FROG

FUN ROBOTIC
OUTDOOR GUIDE

# Deliverable D6.2
# Datasets for benchmarking


**Consortium**

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Grant Agreement no. **288235**

Funding Scheme: **STREP**

SEVENTH FRAMEWORK PROGRAMME


University of Amsterdam · idmind · Universidad Pablo de Olavide Sevilla · Imperial College London · University of Twente.

## DOCUMENT INFORMATION

| **Project** |
|---|

| | |
|---|---|
| Project acronym: | FROG |
| Project Full Title: | Fun Robotic Outdoor Guide |
| Grant agreement no.: | 288235 |
| Funding scheme: | STREP |
| Project start date: | 1 October 2011 |
| Project duration: | 30 September 2014 |
| Call topic: | ICT-2011.2.1 Cognitive Systems and Robotics (a), (d) |
| Project web-site: | www.frogrobot.eu |

| **Document** |
|---|

| | |
|---|---|
| Deliverable number: | D6.2 |
| Deliverable title: | Datasets for benchmarking |
| Due date of deliverable: | M6 - September 30, 2014 |
| Actual submission date: | October 2, 2014 |
| Editors: | |
| Authors: | UPO |
| Reviewers: | |
| Participating beneficiaries: | UPO |
| Work Package no.: | 6 |
| Work Package title: | Dissemination and Exploitation |
| Work Package leader: | UT |
| Work Package participants: | All Partners |
| Estimated person-months for deliverable: | 4 |
| Dissemination level: | Public |
| Nature: | Prototype |
| Version: | 1.0 |
| Draft/Final | Final |
| No of pages (including cover): | 26 |
| Keywords: | Datasets, Benchmarking, Testing |

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**Abstract**

The present work consists of several data sets recorded at Royal Alcázar of Seville (Spain) and at Lisbon Zoo (Portugal) with the FROG robot and at Royal Alcázar of Seville with a Pioneer robot. The data presented is available for free use under CC by-nc-sa. The Royal Alcázar of Seville constitutes a tourist hotspot that may have more than 5000 visitors per day. The Lisbon Zoo is a very irregular scenario with many ramps that makes localization tasks difficult. We recorded a large set of image sequences from a stereo camera and scan measurements from three laser mounted on a moving robot and from an IMU sensor. The datasets are timestamped and stored by means of the well-known Robot Operating System (ROS) log functionality. The robot traveled more than one kilometer in each experiment, and half of the trials were performed at around midday and the other half at evening so we could capture the different light conditions over the images. The tourist attendance also depends on the hour, providing datasets with a lot of examples to model in a social-way the different places such as corridors, gates, queues, groups of people, etc.

This data is interesting due to its usability for the evaluation of visual place recognition algorithms in both indoor and outdoor environments in addition to sensor information to evaluate human-robot interactions in crowded areas.

# 1 Introduction

Along the project, different datasets have been gathered at the two main scenarios of the project (the Royal Alcázar of Seville and the Lisbon Zoo) to allow the development of different modules of the FROG system, like people detection and position estimation and robot localization algorithms.

As a result of Task 6.6, we are releasing these data so that the community can also take advantage of them, and perform benchmarking activities. This document summarizes the data released, which constitutes the actual deliverable, and can be found at the FROG website.

The datasets consist of images and other sensorial data gathered at both scenarios at different times of the day, and can be of interest for researchers in topics like scan matching, visual localization, people detection and tracking, and socially-spatial modeling.

The datasets presented here are noteworthy for several reasons. First, they include a large collection of outdoors and indoors data taken from a mobile robot. It is composed by 15 complete teleoperated tours and 4 autonomous navigation tours (datasets 1, 2, 3, 7), making a total of nearly 12*km* for the entire datasets recorded at Royal Alcázar of Seville and 2.2*km* for datasets of Lisbon Zoo. An important difference with respect [17] and [15] is that they collected data from fixed zenital cameras. Furthermore, this work presents a set of experiments recorded at different times of the day, providing an important database of images of the same places but with different light and crowded conditions. This represents a complete basis of evaluation for several algorithms and techniques that sustain themselves in image processing of the environment.

Many datasets are publicly available for testing localization algorithms, like the New College Dataset [19], a single 2.2*km* trajectory where a Bumblebee is used as stereo pair in addition to two working lasers in orthogonal planes, or St. Lucia Suburbs dataset [9], a single journey through the suburb of St Lucia, Queensland, Australia, where the large scale route was traversed five times during the same day to gather 66*km* of data from webcam, but no lasers were used. Both outdoor datasets are used to research on loop-closure detection or visual odometry [10, 8] by using GPS as source for ground-truth pose. In [4], it is presented a bank of 6 outdoor datasets also based on visual odometry and GPS in a trajectory of 6*km* outside of the School of Engineering at the University of Málaga, mainly road and parking during two different days.

Our contribution focuses on ground autonomous mobile robots at pedestrian level, in a crowded GPS denied area, where reliability, accuracy and human avoidance becomes essential. In the presented work there are enough datasets covering nearly full daylight scenario variations that can be used for algorithm training and validation. Each experiment has been intentionally carried out following the same trajectory approximately, starting at the same point, making the robot trajectories in a similar way and also finishing at the same point. All these elements configure an important basis to evaluate distinct techniques over the several topics that we mentioned before, with a practical set of complementary data for 24/7 localization and navigation analysis in human environments.

The presented datasets are also novel from the point of view of interaction between robot and people surrounding. In contrast to [21], these datasets gather the reaction of people at several places such corridors, gates, open areas, etc. and all the data is collected by the onboard robot's sensors. All the people reactions captured are directly motivated by the presence of the robot, so techniques like the presented at [12] could be applied to these datasets instead of trying to apply from observations between people interaction.

