# 3D Reconstruction from Depth Images
# COMP5115 Project
# Fall 2019

# Outline

- Introduction and Motivation
- Related Works
- Results and Conclusion

# Introduction and Motivation

- Purchased an Intel RealSense D435 Camera.
- Studied STAR paper by Zollhöfer to see how it could be used.
- Installing/compiling IntelRealSense SDK with OpenCV and PCL

# Problem Statement

Problem: process a stream of RGB-D frames for model reconstruction

- Tracking: estimate the pose (position + orientation) of the camera. Camera presumed moving through space – need to keep track of position and which way it's pointing.
- Mapping: (incrementally) build a model of the scene captured by camera.

# Related Works I


Keselman, Leonid, et al.
Intel realsense stereoscopic depth cameras.
IEEE Conference on Computer Vision and Pattern Recognition Workshops. 2017.

Cignoni, Paolo, et al.
Meshlab: an open-source mesh processing tool.
Eurographics Italian chapter conference. Vol. 2008.

# Related Works II

Pagliari, Diana, et al.
Kinect Fusion improvement using depth camera calibration.
The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences 40.5 (2014): 479.

# Fusion Methods

Goal: Reconstruct a global model $\mathbb{M} = (\hat{V}, \hat{N})$ from a sequence of depth frames $D_i = (V_i, N_i)$.
Assuming that the scene is static, depth frames can be fused into a single point cloud by finding the camera pose which aligns the current depth frame with the model.
Outlier points which do not fit in the model should be presumed errors and discarded.

# Challenges I

Measurement

- High volume of data (640x480 @ 30fps = 9 million points per sec)
- Occlusion (stuff in the way), holes
- Measurement errors: incident angles, shiny or transparent materials
- Potentially erratic camera movement: blurry measurements
- Dynamic scenes, moving objects
- Camera drift: accumulation of errors in pose estimation

Video: playing with RealSense PointCloud example:
`https://youtu.be/cQrPQ1dFIYU`

# Frameworks I

Fusion and alignment algorithms are bundled in a few frameworks:

- Robot Operating System (ROS)
- Point Cloud Library
- OpenCV (Kinfu)

Intel RealSense SDK provides “wrappers” for these frameworks.
Idea: encapsulate sensing device so that a stream (or pipe) can be fed into one of these frameworks’ algorithms.
`https://github.com/IntelRealSense/librealsense/blob/master/wrappers/opencv/kinfu/rs-kinfu.cpp`

# Results I

Not good: so far, unable to run any of the open source Fusion algorithms.
Complex development environment because of hardware drivers, operating system and dependencies. Need to use and configure CMake.
OpenCV KinFu dependencies:

- Intel RealSense SDK
- OpenCV and OpenCV_contrib
- OpenMP
- NVidia GPU drivers and CUDA
- Visual Studio 201X
- GLFW and GLEW

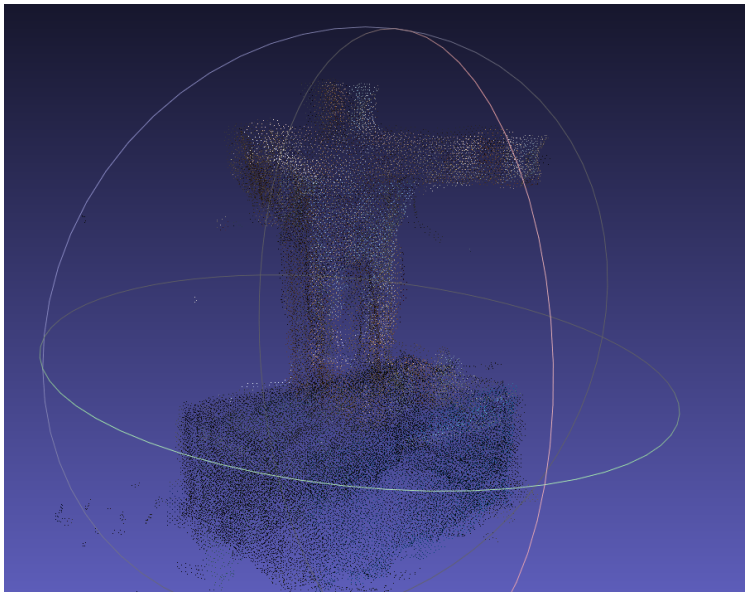
# Alternate Strategy I

Experiment with reconstruction by manually aligning point clouds.
Raw point clouds need to be tidied:
`https://youtu.be/on1zKm5XRmk`
Then aligned together using ICP:
`https://youtu.be/FniwUexwY5g`
The results are not very good...

