dresden elektronik

User Manual

deRFevaluationKit
Positioning 2.4 GHz

powered by:

ZIGPOS

Document version V1.0

2013-03-01

Table of contents

Document history

Date	*Version*	*Description*
2013-03-01	1.0	Initial version

1. Overview

The kit is an evaluation platform for the innovative energy efficient Real-Time Locating System (eeRTLS) developed by ZIGPOS based on Atmel´s ranging technology. It contains six radio modules from dresden elektronik. Four devices are used as fixed anchors with known position. One device is used as mobile node and the last one is connected to a PC. The also included software tool with an intuitive user interface provides comprehensive monitoring, control and commissioning capabilities to easily setup dedicated test-scenarios.

2. Software setup

The Positioning Kit application can be installed on Windows® and Linux operating systems. Officially supported are Windows 7 and Ubuntu Linux 12.04. Initial versions for both operating systems are provided on the CD-ROM contained in the evaluation kit.

2.1. Download

The newest software version can be downloaded at www.zigpos.com/positioning. If requested, enter the validation key from the separate sheet that can be found within the kit.

2.2. Installation on Windows

Before installing the Positioning Kit application, be sure there is a recent Java 7 Runtime Environment installed. To check if Java is installed and to determine the version, open the console and enter:

```
java –version
```

The recent version of Java can be obtained from www.java.com/download.

Plug the USB level shifter via USB to the PC and follow the driver installation dialog from windows. If the driver installation does not start automatically, open the Windows device manager and select the driver from the CD-ROM.

Execute `install.exe` from the CD-ROM and follow the instructions to install the application. To launch the application double click on the desktop or quick start icon.

To uninstall the software, click on `uninstall.exe` in the installation folder. Uninstall the old software version before installing a new one.

2.3. Installation on Ubuntu Linux

Before installing the Positioning Kit application, be sure there is a recent Java 7 Runtime Environment installed. To check if Java is installed and to determine the version, open the console and enter:

```
sudo java –version
```

The Java runtime can be installed from the packages on the command line by executing:

```
sudo apt-get install openjdk-7-jre
```

Execute `install.jar` from the CD-ROM with admin rights:

```
cd /media/cd/
sudo java –jar install.jar
```

Follow the instructions of the installer. The software can be launched by executing `positioning.sh` within the installation path and with admin rights:

```
sudo ./positioning.sh
```

To uninstall the software, execute `uninstall.sh` in the installation folder. Uninstall the old software version before installing a new one.

3. Hardware preparation

For the first-time use, the type of the devices must be configured. Set the type of the node with a jumper on PORTF as described in **Figure 1** and **Table 1**. Configure four devices as anchors, one as coordinator (attach jumper on PORTF in upper position) and one as mobile node (jumper on PORTF in the second row, below coordinator position). Assemble the device as shown in **Figure 2**. Power the devices by inserting the batteries and switch them on. The LEDs D1, D2 and D3 should blink.

