

# Studying Sketch-based Mesh Reconstruction for Robotic Manipulation Tasks

Sketching Geometry and Physics Informed Inference for Mobile Robot Manipulation in Cluttered Scenes  
Sina Masnadi, Joseph LaViola, Karthik Desingh, Odest Jenkins

## Introduction

We introduced GemSketch, an interactive system for extracting the geometries of generalized cylinders and cuboids from single- or multiple-view point clouds. The proposed method requires the user to trace the object's silhouettes to reconstruct the 3D geometries of objects. We implemented a new system which enables users to sketch on the 3D point cloud representation of the scene in addition to the 2D images. We performed a user study to gather users' perspective on the system.

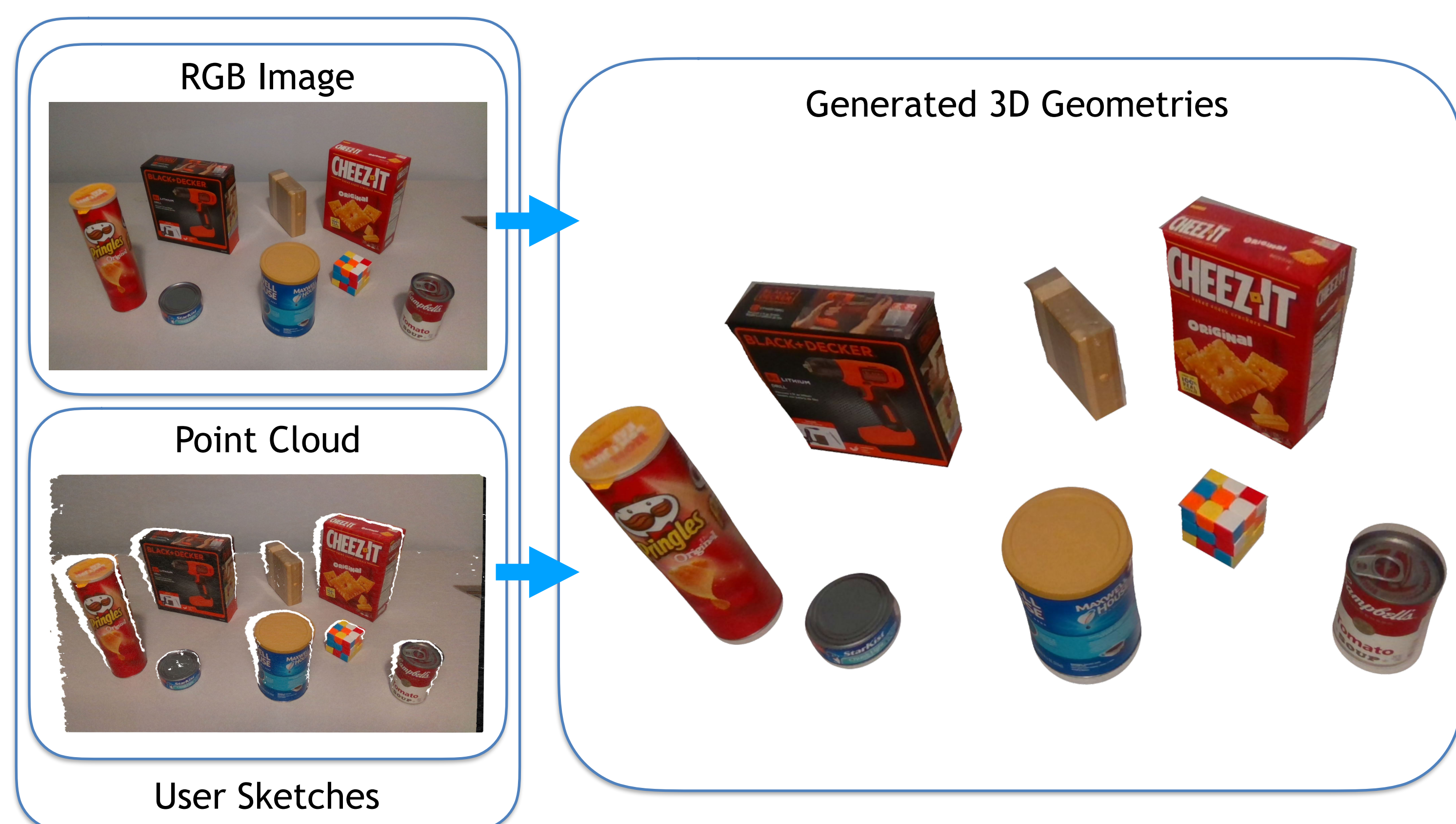


Figure 1. 3D geometries are created using sketches on 2D images or 3D point clouds

