AUTONOMOUS SYSTEMS INITIATIVE

ASI Newsletter Volume 2 Issue 3 March 2021

Welcome to our March edition of the ASI newsletter. This month we learn more detail about one of our University of Calgary project teams working on Autonomous Vehicles in the connected environment. And, we hear from researcher Mostafa Hassan and his work with the use of drones for industrial repair.

ASI News and Updates

ASI's general annual workshop is now in planning. Keep your eyes peeled for news and updates!

Year 4 of our research program commences April 1st, 2021.

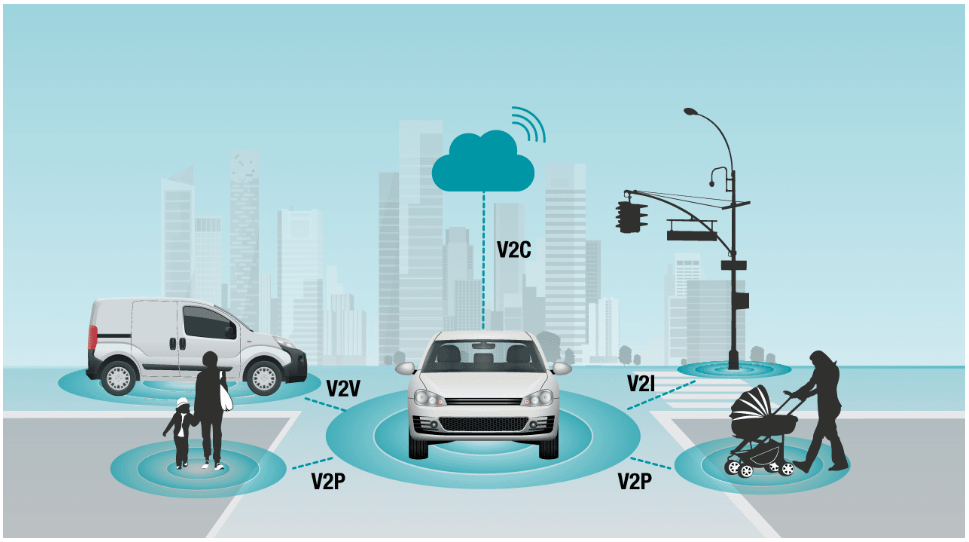
Research Spotlight

One of the most important tasks in autonomous driving is environment perception - the ability to collect information and extract relevant knowledge from the surrounding environment. In our research feature this month, we meet the University of Calgary team using Machine Learning to advance this important aspect of vehicle technology.

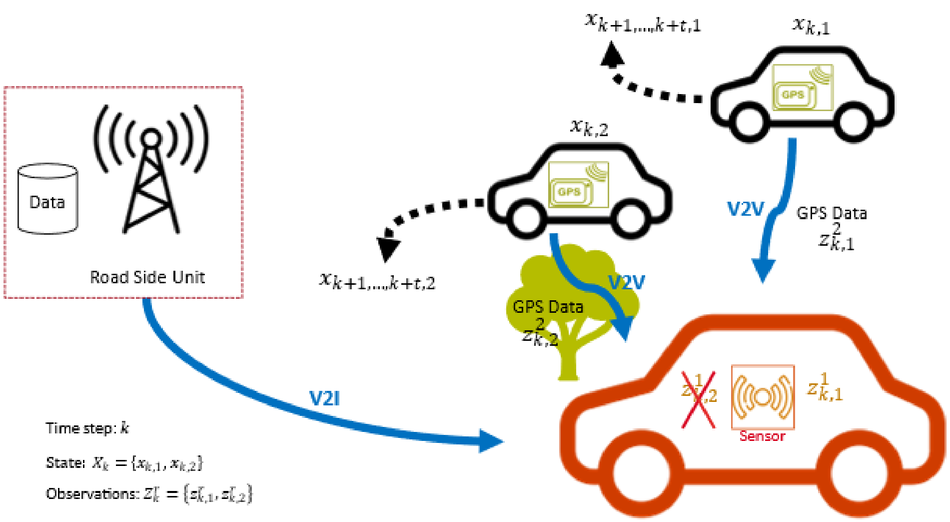
Autonomous vehicles can change everything; road safety, mobility, and even the transportation economy. And although self-driving cars garner a lot of media attention, wireless vehicular communication, also known as vehicle-to-everything (V2X), describes the fundamental basis of all connected transportation.

