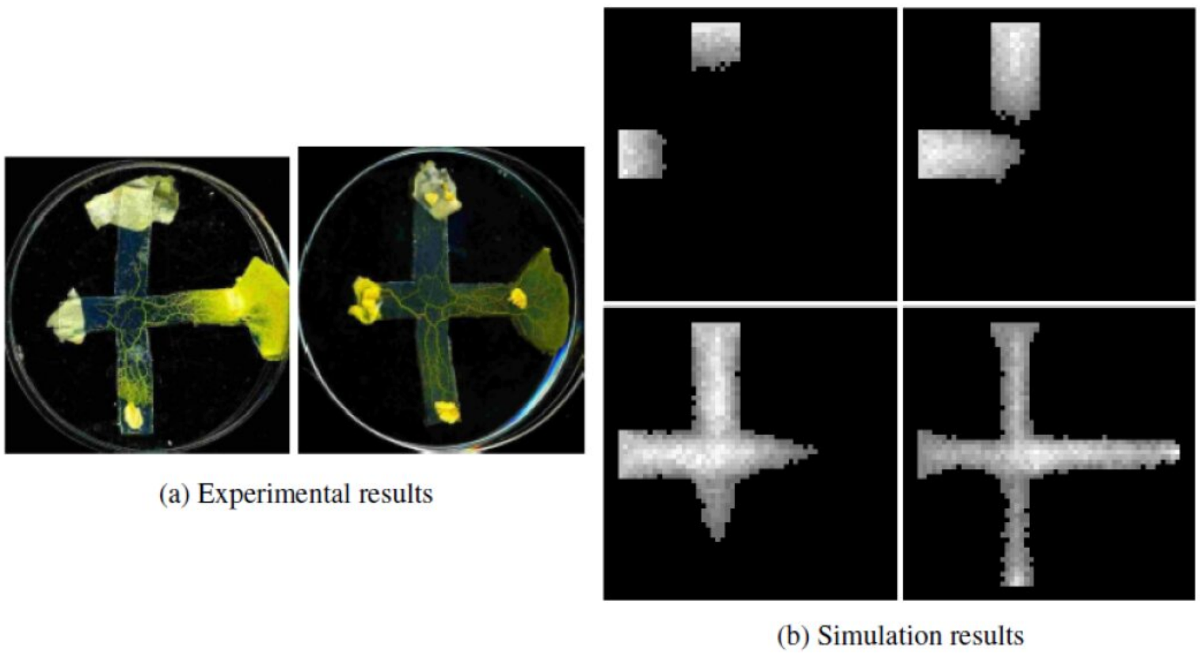
# A model to design logic gates inspired by a single-cell organism

March 2 2020, by Ingrid Fadelli




{1, 1}→ {0, 1} transformation of the proposed model on the gate P2 with plasmodium's presence on output p. Credit: Floros et al.

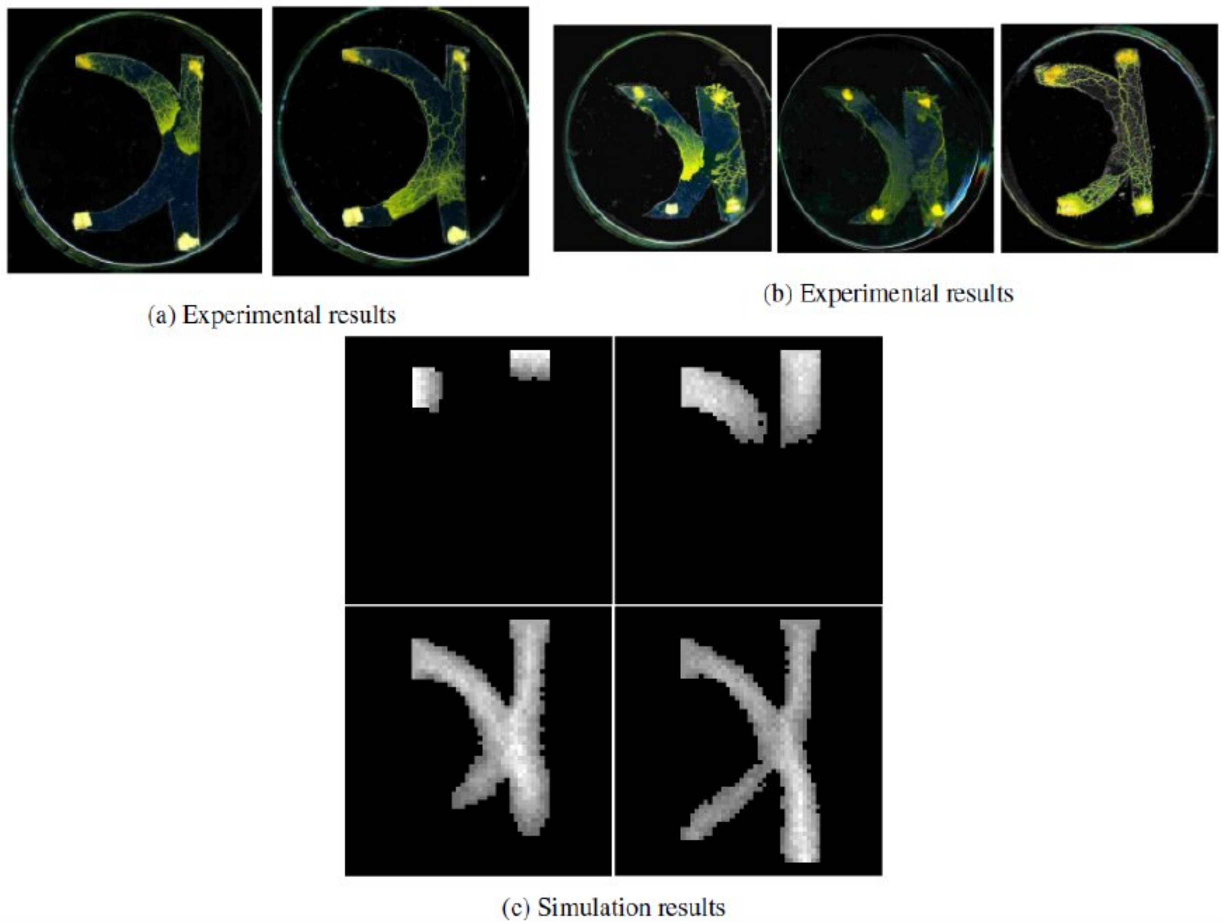
Natural phenomena and biological mechanisms can be great sources of inspiration for scientists developing mathematical approaches, computer systems and robots. Over the past few decades, research has repeatedly proved the value of replicating behaviors observed in nature through the introduction of many fascinating bio-inspired computational techniques and systems.

