jet INTL JOURNAL OF ELECTRONICS AND TELECOMMUNICATIONS, 2023, VOL. 69, NO. 3, PP. 621-626
Manuscript received September 9, 2022; revised July, 2023. DOI: 10.24425/ijet.2023.146516

Local Generating Map System Using Rviz ROS and Kinect Camera for Rescue Robot Application

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Abstract—**This paper presents a model to generate a 3D model of a room, where room mapping is very necessary to find out the existing real conditions, where this modeling will be applied to the rescue robot. To solve this problem, researchers made a breakthrough by creating a 3D room mapping system. The mapping system and 3D model making carried out in this study are to utilize the camera Kinect and Rviz on the ROS. The camera takes a picture of the area around it, the imagery results are processed in the ROS system, the processing carried out includes several nodes and topics in the ROS which later the signal results are sent and displayed on the Rviz ROS. From the results of the tests that have been carried out, the designed system can create a 3D model from the Kinect camera capture by utilizing the Rviz function on the ROS. From this model later every corner of the room can be mapped and modeled in 3D.**

Keywords—**Mapping; Kinectr; Rviz; ROS; Robot**

I. INTRODUCTION

THE dangerous of area building ruins after the disaster is a problem for rescue teams in finding victims, therefore there is a need for a system that can model the room in 3D to help the victim rescue process, where this 3D mapmaking system will later be applied to rescue robots. A robot is a tool that can help humans in carrying out activities, many robots have been developed to help activities at home and in the industrial world [1]. The application of robots in the field of exploration has been widely developed, such as exploration robots in the mining area[2], and underwater exploration robots[3]. The robot's movement and control system can be applied to all types of robots, from robots moving in a restricted area, to robots capable of moving in dangerous areas. ROS (robotics operating system) is a system that can control the robot remotely, where the ROS system can create a 3D map to visualize the robot's area of motion[4].

The creation of a 3D model to map an area is often used to find out the real conditions that exist in a room[5]. The process of creating and mapping areas has been widely developed, where many have built 2D and 3D area maps by utilizing LIDAR sensors[6], and some researchers developed using cameras[7]. In the process of making 3D maps, several methods have been developed including making a 3D area map, by utilizing Rviz in ROS[8].

Solutions that have been developed from several studies, where the mapping system in the room by utilizing visual real-time simultaneous localization[9]. Room mapping by utilizing the robotic movement trajectory system[10]. Room mapping by utilizing lidar and camera, by utilizing geometry and odometry[21]. The use of IMU and camera sets to determine the working environment conditions of robots in the room [22]. And using an RGB-D camera and encoder to create area maps [23].

From several examples of the application of robotics technology in various fields as described above, one of the basic abilities that a robot must have for the scenarios above is the ability to estimate the robot's relative position with respect to environment or map and simultaneously perform mapping. This ability is known as Simultaneous Localization and Mapping (SLAM). SLAM is a term that uses various algorithms to combine multiple sensor data to generate environmental maps that can simultaneously also determine the location of the robot. Previously this problem was a paradox that is difficult to solve because to know position of the robot, the robot must have an accurate map. And to make an accurate map, the robot must know his position[11].

However, no system can map a room directly and become 3D to make it easier for evacuation teams to find victims. The mapping system using LIDAR still has shortcomings, where the LIDAR system is not able to map in detail. The 3D mapping system provides a detailed representation of a room, From the study of pliers that have been carried out, the problem that has been raised in the absence of a robot system that can map the room in real-time, by utilizing Rviz ROS, from that researchers create a system that can mapping with 3D models in real-time using Rviz ROS.

II. RELATED WORK

An autonomous mobile robot (AMR) is a robot that can navigate in indoor/outdoor environments without direct operator supervision. This autonomy is enabled by a set of built-in sensors and maps that enable the autonomous mobile robot to understand, interpret and react to its environment. Autonomous mobile robots are widely used in many fields, such as domestic, light industry, heavy industry, underwater and aerospace applications. Or the process of generating a 3D model. It's an advanced sensor. Environment mapping is one of the key features of mobile robotics with respect to collision-free localization, positioning and autonomous navigation of mobile robots[12].

Most mobile robots are equipped with inertial measurement units (IMUs), accelerometers, gyroscopes, and magnetometers to measure the robot's orientation, angular velocity, and acceleration, which are used to localize the robot. Locating a

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mobile robot using the above inertial navigation system results in navigation errors due to integration errors. Small errors in acceleration and angular velocity measurements are integrated into larger and larger errors leading to positional errors in robot localization[13].

