An Enhanced GIS for Traffic Cross-Roads - Traffic Big Data Needs

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Abstract-- Effective monitoring and traffic management at modern urban area road systems contribute significantly to resolving traffic problems and enhance the quality of life. Congestion caused by lack of capacity and strength of the traffic network due to traffic bursts essentially directs the flow control management in urban area intersections which also imposes restrictions on the development of a city. We propose an enhanced GIS for Traffic Cross-Roads monitoring. We analyse the information size, software needs, quality and format associated with such a system. We developed algorithms for the identification of vehicles, their license plate recognition and the tracking of pedestrians when crossing intersections. The proposed framework is developed in a software standalone application for the image and video processing and it is open for future extensions.

Keywords-- Image, video processing, traffic monitoring, crossroad, camera, temporal database.

I. INTRODUCTION

The geographic information system (GIS) we propose is a computer system designed to capture, store, manipulate, analyze, manage, and present all types of spatial, geographical and cross-road operational data infrastructure, a concept that has no such restrictive boundaries. The traffic cross-road GIS integrates, stores, edits, analyzes, shares, and displays geographic and operational information about cross-road, that assist drivers to create interactive driver-created searches, analyze spatial information, edit data in maps, and present the results of all these operations including traffic engineering, planning, management, transport, etc. GIS and crossroad intelligence enables services that rely on analysis and visualization. Space–time traffic incidents may be recorded as spatial–temporal data and should be relatable. This GIS features can open new avenues of transport inquiry in crossroads incidents and traffic flow.

II. TRAFFIC CROSSROADS

In modern crossroads, we classify traffic problems and parameters, optimise traffic cameras set-up, node statistics, reschedule project, adapt, for static or moving observer camera [1].

We implemented a watermarking scheme for copyright protection as well as proof of ownership for video traffic data, for the protection of critical data obtained from video recording transportation load [2]. Our primary concern is the data protection even when the data receives an intentional or non-intentional degradation process.

Our research project is involved into monitoring traffic problems in traffic cross-roads by image and video cameras. Our work includes traffic parameters studies, traffic police and municipal authorities’ experiences, traffic node statistics, image and video acquisition, large video data bases, modern optical traffic signalling, image processing, moving / standing camera, etc. We studied static and dynamic problems, such as parking, red light violation, cars positioning in cross-road and postures, license plate recognition by different techniques, path tracking, accident prediction, car overtaking, error analysis, speed measurements with an optical multiple cars speed correlator, realistic difficult cross-road problems, node geometry, filtering problems with concern on night vision and focus, etc. We use modern techniques such as MMI, fusion, intelligence, adaptation, etc with focus on traffic load and flow and traffic safety and error analysis. We proposed and realised verified an intelligent traffic camera and we embedded and verified suitable software on this camera, we proposed and simulated a local spin-off enterprise for young engineers.

System integration of traffic monitoring includes intelligence, information fusion, traffic cases implementation, adaptation to changing traffic needs, simulation results and error analysis. An integrated Intelligent Monitoring System of Traffic Flow in Vehicles Crossroads includes crossroads traffic parameters, its data base, 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.

Traffic understanding improves traffic flow, cost, safety and impact on ecosystem. Modern cities present certain traffic problems saturation in critical streets and crossroads. Traffic monitoring by visual means, is the best tool to understand, overcome and control traffic problems.
Table 1
A traffic monitoring statistical package problems parameters classification

- Vehicles presence / approach
- Wave, front, crossing, queue, speed
- Events, classification, hierarchy, etc.
- 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
- Illegal parking, lane change, intersection information, over speeding, cross road lights violation, dangerous driving, car overtaking, racing, speed information, displays etc, on main or special traffic nodes

Intelligent traffic camera includes an embedded software version for a Smart Camera as a Traffic Sensor and the Optical Speed Correlator, i.e. an FPGA-based essential camera controller with a USB 3.0 C/CS vision B/W or color model camera with a super speed data interface capable of 5Gbit/s and throughput of up to 400 Mpix/s with 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 suitable for image quality in the variety of lighting roads conditions.
1. Traffic monitoring of an Agricultural traffic cross-road by image and video processing techniques:

We expanded video analysis tools in agricultural traffic applications, i.e. agricultural cross roads with critical agricultural activities and industries [3]. Traffic application data collection include traffic flow, turning junctions, road geometry, speed measurement and distribution, multiple point vehicle counts, vehicle classification, shape, patterns, poses, forms, dimensions, symmetry, luminosity, bounding box indicator, vehicle and obstacle detection, vehicle presence, number of vehicles, highway congestion, incident detection, flows at intersections, queue-lengths, space and time occupancy rates, detection of the lanes, road boundaries, etc.

