

Experience in Efficient Real Office Environment Modelling in Gazebo: a Tutorial

Bulat Abbyasov

*Intelligent Robotics Department, Kazan Federal University, 35 Kremlyovskaya street,
Kazan, 420111, Russian Federation*

Kirill Kononov

*Intelligent Robotics Department, Kazan Federal University, 35 Kremlyovskaya street,
Kazan, 420111, Russian Federation*

Tatyana Tsoy

*Intelligent Robotics Department, Kazan Federal University, 35 Kremlyovskaya street,
Kazan, 420111, Russian Federation*

Edgar A. Martínez-García

*Department of Industrial Engineering and Manufacturing, Universidad Autónoma de Ciudad Juárez,
Manuel Díaz H. No. 518-B Zona Pronaf Condominio,
Juarez, 32315, Mexico*

Evgeni Magid

*Intelligent Robotics Department, Kazan Federal University, 35 Kremlyovskaya street,
Kazan, 420111, Russian Federation*

*E-mail: abbyasov@it.kfu.ru, k.g.kononov@gmail.com, tt@it.kfu.ru, edmartin@uacj.mx, magid@it.kfu.ru
<http://robot.kpfu.ru/eng>*

Abstract

New robotic solutions should be carefully verified before executing with real robots in real environments. Simulation provides a significant support in testing, but requires test sites with a high level of realism. In this case, 3D modeling can be used to produce the necessary 3D digital representation of real objects with varying difficulty. This article presents a step-by-step tutorial on modeling a realistic office environment. The environment contains a building skeleton frame, windows, building tiles, and furniture. Blender modeling toolset was used to create high-quality 3D models in the Gazebo simulator. The constructed virtual environment was validated with a lidar-based SLAM task for a UGV.

Keywords: 3D modeling, UGV, lidar-based SLAM, Gazebo.

1. Introduction

Real-world objects 3D modeling is the most commonly used technique for producing a 3D digital representation real 3D objects or surfaces¹. In robotics field the

modeling approach is often used for prototyping 3D robot models^{2,3}, designing test sites^{4,5}. The 3D model is a replica of a real object and has actual physical and visual characteristics: size, scale, shape, texture. 3D modeling toolsets allow creating 3D objects, e.g., Blender⁶.

However, to interact with a 3D model, it should first be loaded into a virtual environment.

Simulation is an essential part in robotics research field. The purpose of a simulation is to imitate real environment conditions (e.g., gravity). The benefits of using simulation: no special hardware is required; virtual experiments take less time than real experiments; quick algorithm errors detection in early implementation stages⁷.

Developed novel concepts, approaches, and algorithms should be verified before executing with robots in real environments⁸. In robotics, 3D modeling provides a significant support in proving the correctness of robotics tasks performed. One of these tasks is simultaneous localization and mapping (SLAM)⁹. During a mapping procedure, a robot explores an environment and creates a map. 3D modeling allows creating necessary virtual environments with a high realism level: landscapes, terrains, buildings, building interiors and other objects with varying difficulty.

This paper presents a step-by-step tutorial on creating a realistic office virtual environment. The 14th floor of the second study building of Kazan Federal University (KFU) was used as a real office environment. Blender was chosen as a modeling software tool due to its intuitive interface, good documentation, and free license. For simulating and testing the modeled virtual environment we used Gazebo simulator. Gazebo is a popular well-designed free 3D robotics simulator that makes it possible to design and emulate complex virtual environments and operate robots within them. The constructed virtual environment is validated through a lidar-based SLAM task for a UGV performed using Robot Operating System (ROS). ROS provides necessary interfaces to simulate robots in Gazebo simulator.

2. Environment Modeling

3D modeling requires special 2D CAD drawings of a real model. A 2D drawing represents the top view or side view of an object. An artist uses 2D drawings to get a basic understanding of the model object and its technical characteristics (size, shape, etc.). We used a 2D plan of the 14th floor of KFU 2nd study building that is shown in Fig. 1.

We used the following characteristics of the floor plan:

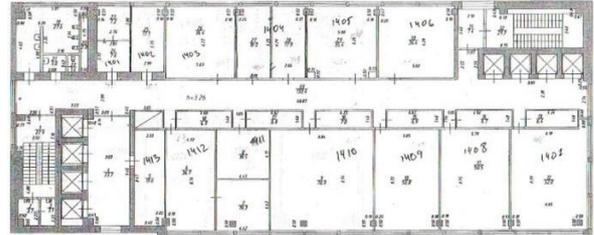


Fig. 1. Top view 2D drawing of the 14th floor of KFU 2nd study building.