In addition, we provide a ground-truth for the robot position with an approximate accuracy between 20*cm* and 40 *cm*.

The Deliverable is structured as follows: Section 2 describes the datasets and the experiments carried out with the robot. Sections 3 summarize the interest of the datasets for various applications, like localization and visual place recognition purposes or analysis of human-robot interaction in crowded scenarios. Finally, Section 4 presents the conclusions.

# 2 Data description

This section will describe briefly the platforms employed, the data included and the main characteristics of each dataset (see Table 1).

## 2.1 Robot Platform: FROG

The robot platform used for datasets from 1 to 11 (see Tables 2 to 9) is the one designed in the project with a simple aluminum structure to place the sensors and the computers. The whole sensors stack is described thoroughly at Deliverable D1.4[1], but for the work presented here only some of them will be taken into account, such as the stereo cameras, the Hokuyo set of lasers rangefinder, the Inertial Sensor IMU and the motor encoders. The position into the robot structure can seen in Fig. 1:

- A stereo camera (2x Dalsa Genie-HM1400 XDR) facing forward at 1.2*m* height.
- A inertial sensor (Xsens MTI-G) in the robot's centre of rotation.
- Two Hokuyo UTM-30LX placed parallel to the floor facing forward and backwards.
- A Hokuyo URG-04LX tilted 30° in front of the robot.
- Encoders in the robot's wheels for odometry computation.

## 2.2 Robot Platform: Pioneer

The robot platform used for datasets from 12 to 21 (see Tables 2 to 9) is a Pioneer 3AT with a simple aluminum structure to place the sensors and the computer. The sensors and the position into the robot can seen in Fig. 2, they are the following:

- A Bumblebee stereo camera facing forward at 1.2*m* height.
- Two Hokuyo UTM-30LX placed parallel to the floor facing forward and backwards.
- A Hokuyo URG-04LX tilted 30° in front of the robot.
- Encoders in the robot base for odometry computation.

## 2.3 Experiments overview

All the datasets can be found in Table 1. They are grouped into three main groups: experiments performed at the Royal Alcázar with the Pioneer robot; experiments performed at the Royal

[1] https://www.frogrobot.eu/wordpress/?page_id=8#delivs

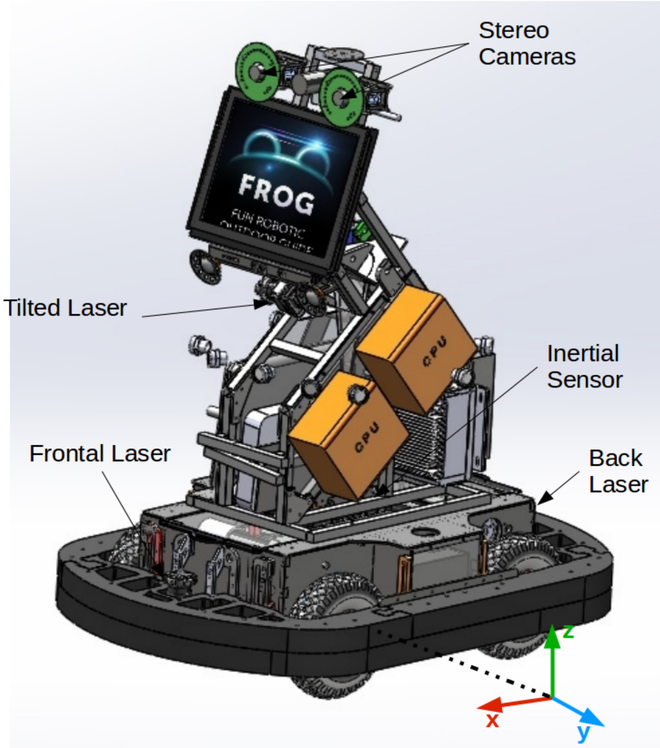



Figure 1: FROG platform configuration: Location of the lasers and the stereo cameras, plus others components. The origin frame is also indicated.

Alcázar with the FROG robot; and experiments performed at the Lisbon Zoo with the FROG robot.

During data collection of datasets 1, 2, 3, 7 the robot navigated autonomously through Royal Alcázar, and in each of the rest experiments the robot was manually guided through both the Royal Alcázar and the Lisbon Zoo. At the Lisbon Zoo the robot had to handle with a very irregular non-planar scenario, with important ramps that may be detected as obstacles by horizontal rangefinders. And at Royal Alcázar the robot passes through large rooms, corridors, small patios and big squares. Figure 4 shows some images of the environment during the robot's translation.

In order to validate place recognition algorithms and also to localize elements into a single reference frame, a map of the Royal Alcázar and the Lisbon Zoo were built using a different dataset; these maps are also provided with the dataset. Thus, a ground-truth has been computed based on this map, rangefinders and Monte Carlo Localization algorithm. Our visual tests show that the robot is always well localized into the map with errors from $20cm$ (most of the time) to $40cm$ (in large open areas scan matching may have poor likelihood). Although we cannot compare with respect a localization ground-truth, both trajectory and localization into the map are coherent with the real robot motion.