Traffic monitoring under difficult varying visual conditions includes shadows, lighting, weather, motion, noise, interactions that need improved algorithms. We used traffic monitoring for car/vehicles counting, long vehicles identifications, agricultural vehicles recognition, traffic accidents, parking conditions monitoring, geometrical measurements, texture analysis, overloading, driving behaviour, etc.

Figure 5. Agricultural vehicles traffic problems

Figure 6. Tractor traffic manoeuvres, Problems of agricultural traffic monitoring, Agricultural scenes

Figure 7. Image / Frame Processing Chain

2. FPGA design of a camera control system for road traffic monitoring:

A vision-based system finds the road geometry and detects and avoids obstacles.

Basic traffic management measurements are approach queue length, approach flow profile, vehicle deceleration and information regarding the environment. Our objective is to design an intelligent surveillance system for traffic monitoring purposes [4].
Figure 8. Intelligent traffic surveillance camera controller and acquisition system; simple block diagram of surveillance camera controller based on DSP/CPU.

Figure 9. FPGA design, system architecture and implementation flow; general layout of the proposed surveillance camera control system; this is essential for road traffic monitoring and image data management purposes.
3. License Plate Recognition

1. Label isolation
2. Digit isolation procedure - resize digits
3. Extract the digit signature by Radon transform
4. Plate quality
5. Brightness of the initial image

Figure 10: License Plate Recognition algorithm, application user interface with examples, image after 2-D convolution, image edges after dilation; normalized Radon transform; used in traffic control (parking stations gates, security, police radar systems etc). The system was tested and the recognition rate of the character strings was 99.15% [5]
4. Trends Of Optical Traffic Measuring Technology

We suggest that there is an enormous need for adapting to optical measuring technology in traffic monitoring and especially at cross-roads [6]. We discriminate between static and mobile camera. Modern technology uses laser, radars, video cameras, GPS to perform monitoring of driverless cars, automata, safe cars, etc that use AI to decide and control emergencies.

![Image of optical traffic signs assistance and monitoring in high IQ roads](image)

**Figure 11.** Optical traffic signs assistance and monitoring in high IQ roads; night signs, weather detection, road obstacles for speed reduction increase visibility; car counting, grouping, tracking and marking; drivers assists safe driving in smart roads with safe distance preservation and brake, cars identification, driver fatigue recognition, car lights operation, off the road/lane deflection control, big and long vehicles identification; All these are capable to avoid the 80% of the collisions.

The needs of traffic management are:

- Incidents and events
- Congestion
- Car parks and parking zones
- Variable message signs
- Equipment status
- Reporting and analysis
- Incident and event management
- Effective delay network management
- Consistent traffic management
- Accurate journey time monitoring
- Car park guidance / wasted journeys
- Reduced congestion

- Reliable traffic / travel information
- Positioning of cars
- Cross roads, national roads entrances
- Emergency side lane stops
- Vehicles classification and routing
- Velocity reduction
- Stops at tolls, crossroads, etc
- Car / driver crossing a street reflection jacket recognition,
- Alarm lights operations
- Rain / fog, restricted visibility
- Special lights operation

We investigated simple static image processing problems, such as parking, crossroad car placement before crossing, red light car violation monitoring and difficult static image processing problems such as parked car licence plate recognition, car accident prediction at crossroad, etc up to difficult dynamic image processing problems, such as dangerous car to car by passing, dangerous driving car manipulation, traffic accident analysis, moving car licence plate recognition, image cross-correlation, optical methods for car velocity measurement, adaptation to traffic changes.
Transparent displays allow modern GUI - IP supports the development, simulation and testing of embedded systems that communicate over IP or Ethernet.

