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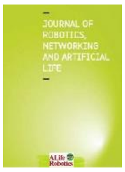

Research Article

A Tutorial on Modelling a Real Office Environment in Gazebo Simulator

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ABSTRACT

Testing is a crucial aspect of robotic systems development. New robotic concepts should be proven to be safe and effective before running on real robotic platforms in real environments. Robotic simulation allows creating virtual environments and repeating real-world scenarios. 3D modelling has become a standard way for creating on-demand compound digital 3D models with a high level of realism. This research paper presents a guide on prototyping a real office environment in Gazebo simulator. Blender modelling suite is used for creating high-quality 3D models. The validation approach applied to the virtual environment is to perform lidar-based SLAM task for a mobile robot. Human-environment interaction tests were executed using extended Gazebo actors.

1. Introduction

For creating 3D digital replicas of real-world objects and surfaces 3D modelling techniques are commonly used [1]. These techniques are frequently employed by roboticists for prototyping 3D robot models [2], [3] and test sites [4], [5]. A 3D model is a digital representation of a real object that has natural physical and visual features of texture, size, shape and scale. 3D modelling software tools (e.g., Blender [6]) allow developing 3D objects, which should be further uploaded into a virtual environment.

A simulation is an important step in robotics that aims to emulate real-life conditions and significantly reduces time and resources consumption during the first stages of a research project [7]. Developing safe and reliable robotic algorithms and concepts is a challenging task often requiring high-quality virtual environments [8]. In this case, 3D virtual environment modelling is used. 3D modelling means creating realistic virtual environment features and objects such as landscapes, terrains, buildings and their interior, and other objects. A 3D virtual models assist in robot task performance preliminary evaluation, e.g., a simultaneous localization and mapping (SLAM) task [9]. During a mapping procedure, a robot explores an environment which can have characteristics of different level of difficulty.

This article presents a tutorial on modelling a real office environment in Gazebo simulator. The tutorial employs the 14th floor of the 2nd study building of Kazan Federal University (KFU) as a source of a real office environment. An environment model and furniture were created with Blender modelling tool, which has a user-friendly interface, a good documentation and is available for a free use. Gazebo, which is a popular free 3D simulator, was utilized to simulate and test the created virtual environment. The simulator allows designing and rendering a complex digital environment and running robot operations within it. The validation approach involved evaluating a 2D lidar-based SLAM task for a UGV under Robot Operating System (ROS). The virtual environment made for Gazebo was evaluated with a human-environment interaction tests that employed extended Gazebo actors from LIRS-HMLG library [10].

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2. Environment Modelling

3D modeling workflow requires a real 2D view of a 3D object. A 2D CAD drawing provides essential information about objects' sizes, shapes, surface types, materials used, etc. in different views. A 2D plan of the 14th floor of KFU 2nd study building that was used for the virtual environment construction is shown in Fig. 1.

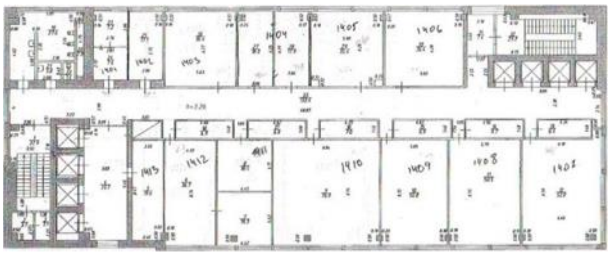

Fig. 1. A floor plan of a real environment: a top view.

The following features of the floor plan were considered: rooms' sizes, corridor dimensions, restricted (for a robot or a general public entrance) room locations, stairs, and washrooms. The restricted rooms, stairs, and washrooms were omitted for an environment mesh simplification in Gazebo 3D rendering. The environment modelling is divided into several steps: creating a model base construction called a skeleton frame; extending the frame model and adding a floor of the skeleton frame and windows; populating rooms' interiors with furniture.

A frame structure model utilized blocks of cuboids and parallelepipeds of different sizes and thicknesses. The 14tth floor frame model is shown in Fig. 2. It has a height of 3 m, a length of 45 m, and a width of 15 m.

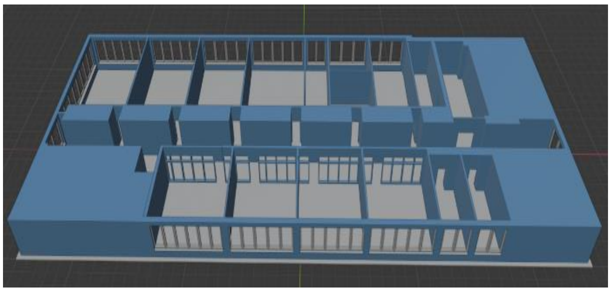

Fig. 2. 3D model of a skeleton frame designed.

The environment floor is a set of building tiles that are designed as a single continuous solid chunk (Fig. 3). The floor has a height of 0.03 m, a length of 45 m, and a width of 15 m. The environment floor color is whitewash.