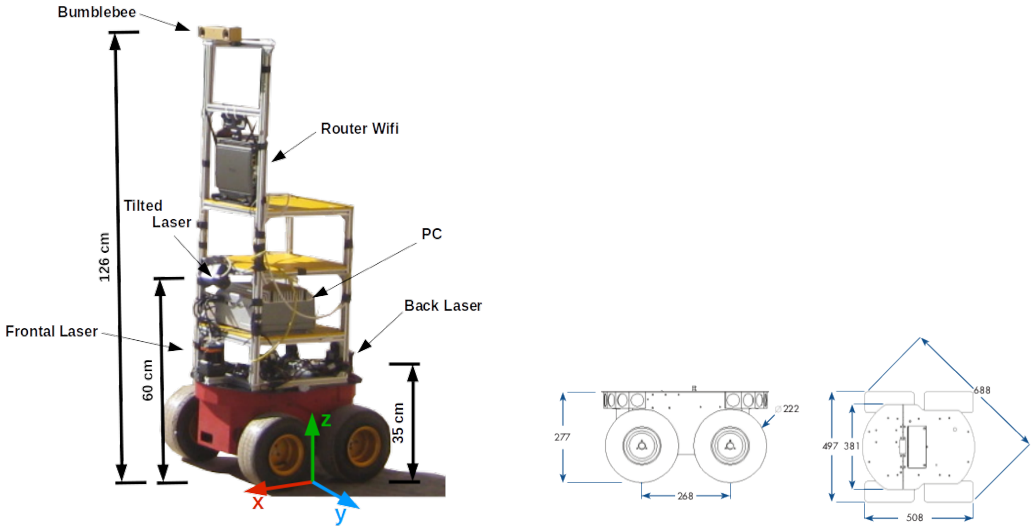



Figure 2: Top: Pioneer platform configuration: Location of the lasers and the bumblebee camera, plus others components. The origin frame is also indicated. Bottom: Dimensions of the platform. Measurements are in *mm*. Source: http://www.mobilerobots.com/ResearchRobots/P3AT.aspx

On the other hand, images and lasers can be used to detect and track persons around the robot. This information is valuable in order to learn and model how people interact with mobile robots. While we are not providing yet the person annotation in images and lasers, there already exists algorithms implemented in ROS that automatically detect persons using laser segments classifiers [1] or Histogram of Oriented Gradients (HOG) in images [6].

The experiments were carried out during several days. We performed 6 different experiments at different times of the day for Royal Alcázar and 2 experiments for Lisbon Zoo (see Tables 2, 3, 4 and 5). The experiments are not in a single day because of the needed time to recharge batteries between experiments. Although the ideal setup would be to have all the datasets in a row, we certified that neither the sunlight nor the tourist attendance changed significantly along the different experiments days, so it may not affect the datasets quality.

## 2.4 Dataset contents

As commented before, ROS[2] was used as main development tool for data gathering and logging, so all the sensors are recorded using the standard interfaces of ROS and also its communication facilities (topics, messages, filters, etc). Thus, the relative position of all sensors with respect the robot base are encoded using ROS Transforms (TF)[3]. All the sensors are time stamped and synchronized.

The datasets presented in this deliverable are available at: `https://www.frogrobot.eu/wordpress/datasets/`. Each of the datasets (see Tables 2 to 9) are stored separately in three main files: one for sensors measurements (raw bag), other for images: in the FROG robot compressed grayscale and disparity images and in Pioneer robot raw RGB images (in addition to grayscale rectified ones); and a third consisting of a computed global transformation of the robot with respect to the map frame, by using a Monte Carlo Localization Algorithm (tf bag).

[2] http://wiki.ros.org/
[3] http://wiki.ros.org/tf

| Group | Dataset# | Location | Robot | Day | Starting Time | Duration | Length |
|---|---|---|---|---|---|---|---|
| 1 | 1 | Royal Alcázar | FROG | 2014-09-26 | 11:00 | 35'33" | 241.42 m |
| 1 | 2 | Royal Alcázar | FROG | 2014-02-18 | 12:37 | 30'07" | 764.09m |
| 1 | 3 | Royal Alcázar | FROG | 2014-09-23 | 13:12 | 11'19" | 199.22m |
| 1 | 4 | Royal Alcázar | FROG | 2014-09-22 | 13:58 | 15'57" | 520.45m |
| 1 | 5 | Royal Alcázar | FROG | 2014-06-21 | 16:03 | 19'32" | 668.76m |
| 1 | 6 | Royal Alcázar | FROG | 2014-06-27 | 16:28 | 32'49" | 635.04m |
| 1 | 7* | Royal Alcázar | FROG | 2014-09-26 | 18:47 | 55'19" | 421.40m |
| 1 | 8 | Royal Alcázar | FROG | 2014-09-24 | 19:22 | 17'58" | 568.61m |
| 1 | 9 | Royal Alcázar | FROG | 2014-09-24 | 19:48 | 15'53" | 549.73m |
| 2 | 10 | Lisbon Zoo | FROG | 2013-09-17 | 11:14 | 61'24" | 1338.61m |
| 2 | 11 | Lisbon Zoo | FROG | 2013-09-20 | 16:50 | 22'46" | 857.05m |
| 3 | 12 | Royal Alcázar | Pioneer | 2014-05-01 | 08:41 | 30'15" | 819.48m |
| 3 | 13 | Royal Alcázar | Pioneer | 2014-04-29 | 09:44 | 29'10" | 757.85m |
| 3 | 14 | Royal Alcázar | Pioneer | 2014-04-30 | 10:31 | 26'42" | 666.84m |
| 3 | 15 | Royal Alcázar | Pioneer | 2014-04-29 | 11:36 | 29'41" | 712.09m |
| 3 | 16 | Royal Alcázar | Pioneer | 2014-04-30 | 12:43 | 31'43" | 717.46m |
| 3 | 17 | Royal Alcázar | Pioneer | 2014-04-29 | 14:57 | 29'09" | 744.76m |
| 3 | 18 | Royal Alcázar | Pioneer | 2014-04-28 | 15:53 | 41'56" | 630.75m |
| 3 | 19 | Royal Alcázar | Pioneer | 2014-04-29 | 16:41 | 29'29" | 774.70m |
| 3 | 20 | Royal Alcázar | Pioneer | 2014-04-28 | 17:40 | 30'16" | 793.95m |
| 3 | 21 | Royal Alcázar | Pioneer | 2014-04-30 | 18:37 | 29'57" | 756.13m |

Table 1: Summary of datasets. Dataset 7 was recorded during the European Researchers' Night demo.

