DENSO

www. densocorp-na.com

Machine Learning for Automated Driving

Description of Project

DENSO is one of the biggest tier one suppliers in the automotive industry, and one of its main goals is to provide solutions to the OEMs in the Automated Driving field. DENSO plans to increase its contribution to the development of automated driving technologies by enhancing the functionalities of existing techniques and invent new solutions. The main objective of this project is to study different Highway driving scenarios and use them to build a training set to teach the system on how to act in similar scenarios. The machine learning solutions that will be developed can help automated vehicles make proper driving decisions in different driving conditions. The goal of the project along with high level description of the main components that will be studied are summarized as follows:

Introduction

Autonomous vehicles are equipped with an array of sensors to collect and analyze data to perceive their environment. These sensors help the vehicle detect, locate, track the movements of other vehicles and extract their dynamics. The collected information through the local sensors helps the vehicle understands its surroundings. Each vehicle undergoes different driving conditions, and therefore it should have the capability of dealing with such conditions. The vehicle should be equipped with intelligent systems to enable it predict the next step movements, and make maneuvers in a safe manner. Otherwise, making improper decisions have a negative impact on safe driving on the roads. The proposed work will be studied in the following aspects.

- Studying the collected scenarios
- Machine Learning Solutions

Highway Driving Scenarios

Different presentable highway scenarios collected using a stereo Camera installed on one of our vehicles. The scenarios range from ramp merge, ramp exit to lane closure and different others. Different driving conditions (speed, heading, etc.) can exist in each scenario. These scenarios will be used as a reference to build a training set and feed it into the computer. Intelligent algorithms are expected to be developed to deal with the proposed scenarios.

Why Machine Learning

There is an infinite number of scenarios and driving conditions that the autonomous vehicle can face, and it has to be smart enough to act and execute commands for a safe path following.

Autonomous vehicle should learn from the information fed into their systems and should use this knowledge, along with the current live information collected through the sensors, to predict the next steps. Figure 1 depicts an example of a lane closure scenario where two lanes merge into one. The figure on the left side shows the vehicle crossing the road mark (yellow) not realizing that the road discontinues. On the other hand, the figure on the right side shows the vehicle is able to deal with this situation and continues driving on the road. In this scenario alone, there can be different driving conditions for the autonomous vehicle as well as for the neighboring vehicles. Based on those conditions, the vehicle should make the proper driving decisions (e.g., slow down, speedup, stop, etc.).

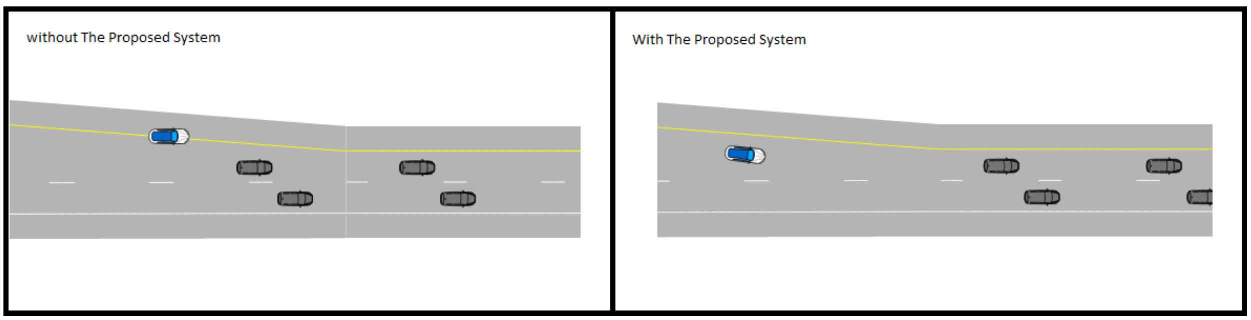


FIGURE 1: LANE CLOSURE SCENARIO, (A) LEFT VEHICLE CROSSES THE ROAD BOUNDARY, (B) RIGHT VEHICLE REMAINS IN THE ROAD

Machine Learning Solutions

An autonomous vehicle is assumed to be equipped with a forward looking camera (or other sensor like LiDAR) that contentiously captures the front view of the vehicle. Feature based extractors can be employed to extract the features and localize the training set with respect to each key feature. If the scenario marking can be classified properly from the captured frames, it can be given to a training set to find out the closest match. The training set continuously builds up from different scenarios and conditions. All these scenarios will build a large database so that later classification becomes much accurate and robust. For example, a supervised learning technique along with the training sets will make the system accurate in decision making. Different Machine Learning techniques (e.g., Baysian networks) can be considered while developing the solutions. However, the main challenge is creating a well-built training set. All output inferences or decisions will be decided by the training set. Training set should have as many practical cases as possible (both negative and positive). The negative cases are helpful in avoiding false predictions. Figure 2 shows the main blocks that can be used to develop the solutions