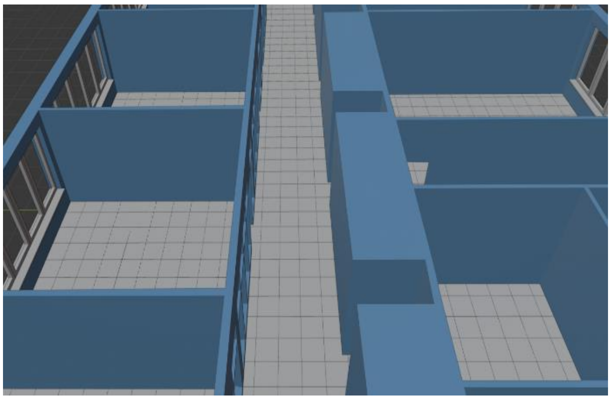

Fig. 3. Floor model: a set of building tiles joined.

The high-quality tiled floor contains windows with transparent and tinted glass [11]. Classroom interior includes chairs, wardrobes, and tables. Dimensions of each table are 0.8 × 0.55 × 1.75 m, dimensions of a chair are 0.9 × 0.4 × 0.41 m. An average depth of a wardrobe is 0.8 m, height and length is 1.6 and 0.8 m respectively. Fig. 4 shows a virtual classroom populated with chairs, wardrobes, and tables.

Fig. 4. A room interior: tables, chairs and wardrobes.

3. Environment Validation

To ensure that a constructed virtual environment is suitable for new algorithms' testing, it should be preliminary validated against typical scene requirements. The most crucial requirement is detecting collisions that occur between different objects. Performing a lidar-based 2D SLAM would demonstrate that LRF beams detect walls and interior objects properly, and measured data could be used to create a 2D environment grid map. ROS *hector_slam* algorithm [12]. which utilizes LRF sensory data to build a 2D occupancy grid map, was selected and run on Servosila Engineer mobile crawler-type robot. Fig. 5 depicts the complete virtual model of the 14th floor.

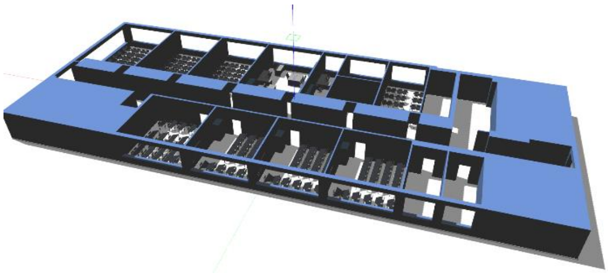

Fig. 5. A virtual environment populated with furniture.

Fig. 6 shows a 2D environment map that was produced by *hector_slam* mapping module. The map is represented as a grid map where each cell pixel encodes environmental information: black color is an obstacle, white is an obstacle-free zone, grey is an unknown area.

Fig. 6. A virtual environment's occupancy grid map.

Human models from LIRS-HMLG library were used to validate the environment with human-environment interaction testing. The LIRS-HMLG library models extend the standard human model of Gazebo and have different gender, body types, age, hairstyle, clothes and accessories. Each human has a collision model and different animations, including walking, running (Fig. 7), standing, talking and sitting on a chair (Fig. 8), which allow interactions with a virtual scene.

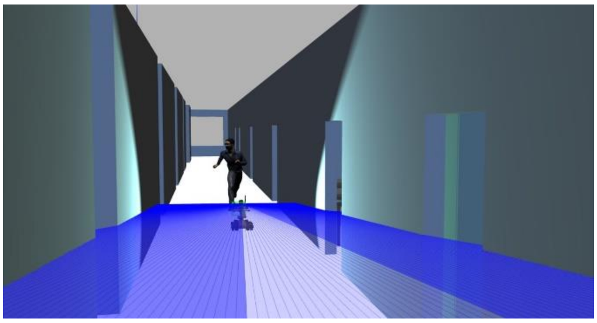

Fig. 7. A human and the Servosila Engineer robot explore the corridor: the robot laser beams (blue color) interact with the walls.

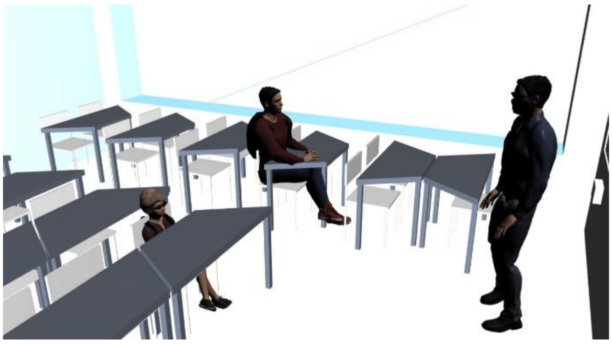

Fig. 8. A teaching scene with three human models.

4. Conclusions

This paper presented a tutorial on modelling a real office environment in Gazebo simulator. The model consists of walls of different thickness, a high-quality tiled floor and windows with transparent and tinted glass. A room interior includes chairs, wardrobes, and tables. Virtual validation of the environment was done by performing *hector_slam* mapping algorithm with the Servosila Engineer mobile crawler-type robot. Human-environment interaction testing was done using extended Gazebo actors.

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