8th INTERNATIONAL CONFERENCE
''TOWARDS A HUMANE CITY"
New Mobility Challenges
Novi Sad 11th and 12th November 2021

Johanna Lebitsch, BSc[1]
E-mail: lebitsch@planum.eu
Kurt Fallast, PhD[1]
E-mail: fallast@planum.eu
Georg Thallinger, BSc[2]
E-mail: georg.thallinger@joanneum.at
Helmut Neuschmied, PhD[2]
E-mail: helmut.neuschmied@joanneum.at
Florian Krebs, PhD[2]
E-mail: florian.krebs@joanneum.at
Christian Pelzmann[3]
E-mail: christian.pelzmann@neuroth.com

[1] PLANUM Fallast Tischler & Partner GmbH, Wastiangasse 14, A-8010 Graz

[2] JOANNEUM RESEARCH Forschungsgesellschaft mbH, DIGITAL – Institute for Information and Communication Technologies, Leonhardstrasse 59, A-8010 Graz

[3] NEUROTH INTERNATIONAL AG, Schmiedlstrasse 1, A-8042 Graz

SIMPLE - SIMPLE SOLUTIONS FOR MORE SAFETY FOR VULNERABLE ROAD USERS

Key Words

Vulnerable road users
Multimodal sensors
I2P/P2I
Mobile app

Abstract

In the research project SIMPLE (road Safety IMProvement for vulnerabLE users), we are currently developing a real-time capable system for assessing the traffic situation at confusing intersections and a warning system by an interdisciplinary project team – with the aim to improve the safety of all road users.
The focus is on the automatic prediction of conflict situations with the help of audiovisual sensors and the timely transmission of information to all affected road users - from pedestrians to autonomous vehicles.
The research team is currently developing a mobile phone app and is testing various signaling variants using sound and / or vibration. A major challenge here is that the signal must be clear, reliable and distinctive in order to neither distract nor fail its effect.

If necessary, people with visual, hearing and mobility impairments can request an extension of the crossing time at the traffic lights. When an emergency vehicle approaches, an early warning is given, and the emergency vehicle is given priority.

The further development of the system is intended to provide general safety information about where dangerous crossings are and how and where it is safest to cross the road.

Currently the technical environment for tests to be conducted in 2022 is defined and implemented. The tests will be performed with vulnerable road user – specifically people with disabilities – at selected traffic junctions.

1. INTRODUCTION

An almost real-time detection of the current traffic situation is an important technical support solution in traffic management. The aim of SIMPLE is to automatically determine movement paths of road users and based on that detect dangerous situations for optimal protection of vulnerable road users. Based on the results of the FFG project SIMMARC [1], the development of an expanded and improved demonstrator system in terms of real-time capability and functionality is underway. This system intends to meet the requirements of continuous operation, scalable to different intersection topologies, based on near real-time multisensory data analysis.

The following goals are pursued in developing this demonstrator system:

(1) Development of components for analysing sensor data (from camera and microphones) to capture the traffic situation in real time. That includes classification, localization, and the estimation of speed and direction of travel of road users.

(2) Development of a component that calculates collision probabilities and generates warning messages, not only about possible collisions, but also about the stay of road users in difficult conditions to report critical areas.

(3) Development of a mobile application to inform vulnerable road users on potentially hazardous situations using acoustic and visual signals, depending on the whereabouts in the intersection area. Also, the location of a disabled person using this app will be reported to the local C-ITS infrastructure (P2I).

(4) Interfaces to existing and deployed C-ITS systems with the option to transmit warning messages to people (infrastructure to person I2P) and vehicles (infrastructure to vehicle I2V).

2. METHOD

As a first step, the relevant requirements for the system were collected and documented. In addition to the purely technical requirements for the selection of sensors and standardized communication protocols, the requirements from different focus groups (pedestrians and disabled people) regarding the needed support was investigated. Specific interest was put on collecting views on how the system can provide warning information to vehicles and target groups (informative, engaging, visually, auditory, tactile, in combination).

In parallel the architectures of the hard- and software systems for the novel system for the warning of vulnerable road users in C-ITS enabled environments were defined.

2.1. Requirements of target groups and vulnerable road users

With the involvement and co-coordination of the Forum Besser Hören - Center for the hard of hearing in Carinthia/Austria as well as the Blinden- und Sehbehindertenverband Kärnten (Association of the blind and visually impaired Carinthia/Austria) and Neuroth (a company providing inter alia hearing aids), small workshops and expert interviews with various target focus groups took place (the participants were hearing and / or visually impaired, physically impaired, unimpaired).

