applications, e.g. incident detection based on acceleration/deceleration and lane change maneuvers. The vehicle tracker is well suited both for permanent surveillance installations and for short term traffic studies such as examining vehicle movements in weaving sections. The vehicle tracking system can also extract vehicle signatures to match observations between detector stations and quantify conditions over extended links. A real-time version of the system has been implemented using a network of DSP chips. The system has been tested on approximately 44 lane-hours of data and has demonstrated good performance under the challenging conditions that have limited earlier VIPS.

References:-

Coifman, B., Beymer, D., McLauchlan, P., Malik, J., 1998. A real-time computer vision system for vehicle tracking and traffic surveillance. Transp. Res. Part C Emerg. Technol. 6, 271–288.