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Conclusion and Future Work

The present research is an outcome of motivation towards an unorthodox approach for solving BPP. Selection of a beacon configuration is equally important, if not more, to choosing an algorithm for localization. This thesis presented a novel concept of modelling BPP and its optimization using the coordinate cloud for representing indoor physical features. Unlike the popular approach of solving BPP with 2D perspective, coordinate cloud gives a more realistic 3D view for experimentation. With this context, we formulated an optimization tool chain that contains a Pareto assessment for total beacon count and average density at its core. The optimization assumes the presence of static obstacles and uses an indigenous algorithm PCOC for beacon to device LoS calculation. As the applicability span of this thesis is with use of RSS values for localization, network simulations consider the presence of noise in range measurements while modelling signal propagation. Resulting configuration are designed to adapt varying levels of signal noise and restrict error propagation with GDoP as a constraint. Optimal configurations are evaluated for their output RMSE and percentage Coverage achieved during simulated network localization. Finally, a normalization and scaling based approach ranks the configurations and presents the winner to the user.

The following points summarize the contributions of this thesis:

1. As the optimization of BPP is a precursor to the live localization, a 3D point cloud approach with proposed design and analytical elements allows the user to approximate the indoor features as per the requirement. This is an unorthodox effort to standardization as explained in Chapter 3 and 4 guided by the OTC in Chapter 5.

2. As MOO problem formulation works with the 3D point cloud of indoor features, the only requirement with the process is the knowledge of observation noise. Moreover, for most of today's wireless scenarios, the availability of RSSI information on device makes the proposed strategy user friendly.

3. As seen in Chapter 5, GDoP constraint assessment in combination with a crude knowledge of observational noise can produce beacon configuration which can readily provide sub-meter level accuracy with over 80% coverage.

4. The designed LoS detection algorithm PCOC is efficient in general with the 3D modelling of indoor spaces. It works with the classified coordinate clouds of CDLs, CBLs and OPCs which can easily be obtained by available techniques of laser scanning and photogrammetry.

5. The choice of two contradictory objectives i.e. beacon count and density is uniquely novel for approaching BPP via MOO. Moreover, as described in Chapter 3 and 4, these objective are linearizable in terms of design and analytical elements with little knowledge of localization. Unlike the complex objectives of accuracy and coverage, which are non-linear and demand posteriori assumptions about localization, using count and density gives a computational advantage considering amount of coordinates in 3D.

6. With the evaluation of the Pareto optimal beacon configurations, we established that the MOO formulation is critical unlike the common SOO approaches in practice. An efficiently synthesized interplay of sensing threshold range, observation noise and GDoP for MOO can generate beacon configurations promising high accuracy and coverage as demonstrated by simulations.

Considering the novelty of our approach to the best of our knowledge, and criticism received over the research duration, we present the open grounds for modifications and enhancements in the following points:

1. To the best of knowledge, the proposed approach in this thesis is novel for its choice of objectives, problem formulation and OTC. The lack of similar space exhaustive approaches presents a promising domain for experimenting with different sets of contradicting linear

and non-linear objectives.

2. The primary objective with solving a BPP remains with the generation and evaluation of output beacon configurations. But, with an increase in the search space due to transition from 2D to 3D perspective, selection of optimization objectives, constraint design and efficient evolutionary algorithms is available as a auxiliary research direction.

3. At this point, a hardware implementation for simultaneous evaluation of Pareto optimal configurations, which can range from < 10 to > 50, is infeasible due to resource constraint, which lead to the assessment by network simulations. Although, the thesis presents a clear guideline for how to approach BPP with 3D perspective, a practical implementation of its dedicated usage is encouraged.

4. For dynamic scenarios with the possibility of obstacle and device movements, using an adaptive beacon configuration is envisioned. To elaborate, for a chosen indoor design, with available placement and movement patterns of devices and obstacles, an optimal master set of beacons can be calculated. Based on the RSS captured proximity of the device for live localization, a slave subset of beacons from the master can provide dedicated connectivity with high accuracy. This is projected to be an output of iterative optimization phases and presents an exciting problem to work around.

With the above context, we intend to work on the proposed prospects taking input from the development of other comparable and useful research works in this domain.