NA 568 - Mobile Robotics Group 23 Project Proposal

William Cohen, Hannah Denomme, Samuel Gonzalez, Shubham Patil, Ruifeng Xu

We propose to perform localization and mapping of a drone in an indoor environment using IMU and relative WiFi signal strength (RSS) sensor measurements. The novelty of our project stems from generating a 3D point cloud of RSS signal strength that is unique to the drone's surroundings. This map of landmarks will be used to correct the integration of IMU data yielding a better estimate of robot location than solely relying on the RSS and IMU data alone.

To achieve this, we will process the IMU data with an invariant extended kalman filter and correct it against the RSS measurement and a model that uses the inverse square strength of the "distance" between the drone and the known global location of our WiFi router. When our measured RSS value disagrees with the model within a given tolerance, a landmark will be recorded in a point-cloud map and a particle filter will be run over it to estimate the most probable location of the drone. This estimate will then be used to correct for drift in the IMU.

In short:

1. <Agreement between model and RSS – No particle filter> Use beacon-range correction, based on known global location of WiFi, in IEKF (localize)
2. <Disagreement between model and RSS – No particle filter> Use last known position + integration of IMU to provide new map location and RSS value (update map)
3. <Agreement between model and RSS – Particle filter> No change
4. <Disagreement between model and RSS – Particle filter> Use particle filter (MAP estimator) to localize position based on time-series of last measured RSS values

To validate our theory we will generate a virtual indoor environment using the programs available from the DeepLocNet paper [2]. A virtual drone running our algorithm will then be flown over the map where we can fine tune its parameters as needed and assess its performance with RSS mapping turned on and off. Next we will test our algorithm in the real world using a Crazyflie 2.1 and a payload consisting of an ESP8266 wifi module connected to a MPU6050 IMU. The builtin Crazyflie AHRS utilizes multiple sensors to correct for error and its measurements will serve as the ground truth position of the drone. We will run our algorithm on the payload and compare it to the ground truth measurements.

[1] P. Kabamba and A. Girard, "Navigation," in *Fundamentals of Aerospace Navigation and guidance*, Cambridge University Press, 2014, pp. 78–112.

[2] K. N. McGuire, C. De Wagter, K. Tuyls, H. J. Kappen, and G. C. de Croon, "Minimal navigation solution for a swarm of tiny flying robots to explore an unknown environment," *Science Robotics*, vol. 4, no. 35, 2019.

[3] S. S. Dhanjal, M. Ghaffari, and R. M. Eustice, "DeepLocNet: Deep observation classification and ranging bias regression for radio positioning systems," *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2019.