Intelligent Monitoring of Traffic Load and Flow of Vehicular Crossroads with Image and Video Processing Techniques

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Abstract— This research project develops an intelligent monitoring scheme of traffic load and flow of vehicular crossroads with image and video processing techniques. The software is tested on specific image / video simulated traffic problems, suitable to be embedded on the intelligent traffic camera. We develop an optical multiple cars speed correlator. We present an innovative automatic number plate recognition system. Traffic video data in real difficult cross-road problems concentrate most traffic cases due to node geometry. We include focus and filtering problems with concern on night vision and focus.

Keywords—Traffic; monitoring; camera; embed; accident; lane; horizon; parking; path.

I. INTRODUCTION

Traffic understanding improves traffic flow, cost, safety and impact on ecosystem. All Greek cities present certain traffic problems saturation in critical streets and crossroads. Traffic monitoring by visual means, seems to be the best tool to understand overcome and control such traffic problems.

High density, efficient and rapid transportation needs to all directions and for all people create intense traffic problems.

Traffic engineering knowledge is critical for optimal traffic flow includes traffic load, flow and other crossroads traffic parameters (queuing parameters, delays, time intervals, speed, density, capacity, level of services, lanes, direction, start-stop effect, cars wave front, etc) and their statistical distributions are monitored and derived.

What we are doing?

- A preliminary monitoring scheme
- Algorithms to support monitoring

What we are not doing(due to time/budget limits)?

- Vehicular Control
- Traffic Control
- Autonomous Vehicles
- Autonomous Traffic Lights
- Traffic Technology

Video surveillance cameras have grown in popularity and use as an effective tool for traffic monitoring. Power over Ethernet (PoE) models add simplicity and convenience. Traffic control systems are embracing the higher bandwidth Ethernet technology. Live video, video surveillance systems, and other outdoor applications, require a transmission bandwidth up to 100 times and must be transmitted over a distance of several miles, usually to a central traffic operations center.

Advanced Transportation Management Systems (ATMS) are evolving rapidly. As city and county governments evaluate their traffic systems, it is good planning to prepare for, if not immediately install, sophisticated video traffic monitoring applications along with traditional traffic control signals and traffic flow management systems. Ethernet over fiber optic cabling is playing a crucial role in the deployment of these sophisticated high-bandwidth systems.

After thorough traffic monitoring and bibliography global research we classify traffic cross-roads problems.

Traffic monitoring (problems - parameters – problems classification): A properly designed automated transportation system offers efficiency increments from 10% up to 100% or even better. Last 20 years all streets were loaded in traffic with consecutive traffic jams, time delays in transports, etc [1, 2, 3].

Streets and geometry in cities is a rigid parameter, but traffic efficiency is assisted by intelligent monitoring crossroad parameters such as vehicles presence / approach, wave, front, crossing, queue, speed, events, classification, hierarchy, etc. Traffic police experience understanding includes technology, networks, night vision, law enforcement, official reports, major cross road, etc.

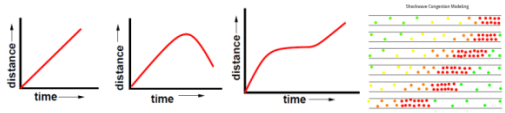


Fig. 1. Traffic parameters by visual means

A traffic statistical package describes and presents:

- Car distribution in x, y axes per lane
- Speed of cars arrival / departure / queue formation / change
- traffic capacity / peak hours / jam
- wave of brake lights due to traffic
- car distances / velocity gradients / traffic wave shift / spread / rarefication / etc
- Traffic jam study / traffic change / cyclic (periodic) phenomena in traffic
- Traffic conditions, control, intelligence
- Parked / stopped cars management
- Traffic crossroads classification, etc

In our project we only cover the basic statistical parameters.

Moving observer implementation: Cameras are airborne of different hights, handheld and car cameras. The moving observer (i.e. a camera on a following car) is useful mainly for traffic monitoring and control.

