Track3 "Smartphone based Positioning (off-site)"special features

Organizational aspects:

Database/dataset download

- Participants can download the databases (logfiles) from this site:
  http://indoorloc.uji.es/ipin2019track3/
  Competitors can only use the data provided for the competition.
  Performing any additional on-site calibration is not allowed.

Submission of the post-processed results

- After processing the evaluation logfiles, participants must submit the position estimates to the contact points of the corresponding track. Each submission must fulfill the format detailed in "Output location file format" described below.
- A participant team can 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.

Submission deadline of the post-processed indoor coordinates

- **The deadline** for submitting the post-processed results is: **SEPTEMBER 14th 2019**

Scope

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 track 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

Off-site competition approach

This track is done off-site, so all data for calibration and evaluation is provided by competition organizers before the celebration of the IPIN conference. The competition teams can calibrate their algorithmic models with several databases containing readings from sensors typically found in modern mobile phones 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. This is an off-line competition where all competitors have the same data of the testing environment, so custom on-site calibration is not allowed.

Multiple sources of information

The multi-sensor data to be processed was captured using a conventional modern smartphone (Samsung A5 2017) at the CNR (Pisa, Italy). The data recorded for evaluation is stored in a logfile that contains all the available signals captured in real-time with that smartphone.

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 moved along a continuous trajectory passing by some known landmarks. Every time a person stepped on a known landmark, this ground truth position information was added to the logfile. Ground truth position can be used for calibrating competitor's algorithms. The length of each individual training and validation trajectory is a few minutes.

There is no guarantee that the trajectory between two consecutive landmarks will be a perfect straight line. Inertial sensors should be used to detect the displacements with more detail. **In the training logfiles, all significant turns have been recorded with a landmark. Please pay special attention to the validation logfiles, where turns, u-turns, stops and other challenging movements could be present between two consecutive landmarks. The supporting visualization maps for the validation logfiles only show the location of the landmarks and the lines only indicate their adjacency, not the real path.**

Realistic walking style

The person in charge of recording the logfiles moved 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., when giving way at door accesses). The change to different floors is only done through stairs.

Phone holding

The phone was kept always on the user's hand, mainly stable in front of his face or chest (typical position for reading or typing with the phone). No other strange handling conditions are expected. Competitors wishing to use the inertial information should process all data to make reliable relative displacement estimates.

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 these data and the ground-truth position given in logfiles to calibrate their 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 like going upstairs, in a lift, etc.), in order to complement the above-mentioned solutions are also acceptable.

Information from building

This year the competition takes place in the facilities of the CNR (Pisa, Italy). Multiple WiFi access points (AP) were registered in the logfiles, but the position of each AP is unknown. Several geo-referenced floor-map images are 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:

```
ACCE;1.851;1447.675;1.51314;1.26414;7.45794;3
GYRO;1.852;1447.676;-0.96883;0.47220;-1.09528;3
ACCE;1.853;1447.680;1.51314;1.26414;7.45794;3
AHRS;1.854;1447.680;12.808264;18.605246;83.654984;-0.02510735;0.19310911;0.66744810;3
ACCE;1.855;1447.685;1.27850;1.07739;7.11796;3
MAGN;1.856;1447.681;5.28000;-49.50000;-28.56000;1
GYRO;1.857;1447.681;-0.86499;0.32620;-1.04886;3
GYRO;1.858;1447.686;-0.81001;0.23152;-1.01770;3
ACCE;1.859;1447.690;1.19231;0.96965;6.90009;3
AHRS;1.860;1447.690;12.228001;18.239840;83.370285;-0.02627454;0.18763289;0.66550219;3
WIFI;1.861;1447.661;SSID_0001;20:19:00:00:00:01;2452;-74
WIFI;1.861;1447.661;SSID_0002;20:19:00:00:00:02;2417;-75
WIFI;1.861;1447.661;SSID_0003;20:19:00:00:00:03;2472;-76
WIFI;1.861;1447.661;SSID_0004;20:19:00:00:00:04;2472;-77
WIFI;1.861;1447.661;SSID_0005;20:19:00:00:00:05;2472;-77
WIFI;1.861;1447.661;SSID_0006;20:19:00:00:00:06;2427;-92
WIFI;1.861;1447.661;SSID_0005;20:19:00:00:00:07;2427;-92
ACCE;1.883;1447.695;1.08457;0.75657;6.49068;3
MAGN;1.884;1447.691;5.88000;-48.72000;-29.16000;1
GYRO;1.885;1447.691;-0.73304;0.05742;-0.94379;3
ACCE;1.885;1447.700;1.16598;0.51715;5.89931;3
MAGN;1.886;1447.701;6.06000;-48.18000;-29.40000;1
GYRO;1.886;1447.696;-0.62186;-0.21808;-0.81489;3
ACCE;1.886;1447.705;1.18752;0.48123;5.81552;3
GYRO;1.886;1447.701;-0.60598;-0.26145;-0.79046;3
GYRO;1.887;1447.706;-0.53756;-0.44410;-0.71349;3
ACCE;1.887;1447.710;1.24498;0.41899;5.62637;3
AHRS;1.888;1447.710;11.352854;17.015602;82.896187;-0.02412710;0.17510089;0.66241527;
```

