Epigenetic development in robotics systems for learning and long-term operation.

Brief Background

Epigenetic robotics is a field of robotics which explores how robots can gain new "cognitive" and sensorimotor capabilities as a function of their interaction with their surrounding environment. In essence this could be summarised as the exploration of naïve models which lead to autonomous robot learning about both the world and its own capabilities through its actions. Allowing such a robot to become "situated", in other words able to behave in an appropriate manner given it's needs, goals and environment. This can range from learning affordance of various objects in the environment and how to respond [1], to gaining skills needed to exploit various dynamics [2], or even learn nonverbal communication [3]. Key is that these behaviours mentioned are not planned nor explicitly programmed, but rather are emergent as part of the developmental process.

Epigenetic models in this field will often be inspired by the developmental process seen in children. Under such a premise epigenetic models will seek to explore how internal, social and environmental inter-actions will shape the long-term development from baby-like capabilities through the emergence of various key developmental milestones such as the notion of object permanence or violation of expectations, through to more complex notions such as internal schemes and creativity. The work here is envision to build upon some of our previous studies such as [1,2] . Under these studies we explored how hormone regulation or neural receptors can lead to significant modulation of learning and development when exposed to different scenarios. Allowing for the emergence of not only unique, but highly adaptive phenotypes. In particularly varying concentrations of simulated hormones representing Cortisol (Often know and the stress hormone) and Dopamine (often known as a pleasure hormone) were shown to lead to vastly different learning and development outcomes. A robot exposed to stressful situations showed reduced risk taking and instead focused on learning about a few key objects in its environment. A robot exposed to more pleasurable stimulation showed much greater interest in novel experience learning a bit about the entire environment.

The purpose of this work is twofold. Firstly, as we move into a robotic future in which we envision autonomous systems becoming increasing part of both our home and general society, trying to predict how these robots should behave in our highly dynamic societies in daunting tasks. Subsequently we are in need of methods and approaches which will allow robots themselves to self-regulate. The task domain itself is flexible with recent and current studies exploring use for epigenetic mechanisms in a range of fields including non-pervasive self-repairing cities, ongoing road maintenance (crack detection and repair), exploratory robotics for unknown environments and Companion robotic (HRI).

Secondly, this work seeks to aid in understanding our own cognitive development by exploring roles that epigenetic mechanism may play in shaping only learning experiences.

Person specifics

A good first degree in Robotics, a related Engineering Subject, Computer-science or Maths and/or preferable a MSc degree in a related Field,

Proficiency in C++ or Python programming language.

Excellent communication skills in English, spoken and written.

The study itself is envisioned to mostly be focused on the use on real robotic systems such as the UniTree go2 or Turtlebot4 (see images taken from manufactories) and subsequently familiarity with robotic hardware is highly desirable.

Familiarity with ROS and Gazebo is desirable but not essential.

Unitree Go2

Turtlebot4

References

[1] Lones, J., Lewis, M. and Cañamero, L., 2017. A hormone-driven epigenetic mechanism for adaptation in autonomous robots. *IEEE Transactions on Cognitive and Developmental Systems*, *10*(2), pp.445-454.

[2] Lones, J., Lewis, M. and Cañamero, L., 2016. From sensorimotor experiences to cognitive development: Investigating the influence of experiential diversity on the development of an epigenetic robot. *Frontiers in Robotics and AI*, *3*, p.44.

[3] Lones, J., 2017. Hormonal modulation of developmental plasticity in an epigenetic robot. PhD thesis