ERL Consumer Service Robots Test Bed Certification

Heriot-Watt@Home ERL Test Bed

Test bed name: Heriot-Watt@Home ERL Test Bed

Test bed web page URL: https://robotic-assisted-living.hw.ac.uk/erl

Name of Institution where test bed is hosted: Heriot-Watt University, Edinburgh, UK

Designation of the lab/department/group where test bed is located: Institute of Sensors, Signals and Systems, School of Engineering and Physical Science

Name of responsible person: Mauro Dragone

Contacts of responsible person:
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Short description of the facility, including the type of furniture used, wall materials, available objects and robot platforms

The test-bed is designed to adhere to the ERL-SR rulebook and is composed of:

- Rooms (accessible to the robot): one inside hallway (with one coat-rack), one large (8mt X 3.825mt) open plan space with kitchen (kitchen worktop and two chairs, a kitchen cabinet with multiple drawers and wash sink, three wall-mounted kitchen shelves), dining (one wooden table and 4 chairs) and sitting room area (a large window, a couch, a sofa, an armchair, one coffee table, one TV table and one large floor lamp), one (3.78mt X 3.14mt) bedroom (one window, a double bed, two side tables, two table lamps and one large wardrobe with mirror) and one (2.7mt X 3.14mt) bathroom
- Spatial areas (inaccessible to the robot): outside hallway, directors' room (with workstation, control monitors and smart home gateways)
- Well-levelled floor, uniform all over the testbed, but including rugs.
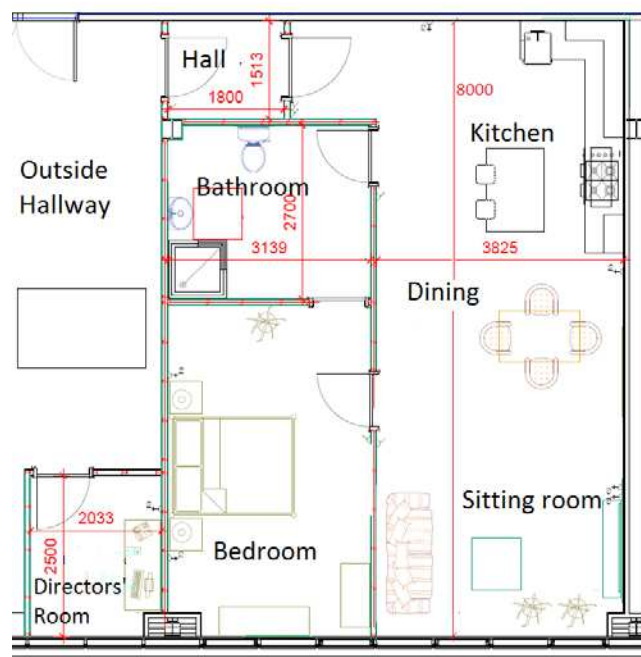- Dry walls, 2.4mt high.

Figure 1: Floor plan of test-bed

Figure 2: Open space room with kitchen, dining and living room areas (left), and view of kitchen and dining areas (right).

Figure 3: Bedroom (left), and Bathroom with view of the bedroom (right). .A sliding door joins the two rooms.

List of home automation devices available, including photo, make, model and main features

- Work station: A computer used to run the RSBB software and a central instance of Robotic Operating System (ROS).
- Server(s): A cluster of remote computers providing storage (e.g. for dataset collection) and additional computational resources for the control of the robots operating in the test-bed. It hosts another instance of ROS and it is connected to the work station through a virtual private network (VPN).
- Switch: An Ethernet switch used to connect the workstation, the smart home gateways, and a network of IP cameras.
- AP: An Access Point the mobile robots and other wireless devices connect to. Acts as a bridge between WLAN and LAN. The Access Point is an Asus RT-AC88U **(Speed:** 802.11ac: 2167Mbps 802.11n: 1000 Mbps, **Connectivity:** 9x Gigabit Ethernet)
- Smart home gateways: The laboratory is equipped with a number of gateways to proprietary smart home technology. A mini-computer (raspberry-pi) running the OpenHAB (https://www.openhab.org/) smart home middleware is used to integrate all the different technology into a single smart home system and it is easily configured to connect new devices. The middleware is fully integrated with the RSBB software.
- User interfaces: one Android tablet running user interface software to interact with the ERL RSBB software and the smart home, and smart speakers, including Amazon Echo and Google Home.
- IP cameras: 4 Power over Ethernet (PoE) cameras (2 Axis M5014 compact IP dome cameras with pan and tilt, HD 720p plus 2 EZVIZ C4S 1080P HD IP Dome Cameras), installed on the ceiling, and 1 wireless camera (Axis M1065-LW, HD 1080p) facing the Outside Hallway. The parameters (frame rate, resolution, and colour gains) of the latter can be changed over wireless.
- Other sensors:
  - RFID floor (passive tags under the floor of each room, ~1000 tags in total)
  - 8 ceiling mounted passive infrared sensors (PIRs)
  - 40 magnetic switch sensors in drawers and doors
  - Energy monitoring
  - Light, CO2, temperature, humidity and smoke sensors
- Home Automation Devices:
  - 3 motor to control the window blinds
  - 4 controlled power plugs
  - 4 automated lights, 2 of which dimmable
  - 6 colour changing LED light strips and 2 colour changing LED lamps
  - 1 video doorbell

Available Motion Capture system (make, model, and main features)

Motion capture is not currently available.

Other relevant information

The test bed includes many Navigation-Relevant Objects (e.g., couch, tables, chairs), Manipulation-Relevant Objects (e.g., glasses, cups, cans, plates, forks, knifes, books) and Perception-Relevant Objects (e.g., cereal box, cans, cups, glasses). There are pillows with different solid colours but also patterns, transparent and opaque cups, wooden and glass shelfs, a mirror in the bedroom, a TV and other domestic appliances etc.

Current list of TBMs and FBMs for which the test bed is certified

Benchmark	Minimum required system / devices	Available in Test Bed
TBM1: Getting to know my home	RSBB	Yes
TBM2: Welcoming visitors	RSBB, IP camera at entrance	Yes
TBM3: Catering for granny Annie's comfort	RSBB, HAD	Yes
TBM4: Visit my home	RSBB	Yes
TBM5: General purpose service robot	RSBB	Yes
FBM1: Object perception functionality	RSBB, MoCap	No
FBM2: Navigation functionality	RSBB, MoCap	No
FBM3: Speech recognition functionality	RSBB	Yes

Table 1: List of the ERL-SR benchmarks with their corresponding required systems