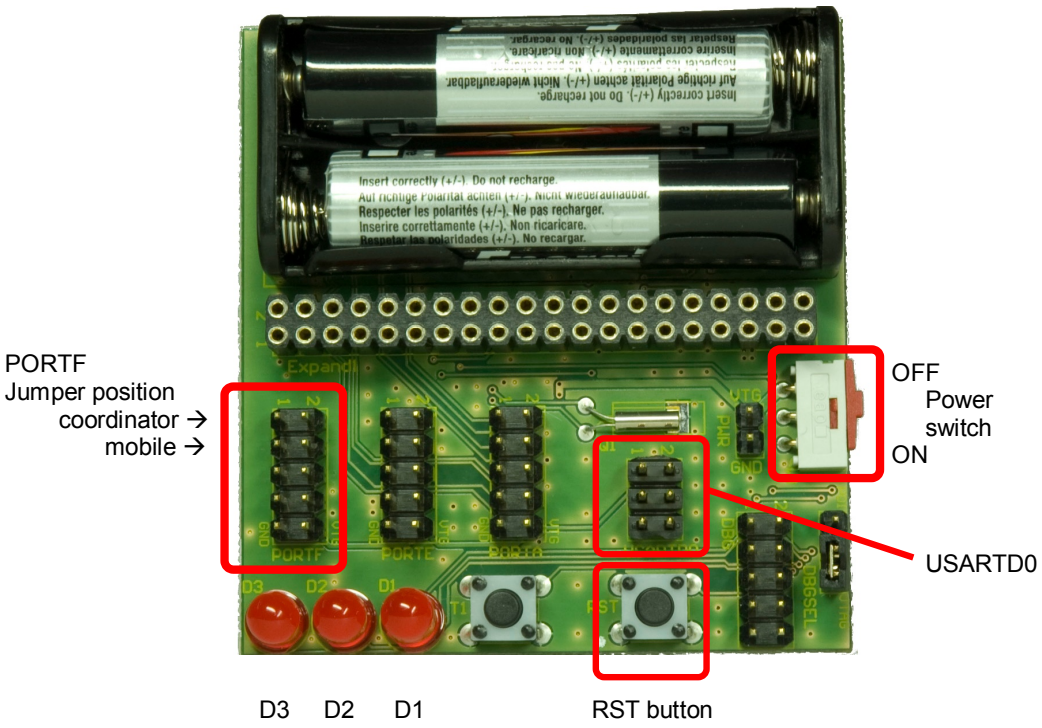

Figure 1: Hardware configuration

Jumper	Device
Jumper on PORTF: PIN 1 and 2	Coordinator
Jumper on PORTF: PIN 3 and 4	Mobile node
No jumper on PORTF	Anchor

Table 1: Jumper settings to configure the hardware

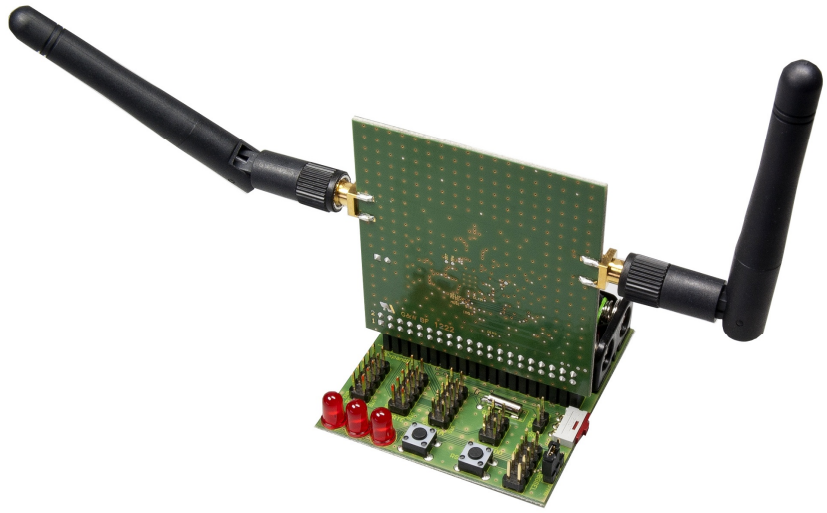

Figure 2: Assembled device

4. Flashing new firmware

New firmware versions can be downloaded from www.zigpos.com/positioning. In order to flash the firmware, the device must be powered and connected to the PC. Use the USB level shifter and connect the device via USARTD0 to the USB port of the PC. Start the software application, open the settings menu and click the 'Flash new firmware' button inside the General tab. The following window should appear:

