Engineering and Innovation Research Studentship 2024/2025

Project title:	**Control and Communication in Connected Autonomous Vehicles**
Discipline	Electronics Engineering
Key words:	Connected and autonomous mobility, V2V communications
Supervisory team:	Dimitar Valchev, Serhan Cosar, Jeffrey Johnson
URL for lead supervisor's OU profile	https://stem.open.ac.uk/people/dv2246

Project Highlights:

- Control in multi-agent systems
- Vehicle-to-vehicle communications
- Connected autonomous mobility

Overview:

Future transportation is associated with connected and autonomous vehicles (CAV). These can be driverless cars, mobile robots, drones, pedestrians with mobile/wearable devices, etc. with the corresponding communication infrastructure, as illustrated in Figure 1.

Figure 1. Connected autonomous vehicles (*Autonomous Driverless Vehicles Set*. Photograph. *Britannica ImageQuest*, Encyclopædia Britannica, Nov 02 2020. quest-eb-com.libezproxy.open.ac.uk/images/186_3417276. Accessed 3 Nov 2023.).

The CAV sector both in UK and worldwide is attracting a high degree of interest in terms of research, regulations, and policy [1], both in UK and worldwide. The growth potential in this sector depends, among other factors, on overcoming certain technical issues in control and communications in this heterogeneous distributed system. Such technical issues are the subject of this doctoral study.

The robustness of the autonomous transportation network depends on the accuracy and the reliability of the information exchanged between the vehicles, and the precision of their control. This proposal aims to investigate critical aspects of control and communication, and their interaction with each other, in a CAV context.

CAV operate in a specific wireless environment – a mobile-to-mobile, also known as vehicle-to-vehicle (V2V), communication channel. Radio propagation lacks the reliability of wired connection and is characterised by large- and small-scale (multipath) fading. Mobility at both the link ends further complicates the communication process through the introduced Doppler spread. Thus, adequate mobile-to-mobile channel modelling is essential for the development of efficient V2V communication techniques [2]. Multipath propagation in the built environment impacts on important characteristics of the communication signals at the link ends and has implications on reception and transmission techniques employing diversity [3].

Based on the information exchanged within the CAV network, control strategies are applied, aimed at transportation safety and optimal routing.

The uncertainty of information gathered by an AV regarding its surroundings, due to sensor noise and algorithmic failures, affects the perception and navigation system of the AV, thereby affecting the vehicle's safe and autonomous driving [4]. Fusion of information from multiple sources is an effective approach for decreasing this uncertainty.

Considering the bandwidth of communication, the interference, and the need for real-time processing, efficient fusion schemes are needed in CAVs. Thus, it is essential to use intelligent control and communications techniques aimed at improving accuracy and decreasing uncertainty by considering the reliability of the sources, the status of the network and the conditions of the communication channels. In particular, the following aspects are planned to be studied:

- V2V communications and channel modelling
- Approaches to compress the shared information
- Adaptive fusion schemes that consider the condition of the wireless channel and the quality of the shared information
- Multipath routing techniques that consider the control and computation mechanisms of the CAVs

Methodology:

The study will be based on theoretical and experimental work. Theoretical work will include modelling of V2V channels, mathematical formulation, and numerical simulation. Experimental work will include wireless channel measurements using portable antennas and a vector network analyser, testing fusion strategies for navigation and perception algorithms, and the corresponding data analysis. Public datasets and robust 3D simulators (e.g. CARLA) are planned to be used in the experimentation.

References & Further reading:

1. HM Government, "Connected & Automated Mobility 2025: Realising the benefits of self-driving vehicles in the UK", available online from www.gov.uk/official-documents.
2. A. Raza, S. J. Nawaz, S. Wyne, A. Ahmed, M. A. Javed, and M. N. Patwary, "Spatial Modeling of Interference in Inter-Vehicular Communications for 3-D Volumetric Wireless Networks", *IEEE Access*, vol.8, pp.108281-108299, 2020.
3. D. Valchev and D. Brady, "Three-dimensional multipath shape factors for spatial modeling of wireless channels", *IEEE Transactions on Wireless Communication*, vol. 8, no. 11, pp. 5542-5551, Nov. 2009.
4. F. Camara, N. Bellotto, S. Cosar, D. Nathaniel, M. Althoff, J. Wu, J. Ruenz, A. Dietrich, and C. Fox, "Pedestrian Models for Autonomous Driving Part I: Low-Level Models, From Sensing to Tracking," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 22, no. 10, pp. 6131-6151, Oct. 2021.

Further details:

The successful applicant should have a strong background in electronics/electrical engineering with focus on communications and control, and an enthusiasm both for theoretical and experimental work. Programming skills with numerical software and knowledge of distributed systems will be an advantage. The student will work in a multidisciplinary team at the Open University. Please contact Dr Dimitar Valchev (dimitar.valchev@open.ac.uk) for further information.

Applications should include:

- A 1000 word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- an Open University application form, downloadable from: http://www.open.ac.uk/postgraduate/research-degrees/how-to-apply/mphil-and-phd-application-process
- IELTS test scores where English is an additional language

Applications should be sent to **STEM-EI-PhD@open.ac.uk** **by 16.02.2024**