## User Study

Benefiting from the user's perceptual understanding of what an object looks like, GemSketch is capable of extracting accurate models, even in the presence of occlusion, clutter or incomplete point cloud data, while preserving the original object's details and scale. In the new system, users can rotate and transfer the point cloud view of the scene to get a better understanding of objects shape and position before drawing the silhouette of the desired object. We conducted a 20-participant (7 female, 13 men) user study to test the usability of the system and comparing the performance of sketching on point clouds versus RGB images. The qualitative and quantitative usability data measured during the study shows that users enjoy using the sketch-based geometry extraction system and high usability indexes for the system. We hypothesized that users would prefer drawing sketches on images of the scene rather than drawing on the point clouds and they would perform better on the RGB image. But, the study shows that there is no statistical significance between them.

## Results

The users were asked to sketch the silhouettes of 8 objects (4 cuboid, 4 cylindrical) on point clouds and RGB images. Users started with a randomly chosen view mode. The results of the study did not show any statistical significance between sketching on point clouds and images for time (Figure 3), accuracy (Figure 4), and overall experience which concludes that the system works consistently in both modes. The results of the usability of the system were promising for SUS ( $\mu=89.8$ ,  $\sigma=7.43$ ) and TLX (Figure 2).

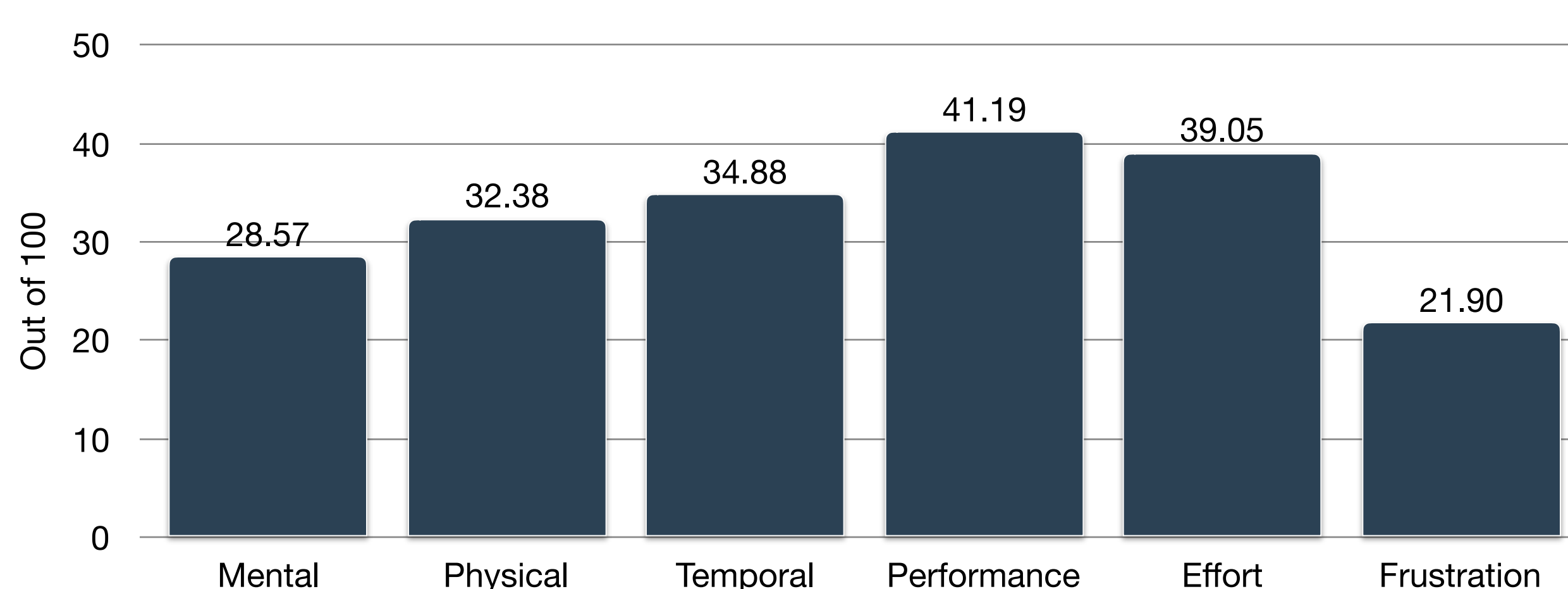


Figure 2. Task Load Index (TLX) workload assessment values

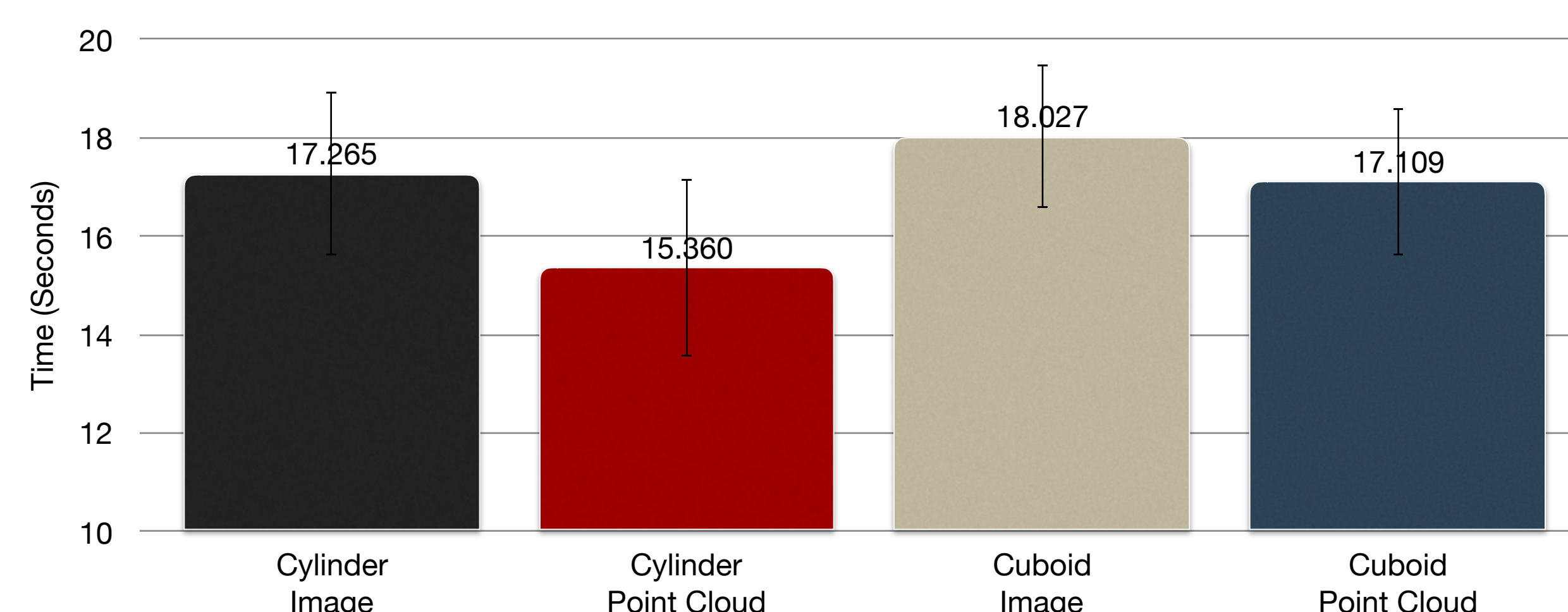


Figure 3. Average users' times for sketching cylindrical or cuboid shapes on images or point clouds