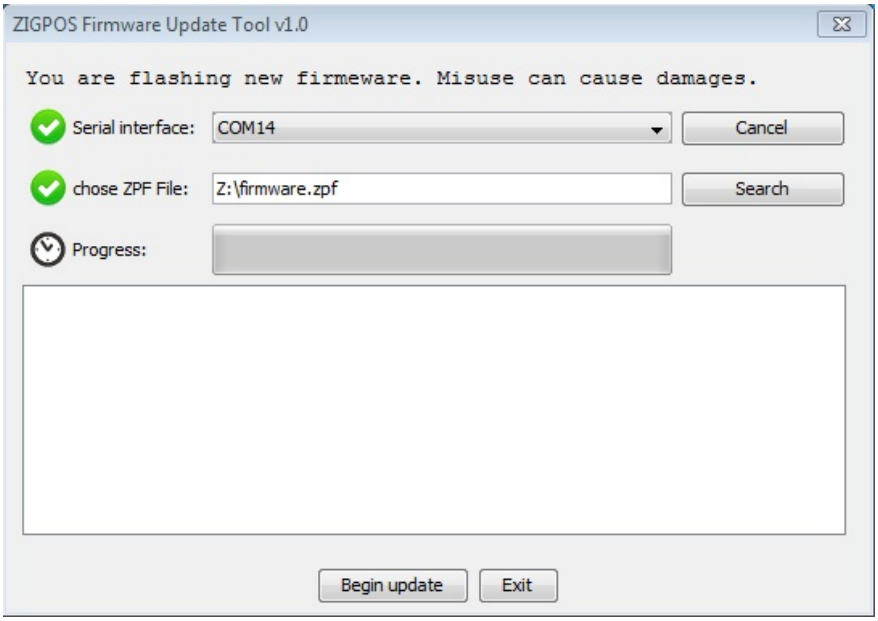

Figure 3: ZIGPOS Firmware Update Tool

First select the correct serial interface and connect it to the device. Select the appropriate ZPF file and click the 'Begin update' button. To start the update, press the RST button on the device. The progress bar visualizes the update process. Flash all devices in the same way.

To restore the device delivery condition, use the firmware file provided on the CD-ROM included in the kit.

5. User interface

Figure 4 shows the user interface of the application. Placed on top is the menu bar. The tool bar below provides direct access to the most important functions and menus. The tree view on the left window panel shows an overview of the connected radio modules. The tab view the right hand side provides three tabs: A tab with general information, a tab containing the localization map and another tab containing logging information.

