Integrated BIM and Robotics - Project Proposal

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I. Introduction

The use and deployment of robotics is increasing in a wide variety of sectors. For example, the agricultural sector sees an increase in different kinds of robots being developed and utilized [1]. One of the companies that develops such robots, Lely, has robots that vary greatly in size and equipment that all need to move around in the same barn. In order to find their way around, most of these robots use sensors to perceive their surroundings and mal REFs n map that they use to find paths to their destination. However, this map-generating process could be done easier and more efficiently if it can directly be obtained from already available data. Building Information Modeling (BIM) models are one such type of data that is widely available for most of the existing buildings and could be exploited to ease the navigation and localization process of robots in buildings. Using this data is advantageous because it could potentially be used to generate maps for robots with different kinds of specifications in different kinds of buildings without the interference of a human prior to deploying a robot. This proposal describes a project that aspires to develop a system that can realize this vision of robot navigation based on input from BIM models.

II. Project objective

The aim of this project is to make a REFs ate an environment using a separately acquired REFs is can be concretely achieved by using a BIM model combined with an Unified Robotics Description Format (URDF) to generate navigation and localization maps that the robots can use to find its way. An overview of the system that is the end goal of this project is displayed in Figure 1. In order to achieve this goal, the system should be able to determine which elements the map needs to contain, and query these elements from the IFC file or a database with information retrieved from the IFC. After that, the robot should be able to locate and navigate based on these maps.

is the system inside the robot, or is the robot inside the system. or what is the difference. Do you propose a system, or a robot?

This project is based on work done by Hendrikx et all [2] [3] which explores a method to use semantic data retrieved from a BIM model for use by a robot-specific world model representation which a robot can then use to query semantic objects in it's immediate surrounding. A graph-based approach is then used to localize the model where it incorporates explicit map features for localization. This results in a method where a robot can use to find routes to previously unexplored locations by using data from the BIM model.

make this more detailed

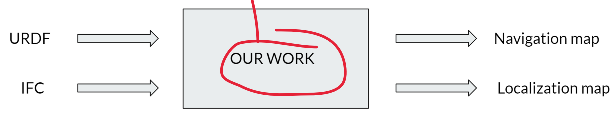

Fig. 1. Overview of the system.

Previous research has shown multiple ways of localizing with the use of BIM. Acharya et all [4] uses a Convolutional Neural Network(CNN) to extract features from synthetic images acquired from a BIM model, which are then used by the robot to locate it's position. Laska [5] proposes ~~a method~~ the also using a CNN but instead of predicting a specific location it is more coarse by predicting only zone/area where the robot is. This results in a faster training that is ~~much less~~ computationally cheaper ~~to run~~.

Schaub et all [6] use a method where a synthetic pointcloud is retrieved from the BIM and then compared with the local pointcloud from the robot to find where the robot is located. This method does not require new training on each new building introduced.

Kim and Peavy [7] convert an entire BIM model into a dynamic URDF model. The result ~~of this~~ is a model where dynamic objects like doors and windows are movable and the robot can interact with them. This URDF model can than also be used for localization and navigation purposes.

INSERT YOUR METHOD OR PROPOSAL HERE.

IV. Project decomposition

Group division

For this project, two groups are formed, which will both focus on one of two aspects. Group 1 will focus on the map generation and querying data from the IFC/database, group 2 will focus on the control of the robot. During the project, the robot control group will investigate what kind of maps the robots will actually need and how these should be formatted and represented. This information will be passed onto the other group so they can make sure the map generation will result in the desired outcome. Group 1 will consist of Marko and Zeph, while group 2 will consist of Alex and Pim.

TABLE I
Milestones

These are actions, not milestones. Please make the distinction.

