



In-Cabin Sensing using Radars

George Shaker

University of Waterloo, Waterloo, ON, Canada; e-mail: gshaker@uwaterloo.ca

Over the past few years, we have been involved in several projects related to vehicular in-cabin sensing. These projects resulted in numerous products that are available today in the automotive market. This talk will describe some of these projects, key lessons learned, and select challenges that remain to be resolved.

Specifically, we discuss the architecture of various sensor systems that employ radar chipsets for detecting the presence of passengers, counting the number of occupied seats, differentiating between adults and children, monitoring the driver behavior, monitoring the vital signs of all vehicle occupants, alongside with detecting gestures for infotainment system control.

In select applications, we showcase that radar signal processing suffices in achieving satisfactory performance. However, in a number of particular cases, we demonstrate the need for pairing machine learning and artificial intelligence with radar sensing to achieve the desired capabilities. For example, we discuss the performance of a Multiple Input Multiple Output Frequency Modulated Continuous Wave (MIMO FMCW) radar operating at millimeter-wave frequencies when placed by the rear-view mirror of a 7-passenger van. We outline the encountered challenges due to the low angular resolution of the radar, which limited the visual perception of the occupant's location. We then describe how machine learning algorithms, such as Support Vector Machine (SVM), Random Forest (RF), and K-Nearest Neighbors (KNN) enhanced the accuracy of the detection system. The talk will feature multiple video demos covering the aforementioned use-cases.

We conclude the talk with a discussion on the co-existence of multiple in-cabin radar sensors, and select approaches to enable seamless operation.

References

- [1] H. Abedi, S. Luo, V. Mazumdar, M. M. Y. R. Riad and G. Shaker, "AI-Powered In-Vehicle Passenger Monitoring Using Low-Cost mm-Wave Radar," *IEEE Access*, vol. 10, pp. 18998-19012, 2022, doi: 10.1109/ACCESS.2021.3138051.
- [2] H. Abedi, C. Magnier, V. Mazumdar, and G. Shaker, "Improving Passenger Safety in cars using Novel Radar Signal Processing," *Engineering Reports*, 2021; 3:e12413. <https://doi.org/10.1002/eng2.12413>
- [3] H. Abedi, M. Ma, J. Yu, J. He, A. Ansariyan and G. Shaker, "On the Use of Machine Learning and Deep Learning for Radar- Based Passenger Monitoring," *2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (AP-S/URSI)*, Denver, CO, USA, 2022, pp. 902-903, doi: 10.1109/AP-S/USNC-URSI47032.2022.9887034.