Software Engineering Capstone

P.C.D - Partially Covered Detection of Humans

Group 14

Department of Computing & Software

Project Background

Problem Statement:

Our project aims to design software that can reliably detect people using point cloud data. Specifically, our product will be able to accurately and consistently detect people whether they are visually obstructed or not.

Use Cases:

- **Robotics Research**
  Our software will help further robotics research by refining human-robot interaction, enabling safer and more adaptive collaboration
- **Assistive Robots**
  Our innovative software enhances human awareness in industrial and domestic robots, paving the way for assistive solutions that seamlessly and safely integrate into every home and industry.

Goals:

- Identifying a Person
- Real-time Processing
- Location Prediction
- Usability
- Analyze and Process offline PCD files

Constraints:

- NO Machine Learning
- Using Kinect Sensor
- Indoor Use ONLY
- Closed Environment

Technology

C++ · KINECT · pcl · OpenCV

Acknowledgement

We would like to thank Dr. Gary Bone for the support and guidance that contributed to our project!

Process Overview

Retrieve Point Cloud Data from Kinect

1 Custom Plane Detection and Removal
- **Surface Normals:** consistent normals over a region indicates a planar surface.
- **Depth Variance:** variability or differences across a surface helps to identify surfaces and remove noise.
- **Depth Discontinuity:** changes in depth between neighboring points allow us to locate plane boundaries.

1 OpenCV Filtering

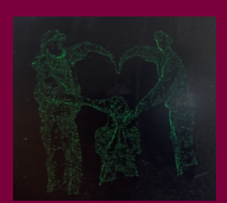
2 Seed Point Acquisition

2 Skin Point Detection
- **Initial Skin Mask:** filter based on HSV ranges.
- **Skin Mask Filtering:** filters out reds and oranges.
- **Skin Confidence Mask:** cleans up mask and store points most likely to be skin as seed points.

3 PCL Filtering
- **Voxel Down Sampling:** Down sample cloud to reduce number of points that need to be processed.
- **Noise Removal:** Clean up any scattered points.
- **PCL Plane Removal:** Further detect and remove previously undetected planes using the RANSAC method.

3 PCL Filtering

4 3D Cluster Extraction



4 Region Growing
- **Determine Skin Point Coordinates:** Use the approximate OpenCV Skin Point and determine its true coordinate in PCL.
- **Grow the Human Cluster:** Continously find the closest relavant neighbour from the skin point until the human cluster is formed.
- **Track Region Growth Process**: Store all neigbours and their computed directions during the growth process for later analysis.

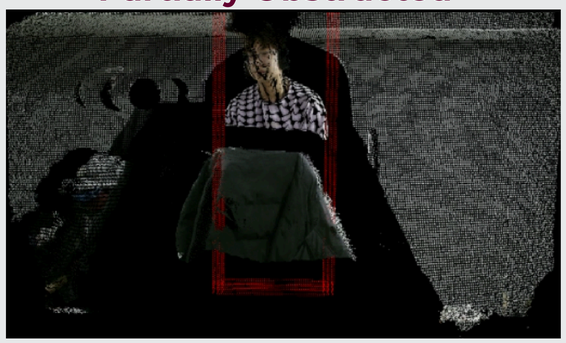
5 Region Estimation
- **Analyze Growth Directions:** Use region growth directional patterns to estimate where a person lies in frame.
- **Analyze Clustered Neighbour Centroids:** Use simplified clustered neighbour centroids to check for linearity and a pattern of consistent horizontal/vertical growth.
- **Predicting Obstructed Regions of a Person:** Use a combined weighted decision of growth direction analysis and clustered neighbour centroids to determine if region is central or at an offset.

5 Region Estimation

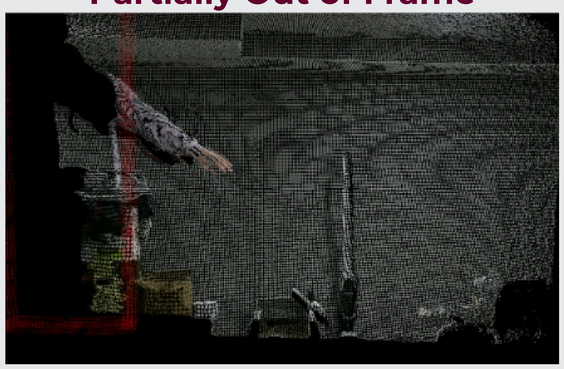
Outcomes

Fully Visible

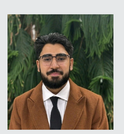
Partially Obstructed



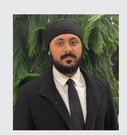
Partially Out of Frame



Team



Tarnveer Takhtar



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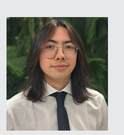

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