R1	Make project proposal
R2	Make midterm report and presentation
R3	Make final report and presentation
G1	Implement IFC querying and map generation for different elements
G2	Figure out database implementation and querying
G3	Generate navigation and localization maps based on URDF
C1	Being able to simulate, control movement and receive sensor data
C2	Implement how the robot will localize itself
C3	Implement combination of navigation and localization map
C4	Implement path calculation
C5	Implement on actual robots

avoid such unstructured steps.

This is not an action, so unlike the other items in this table.

Week:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Group 1		R1		G1		G2		R2			G3				C4		C5	R3	
Group 2				C1		C2					C2	C3							
Events								M	E	E									F

Fig. 2. Planned timeline of the project.

You already have that idea available at this point. You all know.

Milestones and scenarios

~~In order to give both groups an idea of what to work on,~~ the project is split into smaller milestones, which are presented in Table I. The timeline with the planning of when to work on and complete these milestones is given in Figure 2. In the events row, the M stands for the midterm evaluation, the E stands for the exam weeks and the F stands for the final evaluation. In order to give a meaningful way to show completion of these milestones, some of them have a test that should be achieved successfully. Before establishing these tests, let's look at some example scenarios the system should be able to provide maps for. These are just examples which can be used to verify the functionality of the element query

These are three times the same scenarios? Just with different heights. Can you match it with the Lely robots? Or can you be specific about the scenarios you will use in Atlas (or any other place)?

- Scenario 1: A robot needs 2D-LiDAR is at a height of it needs to have a map that see sliced at 1.5 meters high
- Scenario 2: A robot that is (for navigation. This means that it needs an occupancy map containing all the elements that it can't pass trough. In this scenario, tables or o underneath shouldn't be sh
- Scenario 3: A robot that is 2.0 meters high needs a map for navigation. This means that it needs an occupancy map containing all the elements that it can't pass trough.

academic writing style prefers this spelled out in full.

In general, when generating a localization map, all elements that can be seen by the 2D-LiDAR on the robot should be queried and put into a map so the robot can compare it to what it sees to locate. When generation a navigation map, all elements that the robot can not pass through/underneath should be queried and put into an occupation map, so the robot knows where it can go for path calculation.

that

Tests

Generation tests:

- The test to show the completion of milestone G1 will be the ability to query the elements from the IFC needed for the three scenarios.
- The test to show the completion of milestone G2 will be the ability to query the elements from the database needed for the three scenarios, in case it is decided to use a database.
- The test to show the completion of milestone G3 will be the ability to generate both the navigation map and localization map based on the URDF and IFC/Database.

Robot control tests:

- C1 Visualize a robot moving around in a gazebo environment and reading it's 2d lidar sensors
- C2 Get coordinates based on input from robot data.
- The test for the completion of C3 will be a combination of Rviz and Gazebo where the robot already knows the layout of the rooms where it has not been, and is able to localize itself.
- The test for C4 will be a simulation where the different scenarios have to be able to plot and follow routes.
- The test for C5 a robot navigating the Atlas building.

is a

V. Team Planning

A. Team functionality

~~Depending on everyone's availability,~~ we will meet with the project supervisors once every week ~~or once every two weeks~~ on Monday mornings. As a group, we will meet every Thursday afternoon. We will update our supervisors on significant developments through the meeting primarily ~~Teams~~. Furthermore, we will track and monitor our tasks and progress with the use of the Kanban method by using the issue system in the project's Gitlab repository. Lastly, we have a whatsapp group with the team members to easily and quickly communicate with each other about small issues or questions.

B. Team roles

move group decomposition part to here.

At the start of the project, sub-teams to dive deeper into the software and robot control aspects, as detailed in the project decomposition section. In addition, several team roles have been assigned to ensure efficient coordination and collaboration. Alex has been designated as the team leader and will serve as the primary contact person for supervisors to stay informed about the team's progress. Zeph and Pim have been appointed as Notetakers to document meeting discussions, whether online or in-person. Marko and Pim, with their software expertise, will be responsible for providing technical assistance to team members who encounter issues with tools or packages.

References

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