Cameras are often used to detect various moving and also stationary objects, some applications of cameras in automation systems, and also the application of cameras for robotic application[14]–[16]. The camera used on the robot is as the main parameter in the navigation system and also as the main parameter in making an area map, area mapping can be done in various ways, including using RVIZ on ROS[17].

A robot that can map the conditions in a room and the robot can move in the path that has been referenced at the time of start, the dimensions of the robot are large enough that it is difficult to move in narrower areas, where this robot is only able to move on a flat area[18]. Robots that can move in fields that have obstacles and are also able to map the paths passed, robots are also able to detect the presence of gas content in their work area. But the dimensions of the robot are large enough that makes the robot is only able to be applied in a fairly large area, such as in a mining alley[19], [20].

The concept of a robot is helping to explore the ruins area, where the robot is equipped with several sensors to be able to map and find out the conditions in the robot environment, the robot system is still unable to detect any victims in its area[21]. A robot that can detect the presence of people, where this robot can map the surrounding area and can avoid obstacles, where the robot follows the target moving in its work area[22].

Exploration robots are used to compile road maps for efficiency in robotic navigation systems, where navigation paths are randomly set in the environment of the exploration robot, the robot can evaluate the path to get the next best route, and the robot is also able to move efficiently in determining the next target[23]. An environmental mapping system with an efficient 3D model by utilizing stereo vision based on planar surfaces, this method is carried out using feature points with a multi-random sample consensus algorithm to estimate field parameters and then group the data, which is further combined for approximation representation of the 3D environment[24].

SLAM (Simultaneous Localization and Mapping) robots in the environment of the ruins with map making require estimating the trajectory of robots in 3D space. But this is difficult to do if only using odometry or gyro in the ruins area, the use of 3D cameras allows matching 3D and texture scans, and measurements in real-time, 3D maps and robot trajectories are estimated by combining 3D camera scan data, the application of the iterative-closest point method allows the construction of 3D maps to be carried out quickly[25].

A 3D mapping algorithm installed on a robot is used to search for and locate victims in ruin, the use of a 3D map equipped with a laser range finder, and project its location on a global map with a correlation technique[26]. Multi-robotic system in making global maps by utilizing the multi-star optimization method to increase accreditation in global mapping, the use of robots to determine point points on global maps, testing is carried out by utilizing gazebo simulations which will be compared with the results of experiments[27].

The map-fusion (MF) method approach that exploits non-static-figure (NSF) can improve efficiency, where NSF can be easily extracted from SLAM robots without additional processes, with the addition of a feature identification module it can transform identified local maps and can be integrated into global mapping[28]. In this work, the representation of the environment in the building is modeled in 3D directly, based on imagery obtained from the camera Kinect. This new approach allows displaying a map of the room directly to be applied to rescue robots.

I. METHODE

In this study, two methods were used, simulation and experimentation, where simulation is carried out to create a system that can map in 3D, where the simulation system is designed by utilizing GAZEBO ROS, and Rviz ROS. The experiment is by creating a robot equipped with a camera, where the robot's movement is carried out with control from ROS, the robot's movement system can be seen in ROS, and the creation of 3D maps with Rviz ROS. For the experiments carried out this is still in the laboratory stage.

This section discusses the design of the ROS system and the 3D Mapping system using a Kinect camera, in figure 1 is the system blog designed in this study, where the system blog has two parts, namely the master and the slave, the master uses a laptop while for the slave uses a mini PC jetson nano, for more details it can be seen in figure 1.

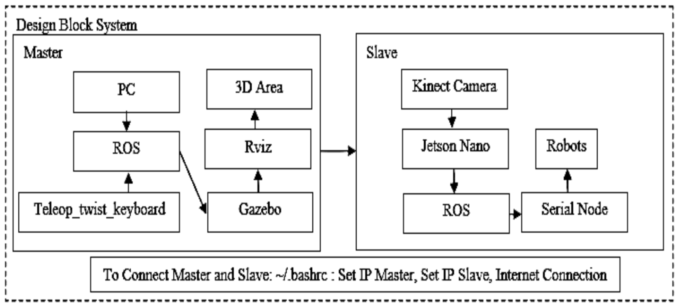

Fig. 1. Propose Blog System

On the blog, a system created there are two main parts, where ROS is on the master and ROS on the slave. ROS in the master functions as a 3D formation of area maps, by utilizing gazebos and Rviz contained in ROS, while teleop_twist_keyboard is a navigation system for robot movement commands contained in slaves. On the slave section, there are a Kinect camera and robotic movement system devices, such as Arduino, motor driver, and DC motor. To connect between master and slave, use the IP protocol set in ~/.bashrc. In the ROS system, a node system and topic will also be created, where the design of a node system for movement and making 3D maps can be seen in figure 2.

