**Research Methodology**

**(IN 6910)**

**Assignment**

D.N.H Senevirathna

139180A

Faculty of Information Technology

University of Moratuwa

**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

According to the study by Coifman and coworkers, they have observed that in recent years the increasing traffic congestion on freeways has become a significant problem for the existing vehicle detectors. Furthermore they have noticed that the early solutions such as to lay more pavement and add more lanes to avoid congestion had become less feasible with time. They have noted that existing commercial vehicle detection systems based on video image processing are working well in free-flowing traffic but having difficulties with situations like congestion, shadows and light transitions occur due to partial occlusion of vehicle and also due to the fact that vehicles appearing differently under various light conditions. Therefore they have stated the significance of introducing a feature based tracking system for detecting vehicles under these challenging conditions.

1. Preliminary study

Coifman and coworkers, in their work, have studied about the commercial video image processing systems (VIPS) available at present and stated that most of them are tripwire systems which mimic the operation of loop detectors rather than tracking vehicles. AUTOSCOPE, CCATS, TAS, IMPACTS and TraffiCam (Hockaday, 1991; Hoose, 1992; Chatziioanou et al., 1994; Klein and Kelley, 1996; MNDOT, 1997) are some of the commercial tripwire systems they have studied. They have identified that these available systems do not identify individual vehicles as unique targets and follow their movements in time distinct from other vehicles.

Furthermore, they have studied about third generation video image processing systems which track vehicles by using region based tracking in which vehicles are segmented based on movement. They have considered commercial system such as 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) as third generation VIPS. They have recognized that in situations like occlusion, two different moving targets may become merged by these systems.

They have also studied about recent evaluations of commercial VIPS, and the evaluations has revealed that the current 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).

In this research, they have also studied about the algorithm developed to differentiate vehicles from shadows by Chao and coworkers Chao et al. (1996).

Different vehicle tracking strategies from computer vision literature has been studied and discussed in this work and they have been classified as model based tracking, region based tracking, active contour based tracking and feature based tracking.

2.1. Model based tracking

Three-dimensional model-based vehicle tracking systems have previously been investigated by several research groups, the most prominent being the groups at Karlsruhe (Koller et al., 1993) and at the University of Reading (Baker and Sullivan, 1992; Sullivan, 1992). The emphasis is on recovering trajectories and models with high accuracy for a small number of vehicles. The most serious weakness of this approach is the reliance on detailed geometric object models. It is unrealistic to expect to be able to have detailed models for all vehicles that could be found on the roadway.

2.2. Region based tracking

In this approach, the VIPS identifies a connected region in the image, a `blob', associated with each vehicle and then tracks it over time using a cross-correlation measure. Typically, the process is initialized by the background subtraction technique. A Kalman filter-based adaptive background model (Karmann and Brandt, 1990; Kilger, 1992) allows the background estimate to evolve as the weather and time of day affect lighting conditions. Foreground objects (vehicles) are detected by subtracting the incoming image from the current background estimate, looking for pixels where this difference image is above some threshold and then finding connected components.

This approach works fairly well in free-flowing traffic. However, under congested traffic conditions, vehicles partially occlude one another instead of being spatially isolated, which makes the task of segmenting individual vehicles difficult. Such vehicles will become grouped together as one large blob in the foreground image. Fig. 1(A) illustrates this phenomena on a hypothetical one dimensional roadway (i.e. no width) viewed from the camera's perspective, henceforth referred to as the image plane. The vehicles have finite length, hence the trajectories are shown as `thick' bands in the time space plane. By time t3, vehicle 2 partially occludes vehicle 1. Region based tracking would erroneously merge the two `blobs' together at this point.

2.3. Active contour based tracking

A dual to the region based approach is tracking based on active contour models, or snakes. The basic idea is to have a representation of the bounding contour of the object and keep dynamically updating it. The previous system for vehicle tracking developed in our group, Koller et al. (1994 a,b), was based on this approach. The advantage of having a contour based representation instead of a region based representation is reduced computational complexity. However, the inability to segment vehicles that are partially occluded remains. If one could initialize a separate contour for each vehicle, then one could track even in the presence of partial occlusion (Koller et al., 1994a). However, initialization is the difficult part of the problem! Consider the example in Fig. 1(A): if the vehicles enter the detection region partially occluded, the system will group two vehicles into a single object and this will result in significant measurement errors.

2.4. Feature based tracking

An alternative approach to tracking abandons the idea of tracking objects as a whole and instead, tracks sub-features such as distinguishable points or lines on the object. The advantage of this approach is that even in the presence of partial occlusion, some of the features of the moving object remain visible. Furthermore, the same algorithm can be used for tracking in daylight, twilight or night-time conditions; it is self-regulating because it selects the most salient features under the given conditions.4 Fig. 1(B) shows feature tracking for the same two vehicles in the earlier example. Individual features are highlighted at three instants in time and the lines indicate their respective tracks.5 For illustration, the features from dierent vehicles are shown with dierent symbols, but, in practice, the features would be indistinguishable at the tracking level. By t3, some of the features from the ®rst vehicle are occluded and lost, however, other features from this vehicle remain and continue to be tracked.

While detecting

1. Problem definition

After the study of existing vehicle detection system, they have identified the following stringent requirements of a system in order to be an effective traffic surveillance tool.

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.

They have stated that many of these criteria still cannot be met by the existing commercial VIPS for monitoring traffic available in the market.

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.