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THE PRAGMATIC ANALYSIS ON REAL LIFE SCENARIOS AND OBSERVATIONS IN MACHINE VISION AND ASSOCIATED ASPECTS

Sanjeev Kumar
Research Scholar (PhD)
Department of Physics
NIMS University, Jaipur, Rajasthan, India

Dr. Rakesh Kumar
Professor
K.S. Jain Engg. College, Ghaziabad (U.P.), India

Traffic Monitoring

There are several techniques used for traffic monitoring bank on sensors which have limited capabilities, are inexible and often, both costly and troubled to establish. The use of video cameras (many of which are already installed to survey road networks, and air traffic), linked with computer vision techniques extends an attractive alternative to current sensors. Vision based sensors have the potential to measure a far greater variety of traffic parameters compared to conventional sensors.

In road traffic monitoring, there are two vision based traffic-monitoring systems. The first is a number-plate acknowledgment system. This is capable of monitoring the output from a video camera and detecting when a vehicle passes by. At this moment an image is captured and the vehicle's number-plate is located and deciphered. The second system is a generic adtraffic monitoring sensor which utilises model based techniques to track vehicles as they maneuver through complex road scenes.

The position of the vehicle in the image is transformed to the vehicle's position in the real world enabling, among other things, vehicle speed and path to be easily measured. The development of each system is described in detail and results from testing the systems on images from real traffic scenes are presented.

4.2 Road Traffic Monitoring:

Road-traffic monitoring involves the accumulation of data depicting the characteristics of vehicles and their movement through road networks. Vehicle counts, vehicle speed, vehicle path, rates, vehicle density, vehicle length, weight, class (car, van, bus) and vehicle identity via the number plate are all examples of useful data.

1. Laser technology: A laser pulse is noticed after its reflection from the vehicle. Exact but is used only for detecting speed violations.

2. Microwave technology: Similar principle as laser. It can also be used to detect other violations, e.g. vehicles in bus lanes.

3. Induction loops: Coils of wire embedded in the road's surface. They detect a change of inductance in a large coil, which forms part of a resonant circuit, caused by the coil's proximity to a conductive (e.g. metal) object. Large installation, maintenance costs (asphalt has to be cut), small region

4. Magnetic sensors: Detection of the changes of a magnetic field (e.g. the earth magnetic field) through the physical influence of a ferromagnetic object in the vicinity of it.

Visual detection: Optical cameras using image processing and/or computer vision to detect moving objects, low-cost installation, larger area is monitored, different approaches

4.3 Road-traffic Monitoring and Computer Vision:

Computer vision is the process of using a computer to draw out high level information from a digital image. A typical vision system for road traffic monitoring might appear. The CCD camera renders live video which is digitalized and fed into the computer which may well contain some special purpose hardware to cope with the exceedingly high data rates (10 MBytes/s). Computer vision algorithms then perform vehicle detection, tracking, classification or identification via number-plate recognition.

Computer Vision is possibly more powerful than any other sensor currently available. The installation of video cameras to monitor road networks is cheaper and less troubled than installing other sensors. In fact, large numbers of cameras are already installed on road networks for surveillance purposes. A single camera is able to monitor more than one lane of trafic along several hundred metres of road. Vision based systems have the potential to extract a much richer variety of information such as precise vehicle path, vehicle shape, dimensions and colour. With suitable positioning of the camera, a vision system is capable of tracking vehicles as they manoeuvre through complex road junctions or along comparatively long extends of road. A vision system could theoretically have the same powers of observation as a human observer but without the damaging effects of weariness and tedium.

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A fundamental requirement for the success of a vision based traffic monitoring system is that it operates in real time. If each image is 720 by 512 pixels and the camera is producing 25 frames per second then the data rate is in the order of 10 MBytes/s. This may be coped with by the use of special purpose, possibly parallel, hardware. Such hardware tends to implement low level functions such as filtering (convolution) or pixelwise operators which involve very simple operations that must be repeated many times per image. The alternative way of coping with the high data rates is by data reduction, spatially or temporally. Spatial data reduction involves processing only small portions of each image known as regions of Interest. In a typical traffic scene, much of the image is of little interest as it contains buildings, vegetation or pavement. These areas are never likely to contain a vehicle and so it is ludicrous to waste processor time on them. Temporal data reduction is achieved by only processing every nth frame. The amount of temporal data reduction that may be applied is dependent on the particular application. A system for measuring queue length at a set of traffic lights might only need to operate at one frame every few seconds whereas a system for tracking vehicles through junctions must process at least several frames per second.

