#navigation #smartphone #android #ibeacon #eddystone #wifi #bluetooth #particlefilter #ble #imu #fingerprinting #compass #pedometer #deadreckoning #pdr #astar

NAVIGATION IN BUILDINGS USING A SMARTPHONE

Ing. Miroslav Voda, supervisor: Štěpán Kopřiva, MSc. (CTU in Prague - FEL) 2016

MOTIVATION

Currently there is a growing demand for an **easy-to-use indoor navigation solutions** in both public institutions (hospitals, schools) and commercial institutions (retail stores and large commercial buildings). The goal of the project was to: **(i) design and develop precise indoor navigation application** and **(ii) design and develop application for interactive floorplan development**. The requirement was to implement both applications solely for mobile devices, specifically Android platform.

MAPMAKER APPLICATION

The application guides an user through creation of his own floorplan of a building allowing the user to create floorplans of complex floors and buildings using the **custom floorplan rendering engine** and using **brief instructions**. The application is designed with **focus on user experince** (UX). Thus the user can create a map by himself without the need of help of a professional. Designed floorplan is **saved in platform independent JSON format** for possibility to distribution.

LOCALIZATION BASIC COMPONENTS

The localization process is using **gyroscope, accelerometer, magnetometer, Wi-Fi and Bluetooth**. To provide precise result of the navigation process we have implemented an application for each of the localization process subcomponent. The **Azimuth application** implements custom compass algorithm (using gyroscope, magnetomer and accelerometer). The **Pedometer application** uses accelerometer for precise counting of steps. **PDR application** deployes the custom pedestrian-dead-reckoning algorithm with custom azimuth estimation and step-counting algorithm. **Motion recorder application** records output from all available smartphone sensors for subsequent analysis.

LOCALIZATION & NAVIGATION PROCESS

The precise localization and navigation process is based on precise absolute location fix. Location fix is achieved by **fingerprinting** of **Bluetooth Low Edition devices** (iBeacons, EddyStones) in combination of **Wi-Fi access points** (2,5+5 GHz) using **Weighted K-nearest neighbours**. User`s location change is detected by **custom made step-counter** in combination with **custom made compass** both using RAW data from device sensors which are filtered using **Butterworth lowpass filter.** New location of user is computed using **pedestrian dead reckoning algorithm** - by composition of absolute location fix and step-length under given azimuth. **GPS location is not used** because of unsatisfactory GPS reception in indoor enviroment. To ensure higher precision of navigation process the **particle filter** is used to keep user`s location inside building and to prevent to cross the walls and other obstacles. The planning of the trajectory is computed using **A-Star algorithm** on the **visibility graph.**

NAVIGATION APPLICATION

Android **application for easy-to-use indoor navigation** from current location to desired point of interest was developed. The practical motivation could be finding a path from the hospital entrance to a specific room in cardiology department. At first an user is informed how to hold the device properly during the navigation process to achieve best results. When the user selects a destination point of interest the **application starts to search for the location of the user**. After receipt of user`s location, application **shows current location of the user and displays path** to destination coordinates step by step. After reaching the desired location the screen with message that user reached the location is shown.

