Multi-talented Microbots: Promoting Neuron Growth and Monitoring Viruses with microbots and xenobots

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1 Introduction

Microtechnology has shown extensive developments in the past ten years, especially in the last six months with biocompatible and biodegradable xenobots[1]. Advanced Simulation technology has allowed for more precise and efficient experimentation with microbots; coordination of microbots with artificial intelligence has allowed for self-learning locomotion and spatial recognition. The real-world applications for microbots such as the inchworm microbot, RoboBee, HAMR-E, and xenobot are yet to come to fruition. Building on research from the California Institute of Technology, the University of Pennsylvania, Max Planck Institute, Stanford University, and Tufts University, we can channel the findings of microbot designs and control to an array of applications including distributing seeds and nutrients in crop fields, monitoring the nutrients in the soil, helping grow and repair neurons, detecting harmful radiation, precisely delivering drugs in the body, and detecting structural proteins in viruses on common surfaces.

Peripheral Neuropathy can manifest due to severe physical trauma (car accidents, sports injuries, etc.), diabetes, autoimmune diseases, viral infections (Varicella-zoster virus, and even vitamin B6 or B12 imbalances. Thirty percent of people that incur an Acquired Immunodeficiency Syndrome (AIDS) after contracting the human immunodeficiency virus develop peripheral neuropathy. An estimated 65 percent of diabetic people experience at least a mild degree of sensory and motor nerve damage.[7] Damage to the nervous system becomes further dangerous and pain-inflicting with the Guillain-Barré autoimmune syndrome which attacks motor nerve fibers close to muscle tissue, leading to myopathy (weakening of muscles). In severe cases, nerve injury can lead to paralysis, a focal or systemic loss of feeling in the body. Current treatment practices only serve to mitigate the pain of nerve damage, but the rapid miniaturization and biocompatibility of robots illuminate hope for regrowing nerve networks and micro-sculpting nerve tissue.

2 Abstract

The microbot/xenobot designs focused on in this paper have applications both inside and outside the body. What you need to know about xenobots, since they are a very new invention, is that they are layered heart and skin tissue robots built from frog stem cells. The observed tasks that have been published are organizing microplastics, self-healing, and chemical communication with pheromones. There has never been an invention similar to xenobots, which is why they are paving a revolution as the first “Living Robots”[1]. These applications include micro-sculpting nerve tissue inside the body and virus detection/monitoring outside the body.

Inside the body, microbots and xenobots working together can represent an effective new treatment against peripheral and diabetic neuropathy, preventing paralysis. Bolstering the body’s response to neural damage by clearing the restrictions of natural neural growth would allow neurons to regrow and connect much faster[2]; xenobots[1] alone can be injected into the traumatized area to decompose myelin sheath if this process is accessible within a few hours of serious nerve damage. In the long-term, after several months/years, xenobots and microbots[3] will come together, carrying neural stem cells, and following an external electromagnetic field to regenerate neurons and micro-sculpt nerve tissue in a three-step process. First, the xenobots (with biogenic magnetite) carry the cargo of neural progenitors, dropping them off at the dorsal root ganglion (also infected with biogenic magnetite). Then, axons of the neurons growing from the neural progenitor would grow in the direction of the microbot pulling it. The infrared light would power the twisted graphene bilayer and direct the microbot, pulling neurons to invoke growth and reconnecting the network of neurons near muscles.[5]

Outside the body, xenobots will monitor virus concentrations with a virus stimulus and fluorescent light indication. After the coronavirus pandemic, virus destruction products such as the MAP-1 spray for coronavirus (distributed by Germagic) have proven successful. Determining exactly when a virus has resided in a particular area has not been proven, but would greatly aid in contact tracing. Microbots[3] and xenobots[1] are essential for determining how long a particular virus has resided on a surface, giving information about when people could have been infected. Horizontal gene integration from synthetic RNA and DNA origami mechanisms give xenobots sensitivity to viruses. Xenobots coming in contact with viruses can indicate surface virus contact by gradually increasing/decreasing the green color that they illuminate as the Green Fluorescent Protein goes through a positive feedback loop as viruses increase and decrease in contact with the xenobot. [8] This half-life of fluorescence is modeled by a differential equation in Attenuation of green fluorescent protein half-life in mammalian cells.[4]

3 Experiment

Using VoxCraft software, several variations of xenobot designs can model the behavior of xenobots inside the body. Beginning with evolutionary algorithms to evolve an optimized quadruped microbot we can also model the microrobots grabbing the end of the neuron tails to promote neuron growth with phototactic sensing.