4.4 A Number-Plate Recognition System

A Generic Road-Traffic Monitoring Sensor

Several number-plate recognition systems which have been developed around the world are reviewed. And non-model based systems have no idea of what a vehicle looks like and are therefore unable to achieve any image understanding. They are able to detect and track objects in the scene but are unable to recognise them. The effect of this is that one of these systems would respond to an elephant walking down the road as if it were a car. These systems merely detect and track groups of image pixels without understanding what the pixels represent in the real world.

Again, relevant techniques are introduced; in this case, motion detection review is then given of several non-model based road-traffic monitoring systems which have been developed. Using information about the position of the camera relative to the road and knowledge of what vehicles look like, the image is transformed into a full 3D description of the scene. Not only are these systems able to locate objects in 3D real world coordinates but they are also able to recognise vehicles. These systems would not be fooled by an elephant walking down the road. The location and recognition processes are able to extract far more information than the non-model based systems, i.e. vehicle dimensions and shape, direction and precise path. Vehicle dimensions and shape can be used to classify vehicles as car, van, bus, etc. Knowledge about the vehicle shape and scene geometry is represented in models and the techniques of model based object recognition are used to locate and track vehicles through sequences of images.

Number-plate Recognition: In order to achieve number-plate recognition, two processes must be performed. The first is to locate the number-plate and its constituent characters in the image. There are no established methods for doing this and developers are reluctant to publish details of their systems due to the commercial nature of the problem. It can be regarded as the most challenging aspect of number-plate recognition. The few systems described in the literature seem to adopt one of two approaches. The first is based on thresholding the image such that number-plate characters are black and the background white. The image is then searched for regions containing several adjacent black blobs which all have similar dimensions to the expected number-plate characters. The second approach is to utilise neural networks although the details of exactly how do not seem to have been published.

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The second process is character recognition. This is a fairly well developed field in computer vision and several techniques are available.

Template matching: This necessitates the use of a database of characters or templates. In this, there is a distinguish template for each possible input character. Recognition is achieved by comparing the current input character to each template in order to find the one which matches the best. If I(x; y) is the input character, Tn(x; y) is template n, then the matching function s(I; Tn) will return a value indicating how well template n matches the input character.

Cityblock:

Character recognition is attained by identifying which Tn gives the best value of matching function, s (I; Tn). The method can only be successful if the input character and the stored templates are of the same (or at least very similar) font. Template matching can be performed on binary, threshold characters or on grey-level characters. In the latter case, comparison functions such as Normalised Correlation are usually used as they render amended exemption to variations in brightness and contrast between the input character and the stored template.

Feature based character recognition: This is performed by first extracting significant features from the input character. These features are then compared to a database of feature descriptors for all of the possible input characters. The best matching descriptor provides recognition. Global transformations and series expansions reduce the dimensionality of the feature vector and can provide some invariance to translation, scale and rotation. Examples include Fourier, Walsh, Haar, Hadamard series expansions and Hough transform, chain-code transform and principal axis transform.

4.5 **Air Traffic Monitoring:**

With the increasing demand for air transportation, all parties involved in the air transportation system have increased their efforts to make the system more efficient without sacrificing safety. This paper presents a new system based on information integration, the Air Traffic Control Command Monitoring System (ATCCMS), which integrates all kinds of fundamental information such as radar information, flight plans, voice communication, and weather conditions into a comprehensive information platform. In this paper, the context of voice communication is analyzed with speech recognition technology and is correlated with radar data and expert knowledge to determine whether any potential danger will emerge from the controller's instructions. Simulation experiments show that the safety level of air transportation systems will be effectively improved by the use of the information integration technique.

