# Modular and Whole Finger Tactile Sensing Gripper

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## Abstract

This work explores a modular gripper with tactile sensing capabilities all-round the surface and not just limited to the inner fingertip. The system makes use of commonly available components to achieve optical tactile sensing by detecting deformations on a soft transparent silicone elastomer skin. Whole body tactile sensing around the gripper not only provides information on the object being grasped, but also of the immediate environment. These contact information can aid in the exploration of unstructured and cluttered environment


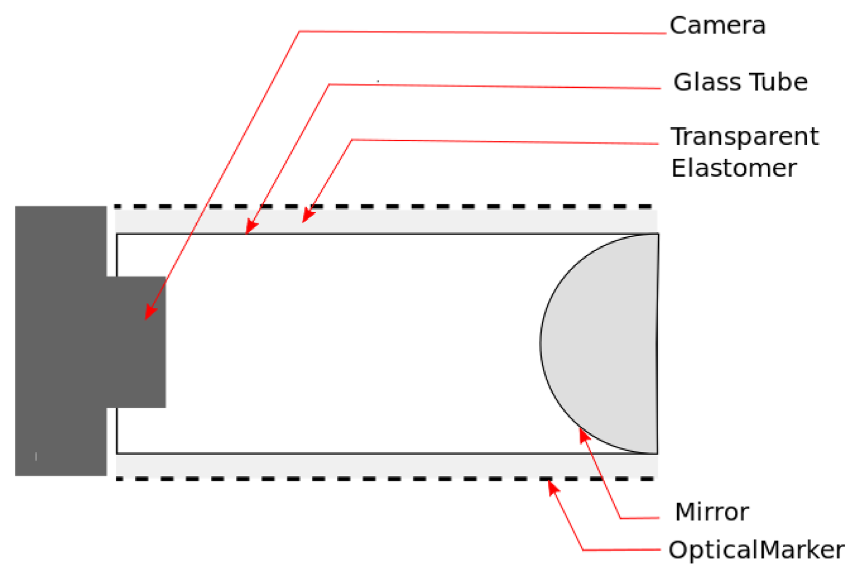


**Figure 1.** Conceptual design of the Modular Tactile Finger.

## Tactile Finger

The tactile finger consists of reconfigurable modules, which can be assembled in various ways. The modules are cylindrical in shape, similar to human fingers. This streamlined shape can aid greatly in the smooth exploratory motion in clutter. It consists of a cylindrical glass tube coated with a layer of transparent silicone elastomer, as in Fig.1. The deformable elastomer has colored markers on its outer surface, which is then tracked by a wide angle camera placed at one end of the glass tube. The camera is able to get a 360 degree image of the surface of the finger, which can be then de-warped to rectangular images for better understanding and processing. The other end of the tube has a spherical mirror. The reflected image of the markers from the spherical mirror provides view from another angle and is intended to be used in future to reconstruct the three dimensional position of the markers using stereo reconstruction.

Using off the shelf components ensured that the cost of the modular tactile finger is kept low. A 75 x 12 mm laboratory test tube is used as the cylindrical tube. The elastomer has Shore A hardness of 15 and is made using high transparent platinum cure silicone, which is molded into a thin sheet and wrapped over the test tube. The parabolic mirror is made using a chrome coated metal ball bearing. The finger is compatible with commonly available webcams and better results were obtained using a wide angle Raspberry Pi Camera

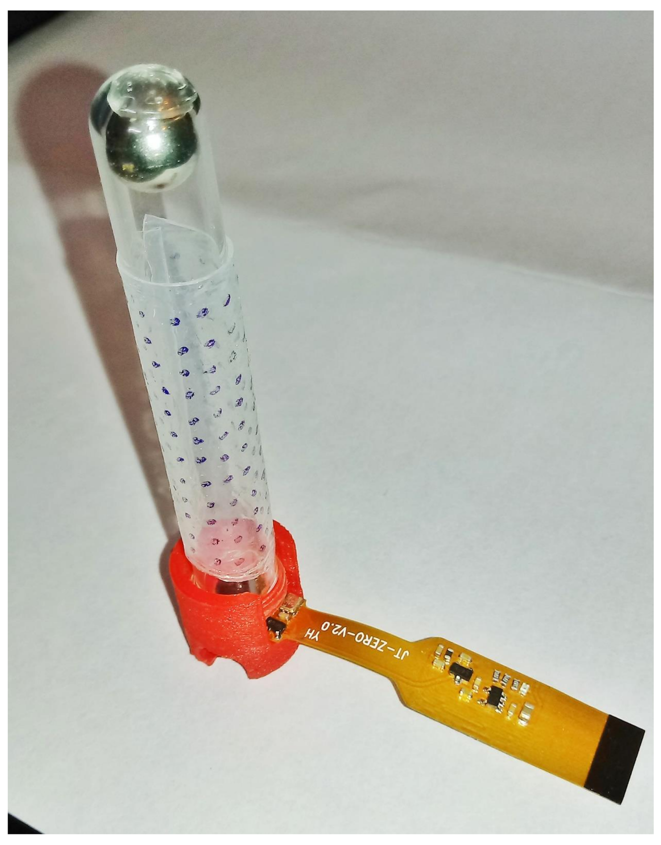

**Figure 2.** The Modular Finger

## Modularity

The modularity of the system is achieved using interlocking mechanism which can couple multiple fingers serially or to a fixed base. The coupling can be flexible or rigid. Fig. 2 shows the prototype modular tactile finger. Two configurations of grippers using the modular tactile fingers are explored as in Fig3. The first one being a simple two finger parallel gripper, using two modules and the second being a cable driven under actuated gripper using four such modules.

