PHD PROPOSAL IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Radar Interference Mitigation, optimization based on V2X and A.I.

Advisor (s): Daniel Delahaye (ENAC) and Vincent Martinez (NXP)

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 ADAS (Advanced Driver Assistance Systems) for assisted and automated transportation systems. Such vehicles, drones or rovers heavily rely on different sensors, and radar is one of the most commonly used. Radar systems are sometimes classified as short-range, or long-range depending on the application targeted, which can be for example Automatic Cruse Control (ACC), Blind Spot Detection (BSD), parking, pedestrian detection.

Still today, a low percentage of vehicles are equipped with such systems, but projections show that the number of radar system is increasing exponentially. By 2030, forecast is that 50% of the cars will be equipped with radar, representing 700 millions of vehicles, for a total of around 3.5 billion of radars systems in use. This leads to an increased risk of life threatening consequence due to radar interference.

Radar interference may originate from a variety of reasons, including high density of signal sources, reflection on other objects, too high emission level, geometry, meteorological (wet road) or environmental (guard rails, tunnels) origins. The effect of interferences can be dramatic, by nulling the signal sent by a source, or flooding a receiver by unwanted signal.

Simple mitigation techniques may include statistical mitigation, detection of interferences and repairing at signal processing level. More promising techniques based interference avoidance by means of coordination of the neighbor vehicles via a communication channel such as V2X (vehicle to everything) or 5G are being investigated, and are the primary scope for this thesis.

New generation radar are based on the following pillars:

- Fine parameterization of radar waveforms, intending to create orthogonal or at least less-interference prone waveform. One of the area of research is investigation of which sequence offers the best framework (FMCW, PMCW, OFDM).
- Coordination between station to exchange & negotiate radars waveforms parameters (frequency and time plans, sequence ID, priority etc.)
- Artificial Intelligence and Machine learning to help tasks of
    - Fast identification of different driving environments that may trigger different waveform designs & parameters in order to maximize efficiency and reduce interferences
    - Understanding of the other vehicles upcoming utilization plans

- Creation of a decentralized control scheme, where each vehicle is able to derive by itself what it should do to globally mitigate interferences, and act accordingly.

STATE-OF-THE ART

Radar interference mitigation started to gain traction in 2016-2017, where first studies have been published and demonstrated the potential of these techniques [1] [2]. Studies confirmed the dangers of interferences, leading reduced range or performance, and some mitigation proposals have been studied [2] [3].

Coordination appears to be a promising technique, but lacks the dynamic adaptation rules and learning aspects. The new generation of V2X or 5G networks may offer a great framework to setup coordination messages.

OBJECTIVES

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

The objectives of this thesis are:

- Preparation work: Identify which sequence format offers the best framework for a frequency/time planning. Several options need to be investigated (FMCW, PMCW, OFDM), in terms of modularity, interference protection

- Propose the best modular format for the coordination messages, conveying all necessary information to organize the channel usage

- Optimization of the radar channel, based on A.I. & ML, with context recognition (urban / highway, emergency brake vs normal road conditions etc.) and creation of a decentralized control scheme procedure that can be applied to a fleet of cars, drones or rovers.

WORK ORGANIZATION

T0 – T6 : Bibliographic research on radar waveforms, radar interference mitigation techniques , and coordination options by means of 5G or V2X

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

- Define the best way to convey the utilization plan messages, define their format, and series of fields/containers.
- Evaluate means of autonomously detecting certain road situations (e.g. pre-crash, hazard on the road

T12 – T15 : Setup of the optimization model. A.I. and ML can be used to determine the most relevant framework and time/frequency sharing strategies. Decision making processes, constraints and objectives will be defined. A decentralized control scheme procedure that can be applied to a fleet of cars, drones or rovers can be defined.

T15 – T25 : Development of the optimization algorithm

T26 – T30 : Simulations and analysis of the results

T30 – T36 : Writing of thesis report

References

[1] MOSARIM. [Online]. Available: https://cordis.europa.eu/project/rcn/94234/factsheet/en.

[2] Rutgers, "Cooperative Among Automotive Radars," [Online]. Available: https://pdfs.semanticscholar.org/0181/1bd05e0c8e321e04cd2f4086e17586b4eec1.pdf.

[3] Chalmers, "Radar Communication for Combating Mutual Interferences of FMCW Radars," [Online]. Available: https://arxiv.org/pdf/1807.01497.pdf.

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/