# Alternate Strategy II

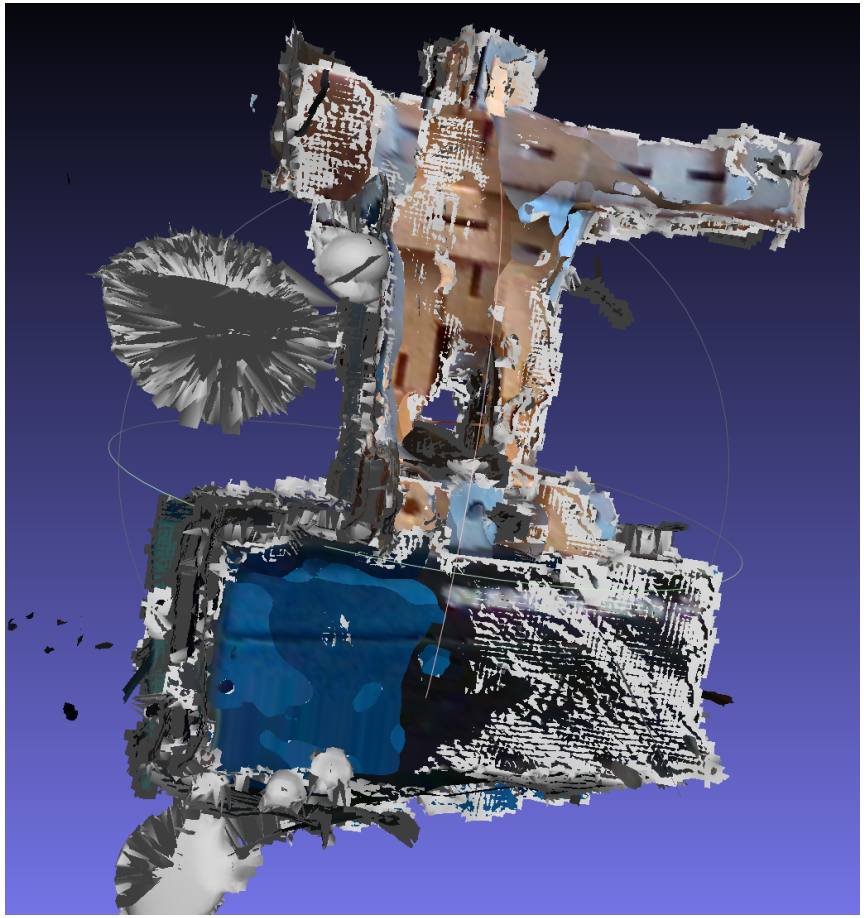
# Reconstruction I

After using Meshlab's different smoothing, sampling and reconstruction filters:
Poisson sampling:



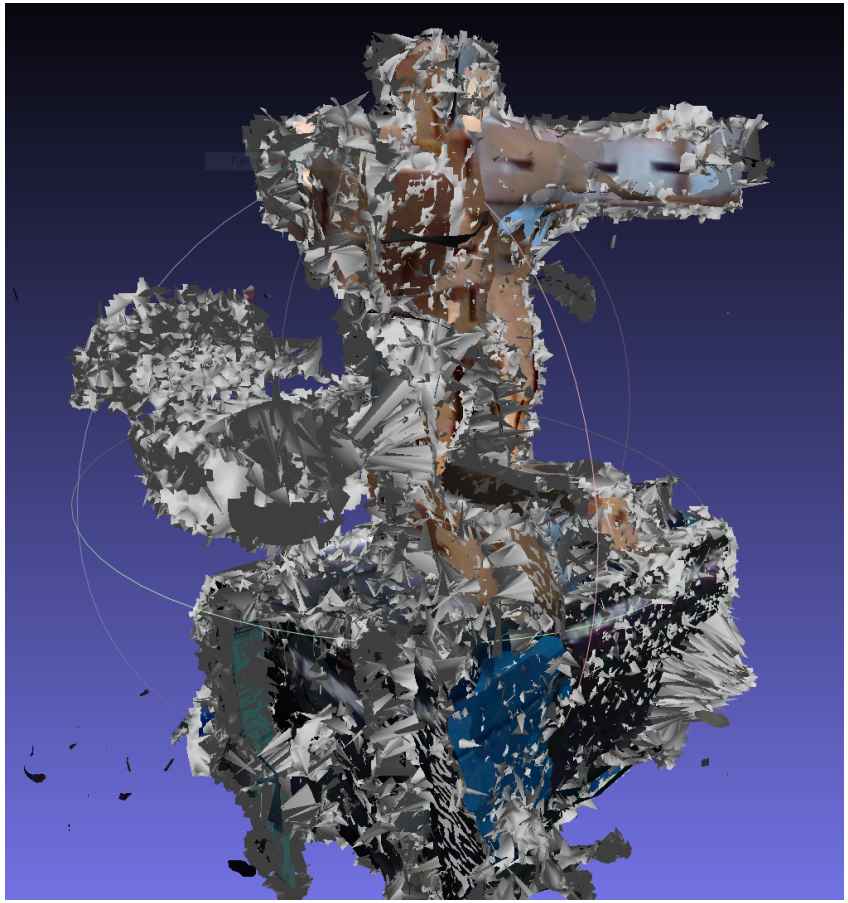
# Reconstruction II

Reconstruction 1:



# Reconstruction III

Reconstruction 2:



# Conclusion

Project needs to be refocused: even if Fusion algorithm run successful, not clear how to improve or modify.
Possible ideas:

- Analyze depth measurements in ".ply" files produced by camera. Perhaps a higher quality point cloud can be obtained by blending several "'identical" frames together.
- Applied project which describes the entire geometry pipeline, from scanning and registration to 3d printing.

# References I


Zollhöfer, Michael et al. (2018)
State of the Art on 3D Reconstruction with RGB-D Cameras
Computer Graphics Forum

Pagliari, Diana and Menna, Fabio and Roncella, R and Remondino, Fabio and Pinto, Livio (2011)
Kinect Fusion improvement using depth camera calibration
Photogrammetry, Remote Sensing and Spatial Information Sciences