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Extended summary

Intelligent sensor systems for traffic monitoring

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Abstract. In recent years (because of the increase in the number of registered vehicles and the growing dissatisfaction with public transport services) traffic congestion problem has been becoming source of discomfort for the community. Local governments are often unable to contain the most critical situations: variables involved are many and too often entrust on common sense rather than cope the problem with scientific approach. The present study was aimed to define the tools and a working methodology that can support experts for choices concerning road networks optimization.

Three types of setting were studied: an unattended parking, a bus station and a road network. The set of solutions designed to manage them are conceived to be independent modules. They constitute a complete collection of tools for the road traffic problem treatment. The preferred technology to managing the matter has been computer vision. Additional information comes from local public transport GSP tracking.

After the data collection phase we have used a dedicated traffic flow network simulator to optimize the traffic flow and analyze the methods to solve its problems.

Keywords. Traffic simulation, traffic estimation.

1 Problem statement and objectives

In recent years the problem of traffic congestion has become a source of discomfort for the community and for local governments, which can not often handle the most critical situations. The growth of vehicles is the main cause of this problem [1]. Alternative mobility is not the only method of improvement: a lot of work can be done in the optimization of road networks. This problem is particularly difficult at least for the following reasons:

- big cities have strong architectural constraints (for example, due to historical assets);
- financial resources are very few;
- there are no standard methods to manage critical situations;
- homogeneous traffic data are not available.

The research aims to develop suitable tools and working methods to the identification and treatment of critical road networks.

2 Research planning and activities

The research begins by experimentation of methods for collecting traffic data in three typical situations: free parking areas, bus stations, road networks. The Computer Vision is the way used, for the following reasons:

- the cameras are easy to install and their cost is low;
- it is not necessary to install devices in vehicles;
- Computer Vision identifies vehicles with high accuracy.

The free parking area has been used for the analysis of the "multicamera" problem. Indeed in large areas is necessary to use multiple cameras.

Different to the free parking, the entrance in the bus station is subjected to restriction. Moreover in this case identification of vehicles is important in order to assign a position to buses. Additional tools are developed to handle also these problems:

- to find free parking spaces;
- to manage the "stop & go" problem;
- to aggregate data with a framework.

For the analysis of a road network software modules has been developed to monitor traffic, especially to:

- to save the exact state of the incoming, outgoing and few focal network areas traffic;
- to divide vehicles into classes, depending on their length;
- to create a historical basis from which to extrapolate statistical data.

The collected data has been used as input to a simulator of vehicular traffic (SUMO [2]). The research has continued with the definition of a methodology for improving the road network by simulation.

3 Analysis and discussion of main results

The most interesting results has been achieved in the identification of vehicles with Computer Vision techniques.

3.1 Stop & Go

Artificial vision is very effective when it has to follow moving objects, but when they will make a stop (assuming that this is long enough) they become part of the background and the tracking system will lose them. When these objects move again, they are treated as entirely new objects, losing all information associated with them. As we are dealing with parking areas, this situation will occur at least once for each vehicle, so this problem must be treated appropriately and carefully: when a vehicle restarts, the application must determine if it is the one stopped before or a new one. The solution adopted is to perform the tracking of the vehicle of interest and to keep track of the position occupied in the area along with some other information such as size, colour and features, for example, identified by applying the SURF (Speeded Up Robust Features) algorithm [3]. In practice, its last recorded position and the features described above will remain associated to each vehicle, ready to be used as it will move again. Really the situation of "new car" should not occur unless an initial transitional period. All vehicles that start after a stop should be already known. The application will only make a choice within a finite and known set of variables that identifies the object. It is not sufficient to limit the analysis to the position. We consider for example the case of a bus that moves down the passengers: if only the position of the vehicle is stored, it is likely to confuse the group of passengers moving away from the bus (still standing) for the same bus, because arrival and departure positions coincide. In this way, the system will believe mistakenly that the vehicle is broken down, generating an error. Extracting features and colour information allows the elimination of this bug, which otherwise would be very frequent.

3.2 Multicamera

The problem is distributed over a very wide area so we need to use multiple cameras. This one allows both to constantly monitor the movements of vehicles, as required by the specifications, both to resolve any problems of occlusion. The goal is to recognize the vehicle in its transition from a field of view to another, keeping all the information associated with it. Possible configurations for camera installations are two: with field of view partially overlapping and with fields of view disjoint.
1) Overlapping fields of view
The management is easier because it will be sufficient to perform the correct mapping of the common field of view of cameras to be able to associate objects seen by two cameras in a biunique way. This configuration also helps in the management of occlusions.
2) Non-overlapping fields of view [4]
To be able to recognize vehicles when switching between cameras with non-overlapping fields of view it is necessary to make the most detailed analysis of the zone of interest, particularly the "blind" part between frames. For example, we should consider the case in which a vehicle stops in the blind zone or the case in which it is overtaken by another subsequent vehicle; we should also create a detailed mapping of all possible entries/exits of the vehicle from the camera field of view to define probable origins or destinations. The proposed solution manages "waiting lists" to identify vehicles passing from a field of view to another, through a blind zone. The basic idea is simple: each vehicle that leaves the field of view of a camera is inserted into a "waiting list" for the blind zone it entered. When a vehicle enters the field of view of a camera, the application will decide whether it is one of the vehicles in the list or a new one. It is difficult to construct an algorithm to adequately per-

form this decision, because this implies a full object recognition module. Various aspects related to the physicality of the vehicle (colour, features) and the characteristics of the movement (the order of arrival, speed) are valued. Then each estimation is weighted according to the quality of the image and the structure of the blind zone. In this way a ranking of expected vehicles is defined on the probability that they match the vehicle to be recognized.

4 Conclusions

The work offers a good working method for data collection and optimization of road networks, consisting of the following strengths:

- it is based on data collected by simple, scalable and low cost solution (GPS in buses and video monitoring), in clear contrast with the solutions currently used (induction loops and radar systems dedicated);
- it is based on the idea to implement small continuous improvements, this solution presupposes less investment and less discomfort for users;
- it uses a traffic simulator which allows the evaluation of alternative scenarios.

An attractive future scenario is that video detection does not only serve as input to the simulator, but carries two additional functions:

- feedback element which verifies the quality of the solutions implemented and the correspondence of expected results with the real ones;
- active element of the traffic management system.

Indeed the current traffic light installations are configurable in order to use an algorithms during a predefined time slots, from a preloaded set. By the same cameras used to monitor the crossroads we may perform the following activities:

- selection of an adequate traffic lights algorithm (by the available ones) in response to real time events detected, for example to facilitate the transit of an emergency vehicle (identified automatically by the camera) or to facilitate queue resolution;
- dynamic creation of a new traffic light algorithm based on the emergency event detected.

5 References

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