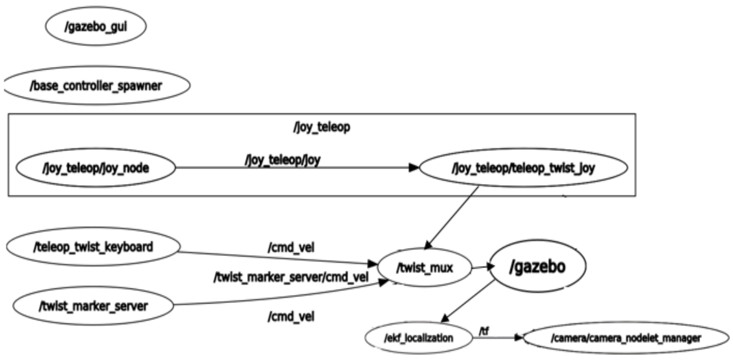

Fig. 2. ROS Node Diagram Proposed

In the planning of the movement system and the formation of 3D maps, there is a node planning in ROS, it can be seen that the initial node is joy_teleop / joy_node, after that the node enters the teleop_twist_joy, from there enters the / twist_mux node, where the teleop_twist_keyboard also enters the / twist_mux, from / twist_mux enters the / gazebo and / ekf_localization nodes, and the last one is to go to /camera_nodelet_manager. Next is the topic of planning the ROS system, which can be seen in figure 3.

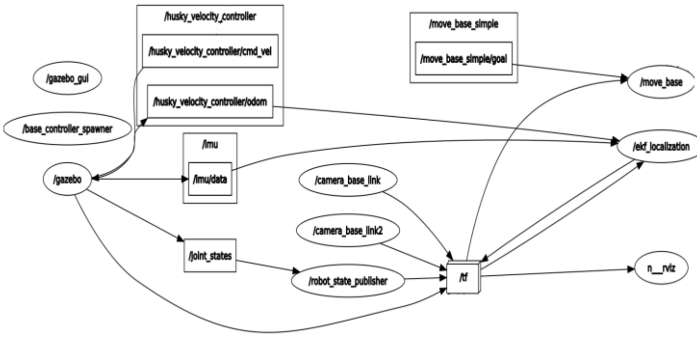

Fig. 3. ROS Topic Diagram Proposed

Topic design system in ROS created based on the needs of the navigation system and 3D map making, in the topic design that is built, from the /gazebo node enters the topic /huzky_velocity_controller and /tf, wherefrom /huzky_velocity_controller then enters the ekf_localization. Whereas from /tf go to the /move_base node and /cmd_vel next go to /twist_mux. While the nodes and topics for camera access in making 3D maps are found in figure 4.

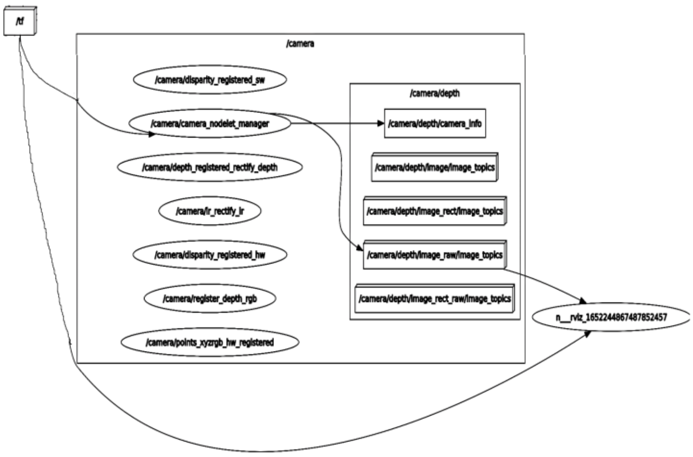

Fig. 4. ROS Topic and Node Camera Diagram Proposed

ROS nodes and topics in making 3D maps on Rviz start with topic /tf, which is then connected in the node /camera_nodelet_manager, then continued to topic /camera/depth/camera_info and topic /camera/depth/image_raw/image_topics, from topic /tf and topic /camera/depth/image_raw/image_topics, merged into a node n_rviz_1652244867487852457, from this node can later generate a 3D map model on the Rviz by utilizing the depth function of the camera Kinect. The node system and ROS topic used in this system can be seen in figure 5.