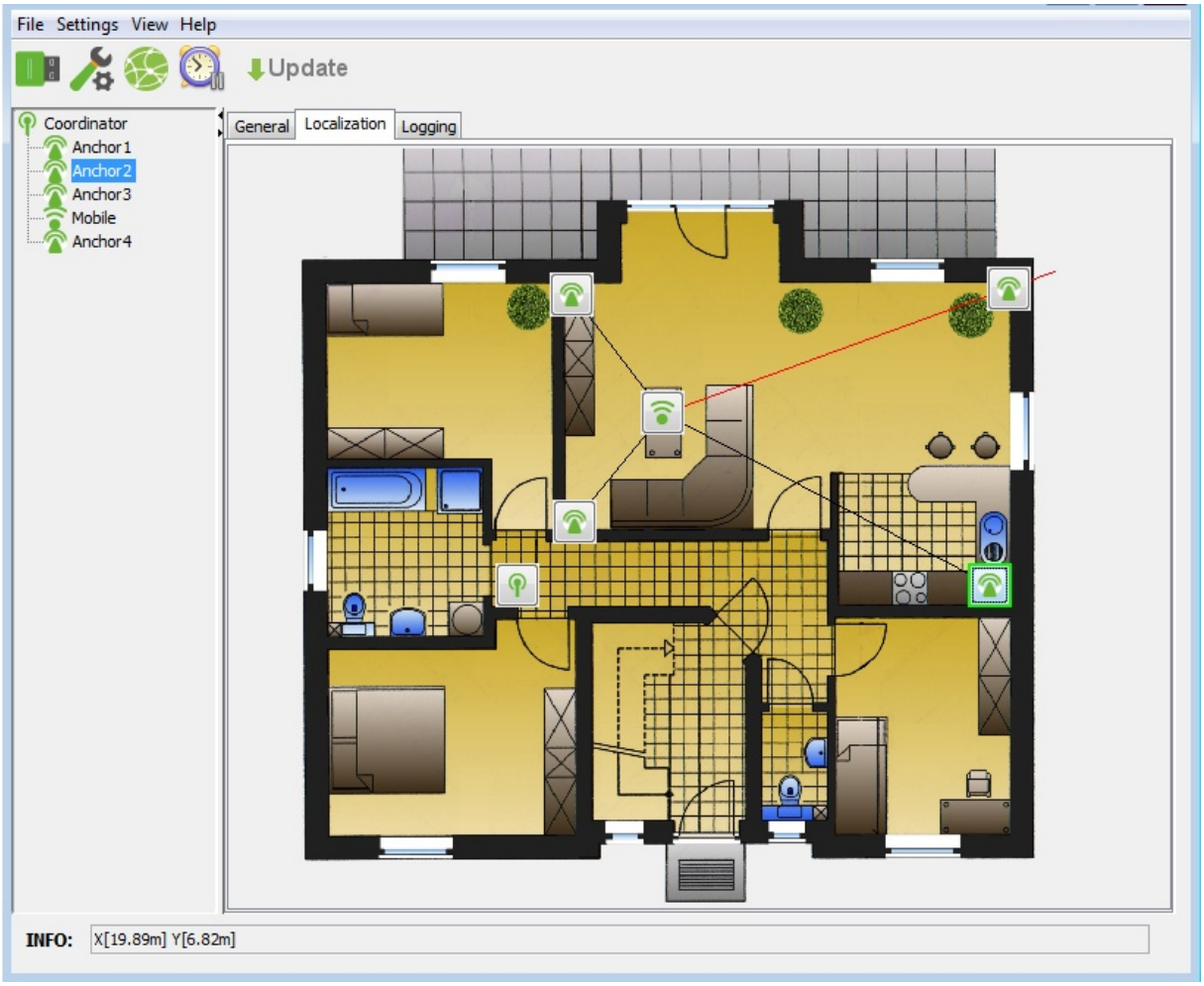

Figure 4: User interface

5.1. Menu bar

The menu bar provides the following drop down menus:

Menu bar	Drop down entry
File	End – closes the program
Settings	Connection – shows a menu to configure the serial connection to the coordinator. Simulation – starts positioning simulation. Settings – show the settings menu.
View	Change visibility of tab views and toolbar.
Help	About – shows manufacturer information.

Table 2: Menu bar

5.2. Tool bar

The following table gives a description of the tool bar icons:

Icon	Description	
	Connection	Shows a menu to configure, start and stop the serial connection to the coordinator.
	Settings	Shows the settings menu.
	Refresh network	Asks the network for new devices and refreshes the node tree panel.
	Start/Stop positioning	Starts and Stops the Positioning application.
	Software update	If the icon is visible software updates are available. Click the icon to reach the update website with your default browser.

Table 3: Tool bar icons

5.3. Node tree panel

The node tree panel gives an overview of the connected radio modules. The devices can be placed on the localization view via drag and drop. The selected device in the tree view is also highlighted in the localization view. A right click on a node shows device specific options and information.

5.4. Tab panel: General

The General tab panel shows a welcome screen and the used communication channel, if connected. In addition, the PAN-ID used for IEEE 802.15.4™ communication is visualized.

5.5. Tab panel: Localization

The Localization tab is the main view of the application. It shows a map and/or a grid where the current position of the mobile node is monitored. The background and the scaling can be configured in the Settings menu. Inside this view you can set different preferences of the map, like changing the grid resolution or visualize different parameters in real-time (node positions, distances, filtered positions etc.).

5.6. Tab panel: Logging

The Logging tab shows information about incoming packets on the left, distance and positioning information on the right and errors and other messages at the bottom. It can be used for debugging purposes and will show any messages or errors.

6. Settings

Figure 5 shows the Settings menu, where the general program behavior, the background image and location settings can be configured. The appearance of the menu differs depending on whether the Expert Mode is enabled or not.