4.5.1. SAFETY PROBLEMS IN AIR TRAFFIC CONTROL:

During busy aviation activity, the concentration and stress of human controllers are so heavy that their mistakes are an important source of danger to flight safety. Most mistakes are related to the controller's speech instructions [6].

At present, TCAS has become the standard device for current civil aviation aircraft, which can effectively provide the pilot with potential conflicts and advice in order to avoid collision. For the controllers, there are several sets of new air control systems and aided-command systems to choose from, such as the Auto Track system of Raytheon, the international airspace management

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system of Hughes, the EUROCAT of Thomson-CSF, the ASTEC system of Lockheed-Martin, and the CTAS of NASA [7]. Most of these systems comply with the CNS/ATM standard of ICAO [7], and have common characteristics such as wide-screen high-differentiability-rate controller workstation, friendly graphical user interface (GUI), and functions such as radar data processing (RDP), flight data processing (FDP), automatic dependent surveillance (ADS), and conflict detection and alerting. For flight safety, however, the following flaws exist in these systems:

(1) speech instructions are not recognized as an important data source so that controllers' behaviour cannot be monitored, and hence alerts for the danger resulting from false instructions cannot be given in advance;

(2) High-level flow management is not combined with conflict avoidance.

The process of ensuring ATC safety may be regard as the one that ensures the basal information to be transmitted quickly and to be processed efficiently so as to provide good decision-making information. There are two ways to improve ATC safety.

One is to upgrade the unit technique in the air traffic control system, such as the radar and controller workstation. This requires great investment and a long time period, and cannot improve monitoring of the controller's voice communication.

The other is to use integration technology, which includes two steps. The first step is information integration. With computer networks and relation databases, all kinds of basal information in air transportation system can be shared by controllers, and dynamic information of aircraft and the condition of controllers and pilots can be acquired in real time and stored in the global database.

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Integrated information about flight safety is extracted, and false instructions and potential dangers are detected using model analysis, on-line analysis & processing, or artificial intelligence, so that alerts and advice are given to controllers in time. The second step is system-integration on the basis of information integration. In this step, the optimal schedule of flow within a whole country or regional area is introduced, and flight safety is ensured at a higher level. Thus profitability can be improved.

4.6 TYPE OF TRAFFIC INFORMATION:

One of the important elements in providing traveler information is to adopt measures that travelers find helpful in depicting roadway traffic conditions. Thus, the survey participants were asked to rate the usefulness of the following measures in helping them understand traffic conditions on the city streets:

- location of possible incidents
- level of congestion
- speed of traffic
- traffic volumes
- camera snapshots
- travel time prediction
- Live video of roadway.

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The possible measures of arterial performance were all perceived positively but of less usefulness than the incident information. Travel speeds, traffic volumes, camera views, and travel time predictions received relatively similar responses. The two lowest rated measures were the camera images, although live streaming video may help users determine whether they are looking at real congestion or just cars waiting at a light on an arterial.

4.7 DEVICES FOR DELIVERING TRAFFIC INFORMATION:

This section addresses the importance of presenting traffic conditions on devices desired by the public. Traffic information can be packaged differently via different devices. For instance, visual/graphic presentation of traffic information is emphasized on the Web. Geographic coverage can be described in more depth on the Web than over a radio broadcast. Therefore, it is useful to find out how travelers rate the usefulness of a variety of information delivery devices. The devices respondents were asked about include the following:

- the Web via desktop or laptop computers
- the Web via handheld and palmtop devices
- radio
- telephone
- in-vehicle devices
- television
- pagers

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• Kiosks.

Not astoundingly since the survey was Web based, the majority of respondents thought that the Web via desktop or laptop computers was an effective medium for getting traffic information. In contrast, obtaining traffic information from the Web via handheld and palmtop devices was not perceived to be nearly as useful.

Reasons for this observation may be associated with usability and cost issues. Currently, only selected Web sites are reformatted for hand held devices. Also, equipment and air time costs appear to have limited respondents' experiences with handheld and palmtop devices.

