

Using Depth Cameras to Measure Foot Clearance on Stairs

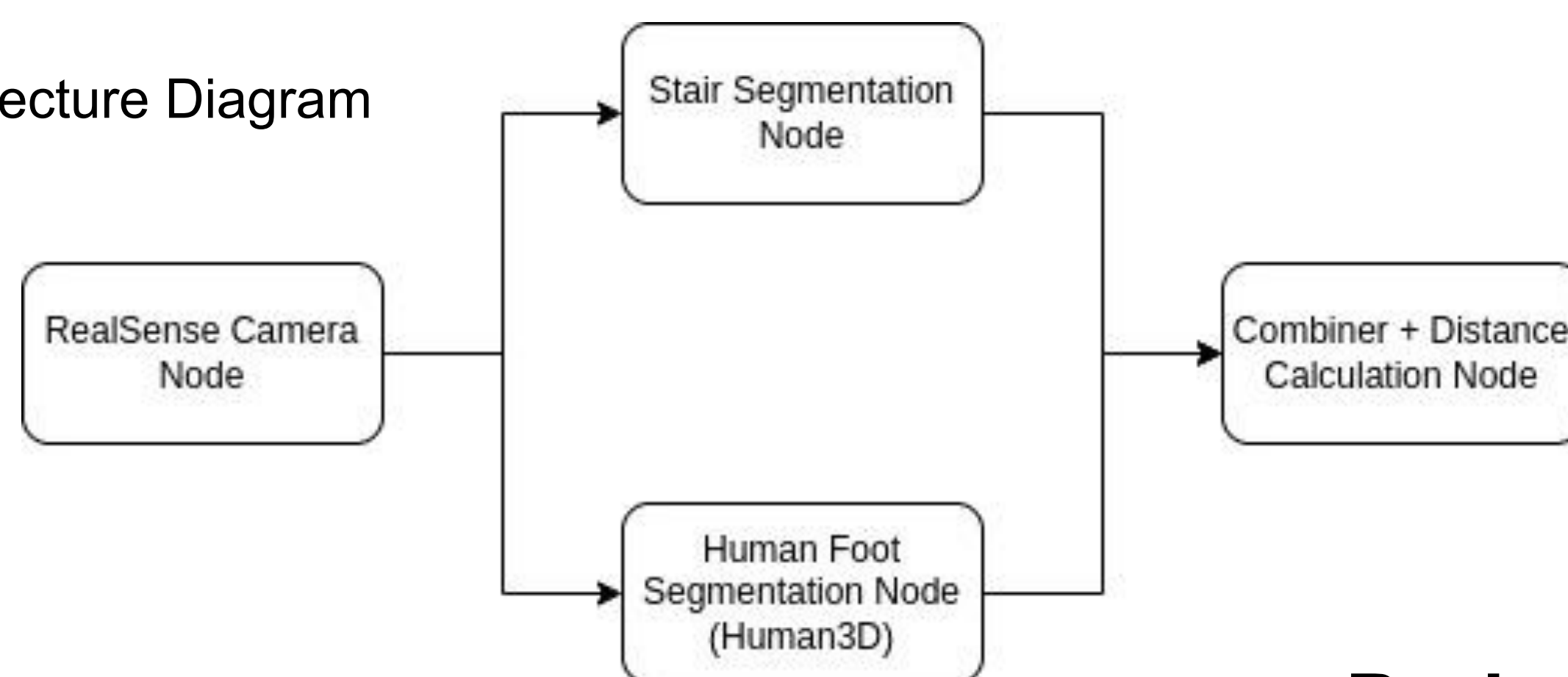
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Introduction

Fall risk is a prominent concern in our society, and environments with steps and stairs posed unique challenges on mobility. A great indicator of someone's fall risk is their foot clearance on stairs. When ascending and descending the stairs, about 5 mm of foot clearance [2,3] from their toe and heel respectively to the edge of the stair, suggests a increase in fall risk. While expensive tools exist that can detect foot clearance in controlled laboratories, it is imperative that innovative approaches at a reduced cost be evaluated that promotes adoption, especially in environments concerned with fall risk. The primary purpose of this study is to investigate the use of depth cameras to detect foot clearance on stairs.

Fig 1. Architecture Diagram



Software Architecture

Using the RealSense D455i and its natively supported ROS2 driver, we are able to obtain Point Cloud data that is sent separately to different nodes to separate out the stairs and the human foot. It then takes those segmented parts and calculates the distance between the tip/heel and the edge of the nearest stair.