A behavior that has attracted particular attention as a means of solving complex mathematical problems is that of Physarum polycephalum, a single-cell slime mold that has often been used as a model in studies investigating biological phenomena. In the past, replicating the behavior of this particular single-cell organism has proved useful for solving different graph-related and combinatorial problems.

Inspired by previous findings, researchers at Democritus University of Thrace and the University of the West of England have developed a model for designing logic gates that is partly inspired by the behavior of P. polycephalum. Their paper, initially posted on arXiv, will soon be published in the *International Journal of Unconventional Computing*.

"Our work was aimed at designing a less complicated cellular automata (CA)-based model to simulate the computational abilities of P. polycephalum," Karolos-Alexandros Tsakalos, a Ph.D. student who conducted the study, told TechXplore. "The ultimate goal was to design more efficient bio-inspired algorithms to solve hard computational problems."

The study carried out by Tsakalos and his colleagues builds on the team's previous work investigating physarum-inspired computational tools and machine learning techniques. The researchers' new technique for designing logic gates embodies principles of cellular automata (CA), a class of discrete models often used to solve computer science, mathematics and physics problems. The features of CA were combined with machine learning techniques, leading to a robust computational model that reflects the behavior of P. polycephalum.




$\{1, 1\} \rightarrow \{1, 1\}$ transformation of the proposed model on the gate P1. Credit: Floros et al.

"Our model uses reinforcement learning within each local area where rules are applied in order to learn what the appropriate path toward the final destination is," Nikolaos Dourvas, another Ph.D. student involved in the study, told TechXplore. "The primary advantage over previously developed ones is its simplicity, its ability to learn and provide stochastically different results, as it was discovered in the actual biological experiments."

The simple method introduced by Tsakalos, Dourvas, and their colleagues can be used to model the behavior of a variety of living organisms. In their study, the researchers applied P. polycephalum and tested its performance in designing logic gates within a simulated environment, where the model had to identify minimal paths in mazes containing food sources.

"The most meaningful achievement of this study is the successful simulation of the behavior and thus of the computational abilities of Physarum polycephalum, using a computer model," Dr. Michail-Antisthenis I. Tsompanas, a researcher at the University of the West of England involved in the study, told TechXplore. "This model is inspired by the inherent parallelism of cellular automata, but their ability to provide adequate simulations of complex physical phenomena is further enriched by the stochasticity of learning automata and corresponding learning abilities."

The bio-inspired computational technique devised by Tsakalos, Dourvas,Tsompanas and their colleagues was found to perform considerably well, effectively modelling logic gates in numerous simulated scenarios. In the future, their model could be applied to a variety of highly complex mathematical and computational problems. It could also be adapted to replicate the behavior of other living organisms and biological phenomena.

"We envisage that the proposed bio-inspired model can serve as an efficient tool in further studies to model the behavior of other, even more complex, living organisms and solve similar graphical represented problems," Prof. Georgios Ch. Sirakoulis, a researcher at Democritus University of Thrace who conducted the study, told TechXplore.

**More information:** Unconventional bio-inspired model for design of logic gates. arXiv:2002.05767 [cs.ET]. arxiv.org/abs/2002.05767

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