Autonomous vehicles (AVs) must sense what is around them, both in the present and near-future, in order to function safely and efficiently. This means that they must be able to 'see' and communicate not only with other vehicles but with the entire roadway infrastructure including traffic signals, railway crossings, signage, work zones, roadway layout and even things like curbs and other street furniture. They must also be able to perceive non-vehicular traffic such as cyclists and pedestrians. Getting this right is crucial.

Until recently, AVs have relied on sensors as their primary source of information about the world around them. But ASI's University of Calgary research team, led by Dr. Behrouz Far in the Schulich School of Engineering, are investigating new opportunities for safety-related applications via information-sharing and extending the perception range of a vehicle beyond the limitations of its onboard sensors. The outcomes will provide solutions that leverage the connected vehicle (CV) environment together with



Problem and Motivation



the sensory data to improve the perception of autonomous and intelligent vehicles.

Certainly, harnessing the advances in 5G is of huge significance for this work. Its low latency and increased bandwidth can exponentially grow both the amount and timeliness of the information gathered and communicated by AVs. Vehicle-to-vehicle (V2V) communication is utilized for the detection and tracking of nearby road users. At the same time, data collection and training Machine Learning (ML) models are done within the infrastructure and cloud. The necessary information is shared with vehicles through vehicle-to-infrastructure (V2I) and vehicle-to-cloud (V2C) communications. Paired together, this means that huge quantities of real-time information can be shared with and by AVs when communicating within a 5G network.

Furthermore, the advances in GPU technology will allow vehicles to run ML algorithms in real-time. As such, this project seeks to use ML together with advance sensor fusion and filtering algorithms – specifically multi-sensor multi-target tracking approaches – all running simultaneously.

Sepideh Afkhami-Goli, a researcher on the project, explains that "self-driving cars have evolved considerably in terms of hardware, but it is the software that is going to take time. It is getting better and smarter every day, but we are still a ways from level five of autonomy where a car can take us from wherever we are to wherever we want to go, any time of day, in any weather, in any country, anywhere. At the moment, there are so many different situations that AVs have to understand."

With this in mind, the team is addressing key challenges for AVs out on the roads. These include environmental uncertainties such as the dynamic number of road users, potential sensor disruption or confusion from noise, occlusion, damage or malfunction, data association (i.e. associating sensor data to targets) and the fusion of heterogenous data sources.

Ultimately, the project's outcome will be a set of algorithms that reduce errors in location estimation and trajectory prediction of nearby cars. The suggested approaches in this research will improve the quality of vehicular safety applications in an intelligent car by providing more accurate estimations and predictions in real-time. AVs will better understand the environment and make more effective decisions thereby reducing the chance of collisions, increasing safety and improving traffic mobility.

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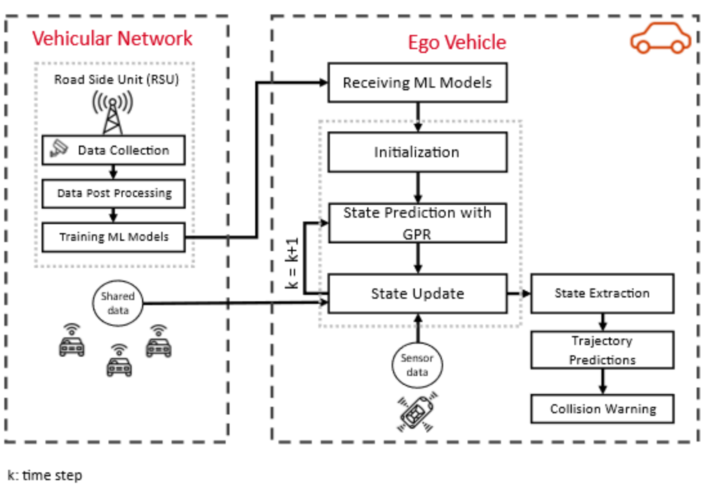
The research has generated significant interest with three papers already published and presented, including at the prestigious IEEE Intelligent Vehicles Symposium. The team currently have another major publication in the pipeline, and the work is currently in progress.