- Size of the rooms: length, width, and height
- Corridor width and length
- Types of windows

Other details of the 14th-floor interior were omitted for simplifying the 3D model. We created only main model parts: a building skeleton frame, windows, building tiles, and furniture.

2.1. Building skeleton frame

Constructing a skeleton frame is done by creating a 14th-floor skeletal frame of pieces of parallelepipeds and cuboids of different sizes and thicknesses. A 3D model of the 14th-floor building frame is shown in Fig. 2. Dimensions of the model are $45 \times 15 \times 3$ (m). The model is a set of building blocks: walls and room dividers.

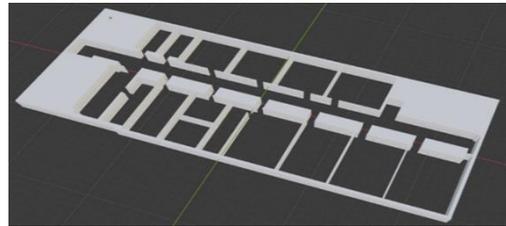


Fig. 2. Top view 2D drawing of the 14th floor of KFU 2nd study building.

2.2. Windows

We modeled two types of windows: transparent glass and tinted glass (Fig. 3). Tinted glass is used between the corridor and classrooms, transparent glass – for exterior windows.

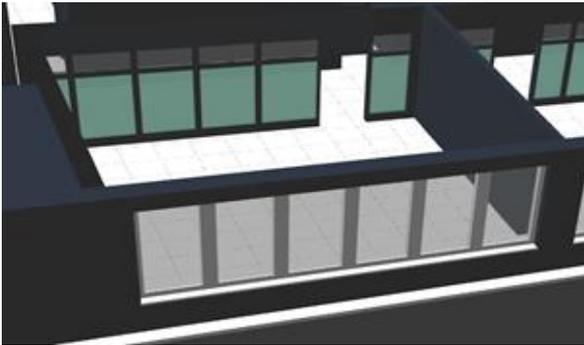


Fig. 3. Window types: transparent glass and tinted glass windows.

2.3. Building tile

A building tile is modeled as a parallelepiped (Fig. 4). Dimensions of the shape are $0.3 \times 60 \times 50$ (cm). In order to optimize simulation, we joined several pieces of building tile into one continuous solid chunk. A tile has a material property that defines color or texture. The material can be easily changed to the necessary material.

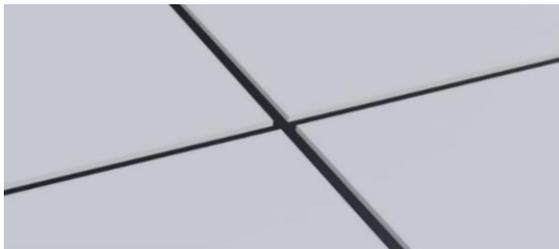


Fig. 4. 3D model of building tiles.

2.4. Classroom furniture

In order to design classroom interior, a chair, a wardrobe and tables were modeled. We modeled two types of tables: a rectangular activity table and a trapezoid activity table. They both have the same size: $80 \times 55 \times 175$ (cm).

The standard chair has an overall height of 90 (cm), width of 40 (cm), and depth of 41 (cm). The average standard depth of a wardrobe is 80 (cm), height and length is 160 and 80 cm respectively. An example of virtual classrooms is shown in Fig. 5.

3. Use of the Real Office Environment

One of the most interesting application of virtual environments is testing and evaluation of Lidar-based 2D SLAM methods. We used *hector_slam* 2D SLAM ROS

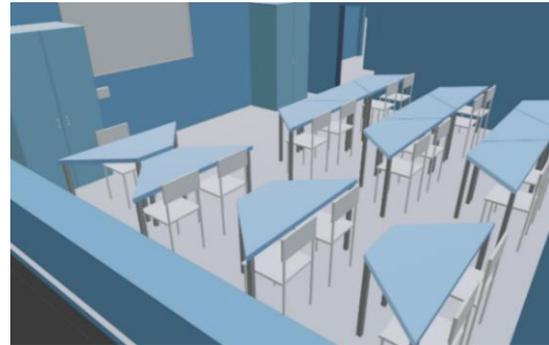


Fig. 5. Example of a virtual classroom.

algorithm¹⁰, which employs LRF sensory data and odometry to build a 2D occupancy grid map.

The created environment usability was evaluated by running *hector_slam* with Servosila Engineer mobile crawler-type robot. In our virtual environment testing, *hector_slam* SLAM method produced the 2D occupancy grid map (Fig. 6, right) of the 14th floor of the KFU second building (Fig. 6, left).



