Towards Enhancing Bike Navigation Safety and Experience Using Sensor Enabled Devices

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***Abstract*—We propose several bike-specific navigation applications for improving bike safety and enhancing cycling experience. We propose an approach for identifying bike types with smartphones to improve the capabilities of navigation services. Navigation services could take specific road conditions into account for different types of bikes to improve safety while cycling. Furthermore, we propose an approach for crowd-avoidance for bikes (similar to congestion avoidance applications for cars) to improve travel duration and potentially also improve safety.**

***Index Terms*—bike, navigation, safety, pervasive, sensors, smartphones**

I. Introduction

People are becoming more environmentally conscious and are increasingly turning to classic means of movement, such as bikes. More and more people use bikes in their everyday lives. In Germany, for example, more than 44% of all people use their bikes regularly [1], with the trend increasing. However the research results in bike related pervasive or ubiquitous applications is limited. Between 2015 and the end of 2019, there were a total of around 235 publications in the field of Computer Science relating to bikes. Of these, in the last 5 years no full- or journal paper has been published in the field of Pervaisve Computing which deals with bikes.

Since bikes play an important role in many societies, this can be used as an opportunity to improve the riding experience in terms of ubiquitous or pervasive applications.

With the advent of smartphones and other IoT hardware equipped with inertial sensors or GPS, a variety of bike-specific applications is possible. The aim of this research is to explore different bike-specific navigation use cases in the context of pervasive/ubiquitous applications.

Bike-aware navigation services with bike friendly routes in mind may guide cyclists on safer routes to their desired destinations. In addition, avoiding crowds by using smartphones could help cyclists get to their destination faster.

II. Research

Today's smartphones and other IoT devices include a variety of sensors such as accelerometer, barometer, GPS and so on that enable the development of pervasive applications/services for bikes. Our goal is to improve the overall bike-specific navigation experience/safety with these aforementioned sensors. In the following, we present bike-specific applications that we want to explore and has to achieve this goal.

A. Bike Type Aware Navigation

A total of 483 participants in a survey on bike-related accidents (33.8% of all accidents without the participation of others) stated that the cause of the accidents was due to poor road conditions. The survey was conducted by the German Federal Highway Research Institute from summer 2012 to 2014 [2]. For example, the tire width (but not limited to) may not be sufficient to safely cross muddy roads or other unfavourable street conditions depending on the type of bike.

Furthermore, a bike-aware application can be used to improve *Virtual Personal Assistant* (VPA) navigation capabilities with non-intrusive, bike specific suggestions. With VPAs it has become much easier to perform actions with the smartphone through voice commands, which is especially helpful if one does not have the hands free, as is the case with cycling. This is confirmed by a survey [3] in which users of VPAs appreciate the hands-free and clutter-free menu navigation capabilities.

Thus, the first application we want to explore deals with safe navigation for different bike types using smartphones and their inertial sensors.

With inertial sensor data, the orientation of the smartphone is an important factor for the performance of the system. The inertial sensors of a smartphone are fixed relative to the smartphone. This means that different values are measured for same scenarios depending on the orientation of the smartphone. However, there are several works that use normalization techniques in order to transform the sensor data to a fixed axis that is not sensitive the orientation problem. In our first experiment [4] we showed that by using machine learning techniques and normalization techniques two different bike types could be successfully distinguished. Whereby the Convolutional Neural Network achieved the best result with an F1 score of up to 0.94.

For further work we plan to extend this idea to the identification of further bike types and to develop a more general approach.

B. Crowd Avoidance

Pedestrian zones are very spacious to allow a large number of pedestrians to pass through in a relaxed manner. These zones are generally closed to normal traffic. An exception are cyclists. They can drive freely through these zones in many cities. As planning bases for the opening of pedestrian zones in Germany [5] show, the speed of cyclists is different depending on the pedestrian density. For example in the city of Leipzig the average speed with less than 0.025 pedestrian per m^2 is about $15\,\mathrm{km\,h^{-1}}$ but between 0.15 and 0.175 pedestrians per m^2 the speed is down to about $7\,\mathrm{km\,h^{-1}}$.

This means that while rinding a bike and depending on the pedestrian density, the time it takes to reach the destination varies greatly. There are navigation systems for cars that detect and inform you about traffic jams and suggest alternative routes to reach the destination faster. However, there is currently no such system for cyclist.

We are currently investigating how to implement such a service. Our first idea is to use acceleration data to detect and/or classify the evasive behaviour of the bicycle while riding. We suspect that in order to avoid collisions with pedestrian in denser areas, a cyclist needs to weave more in and out and brake more often with the bike.

In the context of a bike rental the offered bikes could be additionally equipped with inertial sensors, collect data and make it available for navigation services to improve their capabilities. This can also serve as an additional source of income for bike rentals. In the context of smartphones, navigation service providers could use the already built-in sensors and collect data this way.

Our first experiments (see Section II) showed that the Convolutional Neural Network (CNN) delivered the best and consistently good results. Possibly due to the spatial nature of the data from the experiments. However, whether CNN provides good results for this application aswell needs to be investigated. Nevertheless, the use of CNN provides us with a good starting point for our approach.

Furthermore, evaluation could be problematic since there is no public bike specific acceleration/orientation measurements available, especially measurements taken in a crowded area. This means that extensive measurements must be carried out in order to be able to evaluate the proposed approach.

III. Related Work

There is a large body of work in the field of transportation mode recognition. Reddy et al. [6] used smartphones for GPS and acceleration data to determine with high accuracy whether people are stationary, walking, running, cycling or moving in motorized vehicles.

Similarly, Stenneth et al. [7] were able to distinguish between different motorized means of transport such as bus, train or car. The proposed approach could even predict with high accuracy which bus was ridden. They achieved this by using various machine learning techniques including Bayesian Net, Decision Tree, Random Forest, Naïve Bayesian and Multilayer Perceptron. They suggested that this could be useful for advertising or survey collecting purposes.

As for safety-related applications, Wang et al. [8] proposed a system for detecting transportion circumstances. This system can differentiate between various circumstances such as road surfaces, shoes and vehicle types using sound. The system is used to monitor and maintain roads to improve safe travel. However, continuous monitoring of people in their daily lives is required. The application offers no real incentive to use, which greatly limits its applicability.

In general, problems in the field of transportation mode recognition deal with more broad classfication classes (i.e. walking, motorized etc). Our research extends this idea...

1) ... by dividing a single transportation mode into subclasses (i.e. detecting bike types)
2) ... providing compelling use cases for a single mode of transport (i.e. improving general navigation safety and experience while cycling)

IV. Conclusion

The aim of this research is to improve the safety and experience of bike navigation. We propose two different applications for bike navigation. The first approach is able to distinguish between different types of bikes to improve safety. Lastly, we propose a crowd avoidance approach to improve travel duration while cycling.

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