Track 3: "Smartphone-based (off-site)"

Introduction

A spectacular growth of indoor localization solutions has been witnessed during the last decade. Many different positioning approaches exist. Some of them propose the use of natively designed beacons for localization (such as UWB, ultrasound, infrared, pseudolites, etc.). Alternatively other solutions try to explore ways to localize a person by making use of already existing infrastructure in buildings (e.g. WiFi access points for wireless communication, etc.), as well as, other signals available from the embedded sensors in a smartphone (magnetic, inertial, pressure, light, sound, GNSS, etc.). This smartphone-based unmodified-space approach has significant practical benefits such as ubiquity, low cost, as well as being a constantly-updated technology (growing number of AP, improved smartphones, etc.). Several instances of this "smartphone-based" localization approach have been described in the literature; however there is a need for testing and comparing their performances (e.g. accuracy and robustness) under a common evaluation framework like this competition.

Competition Goal

The goal of this competition is to evaluate the performance of different indoor localization solutions based on the signals available to a smartphone (such as WiFi readings, Inertial measurements, etc..) and received while a person is walking along several regular unmodified multi-floor buildings.

Main features of the competition

<u>Off-site competition approach</u>

This track is done off-site, so all data processing for calibration and evaluation will be done before the celebration of the IPIN conference. The competition teams can calibrate their algorithmic models with several databases containing all kind of sensor readings in a mobile phone and some ground-truth positions. Finally each team will compete using additional database files, but in this case the ground-truth reference is not given and must be estimated by the competitors.

<u>Multiple sources of information</u>

The multi-sensor data to be processed is captured by using a conventional modern smartphone (e.g. Samsung Galaxy S4 or above), and the competition takes place in several buildings which have not been modified by installing any additional hardware. The data recorded for evaluation is stored in a logfile that contains all the available signals that can be captured in real-time with a smartphone: WiFi RSS, Inertial data (Accelerometer and Gyroscope), Magnetic, GPS, the orientation of the phone, Pressure, Temperature, Humidity, Sound intensity and Light intensity.

The WiFi RSS data (the most important source of information for absolute positioning indoors) can be used to implement a fingerprinting localization method, as well as its magnetic data, while the inertial signals available at the phone can give important clues about the motion of a walking person. GPS information can be used if the user's trajectory is partially done outside (patio, main entrance,…). The pressure, sound and light data could also give some other clues about potential floor changes, or a particular discriminant sound/light intensity at some rooms.

Continuous motion and recording process

While recording the logfiles with the smartphone, the person will move along a continuous trajectory passing by some known landmarks. Every time a person steps on a known landmark this ground truth position information will be added to the logfile. Ground truth position can be used for calibrating competitor's algorithms. The length of each individual trajectory can be of about 30 min (~2 km long) moving to multiple rooms, corridors and floors in the building.

Realistic walking style

The person in charge of recording the logfiles will move in a natural and realistic way: most of the time walking forward, but occasionally stopping, taking large turns (90 or 180 degrees at corridor ends), and even moving backward or laterally at certain points (e.g. if giving way at door accesses). The change to different floors is done through elevators and stairs.

Phone holding

The phone will be kept always on the user's hand under mainly two different conditions: 1) stable in front of his face or chest (typical position for reading or typing with the phone), 2) keeping the arm relaxed downwards with the phone low at his hand (in this case if the person is walking the arm will swing as usual), and 3) phoning. No other strange handling conditions are expected. The competitors, if wishing to use the inertial information, should detect transitions among these states in order to make reliable relative displacement estimates. Additionally, logfiles with only pocket use are explicitly labelled.

Desired localization approaches

Any kind of positioning algorithm is admitted. In this competition we strongly welcome:

- **Fingerprinting** approaches using WiFi RSS values, BLE RSS values, or Magnetic patterns. Competitors can use the static these data and the ground-truth position given in logfiles to calibrate their fingerprinting algorithms.
- **Multi-sensor fusion** algorithms trying to exploit, dynamic time-correlated information such as inertial data (for PDR or pedestrian dead-reckoning), and pressure/sound/illumination changes along each trajectory. For those competitors wishing to exploit this dynamic extra information a potential benefit could probably be obtained over static fingerprinting.
- **Any other innovative approach.** The use of map information, or any other approach such as activity recognition (detecting states as: going upstairs, in a lift, etc.), in order to complement the above-mentioned solutions are also acceptable.

Multiple buildings.

A total of 3 different buildings will be tested: **CAR** (CSIC Arganda, Madrid), **UB** (Universitat Jaume I, Castellón) and **TI** (Universitat Jaume I, Castellón).

