Live Demonstration: Tactile Events from Off-The-Shelf Sensors in a Robotic Skin

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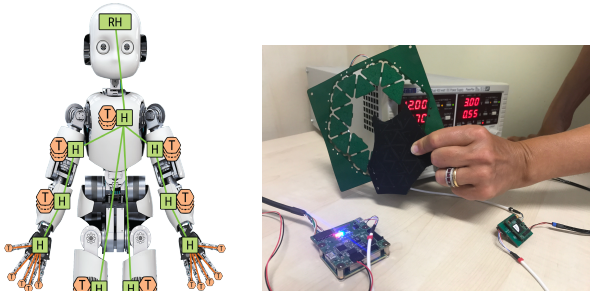
***Abstract*— The demonstration presents a robotic event-based tactile infrastructure for a humanoid robot. It leverages on currently deployed sample-based capacitive sensors to generate tactile events, enabling the investigation and development of event-driven tactile applications, and minimizing communication bandwidth and latency. The modular FPGA-based system samples data from tactile sensors and generates address-events, transmitted through an asynchronous serial address-event representation protocol. To enable performance comparisons of the event-driven approach with respect to standard sample-based solutions, the acquisition modules can directly forward the input samples through the same event-based communication channel. We will show in real time a comparison between the tactile events and the original sampled data generated when the skin patch is touched.**

I. Demonstration Setup

In many applications, such as touch screens and artificial skin (for robots or prosthetics), a large number of pressure sensitive elements are distributed over a surface, but only a small percentage is activated through a localized contact. In this scenario, event-driven encoding reserves communication (and computing) resources to sensing elements that are effectively stimulated, saving power and bandwidth, reducing latency and increasing sampling rate when needed. We developed a setup for the event-driven encoding and communication of pressure [1] based on capacitive sensors and off-the-shelf clock-driven sampling and analog to digital conversion, developed for the iCub humanoid robot. We connected this traditional front-end to an FPGA, that sends data only when a potential contact is sensed, i.e. when the signal is above noise level and when it changes with respect to the previous sample. As a carrier module, we developed an asynchronous serial address-event protocol [2], that is interfaced to a robotic middleware, YARP [3], for data acquisition and high-level processing. The proposed system effectively optimizes communication cost and latency. Fig. 1 shows the final system on the robot and the demonstrator setup. The robot will have a tree-like hierarchy, where tactile hubs gather event-driven information from the local skin patch and stream it to higher level modules. The demonstrator comprises two skin patches, the event-based tactile hub and a main ZynQ platform running YARP.



(a) (b)

Fig. 1: ED Tactile Sensing on the iCub robot: (a) Capacitive sensors are integrated on the fingertips or skin patches, a Tactile Hub acquires clock-sampled data and generates and sends events to the asynchronous serial bus (merged with the events from other skin patches). A ZynQ board in the robot head acquires, deserialises, time-stamps the data and makes them available to the CPU memory. (b) Demonstrator setup.

II. Visitor Experience

Visitors can touch the skin patch and see the resulting activation on a screen, where events and samples will be displayed in real time. The demonstrator effectively shows the constant data throughput of the clock-driven readout and the compressive data throughput of event-driven readout, where activity is transferred only if the skin is touched. Displayed performance measurements such as number of bits transferred and error between samples and reconstructed data from events directly compare the two readout systems.

Acknowledgment

Thank A. Mura and M. Maggiali for the design of supporting electronics and advice on the iCub tactile system.

References

[1] C. Bartolozzi, P. Motto Ros, F. Diotalevi, N. Jamali, and L. Natale, "Event-driven encoding of off-the-shelf tactile sensors for compression and latency optimisation for robotic skin," in *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems*, Nov 2017. 1

[2] P. Motto Ros, M. Crepaldi, C. Bartolozzi, and D. Demarchi, "Asynchronous DC-free serial protocol for event-based AER systems," in *2015 IEEE International Conference on Electronics, Circuits, and Systems (ICECS)*, Dec 2015, pp. 248–251. 1

[3] L. Natale, A. Paikan, M. Randazzo, and D. Domenichelli, "The icub software architecture: Evolution and lessons learned," *Frontiers in Robotics and AI*, vol. 3, no. 24, 2016. 1

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