Radar resource management for autonomous cars in i-CAVE project

Self-driving cars are a very popular research topic in academia and industry at the moment, because it is anticipated that they will revolutionize individual traffic and increase safety and efficiency on the road. Apart from the big traditional car companies, also others are working on solutions for autonomous driving like Google (Waymo), Uber and Tesla [1]. This shows that self-driving cars need novel and innovative solutions in order to become reliable enough for everyday use.

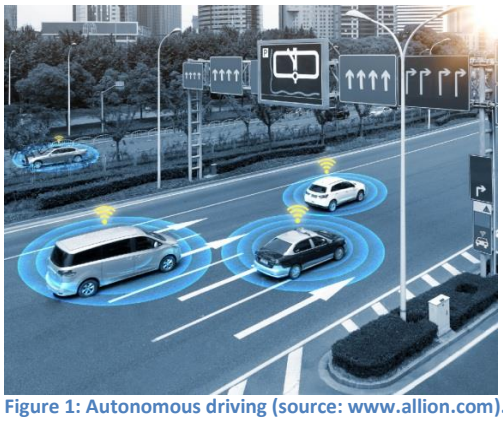

Figure 1: Autonomous driving (source: www.allion.com).

Radars are very important sensors for autonomous cars, because they work in almost every weather condition, contrary to cameras and lidars, for instance [2]. They therefore form an essential part of future traffic solutions.

Within the i-CAVE project (Integrated Cooperative Automated Vehicles) [3], we want to use the automotive radar to transmit sensing as well as communication signals in between of autonomous vehicles. Therefore, radar communication (RadCom) is considered to be another radar task (like detecting, tracking or classification for example) for the task scheduler. Radar resource management (RRM) is going to be applied to find the optimal schedule of all radar tasks in order to minimize the situation uncertainty for all vehicles involved. The radar systems of all cars are being taken into account within a single optimization problem. In order to avoid interference, a time division of the tasks is the most promising approach (see figure 2).

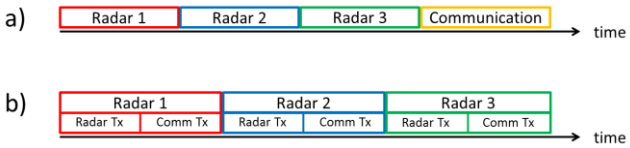

Figure 2: Possible time division scheme of radar tasks in i-CAVE.

An RRM optimization algorithm has already been developed in theory. The main task of this thesis project is to analyze relevant automotive scenarios where such an algorithm can be applied to reduce situation uncertainty. This also involves the development of a cost or reward function that takes into account all necessary important parameters of the radar tasks, as well as the traffic situation.

The master thesis project will consist of several parts:

- Preparing a literature review of basic radar resource management techniques, as well as basic optimization theory [4], [5], [6], [7]. It might be useful to have a look at current RadCom solutions as well [8].
- Investigating common traffic situations. What are the relevant scenarios where RRM could decrease the situation uncertainty and help avoid interference of automotive radars [9]?
- Defining one (or more) traffic situations that are going to be investigated in detail. What are the important parameters that need to be taken into account (related to the radar, the traffic or the vehicles)?
- Defining of a cost or reward function that assigns a value to each radar task based on the current and future situation. Relevant optimization theory needs to be taken into account for this (convexity of the cost function, for example).
- Implementing of a simulation that shows how the solution approach deals with the chosen situations compared to simpler ad-hoc approaches.

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References:

[1] David Welch and Elisabeth Behrmann, “Who’s Winning the Self-Driving Car Race?”, *Bloomberg*, 7 May 2018. [Online]. Available: https://www.bloomberg.com/news/features/2018-05-07/who-s-winning-the-self-driving-car-race [Accessed 10 December 2019].

[2] VIA Technologies, Inc., “Which Sensors are Best for Autonomous Vehicles? Cameras, Radar or Lidar?”, 16 September 2019. [Online]. Available: https://www.viatech.com/en/2019/09/which-sensors-are-best-for-autonomous-vehicles-cameras-radar-or-lidar/?cn-reloaded=1 [Accessed 10 December 2019].

[3] i-CAVE project, “Project website”. [Online]. Available: https://i-cave.nl/ [Accessed 10 December 2019].

[4] S. Boyd and L. Vandenberghe, “Convex Optimization”, Cambridge University Press, 2004.

[5] P. Moo and Z. Ding, “Adaptive Radar Resource Management”, London: Academic Press, 2015.

[6] A. O. Hero and D. Cochran, “Sensor Management: Past, Present, and Future”, in IEEE Sensors Journal, vol. 11, no. 12, pp. 3064-3075, Dec. 2011. doi: 10.1109/JSEN.2011.2167964.

[7] Max Ian Schöpe, Hans Driessen and Alexander Yarovoy, “Optimal Balancing of Multi-Function Radar Budget for Multi-Target Tracking Using Lagrangian Relaxation”, Proceedings of 22nd International Conference on Information Fusion (FUSION), Ottawa, 2019.

[8] F. Lampel, R. F. Tigrek, A. Alvarado and F. M. J. Willems, “A Performance Enhancement Technique for a Joint FMCW RadCom System”, *16th European Radar Conference (EuRAD)*, PARIS, France, 2019, pp. 169-172.

[9] MOSARIM project, “Study report on relevant scenarios and applications and requirements specification”, 2010. [Online]. Available: https://cordis.europa.eu/docs/projects/cnect/1/248231/080/deliverables/001-MOSARIMDeliverableD121V11.pdf [Accessed 10December 2019].