Project Status

Using the RealSense ROS2 driver, we are able to properly segment out stairs using a technique called planar segmentation repeatedly. We are still working toward integrating Human3D's multi-body part segmentation [1] into the ROS2 middleware. Once this is complete, we can then use the resulting Point Cloud data to measure distances.

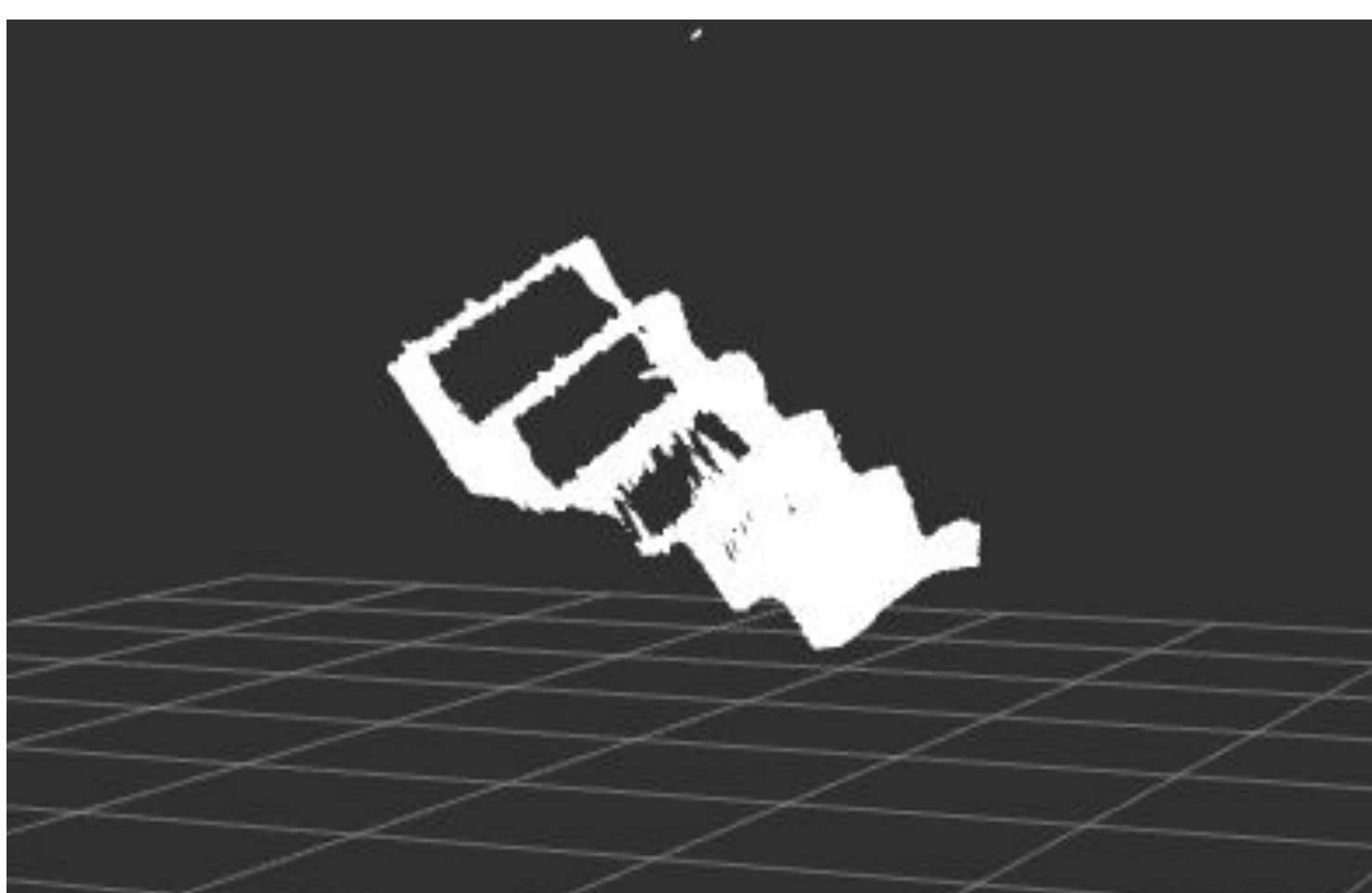


Fig. 2. Picture of stairs captured by the Stair Segmentation Node.



Fig 3. RealSense D455 picture from intelrealsense.com.

