Track3 "Smartphone based Positioning (off-site)"

Organizational aspects:

Database/dataset download

- The dataset is split into three subsets as usual: training, validation and test. This year we introduce a change in the terminology having thus:
  - **Training data**, which are provided as off-line files and are used to calibrate the system (former training logfiles). http://evaal.aaloa.org/files/2022/IPIN2022_T3_TrainingData.zip
  - **Testing trials**, which are provided through the EvaalAPI and are reloadable. Competitors can run them as many times as they like to evaluate and fine-tune their system as well as to get used to the EvaalAPI (former validation logfiles or validation subset)
  - **Scoring trials**, which are provided through the EvaalAPI and are non-reloadable. **Those are used to evaluate the competitors and can be run only once (former evaluation logfiles).**
- Training, testing and scoring data have been recorded with several smartphones and they have been stored in txt logfiles. Training data are provided as txt files (logfiles), whereas testing and scoring data are provided by means of the EvaalAPI respectively as testing trials (reloadable) and scoring trials (non-reloadable).
- In order to run a trial in the EvaalAPI, competitors have to ask info@evaal.aaloa.org for a trial code.

Submission of results

- Despite being an off-site track, we will ask to competitors to process data as if they were streamed in real time. To do so, we rely on the EvaalAPI. This API will be used by competitors for sending position estimates and reading the sensor readouts: https://evaal.aaloa.org/evaalapi/
- A participant team can run the process up to 3 times. This lets a chance to catch-up if any issues happen. Although the competition organizers will evaluate the three scoring trials, only the best one will be considered for the contest. For the first scoring trial, the logfile ScoringTrial01 will be used. For the second trial, the logfile ScoringTrial02 will be used. For the last trial, the logfile ScoringTrial03 will be used. These three scoring trials correspond to three different data collection sessions.

Submission deadline of the post-processed indoor coordinates

- Data will be published in website (training) and EvaalAPI (testing/scoring):   **June 30th, 2022**
- The deadline for submitting the post-processed results is: **August 31th, 2022**
- Proclamation of winners: **September 7th, 2022**

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, 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, 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 is provided by competition organizers before the celebration of the IPIN conference. The competition teams can calibrate their algorithmic models with several files (training data and testing trials) containing readings from sensors typically found in modern mobile phones and some ground-truth positions. Finally, each team will compete using additional 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 environment and custom on-site calibration is not allowed.

Multiple sources of information (novelty in 2022)

We captured multi-sensor data at the School of Engineering of the University of Minho (Guimarães, Portugal) in May 2022 and distributed into training data, testing trials (reloadable) and scoring trials (non-reloadable) as mentioned before. We used GetSensorData app to collect all data, whose description can be found in:

- R. Jiménez, F. Seco and J. Torres-Sospedra, "Tools for smartphone multi-sensor data registration and GT mapping for positioning applications," 2019 International Conference on Indoor Positioning and Indoor Navigation (IPIN), 2019, pp. 1-8, doi: 10.1109/IPIN.2019.8911784.
- https://lopsi.weebly.com/downloads.html - https://gitlab.com/getsensordatasuite

The BLE RSS, WiFi RSS and magnetic data can be used to implement a fingerprinting localization method, while the inertial measurements 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. 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. This year, no dedicated infrastructure is provided for BLE.

Device Heterogeinity (novelty in 2022)

We collected training, testing and scoring data by means of eight modern smartphones with different features and Android OS versions. Finally, three scoring trials were selected for the competition. This approach enables competitors to exploit and integrate data collected with several devices. In addition, nine different users participated in the data collection which adds diversity in the collected data. To enhance diversity, a particular training or testing trajectory might not have been surveyed by all devices/users.

- Samsung (SM-A528B with Android 12) – User 1
- Xiaomi (M2102J20SG with Android 11) – User 2
- LGE (Nexus 5 with Android 6.0.1) – User 3
- Samsung (SM-A520F with Android 8.0.0) – User 4
- BQ (Aquaris X5 Plus 3 with Android 7.1.1) – User 5
- Samsung (SM-A315G with Android 11) – User 6 and User 8
- Samsung Note 9 (SM-N960F with Android 10) – User 7
- Samsung Galaxy S7 (SM-G930F with Android 8.0.0) – User 9

All trials's data includes a header with the phone manufacturer, model and Android release.

