Developing and Evaluating a Smartphone Application Aimed at Reducing Crashes Involving Bicycles

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Introduction

As presented by statistics, fatal crashes are considerably more likely to happen when riding on motorcycles than any other means of transportation. Bicycles, which are similar to motorcycles in structure, also account for a significant number of crashes. Connected vehicle technologies have enabled researchers to develop safety applications using dedicated short range communication (DSRC). A highlighted characteristic of DSRC is its low latency which is critical for real-time applications. However, recent developments in cellular technologies as reported by cell phone provider companies introduced Fourth Generation, Long Term Evolution (4G LTE) which provides low latency services, too. To reduce and mitigate crashes involving bicycles a smartphone application is proposed to gather required information and inform riders and drivers of potential conflicts in real-time. The goals of this research are twofold: (1) safety improvements regarding crashes involving bicycles (2) utilization of cellular communication. In developing the smartphone application, the Appcelerator titanium and PhoneGap mobile development platforms will be considered. The application would require a server for which Python and PHP programming languages will be considered. Two processing methods for server design will be evaluated namely, centralized and distributed approaches. Image processing will be applied to improve the accuracy of smartphones' built-in GPS receivers. Five scenarios will be developed and examined to test the applicability of the application. Scenarios will be constructed with regard to the following factors: (1) utilization of 4G LTE, (2) utilization of DSRC, (3) use of high sensitivity GPS receivers, and (4) data processing method. To compare the scenarios, the following features will be taken into account: (1) latency, (2) accuracy, (3) cost, and (4) convenience.

Icon	Representation of	Icon	Representation of
	Smartphone	V	Vehicle
	DSRC on-board unit	M/B	Motorcycle/Bicycle
	Server		High sensitivity GPS
	Location information		Warning information

Table of Study Icon Definitions for Scenario Architectures

Anticipated Results and Benefits

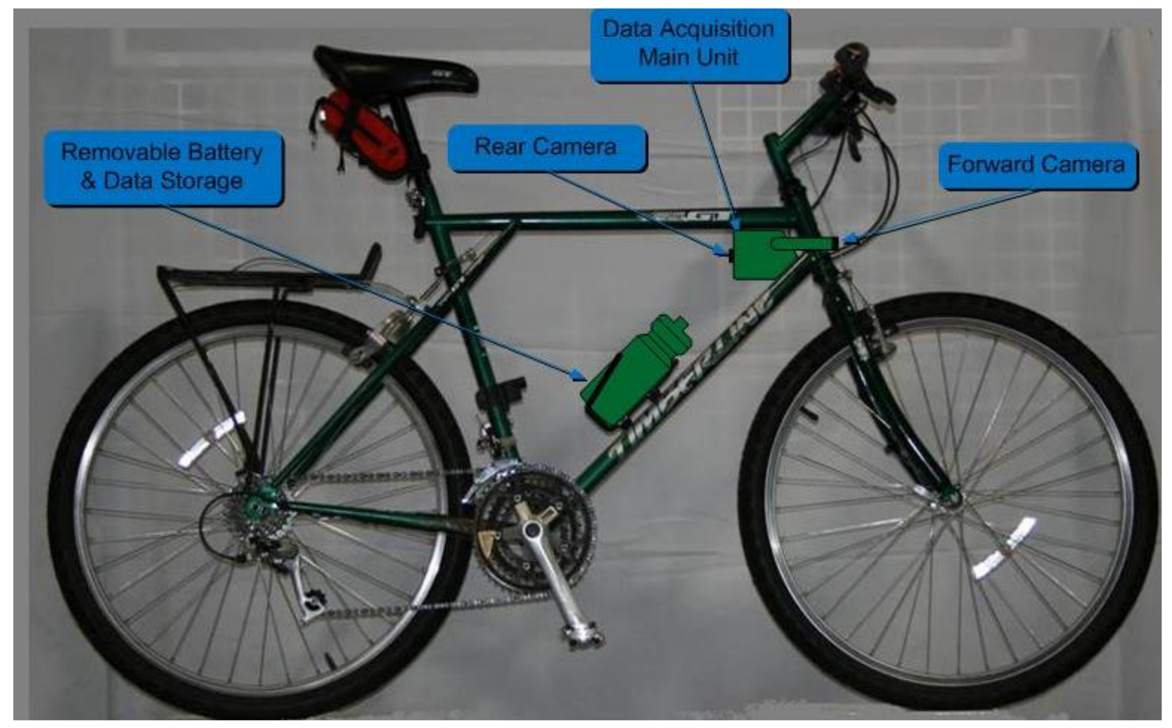
1. The smartphone application would inform bicyclists as well as other motorists of the potential danger. Safety improvements in terms of crash reduction and mitigation for bicyclists as well as other drivers are anticipated.