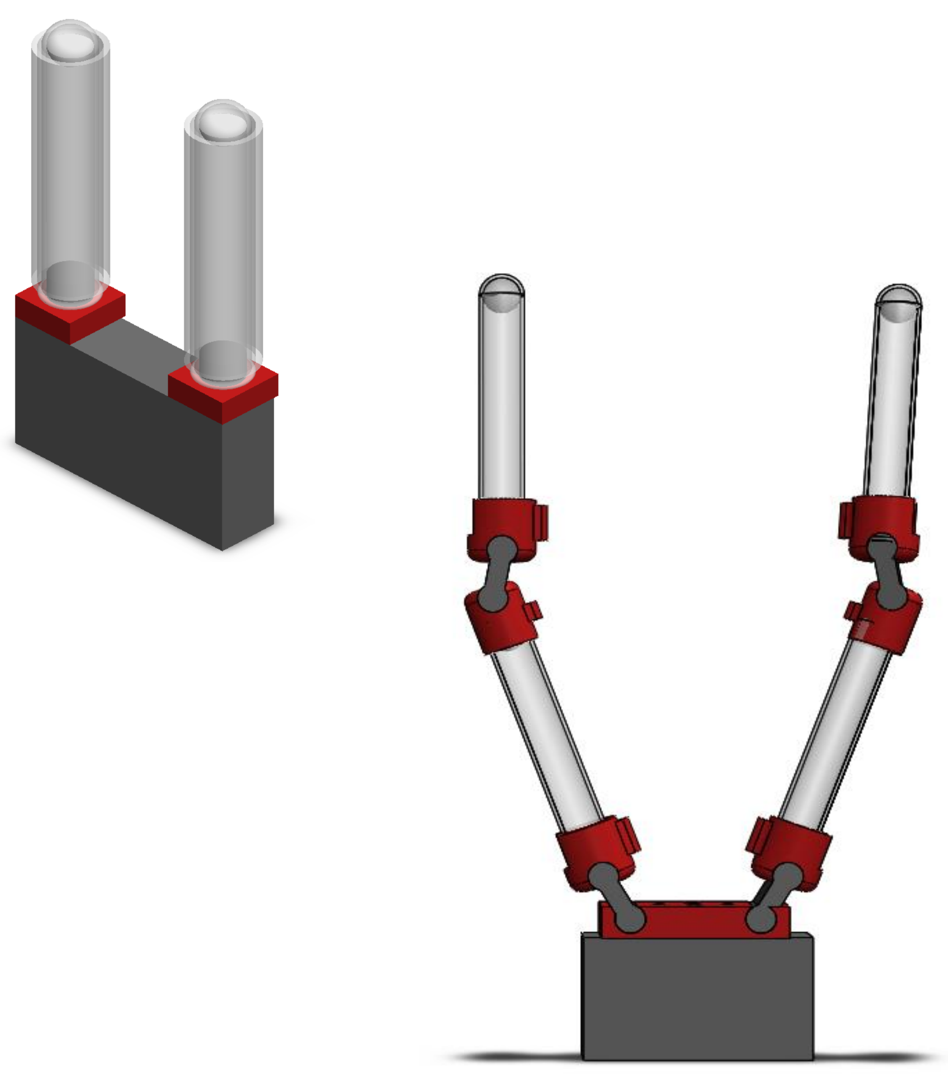

**Figure 3.** Two gripper configurations possible with the Tactile Finger

## Results

The colored markers around the finger are detected using blob detection in OpenCV and tracked by comparing their position with the initial positions. One can then estimate the contact force and force field distribution from the difference estimated between current position of markers and their initial calibrated positions.

**Figure 4.** The raw image

**Figure 5.** The preprocessed image

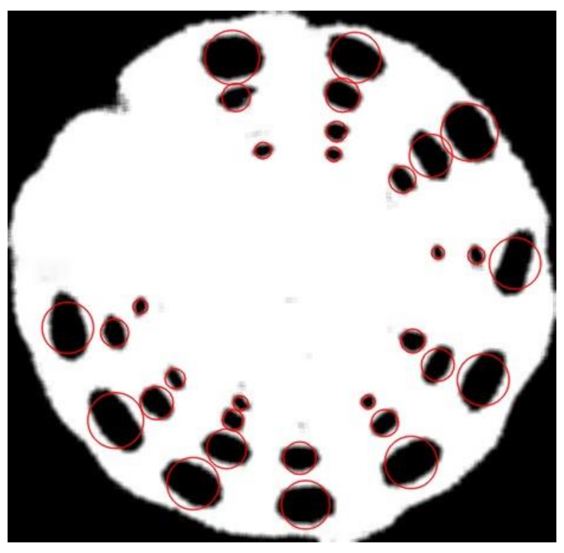

**Figure 6.** Detection and Tracking of Markers

## Conclusions

The concept of whole finger tactile sensing can be achieved using the proposed modular tactile finger. Various future directions of research are identified. One will be able to make use of the image reflected from the spherical mirror to improve the sensing accuracy. The system also may need an active lighting system. Replacing the markers with technologies like GelSight, which can provide high resolution tactile information, can help to bring human level tactile resolution to the system.

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