VLOCI: Using Distance Measurements to Improve the Accuracy of Location Coordinates in GPS-Equipped VANETs

Farhan Ahammed¹, Javid Taheri¹, Albert Y. Zomaya¹, and Max Ott²

¹ School of Information Technologies,
The University of Sydney, NSW 2006, Australia
faha3615@it.usyd.edu.au
² NICTA, Australia, Australian Technology Park,
Level 5, 13 Garden Street, Eveleigh NSW 2015, Australia
max.ott@nicta.com.au

Abstract. Many vehicles rely on the Global Positioning System (GPS) to compute their locations. The inaccuracy of GPS devices means sometimes vehicles believe they are located in different lanes or roads altogether. Vehicular Ad Hoc Networks (VANETs) allow vehicles to communicate with each other using wireless means and thus connect them in a very dynamic wireless network. The algorithm VANET LOCALation Improve (VLOCI), proposed in this work, uses VANETs and distance measurements taken by each vehicle to improve the location estimates provided by all GPS devices. VLOCI is shown to perform efficient when erroneous distance measurements are present in the environment/computations.

Keywords: vehicular ad hoc networks, localization, GPS, distance measurements, location improve/refinement.

1 Introduction

VANETs are types of mobile networks—where the nodes are vehicles. The vehicles are equipped with wireless communication devices allowing them to transmit and share real-time information. With this information vehicles and drivers will have up-to-date information regarding the state of traffic, allowing them to avoid congested and other abnormally affected areas. VANETs are dynamic with vehicles travelling at speeds up to, and in excess of, 100 km/h. This leads to ever-changing wireless connections between vehicles resulting in some dense (on some city roads) and sparse (on country roads) areas which change over time (some city roads are dense only during certain hours of the day).

Many vehicles are nowadays equipped with GPS devices and it is quite possible that most, if not all, vehicles will have these devices as well in the future. GPS devices are accurate to within 10 metres [1]—more than the length of most family cars—resulting in situations where the GPS device incorrectly places its vehicles on the wrong road. Obtaining more accurate coordinates (position...
estimates) allows the vehicles to construct more precise models of their local traffic conditions.

With increased accuracy and better models, accidents can be prevented. Multi-car ‘pile-ups’ can be avoided if vehicles know immediately that other vehicles further in front are stopping suddenly or skidding. Although some sensors are already providing information about the vehicles directly in front and around the vehicle—VANETs can be used to provide information about vehicles further away. For example, when a vehicle detects a dangerous pot hole or other situation on the road, the exact co-ordinates of the problematic area can be immediately passed on to nearby vehicles. VANETs can be used to increase driver safety on the roads, but accurate coordinates is required for all vehicles—some drivers may incorrectly assume an accident or other incident is occurring on the wrong road.

This paper will look at using VANETs to improve on the position estimates provided by the GPS devices. Every vehicle can provide their position estimate to all vehicles within broadcasting range. It is also assumed every vehicle can measure the distance between them and other vehicles using already existing sensors/equipments [2,3]. When all vehicles combine the collected information, the algorithm LOCI can be used to adjust the GPS estimated position into a more accurate one.

An overview of previous work found in literature is presented in Section 2. Section 3 introduces the notation and defines the problem addressed in this paper. The method used to solve the problem is described and the VLOCI algorithm is presented in Section 4. Section 5 describes the simulations performed to test the devised algorithm. An discussion of the simulation results and concluding remarks are presented in Section 6 and 7, respectively.

2 Related Work

There does not seem to be much work in literature with the idea of improving location estimates in VANETs. There are algorithms designed to take advantage of some nodes that have GPS, or some other positioning, functionality to allow all nodes to compute their location.

Priyantha et al. proposed a technique called anchor-free localization (AFL) of providing localization to wireless sensor networks [4]. Their algorithm is decentralised where each node starts with a random initial coordinate assignment, and modifies its location estimates based on local distance measurements. The only information each node collects is the relative distance to its neighbouring nodes. With this information, the nodes construct a graph with the edges at the measured length/weight. A mass-spring based optimization is used to adjust the edge lengths of the graph. The edge lengths are adjusted based on the difference between the measured distances between neighbouring nodes and the corresponding computed distances in the constructed graphs.

Barani and Fathy [5] looked at the problem where not all vehicles are equipped with GPS devices or cannot receive signals from the GPS satellites. In their