Pothole Detection and Warning System using Wireless Sensor Networks

Sudarshan S Rode, Shonil Vijay, Prakhar Goyal, Purushottam Kulkarni, Kavi Arya
Embedded Real-Time Systems Laboratory
Indian Institute of Technology Bombay
{sudarshansrode,shonil.vijay}@gmail.com, {prakhargoyal,puru,kavi}@cse.iitb.ac.in

Abstract:

This position paper aims at proposing a novel Pothole Detection System which assists the driver in avoiding potholes on the roads, by giving prior warnings. The architectural design further proposes a low response time, low maintenance and deployment cost solution to this problem.

Interest in Intelligent Vehicle Systems comes from the problems caused by traffic congestion worldwide and a synergy of new information technologies for simulation, real-time control and communications networks. One of the increasing problems roads face are worsened road conditions. Many reasons like rains, oil spills, road accidents or wear and tear; make the road difficult to drive upon. Also while driving in the night just the headlights might not be a sufficient assistance for driver. Unexpected hurdles on road may cause more accidents. Also because of bad road conditions, fuel consumption of the vehicle increases; causing wastage of precious fuel. All these reasons urge that it is important to get information of such bad road conditions, collect this information and distribute it to vehicles, which in turn can warn the driver.

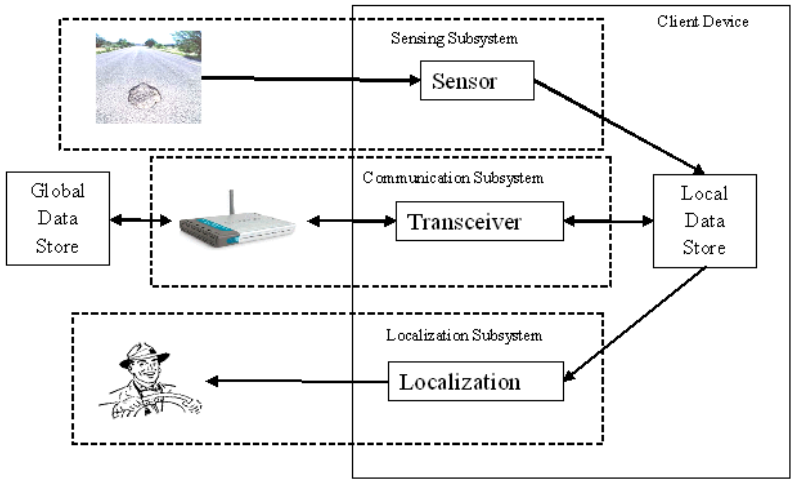
Brief overview of the approach:

The pothole detection system is divided into three subsystems. First is sensing subsystem which senses the potholes encountered by it, about which it did not have the prior information. Second is communication subsystem which handles the information transfer between Wi-Fi Access Point and Mobile Node. Third subsystem is the localization subsystem which analyzes the data received from Access Points and warns the driver regarding the occurrence of potholes.

Architectural design:

The system has two components namely, Access Point (AP) and Mobile Node (MN). APs are responsible for storing information about potholes in its vicinity, taking feedback from vehicles, updating information in the repository and broadcasting information to other vehicles. MN is a small device placed in a vehicle to sense potholes about which it does not have prior information, to locate and warn the driver about potholes; about which it has prior information, and giving data about newly sensed pothole to access point.

The architectural design of the system is represented in the figure below:



Architectural choice for Sensing Subsystem:

Based on the comparison given in the below table, it is advantageous to choose Vibrations based approach owing to its low response time, processing time and maintenance cost of the device.

	Vision based	**Vibration based**
Sensor	Camera	Accelerometer
Response time	High	Low
Sensing period	While approaching the pothole	While going through the pothole
Processing	Complex image processing algorithms	Readings are directly used
Maintenance cost	High (because of delicate parts like lens)	Low
Characterization of pothole	Based on size	Based on vibrations

Architectural choice for Communication Subsystem:

The table below shows comparison of above three methods. For the communication subsystem, it is advisory to apply Hotspot approach because of its coverage and flexibility.

	Entire Wi-Fi Coverage	**Public transport as AP**	**Hotspot**
Deployment	Deploy AP wherever coverage is required	Only on public transport vehicles	At particular location where vehicle density is high
Coverage	Wherever APs are deployed	Wherever public transport vehicles commute	Wherever the vehicles can go
Cost of APs deployment	High	Medium	Low

Architectural choice for Feedback Subsystem (a part of Communication Subsystem):

Feedback Subsystem ensures that information with the Access Point is correctly and timely updated. Here are a few architectural choices we present for the deployment of sensor:

- **In each vehicle:** In this case sensor is deployed in every vehicle. However this leads to increment in the load on the channel. Therefore this option is feasible only in the case of dynamic conditions like congestion avoidance where movement of every vehicle is significant. This is also advantageous in collision detection systems where vehicles take decision themselves.
- **Public transport:** This approach proposes the deployment of sensor in public transports like cabs, buses etc and thus leads to reduction in redundancy. This architecture can be used for moderately dynamic conditions like pothole detection, distribution of relevant congestion information etc.
- **Pilot vehicle:** Pilot vehicle is termed as the vehicle meant for specific purposes. The vehicle is supposed to periodically move through the roads of which the data about potholes needs to be collected. The architecture is advantageous especially in less dynamic conditions e.g. data collection from roadside APs etc.

'Public transport' approach ensures that small changes in road conditions due to wear and tear of the road are conveyed timely to the AP. Pilot vehicle can be used when there is non-zero probability that road conditions will change drastically, for instance in case of heavy rains, road construction, maintenance work and earthquakes.

Architectural choice for Localization Subsystem:

Localization Subsystem uses the data given by Access Point to actually find the location of the pothole and subsequently warn the driver about it. Localization is challenging especially when Access Points are not in range. In that case the vehicle needs to find its own way or it should be given some external help to localize itself.

Global Positioning System (GPS) is one of the popular and effective systems for location finding. When vehicles receive the data from Access Point, they can easily identify the location of potholes on the GPS map.

Conclusions:

Taking into account the current road scenarios, there is a need to devise a system which warns the driver about the upcoming potholes. Many on-going projects in the field of vehicular networks are working in the direction of providing driver with relevant information about roads and traffic movements. We present here, a novel idea of Pothole Detection & Warning System based on three subsystems, which aims at providing appropriate information to the driver about potholes. In the sensing subsystem, accelerometer was used as sensor due to its low response time and low maintenance cost. 'Hotspot approach' was used for communication subsystem, in which an Access Point is deployed at high-traffic locations, ensuring that the information reaches maximum number of vehicles. It is advantageous to use GPS for localization subsystem owing to its high effectiveness and popularity.