Figure 1. Log file example of the format used for sensor data registration. The registered measurements correspond to the time interval from 1.851 to 1.888 seconds (37 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;Frequency(Hz);RSS(dBm)
Example	WIFI;1.184;130.671;eduroam;00:0b:86:27:37:b0;2472;-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 for most 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 it is in a time reference common to all sensors).
2. 'SensorTimestamp' is set by the sensor itself. The sampling interval is the difference between SensorTimestamp(k) and SensorTimestamp(k-1).
3. WIFI lines now include the frequency.

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, but we forced the sensor to the maximum rate. Pressure, Sound, Light sensors have a much lower update rate (<10Hz). WiFi scans are available approximately every 3.95 seconds (0.25 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 provided logfiles should be parsed by the competitor's teams in case they need to rearrange data into another preferred format. A parser in Matlab code is available in the supplementary materials to competitors want to use it to help to manipulate and rearrange data.

Important note: the key points (landmarks) are not publicly available in evaluation logfile and they will be inserted by the organizers using the timestamp in the submitted files. In Track 3, the data recording starts in apptimestamp 0. In the evaluation logfile, the apptimestamp 0 corresponds to 1553850591000 (Fri Mar 29 10:09:51 GMT+01:00 2019) in Unix Timestamp.

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, so each competitor should extract the relevant information from the different logfiles.

Dataset types and download link

There are some datasets available for calibration: the **training** and **validation** logfiles. 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.

There are two types of training logfiles, the regular training logfiles and the floor transition training logfiles. The regular training logfiles contain a path without any floor transition. The floor transition training logfiles includes a path with multiple floor transitions using the stairs.

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 logfiles, although possibly by different users or phone models. The evaluation of the competitor's algorithm will rank its performance according to the metrics previously described in section "Evaluation criterion". In Track 3 of the 2019 IPIN competition, a single evaluation logfile is provided.

Sensor Calibration

All training and validation logfiles start with a calibration. First, the phone is arbitrary moved during around 15-30 seconds. Then, it remains static in from of user's face for around 15-30 additional seconds. After that, the first landmark is provided. A similar calibration procedure is done in the evaluation logfile.

Inputs given to competitors

The materials and methods provided by the competition organizers are:

- **Supplementary materials**

    - **Matlab Parser**

        - **Note: This year Wi-Fi data includes the frequency**

    - **Map floors** as vector images (exported from QGIS):

        - 6 pdf files (3 with maps, 3 with maps and 5 points) two for each floor level

        - 1 file with the correspondence of 5 points to WGS84 coordinates

- o **Map floors** as raster images (exported from QGIS):

  - 6 png files (3 with maps, 3 with maps and 5 points) two for each floor level

  - 3 pgw calibration files, one for each floor level;

  - 1 file with the correspondence of 5 points to WGS84 coordinates

- o **Map floors** as raster images (old format – same as IPIN2016 competition):

  - 3 jpg files, one for each floor level;

  - 1 calibration text file with "*.cal" extension (contains the Latitude, Longitude of central pixel in image, the image CCW rotation in order to be aligned to the North, and the scale of size of pixels) used to generate the route visualization. The calibration corresponds to an approximation.