The tf bag can be used to compare different localization algorithms, and the transformation mentioned is used to generate robot localization in the map frame.

Furthermore, to provide a quick glance over the different data contained at each raw and image bag (and also some extra information such as number of messages or timespan) a set of *. txt* files is included. Also, two extra files are available: one with extension *.dat* in which the traveled distance, the coordinates of the start and end points and the timespan are indicated; and the other with extension *.txt* in which the real time-stamped poses of the robot during the trails are shown. All the datasets are logged and also processed using ROS tools, such as the *ROS Bag*[4]. The different information stored into the logs also follows ROS interfaces and development main guidelines, so that the reader can understand easily the dataset with minimum ROS background.

The three log files per dataset contain the following information:

- Robot odometry. Topic */pose* in Pioneer, */odom* in the FROG robot, datatype *nav_msgs/Odometry*[5]. This odometry corresponds either to the FROG robot or Pioneer platform. Both are differential platforms. The odometry is computed by incremental distance travelled measurements from the wheel encoders and, in FROG, a algorithm of integration and filtering the information provided by the IMU to correct errors when rotating. The information is published at a rate of 10 *Hz*.
- IMU readings (only in the FROG robot). The IMU data is stored in the topic */imu/data* of datatype *sensor_msgs/Imu*, with interesting information relative to linear an angular

[4] http://wiki.ros.org/Bags
[5] http://wiki.ros.org/nav_msgs

(a) (b) (c) (d)

Figure 3: Different indoor and outdoor places at the Lisbon Zoo.

(a) (b) (c) (d)

Figure 4: Images gathered by the robot while teleoperated at Royal Alcázar.

velocities and accelerations. The IMU is established in the center of the robot to make easier working with its values.

- Laser measurements. Both platforms are equipped with 3 Hokuyo Lasers, one frontal (topic */scanfront*), a second in the back of the robot (topic */scanback*) and a third one tilted 30° in the front of the robot (topic */scanvtcal*) for negative height obstacles avoidance and better anticipation of positive obstacles. These topics follow the datatype *sensor_msgs/LaserScan*[6]. Both frontal and back lasers publish data at a rate of 40 *Hz*, while tilted one does at 10 *Hz*.

- Transformations between sensors. Topic */tf* of datatype *tf/tfMessage*[7] offers information about static transformations between sensors and robot system reference, as sensors are fixed to robotic platform, and also transformation between starting point (frame_id: /odom) and robot (frame_id: /base_link). Frame_id's of sensors are: /bumblebee (camera used in Pioneer), /stereo_cam (in case of the camera used in the FROG robot), /laserfront (frontal laser), /laserback (back laser) and /laservtcal (tilted laser). This information is published at a rate of 10 *Hz* each.

- Raw RGB image (only in Pioneer). Topics */bumblenode/left/image_raw* and */bumblenode/right/image_raw* of datatype *sensor_msgs/Image*[6] with the images gathered form the stereo pair. The images are captured at 5 *Hz* approximately.

- Rectified image (only in Pioneer). Topics */bumblenode/left/image_rect* and */bumblenode/right/image_rect* of datatype *sensor_msgs/Image*[6], this time grayscale rectified images. They have been computed offline, the rectified images and camera info contain the same time stamp as the source raw image.

- Camera Info in Pioneer. Topics */bumblenode/left/camera_info* and */bumblenode/right/camera_info* of datatype *sensor_msgs/CameraInfo*[6] carry information about camera calibration. They contain the camera calibration for left and right cameras using ROS interface. They are published synchronized with the images at 5 *Hz* approximately.

- Compressed grayscale images (only in FROG). Topics

[6]http://wiki.ros.org/sensor_msgs
[7]http://wiki.ros.org/tf

(a)

Figure 5: People detection based on stereo pair. The FROG robot at Lisbon Zoo.

*/stereo/left/image_raw/compressed* and */stereo/right/image_raw/compressed* of datatype *sensor_msgs/CompressedImage*[6] with the images gathered form the stereo pair. The images are captured at 5 *Hz* approximately.

- Camera Info in FROG. Topics */stereo/left/camera_info* and */stereo/right/camera_info*. They are published synchronized with the images at 5 *Hz* approximately.
- Disparity info (only in FROG). Topic */stereo/disparity* of datatype *stereo_msgs/DisparityImage*[8] with the disparity info corresponding to the stereo pair. The data is captured at 5 *Hz* approximately.
- Camera based person detection (only in FROG). Topic */UvA_PersonDetectionAndPose* of datatype *FROG_msg/PersonsUVA*[9].

