Curiosity driven motor babbling for Body Map acquisition.

The aim of the present work was to study how the autonomous acquisition of body maps on artificial agents can be improved by means of active learning. To this end, we applied the body map acquisition method proposed by Olsson et al. (2004) with some small modifications, and coupled it with the Robust Intelligent Adaptive Curiosity algorithm by Oudeyer & Baranès (2010) to achieve a *Curiosity Driven Motor Babbling* algorithm. This procedure starts by learning from the sensorimotor information generated by random movements, and incrementally modifies them in such a way that movements for which the learning outcome about the agent's body map is higher are more likely to be performed.

The realization that sensors which are closer will tend to receive more correlated information than those which are far apart allows to build topological body maps based only on sensory information. Based on this idea, Olsson's technique is able to generate body maps from Crutchfield's information distance (Crutchfield (1990)) between every pair of sensors, which measures their mutual information in terms of the added bidirectional conditional entropy, independently of the sensor modality.

Random motor babbling is a way to acquire the sensorimotor information required to study these correlations without the need to imbue the system with external knowledge. However, learning might stagnate after the most apparent correlations have been discovered, due to the statistical uniformity of the sensorimotor information received. An active learning algorithm, such as R-IAC used in the present work, can be used to prevent stagnation from happening by steering the agent actions so that they evolve into "purposeful babbling" (Oudeyer, P., Hafner, V. V, & Kaplan, F. (2007)), meaning that the actions carried out are chosen so that the learning progress is maximal, i.e. they will lead to subregions of the sensorimotor space where the predictions of the learnt forward model improve fastest .

In order to test this hypothesis, we performed body map acquisition on several simulated robotic platforms (NAO, AIBO and ePuck), first controlled with random motor babbling and then with curiosity driven motor babbling. Results show that whereas on the first case the algorithm was unable to obtain any meaningful body schema, the application of the active learning algorithm led to the organization of the sensor space into a cluster scheme which shows some correspondence with the functional and morphological properties of the sensors in the robot.

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