It assists diagnosis, local data transmission, accessories, etc Real-time and predicted journey-critical information to travellers displays for regular updates about public transport issues across the whole city.

Figure 12. MMI of Traffic Monitoring System, traffic cross-roads wi-fi network and mobile Input Output Feedback

Embedded Vision, creates machines that see. New super camera designs use parallel optical processor. The cameras support a wide variety of different communications methods including GPRS, DSL and Ethernet.

They use a multi-scale optics design with micro optical field processors to seamlessly stitch very large panoramic scenes. High density of pixels allows for many levels of zooming.

Fig. 13a. Lane and parking detection enhanced environment.

Car park guidance and management provides motorists with accurate, up to date information, informing about a choice to be made for the best parking options and traffic conditions. Cloud communication protocols are not secure;

The Internet of Things in intelligent transportation systems, (intelligent vehicles, vehicle active safety, driving simulation systems, discrete event systems, error diagnosis and detection, etc) uses electronics, sensors, actuators and communications technologies.
5. A Road-Intersection Monitoring System:

Vehicle monitoring systems use tracking models which calculate the location of a vehicle in a tracking zone. We can discover the contour, calculate the speed and count passing vehicles in an intersection by video frame acquisition, background extraction, intensity and classification, (according to the illumination variability conditions), calculation speed and other statistics. The functionality of the Intersection Monitoring System for the Vehicle Identification, uses the OpenMI Configuration Editor [7]. We discriminate between static and mobile cameras.

Urban Traffic Control Systems play a major role in vehicle and driver safety as well as in pedestrian safety when crossing intersections. We can couple the components using a loose integration paradigm. Loosely integrated models/components are written as software libraries which can then be integrated into a modeling framework. We presented a collaborative road-intersection monitoring prototype which identifies five major milestones for its development: (a) system conceptualization, (b) component development, (c) component coupling, (d) monitoring and (e) assessment analysis. Models can be coupled and intercommunicate in an integrated monitoring system by temporally synchronizing our models using the OPENMI standard [8].

Software components include traffic light detector, small vehicles detection (bicycles, motorcycles) and detection of parked vehicles. We integrate a database that not only manages the huge data store of videos and images but also establishes the set of parameters needed to be focused on for better monitoring and management. To move traffic safely and efficiently, are among every city’s most challenging issues.

TMS manage the incident rather than the systems. It reduces the operator workload by creating and maintaining historic profiles of congestion, flow, journey time, car park occupancy and other parameters. School holidays, public holidays are monitored while short-term future prediction offer information to travellers about their journey. Warning systems prevent bicycle-related collisions in dense bike lanes, by laser presence alert of an approaching bicycle in the driver’s blind spot.

We propose a hybrid watermarking scheme, where embedding is performed in transform domain and detection is performed in spatial domain through a proposed SAR model. PSNR (Peak Signal to Noise Ratio) criterion, a measure of quality degradation, has constant value for all video data’s frames [9].
Temporal data warehouses (TDWs) have been developed for the management of dimensional time-varying data. The novel design is based on the integration of two schemas, the star schema and the snowflake schema, to the temporal star nest schema. It expresses naturally hierarchy levels by the clustering of data in nested tables, with result the description of aggregation levels for a dimension in a natural way. Time in the temporal star nest schema is not treated as another dimension but as time attributes in every temporal dimension, i.e., dimension tables dependent on time. Time manipulation functions for the treatment of time attributes are provided in the query language [10]. The proposed extension is applied to a TDW for accident monitoring in crossroads where the expressive power of the model is exemplified with several temporal queries expressed in a suitable extension of SQL standard [11].

Time is used to distinguish between past, present or future states. Image / video data bases include videos from 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 [12]. We used technology of data bases in local municipalities and Traffic Police Experience [13].

III. CONCLUSIONS

We presented a geographic information system (GIS) to capture, store, manipulate, analyze, manage, and present all types of spatial, geographical and cross-road operational data infrastructure, a concept that has no such restrictive boundaries. This GIS features can open new avenues of transport inquiry in crossroads incidents and traffic flow [14, 15].

Acknowledgements

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