# VISION-GUIDED COLLABORATIVE ROBOTS

Mugdho Jeferson Rozario , Aravind Narayanan and Gary M. Bone
Robotics and Manufacturing Automation Laboratory ,Mechanical Engineering Department, McMaster University, Hamilton, Canada

## Introduction

- Collaborative robots , otherwise known as “cobots” are being used in factories, or anywhere where collaboration with people is required.
- The use of sensors and proper algorithms allows such robots to be used safely when in close proximity to human co-workers.
- In our research , we created an algorithm which automatically maps the 3D camera coordinates to the robot’s coordinate system. The robot which is being used for our purpose is shown below.

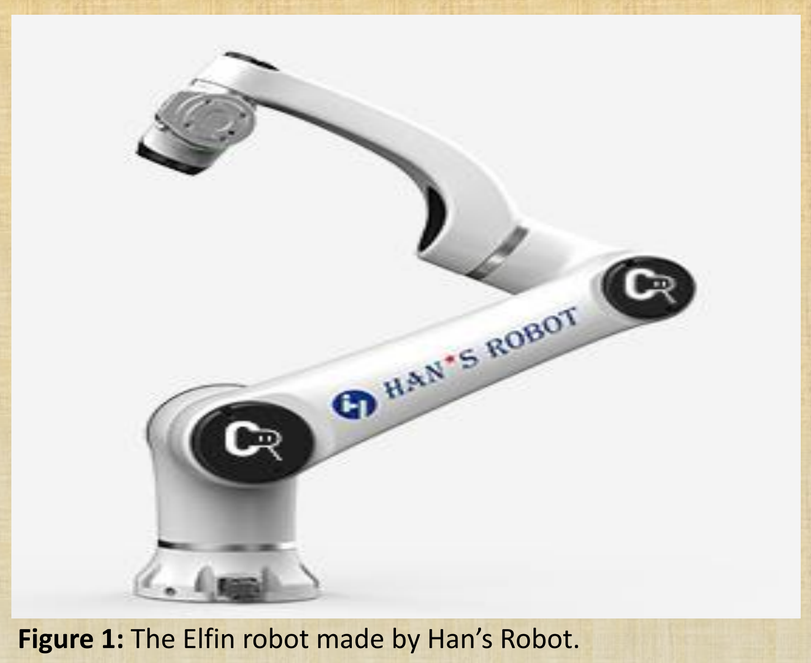


**Figure 1:** The Elfin robot made by Han’s Robot.

## Objectives

- The goals of this project are to design, program and experimentally test the robot software for collaborative tasks.
- A point cloud produced by a 3D camera had to be simulated. A point cloud is a set of data points in three dimensions. In our case, the points represent the points of our robot in an open space.
- The main goal of our algorithm is to have a function that calculates a 4 by 4 transformation matrix that converts a point from our camera , 3D camera into coordinates that are comprehended by the robot.
- The computational speed of our program had to be improved, and this was achieved by simplifying our STL files of our robot. This allowed us to work with less triangles that were formed on the surface of the robot.

## Subjects and Methods

- The 3D point cloud created by the camera mounted on a tripod is simulated for a given scene.
- The user enters a guess for the homogeneous transformation matrix relating the robot’s coordinate frame and the camera’s coordinate frame.
- The flowchart below shows the detailed processes undertaken to create the simulated points.