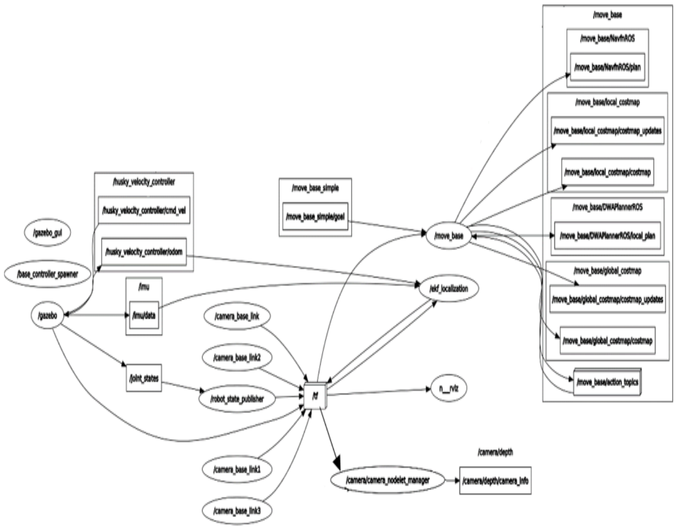

Fig. 5. ROS Topic and Node System Proposed

For more details on knowing the process of the research carried out, a flowchart is made on how it works as a whole in the formation of a 3D map of the area, which can be seen in the flowchart figure 6 below.

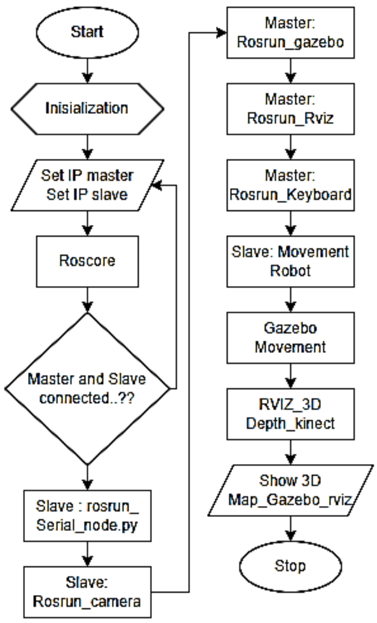

Fig. 6. Flowchart System Proposed

From the flowchart, can see how the system is created, where the initial process is to connect between master and slave, where to connect this using an IP connection that is set as master and slave, after the master and slave are connected, to run the system on the slave we can open cmd then ssh@jetson and IP slave, after entering the slave, we open cmd and we run the rosrun_serial_node.py, this is done to connect the ROS system on the slave to Arduino which is used as a robot movement control system.

Next on the ROS slave using cmd, for the Kinect camera process with the command rosrun_camera, after completion next we enter the master, open the cmd then we run the command rosrun_gozebo, rosrun_rviz, and rosrun_keyboard, after that for the process of running the robot we use commands from rosrun_teleop_twist_keyboard, with keyboard i, j, l, k, m, as a command of the movement of the robot, where i to forward, k to stop, j to turn left, l to turn right and m to turn backward. The results of the robotic movement system can be observed from the ROS gazebo display, while the results of making 3D maps can be observed from the ROS Rviz display.

III. EXPERIMENTAL RESULT

In this section, the results of testing the making of 3D maps by utilizing Rviz ROS are explained, the results of the process of running the ROS system in this study can be seen in figure 7.

