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Spontaneous Memory Transition on Amoeba Neurocomputer composed of Unicellular Organism with Optical Feedback

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The unicellular amoeboid organism, true slime mold *Physarum Polycephalum* is a fascinating research subject of spatiotemporal behavior-based information processing of biological oscillatory media realizing reasonable and functional behavior. In the previous research, it was shown that the organism could solve a maze on a physical metric space by connecting the minimum-length route between two food sources [1]. Here we demonstrate an associative memory device composed of an amoeboid cell with optical feedback incorporating Hopfield's neural network algorithm [2]. Our system can associate an input with one of suitable memories, as the organism having photoavoidance can search for the stable memory configuration by changing its planar shape inside a branched structure, so as to maximize the body area without being irradiated. Further, even though no external perturbation is applied, the organism spontaneously starts to destabilize the once-recalled memory to seek another memory, as some branches of the organism grow under irradiation contrary to photoavoidance. By repeatedly switching between stabilizing and destabilizing modes with spontaneous transition of spatiotemporal behavior in the organism's oscillating cellular membrane, our system achieves dynamic transition among memories. Our demonstration suggests the unicellular organism's potential to solve optimization problems on a more abstract space than a physical metric space by optimizing the spatiotemporal oscillation patterns.

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[1] T. Nakagaki, H. Yamada, and A. Toth, *Nature* **407**, 470 (2000).

[2] M. Aono and M. Hara (submitted).