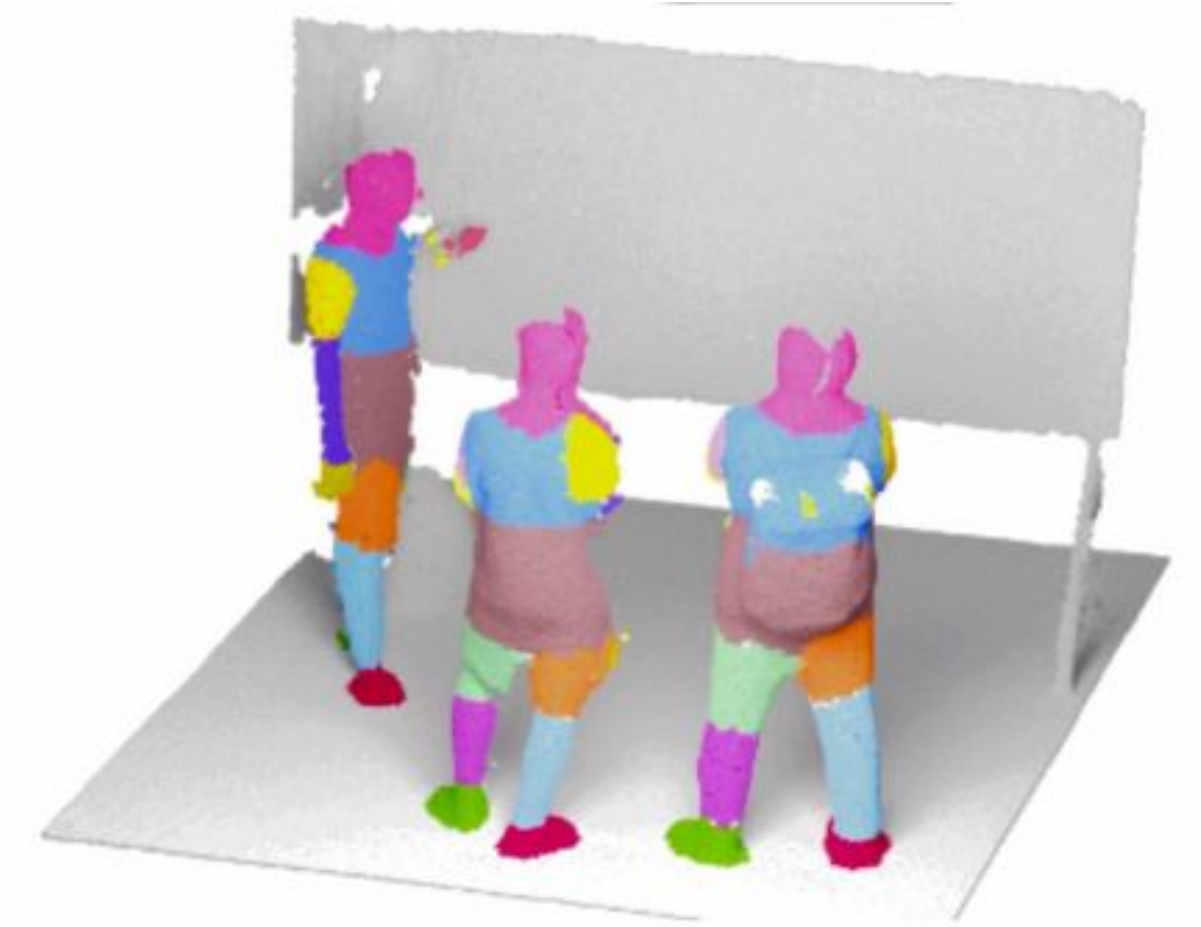


Fig 4. Human3D multi-body part segmentation. [1]

Conclusions

Stairs have been properly segmented out using planar segmentation while human segmentation is currently being developed and tested alongside the existing architecture. If more accuracy is needed, the RealSense camera can be swapped out with any sensor that integrates with ROS2 and provides Point Cloud data.

References

- [1] Takmaz, A., Schult, J., Kaftan, I., Akçay, M., Leibe, B., Sumner, R., ... Tang, S. (2023). 3D Segmentation of Humans in Point Clouds with Synthetic Data. Proceedings of the IEEE/CVF International Conference on Computer Vision (ICCV).
- [2] Hamel KA, Okita N, Higginson JS, Cavanagh PR. Foot clearance during stair descent: effects of age and illumination. Gait Posture. 2005 Feb;21(2):135-40.
- [3] Cohen HH. A Field Study of Stair Descent. Ergon Des. 2000 Apr 1;8(2):11-5.

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