Continuous motion and recording process

While recording the trial's data with the smartphone, the person moved along a continuous trajectory passing by some known landmarks. Every time a person stepped on a known landmark, we saved this ground truth position information in the logfile. Ground truth position can be used for calibrating competitor's algorithms. The length of each individual training and testing trial is a few minutes.

There is no guarantee that the trajectory between two consecutive landmarks will be a perfect straight line. **In the training data, all significant turns have been recorded with a landmark. Please pay special attention to the testing/scoring trials, where turns, u-turns, stops and other challenging movements could be present between two consecutive landmarks. The supporting visualization maps for the testing trials 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 trial moved in a natural and realistic way: most of the time walking forward, but occasionally stopping, sitting, taking large turns (90 or 180 degrees at corridor ends), simulating phone calls and messaging, and, even, moving backward or laterally at certain points (e.g., when giving way at door accesses). In the testing and scoring trials, we have performed some challenging movements to test the robustness of the evaluated system. The change to different floors is preferably, but not limited, through stairs.

Phone holding

The user always carried the smartphone in a realistic way resembling a real situation. For the training trials, the user always kept the smartphone (mostly) stable in front of his face or chest (typical position for reading or typing with the phone) as shown in the video. For testing and scoring trials the user's movements are not that strict but they remain realistic. Although the user hold the device as in the training trials most of time, the user may leave the smartphone on a table and occasionally do other realistic movements, e.g. attending a phone call, answering a message or taping the screen to read recent notifications. Anyway, extreme non-natural handling conditions are not expected.

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 training trials 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 School of Engineering of the University of Minho (Guimarães, Portugal). Multiple WiFi access points (AP) were detected, but the position of each AP is unknown. Some beacons may be present in the environment to support indoor location but their reliability and location are not guaranteed. 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/Trials)

Data Format

Each logfile or trial is a "txt" file containing multiple rows with different types of data. For the training data, the txt files are provided "as is" and can be directly downloaded from the EvAAL website. For the testing and scoring trials, data is streamed using the EvaalAPI. 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', 'ACCE','MAGN', etc.) that determines the kind of sensor read, and several fields separated by semicolon with different readings.

Examples of the logfiles can be found in the technical annex for competitions 2016—2021.

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);Protocol;MAC Address; RSSI; Power; MajorID;MinorID;UUID
Example	BLE4;8.8800;iBeacon;CA:EF:C9:33:23:20;-79;0;33;2;21BEAC2F-0000-0000-0000-000000000000

POSI: ground-truth position (only in training and testing trials, not present in scoring trials)	
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.
4. BLE includes MAC address, Major ID, Minor ID, and UUID for identification. Power may correspond to the default value for the power at 1m and should not be trusted.

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.

New in 2022:

- **All the logfiles include data of the BLE beacons but there is no official BLE infrastructure in the building, therefore that information can belong to beacons we do not operate or other devices.**
- **The sensors sampling rate has been limited to 100 Hz but some smartphones have higher rate.**
- **Wi-Fi and BLE data may behave differently depending on the smartphone. Please, have in mind that Wi-Fi data may not be trustable in the smartphones with Android 10 and Android 11. In some Android 10-12 smartphones we have disabled limitations on Wi-Fi collection.**
- **The area cover a semi-outdoor patio on the ground floor and two outdoor areas with four entry points to the building.**
- **Each of the three scoring trials are performed over different logfiles, which correspond to different data collection sessions performed on the same path but not at the same time.**

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 relevant information from the different logfiles.

Dataset types and download link

There are some datasets available for calibration: the **training data** and the **testing trials**. Both training data and testing trials include reference ground-truth positions (lines with a "POSI" header, followed by Latitude, Longitude, floor ID and Building ID). While the training data are available as off-line txt files, the testing trials are provided by the organizers through the EvaalAPI , which should be used to have an initial estimation of the IPS accuracy on four simple trajectories.

- There are two types of files for training data, 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. All training data are provided as txt logfiles (i.e., the logfiles).

- In the testing trials, the movement between keypoints is free, so the actor could have done non-rectilinear movement between POSI landmarks and visited unknown areas. The user may have done other realistic movements such as stopping, sitting, attending a phone call, taking an elevator, among others. The testing trials are provided through the EvaalAPI and are reloadable. i.e. the competitors can access to them and provide the position estimated many times.

Figure 1. Some challenging spaces in the competition area.