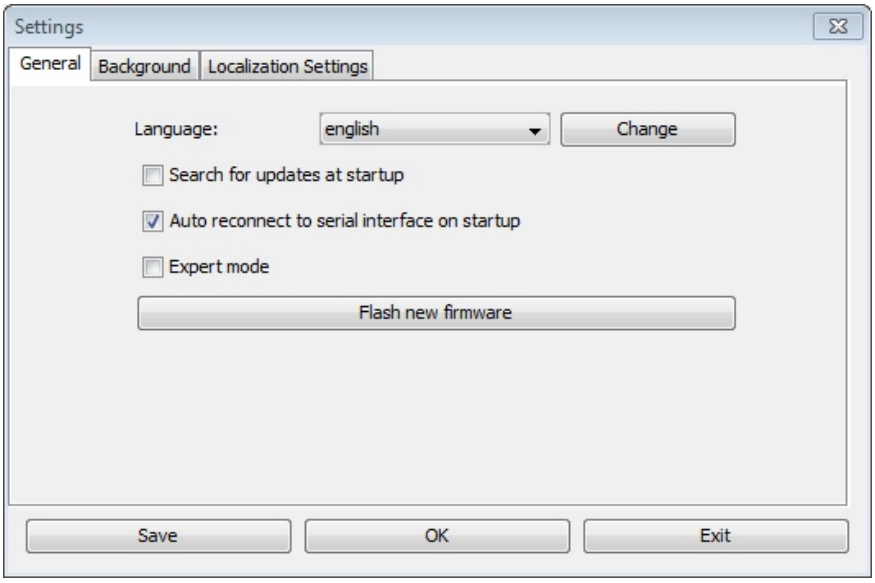

Figure 5: Settings menu (standard mode)

6.1. General

In the General settings menu, the language can be changed. Therefore every available language is shown in the box. Choose your preferred language and press the ‘Change’ button next to it.

The program automatically searches for available updates at startup and will give information by the visibility of the update button in the toolbar. To deactivate this function, disable the related check box.

The Auto reconnect functionality for the serial interface can be enabled or disabled. If this function is enabled, the application tries to connect to the coordinator at start up given the last serial port that has been used with this application. Change this port via the Connection menu.

The Expert mode can be activated via a check box. A deactivated box will result in a reduced Settings tab (see **Section 6.3**) that allows the user to setup positioning parameters intuitively. If the expert mode is activated, three different tabs appear instead to setup all parameters manually (see **Figure 6**).

The last function in this tab gives access to the firmware update. Start the bootloader tool, using the ‘Flash new firmware’ button. Refer to **Section 4** for details.

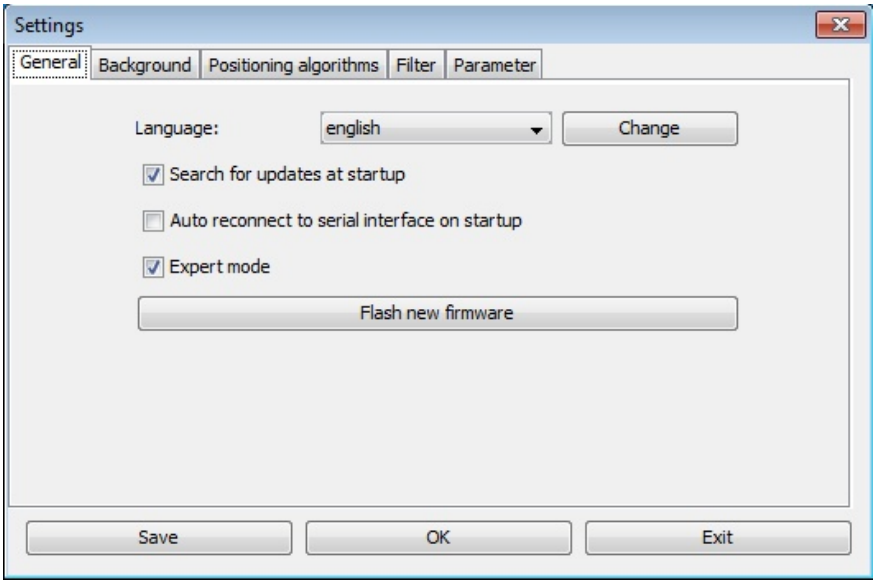

Figure 6: Settings menu (expert mode)

6.2. Background

The Background settings menu enables user defined maps and ground plans. To switch between backgrounds another background has to be selected and confirmed by pressing the ‘Save’ or ‘OK’ button.

