Research Internship Proposal

Title: Extending Wireless Sensing Generalisability through Novel Machine Learning Approaches

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Wireless networks are more and more pervasive and ubiquitous in our society where they enable a large variety of applications for our daily lives, while still facing challenges that require them to constantly evolve. At the same time, if they are primarily designed for communication, their spectrum of services is increasingly expanding to include related uses to which they are particularly well suited. Ongoing research around *wireless sensing* has shown that these networks can be used, among other things, to track the position of users [1], monitor their health (heart rate, breathing rate, sleep quality, etc.) [2], authenticate them in a biometric way (recognize their walking, breathing, etc.) [3], or to recognize what they are doing (gesture and activity recognition [4]). The list is far from being exhaustive. As an emerging multidisciplinary research field, wireless sensing takes advantage of the physical properties of electromagnetic waves when they encounter or travel through obstacles (reflection, absorption, diffraction, etc.) and builds on top of knowledge from different scientific fields – including Networking, Signal Processing and mostly recent advances in Machine Learning/Artificial Intelligence – to enable a wide variety of applications and therefore speed up the entrance in a more connected and smarter world.
However, although being in full expansion, most existing wireless sensing approaches still suffer a lack of generalization capability, i.e., sensing systems generally tend to perform pretty bad in environments different from the one they were trained in. This is because signals used for training the system inherently captures specific characteristics of the environment they are collected in.

The aim of this internship is to develop a novel approach to tackle this problem and make those systems more robust to environment changes. The envisioned approach is to reuse publicly available datasets to train a model capturing a large variety of different environments, while solving the multiple challenges raised by their diversity with the help of Transfer Learning, Multi-task Learning or other suitable approach. Evaluation will be done with existing datasets as well as custom ones collected on real hardware that we already possess.

Expected candidate skills:

The most important skill for this internship is **to be eager to learn while trying new solutions.** On top of that, the following skills would be strongly appreciated.
- Hands-on experience and strong skills in Machine and Deep Learning. Knowledge of modern learning schemes such as Multi-task Learning, Autoencoders and Transfer Learning would be appreciated.
- Strong programming skills in any common language such as C++, Python, Java, etc.
- Knowledge of network protocols functioning would be appreciated

This internship can lead to a PhD thesis. Funding already available.

References

[1] J. Wang, X. Zhang, et al., "Device-free wireless localization and activity recognition: A deep learning approach," IEEE Transactions on Vehicular Technology, vol. 66, no. 7, pp. 6258–6267, 2017. doi: 10.1109/TVT.2016.2635161.
[2] S. Yue, H. He, et al. "Extracting multi-person respiration from entangled rf signals," Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, vol. 2, no. 2, pp. 1–22, Jul. 2018. doi: 10.1145/3214289.
[3] F. Lin, C. Song, et al., "Cardiac scan: A non-contact and continuous heart-based user authentication system," in International Conference on Mobile Computing and Networking (MobiCom), ACM, 2017, pp. 315–328. doi: 10.1145/3117811.3117839.
[4] E. Kim, S. Helal, et al., "Human activity recognition and pattern discovery," IEEE Pervasive Computing, vol. 9, no. 1, pp. 48–53, 2010. doi: 10.1109/MPRV.2010.7.