Fig. 2. Fuzzy environment, road or vehicle

Fig. 3. Filters blur and reflections by rain

A badly focused photograph evokes a universal sense of loss, because we all take it for granted that we cannot change the focus in a photograph after the fact; the depth of field and blur of objects decreases as the aperture size increases and needs short exposure times in bright light.

Fig. 4. Shadows in traffic

Fig. 5. Hanoi cross road group of cars, group of tracks and thresholding [4, 5]; temporal window should not be too small nor the detection threshold too high; the images are further eroded or dilated to form the traffic areas within the crossroad.

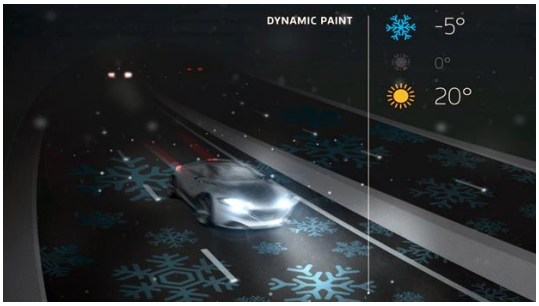


Fig. 6. Optical Traffic Signs [12]

Image / video retrieval and data bases include videos from marked cameras, visible, located in places with a history of serious accidents and where there was evidence of a speeding problem or where was a local community concern.

Fig. 7. Image / Video Retrieval

We try to establish a simple to use crossroads traffic data base application, understand traffic police data bases and grasp municipality traffic experience by cross-road field sampling - simulating real data in static and moving observer implementations in order to solve common static traffic cross-roads problems / solving with image processing techniques [6, 7, 8].

Fig. 8. Detection of rain and water pools in the road - Holes on the road and artificial obstacles for speed reduction

After years using backing glass mirrors to try and drive backwards for parking and not hit things, rear view back up cameras are becoming common on cars. Blind spot warning systems on the side view mirror alarm drivers when another car is placed in car mirrors blind spot. When you look at the side mirror to see if it is safe to change lanes, it is very reassuring to have that extra safety support software.

Car placing on crossroad can be seen by static camera or moving observer cameras (we examine the case of overview static camera. Car placing and manipulation in crossroads is of paramount importance for crossroad safety statistics indices.

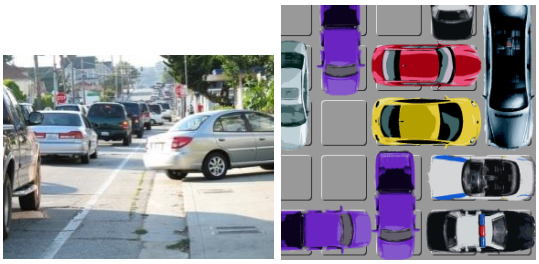
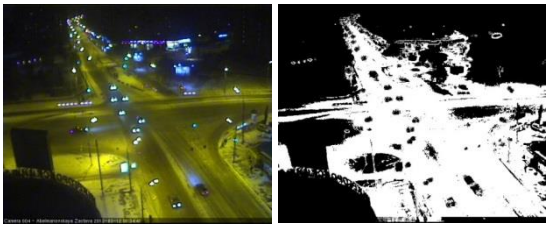
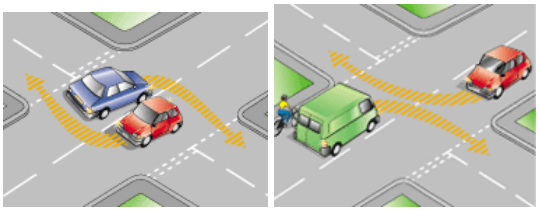


