Floor Plan Generation from Tracked Physical Objects

Mixed Reality Project Proposal
Supervised by: Dr. Anton Savov, Wenqian Yang
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GROUP MEMBERS

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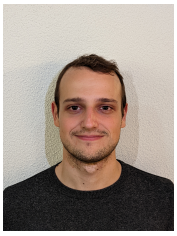

Gonca Yilmaz

I. DESCRIPTION OF THE PROJECT

In this project, we aim to track 3D printed furniture models to generate and display a home layout. The traditional approach for designing a home layout involves drawing wall lines to define zones and rooms where subsequently furniture symbols are placed to judge the functional and spatial qualities of the home layout. We reverse this approach and let the user arrange 3D printed furniture models on a table. Based on their location and orientation a design is generated and displayed to them. Our main task is to develop object tracking for 5-7 different furniture models and overlay the home layout 3D model.

II. WORK PACKAGES AND TIMELINE

The responsible group member for each task is specified below between curly brackets: {Name}.

A. Work Packages

1) Furniture Tracking: Our project hinges on estimating the pose of 3D printed models. This is a challenging task, but in our case, we have access to the 3D models of the tracked objects, which makes the task easier. Indeed, there are libraries, such as Vuforia {Thomas} and Visionlib {Lucas}, that can overlay a 3D model to its corresponding real object. At first, we will experiment with them as they are compatible with Unity and Hololens. They can help us track 3D objects in order to retrieve their unique identifier, orientation and position.

Alternatively, we can conduct further research {Thomas, Lucas} on 3D object tracking and implement the models ourselves. We would have to create a dataset using synthetic images rendered from the 3D models with our furniture and then train the model on it [2]. There are other approaches where computer-aided design (CAD) models are not required, but this is a whole other project: [1].

2) User Interface for Inputs: User input needs to be collected to obtain the size of the room and the connections between the furniture which represents the links between rooms. During floor generation, those rooms will have a passage connecting them.

First, we will start by designing an intuitive user interface for the different inputs we have to collect {Hugo}. After sketching a user interface with pen and paper, we will present it to the advisors to get some feedbacks. Once we have chosen our user interface, we will start implementing it in Unity using C# {Hugo, Gonca}. Our first implementation will have to work without the furniture tracking, so we will start using fake coordinates to test the user interface.

We will ultimately generate a graph containing the chosen furniture and their positions/rotations (information coming from furniture tracking), as well as the sizes and connections of rooms (information coming from the user input). The user interface will then provide a way to send this graph to the “room generation API”, to obtain the final visualization of the room with the 3D mesh representing the walls. The final phase will be to integrate the user interface with the furniture tracking {All}.

3) Visualization of 3D Mesh: Once the floor plan is generated by the server, it will return the mesh to be visualized in 3D to the user. This visualization part is the final outcome generated from the user input. The visualization needs to be done in such the floor plan mesh is correctly scale and oriented with respect to the furniture.

This part can be done independently by taking a floor plan mesh with a chosen input. We will implement this component in Unity with C# {Gonca}. Once this component is working and the API to generate the floor plan is available, we will integrate this component to overlay the home model on the furniture {All}.

B. Proposed Timeline

Expected Steps	*Expected Timeline*
1. Review of 3D Object tracking techniques	19.10.2022
2. Start Developing the User Interface to collect User Input	22.10.2022
3. Start Implementing the 3D Object Tracking	29.10.2022
4. First Version of the User Interface	07.11.2022
— Midterm Presentation —	07.11.2022
— Midterm Report —	14.11.2022
5. Start Developing the Visualization of 3D Mesh	14.11.2022
6. Release of Visualization of 3D Mesh	05.12.2022
7. Release of 3D Furniture Tracking	12.12.2022
8. Final Version of the User Interface	12.12.2022
9. Start Final Testing	12.12.2022
— Final Presentation & Demo —	19.12.2022
— Final Report —	09.01.2023

III. Outcomes and Demonstration

A. Expected Outcome

By the end of this project, we should have achieved the following milestones. Firstly, we localize and track the 3D furnitures and match them accurately. Secondly, the user chooses the size of the rooms and connect them. Thirdly, the graph is generated based on the user input. Finally, using the API, we retrieve the corresponding floor plan and visualize it to the user.

B. Planned Experiments

As our project requires a robust 3D tracking to work well, we will perform the following:

- *Exp. 1: Luminosity influence:* We will check how the luminosity of the room (dark versus bright) influences the tracking performances.
- *Exp. 2: Background influence:* We will check how the background, its texture (white versus black versus checkerboard versus wild) of the surface on which the 3D printed object are placed influences the tracking performances.

We will also perform some experiments on the API to check how the floor plan generation responds when 3D printed models are not placed correctly:

- *Exp. 3: Incorrect orientation:* 3D printed objects are placed on their sides.
- *Exp. 4: Incorrect position:* 3D printed objects are placed on top of each other.

C. Demonstration

The final demonstration should be the following: we would place some 3D printed small furniture on a plan and move them to form the dreamed apartment. One would then adjust room sizes and connections using our user interface in mixed reality. Finally, thanks to the provided API, we would obtain the generated floor plan that will be displayed in mixed reality around the physical furniture. This demo will need to be online so that we can access the API.

References

[1] Jiaming Sun, Zihao Wang, Siyu Zhang, Xingyi He, Hongcheng Zhao, Guofeng Zhang, and Xiaowei Zhou. Onepose: One-shot object pose estimation without cad models. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pages 6825–6834, 2022.

[2] Bugra Tekin, Sudipta N. Sinha, and Pascal Fua. Real-time seamless single shot 6d object pose prediction. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, June 2018.