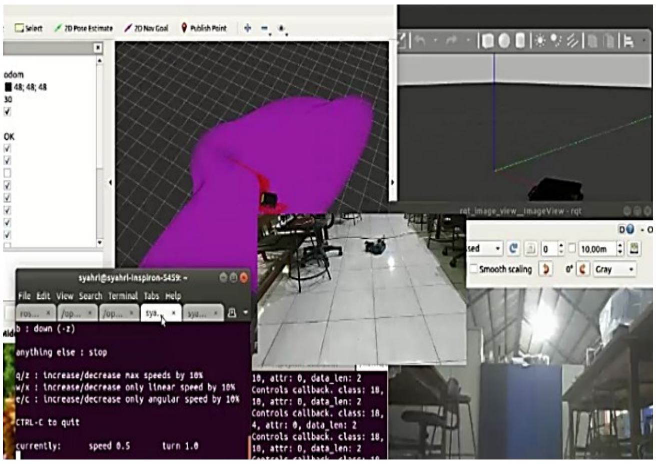

Fig. 7. Process of Running ROS System

Figure 7, is the result of the process of running the ROS system, where for the master we use a laptop, and for slaves, on the robot, we use a jetson, seen in the picture, for the process of robot movement displayed in the ROS gazebo, where the red track is the result of the process of movement of the robot from the starting point to the end, for more details the results of the robot movement system can be seen in figure 8.

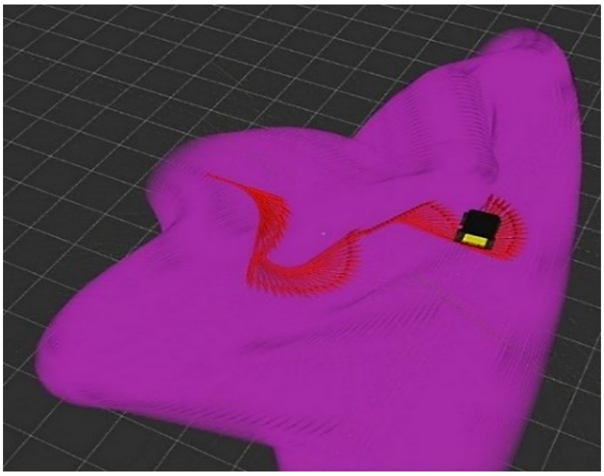

Fig. 8. Movement Robots in Gazebo Display

Figure 8 is the result of the robotic movement system displayed in the ROS gazebo, this animation system is carried out to find out the real movement of the robot. Next is the result of the 3D area map-making system, in this system utilizes Rviz ROS for 3D creation, the results of 3D can be seen in figure 9.

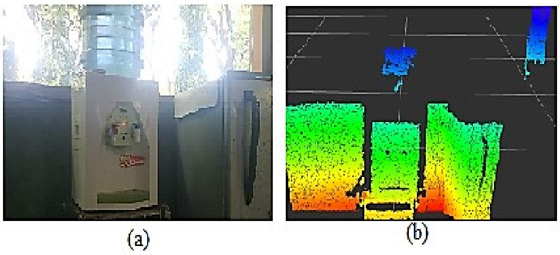

Fig. 9. Rviz (a) Real Image BGR, (b) 3D Image Result

Figure 9(a) is the result of capturing images, by utilizing the Kinect camera images converted into 3D shapes displayed on Rviz ROS, whereas image 9(b) is the result of the 3D creation process of the system. In the test above, it can be seen that the system has not been able to model the alignment of the RGB image into 3D, this is because the Infra-Red system on the Kinect has not worked optimally. The next test is the creation of 3D models of the tables and chairs in the laboratory, where the results can be seen in figure 10.

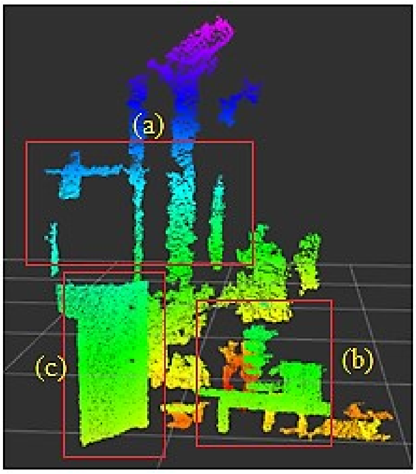

Fig. 10. 3D Image Result

Figure 10 shows that the 3D manufacturing system on Rviz has increased, this is due to changing the parameters used to make the 3D model, in this test, there are several that are modeled in 3D, including the end of the table (c), and there is also a glass frame of room (a), and the bottom of the chair (b). The next test is to try to make 3D from the laboratory table, where the test results can be seen in figure 11.

