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# Autonomous Last Mile Shuttle ISEAUTO for Education and Research

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## ABSTRACT

The article introduces an educational and research project ISEAUTO, targeted to using self-driving cars to solve urban mobility issues. The project focusses on the design and development of an autonomous shuttle as a collaboration between academic staff of the university, students, and a partner company. The article presents an account of the experience of developing vehicle from scratch in one year using a stock electric vehicle, widely available sensors and open source software. Technical solutions based on the latest trends in autonomous mobility are conferred, special attention is given to control and software architectures. In addition to reaching the goal of making the shuttle drive autonomously by the end of the first year of the project, it was possible to combine various tasks with teaching and award more than 460 ECTS to participating students. The project continues and a commercial version of the vehicle is in development.

## KEYWORDS

Autonomous Vehicle, Autonomous Shuttle, Autoware, Freertos, ROS, Self-Driving Car, Simulation, Urban Mobility

## 1. INTRODUCTION

The fast development of sensor and communication technologies together with available open source software supporting vehicle autonomy as implementations of recent results in AI research has given rise to a wave of new autonomous vehicles (AV) being developed around the world (Burnett et al., 2019). The current paper presents an account of developing an autonomous last mile shuttle within 1 year starting in the Summer of 2017 and the follow up developments during year 2. The general expectations to autonomous vehicles are the ability to cover long distances in a safer way, i.e. decreasing the rate of accidents and traffic jams while providing convenient transport to ever increasing number of passengers. In the foreseeable future the autonomous vehicles are expected to share public roads with vehicles driven by human drivers, so the software for autonomy needs to have a good representation of both the traffic regulations and best practices of traffic. There are more than 10 trillion automobile kilometers driven each year worldwide, with complex and novel conditions

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generating millions of situations in which AV could fail (Daily et al., 2017). The control software of an autonomous vehicle needs to take into account road markings, traffic signs and lights, other vehicles, pedestrians, cyclists and other forms of transport on the road, while being able to cope with missing information, i.e. damaged road markings and being able to cope in congestions. Autonomous driving technology has already prominently reduced the accidents caused by human error or choice such as impaired driving, distraction, and speeding or illegal maneuvers which caused 94 percent of crashes in the US in 2017 (Automated Vehicles 3.0 Preparing for the Future of Transportation US Department of Transportation, 2018). There are still many challenges in solving autonomous driving in general because of the large number of edge cases and small permissible error margins in the real world, but there are active efforts to collect relevant data and use that towards solving the remaining problems (Fridman et al., 2019). In addition, the autonomous vehicles should be able to handle adverse driving conditions, such as rain, wet and icy roads (depending on the geographic location), the control algorithm must be able to recognize roads within a tolerable margin of error, using measuring instruments, such as cameras, lidars assisted by inertial measurements and GNSS. The autonomous vehicle software is expected to make quick decisions based on incomplete information in situations not necessarily foreseen at the time of development (Goodall, 2016).

In order to be able to develop software that is able to support autonomy it is important to be able to test it in a wide variety of situations. An important step in that direction was taken in Germany in 2017 (Daily et al., 2017), when German legislators defined the legal framework for allowing self-driving vehicles on public roads, as long as a human driver is at the controls to take over in critical situations. Similar laws are applied in the US (California and Nevada) (Greenblatt, 2016) and many other countries. Estonia has allowed the testing of self-driving cars on public roads also in 2017 by allowing an AV into the traffic for a limited testing period after completing a simple permit application procedure (Estonian Road Administration, 2017). China laid out national guidelines for testing self-driving cars in April 2018 when Beijing, Chongqing, Shenzhen, and Guangzhou, in addition to Shanghai opened their city roads to AV testing. Traffic can be as unpredictable as the weather and being able to respond to both means navigating countless scenarios. To fully test all possible scenarios in the real world by simply driving around is impossible and achieving a significant coverage of different situations may well take millions of kilometers. Therefore, computer simulations and mathematical modeling need to be incorporated into the development loop (Coelingh et al., 2018).

The current paper describes a project where a self driving last mile autonomous shuttle called ISEAUTO was developed. The project took place at the Tallinn University of Technology in cooperation with an Estonian automotive company Silberauto Estonia. The autonomous shuttle ISEAUTO is a research and educational platform targeted towards the design and development of self-driving vehicles in cooperation with a private company, university researchers and students.

The current paper is an extended and updated version of the conference publication (Sell et al., 2018).

## 2. SIMILAR PROJECTS

The computerisation of driving can be traced back to the 1970s, with the introduction of electronic anti-lock brakes. Today more advanced features like automated steering, acceleration and emergency braking are emerging every year. (Goodall, 2016). There are a huge number of automotive and technology companies worldwide working on self-driving car projects, such as e.g. Volkswagen, BMW, Hyundai Motors, Audi, Ford, General Motors, Honda, Mercedes, Nissan, NVidia, Tesla, Toyota, etc. It is interesting to note that large technology companies, including Google, Apple, and Uber, are seeking to become key players in this market even though their history is not directly tied to the production of cars (Montgomery, 2015).

Several Asian countries are making significant contributions to the field: in Japan, automakers are working together to make self-driving cars a reality in time for the 2020 Tokyo Olympics (Daily et al., 2017). Tata and Mahindra in India, which is one of the larger markets, are making progress in

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