EGR 557 Foldable Robotics

Develop A Research Question

Team 2

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Research Question:

How can a snake-inspired biodegradable robot be created using foldable robotics principles?

Tractability:

This research question is tractable because it allows various aspects to be further explored. Some of these aspects include: how long the robot will be of use before it degrades, will the robot be able to locomote in different environments , will the robot use a bioinspired method of motion, etc. As the question is, it incorporates the entire desired scope of the project with both room for expandability and specific enough constraints to be achievable in a semester.

The team will break the project into three parts over the course of the 15 week semester allowing adequate time to research each three parts and integrate them into one functioning unit. These three parts consist of: using a degradable material that can be folded and unfolded to create a desired motion, research and apply a biodegradable energy storage system, ensure that the robot can operate long enough to complete a desired task.

Because creating a disposable snake inspired dynamic foldable robot is relatively broad, the team will start by researching potential solutions with the following constraints: the robot must be degradable within a reasonable time (less than one year), the robot must be able to be mobile for a period of time (1min) , and the robot will used bio inspired motion of a snake.

There are multiple problems to be solved in the construction of a simple snake-inspired biodegradable foldable robot, but these obstacles need to be broken down to verify that they are able to be addressed in a single semester. These questions include: how can this robot be powered and be biodegradable? What is the exact environment the device will be in and how does that affect performance/degradability? How long will these materials last, and how will performance be affected by degradation.

Novelty:

Using search engines provided by the ASU Library website, the following keywords were used to find potential references and other journal articles regarding the same and/or similar topics: robotics, water, disposable, degradable, foldable. When searching for references with the keywords “foldable robot”, “snake” and “degradable”, no relevant results were found. This

indicates that there may not be much research done under this topic which shows that this research question is novel.

While there were no relevant results that pertained to the research question, this does not mean that there are not useful literary resources available to the team. By breaking down the question into parts, more relevant research literature can be found.

Keyword: Degradable material

(Bio)degradable polymeric materials for a sustainable future – part 1. Organic recycling of PLA/PBAT blends in the form of prototype packages with long shelf-life. [1]

Summary: This paper has not done what the team has set out to do. Instead, this paper offers insight to the team on potential biodegradable material that can be used to make a laminate folding robot. This article covers how PLA and PBAT blended material degrades in industrial composting and in a container system. This article also compares the environments of which the material degraded, in an open air pile and in 70°C distilled water, as well as their thickness. It is important to note that this article was using the material as packaging, which means that material was made into a film to create disposable bags. While the team may not use material in the form of a film, the findings assist the team in helping select a material to further research.

Magnetic Liquid Metal (Fe-EGaIn) Based Multifunctional Electronics for Remote Self-Healing Materials, Degradable Electronics, and Thermal Transfer Printing. [2]

Summary: This paper has partly done what our team has set out to do, by making an electronic device that can degrade in water. However, this paper applies their findings to soft and flexible robotics, and not foldable robotics. The most important part of this paper are the findings on the water soluble PVA substrate that was used. The paper explains that the PVA substrate will dissolve in 25° C water after 205 s. The paper also notes that the rate of dissolution of the PVA could be increased by changing the temperature of the water. Additionally, the paper points out that other electronic components such as LED lights did not dissolve in the water and had to be collected and put into a HCL solution to further dissolve it. These findings show another degradable material that offers different characteristics that could be useful to answering the team's research question.

Keyword: Foldable robots

Foldable Joints for Foldable Robots. [3]

Summary: This paper has partly done what our team has set out to do in terms of making a foldable robot. This paper shows findings on how to make a foldable robotic joint to the degree of freedom desired by the user. The paper explains how using foldable joints can increase

movement complexity. This article is a great resource for the team in understanding foldable robotics and how to apply these techniques to a degradable material.

The Effect of Large Deflections of Joints on Foldable Miniature Robot Dynamics. [4]
Summary: This paper has not done what the team has set out to do. However it does relate to foldable robotics and is a great resource for the team. The paper reviews how to accurately estimate leg kinematics and dynamics of a rigid body foldable robot from large deflections on the miniature scale. The team can utilize these findings when further researching the kinematics and dynamics to satisfy the research question.

Interesting:

For sustainability more biodegradable products need to be used to decrease generated waste. This is especially important for products intended for use in the forest or desert, as plastic pollution is becoming a big issue as ecosystems are negatively affected by the waste. A biodegradable snake robot could be used in efforts to plant seeds or accomplish other tasks affordably without producing additional waste.

As the population of the world continues to increase, so will the waste that humans create. This research question could potentially help find a low cost solution to decreasing waste in the environment that can be implemented worldwide, while not creating waste at the end of its use. Additionally, because it is aimed to be a robot that can degrade, it can be used in many other use cases that could also benefit society.

Open-ended:

The question is very open-ended in that its requirements are implicitly that the foldable robot must be biodegradable and snake-like. The first robot created in this project will likely be a very simple robot capable of a simple task, such as basic movements and being able to locomote forward. This will leave a lot of room for deeper investigation and development into robots that are capable of more complex tasks and help us better understand terrestrial and other environmental issues. These tasks could include better control methods, multi-robot control in swarms, improved manufacturing, or improved materials. The final destination of this question would be a completely autonomous biodegradable robot that would be useful in planting seeds in the environment and accomplishing complex tasks.

Modular:

This project fits with complementary research thrusts within foldable robotics and biodegradable materials. This project is chiefly concerned with creating foldable robotics with biodegradable materials that are affordable, so much research using normal materials in foldable robotics will be useful here, however extra attention needs to be given to the possible

degradation of materials preventing performance in the robot. This project will be modular, so any developments in new actuator design or manufacturing techniques could be potentially applied to the project to improve it. Also newly created biodegradable materials could replace the biodegradable materials used in the project if they were able to function similarly with better performance.

Team-fit:

The team is interested in learning how to apply foldable robotics techniques into a project that is socially beneficial. This research has the potential to positively impact future research to help solve a problem that jeopardizes everyone's future. In addition to this, this project will allow the team to build on previous skills while also learning new ones.

As listed previously, there will be multiple problems that will need to be addressed that can be great learning experiences, especially when attempting to use foldable robotics techniques to construct a robot. The team has previous experience in academic research, dynamic and kinematic modeling, CAD modeling, control systems, and rapid prototyping that will all be valuable addressing the problems this project will entail.

Topic-fit:

Foldable robotics techniques will be used to create the structure and actuators for the robot. These techniques are integral to the construction of this robot because they will allow the robot to be easily and affordably fabricated. Using foldable robotics techniques, however, will have its own challenges especially with biodegradable materials whose actuator functionality may degrade with use and time. The exact foldable robotics techniques that will be used in the project will be better known to us as we progress through the semester and are better educated on how to implement them into our project. Preliminarily, some spherical foldable robotic actuators will need to be implemented in order to replicate the motion of a snake.

References:

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3. C. Sung and D. Rus, “Foldable Joints for Foldable Robots,” Journal of mechanisms and robotics, vol. Vol.7 (2), 2015.
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