4.8 Wide Area Video Vehicle Detection System:

Wide Area Video Vehicle Detection System system uses machine vision technology and an embedded processor to produce highly accurate traffic measurements:

- speed data
- estimation of traffic statistics (e.g. volume)
- vehicle classification
- Detection of incidents in highways.

Each camera can be individually configured with Virtual Detectors, virtual Detectors: "Regions of Interest" that can detect local motion (target presence) using contrast recognition and learned patterns. All cameras are addressable by a unique IP address and are linked using serial cables (RS-485 similar to RS-232 but suitable for larger distances up to 1Km)

4.9 Video Sensor Data Fusion

Periodically polls the event data (VD states) from the cameras (constant cycle), Processes the data received to detect and avoid possible false alarms Forms the observations (plots) that contain:

- The time of the event
- The ground position and size of the target (uses calibration)
- Additional information (e.g. velocity)

Sends observations to the tracker of the system (SDS) in ASTERIX format (radar data exchange standard). Supports an optional visualization window, which shows VDs and observations on an airport map.

4.10 Camera Calibration

For each camera, a function to convert ground to image coordinate and vice versa is estimated. Calibration is used to create a VSDF configuration file, which contains the ground coordinates of the four corners of each detector. The detector centers (in ground coordinates) are then used for producing VSDF observations.

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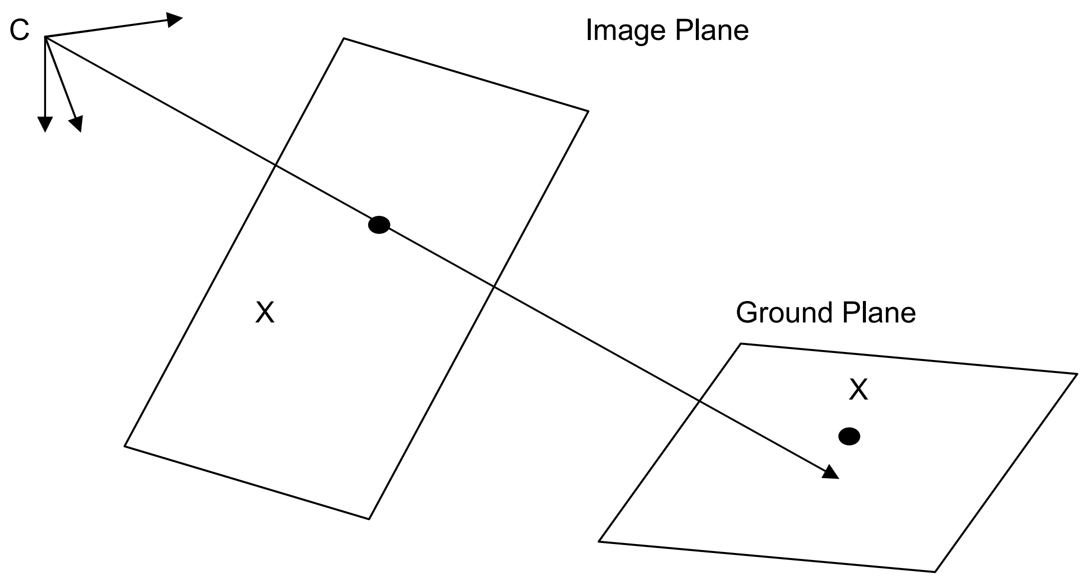

If X=(X,Y,1) and x=(x,y,1) (projective coordinates) and C is a projective camera then x and X are related by an homography M (3x3 matrix with 8 degrees of freedom – scale is arbitrary): X=Mx

We fix scale by setting M33=1

$$M = \begin{pmatrix} M_{11} & M_{12} & M_{13} \\ M_{21} & M_{22} & M_{23} \\ M_{31} & M_{32} & M_{33} \end{pmatrix}$$

$n \geq 4$ corresponding points (X,x) are marked both on the map (ground coordinates) and the image. Calibration is then achieved by solving an over-determined system of n equations and 8 unknowns, using least squares estimation.

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