Information from buildings

Multiple WiFi access points (AP) will be registered in the logfiles, but the position of each AP is, a priori, unknown. Only the positions of the BLE tags and a few WiFi APs will be provided to competitors. Several geo-referenced floor-map images for each building will be available; competitors are free to decide whether to use or not to use that information for positioning.

Description of Datasets (Logfiles)

Data Format

Each logfile is a "txt" file containing multiple rows with different types of data. Each row registers the data received from a particular sensor type in the phone at a given time. The stream of sensor data generated in the phone is stored, row by row, in the logfile in sequence as they are received. Each row begins with an initial header (4 capital letters followed by a semicolon, e.g. 'WIFI', 'ACC','MAGN', etc.) that determines the kind of sensor read, and several fields separated by semicolon with different readings. This is an extract of a real log file shown as example:

```
GYRO;4.410;-0.03726;-0.16860;-0.17318;3
AHRS;4.410;28.7201;0.4508;177.5888;0.00141;0.24804;0.96855;-106
LIGH;4.410;4767.0;0
ACCE;4.411;-0.67995;4.85544;8.30309;3
MAGN;4.411;1.26000;-39.48000;-17.76000;3
PRES;4.419;948.5206;0
GYRO;4.420;-0.04948;-0.13347;-0.16463;3
AHRS;4.420;28.7140;0.5296;177.4918;0.00095;0.24800;0.96855;122
LIGH;4.420;4748.0;0
ACCE;4.421;-0.69911;4.90333;8.35098;3
MAGN;4.421;1.26000;-39.36000;-17.76000;3
GYRO;4.430;-0.06017;-0.09407;-0.13347;3
AHRS;4.430;28.6960;0.6096;177.4190;0.00043;0.24786;0.96858;-3
ACCE;4.432;-0.70868;4.88417;8.34140;3
MAGN;4.432;1.38000;-39.42000;-17.64000;3
LIGH;4.432;4748.0;0
WIFI;4.432;eduroam;00:0b:86:27:36:c0;-73
WIFI;4.432;portal-csic;00:0b:86:27:36:c1;-74
WIFI;4.432;eduroam;00:0b:86:27:32:e0;-65
WIFI;4.432;portal-csic;00:0b:86:27:32:e1;-65
WIFI;4.432;eduroam;00:0b:86:27:35:90;-82
WIFI;4.432;portal-csic;00:0b:86:27:35:91;-80
WIFI;4.432;WiFiArganda;00:0d:97:00:d2:55;-89
WIFI;4.432;eduroam;00:0b:86:27:35:80;-97
WIFI;4.432;portal-csic;00:0b:86:27:35:81;-95
GYRO;4.440;-0.06353;-0.05528;-0.08460;3
AHRS;4.440;28.6667;0.7015;177.3758;-0.00026;0.24763;0.96863;-68
LIGH;4.441;4748.0;0
```

Figure 1. Log file example of the format used for sensor data registration. The registered measurements correspond to the time interval from 4.410 to 4.441 seconds (31 milliseconds).

The detailed list of fields in each sensor's row, and one specific example, is shown next:

WIFI: the RSS (in dBm) received from a particular AP	
Format	WIFI;AppTimestamp(s);SensorTimeStamp(s);Name_SSID;MAC_BSSID;RSS(dBm)
Example	WIFI;1.184;130.671;eduroam;00:0b:86:27:37:b0;-91
MAGN: the local magnetic field, as measured by the 3-axis magnetometer in the phone	
Format	MAGN;AppTimestamp(s);SensorTimestamp(s);Mag_X(uT);;Mag_Y(uT);Mag_Z(uT);Accuracy(integer)
Example	MAGN;0.035;8902.708;-20.70000;-34.02000;-19.20000;3
ACCE: the phone's acceleration, as measured by the 3-axis accelerometers in the phone	
Format	ACCE;AppTimestamp(s);SensorTS(s);Acc_X(m/s^2);Acc_Y(m/s^2);Acc_Z(m/s^2);Accuracy(integer)
Example	ACCE;0.034;8902.708;-1.80044;6.41646;7.17303;3
GYRO: measures the phone's rotation, using the 3-axis orthogonal gyroscopes in the phone	
Format	GYRO;AppTimestamp(s);SensorTimestamp(s);Gyr_X(rad/s);Gyr_Y(rad/s);Gyr_Z(rad/s);Accuracy(int.)
Example	GYRO;0.032;8902.705;-0.22846;-0.21930;-0.05498;3
PRES: the atmospheric pressure	
Format	PRES;AppTimestamp(s);SensorTimestamp(s);Pres(mbar);Accuracy(integer)
Example	PRES;0.038;8902.726;956.4289;0
LIGH: for light intensity in Luxes	
Format	LIGH;AppTimestamp(s);SensorTimestamp(s);Light(lux);Accuracy(integer)
Example	LIGH;0.032;8902.693;292.0;0
SOUN: the sound pressure level in dB	
Format	SOUN;AppTimestamp(s);RMS;Pressure(Pa);SPL(dB)
Example	SOUN;0.248;594.57;0.01815;59.15
TEMP: the temperature in degrees Celsius.	
Format	TEMP;AppTimestamp(s);SensorTimestamp(s);temp(ºC);Accuracy(integer)
Example	TEMP;0.505;134.194;26.9;1
PROX: Proximity	
Format	PROX;AppTimestamp(s);SensorTimestamp(s);prox(1/0);Accuracy(integer)
Example	
HUMI: Humidity	
Format	HUMI;AppTimestamp(s);SensorTimestamp(s);humi(%);Accuracy(integer)
Example	HUMI;0.501;134.194;47.0;1
GNSS: the Latitude, Longitude and Height estimated from GPS/Glonass	
Format	GNSS;AppTimestamp(s);Latit(º);Long(º);Altitude(m);Bearing(º);Accuracy(m);Speed(m/s); UTCTime(ms);SatInView;SatInUse
Example	GNSS;0.611;40.313524;-3.483137;600.865;0.000;4.0;0.0;1358782729999; 17;15
AHRS: the mobile phone 3D orientation in terms of pitch, roll and yaw	
Format	AHRS;AppTS(s);SensorTS(s);PitchX(º);RollY(º);YawZ(º);RotVecX();RotVecY();RotVecZ();Accuracy(int)
Example	AHRS;0.033;8902.705;41.6550;11.7495;-124.0558;0.25038;-0.26750;-0.80406;-2
BLE4: Bluetooth Low Energy 4.0 data	
Format	BLE4;AppTS(s);MajorID;MinorID;RSS(dBm)
Example	BLE4;0.420;2016;12;-86