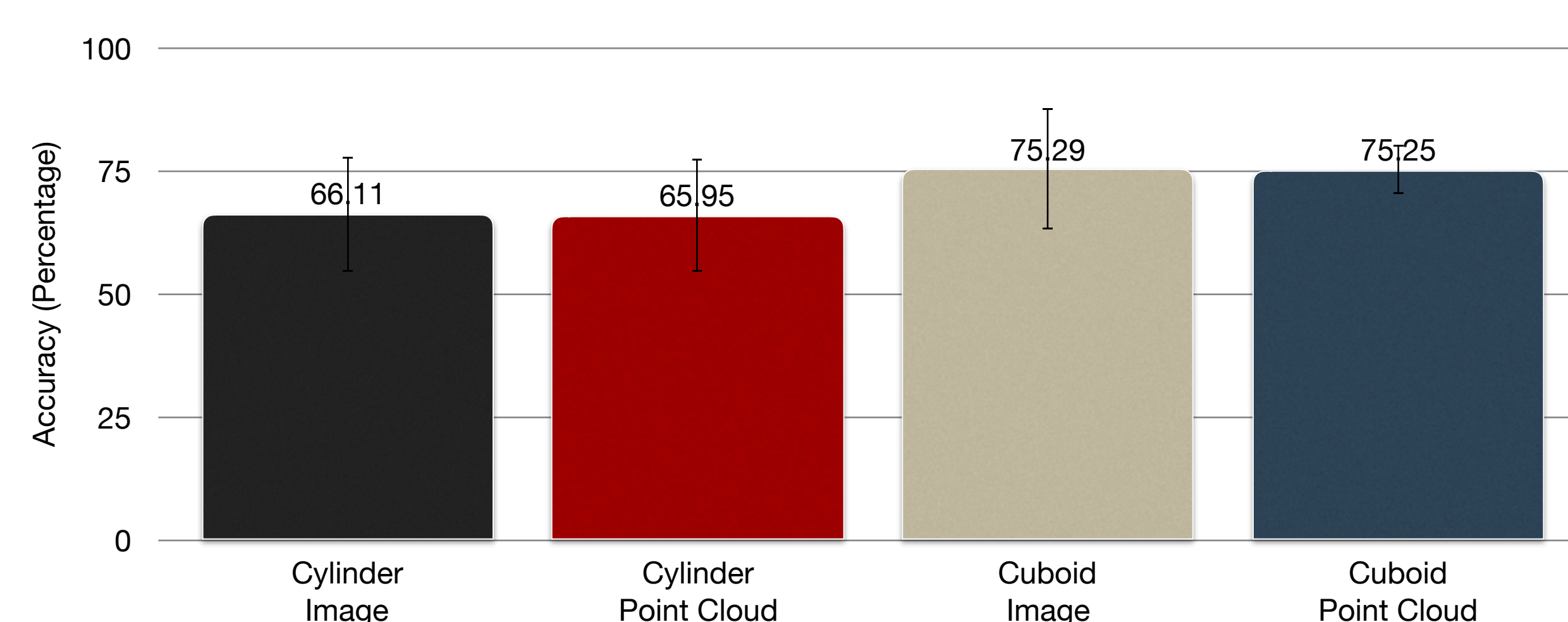


Figure 4. Average accuracy (Hausdorff) of the extracted geometries from sketches of cylindrical or cuboid shapes on images or point cloud

## References

- [1] Maghousi, Mehran, Joseph J. LaViola, Karthik Desingh, and Odest Chadwicke Jenkins. "GemSketch: Interactive image-guided geometry extraction from point clouds." In 2018 IEEE International Conference on Robotics and Automation (ICRA), pp. 2184-2191. IEEE, 2018.
- [2] Masnadi, Sina, Joseph J. LaViola Jr, Jana Pavlasek, Xiaofan Zhu, Karthik Desingh, and Odest Chadwicke Jenkins. "Sketching Affordances for Human-in-the-loop Robotic Manipulation Tasks." 2nd Robot Teammates Operating in Dynamic, Unstructured Environments (RT-DUNE) (2019).