Bubbles in the Robot

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Abstract—Dynamic Neural Field models have been used extensively to model brain functions, but mostly through computer simulations. However, there are recent examples of applications in robotics that I will discuss in this presentation. I will also discuss neurocognitive robotics that has the aim of understanding brain functions in contrast to neuromorphic robotics that has mainly the aim of solving robotics tasks with biologically inspired method.

I. EXTENDED ABSTRACT

Dynamic Neural Fields (DNFs) have been used extensively to model neurophysiological and cognitive processes. John Taylor has himself studied them extensively, for example to explain illusions in visual perception [1], competition in the thalamic reticular nucleus [2], and to generalize Amari’s famous paper [3] to two dimensions [4]. In 2003 John wrote a commentary with the title ‘Bubbles in the brain?’ [5] in which he commented on work of an Oxford group [6], [7] on neural fields and their application to motor control and spacial representations.

Recently, there are several examples of using DNFs in robotic implementations, and the aim of this presentation is to discuss such bubbles in robots. While reviewing some of the recent progress, I want to discuss specifically how embedded systems are useful in highlighting limitations in our understanding of biological mechanisms, and if such neurocognitive robotics can advance our understanding of brain functions.

DNFs have been a model of place fields in the hippocampus that are frequently recorded in navigating rats [8]. Such place fields seem to be representations of space and are thought to be important for navigation. However, there has been no considerable attempt to show how such mechanisms can actually solve a navigation task. It is therefore extremely important to see the work of Milford and colleagues who have implemented DNFs in robots to perform a variant of simultaneous localization and mapping (SLAM), which has become known as RatSLAM [9]. RatSLAM is a great example of bridging the gap between neurophysiological findings and showing how such biologically inspired mechanisms and information representations can be used to solve cognitive tasks.

The DNF in RatSLAM describes the pose of a simulated rat. An example is shown in Fig. 1. While there are several bubbles that correspond to possible poses in this situation, a dominant activation is chosen as the guess for the pose. Another example is shown in Fig. 2 in a situation where the simulated rat tunes and loses some confidence of its pose. This is reflected by a distributed activity in this pose network.

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Interestingly there are other examples of bubbles in robots where DNFs have been used in quite different robotics applications. In particular, Schöner and colleagues have an active research program where DNFs are a principle mechanisms used on several levels of an embedded cognitive architecture (e.g. see [10] for an example). Another interesting example is the work by Strauss and Heinke [11], who have implemented DNFs in a robotic arm to simulate arm movements in a decision task. Their implementation experiment revealed some unexpected findings.

Finally, a lot of progress has been made in engineering robotics by applying probabilistic methods and Bayes filtering. DNFs can be seen as a biological implementation of such strategies, and I want to discuss this relation with some examples.

REFERENCES