2. Cellular communication as a potential alternative to DSRC is examined for safety applications. Considering the reported round-trip latency of 4G LTE, it is anticipated that cellular communication would be as beneficial as DSRC. Lower costs are anticipated when using cellular communication instead of DSRC. In terms of convenience, it is expected that bicycle users would prefer to use their own smartphone since although feasible, it seems a little clunky to use DSRC devices for those users.

3. The smartphone application has the potential to be adopted in the possible future projects for other road users and crashes than what this research focuses and also for other applications (e.g. mobility, environmental).

Research Objectives

- Identify significant factors leading to crashes involving motorcycles and bicycles,
- Develop a smartphone application in order to reduce/mitigate these crashes,
- Test and evaluate the applicability of the application using smart road facilities, and
- Compare cellular communication versus DSRC.



Possible Installation for Bicycle Instrumentation

Research Methodology

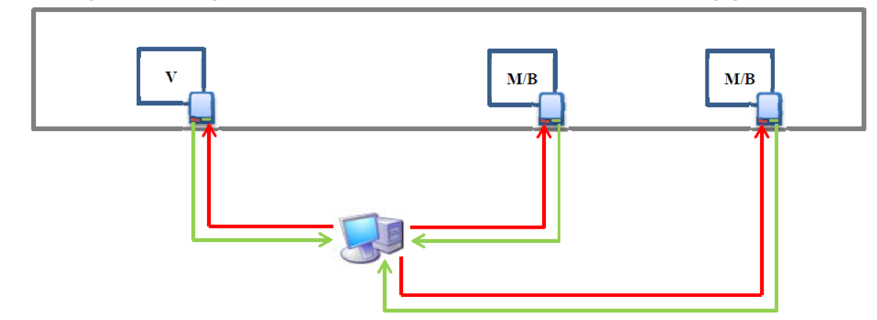
A smartphone application will be developed in order to warn motorcyclists, bicyclists, as well as the other drivers of possible impending crashes involving motorcycles and bicycles. A backend server will be designed to collect information from smartphones and communicate back with the mobile application running on cellular smartphone devices. Depending on the selected scenario the server can do all data processing and issue the warnings or it can serve as a database to inform users of surrounding users and the smartphone devices can determine whether or not to issue warnings. The two aforementioned approaches are entitled centralized and distributed processing, respectively. For server design, Python and PHP programming languages will be considered and the most appropriate one that best matches the research needs will be selected for use. For application development, Appcelerator titanium as well as PhoneGap as the two mobile development platforms will be examined to choose the most appropriate for the purpose of this research. Both of these platforms can support iPhone- and Android- based mobile applications. For all scenarios, the mobile application acts as the human interface to issue the warnings.

Scenarios are compared with each other through statistical analysis in terms of accuracy, latency, cost, and convenience. Although it is not possible to know the exact location of a moving user, high accurate GPS receivers as standalone devices are considered as reference points. Latency as another important issue is assessed. DSRC is known to have very low latency making it appropriate for critical safety applications. Cellular communication technology with the latest improvements (4g LTE) is examined in comparison with the DSRC. As technical benefits of 4G LTE, round trip average low latency of 30ms is reported by Verizon. Considering the costs associated with purchasing different devices and service usages, a cost-benefit analysis will be conducted. Also, to improve the accuracy of GPS receivers, image processing will be used to identify travel lanes from road images taken by smartphone devices.

Experimental Scenarios

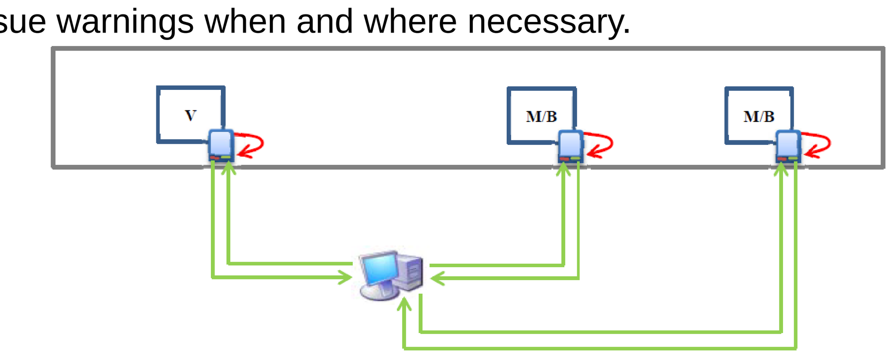
Scenario 1: Centralized - 4G LTE

In this scenario smartphone devices provide their location information to the server, the server determines all users within a certain radius of the subject user and issues any warning messages if a potential dangerous conflict is identified. In other words, the server here acts as a center to collect all information and to monitor in real-time to ensure that safe distances are maintained between users. The built-in GPS of smartphones provide the location data to the application.