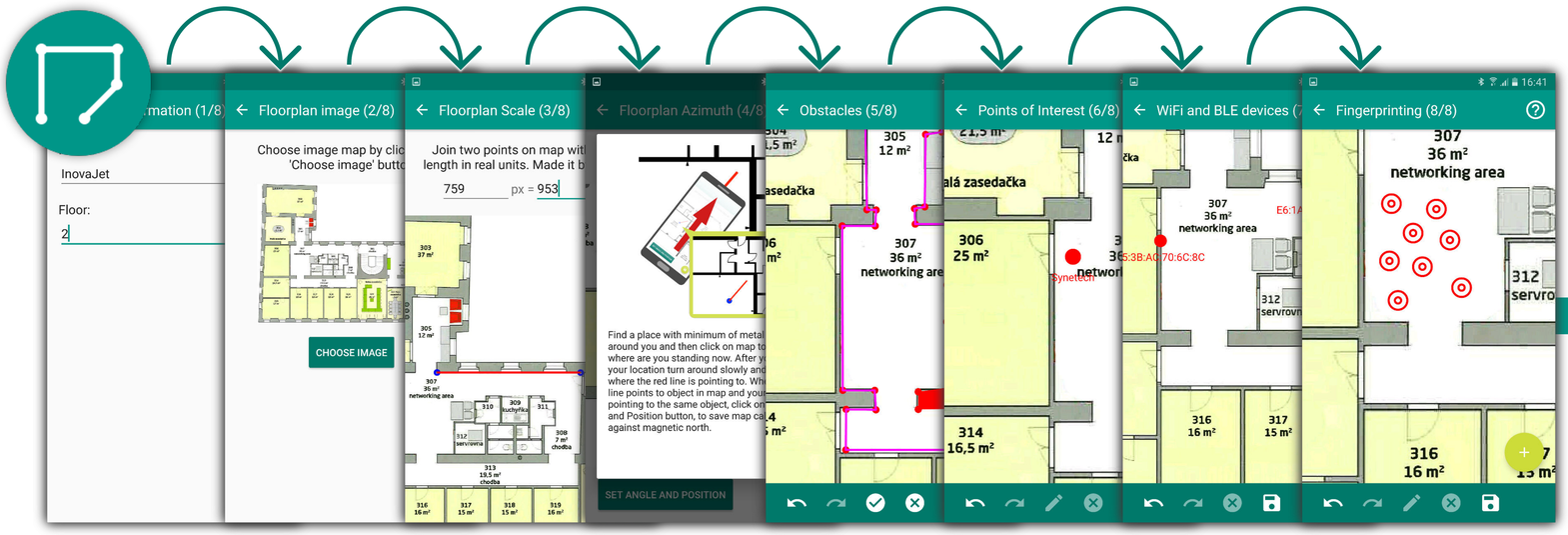
SOFTWARE SOLUTION

6 native Android applications were made, where 4 of them are **supporting applications (Azimuth, Pedometer, PDR, Motion recorder)** for analysis and testing. 2 remaining forms **complete indoor navigation solution (Map Maker, Indoor Navigation).**

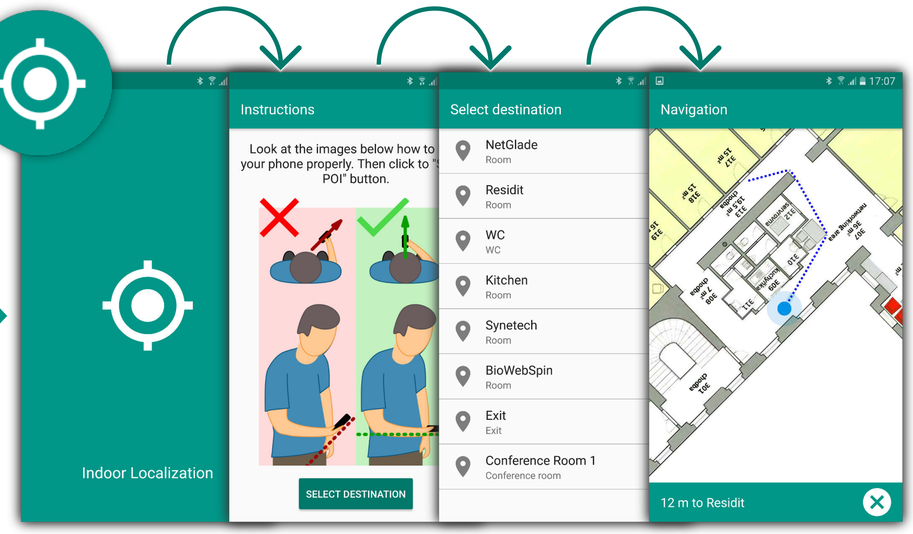
The figure above shows visualization of three different paths. The purple one is traditional PDR method, blue one is our proposed solution and the green one is the real path taken by the user.

The table below describes the precision of our navigation solution.

Method	*AVG error*	*MAX error*	*90% of time error*
PDR	289 cm	450 cm	<= 399 cm
Proposed	**81 cm**	**172 cm**	**<= 154 cm**



STEP-BY-STEP APPLICATION FOR CREATION OF FLOORPLANS USED IN NAVIGATION APPLICATION



EASY-TO-USE NAVIGATION APPLICATION (FOR END USER)