PHD PROPOSAL IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Collective Perception, optimization of the V2X frequency channel(s) usage and CP message contents based on A.I.

Advisor (s): Daniel Delahaye and Vincent Martinez

delahaye@recherche.enac.fr, vincent.martinez@nxp.com

Net salary: 2096€ per month with some teaching (64 hours per year on average)

Duration: 36 months

CONTEXT

Today we see the rise of connected vehicles and drones in the quest for safer, greener and more automated transportation systems. They heavily rely on ADAS (Advanced Driver Assistance Systems), and sense their environment, via a large number of different sensors (radars short-range or long-range, camera, lidar, V2X (vehicle to everything)), and creation of a 360-degrees safety type of cocoon around the vehicle.

Today, V2X is one of the many sensors embarked. It is valuable as it brings complementary information from radars and camera; in particular V2X has the capability to operate in non-line-of-sight and over long ranges of up to 1 or 2 km. V2X has been developed part of the Cooperative intelligent transport systems (C-ITS) to provide a framework for road users and traffic managers to share information that is typically different from other sensors. Currently, with V2X, ITS stations (ITS-S) periodically (every 100 ms to every 1 sec) broadcast their status (geographical coordinates, headings, speed, trajectory etc.). V2X is typically deployed in the ITS 5.9 GHz band, in one or more 10 MHz channels. It is based on the ITS-G5 standard developed by ETSI in Europe, and DSRC by SAE in the U.S.

The next generation of V2X targets a deeper and more interactive cooperation amongst pools of stations (vehicles, pedestrians, drones). Collective Perception (CP) describes the concept of sharing the perceived environment of an ITS-S based on perception sensors. In contrast to the current Cooperative Awareness (CA), an ITS-S broadcasts information about its current environment rather than about itself. Hence, CP is the concept of actively exchanging locally perceived objects between different ITS-Ss by means of V2X communication technology. CP decreases the ambient uncertainty of ITS-Ss by contributing information to their mutual Field-of-Views. The objective is to publish the objects perceived by local perception sensors in addition to the envisioned self-announcement procedure of V2X enabled stations. They should be able to either stream raw data originating from the sensors of the stations, or pre-processed and more compressed information. The key idea is to sense the local environment collectively, in order to mutually enhance safety and awareness. V2X is not anymore only a sensor, but becomes a communication channel able to convey other sensors' info. Below are provided a few examples of such concept:

- A vehicle can identify a pedestrian / cyclist / non-V2X-equipped-vehicle thanks to its radars & camera, and report this object to other V2X stations via a target list (providing the object's perceived location, speed and headings). The receiving stations can eventually confirm / complement the information.
- A traffic light can be equipped with pedestrian detection, and broadcast this information to the incoming vehicles (which may not have line-of-sight visibility).
- A large and obfuscating vehicle, such as a bus, can stream the raw output of its front-camera to the cars driving behind it.

STATE-OF-THE ART

Collective perception started to gain traction in 2016-2017, where first studies have been published and demonstrated the potential of these techniques [1] [2].

Extensive network simulation studies based on SUMO, ns-3 and OMNeT++ [1] have been performed to analyze the potential of the technology and findings indicate that a significant leverage can be achieved

for scenarios with a low level of V2X deployment, and that the awareness ratio is increased. Baseline proposals for EPM (Environmental Perception Message) format and contents fields have been simulated and seem to provide a good tradeoff between additional data traffic in the channel and increased awareness [2], although more study is needed and artificial intelligence should be used to determine the most important information to be transmitted depending on the road context. Amongst the options envisioned for conveying more EPM data traffic is the use of the mmWave bands, as studied in [3], which can be investigated to offload demanding streams such as video streams.

Nowadays, collective perception is perceived a promising technique, as advertised by leading manufacturer consortiums [4]. The format of the CP messages is started being standardized by regional ITS regulatory bodies. For example, it is becoming part of the ETSI ITS-G5 V2X standard in Europe. Draft documents are already available and technical reports are under progress [5], and studies for 5G- based V2X networks are ongoing [6].

OBJECTIVES

NXP is one of the major suppliers for automotive, with significant footprint on radar and ITS-G5 V2X chipsets (ref. SAF 5400) and is working with major OEMs on V2X roll-out. These chipsets may also be used in drones.

The objectives are:

- Propose the best modular format for Collective Perception messages, conveying either raw data or pre-processed information (such as a radar targets-list)
- Optimization of the data traffic in the V2X channel(s), and content of the messages based on A.I., used for context recognition (urban / highway, emergency brake vs normal road conditions etc.) and to select and send the most relevant information for the surrounding vehicles (without saturating the channel). The system needs to filter, classify and prioritize the messages based on their relevance for other parties etc.
- Evaluation of the benefits of CP on local awareness and impact on safety

- As a stretch goal, study of the architectural impact on the Data-Fusion central brain, given the possible large-growing number of sensors information sources (computational needs for neural networks etc.).