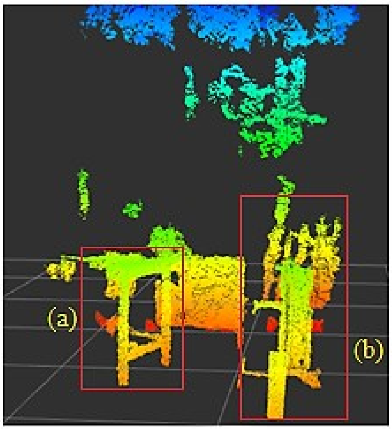

Fig. 11. Table and Chair Image Result

The next test is to try to model the bottom of the table, where there is a point (a) the foot of the table can be modeled on the Rviz ROS, the next part (b) is part of a row of tables that are partially detected, there is an area that is also mapped at the top of the picture, where the image is part of the wall of the room that is included in the 3D process. Where the results of 3D creation can be seen in figure 12.

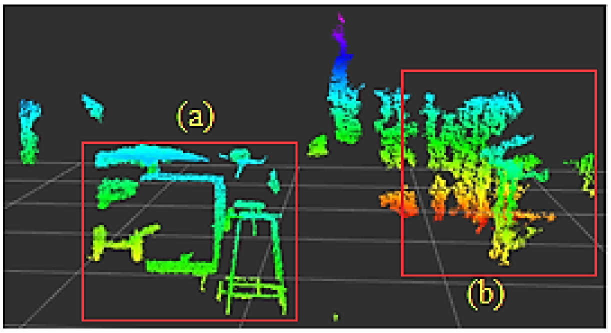

Fig. 12. 3D Image Result

In the tests carried out, there are results as in figure 12, where point (a) is the leg part of the table and a chair in the laboratory, while point (b) is the filing cabinet, where the result of filling the cabinet is not as good as to point (a), this is because the angle of taking imagery from the camera is too narrow, so the 3D result is not as good as to point (a). Further testing by changing the parameters on the Rviz to maximize the creation of a 3D model of the area captured by the camera, where the test results can be seen in figure 13.

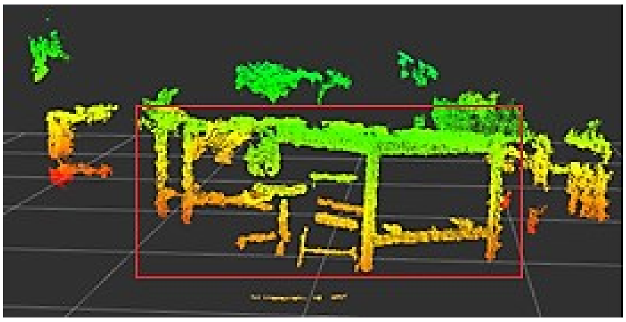

Fig. 13. 3D Image result

In the tests carried out by changing the parameters in Rviz to maximize the creation of 3D maps, the results obtained have been able to make a 3D model from a long table in the laboratory, and indeed the end of the table cannot be made a 3D model, this is due to the limitations of their depth Kinect camera. From the tests that have been carried out, it was found that the system can create a map of the area in 3D.

IV. Conclusions

From this paper, we propose mapping the area of the room and modeling it in 3D on Rviz ROS, the advantage of the system is that it is easy to use whereby utilizing the camera Kinect and ROS we are already able to make the area into a 3D view. When mapping the area using the ROS system, the process of creating a 3D structure from the one captured by the camera takes a few seconds, this is because the process of sending data from the slave to the master has problems due to internet network factors. From the tests carried out, the system designed can create 3D structures from the surrounding area captured by cameras and robots, this is based on the results of tests that have been carried out, and proves that the system created can map the area of the room into 3D. From research there are limitations of the designed system, where the distance mapped and made in 3D cannot be too far, this is due to the limitations of the camera.