Figure 1: Quadruped Microbot actuating with phototactic control

Figure 2: Quadruped Microbot jumping with phototactic and position sensing

Figure 3: Xenobot Simulation 5 by 5 moving in straight direction

4 Research Results

Access to cheap computing power is exponentially increasing as the artificial intelligence revolution continues. With the support of this computation, simulation designing can help model modified systems of xenobots and microbots to solve neurobiology and virology issues. Carving the ventral side of xenobots cell

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Time 26 sec
Step Num 573401
Time Step = 4.53e-05 sec
Display Rate = 2.4e+04 Steps/sec
CoM X:-85.7 Y:-34.4 Z:1.83 mm
CoM Displacement = 97 mm
CoM Velocity = 3.71 mm/s

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Figure 4: Dataset for Xenobot Design pulling neurons

Figure 5: Xenobot Simulation 5 by 5 moving in circles

by cell creates permutations of movement patterns. Quadruped xenobots, 5 cells (length, width, height), in an unrestricted space move in an almost straight line. Xenobots with this design and attached with biogenic magnetite will linearly coordinate with the electromagnetic field of an external device, decomposing debris and scaffolding a microbot path. The Quadruped design with balanced legs was optimized over 20 generations using an evolutionary algorithm, guided by Dr. Sam Kriegman at the University of Vermont.[6] The resulting average velocity of a linear path and static gait was found to be 3.70 millimeters per second.(Figure 3) Analyzing the behavior of 30 xenobots in a contained space with Dr. Li shows that the interactions in a swarm-intelligent environment increase average velocity, but decrease robotic control and increase the work expended by individual xenobots. Taking this further, Dr. Li and I are currently simulating xenobots with a hydrogel-based skin to experiment with self-healing abilities and gluing the nanobots together like blocks to create a single, complex nanobot unit. Detailing our observations of the individual nanobot velocities and group interactions, Dr. Li and I conceptualize and discuss how we can use this to model a swarm-intelligent group of nanobots swimming in the digestive system carrying nanomedicine and detecting neurotransmitters, particularly dopamine, in a rat's brain.

5 Discussion

Programming and sculpting varying xenobot designs was time-consuming and inefficient to build individuals. With the evolutionary algorithms, it was much simpler to store the observations for a new set of xenobots and explore dozens of designs within minutes. Some designs that were not well-suited, or "fit" in terms of evolution, are displayed below.

Figure 6: Second generation xenobot design

Figure 7: Donut Xenobot design, gait not optimized

6 Implications and Conclusion

Conducting simulation and robotic control research at UC Berkeley, executing quadruped simulations using pyrosim, executing xenobot simulations based on evolutionary algorithms in VoxCraft, and elaborating/applying the research from various universities bridges neurobiology, virology, and computer science for the first time. Exploring these applications of microbots and xenobots will revolutionize biomedical engineering. By increasing safety from deadly viruses such as the coronavirus and reconnecting synapses and micro-sculpting nerve tissue, microbots and xenobots will help eliminate contagion and allow for people to feel their bodies again — leading to peace of mind in the future.

Currently, the control of viruses and pathogens is critical as the United States gets deeper into the coronavirus pandemic and the world fears another possible outbreak due to a mutation of coronavirus or even a new virus more fatal and contagious. In the past years, we have endured an Ebola outbreak, a coronavirus outbreak, and an Influenza A outbreak that led to millions of deaths. We risk countless lives and the global economy by not taking proactive efforts to prevent another contagious virus. With the virus monitoring systems proposed in this research, we can further these proactive measures and prevent large-scale infections, monitoring surface viruses in hospitals, subways, and malls.

I envision myself designing xenobots sculpted from unique, human skin stem cells, stored in a medical xenobot bank for secure hospital access when needed. My xenobot simulations and evolutionary algorithms will be taken further: optimizing computer-generated, synthetic animal body parts, without the virus receptors of Dengue and Herpes.

I hope to take my microbots to Mars, laying the infrastructure for a new civilization. My microbots will swim in the body, monitoring cellular/molecular changes and supporting the new branch of the human tree on Mars. My mi-

crobots will facilitate an exchange of life, rebuilding spaceship parts, living in the system of astronaut bodies, feeding a little on the astronauts' hemoglobin, and detecting alien viruses. How can a new generation of humans adapt to a new world?

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