ba604a3c-e95a-4569-84a9-7d4dedd08310
c505c105-3f39-486f-b2b9-ab0b94143eaf
false
false

Neuromorphic architecture for robotic spatial navigation

- Marcello Mulas[1]
- Nicolai Waniek[1]
- Jörg Conradt[1]

1. Laboratory for Neuroscientific System Theory, Fakultät für Elektrotechnik und Informationstechnik, Technische Universität München, Karlstr. 45, 80333 Munich, Germany

Robotic systems can perform well-defined tasks with exquisite precision at high speeds, but they have much more difficulty when operating in unstructured environments. Improved spatial navigation skills would increase autonomy of robots and would extend the range of tasks they could potentially address. Standard solutions integrate different sensory signals to localize a robot's position with reference to external objects. However, such localization algorithms only work well in static surroundings. On the contrary, animals such as rats and humans effortlessly adapt to new environments and learn to orient themselves even in dynamical situations. With the discovery of place cells and grid cells, neuroscientists are starting to disclose the mechanisms underlying spatial navigation skills in animals. In this work we propose a neuromorphic architecture for robotic spatial navigation that aims at taking advantage of the flexibility and robustness of biological neural networks. Our architecture runs on the neuromorphic hardware SpiNNaker, a massively-parallel computing architecture specifically designed to model large-scale spiking neural networks (Khan et al. 2008). We take advantage of SpiNNaker's support for PyNN, a simulator-independent language for modeling spiking neural networks and we adapt existing models of grid and place cells based on recent experimental evidence (Couey et al. 2013). We validate our neural controller on a mobile robot that continuously acquires odometric and visual information about its motion and its local position to update its internal spatial representation. The neuromorphic architecture drives the robot in dependence of pre-set goal locations that affect the neural dynamics. The close integration of goals and sensory information could be crucial to build robotic systems that can ultimately match human spatial navigation performance.

Acknowledgements

This work is supported by the EU FET FP7 GRIDMAP project.

References

1. Couey, J.J. et al., 2013. Recurrent inhibitory circuitry as a mechanism for grid formation. Nature neuroscience, 16(3), pp.318–24 (http://www.ncbi.nlm.nih.gov/pubmed/23334580)
2. Khan, M.M. et al., 2008. SpiNNaker : Mapping Neural Networks onto a Massively-Parallel Chip Multiprocessor. IJCNN, pp.0–7. (http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4634199&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D4634199)

- Conference:
- Citation: Mulas M, Waniek N, Conradt J (2014) Neuromorphic architecture for robotic spatial navigation. Bernstein Conference 2014.
- doi: 10.12751/nncn.bc2014.0165 (http://dx.doi.org/10.12751/nncn.bc2014.0165)

Contact (/contact) Imprint (/impressum) About (/about)

The G-Node Conference Site — © G-Node (http://www.g-node.org) 2014