Another type of trials, the **scoring** trials, are used for evaluation at the competition and do not contain any position reference (no 'POSI' header). These trials contain measurements that were taken following the same procedure used in the training and testing trials. There is no guarantee that the users and/or phones involved in the evaluation participated in the training and testing data collection. The evaluation of the competitor's algorithm will rank its performance according to the metrics described in section "Evaluation criterion". In Track 3 of the 2022 IPIN competition, we provide 3 scoring trials through the EvaalAPI https://evaal.aaloa.org/evaalapi/. Users have just one attempt to submit the position estimates for each scoring trial. i.e., competitors can only run once each scoring trial.

Sensor Calibration
All training logfiles and testing trials start with a calibration. First, the phone is arbitrary moved during around 25-35 seconds. Then, it remains static in from of user's face for around 25-35 additional seconds. After that, the first landmark is provided. A similar calibration procedure is done in the scoring trials.

Inputs given to competitors

The materials and methods provided by the competition organizers are:

- **Supplementary materials**

    - **Calibration Floormaps**

    - **Files for GetSensorData Matlab Tools**

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

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

    - Regular Training logiles – 9 routes (89 logfiles)

    - Floor transition Training lofgiles – 3 routes (24 logfiles)

    - http://evaal.aaloa.org/files/2022/IPIN2022_T3_TrainingData.zip

- **Testing trials (reloadable) with ground-truth inserted (POSI lines):**

    - Testing trials – 4 routes (24 trials)

    - https://evaal.aaloa.org/evaalapi/

- **Scoring trials (non-reloadable) without ground-truth:**

    - Scoring Logfiles – 3 routes

        - IPIN2022_T3_ScoringTrial01, IPIN2022_T3_ScoringTrial02, and IPIN2022_T3_ScoringTrial03

    - https://evaal.aaloa.org/evaalapi/

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

Note: The supplementary materials are confidential and should be requested by the email to the competition chairs jtorres@algoritmi.uminho.pt, antonio.jimenez@csic.es, aperezn@uoc.edu.
Re-distribution of the maps is not allowed out of the competing group who has requested them, not even inside the same organization.

Description of the Output

For each trial, you must submit your estimates with the EvaalAPI whose format is now described.
- 3 columns :
    - Column 1: WGS84 longitude in decimal degrees with at least 12 decimal digit resolution
    - Column 2: WGS84 latitude in decimal degrees with at least 12 decimal digit resolution
    - Column 3: Floor Number in integer (0: Ground Floor, 1, 2)
- Comma (",") used as data delimiter
- No header
- Track3 requirement: frequency 2 Hz synchronized with the beginning of the scoring trial (apptimestamp 0) until the last record in each of the scoring trials.
- Use 0,0,0 for those cases where you cannot estimate the coordinates (avoid use nan, NaN, N/A or other terminology).

Example :

```
0,0,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,0
-0.069379345497595, 39.993948886482599,1
-0.069379345497595, 39.993948886482599,1
...
-0.069379345497595, 39.993948886482599,2
```

For additional information, please visit the EvaalAPI documentation.

- https://evaal.aaloa.org/evaalapi/
- https://evaal.aaloa.org/evaalapi/demo-auto.out

Evaluation criterion

The best accuracy score of the three scoring trials will be taken for final score, the team with lowest final score will be the winner

The accuracy score for a particular scoring trial is provided by the following equations:

Accuracy Score = 3rdQuartile{SampleError(R_i, E_i)}, ∀ reference location in the scoring trial

SampleError(R_i, E_i) = Distance(R_i, E_i) + (penalty × 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.
- R_i is the actual position (ground truth).
- E_i is the predicted position by the method proposed by the contest participant.
- floorfail is the absolute difference between actual floor and the predicted one.
- penalty is used to penalize errors in estimating the floor. penalty is set to 15 m.
- Distance(R_i, E_i) calculates the Euclidean distance between coordinates (longitude and latitude) of R_i and E_i.

