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Discrimination of Social Tactile Gestures using Biomimetic Skin

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The implementation of novel tactile sensors has yielded original mechanisms for human-robot interaction that support the interpretation of complex social scenarios. For instance, the recognition of social tactile gestures is an important requirement in the design of robot companions because it enables the android to engage with human drives. We are interested on implementing such a functionality upon the biomimetic skin of the iCub android [1].

The iCub robot has been provided with a capacitive-based artificial skin in order to augment its sensorial capacities. The robot has 384 tactile sensors (*taxels*) that acquire force data during contact over arms and torso, with a sample rate of $50Hz$. Additional sensors are located in fingertips, whose hyperacuity allows shape recognition.

Other recent studies have also been focused on tactile gesture recognition using different types of artificial skin. The work in [2] utilizes photoreceptors to extract information about force, position and frequency. Models are generated using *Support Vector Machines* (SVM) and *k-Nearest Neighbour* to classify different affective gestures. The classification rate obtained with only tactile information was 67%, requiring of visual information to increase reliability up to 90.5%. On the other hand, Silvera, et.al. [3] employed an impedance-based skin to recognize gestures using spatio-temporal features such as pressure, contact area and duration. A boosting-based classifier produced a classification rate up to 90%, using tactile data generated from only one participant. The classification accuracy decreased up to 70% when tactile data was generated by several participants.

In order to evaluate the feasibility of using the artificial skin for gesture discrimination, eight tactile gestures with high social content (*C1=poke*, *C2=caress*, *C3=grab*, *C4=stroke*, *C5=tickle*, *C6=pat*, *C7=slap* and *C8=pinch*) were selected from the state of art [3], considering that these gestures are also well discriminated by the human being. Several participants were instructed to perform similarly the tactile gestures over the skin (see Fig. 1a).

The extraction of tactile features involved three steps. First, contact areas for each frame were computed using hierarchical clustering with cutoff at $2.5cm$.

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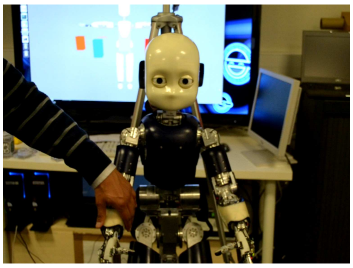
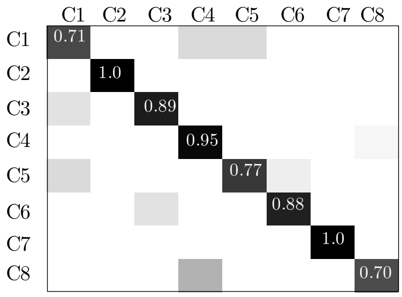
Second, static tactile features such as contact force, area and position were extracted from each contact region. And third, a set of temporal features were computed for each gestures, such as magnitude of displacement and duration. Finally, we gathered a set of 301 instances.

The classification was achieved using an ensemble of classifiers based on Least Squares Support Vector Machines [4]. Each classifier was trained to recognize one type of gesture. The type of each instance was determined by the classifier with the highest ranking. The classification rate is illustrated in Fig. 1b by the confusion matrix with a k-fold cross validation (k=*4*). The total classification rate was of 86.2%, which is comparable with respect to the state of art. Other experiments involving less classes (e.g. caress, poke, grab and stroke) generated a classification rate up to 97%.



a. Tactile gesture over the forearm.



b. Confusion matrix.

Fig. 1: Tactile gesture discrimination

On the contrary to other works that require either additional information about the contact body part or visual support, this is the first work that demonstrates successfully that the iCub skin provides sufficient information to discriminate tactile gestures. The extracted tactile features produced a consistent classification, although it is not possible to define simple rules directly from them. These features are easily identified by the human being because they are programmer-based, but it might be difficult to provide an intuitive description of each tactile gesture. Our future work involves exploring other more bioinspired strategies to generate more grounded tactile features.

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