Datasets 2, 5, 6 from the Royal Alcázar of Seville and 10, 11 from the Lisbon Zoo (see Tables 2 to 5) are quite interesting from the point of view of testing person detection based on the stereo pair, corresponding to Milestone MS2 (see Fig 5) as they have this data under the topic */UvA_PersonDetectionAndPose* commented above. The camera data can be used for testing alternative algorithms, or even comparing against laser-based algorithms. The datatype *FROG_msg/PersonsUVA* can be added to any ROS installation and follows this structure:

```
Header header
timeUVA Timestamp
UVAPerson Person
uint32 ID
```

[8]http://wiki.ros.org/stereo_msgs

[9]https://www.dropbox.com/sh/lbxa0lyhsieyl0i/AABJ1i5KPVlUTCDU_kN3Dna?dl=0

*FROG_msg/timeUVA*:

```
uint32 Seconds
uint32 Microseconds
```

And *FROG_msg/UVAPerson*:

```
float64 Prob
float64 X
float64 Z
float64 Height
float64 Orientation
float64[] OrientationPDF
```

consisting of the distance in mm (X, Z) from the detected person to the camera (Z orthogonal to the left lens), the probability of success, the estimated height (mm) of the person and his estimated orientation (degrees, $0^{o}$ when orientated in the same direction of the robot and increasing to the right) and orientation probability density function (discretized in 360 values). The amount of detections relative to this topic stored in these datasets is:

Dataset 2 (12:37, FROG at Royal Alcázar of Seville): 4085 msgs
Dataset 5 (16:03, FROG at Royal Alcázar of Seville): 1089 msgs
Dataset 6 (16:28, FROG at Royal Alcázar of Seville): 1808 msgs
Dataset 10 (11:14, FROG at Lisbon Zoo): 634 msgs
Dataset 11 (16:50, FROG at Lisbon Zoo): 253 msgs

As the rest of datasets, these ones have not only image data or people detections, they also have the rest of sensorial data described above.

# 3 Applications

From the point of view of possible applications of this data localization is the main one: the challenging scenarios considered in this work are crowded (see Fig. 6) and mostly planar areas. Some ramps are present in robot's trajectory that can be eventually detected as obstacles by horizontal lasers, affecting to localization and navigation (mainly in Lisbon Zoo). A tilted laser is aggregated to be used for small steps and ramps detection and determine by software if the robot will be able to cross the area or not.

Most traveled area in Royal Alcázar presents good scan matches even when the robot is partially surrounded by people, being worst in Lisbon Zoo due to environmental structures (see Tables 2 to 9). But, as Royal Alcázar is a highly crowded scenario, the robot may become complete surrounded and lost or converged to a wrong location. To solve this situation, images gathered with both left and right cameras make the dataset interesting for testing loop closure and kidnapping algorithms based in scene recognition.

Having a nearly full day dataset allows training algorithms for different situations or illumination variances, as shown in Fig. 7. These datasets offer the possibility to study daylight variation in a mixed indoor outdoor structured environment and use this information for improving localization or augmenting accuracy.

This dataset is also useful for testing algorithms for removing illumination effect in scenes [5, 14, 16] destined to provide outdoor long-term localization based on scene recognition for

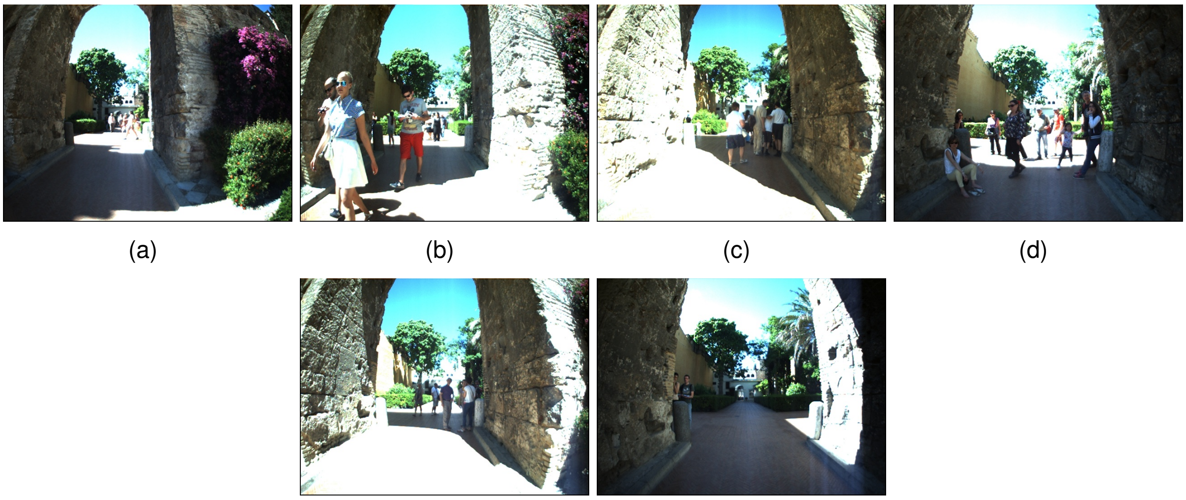
Figure 6: (a) Camera occlusion; Blocked gates: (b) still standing people, (c) walking people; Crossing people: (d) no socially conventional way (by the left), (e) socially conventional way; (f) Approaching people; (g) Crowded corridors ; (h) Crossing people; (i) Following groups of people ; (j) Close interaction

mobile robots, because of the recording of illumination variation in same scenes over the range of time covered by datasets.

Another important application is human-robot interaction. The datasets presented in this work represent a valuable set of images and range measurements that could be used to the comprehension of several human-robot behaviours or interactions. Lengthwise for more than $10h26m$ of collected video, a great collection of real interaction scenes could bring us a qualitative idea of the different behaviours by studying and tagging it.

Qualitative information can be extracted from the visualization of the videos or the images to propose new algorithms or techniques to tackle this kind of problems. Furthermore, we could have a rich set of examples even in changing situations (avoid people in more narrow or wide corridor, or maybe at big squares; it is also possible to find examples of avoiding people at a corridor which perimeter is a vegetable fence,...). For some examples of detailed scenes, please refer to Fig. 6. On the other hand, all the data is available as images and range measurements, both from onboard sensors (like we described before). This kind of data is useful for many applications, such as validating techniques about people detection and tracking (from camera visual [11] or range laser measurements, as well as if we are interested for individual [2] or groups [13]).