To create a new background, type a new name, select a PNG or JPEG image from the file system and specify the height and the length representation of the image in meters. Press ‘Create new background’ to add a new background to the list. The meter-per-pixel-scaling can also be changed within the localization view by drawing a line and setting the length of the line in meters. Therefore do a right click within the localization view and select ‘Set map scaling’. Please note, that the resolution of single backgrounds has a big influence on the algorithms to calculate a mobile node position. It is recommended to use a picture with minimum scale of 0.05 m/px.

A background can be removed with the ‘Delete background’ button.

6.3. Localization Settings

The localization settings are only visible in non-expert mode and designed for non-experts. They provide an intuitive slider to tune the algorithm parameters. The algorithm can be either faster or more accurate. In addition, you can choose if a filter should be used to harmonize single positions to a real-time tracking. Therefore it has to be defined if the position should be calculated only inside the anchor area or outside as well. The application will then automatically choose an algorithm based on the user preferences.

For simulation purposes one can set a small amount of parameters as well. The user is able to choose the direction and amount of offset that will be added to perfect distances.

6.4. Positioning algorithms

The positioning algorithms menu is only visible in expert mode. Here you can choose between the positioning algorithms MDS, IMDS, LMS, ZIGPOS_Plain and ZIGPOS_3D and configure the specific algorithm values. More details about the algorithms are described in **Section 8.1**.

Next to the position algorithms, choose the values that will be used to calculate a node position based on measured distances. Positions can be calculated either in 2D or in 3D. The used distances can be directly used or chosen to take averaged distances from the past. Therefore, different options are available.

6.5. Filter

The Filter menu enables the user to increase the positioning accuracy by using a tracking filter. More details about the different filters are explained in **Section 8.2**.

6.6. Parameter

The Parameter menu gives direct access to the hardware parameters of the radio modules. The focus of these values is the evaluation of the new phase measurement technology provided by Atmel®. Different options are available to increase the accuracy or the time, beginning from single options that can be activated/deactivated up to values that can be inserted to define the frequency range of single measurements. Subsequently each parameter is briefly described:

- State [check box]: Change the current state of the network between sleep, active and range period. For changing the mode between active and range there is a shortcut in the toolbar (Start/Stop Measurements).
- Sleeping period: Sets the time of the sleeping period, that is inactive time, no device will be available during it after the status has been set to sleep.
- ED-scan: An energy detection is performed during the measurements.
- Distance array diversity: If diversity is used, the algorithms themselves optimize all measured distances to a single value and a quality factor. If this box is enabled one gets all values without optimization.
- PMU compression: The values determined by the Phase measurement unit will be compressed before transmission.
- Diversity: Activate or deactivate Antenna diversity. If activated each antenna will be used to perform a distance measurement. If deactivated just one of both antennas will perform a distance measurement.
- Choose antenna: If diversity is deactivated this box sets the current antenna that will be used.
- Start frequency: This is the starting frequency of the band that will be used to perform a phase measurement; this value can range from 2403 MHz up to 2483 MHz.
- Steps: The phase measurements will calculate phases on different steps starting from the Start frequency value; steps are 0.5 MHz, 1 MHz, 2 MHz or 4 MHz.
- Stop frequency: This is the stop frequency of the band that will be used to perform a phase measurement, this value can range from 2403 MHz up to 2483 MHz and has to be greater than the start value, otherwise the measurements will not perform.
- Range partner: Defines the area of range partners that has to be involved in a positioning request. The values define the minimum and maximum number of range partners that will be used to perform a positioning.
- Minimal dBm: Set the minimum of the received signal strength that will be accepted to range with another device. 0 means accept every request. Values until -100 dBm are accepted.

7. Getting started

Connect the coordinator device via the USB level shifter on header USARTD0 to the PC and establish a serial connection. Therefore click this button . Switch all devices on.