POSI: ground-truth position (only in calibration files)	
Format	POSI;Timestamp(s);Latitude(degrees); Longitude(degrees);floor ID(0,1,2..4);Building ID(0,1,2..3)
Example	POSI; 0.0330;41.12245678,-3.12355678,2,0

Note that in most of the sensors there are two timestamps (both in seconds):

1. 'AppTimestamp' is set by the mobile App as data is read. It is not representative of when data is actually captured by the sensor (but has a common time reference for all sensors).
2. 'SensorTimestamp' is set by the sensor itself. The sampling interval is the difference between SensorTimestamp(k) and SensorTimestamp(k-1).

The sampling rate of each type of sensor can be different from logfile to logfile, since it is dependent on the embedded sensor chips used by a particular phone. Typical sampling frequency values for the inertial data is about 50Hz. Pressure, Sound, Light sensors have a much lower update rate (<10Hz). WiFi scans are available approximately every 6 seconds (0.17 Hz).

Each logfile includes in its firsts rows (those starting with character '%') some informative text about the sensor data format, the date of recording and identification of the used phone (model and android version). The logfiles in this format should be parsed by the competitor's teams in case they need to rearrange data towards another preferred format. A parser in Matlab code will be available (http://indoorloc.uji.es/ipin2017track3/) if competitors want to use it to help to manipulate and rearrange data.

Calibration process for fingerprinting

It is known that Wi-Fi Fingerprinting methods require to be calibrated before being operative for localization. In order to do this calibration, the competitors should extract the ground-truth position within the logfile ('POSI' header) and get the WiFi readings closest in time to each reference landmark. Several logfiles are available for calibration in different buildings, so each competitor should extract the relevant information from the different logfiles.

Dataset types and download link

The different datasets available for **training** and **validation** can be downloaded from this site http://indoorloc.uji.es/ipin2017track3/. Both training and validation logfiles include reference ground-truth positions (lines with a "POSI" header, followed by Latitude, Longitude, floor ID and Building ID). The validation logfiles will be explicitly provided by the organizers and should be used to have an estimation of the IPS accuracy for the IPIN Conference paper.

Another type of logfiles, the **evaluation** logfiles, are used for evaluation at the competition and do not contain any position reference (no 'POSI' header). These logfiles contain measurements taken following the same procedure used in the training and validation stages, although possibly by different users or phone models. The evaluation of the competitor's algorithm will rank its performance according to the metrics described below (section "Evaluation metrics").

How to participate?

Next we describe the necessary steps to be followed by competition teams:

Step 1). Request for admission.

The competitors should firstly apply for admission to this competition track by providing a short (2 to 4 pages) "technical description" of their localization approach, including some algorithm details and some preliminary tests. This document must be sent by e-mail to the organizers of this track (see contact information at the end of this document).

Any doubts prior to sending the “technical description” can be also solved via e-mail. The IPIN 2017 Program Committee will accept or refuse the application in a short time (a few days) by e-mail, based on technical feasibility and logistic constraints.

