

Low Cost Video-Based Traffic Congestion Monitoring Using Phones As Sensors

Rose Nakibuule
Makerere University
Kampala, Uganda
rnakibuule@cit.mak.ac.ug

Joseph Ssenyange
Makerere University
Kampala, Uganda
jssenyange@gmail.com

John A. Quinn
Makerere University
Kampala, Uganda
jquinn@cit.mak.ac.ug

ABSTRACT

Traffic congestion is a serious problem in developing-world cities, compounded by the fact that it is unpredictable. Better real-time information about congestion levels can help with more effective use of infrastructure, for example allowing journey planning based on predicted congestion levels, or on selecting optimal routes based on current congestion levels at different places. In this paper we describe hardware and image processing methods for constructing a vision-based traffic congestion monitoring system tailored to the constraints of monitoring chaotic developing world traffic. By designing roadside monitoring units around camera phones, our prototype radically reduces costs compared to conventional CCTV systems and hence makes it practical for deployment in this context. We show results from this system operating in Kampala.

Keywords

Road congestion, traffic flow, image processing, intelligent transportation systems, mobile devices.

1. INTRODUCTION

Traffic congestion is a problem in many developing world cities where road infrastructure is inadequate. Money and time is wasted for those waiting in traffic, and business logistics are constrained. The problem is compounded by a lack of real time information on traffic flow levels in a city, which can be unpredictable, and a lack of facilities for optimizing flow levels (e.g. traffic lights and police manpower). More information about traffic congestion patterns would enable better use of existing infrastructure in resource-constrained cities [1]. Collecting real time congestion information with current technologies in use is expensive, prohibitively so in many developing countries. The US Department of Transport lists the unit costs of a number of congestion monitoring technologies [2]. A set of inductive loop sensors at a single intersection cost 8.6-15.3k USD, for example. Traffic CCTV installations are estimated at 9.0-19.0k USD per camera,

while a machine vision sensor at an intersection is estimated at 16.0-25.5k USD per installation. Maintenance costs are also high. To lower the deployment cost of traffic monitoring system, we are interested in the use of phones as units of processing, storage, network and sensing capacity which can be built into other systems. Some work has been done using phones and other mobile devices to cheaply provide road congestion information as in [5, 4]. This work does not provide visual information on the congestion level and chaotic nature of traffic flows. Therefore in this abstract we describe hardware and software methods for using phones as the basis for low cost video-based traffic congestion monitoring. A lot of work has been done on video-based traffic flow monitoring. This work relies on segmenting individual vehicles in each frame to be tracked, dealing with issues such as shadow detection and need for sophisticated schemes to deal with occlusion. It also requires expensive technologies in collecting and extracting traffic information. The work in this abstract presents the development and testing a vision based traffic congestion monitoring system in resource constrained crowded cities in developing countries. The proposed system uses a combination of a monitoring unit built around a phone with a solar panel as the source of power for very low cost with image processing techniques for robust traffic monitoring. It is aimed to demonstrate that a self-contained solar powered traffic monitoring devices can be constructed for less than \$100 per unit. Our most recent prototype cost approximately 450,000 UGX (\$180) for all parts and fabrication which is two orders of magnitude lower in cost than those quoted above.

2. CONSTRUCTION OF SOLAR TRAFFIC MONITORING UNIT

The basic idea of our units is to house a battery, charging regulator and camera phone in a steel box, as shown in Figure 1(a). The box is locked and mounted underneath a solar panel as in Figure 1(b)

The charge in the phone is maintained by a 14W, 22V solar panel above the unit, and excess charge tops up a 7.2Ah battery pack via a charging regulator, in case of several consecutive overcast days. An arm extending from the solar panel allows the unit to be bolted to a wall or post, and the camera can be rotated through two axes. A steel box is necessary for security but has the issue that it acts a Faraday cage, cutting out reception for the phone. In order to be able to upload images, we have to connect a wire from the phone's internal antennae to a wire coil outside the case as shown in Figure 2

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Figure 1: Construction of traffic monitoring unit. Figure 1(a) shows a battery, charging regulator and cameraphone in a steel box while Figure 1(b) shows The box locked and mounted underneath the solar panel

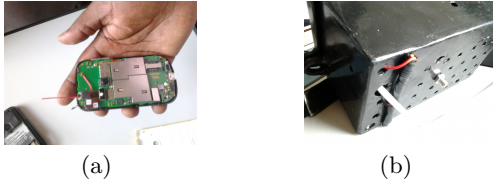


Figure 2: Securing camera phone reception.

The prototype unit has been deployed at the main gate of Makerere University. It captures a set of 3 images taken 0.5s apart, with a delay interval of 2 minutes between each set. It then uploads them to an application running on an Amazon AWS cloud server. We use the RabbitMQ message queuing server to deal with processing of many streams of images. When the images are uploaded, they are not processed in the real-time; they are instead published to the work queue with all the necessary data to allow worker processes to proceed with the image analysis. This is done to avoid doing resource-intensive computer vision processing immediately in the short HTTP request window that could slow down the system.

After traffic speed estimates are made from the image sets using the method described in [3], results are made available on the server in real time. In order to visualize results a map display was implemented as shown in Figures 4(c) and 4(d), such that road users can see the current state of traffic on the road. Sample images collected using the prototype are shown in Figure 3. Figures 4(a) and 4(b) show time series of traffic flow speeds on two different days starting from 6:00am to 7:00pm.

3. CONCLUSION

In this abstract we have described a software and hardware prototype for video-based monitoring of traffic congestion. It has the advantages of video-based monitoring by using camera phone as the basic unit of data capture and transmission, yet reduces the cost of deployment by two orders of magnitude compared to video systems currently on the market. The speed estimation method used is further suitable for developing countries in that it makes no assumption of vehicles travelling in fixed lanes, absence of clutter or possibility of segmenting individual vehicles.

We are in the process of installing two other units at different places. This will help us in the correlation of traffic speeds at different places. It also helps in providing public real time access to data from permanent installations of our prototype in Kampala as a resource for researchers of developing-world



Figure 3: Sample pictures collected by the prototype. Figure 3(a) shows traffic in early morning hours, with no much activity. Figure 3(b) shows traffic during rush hours of the day while Figure 3(c) shows traffic situation during nighttime.

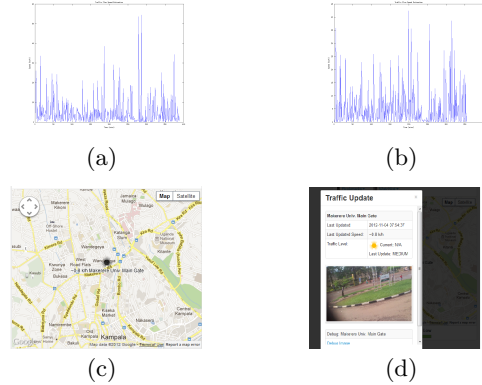


Figure 4: Estimation and display of Traffic flow Speed in the visual field. Figure 4(a) shows traffic flow speed on 12th October 2012. Figure 4(b) shows traffic flow speed on 14th October 2012 while Figure 4(c) shows results of speed calculation displayed on the map. Figure 4(d) shows detailed display with image visualization

traffic conditions and application developers. We have noted that data collected during the dark hours presents a vision problem which needs an investigation based on how to track the traffic flow during nighttime.

4. REFERENCES

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