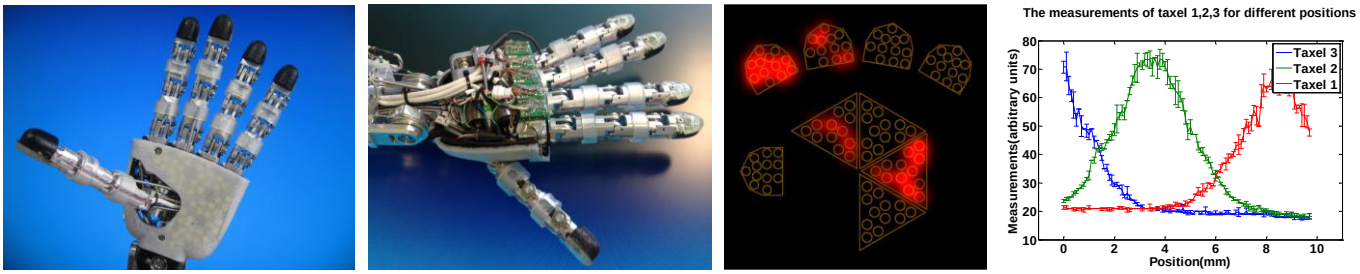
Integrating Tactile Sensors into the Hands of the Humanoid Robot iCub

Alexander Schmitz[*+], Marco Maggiali[*], Lorenzo Natale[*] and Giorgio Metta[*#]

* Italian Institute of Technology + University of Sheffield # Universita degli Studi di Genova

e-mail: {alexander.schmitz, marco.maggiali, lorenzo.natale, giorgio.metta}@iit.it



(a) (b) (c) (d)

Fig. 1. (a) (b) Pictures of the hand. (c) An example of the visualization. (d) A graph indicating the crosstalk of the taxels.

I. Introduction

TACTILE sensing is a key requirement for grasping and object manipulation. Many touch sensors have been described in literature, using various different methods of transduction [1]. Nevertheless, there is still a lack of satisfactory tactile sensors for the hands of humanoid robots. This is because "they are too big to be used without sacrificing dexterity or because they are slow, fragile, lack elasticity, lack mechanical flexibility, and lack robustness" [1]. As such, few tactile sensors have been integrated into robots and few of them have gone beyond the prototype stage.

II. Our Approach

We have integrated a capacitive pressure sensor system with 108 sensitive zones into the hands of the humanoid robot iCub, i.e. into the palm and all fingertips, see Fig. 1 (a), (b) and (c). The hand of iCub is roughly 14cm long and 6cm wide and has five underactuated fingers [2]. When designing the sensors, we gave special attention to the integration on the robot. Also the ease and speed of production was an important design factor. Furthermore, an integral part of the capacitive sensor is soft silicone foam, and therefore the fingertips and the palm are compliant.

The palm consists of four triangular modules, which can be used to cover generic curved surfaces and will be used to cover also other parts of the robot body in the future [3]. On the contrary, the small size and round shape of the fingertips made it necessary to design a specific solution that fits on the fingers of iCub. As a result each fingertip is 14.5 mm long and 13 mm wide and high. It has a round shape that resembles a human fingertip.

Each triangular module and each fingertip incorporates a flexible PCB with the electronics to obtain 12 capacitive pressure measurements and send them over a serial bus. In particular, each PCB includes 12 round pads for the capacitive pressure sensor and a capacitance to digital converter (CDC) (AD7147 from *Analog Devices*). The CDC chip is able to measure either all 12 taxels independently at 50 Hz or an average of the 12 taxels at about 500 Hz. The CDC can provide twelve 16 bits measurements of capacitance and send them over an I²C serial bus. As a result, for the fingertips, only 4 wires travel along the side of the fingers to small boards at the back of the hand. In the case of the palm, the triangles also include the electronics to communicate between themselves over a serial bus, therefore only one of them is connected to the boards in the back of the hand. These boards relay the data from all five fingertips and the four modules in the palm to a microcontroller board, which is small enough to be included into the forearm of iCub. The microcontroller unit can collect the measurements from all the CDC chips and send the measurements through a CAN bus to the PC104 in the iCub head.

We developed a test setup to identify the characteristics of the sensor. For example, we used it to test the spatial resolution of the sensor. We applied the same pressure to the fingertip at different positions, along a straight line from the back of the fingertip to the front. We show the measurements of the 3 taxels that the probe traverses while going from the back to the front in Fig. 1(d). The results show that there is little cross-talk between the taxels and that the fingertip can be used to localize where pressure is applied to it.

References

[1] R.S. Dahiya, G. Metta, M. Valle and G. Sandini, "Tactile Sensing: From Humans to Humanoids," *IEEE Transactions on Robotics*, vol. 26, no. 1, 2010

[2] G. Metta, D. Vernon, L. Natale, F. Nori and G. Sandini, "The iCub humanoid robot: an open platform for research in embodied cognition," in *IEEE Workshop on Performance Metrics for Intelligent Systems Workshop*, 2008

[3] G. Cannata, R. S. Dahiya, M. Maggiali, F. Mastrogiovanni, G. Metta and M. Valle, "Modular Skin for Humanoid Robot Systems," in *4th Int. Conf. on Cognitive Systems*, 2010