Beauty of Life in Dynamical Systems

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Information plays a critical role in complex biological systems. Complex systems like immune systems and ant colonies co-ordinate heterogeneous components in a decentralized fashion. How do these distributed decentralized systems function? One key component is how these complex systems efficiently process information.

It has been suggested previously that information processing capabilities distinguish life from other so-called non-living matter [1]. Information processing is one amongst many key ingredients for life. Chemical reaction systems called reaction-diffusion systems have been studied for their complex properties for a long time. One example is the Belousov-Zhabotinsky (B-Z) reaction which is a chemical oscillator and displays complex properties reminiscent of life (Fig. 1) [2,3].

The image of this reaction-diffusion system was then through a deep-learning algorithm (Google DeepDream) [4,5] to generate the image depicted in Fig. 2. The image has a dream-like quality and emphasizes the beauty in life and points to the computational origins of beauty in life itself.

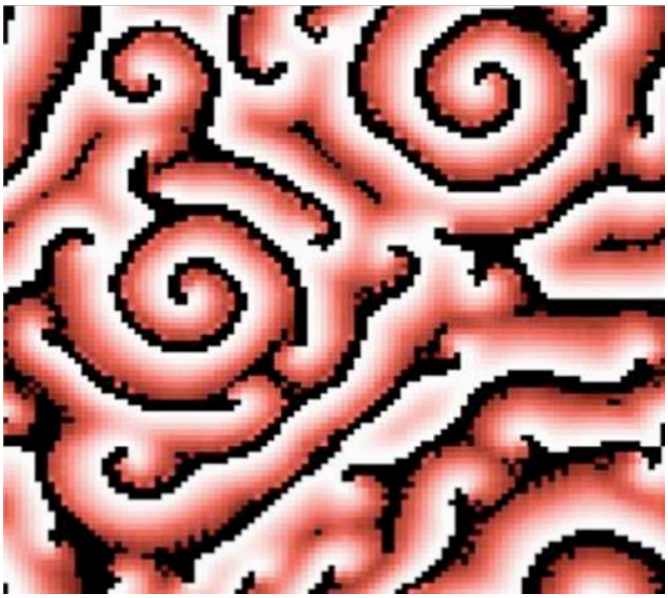

Figure 1. Screenshot from the NetLOGO simulation tool for the Belousov-Zhabotinsky (B-Z) reaction showing wave like patterns that persist [2, 3]

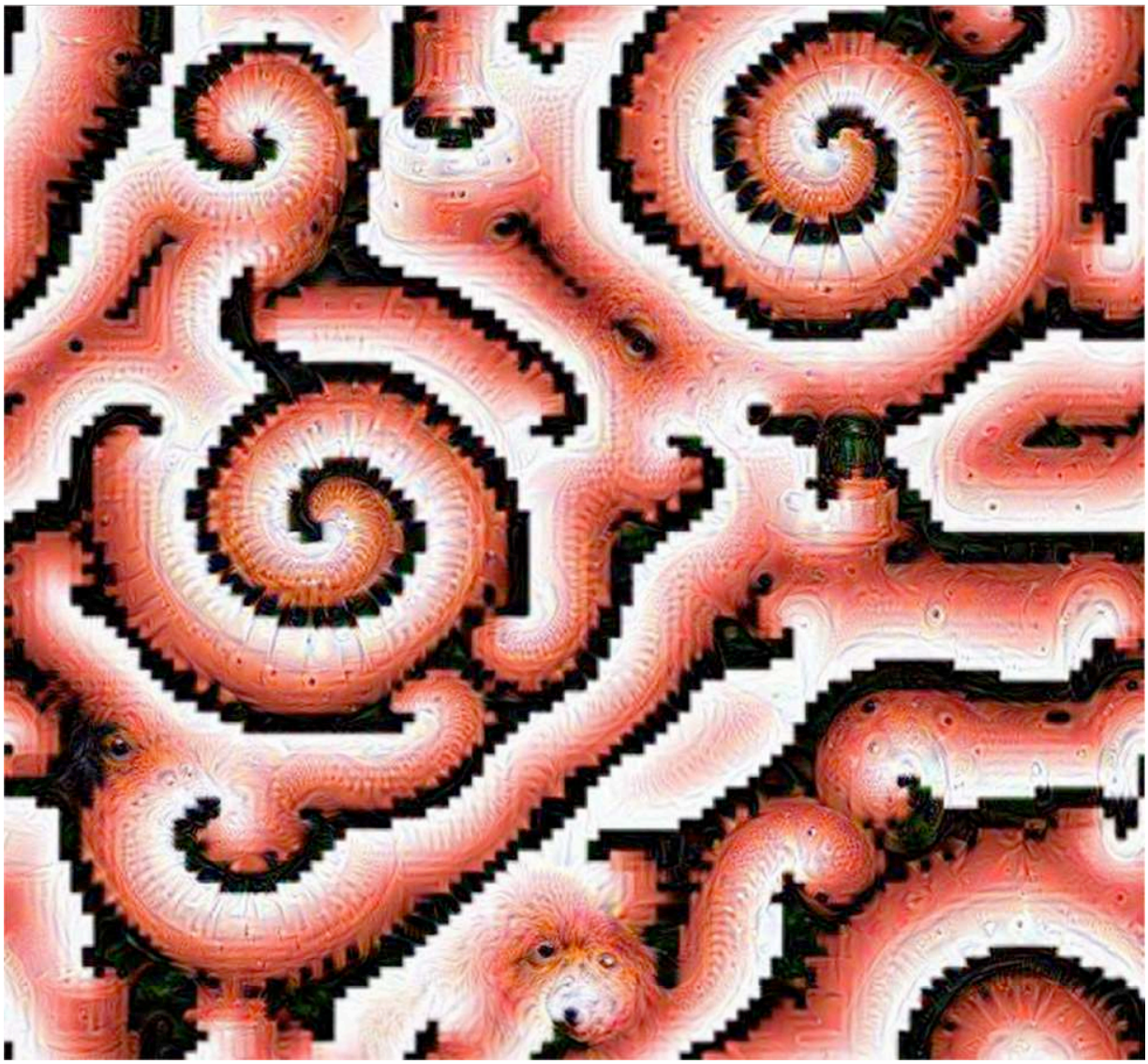

Figure 2. The image of the life-like reaction-diffusion system run through a deep-learning algorithm (Google DeepDream).

Methods

The original picture of a dynamical system for the B-Z reaction was generated using the NetLOGO platform [2,3]. This was then fed into a web interface for Google Deep Dream. Photos are processed with Google Deep Dream python code with BVLC GoogleNet Model on the deep learning framework Caffe on cloud servers. The full picture is available online at http://psychic-vr-lab.com/deepdream/pics/1171899.html

The code is available online here https://bitbucket.org/neelsoumya/deep_dali_waves

Discussion

This submission emphasizes the beauty of mathematics and dynamical systems especially in questions around origin of life. Our conception of life is shaped by what we see around us on Earth. What life forms might we expect to see on alien planets? Would they be carbon-based like us or can they be even more exotic? Answering questions like these mean we must come up with an objective definition of life. We have previously hypothesized that an objective definition of life is that it should be capable of information processing [1].

Our work also suggests that we may need an "aesthetic sense" to recognize life we have never seen before. Such aesthetic versions of life-like systems can be generated using the computational framework presented here. Our computational framework combines dynamical systems with deep learning to generate aesthetically appealing forms of life-like systems.

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