To change the background image, go to the ‘background’ tab in the settings menu . Select a background and set the height and the width of the background image in meters. The meter-per-pixel-scaling can also be changed within the localization view by drawing a line and setting the length of the line in meters. Therefore do a right click within the localization view and select ‘set map scaling’.

Place the devices via drag and drop from the tree panel on the map. Press the start/stop-positioning-button / to start and stop the positioning application. When the positioning is running, LED D3 should blink on the mobile node and LED D2 should blink on the anchor nodes after each ranging. LED D1 on the coordinator blinks when data is received.

A right click on the nodes gives you further information about the device. The option ‘detect device’ lets the LEDs of the selected device blink, to identify the module. The option ‘show distance’ visualizes the distances between the radio devices as black and red lines, whereas red lines are signaling a potentially too long distance.

8. Positioning

This section gives a brief description of the implemented algorithms and filters to evaluate the technology. Each algorithm is independent and can be combined with each filter.

8.1. Algorithms

The positioning algorithms are used for calculating a position out of the measured distances between the ranging nodes.

8.1.1. Multidimensional Scaling (MDS)

The MDS algorithm needs the distances between all radio modules to calculate the position of a mobile device. The distances between the anchors will be calculated based on their known position in the map. The result is a Matrix with Coordinates of each device. This Matrix will then be scaled, rotated and shifted based on the original coordinates of the Anchors.

8.1.2. Iterative Multidimensional Scaling (IMDS)

The IMDS is an iterative extension of the MDS to handle incomplete distance matrices. The distance estimation gets more accurate for each iteration step. The parameter ε defines a canceling criterion, which is compared to the changing of the last two iteration steps. The algorithm stops, if the changing between the last two iteration steps is too small.

8.1.3. Least Median Squares (LMS)

This algorithm uses different distance matrices, calculates residua of all anchors, and searches the median. If all anchor combinations have been tested the least median will be used on the network for calculating the position of the mobile node.

8.1.4. ZIGPOS_Plain

This algorithm is an improvement of the MDS algorithm from ZIGPOS, to increase the accuracy. It is directly made to perform inside the virtual area of the anchors and can be used in 2D and 3D scenarios. Therefore the positions of all anchors have to be at the corner of the available area (e.g. in the corners of a room or defined area).

8.1.5. ZIGPOS_3D

This algorithm is an improvement of the MDS algorithm from ZIGPOS, to increase the accuracy of the position inside and outside of the anchor area. It can only be used in 3D which means the anchors should be placed in different height levels to increase the accuracy.

8.2. Filters

The noise of the calculated positions can be reduced by using filters, which are estimating the state and behavior of the mobile device.

8.2.1. Kalman Constant Position (CP)

The Kalman Constant Position filter expects a static nonmoving object. It is used to give high accurate position after evaluating various position coordinates and is very slow for tracking objects. This filter should be used only in static scenarios.

8.2.2. Kalman Constant Velocity (CV)

The Kalman Constant Position filter expects a moving object with a constant velocity. This filter performs dynamically changes of moving objects and should be used in case of moving objects.

8.2.3. Interacting Multi Model (IMM)

The Interacting Multi Model filter combines different moving models. This enables a more dynamic behavior and can be used for static and moving objects.

8.2.4. Interacting Multi Model Smoother (IMMS)

The interacting Multi Model Smoother filter is an extension of the IMM filter. This filter allows a smooth shifting between different moving models, when the moving state changes. This filter is useful, if the moving state changes frequently.

8.2.5. Multi Model Filter using inertial sensor (MMI)

This filter uses values from given inertial sensors of mobile devices to switch between static and dynamic filters. This filter is not available in this version, as the hardware has no inertial sensors that can be used to detect accelerometer values or movements.

8.2.6. Particle Filter (PF)

The Particle Filter is used for strong non-linear behavior and for non-normally distributed signal noise. This filter is an alternative approach using particle likelihoods.

8.2.7. Rao-Blackwellized Particle Filter (RBPF)

The Rao-Blackwellized Particle Filter is combination out of Kalman and Particle filter.

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