Fig. 9. Parking geometry - Illegal parking





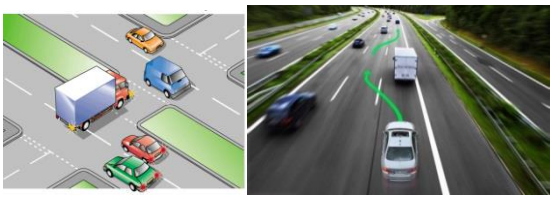


Fig. 10. Accident prediction on overtaking

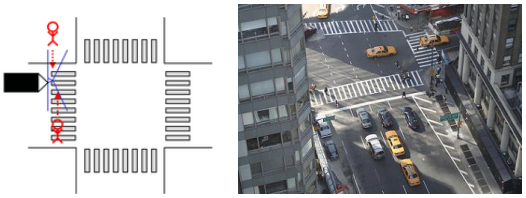


Fig. 11. Pedestrian detection / management

Fig. 12. Ramps for persons with special needs

Red light violation reduction and stoplight progress indicator concept improves utility of traffic signals. Traffic lights haven't been updated much. A new stoplight design concept adds a progress indicator to calm drivers and give them more accurate feedback. It informs drivers how long they will rest at a stoplight. A driver can even shut the vehicle's engine off at a long light without fear that traffic.

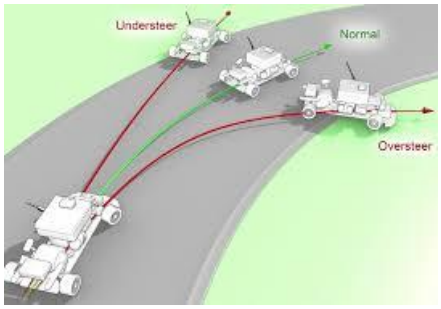


Fig. 13. Loss of control conditions - Simple turn

may suddenly restart A better understanding of stoplights, step on the way to a smarter city and assists drivers to figure out if a stoplight is stuck. The way a driver becomes smart is to store in his brain only the information that he has to know, dismissing the rest. If it's written down, I don't need to know it. This stoplight is promoted as an ecological solution since we get the amount of time to stop in front of it, we can shut our engine off, wait, be calm, and turn it back on again when the time is almost up. This not only lessens the amount of gas you use sitting still, but it lessens the amount of crazy madness you have wondering if the stoplight is stuck, or just really, really long. The average level of red light overrunning is about some times higher than in northern European countries. These levels are unacceptable and therefore indicate that traffic signals are not an ineffective way of controlling traffic and these trends should be reversed by raising awareness of drivers and more education measures as well as more vigorous enforcement measures implemented in the country.

Fig. 14. 3D problems in traffic problems images

Fig. 15. Car on the air (flying car)

In dangerous manoeuvring, the driver judges accurately whether it's safe to make a turn; road testing driver's assistance technology can prevent a collision in a potentially dangerous mistake.

For stationary or moving car template reading we apply on a single/multiple video frames recording the car template reading software developed by D. Carras, 2007 and use under his kind permission.

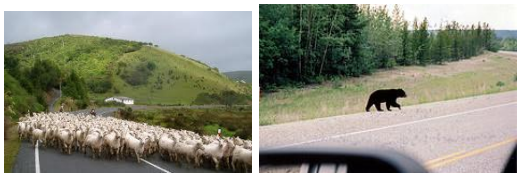


Fig. 16. Animals on the road

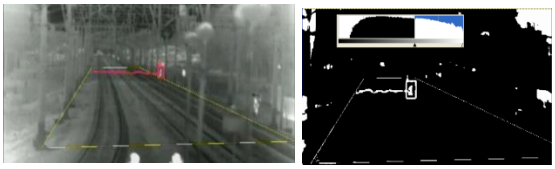


Fig. 17. Human obstacle detection on the road

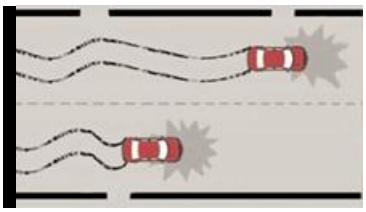


Fig. 18. Car accident prediction by cars trajectories

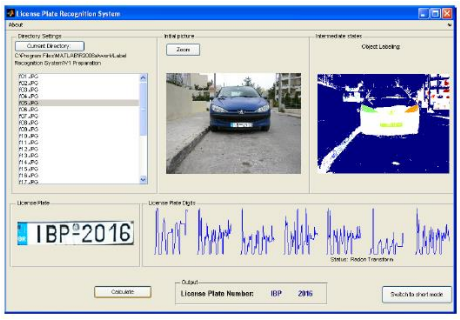


Fig. 19. Radon transform for letters A, B [9, 10]