References

[1] V. N. Lu *et al.*, ‘Service robots, customers and service employees: what can we learn from the academic literature and where are the gaps?’, *J. Serv. Theory Pract.*, vol. 30, no. 3, pp. 361–391, Jan. 2020, https://doi.org/10.1108/JSTP-04-2019-0088

[2] J. Luong *et al.*, ‘Eversion and Retraction of a Soft Robot Towards the Exploration of Coral Reefs’, in *2019 2nd IEEE International Conference on Soft Robotics (RoboSoft)*, Apr. 2019, pp. 801–807. https://doi.org/10.1109/ROBOSOFT.2019.8722730

[3] A. Martins *et al.*, ‘UX 1 system design - A robotic system for underwater mining exploration’, in *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Oct. 2018, pp. 1494–1500. https://doi.org/10.1109/IROS.2018.8593999

[4] L. Zhi and M. Xuesong, ‘Navigation and Control System of Mobile Robot Based on ROS’, in *2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)*, Oct. 2018, pp. 368–372. https://doi.org/10.1109/IAEAC.2018.8577901

[5] D. R. dos Santos, M. A. Basso, K. Khoshelham, E. de Oliveira, N. L. Pavan, and G. Vosselman, ‘Mapping Indoor Spaces by Adaptive Coarse-to-Fine Registration of RGB-D Data’, *IEEE Geosci. Remote Sens. Lett.*, vol. 13, no. 2, pp. 262–266, Feb. 2016, https://doi.org/10.1109/LGRS.2015.2508880

[6] J. Lee, S. Hwang, W. J. Kim, and S. Lee, ‘SAM-Net: LiDAR Depth Inpainting for 3D Static Map Generation’, *IEEE Trans. Intell. Transp. Syst.*, pp. 1–16, 2021, https://doi.org/10.1109/TITS.2021.3111046

[7] S. Muharom, ‘Automatics Detect and Shooter Robot Based on Object Detection Using Camera’, *Przegląd Elektrotechniczny*, vol. 1, no. 1, pp. 52–56, Jan. 2022, https://doi.org/10.15199/48.2022.01.07

[8] K. Koide, J. Miura, M. Yokozuka, S. Oishi, and A. Banno, ‘Interactive 3D Graph SLAM for Map Correction’, *IEEE Robot. Autom. Lett.*, vol. 6, no. 1, pp. 40–47, Jan. 2021, https://doi.org/10.1109/LRA.2020.3028828

[9] Y. Zheng, S. Chen, and H. Cheng, ‘Real-Time Cloud Visual Simultaneous Localization and Mapping for Indoor Service Robots’, *IEEE Access*, vol. 8, pp. 16816–16829, 2020, https://doi.org/10.1109/ACCESS.2020.2966757

[10] T. Lee, C. Kim, and D. D. Cho, ‘A Monocular Vision Sensor-Based Efficient SLAM Method for Indoor Service Robots’, *IEEE Trans. Ind. Electron.*, vol. 66, no. 1, pp. 318–328, Jan. 2019, https://doi.org/10.1109/TIE.2018.2826471

[11] J. J. Leonard and H. F. Durrant-Whyte, ‘Simultaneous map building and localization for an autonomous mobile robot’, in *Proceedings IROS ’91:IEEE/RSJ International Workshop on Intelligent Robots and Systems ’91*, Nov. 1991, pp. 1442–1447 vol.3. https://doi.org/10.1109/IROS.1991.174711

[12] M. Köseoğlu, O. M. Çelik, and Ö. Pektaş, ‘Design of an autonomous mobile robot based on ROS’, in *2017 International Artificial Intelligence and Data Processing Symposium (IDAP)*, Sep. 2017, pp. 1–5. https://doi.org/10.1109/IDAP.2017.8090199

[13] J. Yi, J. Zhang, D. Song, and S. Jayasuriya, ‘IMU-based localization and slip estimation for skid-steered mobile robots’, in *2007 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Oct. 2007, pp. 2845–2850. https://doi.org/10.1109/IROS.2007.4399477

[14] S. Muharom, A. Rizkiawan, I. Masfufiah, R. A. Firmansyah, and Y. A. Prabowo, ‘Detection and Erasing Scribble Blackboard System Based on Hough-Transform Method Using Camera’, *J. Phys. Conf. Ser.*, vol. 2117, no. 1, p. 012010, Nov. 2021, https://doi.org/10.1088/1742-6596/2117/1/012010

[15] R. A. Firmansyah, I. K. Wicaksono, S. Muharom, Y. A. Prabowo, and A. Fahruzi, ‘Sorting Device Coding Print Quality Machine on Packing Box Prototype Utilizing Optical Character Recognition’, *J. Phys. Conf. Ser.*, vol. 2117, no. 1, p. 012017, Nov. 2021, https://doi.org/10.1088/1742-6596/2117/1/012017

