Sensory-motor map fragments are the substrate of body models?

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Our work at Aberystwyth University uses a strong developmental approach whereby we attempt to reproduce early infant behaviour in synthetic robotic experiments. This involves the modeling of the growth of competence, drawing on psychological data. Our experiments cover the early postnatal months and deal with the learning of basic body motor control and ego-centric space. We are particularly interested in the way staged growth emerges and seems to offer important learning advantages. Recent papers best describe this work [1,2].

An important part of our approach is to adopt minimal representational complexity for the computational models. We try to avoid pre-structured internal representations or pre-selected techniques. This "content-neutral" approach allows the experiments to detect whatever patterns of experience emerge from growing behavior. Consequently, we have used a series of 2D maps, across and within modalities, to act as the substrate for sensory-motor coordination and spatial perception. These grow during the development process to coordinate eye saccades, gaze control, and eventual eye-hand coordination. Mappings between the individual maps record spatial contingency during behaviour, and so an ego-centric model of space can be seen in the collection of mappings built up through experience.

One problem with spatial learning, and robot arm control in particular, is that the data are sparse, multi-dimensional, and can be inconsistent. This is a serious issue in much of robotics. We took inspiration from the fields in the brain and use overlapping regions in our maps rather than points or contiguous elements [3]. Experiments showed this gives significant advantages in early growth: the maps can be populated quickly (and coarsely, but can be refined later); accuracy can be increased by "averaging" over several local fields; the number of connections (or mappings) between maps in even complex spatial relations can be surprisingly small. This simple device also has the feature that space is covered quickly (if the fields are large) and thus incomplete, inchoate maps can be used while they are being learned.

[1] J. Law, P. Shaw, K. Earland, M. Sheldon, M. Lee (2014) A psychology based approach for longitudinal development in cognitive robotics. Frontiers in Neurorobotics 8 (1) pp. 1-19. 10.3389/fnbot.2014.00001

[2] J. Law, P. Shaw, M. Lee, M. Sheldon (2014) From Saccades to Grasping: A Model of Coordinated Reaching Through Simulated Development on a Humanoid Robot. IEEE Transactions on Autonomous Mental Development 6 (2) pp. 93-109. 10.1109/TAMD.2014.2301934

[3] K. Earland, M. Lee, P. Shaw, J. Law (2014) Overlapping Structures in Sensory-Motor Mappings. PLoS One 9 (1) e84240 10.1371/journal.pone.0084240