WORK ORGANIZATION

➢ T0 – T6: Bibliographic research on ITS networks capacities, Collective Perception messages format, and context-driven optimization.

➢ T6 – T12: Establish the CP framework: messages format & context-driven info

- Define the best way to convey the CP messages (CPM messages), define format, and series of fields/containers. Should be future-proof and compatible with any sensor, able to send raw data and pre-processed info (e.g. radar target-lists)
- Establish the metrics & baseline for Filtering/Classifying/Compress sensors' info, in an attempt to send only the most relevant information. Need to autonomously detect certain road situations (e.g. pre-crash, cyclist spotted, hazard on the road), and send the most relevant information into the bandwidth-limited V2X channel communication pipe (need to avoid congesting the V2X channel)

➢ T12 – T15: Mathematical model of the optimization problem of CP messages over a V2X channel. A.I. and ML can be used to determine the most relevant information to be sent in which context, and in which shape and form. Decision making processes, constraints and objectives will be defined.

➢ T15 – T25: Development of the optimization algorithm ➢ T26 – T30 : Simulations and analysis of the results

➢ T15 – T30: Stretch goal: study of the architectural impact for the data fusion layer (for example if Data Fusion is based on neural networks, can it cope with 10x or 100x more input sensors)

➢ T30 – T36 : Writing of thesis report

References

[1] VW, "The potential of collective perception in vehicular ad-hoc networks," [Online]. Available: https://ieeexplore.ieee.org/document/7377190.

[2] VW, "Realizing collective perception in a vehicle," [Online]. Available: https://ieeexplore.ieee.org/document/7835930.

[3] K. Sakaguchi, "Cooperative Perception realized by Millimeter-wave V2V2X," [Online]. Available: https://5g-miedge.eu/wp-content/uploads/2018/05/IEEE_ICC2018_Keynote_Prof_Sakaguchi.pdf.

[4] C2C, "The Car-2-Car Communication Consortium Roadmaps beyond Day-1," [Online]. Available: https://www.codecs-project.eu/fileadmin/user_upload/pdfs/City_Pool_Workshop_1/CIMEC- CODECS_2016-03-3_Buburuzan.pdf.

[5] E. I. WG1, "ITS-00183 (TR 103 562)".

[6] 5GAA, "Roadmap of monetisable features and business models for LTE V2X," [Online]. Available: http://5gaa.org/wp-content/uploads/2018/09/5GAA_180912_CV2XRoadmapWhitePaper.pdf.

[7] D. I. Thibault, "Next Generation Mobile Networks: An industry perspective with a focus on Cellular–V2X technologies, " [Online] Available: http://www.robertoverdone.org/wp-content/uploads/2017/10/Thibault.pdf. [7] F. Dehais, A. Duprès, S. Blum, N. Drougard, S. Scannella, R. N. Roy, and F. Lotte, "Monitoring pilot's mental workload using ERPs and spectral power with a six-dry-electrode EEG system in real flight conditions," Sensors, vol. 19, no. 6, p. 1324, 2019.

[8] C. Poussot-Vassal, R. N. Roy, A. Bovo, T. Gateau, F. Dehais, and C. Ponzoni Carvalho Chanel, "A loewner-based approach for the approximation of engagement-related neurophysiological features," 2017.

[9] T. Golany and K. Radinsky, "Pgans: Personalized generative adversarial networks for ECG synthesis to improve patient-specific deep ECG classification," 2019.

[10] F. Zhu, F. Ye, Y. Fu, Q. Liu, and B. Shen, "Electrocardiogram generation with a bidirectional LSTM-CNN generative adversarial network," Scientific reports, vol. 9, no. 1, p. 6734, 2019.

[11] R. T. Schirrmeister, J. T. Springenberg, L. D. J. Fiederer, M. Glasstetter, K. Eggensperger, M. Tangermann, F. Hutter, W. Burgard, and T. Ball, "Deep learning with convolutional neural networks for EEG decoding and visualization," Human brain mapping, vol. 38, no. 11, pp. 5391–5420, 2017.

APPLICATION PROCEDURE

Formal applications should include detailed cv, a motivation letter and transcripts of bachelors' degrees.
Samples of published research by the candidate and reference letters will be a plus.
> applications should be sent by email to: advisor email
More information about ANITI: https://aniti.univ-toulouse.fr/