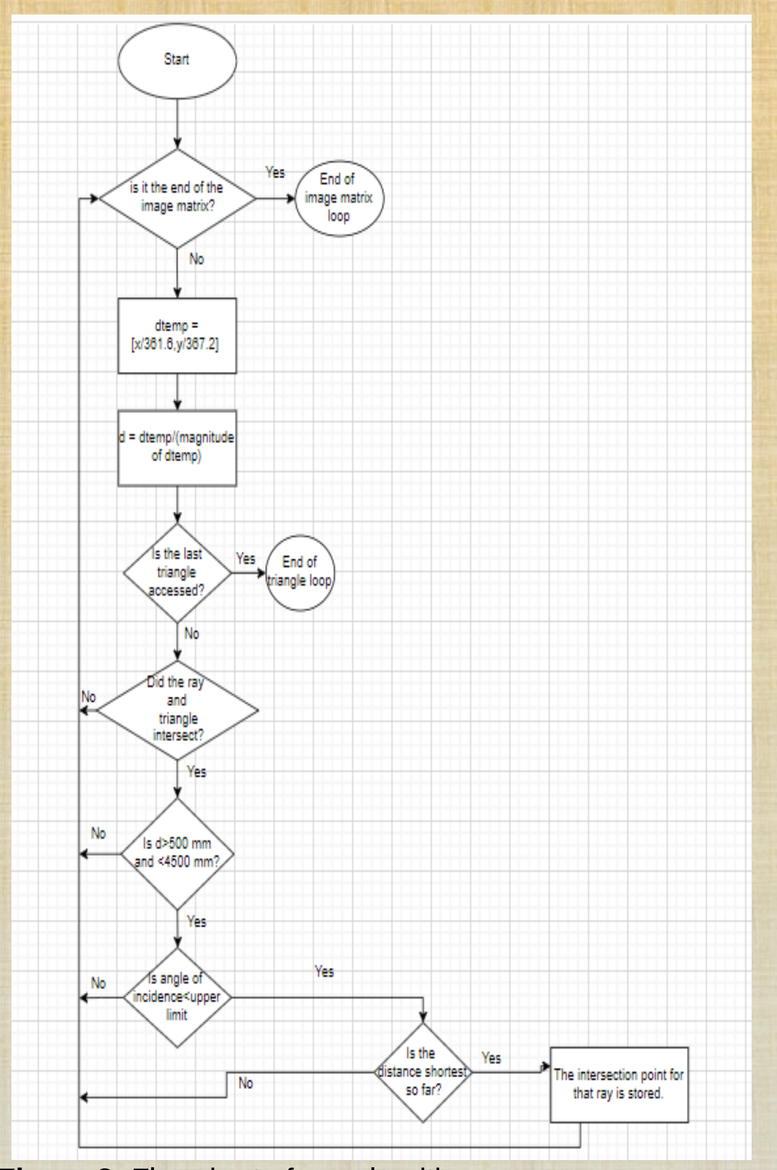


**Figure 2:** Flowchart of our algorithm

- Our algorithm takes in two inputs which are the user’s guess for the translation and rotations of the camera’s coordinate frame relative to the robot’s coordinate frame; and the joint angles of the robot.
- Different point clouds can be created by changing the parameters or joint angles. This changes can be used to create the 4 by 4 matrix that changes the camera coordinates into robot coordinates.
- In order to cross check if the matrices are correct , we can multiply the matrix obtained to our first point cloud and see if the points properly lay on the surface of the triangles.

## Results

- The links of Elfin are properly placed over one another using proper transformation matrices.
- The intersection point of each ray is stored in the cloud point array, which is then displayed using MATLAB

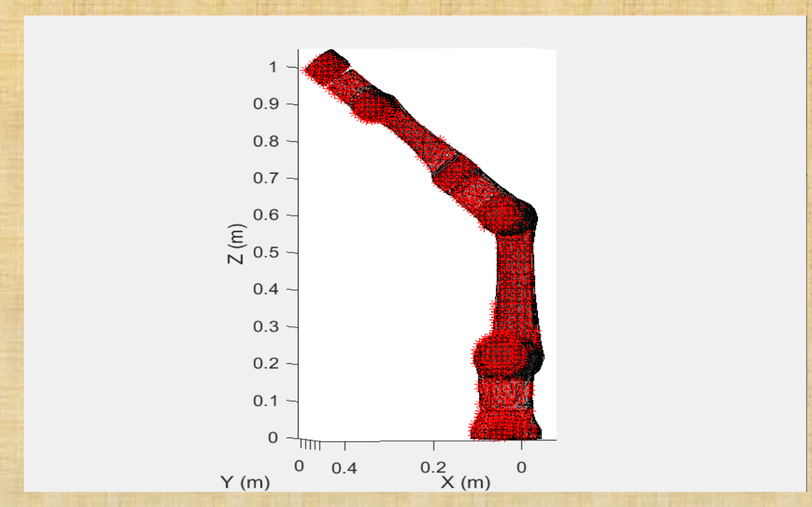


**Figure 3:** Cloud points displayed over Elfin

- The transformation matrices were accurately placing the cloud points over Elfin for different joint angles as well as different translation and rotation.
- The red points on the figure above shows the result of applying the algorithm when a different parameter was used for our rotation and translation.
- The algorithm will be further fine tuned so that it can be used in more scenarios than it is currently capable to calculate.

## Conclusions

- The algorithm accurately predicts and maps the 3D camera coordinates to robot coordinates.
- This algorithm will be essential for tasks such as the robot handing tools to the hand of a human co-worker. The robot will use the hand location measured by the 3D camera, after it has been mapped, and move to the correct position accordingly.
- The use of vision guided collaborative robots loaded with our algorithms will enable future robots to provide greater assistance to people at work, and in their daily lives.

## References

- L. Bergamini, M. Sposato, M. Pellicciari, M. Peruzzini, S. Calderara, and J. Schmidt, “Deep learning-based method for vision-guided robotic grasping of unknown objects,” *Advanced Engineering Informatics*, vol. 44, Apr. 2020, doi: 10.1016/j.aei.2020.101052.
- Gao, G., Gao, Y., Liu, F., & Na, J. (2022). Calibration of Collaborative Robots Based on Position Information and Local Product of Exponentials. *Journal of Sensors*, *2022*. https://doi.org/10.1155/2022/2815164
- Möller, Tomas; Trumbore, Ben (1997). "Fast, Minimum Storage Ray-Triangle Intersection". *Journal of Graphics Tools*. **2**: 21–28. doi:10.1080/10867651.1997.10487468.

**Dr. Gary M. Bone**
Professor, McMaster University
McMaster University, Mechanical Engineering Department
JHE-326F
Email: gary@mcmaster.ca
Phone: +1(905) 525-9140 Ext. 27591

BRIGHTER WORLD