As a result of these discussions, a questionnaire was created to capture the specific requirements of the various target groups in connection with the use of the infrastructure and the interaction with other road users.

The main questions were:

- How are different situations in the street space perceived?
- What are the problems in connection with these situations?
- How can SIMPLE support these target groups?
- In what form can users be additionally supported (auditory, visual, tactile, in combination)?
- How are different use scenarios of SIMPLE assessed?

2.2. Software architecture

The architecture of the envisaged demonstration system with its software components and interfaces is shown in Figure 1 and is inspired by SIMMARC [2]. The sensor data analysis and thus the recording of the traffic situation takes place within the video and audio analysis components, which produce geo-referenced position data for road users. The audio analysis application consists of two parts: a classification part and a localization part. Both work in real time and have the highest possible classification and localization performance.

The traffic situation analysis component determines from the position, direction and type of road users on which routes (towing curves, pedestrian paths defined by the traffic route plan) they are traveling. With additional speed and acceleration data, collision predictions are made. Using a rule-based definition of potentially hazardous situations, the traffic analysis application then determines whether a warning should be issued. The description of the warning situation, the position of the road users to be warned and the estimated time until the potentially dangerous situation occurs are then transmitted to the mobile app gateway.

The task of the mobile app gateway is, on the one hand, to forward the collision warnings to the road users concerned (mobile phone user application), and to report the positions of road users using the SIMPLE mobile app to the traffic analysis component. On the other hand, it communicates with the C-ITS gateway and forwards warning messages from the traffic situation analysis component or requests for traffic light control as well as position data from mobile app users to the C-ITS infrastructure, i.e. to control traffic lights (e.g. to extend a green phase). Direct communication with autonomous vehicles is not planned within the scope of the project. But C-ITS messages emitted by the SIMPLE System could be received by autonomous vehicles or the SIMPLE mobile app could also be used in vehicles.

The messages to the mobile phone application are to be sent via a mobile network (UMTS or LTE) in the form of standardized CAMs (Cooperative Awareness Messages) and DENMs (Decentralized Environmental Notification Messages), which are mainly used today in research on V2X communication in autonomous vehicles. For traffic light control the use of SRE/SSE in combination with MAP and SPAT messages is envisaged. The communication between the mobile app and the Simple System is REST-based.

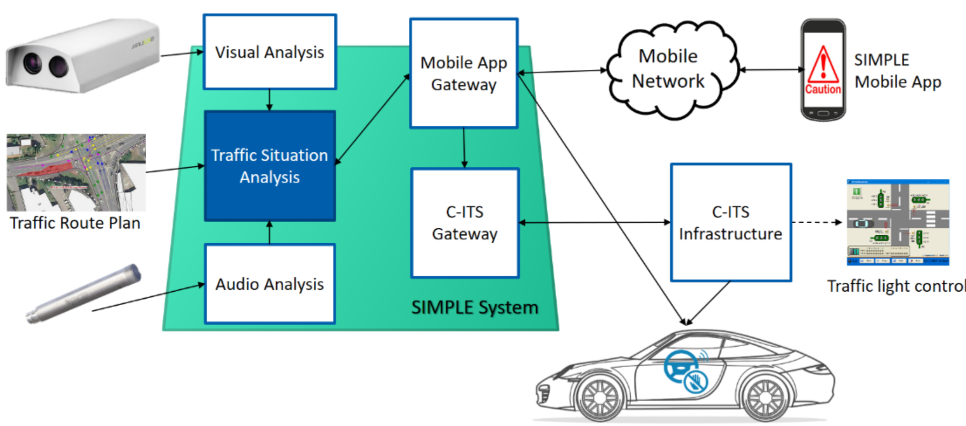

Figure 1. Software components and interfaces of the SIMPLE demonstration system (© SIMPLE consortium)

2.3. Deployment

Video cameras and directional microphones are used as sensors to record the traffic situation. Additional data on the location of road users come from the mobile phone application, which is also used to warn road users.

In order to be able to cover the largest possible surveillance area with a camera, a light-sensitive wide-angle camera is used. The AXIS Q1615 MK III camera with a wide-angle lens (horizontal 115 °) has been selected for use in the project.

For the audio analysis a microphone array was chosen, that was suitable for outdoor applications and thus be waterproof and windproof.

Bluetooth tokens will be used in order to enable more precise localization of pedestrians (who use the mobile application) on selected positions (e.g. traffic light posts).

