M-Traffic - A Traffic Information and Monitoring System for Mobile Devices

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Abstract. This paper presents Mobile Traffic (M-Traffic), a multiplatform online traffic information system, which provides real time traffic information based on image processing, sensor's data and traveller behaviour models. In order to estimate route delay and feed the optimal routing algorithm a traffic microscopic simulation model is developed and simulation results are presented. This mobile information service ubiquitously provides users with traffic information regarding their needs and preferences, according to an alert system, which allows a personalised pre-definition of warning messages.

1 INTRODUCTION

Mobile Traffic (M-Traffic) is a R&D project developed jointly by YDREAMS (www.ydreams.com), Universidade de Évora (www.uevora.pt) and Siemens AG (www.siemens.com), and it proposes an advanced technological solution for providing street traffic information. The proposed solution takes advantage of video cameras in places where traffic conditions are most difficult. Based on these images, the system will provide its functionalities, which go far beyond displaying video information in real time. Images are processed in order to adapt to various types of devices, which in turn permit the extraction of quantitative and qualitative data about the traffic flow. All the information is georeferenced with a geographic information system and can be visualised on different devices such as PCs, mobile phones or PDAs. Together with the streamed video, M-Traffic offers a set of functionalities suitable for different types of users and appropriate to diverse distribution devices. These functionalities rise from image processing, sensor data and the use of traffic flow models, which simulate and predict traffic conditions. The purpose of traffic simulation models is towfold. First, to estimate the traffic flow and time delay in segments of street network which are not covered by sensors and second, to predict the evolution of traffic conditions. These estimates are the base to routing algorithm. M-Traffic has been developed for the city of Lisbon, but its modular structure turns its adaptation to be used in any other city in a straightforward task.

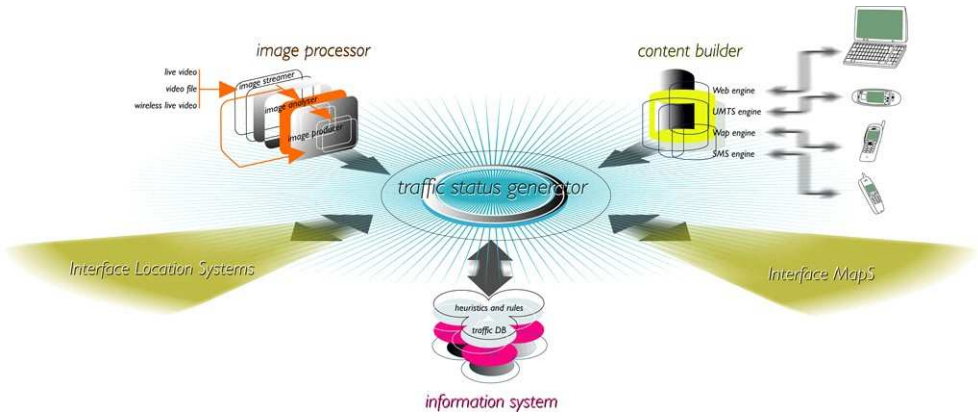

Fig. 1. M-traffic system architecture

2 Related Work

In addition to the traditional traffic information services available through the radio and television, several web sites offer on-line traffic information. Typically this information is manually maintained by human operators and may not be appropriately updated. Usually, these services do not provide reliable estimations for the duration of trajectories, once they consider just a few points of measure, and they only provide information concerning the current situation, not predicting traffic condition.

TrafficMaster (*http://www.trafficmaster.net/*) provides traffic information services for UK, including live traffic information on WWW enabled devices, map-based congestion information and a suite of personalised mobile telephone traffic information services, WAP traffic maps and favourite journey reporting. Traffic information is also made available by AA (Automobile Association), (*http://www.theaa.com*), where users are able to plan routes, examine traffic conditions and view incident reports. Some systems also provide real time contextual traffic images for monitoring traffic conditions including video streaming. The AirVideo traffic service available by TrafficLand Company (*http://www.trafficland.com/airvideo_intro.php*) displays live views from several public traffic cameras, in Washington DC area, on Web-enabled cellular phones. Inrix (*http://www.inrix.com/default.asp*) uses Bayesian machine learning algorithms to make statistical inferences and predictions about traffic, based on variables such as weather conditions, construction schedules, holidays, sporting events, and historical traffic patterns. Users will be able to acess the technology via partner channels on a variety of devices. Circumnav Networks (*http://www.circumnavnetworks.com/*) turns the cars themselves into traffic data-collection devices, which then share the data wirelessly with other Circumnav-powered cars. The Autoscope system by Image Sensing Systems, Inc., (*http://www.autoscope.com/index.htm*), provides wide area video vehicle detection by using a high performing microprocessor-

based CPU with specialised image processing boards contained in either a camera, box or card format and software to analyse video images. Research undertaken at MIT prompted the development of DynaMIT system, which anticipates traffic flows using a database of past conditions and real-time speed measurements and vehicle counts (*http://mit.edu/its/dynamit.html*) [2, 3]. The key to the functionality of DynaMIT is its detailed network representation, coupled with models of traveller behaviour.

Classic approaches to traffic modelling is based either on fluid flow model either on microscopic behaviour of each car-driver system [4]. Approaches based on cellular automata have also been successfully develop to traffic modelling [5].

3 System description

The Mobile-Traffic project comprises the conception, design and validation of a geo-referenced multiplatform online traffic information system, which provides real time traffic information based on image processing, sensor's data and traveller behaviour previewing models.