Finally, this rich information source could be used to classify and to identify the observe behaviors. We might extract some of the human-robot interaction features from the sensors mounted into the mobile robot. It turns out that, in contrast to [3], [20], [18], [22], [7], the training data needs to be captured while the robot is actually present.



(a) (b) (c) (d)

(e) (f)

Figure 7: Strong daylight variations at Royal Alcázar of Seville, that may cause in the same scene different features detection in visual algorithms.

# 4 Conclusions

In this deliverable we present a set of datasets collected at Royal Alcázar of Seville at many different hours and 2 datasets collected at the Lisbon Zoo. As explained above, both scenarios have mixed indoor and outdoor areas and the Royal Alcázar is a crowded mostly planar scenario while the Lisboon Zoo is a non-planar scenario. In these datasets two platforms were used in Royal Alcázar (FROG robot and Pioneer) and only one in the Lisbon Zoo (Pioneer).

These datasets present a valuable HRI information according to the used setup. As we mentioned before, they provide a large set of scenes which could be labeled or tagged, and after that the data could be analyzed by range measurements and/or image processing to propose models of human behaviors, predictions, etc. It is also a great source of qualitative information that could help researchers to prepare HRI experiments.

The data is very interesting for localization purposes, particularly for testing long-term localization algorithms based in rangefinders or image processing. More than 14*km* of data was gathered, with information of lasers, camera and odometry stored in ROS format. Commented repeatability is an added value to raw data, through the possibility to analyze algorithm responses in many tests with people and illumination variations in similar trajectories.

## Description of datasets

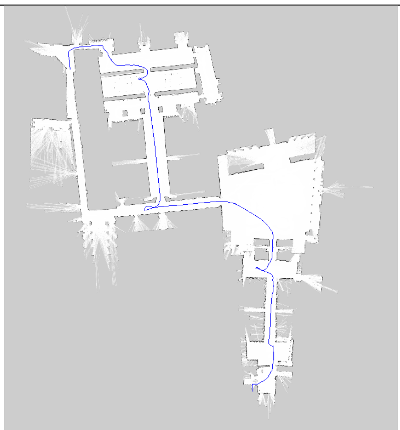
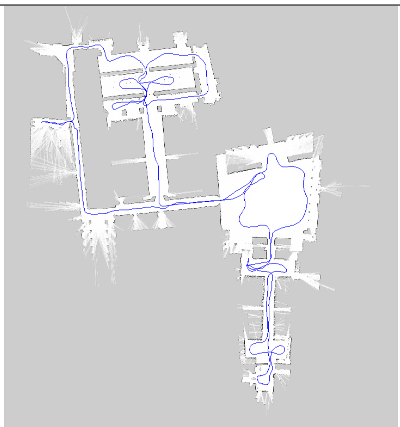
| Robot Path (FROG at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 1<br>11:00am | The robot navigated *241.42 m* for *35:33s* receiving 6312 images and more than 86440 range measurements (frontal laser). |
|  | Dataset 2<br>12:37am | The robot navigated *764.09 m* for *30:07s* receiving 8200 images and more than 72622 range measurements (frontal laser). |
|  | Dataset 3<br>13:12am | The robot navigated *199.22 m* for *11:19s* receiving 1331 images and more than 27225 range measurements (frontal laser). |

Table 2: Plot and description of datasets 1-3 (FROG at Royal Alcázar of Seville).

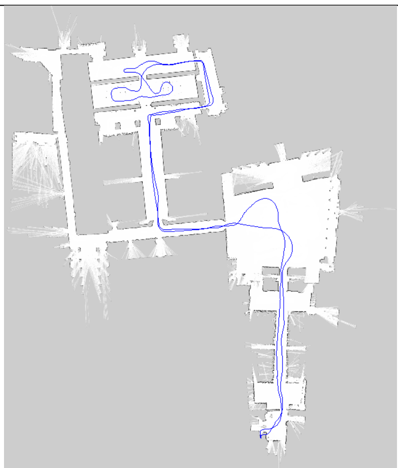
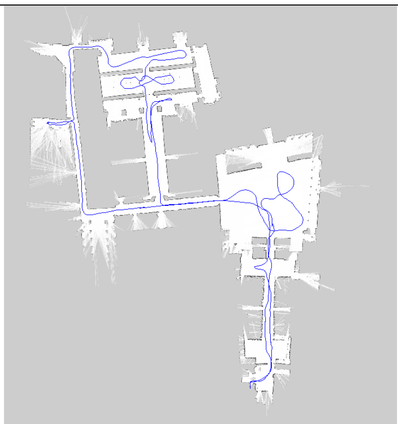
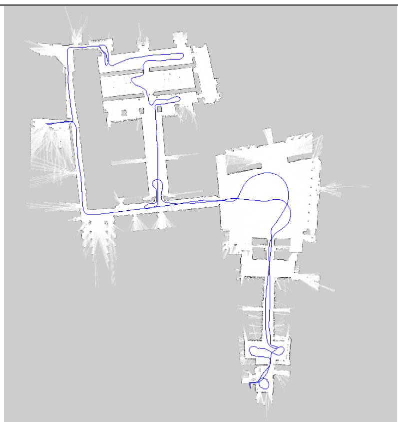
| Robot Path (FROG at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 4<br>13:58am | The robot was teleoperated *520.45 m* for *15:57s* receiving 3660 images and more than 38271 range measurements (frontal laser). |
|  | Dataset 5<br>16:03am | The robot was teleoperated *668.76 m* for *19:32s* receiving 5081 images and more than 47316 range measurements (frontal laser). |
|  | Dataset 6<br>16:28am | The robot was teleoperated *635.04 m* for *32:49s* receiving 8741 images and more than 79140 range measurements (frontal laser). |

Table 3: Plot and description of datasets 4-6 (FROG at Royal Alcázar of Seville).