[16] S. Muharom, I. Masfufiah, D. Purwanto, R. Mardiyanto, B. Prasetyo, and S. Asnawi, ‘Room Searching Robot Based on Door Detection and Room Number Recognition for Automatic Target Shooter Robot Application’, *Proc. 1st Int. Conf. Electron. Biomed. Eng. Health Inform.*, pp. 43–54, 2021, https://doi.org/10.1007/978-981-33-6926-9_4

[17] W. Deng *et al.*, 'Semantic RGB-D SLAM for Rescue Robot Navigation', *IEEE Access*, vol. 8, pp. 221320–221329, 2020, https://doi.org/10.1109/ACCESS.2020.3031867

[18] H. Wang, C. Wang, and L. Xie, 'Intensity-SLAM: Intensity Assisted Localization and Mapping for Large Scale Environment', *IEEE Robot. Autom. Lett.*, vol. 6, no. 2, pp. 1715–1721, Apr. 2021, https://doi.org/10.1109/LRA.2021.305956

[19] F. Niroui, K. Zhang, Z. Kashino, and G. Nejat, 'Deep Reinforcement Learning Robot for Search and Rescue Applications: Exploration in Unknown Cluttered Environments', *IEEE Robot. Autom. Lett.*, vol. 4, no. 2, pp. 610–617, Apr. 2019, https://doi.org/10.1109/LRA.2019.2891991

[20] S. Muharom, Tukadi, T. Odinanto, S. Fahmiah, and D. P. P. Siwi, 'Design of Wheelchairs Robot Based on ATmega128 to People with Physical Disability', *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 462, p. 012016, Jan. 2019, https://doi.org/10.1088/1757-899X/462/1/012016

[21] R. Firmansyah, 'Thermal Imaging-Based Body Temperature and Respiratory Frequency Measurement System for Security Robot', *Przegląd Elektrotechniczny*, vol. 1, no. 6, pp. 128–132, Jun. 2022, https://doi.org/10.15199/48.2022.06.23

[22] M. Aggravi, A. A. S. Elsherif, P. R. Giordano, and C. Pacchierotti, 'Haptic-Enabled Decentralized Control of a Heterogeneous Human-Robot Team for Search and Rescue in Partially-Known Environments', *IEEE Robot. Autom. Lett.*, vol. 6, no. 3, pp. 4843–4850, Jul. 2021, https://doi.org/10.1109/LRA.2021.3067859

[23] C. Wang, W. Chi, Y. Sun, and M. Q.-H. Meng, 'Autonomous Robotic Exploration by Incremental Road Map Construction', *IEEE Trans. Autom. Sci. Eng.*, vol. 16, no. 4, pp. 1720–1731, Oct. 2019, https://doi.org/10.1109/TASE.2019.2894748

[24] B. Guo, H. Dai, Z. Li, and W. Huang, 'Efficient Planar Surface-Based 3D Mapping Method for Mobile Robots Using Stereo Vision', *IEEE Access*, vol. 7, pp. 73593–73601, 2019, https://doi.org/10.1109/ACCESS.2019.2920511

[25] K. Ohno, T. Nomura, and S. Tadokoro, 'Real-Time Robot Trajectory Estimation and 3D Map Construction using 3D Camera', in *2006 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Oct. 2006, pp. 5279–5285. https://doi.org/10.1109/IROS.2006.282027

[26] H. Wang, C. Zhang, Y. Song, B. Pang, and G. Zhang, 'Three-Dimensional Reconstruction Based on Visual SLAM of Mobile Robot in Search and Rescue Disaster Scenarios', *Robotica*, vol. 38, no. 2, pp. 350–373, Feb. 2020, https://doi.org/10.1017/S0263574719000675

[27] H. Lu, S. Yang, M. Zhao, and S. Cheng, 'Multi-Robot Indoor Environment Map Building Based on Multi-Stage Optimization Method', *Complex Syst. Model. Simul.*, vol. 1, no. 2, pp. 145–161, Jun. 2021, https://doi.org/10.23919/CSMS.2021.0011

[28] W. Ali, P. Liu, R. Ying, and Z. Gong, 'A Feature Based Laser SLAM Using Rasterized Images of 3D Point Cloud', *IEEE Sens. J.*, vol. 21, no. 21, pp. 24422–24430, Nov. 2021, https://doi.org/10.1109/JSEN.2021.3113304