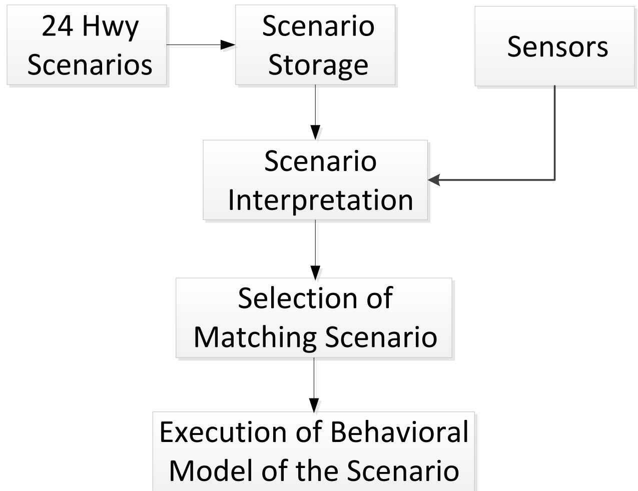


FIGURE 2. MAIN BLOCKS OF THE PROPOSED SOLUTIONS

Data Provided for Students

DENSO will provide Camera data only (no other sensors involved in this project). The camera is able to capture the front view of the vehicle as it moves through different driving scenarios. For each scenario, we will provide you with multiple recordings representing that particular scenario (e.g., for the lane closure scenario there will be different videos taken in different places).

Measuring Success

Students on this team will collaborate with DENSO engineers to develop metrics for evaluating the performance of the system. Measurements to be agreed upon include tolerances for response delay and system accuracy.

Communication Protocol

DENSO utilizes "OpenCV" for Camera data processing. For machine learning implementation, students can propose the algorithms and communication tools for feedback from DENSO engineers.

Include a Deliverable (Phase I) and Details Here: BASELINE GOAL

What is the baseline deliverable the students must produce in order to be successful?

Scope	Duration
• The problem Understating • Outlining a solution • Defining proper well-defined sequence of procedures to solution	4 wks

Include a Deliverable (Intermediate – Phase II) and Details Here: SUCCESS

What is the polished/functionality the students should plan time to add?

Scope	Duration
• Development of the algorithm in software platform • Unit testing and behavior testing on sample Data • Integration among other modules and coverages on different test cases	14-16 wks

Include Stretch Goals and Details here: HIGH SUCCESS

Stretch Goals for the project. After Phase II, what would you LIKE to see the students complete? What would "Wow" your organization?

• Final Results. • Regression testing • Inclusion of more scenarios for automated driving and achieving it	8 wks

Location

Most project work will take place on campus during the semesters

Project Sponsor Mentor

Zaydoun Rawashdeh: Received his Ph.D. degree in Electrical and Computer Engineering from Wayne State University, Detroit, USA, in 2011. He is currently with DENSO Research and Development North America leading the Connected-Autonomous Driving project. His research experience includes active safety systems based on V2V technology, Object matching and tracking, Embedded Systems, and Mobile Ad Hoc Networks.

Rajesh Malhan: Received his PhD. Degree from the University of Delhi, India in 1989. He was post-doctoral research fellow in the Department of Electrical and Electronic Engineering, Toyohashi University of Technology, Japan till Mar. 1991. He Joined DENSO in 1991. Now, he is the director of advanced research at DENSO's North American Research and Development Department. He is responsible for DENSO's Automotive (Autonomous drive, Vehicle electrification, Vehicle wireless charging, Alternative fuel and Metal air battery technologies) R&D work. He has published more than 50 research journal papers, inventor or co-inventor on over 25 US and 150 International patents, and contributed chapters in 4 books. He is a winner of 24th JSAP (Japan Society of Applied Physics) year 2002 award for outstanding achievements in the field of applied physics. He is a member of the Society of Automotive Engineers (USA), the Institute of Electrical and Electronics Engineers, Inc. (USA), the Japan Society of Applied Physics (Japan) and served on many international professional society committees.

Project Faculty Mentor

Please advise if there are any specific members of the faculty whom you would like us to approach for your project. All projects receive a faculty mentor for each student team.