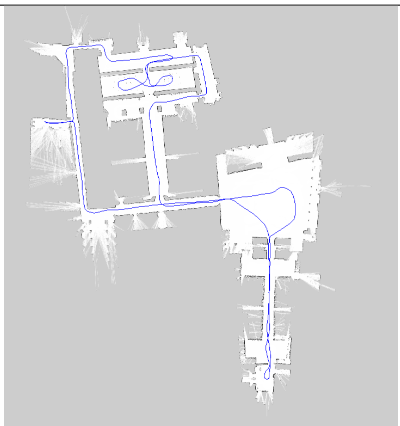
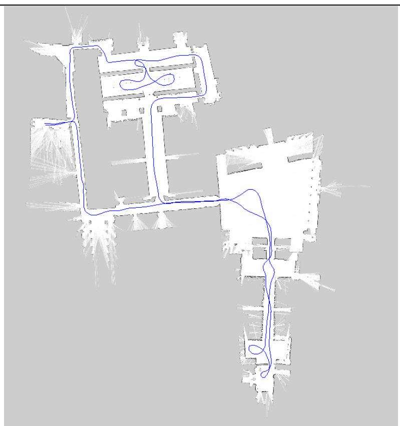
| Robot Path (FROG at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 7* 18:47am | The robot navigated *421.40 m* for *55:19s* receiving 13181 images and more than 134978 range measurements (frontal laser). |
|  | Dataset 8 19:22am | The robot was teleoperated *568.61 m* for *17:58s* receiving 5568 images and more than 43097 range measurements (frontal laser). |
|  | Dataset 9 19:48am | The robot was teleoperated *549.73 m* for *15:53s* receiving 4322 images and more than 38245 range measurements (frontal laser). |

Table 4: Plot and description of datasets 7-9 (FROG at Royal Alcázar of Seville). Dataset 7 was recorded during the European Researchers' Night demo.

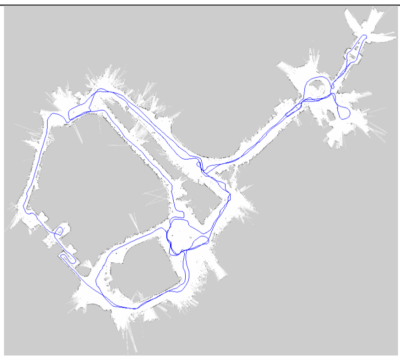
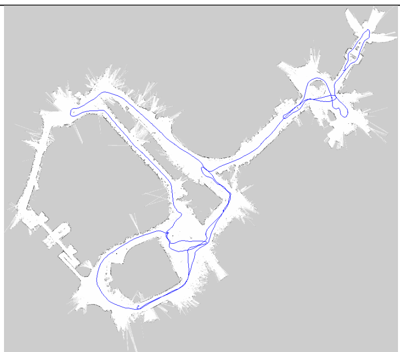
| Robot Path (FROG at Lisbon Zoo) | Dataset name | Description |
|---|---|---|
|  | Dataset 10<br>11:14am | The robot was teleoperated *1338.61 m* for *61:24s* receiving 14734 images and more than 146903 range measurements (frontal laser). |
|  | Dataset 11<br>16:50am | The robot was teleoperated *857.05 m* for *22:46s* receiving 5345 images and more than 55404 range measurements (frontal laser). |

Table 5: Plot and description of datasets 10-11 (FROG at the Lisbon Zoo).

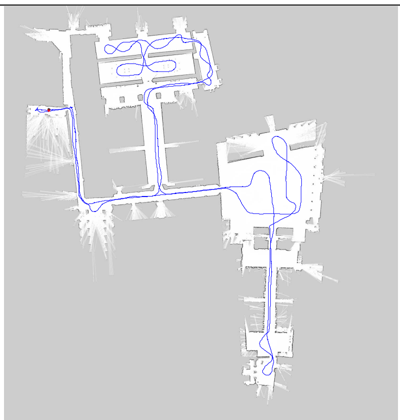
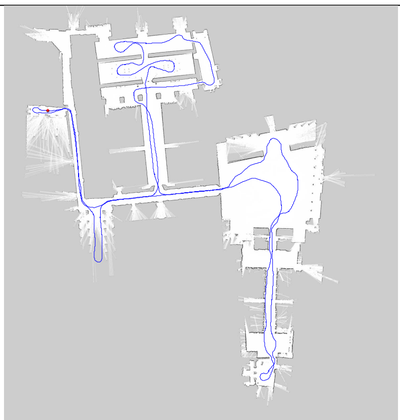
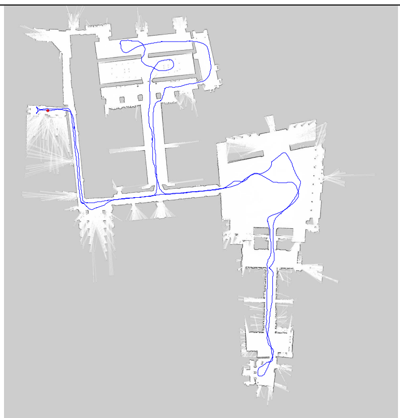
| Robot Path (Pioneer at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 12<br>8:41am | The robot was teleoperated *819.48 m* for *30:15s* receiving 8170 images and 72644 range measurements (frontal laser). |
|  | Dataset 13<br>9:44am | The robot was teleoperated *757.85 m* for *29:10s* receiving 7876 images and 70046 range measurements (frontal laser). |
|  | Dataset 14<br>10:31am | The robot was teleoperated *666.84 m* for *26:42s* receiving 7212 images and 64238 range measurements (frontal laser). |

Table 6: Plot and description of datasets 12-14 (Pioneer at Royal Alcázar).