This system architecture follows the client-server model and is based on several structurally independent, but functionally interdependent modules (fig. 1). Therefore, the system can easily be adapted to new data resources and additional distribution platforms. The most relevant modules composing M-Traffic system are Image Processor, Information System, InterfaceMapS, Interface Location Systems, Traffic Status Generator, and Content Builder. M-Traffic provides georeferenced data in diverse formats, according to the user's needs and the characteristics of the client devices (PDAs, mobile phones, PCs). Fig 2 exemplifies the system's user interface for mobile phones. The system allows users to personalise the application to facilitate the access to the data they most frequently need. Users may create their own profile, which allows them to receive the information they require as soon as they enter the system. They can also configure an alert service, which will send them an alert whenever a specific traffic condition occurs in a defined area. Moreover, users interacting with the M-Traffic system through mobile phones are able to forward traffic information to other users sending SMS or e-mail messages.

3.1 Image Processor

The objective of this module is to gather and process the images captured by traffic cameras in order to extract quantitative data and visual data in different formats.

3.2 Information System

The M-Traffic information system stores, manages and provides the Traffic Status Generator with all the data related with the traffic and the users, such as: vehicle count, average speed; accident related data, weather conditions, data collect from video cameras and magnetic sensors, rules, heuristics and simulation

Fig. 2. Mobile phone interface

data used to assess and predict the traffic conditions, users' personal data, users' preferences and alert configuration data.

Traffic data is stored in an incremental approach, allowing the prediction of future traffic conditions based on the analysis of previous historical data, as well as weather conditions or the occurrence of events that affect the traffic normal flow.

3.3 Traffic Status Generator

The Traffic Status Generator component keeps an updated data structure that can be seen as a real time snapshot of the traffic status in the whole area covered by the system. It makes the connection between the different modules composing M-Traffic system and fulfils the information requests. This module should:

- Periodically, processes traffic data continuously received from the various system inputs and generates statistical information regarding the traffic conditions, including average traffic or average speed for a specific road on a certain day or hour.
- Maintain an updated data structure containing the current traffic status information.
- Manages the alert system, by periodically verifying users options, compares it with the current traffic conditions and if necessary sends an alert message. These alerts are send via Content builder.
- Manages the interaction between the different system modules.

3.4 Content builder

This module should support the access to M-Traffic by different mobile devices with distinct characteristics and information processing power.

The ever increasing diversity of mobile devices with diverse technical and functional capabilities (CPU power, display size, interaction paradigms) brings further complications concerning the adaptation and dissemination of content. Content builder is designed to be easily extended to support the use of M-Traffic by additional mobile devices and to provide formatted content including:

images generated from camera captured images overlaid with traffic data, using colour and text; colour or black and white synthetic images that sketch the traffic conditions in a defined area; real-time video captured by traffic cameras; Textual structured information formatted according to the characteristics of the requesting device.

3.5 InterfaceMapS - Traffic Simulator

This module establishes the interface betwee the Traffic Status Generator and the Geographic Information System. It includes the routing algorithm that runs over the graph representing the street network as a submodule. In order to reply to user requests, the routing service must apply a minimum path algorithm as Djiskstra over the graph representing the Lisbon street's network. However, not every street has sensors (either image or ground sensors). Thus, in order to find minimum time routes it is necessary to estimate the delay in each street from a simulation model.

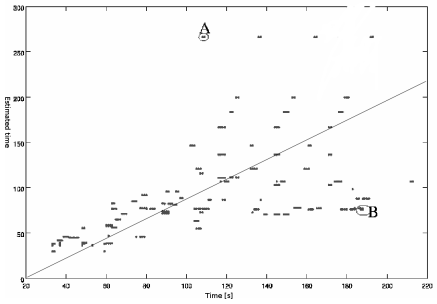

Fig. 3. Estimated vehicle delay

Simulation Model The model presented in this work has two regimes: a car-following regime and a free-flow regime. These regimes are according to driver behaviours that try to follow the leading vehicle with a safety space headway, if it is close enough or else will drive at a desired speed that depends on the street and the driver. From kinematics laws a car following accelaration dynamic model is defined taking into account: the characteristic street speed, vehicle characteristic parameter, driver perception pure delay, and the driver eagerness to follow the preceding car. In this work the effect of traffic lights is taken into account. Whenever the vehicle is in the traffic light influence area it responds to the red lights generating a negative acceleration that is calculated such that the vehicle stops under the traffic light position. The simulator is implemented in java. The simulator outputs the position of each vehicle for every sampling time as well as sensor signals that give vehicle counts and average speed at a predefined time interval. These sensor signals correspond to those given by the Lisbon's Traffic Management system.

Simulation Results In this section some results are presented. The parameters used in the simulations presented bellow result from a calibration made

with just one driver-vehicle system and does not include a parameter variability study. Simulations were performed using Euler integration method with a fixed integration time of 1 second. Since there are some streets with sensors that count vehicles and measure speed, it is a natural choice to use the speed information in order to estimate street transit delay. Fig. 3 shows the result of estimated delay versus the simulation delay for a wide set of conditions (short and long queues). Though there is a correlation between estimated delay and simulation, there are some results quite far from the ideal linear correlation. Results indicated in A and B represent extreme situations with very long and very short queues near a traffic light. The results indicate an alternative estimate should be used, including other information besides the average speed such as vehicle count in a fixed period of time.

4 Conclusions and Future Work

This paper presents a multiplatform Mobile Traffic information and monitoring system, which provides real time traffic information. M-Traffic service ubiquitously provides users with traffic information regarding their needs and preferences, according to an alert system. This paper describes the system modular architecture. A simulation model is presented and some results are shown. One of the services in this system is a routing service based on a minimum path criterium. In order to change this criterium to minimum time a delay estimate precision was studied against sensor location.

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