The team for Location Estimation and Trajectory Prediction for Collision Risk Assessment in Connected Vehicle Environment, based at the University of Calgary, includes Dr. Behrouz Far, Prof., Dept. of Electrical and Computer Engineering; Dr. Abraham Fapojuwo, Prof., Dept. of Electrical and Computer Engineering; Dr. Mozhdeh Shahbazi, Prof., Dept. of Geomatics Engineering; Sepideh Afkhami-Goli, Ph.D. Electrical and Computer Engineering Engineering.

Methodology



HQP Profile

Mostafa Hassan is in our spotlight this month. A Ph.D. student in the Department of Mechanical Engineering and HQP in ASI's Theme 3, Sustainable Communities, Mostafa's work focuses on helping industry spot problems before they happen.

Infrastructure failure is a significant problem that can cause fatalities, property damage, and economic losses. Therefore, early detection of potential failures is essential to save lives and assets. Mostafa's research, under the supervision of Dr. Walied Moussa, investigates new technology, based on a 3D MEMS stress sensor, to monitor infrastructure conditions, where a sensing 'package' is attached to the main infrastructural body of the constructed edifice to monitor stresses in all directions. The sensing package includes the sensing chip, the circuitry board, and the wireless modules to send acquired filtered data to a drone.

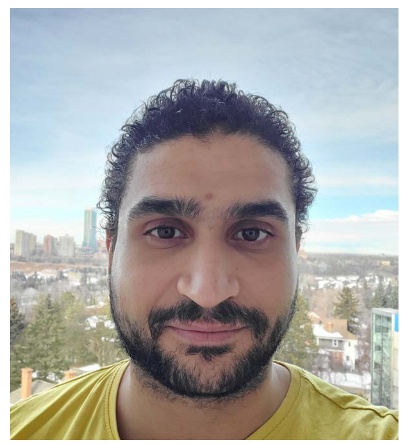
Power consumption and physical data collection are considered challenging aspects for wireless sensing, and deploying hundreds of sensory packages over a particular structure requires a tremendous amount of operational power. A drone can get close to the package, collect the data and provide it with power safely and efficiently. The drone can also collect and analyze the data through an AI algorithm, accelerating decision-making. In addition, it is a more economical method of data transmission than a wireless antenna.

This process, using both the sensing package and the drone, can extract all components of stress under different kinds of loads and reasonable temperature ranges. An Artificial Neural Network (ANN) is used as a high accuracy calibration algorithm to compensate the uncertainties coming from calibration, microfabrication, and temperature, on the sensor readings.

"These uses of autonomous systems will improve human performance in terms of strength and speed," explains Mostafa. "And, more generally, their prime assets in industrial use are accuracy and endurance. These systems will also replace the need for direct human intervention in harsh, precarious and dangerous environments, saving many lives."

Mostafa has been immersed in engineering for over a decade now. Having received his B.Sc. and M.Sc. degrees from Cairo University, Giza, Egypt, in 2013 and 2019 respectively, he worked concurrently as a research and teaching assistant with the Department of Mechanical Design and Production in Cairo University's Faculty of Engineering. In 2019, he was promoted to Lecturer Assistant at the same institution. Now he is working towards his Ph.D. at the University of Alberta, focusing on key research areas that include MEMS, structural health monitoring, solid mechanics, elasticity, and failure analysis.

He says he does intend to stay in Alberta and hopes to land a job working as a MEMS process engineer to enhance sensor performance and automation through ANNs.



"As Alberta's economy is based on oil and gas, I would propose that a net of sensory packages be deployed along the rail track network throughout the province. That would be a dream project for me."

About ASI

The Autonomous Systems Initiative (ASI) is a forward-thinking, multi-million-dollar research program that teams up research and industry experts across Alberta to develop automated technologies spanning key areas of health, transportation, sustainability, and industry. Understanding and developing these systems will help us to remain economically competitive in a global context while effectively addressing the challenges of climate change, efficient energy production and use, transportation needs, advanced manufacturing, and medical advancement. This program develops new Information, Communications and Technology (ICT)-enabled Autonomous Systems to support healthy and sustainable communities with a focus on sensing, communication, control, and computation technologies, all linked together by artificial intelligence.

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