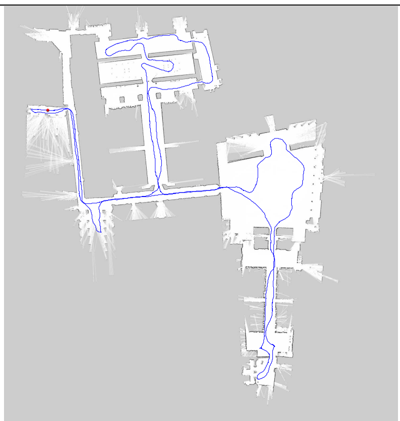
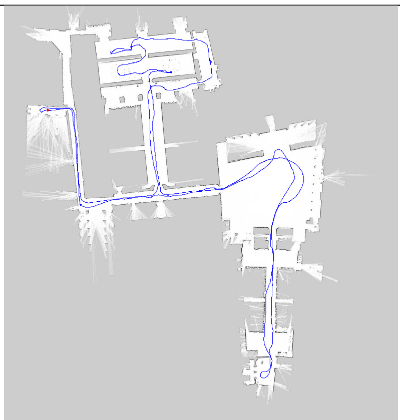
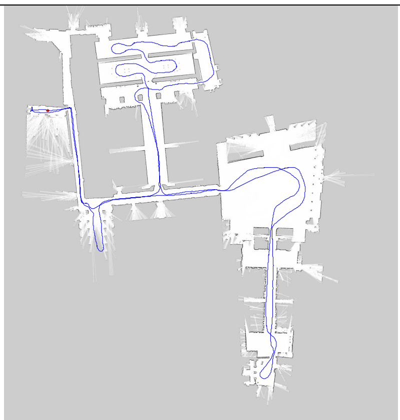
| Robot Path (Pioneer at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 15<br>11:36am | The robot was teleoperated *712.09 m* for *29:41s* receiving 8015 images and 71417 range measurements (frontal laser). |
|  | Dataset 16<br>12:43am | The robot was teleoperated *717.46 m* for *31:43s* receiving 8567 images and 76088 range measurements (frontal laser). |
|  | Dataset 17<br>14:57am | The robot was teleoperated *744.76 m* for *29:09s* receiving 7870 images and 70062 range measurements (frontal laser). |

Table 7: Plot and description of datasets 15-17 (Pioneer at Royal Alcázar).

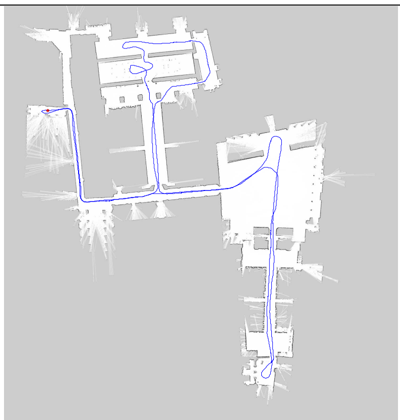
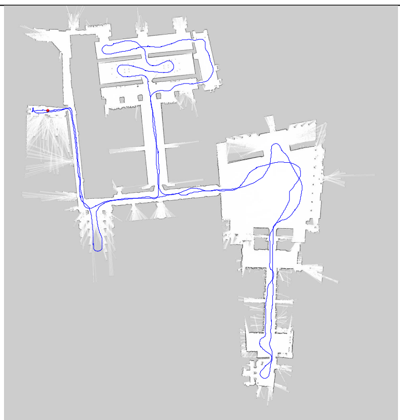
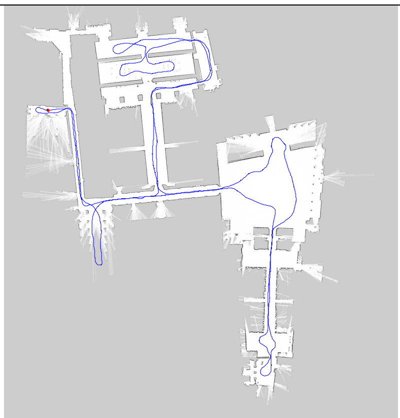
| Robot Path (Pioneer at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 18 15:53am | The robot was teleoperated *630.75 m* for *41:56s* receiving 6825 images and 60758 range measurements (frontal laser). |
|  | Dataset 19 16:41am | The robot was teleoperated *774.70 m* for *29:29s m* receiving 7963 images and 70923 range measurements (frontal laser). Back laser crashed after 914s of execution. |
|  | Dataset 20 17:40am | The robot was teleoperated *793.95 m* for *30:16s* receiving 8176 images and 72833 range measurements (frontal laser). |

Table 8: Plot and description of datasets 18-20 (Pioneer at Royal Alcázar).

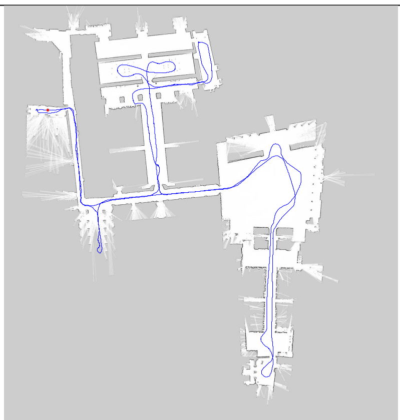
| Robot Path (Pioneer at Royal Alcázar) | Dataset name | Description |
|---|---|---|
|  | Dataset 21 18:37am | The robot was teleoperated *756.13 m* for *29:57s* receiving 8087 images and 71945 range measurements (frontal laser). |

Table 9: Plot and description of dataset 21 (Pioneer at Royal Alcázar).

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