Visio-tactile binding through double-touching by a robot with an anthropomorphic tactile sensor

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Binding is one of the most fundamental cognitive functions, how to find the correspondence of sensations between different modalities. Although there are already some binding models between visual attributes (ex. [1]), it is still unclear how to bind different sensor modalities such as vision and touch. Without *a priori* knowledge on its sensing structure (sensor configuration), it is a formidable issue for a robot even to match the foci of attention in different modalities since the sensory data from different sensors are not always caused from the same physical phenomenon.

Supposing that learning multimodal representation of self-body should be the first step toward binding multi-modalities, we have proposed a learning method to match the foci of attention in vision and touch through touching its body with its another body part, that is *double-touching* [2]. However, although the designer had to quantize the sensory space of touch to represent double-touching, it is not straightforward if the responses of tactile receptors are not independent on each other like in an *anthropomorphic tactile sensor* which consists of a lot of receptors embedded in soft material (ex. [3]). Therefore, in this study, we extend the previous method to make a robot capable of quantizing touch sensors by itself.

Sensation of a robot is invariant with its posture when its sensors receive its own body [4]. Therefore, it can find out the relationship between its posture and tactile sensory data during double-touching by fitting them to a function of its posture with respect to tactile sensory data. If we adopt the modular structure for a fitting function, its modules are expected to be utilized as quanta of the tactile sensory data in a double-touching posture. In this study, therefore, we apply a normalized Gaussian network (NGnet) to fit the sensory data, which is a network of local linear regression modules each of which is responsible for a region softly partitioned by normalized Gaussian functions [5]. Since the similar postures cause similar responses of close receptors of an anthropomorphic tactile sensor, each module is expected to respond to double-touching at a certain region on its body surface.

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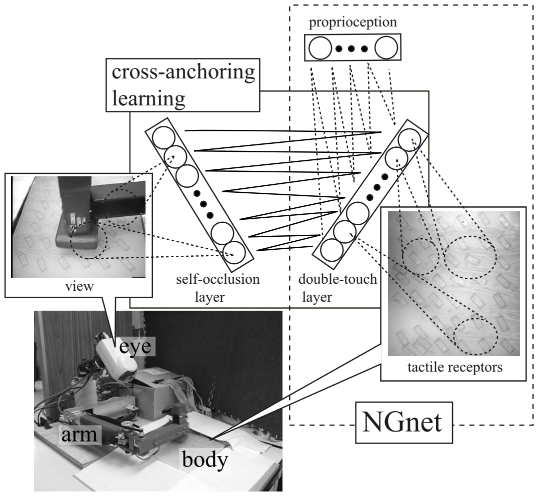

Fig. 1. A robot with a camera and an anthoropomorphic tactile sensor

In the experiments with a test-bed robot (see Fig. 1), first we test if it can quantize its anthropomorphic tactile sensor by the proposed method. Then, we test if it can perform binding touch and vision by the cross-anchoring learning [2] with the acquired double-touching quanta.

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