Key Skills & Project Roles

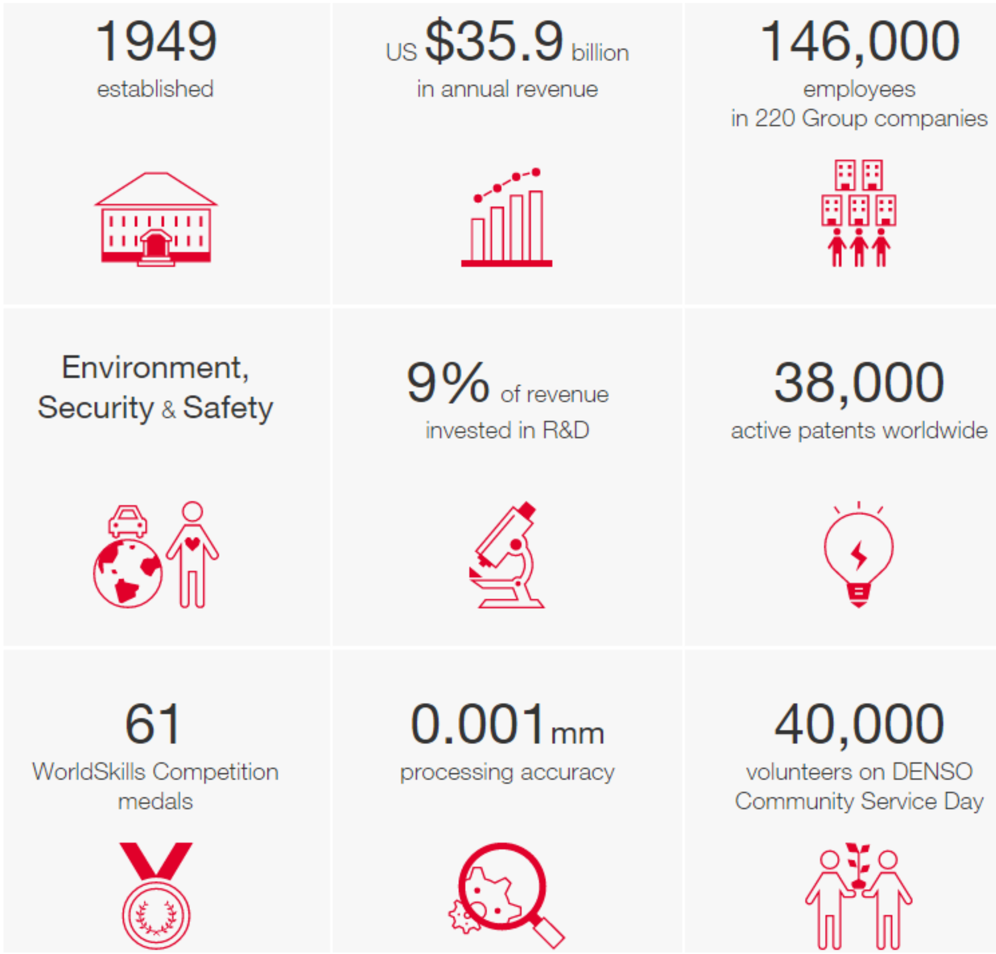
Areas of Experience: Artificial intelligence, Machine Learning, Control, Robotics

Student Role	Likely Majors
(1) Computer Networks	Electrical Engineering, Computer Engineering, Computer Science (CSE/CS-LSA)
(1) Artificial Intelligence/Machine Learning	Electrical Engineering, Computer Engineering, Computer Science (CSE/CS-LSA), Robotics
(2) Control Systems	Electrical Engineering, Computer Engineering, Computer Science (CSE/CS-LSA), Robotics, ISD-AUTO
(1-2) Wireless Communications	Electrical Engineering, Computer Engineering, Computer Science (CSE/CS-LSA)
(1-2) Data Analysis	MIDAS / MICDE Certificate Program Graduate Students, STATS, Industrial & Operations Engineering

Desired skills: Strong analytical modeling and programming (C, C++, Matlab, etc.), Interest in autonomous vehicles and V2V communications.

Company Overview

DENSO is a leading supplier of advanced automotive technology, systems and components for major automakers. DESNO has committed to making the world better place through its world-first products and technologies.



More information about DENSO can be found at the following link:
http://www.globaldenso.com/en/about-us/at-a-glance/

Legal Requirements

- This project is open to all students regardless of citizenship status

Intellectual Property Agreements / Non-Disclosure Agreements (please select)

- Students will sign the standard MDP IP/NDA agreement

Internship Information

- Summer Funding Available