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| In my last BSP-2, my scientific question was as follows: ” How can the information available in BIM models be used by robots for their autonomous navigation?”.  In the Scientific part, I worked with BIM (Building Information Modeling) and explored what data was relevant from BIMS, methods, and techniques of extracting said data and briefly introduced S-graphs. In my upcoming BSP-3, on the Scientific part, I want to further explore BIMs, but with an emphasis on S-graphs, what they are, how are they generated, their purpose, etc. | In my last BSP-2, I worked on data extraction and manipulation using Dynamo for Revit.  One of the proposed targeted technical deliverables is to further delve into data manipulation, this time using C++ with the library IFC++. Another targeted technical deliverable is to generate a BIM from the robot map, i.e. making the information flow in the other direction than in the last BSP. The work will be related to BIMs, S-graphs, and data manipulation. |

A Scientific Deliverable 1 ([±40%] of totalwords)  
The description of what will be presented in the scientific deliverables section of the final report. This section must present and be based on a state of the art of the topics addressed by the scientific part of the project.  
DO NOT PRESENT THE ANSWER TO THE SCIENTIFIC QUESTION IN THIS SECTION NB: A program is NOT a scientific deliverable. A good rule of thumb is that the scientific deliverable should not  
address the program or product concerned by your technical deliverable.  
After having given the scientific question, it is advised to structure this section in sub-sections and sub-sub sections. A possible structure could be:

1) Context: the scientific context of the question: here it should be presented the links between the question and the scientific fields of computer science (cf. CS2013), it should be used and commented related general refer- ences, and provided motivations for this question.

2) Sub-questions: the sub-questions deduced from the main question.

3) Ideas: the ideas/directions/type of solution you would propose to produce the answer to the question and subquestions. In this sub-section, it must be presented an overview/high level understanding of what is expected to be the solution. This section corresponds to the ”design”  
of the answer.

In the three sub-sections proposed it must be provided a commented use of the relevant references on which the work is proposed to be based on.

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In my last BSP-2, my scientific question was as follows: ” How can the information available in BIM models be used by robots for their autonomous navigation?”.   
In the Scientific part, I worked with BIM (Building Information Modeling) and explored what data was relevant from BIMs, methods, and techniques of extracting said data and briefly introduced S-graphs. In my this BSP-3, on the Scientific part, I want to further explore this scientific question. The scientific research explores BIMs with an emphasis on S-graphs, what they are, how are they generated, their purpose, etc.

1) Context: the scientific context of the question: here it should be presented the links between the question and the scientific fields of computer science (cf. CS2013), it should be used and commented related general refer- ences, and provided motivations for this question. [207]

Fields:

* Computer vision
* Robotics
* Data handling
* Programming
* Sensor IO in robots

Information available in BIM models is vast, in this project the aim is to explore S-graphs.

S-graphs contain topological and metric-semantic information about a building. This information can be extrapolated from BIM models, and, from direct and odometrical robot data.

It’s worth mentioning that my contribution, to the autonomous navigation of a robot within a building and the building’s BIM model, is but a small part. More notably, my goal in this specific BSP-3 is to alter or create BIM models from a default template, or standardized data. All the while learning about the processes used and using that knowledge to describe S-graphs.

I personally, will not be working on the robot, however, scientific background on the working principles of how robot data is used will be explored. So Robotics, and Sensor Input/Output and Computer Vision will be explored.

To complement the robot data, BIM models, which contain geometrical, semantic, and topological data from a building is explored. This means exploring BIM as a digital data format.

Furthermore, data within BIM must be handled. This permits us to access specific data, altering data if needed, overall, allowing making available data useful. So, Data Handling and Data Processing is a key component.

Finally, to utilize all available data, Python and Dynamo for Revit are used, so Programming is necessary. To conceptualize S-graphs, Computer Vision and Graphs are necessary.

There are a lot of topics to cover, but, the goal is not to explore them all deeply, but to cover enough topics, just enough, to be able to explore S-graph. By the end of the scientific part, certain sub-questions should be answered.

2) Sub-questions: the sub-questions deduced from the main question. [349]

Some sub-questions, necessary to understand S-graphs are proposed:

How to construct an S-graph? why make an S-graph? What does an S-graph provide to the robot? What information in an S-graph can the robot use? How can the robot use that information? etc

These are not set in stone; however, they serve as a guideline for providing a path for exploring and understanding S-graphs.

To answer the S-graph questions, some other questions arise, such as: why use BIM as a format?

This is quite a relevant question, because, answering this question by focusing on the proper aspects, gives understanding behind the reasoning on certain technical decisions on making S-graphs.

Other questions relating to robots and sensor I/O will be addressed as well. These will be explored in much less detail however.

Finally, after all the necessary information is introduced, S-graphs will be explored.

Why BIM:

Construction plans contain the necessary data to explore the scientific question, as such digitalized building plans in BIM format is used.

BIM format is a widely used digital format to display 3D information of a building. The relevant information for this project in BIM, is that of a building’s components, including walls, doors, windows, rooms, stairs and the floors or levels of the building.

The format BIM includes geometric and semantic data on the different components the building.

3) Ideas: the ideas/directions/type of solution you would propose to produce the answer to the question and subquestions. In this sub-section, it must be presented an overview/high level understanding of what is expected to be the solution. This section corresponds to the ”design”  
of the answer.

S-graphs are quite complex data. They comprise topological and metric-semantic data. These terms can be quite vague, so I will first give some meaning to these terms by defining them in the context of S-graphs and buildings.

Further on, I will explore which data is available from the available sources, BIM models and Robot Outputs.

As such, I will first try to explain what data is available, resulting in exploring geometric, semantic, topological data from BIMs. Also exploring odometry and how sensors work in a basic sense in from robots. How to obtain this data from BIM models and from Robot Outputs is also relevant.

As such, BIM as a digital format and basics robotics and robot sensor IO will be explored.

Additionally, what data from these available data sources is relevant for the purposes of S-graphs.

Finally, everything S-graph will be explored. If possible, an S-graph will be constructed as well.

In the three sub-sections proposed it must be provided a commented use of the relevant references on which the work is proposed to be based on.