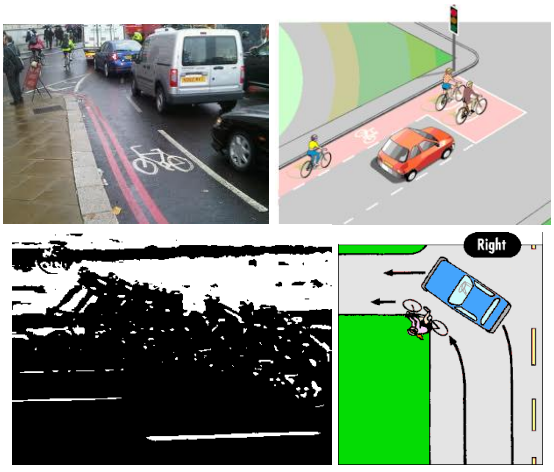


Fig. 20. Bicycles lanes and traffic accidents

Drivers should always ensure it was safe to overtake before doing so. All motorists should follow the Highway Code for safety. We expect the van to slow down and wait for the subsequent straight bit of road ahead to overtake. Instead the van decided to hammer it past the car and the artic

in front on a blind corner with oncoming traffic. Video captures driver's dangerous driving moves.

The information of vehicles is obtained by background-frame difference, and distance measurement between the vehicle and line.

In fatal car accident analysis cases,eg we examine a car overtake by another car in the following phases:

Fig. 21. Vehicle overthrown on the road

Fig. 22. For directivity and vehicle placement in cross-road we need to substitute cars by vectors

Fig. 23. Video filmed from a following car tracking

Fig. 24. Big and long vehicles

Fig. 25. Car tracking

- A car 1 is following another heading car 2
- Car driver decides to bypass heading car 2
- The car driver takes its car out of its course slightly and checks the opposite lane if occupied for some unsafe length

Fig. 26. Agricultural traffic nodes problems [11]

Fig. 27. Horizon detection and faulty detection

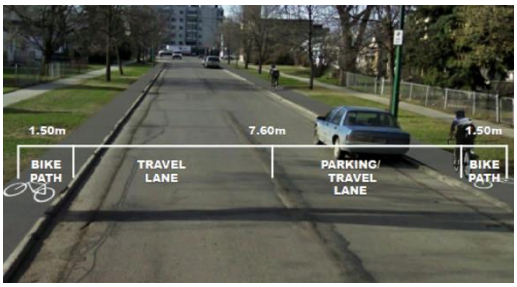


Fig. 28. Lanes width calibration

Fig. 29. Grouping vehicles in a traffic wave

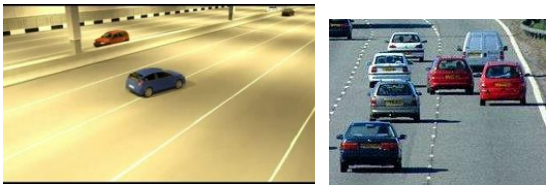


Fig. 30. Car accident analysis - Car crossing a lane

Fig. 31. Geometrical parmeters of the road

Fig. 32. Night traffic monitoring

- Car 1 is placed on opposite lane and speeds up to bypass in time and fast

We solve and integrate common or difficult static and dynamic traffic cross-roads problems.