- o **Visualization of the routes** using the map floors in raster format as reference

  - 1 pdf file for the training logfiles

  - 1 pdf file for the validation logfiles

  - *Note: In the training logfiles, all significant turns have been recorded with a landmark. Please pay special attention to the validation logfiles, where turns, u-turns, stops and other challenging movements could be present between two consecutive landmarks. The supporting visualization maps for the validation logfiles only show the location of the landmarks and the lines only indicate their adjacency, not the real path.*

- **LogFiles** with ground-truth inserted (POSI lines):
  - o Regular Training Logfiles:

    - 4 log_files for Route T01-2019 with 10 landmarks (364, 370, 386, 319 s. of duration)

    - 4 log_files for Route T02-2019 with 18 landmarks (741,765,815,697 s. of duration)

    - 4 log_files for Route T03-2019 with 4 landmarks (199.,195,211,178 s. of duration)

    - 4 log_files for Route T04-2019 with 8 landmarks (187,199,193,183 s. of duration)

    - 4 log_files for Route T05-2019 with 4 landmarks (235,258,262,220 s. of duration)

    - 4 log_files for Route T06-2019 with 8 landmarks (358,374,345,336 s. of duration)

    - 4 log_files for Route T07-2019 with 10 landmarks (186,195,176,188 s. of duration)

    - 4 log_files for Route T08-2019 with 10 landmarks (373,371,428,335 s. of duration)

    - 4 log_files for Route T09-2019 with 12 landmarks (360,349,381,296 s. of duration)

    - 4 log_files for Route T10-2019 with 10 landmarks (333,376,369,347 s. of duration)

- Floor transition Training Logfiles:
  - 2 log_files for Route T11-2019 with 16 landmarks (333,376 s. of duration)
    - User climbs up from level 0 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs up from level 1 to level 2 using the stairs
    - User remains static in floor 2
    - User climbs down from level 2 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs down from level 1 to level 0 using the stairs
    - User remains static in floor 0
    - Repeat the procedure
  - 2 log_files for Route T12-2019 with 16 landmarks (369,347 s. of duration)
    - User climbs up from level 0 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs up from level 1 to level 2 using the stairs
    - User remains static in floor 2
    - User climbs down from level 2 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs down from level 1 to level 0 using the stairs
    - User remains static in floor 0
    - Repeat the procedure
  - 2 log_files for Route T13-2019 with 16 landmarks (396,381 s. of duration)
    - User climbs up from level 0 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs up from level 1 to level 2 using the stairs
    - User remains static in floor 2
    - User climbs down from level 2 to level 1 using the stairs
    - User remains static in floor 1
    - User climbs down from level 1 to level 0 using the stairs
    - User remains static in floor 0
    - Repeat the procedure

- 2 log_files for Route T14-2019 with 16 landmarks (391,380 s. of duration)

    - User climbs up from level 0 to level 1 using the stairs

    - User remains static in floor 1

    - User climbs up from level 1 to level 2 using the stairs

    - User remains static in floor 2

    - User climbs down from level 2 to level 1 using the stairs

    - User remains static in floor 1

    - User climbs down from level 1 to level 0 using the stairs

    - User remains static in floor 0

    - Repeat the procedure

- 2 log_files for Route T15-2019 with 12 landmarks (271,253 s. of duration)

    - User go to floor 0 stairs

    - User climbs up from level 0 to level 1 using the stairs

    - User remains static in floor 1

    - User climbs down from level 1 to level 0 using the stairs

    - User goes to starting point

    - User remains static in starting point

    - Repeat the procedure

- Validation Logfiles:

    - 1 log_files for Route V01-2019 with 11 landmarks (730 s. of duration)

    - 1 log_files for Route V02-2019 with 11 landmarks (621 s. of duration)

