Evolving Soft Robots with CPPN-NEAT in a Randomised Domain with Realistic Fluidic Elastomer Actuators

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ABSTRACT

Robotics is becoming more and more integrated into our lives; however, there are limitations to what can be achieved using traditional robots. Traditional robots perform well in closed environments for repetitive tasks but underperform in unknown, open environments. Additionally, they can potentially damage animals, people, and environments around them and are very expensive to design and manufacture. In contrast, soft robots are inherently safe, are cheap to make and are excellent at adapting to variations in their environment. This makes soft robots more suitable than rigid robots for medical applications, hospitality, research and exploration in natural environments, and extra-terrestrial exploration. Unfortunately, soft robots are difficult to design due to the nonlinearity of their behaviour.

Previous research has shown an evolution strategy, CPPN-NEAT, could be used to design both the morphologies and controllers of virtual soft robots. However, these studies do not accurately represent real soft robots and real environments, such that their results have no real-world applicability. In this research, the gap between evolving virtual soft robots and soft robots with real applicability is reduced by using a more realistic simulation environment, SOFA, realistic fluidic elastomer actuators in the evolution, implementing domain randomisation during the evolution, and lastly, by growing soft robots from central mesh like what occurs in developmental biology.

It was successively shown that the entire structure and composition of soft robots that use fluidic elastomer actuators can be evolved in SOFA. Interestingly, with these improvements, designs that resembled real soft robotic designs were evolved showing the realism of the environment and set-up. Furthermore, it was shown how domain randomisation can improve the evolutions' ability to find soft robots that can handle unknown environments better. Lastly, soft robots were successively evolved by growing them from central elements, which in turn expanded the possible sizes and shapes of the soft robots.