Useful datasets and baselines

The IPIN 2021 Competition (Track 3, Smartphone-based off-site) is using the same log file structure (with minor changes) since 2016. The full datasets and competition results are publicly available for those research teams and developers interested in evaluating their solutions on them:

- https://zenodo.org/record/5948678
- https://zenodo.org/record/4314992
- https://zenodo.org/record/3606765
- https://zenodo.org/record/2791530
- https://zenodo.org/record/2823924
- https://zenodo.org/record/2823964

Previous papers describing the competitions 2016-2021 are available in:

- Potortì, F.; Torres-Sospedra, J.; Quezada-Gaibor, D.; Jiménez, A.R.; Seco, F.; Pérez-Navarro, A.; Ortiz, M. et al. Off-line Evaluation of Indoor Positioning Systems in Different Scenarios: The Experiences from IPIN 2020 Competition IEEE Sensors Journal, Early Access (in press), 2021. https://doi.org/10.1109/JSEN.2021.3083149

- Potorti, F.; Park, S.; Palumbo, F.; Girolami, M.; Barsocchi, P.; Lee, S.; Torres-Sospedra, J.; Jimenez Ruiz, A. R.; et al. The IPIN 2019 Indoor Localisation Competition - Description and Results IEEE Access Vol. 8, pp. 206674-206718, 2020. https://doi.org/10.1109/ACCESS.2020.3037221

- Renaudin, V.; Ortiz, M.; Perul, J.; Torres-Sospedra, J.; Ramón Jimenez, A.; Pérez-Navarro, A.; et al. Evaluating Indoor Positioning Systems in a Shopping Mall: The Lessons Learned from the IPIN 2018 Competition IEEE Access Vol. 7, pp. 148594--148628, 2019. http://dx.doi.org/10.1109/ACCESS.2019.2944389

- Torres-Sospedra, J.; Jiménez, A. R.; Moreira, A.; Lungenstrass, T.; Lu, W.-C.; Knauth, S.; Mendoza-Silva, G.M.; Seco, F.; Perez-Navarro, A.; Nicolau, M.J.; Costa, A.; Meneses, F.; Farina, J.; Morales, J.P.; Lu, W.-C.; Cheng, H.-T.; Yang, S.-S.; Fang, S.-H.; Chien, Y.-R. and Tsao, Y. Off-line evaluation of mobile-centric Indoor Positioning Systems: the experiences from the 2017 IPIN competition Sensors Vol. 18(2), 2018. http://dx.doi.org/10.3390/s18020487

- Torres-Sospedra, J.; Jiménez, A.; Knauth, A.; Moreira, A.; Beer, Y.; Fetzer, T.; Ta, V.-C.; Montoliu, R.; Seco, F.; Mendoza, G.; Belmonte, O.; Koukofikis, A.; Nicolau, M.J.; Costa, A.; Meneses, F.; Ebner, F.; Deinzer, F.; Vaufreydaz, D.; Dao, T.-K.; and Castelli, E. The Smartphone-based Off-Line Indoor Location Competition at IPIN 2016: Analysis and Future work Sensors Vol. 17(3), 2017. http://dx.doi.org/10.3390/s17030557

Note: The datasets collected for the previous competitions correspond to evaluation areas in research centers in Arganda del Rey, Alcalá de Henares, Castellón and Badajoz (Spain), a Shopping Mall in Nantes (France), the CNR center in Pisa (Italy), and a Library building in Castellón (Spain).

This year, due to the current health situation, the evaluation area is within a University Campus in Guimarães (Portugal). All data was collected according to the strict protocol because the COVID-19 situation.

GetSensorsData Suite and Tools

The GetSensorsData Suite is available to the community for its usage and improvement. The full description of the application used to collect the data, as well to get the calibrated maps, can be found below.

- Jiménez-Ruiz, A. R.; Seco, F.; and Torres-Sospedra, J. Tools for smartphone multi-sensor data registration and GT mapping for positioning applications Proceedings of the Tenth International Conference on Indoor Positioning and Indoor Navigation, 2019. http://dx.doi.org/10.1109/IPIN.2019.8911784

Please, get involved in the development of this evaluation framework and provide us your contributions through the GetSensorsData Suite GitHub project:

https://gitlab.com/getsensordatasuite

Contact points and information

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

Joaquín Torres (jtorres@algoritmi.uminho.pt; info@jtorr.es) at Centro ALGORITMI, Universidade do Minho, Guimarães, Portugal. Please carbon copy (CC) also to Antonio R. Jiménez (antonio.jimenez@csic.es) at the Centre of Automation and Robotics CSIC/UPM, Madrid, Spain and Antoni Pérez-Navarro (aperezn@uoc.edu) at Universitat Oberta de Catalunya, Barcelona, Spain.

Introduced changes

Version 2   June 30th   First final version

Version 1   June 15th   Tentative technical annex