Step 2) Database download

Participants can download the training, validation and evaluation logfiles from this site http://indoorloc.uji.es/ipin2017track3/. Using that training and validation logfiles, the competitors can tests and tune their algorithms. Whenever the competition team feels confident with the data and his preliminary processing results, they should as soon as possible to formalize its participation by registering to the competition via the IPIN general registration process (detailed in step 3).

Competitors can use the 2016 IPIN Competition database, http://indoorloc.uji.es/ipin2016track3/, in the current competition ***at their own risk***.

Step 3) Registration for participation in the IPIN conference

At least one member of the team is required to be registered to the IPIN conference through the 2017 IPIN Registration link: http://www.ipin2017.org/registration.html (during the process they will indicate that the registration is linked to a competition track). The full registration fee for the conference covers the submission of a paper describing the system and the allocated time, support and space for the competition.

Step 4) Results submission

After processing the evaluation logfiles, participants must submit the results to the contact points of this track (see contact details below). Each submission must include some Comma Separated Value (csv) text files with the predicted locations for the final test sets (one cvs for each evaluation logfiles). Each csv file must have a new position estimation line **every 0.5 seconds**. Each line should have the following format: **TimeStamp, latitude, longitude, FloorID, BuildingID**

The longitude & latitude should maintain the coordinate system of training test files, and use the dot symbol “.” as decimal separator. Specifically it has to be used a **signed degrees format** (DDD.dddddddd) with 8 decimal places pinpointing a location to within 1 millimeter. Precede south latitudes and west longitudes with a minus sign. Note than latitudes range from -90 to 90 and longitudes range from -180 to 180. Examples: “41.12345678” and “-3.12345678”.

The FloorID can be 0, 1, 2, 3 or 4 (same FloorIDs as in training files) and the BuildingID can be 0, 1 or 2 (same BuildingIDs as in training files).

A cvs example (for a movement from time 0.0 to 2.0 seconds, in floor 2 and building 0):

```
0.0,41.12345678,-3.12445678,2,0
0.5,41.12385678,-3.12355678,2,0
1.0,41.12245678,-3.12355678,2,0
1.5,41.12545678,-3.12355678,2,0
2.0,41.12845678,-3.12325678,2,0
```

A participant team is able to upload up to 3 different contributions, which will be evaluated by the competition organizers. Although the three alternatives will be evaluated on the final test set, only the best one will be considered for the contest.

Dead-line for result submission: **SEPTEMBER 10th 2017**

Step 5) Results oral presentation at IPIN

Competitors will present their methods, algorithms and preliminary results with the validation data in the IPIN 2017 conference (Sapporo, Japan) in a special session. During the session’s closing, the competition organizers we will show the results of the contest and the accuracy of the methods in the competition test set.

Evaluation metrics

The final metric will be based on:

- The accuracy on correctly detecting the correct building (some logfiles could include transitions between several buildings).
- The accuracy on correctly detecting the correct floor.
- The horizontal error in positioning (meters) from the actual reference points and the estimated position.

In particular, the error for comparing the different location systems will be based on the following equations:

Accuracy Score= 3rdQuartile(SampleError(Ri, Ei)), ∀ ground-truth reference in all final test sets

SampleError(Ri, Ei) = Distance(Ri, Ei) + (penalty1 * buildingfail) + (penalty2 * floorfail)

where:

- “3rdQuartile” is the third quartile error, in meters, of a cumulative error distribution function, i.e., the error value that includes 75% of estimations (sample errors) with a lower error.
- Ri is the actual position.
- Ei is the predicted position by the method proposed by the contest participant.

- buildingfail is 1 if the building prediction is wrong, 0 otherwise.
- floorfail is the absolute difference between actual floor and the predicted one.
- penalty1 is used to penalize errors in estimating the building. penalty1 is set to 50.
- penalty2 is used to penalize errors in estimating the floor. penalty2 is set to 15.
- Distance(Ri, Ei) calculates the Euclidean distance between coordinates (longitude and latitude) of Ri and Ei.

Important Dates

Technical description	From April 1st to July 15th
Notification of admission	Shortly after requested by e-mail
Regular paper submission (optional)	Same as Conference
Work-in-progress submission (optional)	September 10th
Off-site submission of competitors' results (track 3)	September 10th

Contact points and information

For any further question about the database and this competition track, please contact to:

- Main contact point: Joaquín Torres (jtorres@uji.es) at Institute of New Imaging Technologies, Universitat Jaume I, Castellón, Spain. Please carbon copy also to Antonio R. Jiménez (antonio.jimenez@csic.es) at the Center of Automation and Robotics (CAR)-CSIC/UPM, Madrid, Spain.
- There is also the option to use the contest@evaal.aaloa.org mailing list to suggest ideas or ask for clarifications related to all tracks.