    - 1 log_files for Route V03-2019 with 12 landmarks (414 s. of duration)

    - 1 log_files for Route V04-2019 with 12 landmarks (530 s. of duration)

    - 1 log_files for Route V05-2019 with 10 landmarks (582 s. of duration)

    - 1 log_files for Route V06-2019 with 10 landmarks (524 s. of duration)

    - 1 log_files for Route V07-2019 with 9 landmarks (346 s. of duration)

    - 1 log_files for Route V08-2019 with 9 landmarks (347 s. of duration)

    - 1 log_files for Route V09-2019 with 8 landmarks (359 s. of duration)

- **LogFiles** without ground-truth:
  - Evaluation Logfiles:

    - 1 log_file for Route EVALUATION-2019 without landmarks (1319 s. of duration)

- **Videos**:
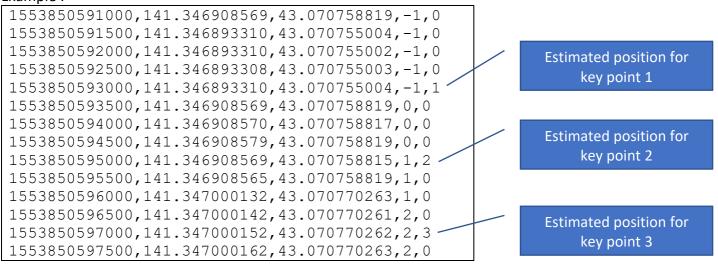 - 1 video showing how a training logfile was collected

All the data sets and supplementary materials are available here:

http://indoorloc.uji.es/ipin2019track3/

Description of the Output File

For each trial, you must submit a CSV file whose format is now described.

- 5 columns :
  - Column 1: Timestamp in ms
  - Column 2: WGS84 longitude in decimal degrees with at least 9 decimal digit resolution
  - Column 3: WGS84 latitude in decimal degrees with at least 9 decimal digit resolution
  - Column 4: Floor Number in integer (0: Ground Floor, 1, 2)
  - Column 5: index in integer (key point number from 1 to N. 0 represents no landmark. Each specific integer represents the specific key point)
- Comma (",") used as data delimiter
- No header
- Track3 requirement: frequency 2 Hz synchronized with the beginning of the evaluation trajectory.
- Track3 requirement: The first estimation is on Timestamp 1553850591000, that corresponds to apptimestamp 0 in the evaluation logfile
- Track3 requirement: The column 5 for the key point number must be filled with 0, the organizers will add the key points indexes
- Track3 requirement: Please provide your estimates until the last record in the evaluation logfile record: 1553851910500 (apptimestamp 1319.5)

Example :

```
1553850591000,141.346908569,43.070758819,-1,0
1553850591500,141.346893310,43.070755004,-1,0
1553850592000,141.346893310,43.070755002,-1,0
1553850592500,141.346893308,43.070755003,-1,0
1553850593000,141.346893310,43.070755004,-1,1
1553850593500,141.346908569,43.070758819,0,0
1553850594000,141.346908570,43.070758817,0,0
1553850594500,141.346908579,43.070758819,0,0
1553850595000,141.346908569,43.070758815,1,2
1553850595500,141.346908565,43.070758819,1,0
1553850596000,141.347000132,43.070770263,1,0
1553850596500,141.347000142,43.070770261,2,0
1553850597000,141.347000152,43.070770262,2,3
1553850597500,141.347000162,43.070770263,2,0
```

Estimated position for key point 1

Estimated position for key point 2

Estimated position for key point 3

Evaluation will only take into account the estimated position at each indexed key point position, so that each track is considered as a series of key point positions (from 1 to N).

Contact points and information

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

Joaquín Torres (jtorres@uji.es) at Institute of New Imaging Technologies, Universitat Jaume I, Castellón, Spain. Please carbon copy (CC) also to Antonio R. Jiménez (antonio.jimenez@csic.es) at the Centre of Automation and Robotics (CAR)-CSIC/UPM, Madrid, Spain.