2.4. Field of use and demonstration

For the selection of suitable test regions and ultimately also potential marketing areas, an Austria-wide screening was carried out. Different types of intersections were recorded and categorized according to the following criteria:

- Control type (unregulated, with priority control, signal-controlled)
- Equipment of the signal system
- Existing user groups and means of transport

For the pilot study the following three scenarios are considered:

(1) Extension of the green phase of the traffic lights for certain users

(2) Influencing the traffic lights program and warning to road users via the mobile app when an emergency vehicle is approaching

(3) Warning road users via the mobile app when turning right and the crossing of a pedestrian occurs at the same time

3. RESULTS

3.1. Focus groups and vulnerable road users

At the beginning of the year 2021, 127 people across Austria were asked about their satisfaction and how they felt in various traffic situations using questionnaires. Amongst the participants, 20 were visually impaired, 9 were hearing impaired and 9 were both visually and hearing impaired.

It showed that additional support is particularly required at unregulated intersections without a zebra crossing and without traffic lights, but also at regulated, but very confusing crossings. Additional support would be very important for 34% respectively 22% of the interviewees (see Figure 2).

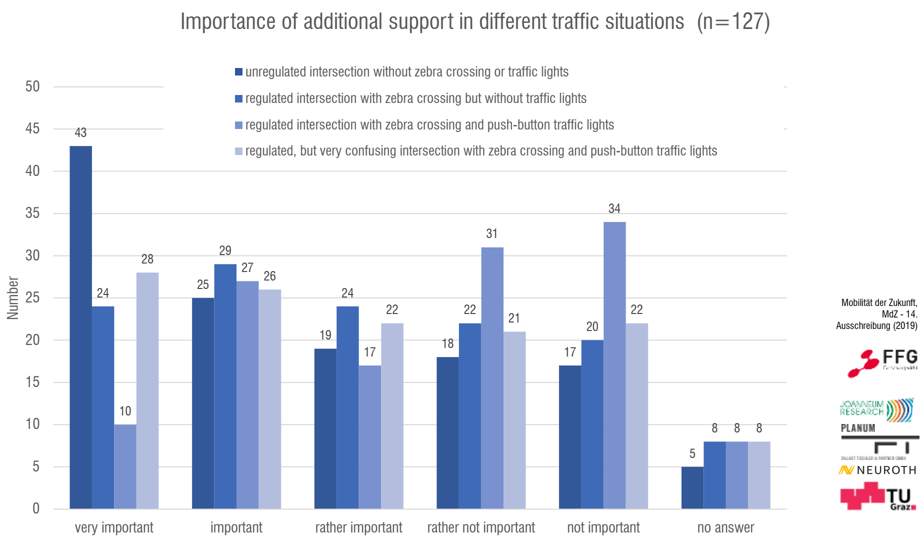

Figure 2. Importance of additional support in different traffic situations (© SIMPLE consortium)

Emotions such as anger, fear and stress are very high at unregulated intersections without a zebra crossing and without traffic lights. Confidence is highest when there are regulated intersections with a zebra crossing and a push-button traffic light (see Figure 3).

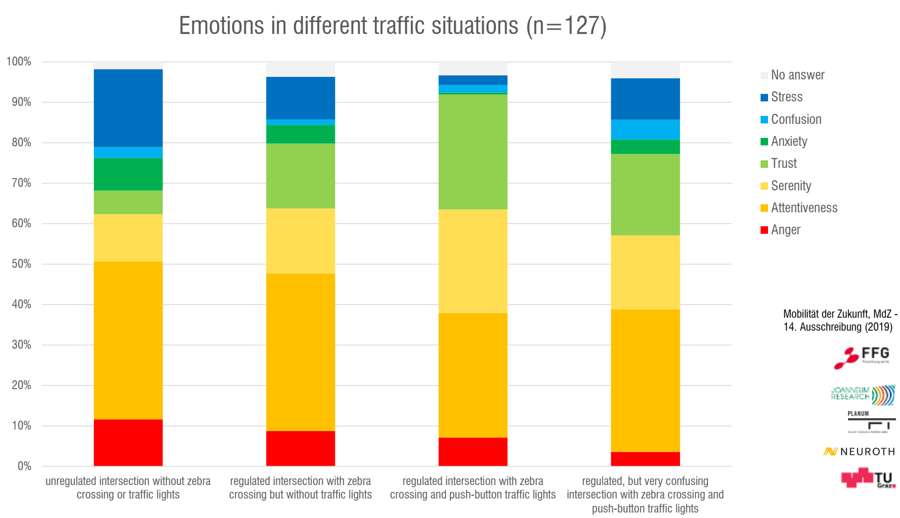

Figure 3. Emotions in different traffic situations (© SIMPLE consortium)

The most prominent requirements of the interviewees were data protection, ease of use of the app (few interactions and few settings), individually configurable notifications / signals, and a system that could be used internationally and could be switched on an off as required.