Fig. 33. Traffic tolls as a motor way special node

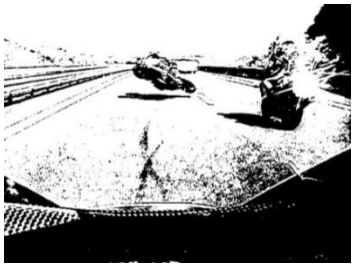


Fig. 34. Motorbike demolition

An accurate design of a camera controller for surveillance is essential for road traffic monitoring and image data management purposes. We design an FPGA-based method of designing an essential camera controller. Simulation models were used in functional evaluation of the controller. The controller is capable of achieving real image data and realize efficient flow control as captured through traffic monitoring. The validity of the proposed system design remains to be evaluated through actual experiments on traffic road monitoring. Intelligent traffic camera includes an embedded software version for a Smart Camera as a Traffic Sensor and the Optical Speed Correlator.

Fig. 35.Intelligent traffic camera acquisition system

System integration of traffic monitoring includes intelligence, information fusion, traffic cases implementation, adaptation to changing traffic needs, simulation results and error analysis.

There is a build-up financial interest from scientists, enterprises in the job area of automation, software engineering and traffic monitoring and control in our application design and results. We propose and design a spin-off company for new scientists, dealing with DSP, Image and Video Processing and / or Traffic Engineering Software. The resulting technology know how, legal advices and links will be handled to a group of young scientists to form and organize a local spin-off traffic technology enterprise for installation service.

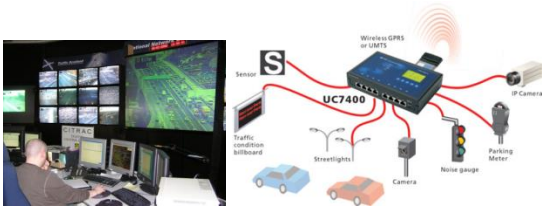


Fig. 36. MMI of Traffic Monitoring System of traffic cross-roads problems Input Output Feedback

Fig. 37. Intelligent cross road node wi-fi network

Fig. 38. Adding thresholded video frames/erosion/ edge detection/skelotonization defines car paths

Progress beyond the state of the art will be new approaches and algorithms, innovative techniques, better understanding, parameters reveal / enhancement, integrated approach, modular prototype traffic software, intelligent monitoring, embedded software, extending software for nodes types, prospective depth transforms, traffic management evaluation, efficient number and

modes, traffic knowledge acquisition, traffic technology support.

An integrated Intelligent Monitoring System of Traffic Flow in Vehicles Crossroads includes crossroads traffic parameters, data base of crossroads traffic parameters, moving observer implementation, test results on simulation and real data, embedded software intelligent camera, cross-correlator car speed measurement, automatic number plate recognition, car deformation, etc. The software will run off-line and faces a sufficient set of indicative traffic problems (**such** as flow, illegal parking, etc selected by the research team).

We deliver the developed and tested software for simulation of images and videos for the traffic load monitoring. The research objective and result is the intelligent monitoring (and not control) of the traffic motion in a cross road, assisted by image and video processing techniques.

The **main traffic application problems** that we algorithmically face are [13]: illegal parking, lane change, intersection information, over speeding, cross road lights violation, dangerous driving, car overtaking, illegal racing, speed information, road-type, display all the information etc, on main or special traffic nodes, such as close to major city utilities (i.e. hospitals, parking, etc).

Camera and Hardware: USB 3.0 C/CS vision B/W or color model camera features a super speed data interface capable of 5Gbit/s and throughput of up to 400 Mpix/s with the CMOS sensors and global shutters and improved quantum efficiency in the visible and NIR spectral ranges with sensor resolution from VGA to 4Mpix, frame rates of up to 600fps, with dynamic range of 100 dB, opto-isolated trigger input and lighting synchronisation output, on-board non-volatile memory for user settings and custom data, ADCs, smallest dimensions and volume of any weight, very low power consumption is suitable for image quality in the variety of lighting roads conditions.

CONCLUSIONS

This project [14] mainly classifies and develops intelligent monitoring algorithms for traffic load and flow of crossroads with image and video processing techniques. The software is tested on image / video simulated traffic problems, ready to be embedded on an intelligent traffic camera. We present two optical tools, ie multiple cars speed correlator and number plate recognition system.

ACKNOWLEDGMENT

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: ARCHIMEDES III. Investing in knowledge society through the European Social Fund.

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