Indoor Localization System

VL3-13

STUDENTS: FU, WAN TING LEE, HO MAN WONG, HO YIN

SUPERVISOR: PROF. VINCENT LAU

Introduction

Nowadays, people are highly reliant on navigation systems to get their position. Everyone knows the mobile application “Google Maps”, which utilizes Global Positioning System (GPS) to localize the exact position of a user in the map in real time. Despite the popularity of GPS, its signals do not penetrate buildings well and thus it will in general not work inside buildings. “Google Maps” is trying to enable the users to find their indoor position more easily by integrating indoor floor plans all over the world seamlessly into the map. After implementation, our system can be integrated into the indoor maps of “Google Maps” to localize users so that people can enjoy the most convenient way to go to their destination.

Objectives

- Design an accurate real time indoor localization system
- Utilize readily available resources in the system implementation (Wi-Fi signals and IMU-enabled smartphones)
- No additional installation of hardware is required (Wi-Fi access points and smartphones are common)
- Increase the flexibility of the system (ie. Can be implemented on different platforms and devices)

Methodology

Recursive Bayesian Estimation

It is a general probabilistic approach to estimate posterior distribution when the mobility model and the sensor model are given. In the system, the posterior distribution represents the most updated probability of the user’s location at different points over the entire environment.

Step 1: Action update

\[ p(x_t | x_{t-1}) = \int p(x_t | x_{t-1}, z_t) p(x_{t-1}) dx_{t-1} \]

This is state transition, in our case, the state is the coordinates x, y.

Step 2: Measurement update

\[ p(x_{t-1} | z_t) = \int p(z_t | x_{t-1}) p(x_{t-1}) dx_{t-1} \]

where

- Sensor model: compares the signal strength from the Wi-Fi receiver in smartphone with the RSSI data in the database
- The weight of each particle can be found (The weight of a particle is the likelihood that the user is in the position of the particle)
- Mobility model: uses the IMU signal to predict the step distance and the orientation of the user
- Particle filter: Implementing Recursive Bayesian data fusion from the sensor model and the mobility model

Graphic User Interface

Building the sensor model

- Wi-Fi signal strength was measured in some positions
- Distance between each position: 1 meter
- Duration for each position: 3 minutes

Results and Analysis

Experiment 1 – IMU only

- Red line: True path; Blue line: Estimation
- In short-term: accurate
- In long-term: Error is unacceptably large

Experiment 2 – RSSI only

- Blue star: User’s location; Red numbers: Probability in that position
- Large error in estimation

Experiment 3 – both the IMU and the RSSI

- More accurate than in experiment 1 & 2
- In short-term: Rely on the IMU
- In long-term: Rely on the Wi-Fi to correct error

Experiment 4 – The error in the system

- A user walked in straight line for 3 times
- The error is bounded between 4.5 meters
- The average error is 1.6 meters