The interviewees spoke out for longer green phases at traffic lights for visually impaired, hearing impaired or mobility impaired people. The signals used to provide information on the traffic situation should be unambiguous, reliable and distinctive.

3.2. Multimodal Traffic Analysis

The visual traffic analysis is working in several phases. In the first phases road users are detected by means of a deep-learning based, object detection method. This gives 2D-bounding poxes and classifies the road users in several types (pedestrian, bicycle, motor-bike, car, truck, bus etc). Additionally, significant points are extracted and tracked. Based on the 2D-bounding box, the tracked points, and the calibration information the 3D-bounding boxes are derived and from that estimates for the velocity and acceleration. Figure 4 shows one frame with the visualization of the detected road users.

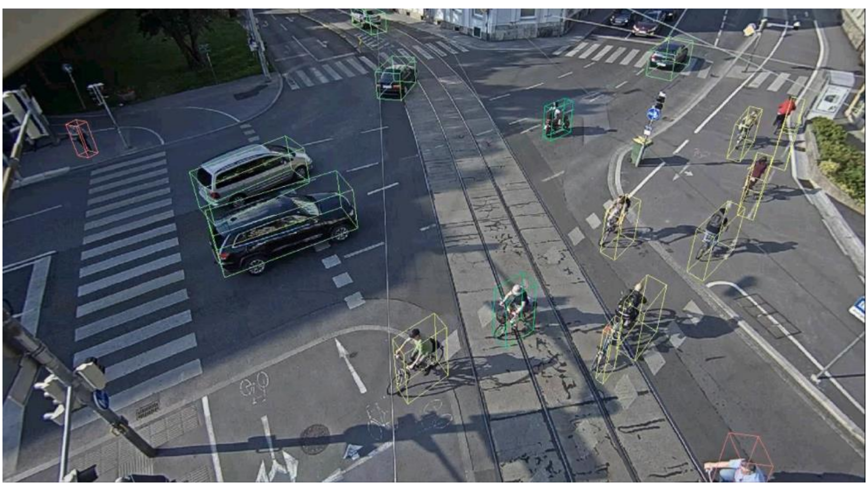

Figure 4. Results from the visual traffic analysis. The 3D-boxes show the position and type of the different road users.

For the detection of martin horns, a dataset of approximately 45 days, recorded in a previous project [1] has been used for development and evaluation. As the martin horn is a very loud and distinct event, it can be detected reliably. On our test set of 10 hours, which contained approximately 10 minutes of martin horn, we achieved a frame-wise detection F-measure of 95.9%. The most common confusion is with car horns, which sound very similar, especially if the martin horn is only activated for a short period.

4. CONCLUSION

The approach presented in this paper aims on improving the safety of vulnerable road users in future situations where autonomous vehicles will be more and more prominent. By providing them with a mobile app, they can participate on an equal footing in C-ITS-using traffic scenarios, and so get “visible” earlier to autonomous vehicles. The design of the user interface of such an app is of particular importance as the app users have on the one side, to be reliably informed about potential hazardous situations and on the other side, must not be distracted from monitoring the traffic situation.

ACKNOWLEGDEMENT

The project SIMPLE is funded by the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) as part of the "Mobility of the Future" programme.

REFERENCES

[1] Krebs F., Thallinger G., Neuschmied H., Graf F., Huber G., Fallast K., Vertal P., Kolla E., Evaluation of SIMMARC: An Audiovisual System for the Detection of Near-Miss Accidents, In: Martins A., Ferreira J., Kocian A. (eds) Intelligent Transport Systems. From Research and Development to the Market Uptake. INTSYS 2019. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 310. Springer, Cham. https://doi.org/10.1007/978-3-030-38822-5_13

[2] Thallinger G., Krebs F., Kolla E., Vertal P., Kasanický G., Neuschmied H., Ambrosch K. (2018) *Near-Miss Accidents – Classification and Automatic Detection*. In: Kováčiková T., Buzna Ľ., Pourhashem G., Lugano G., Cornet Y., Lugano N. (eds) Intelligent Transport Systems – From Research and Development to the Market Uptake. INTSYS 2017. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 222. Springer, Cham. https://doi.org/10.1007/978-3-319-93710-6_16