4TU.NIRICT Community Fund 2021: Smart bikes – Final report

Dr. Yanqiu Huang, Prof.dr. Paul Havinga, Prof.dr. Karst Geurs, University of Twente
Dr. Frauke Behrendt, Prof.dr. Marieke Martens, TU Eindhoven
Dr. Jason Moore, Dr. Jacky Bourgeois, Prof.dr. Gerd Kortuem, TU Delft
Contact Person: dr. Yanqiu Huang / yanqiu.huang@utwente.nl / +0534895311

Introduction

This project aims to build up a collaborative research community in the Netherlands and co-organize a competition on making bikes smarter by leveraging the ICT knowledge. The world of mobility is being digitized, resulting in an intelligent transportation system (ITS). Bicyles can play a significant role in this, and can even become a key pillar of a sustainable, safe and effective mobile society. However, so far they are not fully integrated into the new era, which will bring potential risks due to the shared road infrastructures and unexpected cycling behaviour. We believe collecting data in real-time, analyse them using the intelligent technologies and dessiminate the important information will make cycling safer, more comfortable, and healthier

We organized the competition on a team basis. Each team has 3-5 members and designs/tests the smart system under the financial support of 4TU.NIRICT. We announced this event on October 20, 2021 using different mediums, e.g., LinkedIn, the website of UT, TU Delft, TU Eindhoven, and students' associations. One example can be found at the smart connected bikes project website with detailed procedures and requirements. Participants need to submit a one-page proposal including the ideas and budget requests. After receiving the proposals, the committee has selected 5 projects with 18 participants in total. Each project addresses a specific problem of cycling, ranging from collision warning system, short range communication, and enhancing visual abilities of cyclists for improving cycling safety, to anti-theft system and cyclists' physical status monitoring for improving user experience.

System design

After the approval, each team started to order the requested materials and organized the meetings internally for the system design. By the end of the project, each team was asked to send the progress report to the committee. This section presents the designed system of each team.

Project 1: KIND bike, TU Delft

It aims to collect cyclist's physiological data and surrounding information to understand cyclist's behavior and improve user experience. As shown in Fig. 1, the team selects K210 edge computing camera to detect and classify object, and BLE beacons to estimate the distance between itself and other bikes; the GSR and heart rate sensors are used to collect cyclist's physiological data. A smartphone app is used to assist in bike to bike and bike to cloud communication.

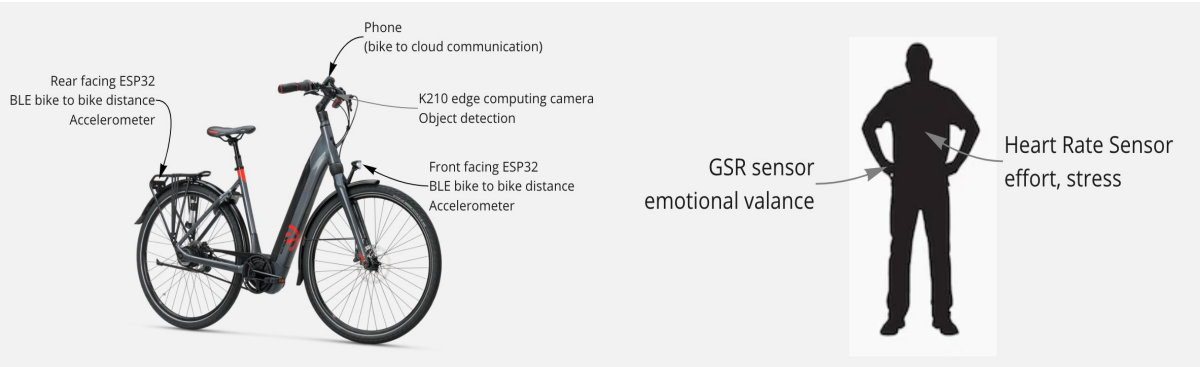


Fig.1. Project 1: KIND bike

Project 2: Collision warning system for cyclists, University of Twente

It aims to build a forward and rear collision avoidance system based on multi-modal sensors to improve cycling safety. The team uses mmWave Radars and ultrasonic sensors as shown in Fig.2 to detect obstacles outside the peripheral vision of the cyclist. The analysis is done in the Raspberry Pi 4 and when obstacles are closer than an arbitrary minimum safe distance, a warning signal will be used to alert the cyclist.