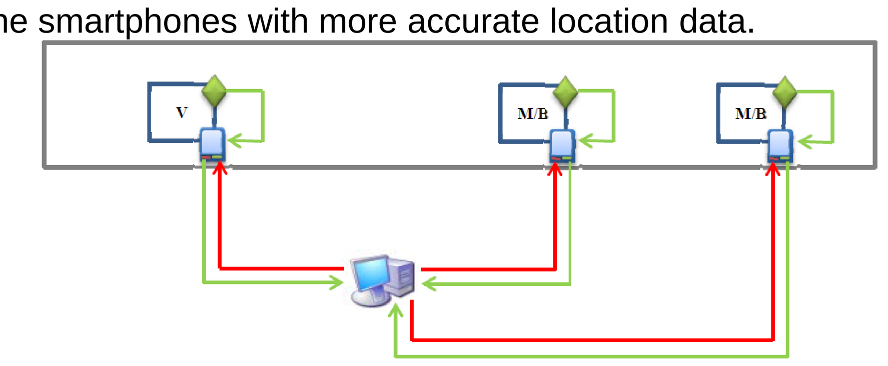
Scenario 2: Distributed - 4G LTE

This scenario is identical in architecture to scenario 1, but data are processed by both the server and cell phone devices. The server collects all location information of the users in a real-time database. Then each smartphone device communicates with the server and queries its surrounding users. The smartphone device would be able to examine only its surrounding devices whether safe distances are maintained and issue warnings when and where necessary.



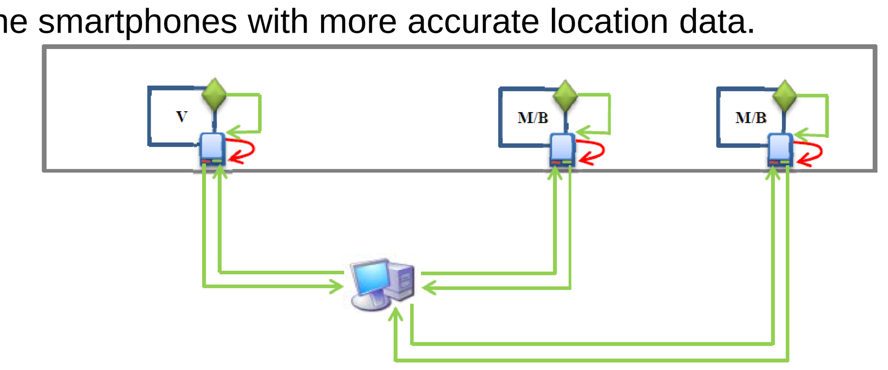
Scenario 3: Centralized - 4G LTE – High Sensitivity GPS

This scenario is similar to scenario 1 with an addition of high accuracy GPSs for each smartphone device. To improve the built-in GPS accuracy either high sensitivity GPS devices can be purchased or a smartphone application can be used. High sensitivity GPS devices (or any application of the same purpose) provide the smartphones with more accurate location data.



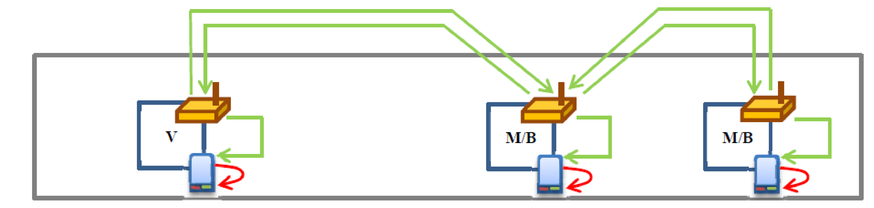
Scenario 4: Distributed - 4G LTE – High Sensitivity GPS

This scenario is similar to scenario 2 with an addition of high accuracy GPSs for each smartphone device. To improve the built-in GPS accuracy either high sensitivity GPS devices can be purchased or a smartphone application can be used. High sensitivity GPS devices (or any application of the same purpose) provide the smartphones with more accurate location data.



Scenario 5: Distributed - DSRC

Unlike previous scenarios for which cellular communication is used to transfer data, in this scenario DSRC is adopted. Each user has an on-board DSRC device and this is similar to what the C2X consortium developed as part of the C2X project. In scenario 5, the smartphone application still processes the data received from surrounding devices in range and issues the warnings when and where necessary.



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