Fig. 6. The original 3D environment (left) and sensory.

4. Conclusions

This paper presented a tutorial on modeling a realistic office environment in Gazebo. The environment consists of a building skeleton frame, transparent glass and tinted glass windows, building tiles, and furniture. The constructed virtual environment was validated with *hector_slam* SLAM for Servosila Engineer UGV.

Acknowledgements

This paper has been supported by the Kazan Federal University Strategic Academic Leadership Program ("PRIORITY-2030").

References

1. T. Linner, A. Shrikathiresan, M. Vetrenko, B. Ellmann, and T. Bock, "Modeling and Operating Robotic Environment Using Gazebo/ROS", Chair for Building Realization and Robotics, 2011.
2. K. Shabalina, A. Sagitov, K.-L. Su, K.-H. Hsia, and E. Magid, "Avrora Unior Car-like Robot in Gazebo Environment", International Conference on Artificial Life and Robotics, pp. 116-119, 2019.
3. A. Dobrokvashina, R. Lavrenov, E. A. Martínez-García, Y. Bai, "Improving Model of Crawler Robot Servosila "Engineer" for Simulation in ROS/Gazebo", Proceedings of the 13th International Conference on Developments in eSystems Engineering (DeSE), pp. 212-217, 2020.
4. B. Abbyasov, R. Lavrenov, A. Zakiev, K. Yakovlev, M. Svinin, E. Magid, "Automatic Tool for Gazebo World Construction: from a Grayscale Image to a 3D Solid Model", IEEE International Conference on Robotics and Automation (ICRA), pp. 7226-7232, 2020.
5. T. Wright, A. West, M. Licata, N. Hawes, B. Lennox, "Simulating Ionising Radiation in Gazebo for Robotic Nuclear Inspection Challenges", Robotics, Vol. 10, No. 3, pp. 1-27, 2021.
6. M. Zając, S. Paszkiel, "Using Brain-Computer Interface Technology for Modeling 3D Objects in Blender Software", Journal of Automation, Mobile Robotics and Intelligent Systems, pp. 18-24, 2021.
7. K. Takaya, T. Asai, V. Kroumov, and F. Smarandache, "Simulation environment for mobile robots testing using ROS and Gazebo", International Conference on System Theory, Control and Computing, pp. 96-101, 2016.
8. C. S. Timperley, A. Afzal, D. S. Katz, J. M. Hernandez, C. Le Goues, "Crashing Simulated Planes is Cheap: Can Simulation Detect Robotics Bugs Early?", 11th International Conference on Software Testing, Verification and Validation (ICST), pp. 331-342, 2018.
9. Y. Liu et al., "The Design of a Fully Autonomous Robot System for Urban Search and Rescue", International Conference on Information and Automation, pp. 1206-1211, 2016.
10. S. Kohlbrecher, J. Meyer, T. Graber, K. Petersen, U. Klingauf, O. Stryk, "Hector Open Source Modules for Autonomous Mapping and Navigation with Rescue Robots", Robot Soccer World Cup, pp. 624-631, 2013.

Authors Introduction

Mr. Bulat Abbyasov



He received a BSc degree in Computer Science at the Institute of Information Technology and Intelligent Systems (ITIS) of Kazan Federal University (KFU) in 2020. Currently, he is a second-year student of Master degree program in Intelligent Robotics at the ITIS, KFU

Mr. Kirill Kononov



He is a fourth year undergraduate student at the Institute of Information Technology and Intelligent Systems (ITIS), Kazan Federal University

Ms. Tatyana Tso



In 2012 she graduated from International Area Studies Master's Degree Program at the University of Tsukuba. Since 2018 she has been a PhD student in Robotics at the Institute of Information Technology and Intelligent Systems (ITIS) of Kazan Federal University.

Professor Edgar A. Martínez-García



He is a full Professor at the Universidad Autónoma de Ciudad Juárez, Mexico; founder and Head of the Robotics Laboratory; leader of the Mechatronics academic body at the Institute of Engineering and Technology, since 2007. He obtained his Ph.D. degree in Robotics Engineering from the University of Tsukuba, Japan (2005). His academic interests are mathematical modeling and dynamic control of robots

Professor Evgeni Magid



He is a Head of Intelligent Robotics Department, a founder, and a Head of Laboratory of Intelligent Robotic Systems (LIRS) at Kazan Federal University, Russia. Senior member of IEEE. He obtained Ph.D. degree in Robotics Engineering from the University of Tsukuba, Japan. His research interests include urban search and rescue robotics, mobile robotics, path planning, robotic teams, and human-robot interaction. He authors over 200 publications in English, Russian and Japanese languages.