Review of dissertation thesis

Author of the Thesis: **Tomas Bravenec**

Title of the Thesis: **Exploiting Wireless Communications for Localization: Beyond Fingerprinting**

Reviewer of the Thesis: **Antonino Crivello, National Research Council of Italy (CNR), Institute of Information Science and Technologies (Italy)**

Theoretical framework and bibliography:

The author reports on their research and results in advancing the state of the art of indoor positioning systems by presenting a set of scientific developments in the field. The author's work was conducted within the H2020 Marie Skłodowska-Curie Innovative Training Network (ITN)/European Joint Doctorate (EJD), specifically in the "A Network for Dynamic WEarable Applications with pRivacy constraints (A-WEAR)" project.

The concepts and ideas behind this work are well-explained and thoroughly discussed. The thesis begins by highlighting the two research objectives. These objectives are related to end-user privacy concerns and ML-based algorithm optimization. To evaluate the later-described developments, the author created two common and public datasets containing probe requests captured during an international conference and, from a network perspective, the obtained RSSI measurements. Furthermore, the author released an interesting firmware for ESP32 that enables Wi-Fi packet capturing, filtering, collection, and storage. These choices are quite interesting and well-executed, thus allowing a performance evaluation and comparison of the proposed systems and algorithms, especially those concerning end-user privacy concerns.

Finally, the author focused on finding an optimization that balances accuracy needs and algorithmic complexity. In particular, the author describes the possibility of reducing the memory requirements of CNN and explores the use of interpolation techniques, along with the related tradeoffs between radio map size, the time required to create and maintain it, and the computational complexity of an algorithm for localization purposes.

The application-oriented approach is extensively explained throughout the work. The entire report results in a descriptive work. Hence, due to the chosen framework, no in-depth theoretical developments are provided, but the author was able to delve deeply into technical solutions and implementations.

The bibliography is complete and fully reflects a deep knowledge of the state-of-the-art in this field.

Novelty of the topic:

The thesis primarily focuses on two different and crucial aspects of indoor positioning. Specifically, the authors concentrate on optimizing ML-based methods and on identifying and exploiting vulnerabilities in the Wi-Fi protocol for positioning purposes.

Within the European project the author was involved in, the main research revolves around wearable devices.

Regarding the study of vulnerabilities in the Wi-Fi protocol, while the topic is not new, within the context of indoor positioning and localization, this research question - with all its potential implications - is relatively novel in the literature. Only in the past few years have researchers begun to explore it. The author leverages Wi-Fi packets for presence detection purposes as well. In this case, the task is notably challenging due to the recent introduction of MAC randomization, especially in wearable devices.

Methodology:

The methodology used, as well as the initial hypotheses, is oriented towards experimentation in real settings. This approach aligns with the thesis's objectives. The methodology chapter is well-written, easy to follow, and demonstrates a strong understanding of the literature in this field. Moreover, the candidate is fully capable of describing his own approach. An important and interesting aspect concerns Reproducible Research. The author effectively addresses reproducibility in research, thereby releasing all the software developed and described in this work as open-source code.

Some machine learning techniques are utilized in certain parts of the work. They are not extensively analyzed but applied in real-world contexts.

Relevance of the results:

The results presented in this thesis hold significant relevance within the literature on indoor positioning and localization. They have been published in important and well-established conferences or journals. Regarding reproducibility, the author released software for Wi-Fi probe sniffing and two compelling datasets for further study in the field.

Concerning presence detection or room occupancy, the work presented offers a less invasive approach, providing an intriguing alternative. Exploring the generalization capabilities of the proposed algorithms in other environments or scenarios could prove to be an interesting avenue for further investigation.

Regarding algorithm optimization, the author reports a reduction in the memory requirements of CNN by one-quarter of the original size. Additionally, the reduction of computational requirements and the tradeoff between computational resources and the need to enhance system accuracy were demonstrated. These results were both interesting and published in well-established journals and conferences.

The two research questions proposed at the beginning of this work and thesis are adequately addressed and explored, opening pathways for future developments in both directions.

Evaluation:

The thesis is well-structured and engaging to read. While it doesn't extensively explore a single topic, it encompasses several noteworthy and original scientific contributions to the indoor positioning field. The results have been published in reputable journals and presented at conferences. It's important to note and consider it a significant advantage, the author's emphasis on reproducibility and the efforts made in writing, publishing, and releasing open-source code. In my opinion, the thesis is well-suited for public reading.

Pisa, Italy 22/11/2023

(Place and Date) (Signature)