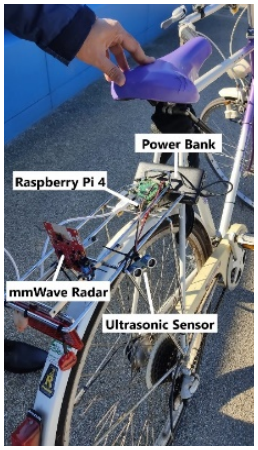
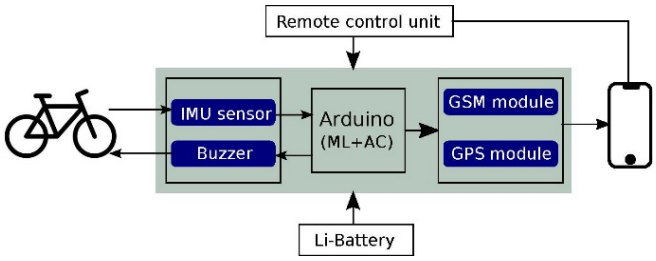


Fig. 2. Project 2: collision warning system

Project 3: Anti-theft IoT system for bikes, University of Bremen

This project aims to detect abnormal movement of bikes and notify users in time to against theft. As shown in Fig.3, the team has selected the Arduino Nano 33BLE as the processing unit, which has the integrated IMU sensor to collect the accelerations. The data is analyzed on-board and used to monitor the movement of the bike. When the bike is locked but is moving, the position of bike measured by the GPS module will be sent to the user's smartphone.



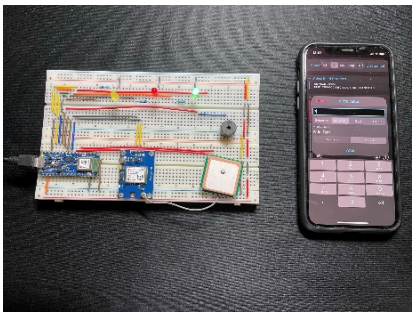


Fig. 3. Project 3: Anti-theft IoT system for bikes

Project 4: Vision Enhancement for Safety Cycling, University of Twente

It focuses on enhancing the visual abilities of cyclists to enable them seeing clearly in low visible conditions, e.g., low light conditions, raining, and/or snowing. As presented in Fig. 4a, the vision is degraded due to rain. This is enhanced with AR in Fig.4b to remove background noise and critical objects are further detected in Fig.4c to send a warning message when necessary.

a) b) c)

Fig. 4. Project 4: vision enhancement system. a). The original captured image; b) The enhanced image via AR; c) Object detection and classification.

Project 5: Platooning system for bikes, University of Twente

This project aims to use short range wireless communication to help cyclist maintain a safe lateral distance during overtaking (Fig. 5a) as well as longitude distance (Fig. 5b) in dense cycling networks. For communicating the intention information of the following cyclist, the team uses two Bluetooth modules (ESP32) shown in Fig. 5c, one for each bicycle. When a cyclist wants to overtake, a BLE beacon will be broadcasted by pressing a button. For keeping a safe distance between the two cyclists, they retrieve the relative distance between the cyclists from the Received signal Strength (RSSI). When the threshold of the safe distance is reached, a warning will be communicated to the cyclist via a motor vibrator.

a) b) c)

Fig. 5. Project 5: Platooning system with bike to bike communication. a) Lateral distance maintaining during overtaking; b) longitude distance maintaining; c) the system prototype.

Conclusion

The organization of the event is successful and has achieved our goal. We have built up a consortium with partially overlapping and complementary expertise, which is helpful for promoting cross-disciplinary collaboration and facilitating the collective expertise for solving the ITS challenge. A follow up discussion on how to continue the collaboration is planned. Moreover, we have attracted many participants for designing different systems on helping cycling and most of them are bachelor/master/PhD students, who will play an active role in the development of ICT research in the future. This event enables them to realize the importance of ICT on our daily lives and stimulates their further studies. Last but not the least, **we appreciate the 4TU NIRICT research impulse program for supporting this research and collaboration**.