

Develop a Research Question

Biodegradable Seed Spreading Robot

Team 1: James Arnold, Katie Brauckmann, Cree Hutcherson, and Daniel Stockwell

Research Question:

How can the concepts of foldable robotics be applied to the design of a seed spreading robot that is constructed entirely from biodegradable materials?

1. **Tractability: Is your question tractable and achievable? Discuss your plan for scoping your problem to fit in a 15-week course.**

- **How have you focused or constrained the problem to differentiate yourself and/or become more tractable? Examples include looking at one specific type of motion, using a specific animal as a source of inspiration (for generating unique specifications), or limiting yourself to a particular set of materials, parts, cost requirements, etc.**

Our group's topic for the project this semester is "Disposable/Degradable Robots." However, the design of a foldable robot composed entirely of degradable materials is too broad of a topic due to the variety of different approaches and applications. There, we decided to focus our research this semester on an agricultural/environmental application of the idea of creating a disposable/degradable robot. The application we selected is the spreading of seeds in the environment. We chose this application because it leverages the benefits of biodegradability into the design of our robot while limiting the scope of our project to a single goal. Using only biodegradable materials will greatly limit the possible materials and approaches that we take to solving the problem of autonomous seed spreading, and this limitation will make our problem much more tractable to solve within the 15-week course.

The research question itself does not specify the complexity of any given design that aims to address the question, but we believe that our goal-oriented research question balances the tradeoff between an overly broad question that would leave us with no clear direction and an overly specific research question that does not offer many

different solutions. Based on the material covered in the course, especially locomotion, we believe that our research question can be answered with approaches that align well with the course material. Additionally, our research question explicitly states that we intend to use concepts from foldable robots to solve our problem, and given the biodegradability constraint included in our research question, using the same material for joints and links will simplify our possible designs. Overall, we believe our research question is tractable by clearly specifying our goals, which were selected to align with material covered in the course.

2. Novelty: Is your question novel? How have you established novelty?

- ***What keywords did you use when performing a literature review on your topic?***

A list of different keywords that we used when performing the literature review are included below. Many of these keywords were paired with the word “robot” or “autonomous” to narrow down our searches to robotics-oriented research, and a number of different combinations of the following keywords were used.

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|--------------------|---------------------|
| i. Degradable | vii. Reforestation |
| ii. Disposable | viii. Tree planting |
| iii. Agriculture | ix. Foldable |
| iv. Seed spreading | x. Origami |
| v. Seed sowing | xi. Printable |
| vi. Seed dispenser | |

- ***What were the four most highly cited references? Provide a short summary of each, focusing on whether these papers have already done what you set out to do.***

While previous research in degradable robotics has focused on possible medical applications, there is little research on the environmental and agricultural applications of such robots. In [1], the authors introduce a seed spreading robot for agricultural applications called “Agribot” which both ploughs and sows seeds. Agribot is a wheeled robot made of metal components and controlled by a microcontroller. While this robot is not biodegradable, its goal in spreading seeds matches our research question’s end goal. The seed dispenser used in [2] is another robot that was used for dispersing seeds

across a field that could be used for reforestation. By utilizing a quadcopter, seed dispenser, and an Arduino coded to generate its coordinates, the user can not only control but also communicate with this device. In the event that the device fails, the operator can take control of it. Due to the amount of hardware in this device, it is not degradable and is quite large. In [3], a smart seed sowing robot was fabricated to aid in the process of sowing seeds. This robot is able to dispense seeds from a seed container, while being controlled from a mobile application. Unfortunately, this robot's design is not biodegradable but it still aims to spread seeds like our research question. In [4], a tree planting robot was designed and prototyped. This robot is able to spread seeds by using an array of sensors, wheels and motors. This design was meant to be priced mid-range and solve the solution of deforestation. This design however, was not created to be biodegradable. This is a flaw of the widespread nature of this design, and something that this project will be aiming to improve.

Unlike previous research, we intend to design a fully biodegradable robot that can be used for agricultural and reforestation applications. By designing a low-cost, highly manufacturable robot using foldable materials, we aim to design a robot that could be mass produced and be safely left in the environment once the robot's task (seed spreading) is complete.

3. Interesting: Is your question interesting, timely, and relevant?

- **What makes it important to others?**

Our research question is important to others since a biodegradable robot that is able to spread seeds has the potential to positively affect both people and the environment. First, the agricultural application of such a robot could increase the production of food, especially in places where buying expensive farm equipment is cost prohibitive. Our research question was selected to encourage the design of a low-cost and easy to manufacture robot, and such a robot could help those in need of assistance in food production. Another important aspect of our question is the focus on the biodegradability of the robot. With a biodegradable robot, people would be able to set-up the robot and let it spread seeds autonomously without worrying about tracking the robot to retrieve it. Therefore, such a robot could have a positive environmental impact, which is clearly important to many people.

- **Why is this idea important now? What prevented it from being answered 10 years ago?**

Our idea is important now because of the usefulness of engineering devices that have a positive impact on the environment. The effects of climate change are clear, so many engineers, scientists, and policymakers must work together to address these problems. Our idea can be used for environmentally positive goals such as reforestation, but is also designed in a way such that once the robot has completed its task, it can safely decompose into the environment. Therefore, our idea is environmentally friendly in both its intended goal and design. The recently growing field of foldable robots is what allows us to answer our question now. Within the past 10 years, many researchers have developed useful foldable robotic designs and analysis methods, so now we are poised to use this technology to solve our research question using these methods.

- **Within what contexts could other people use your results?**

By the end of this semester, we will have designed one possible robot that addresses our research question. This robot, if effective, could be used for applications such as agriculture or reforestation. However, since this robot is only one possible solution to our research question, other people could use our results to come up with other, possibly better solutions. From our literature review, we did not find any other research that solves our specific research question, but our results could encourage other researchers to try to tackle this problem or similar ones. Therefore, both our robot and the idea of the robot could be used by others.

- **What are the potential broader impacts on society?**

As referenced previously, if we can successfully design low-cost, easy-to-manufacture robot that is biodegradable and able to spread seeds, our robot could be used for both agricultural and environmental applications. In the agricultural application, our robot could improve the efficiency of food production in disadvantaged regions of the world where expensive farming equipment is cost prohibitive. In the environmental application, reforestation is currently an important goal that our robot could be well suited for. If our robot could in fact be mass produced, many robots could be released into the environment to spread seeds and simply be left once they complete their task.

4. Open-Ended: Is your question open-ended? Could it leave room for a deeper look if given more time and resources? Discuss how you have structured your research question to permit further, deeper investigation.

The question that was created by the group is an open-ended question. It does not suggest a certain solution to the problem and allows room for the group to explore the question with multiple designs. It is not a goal-based question and does not start with the phrases “what” or “can.” This means that the question is not aimed at achieving a specific goal and is not a yes or no question. We have structured the question to leave space open to explore any possibilities within the field of foldable robotics to find a solution for seed spreading. That said, there are no specifics required for the robot in terms of its movement/locomotion, size, or the specific materials that we plan to use.

5. Modular: Is your question modular? How does it fit with other complementary research thrusts?

This research question is modular because it incorporates an element that has not been tested currently. Some devices have implemented a seed spreading design but not with degradable materials in mind. Degradable materials keeps this question relevant as new materials will always be created, which can aid in researching this question further. This research question can benefit the research field by using the same idea but applying it to different problems. A degradable robot can be applied to the medical field [5] and to home projects with differing problems, resulting in similar solutions.

6. Team Fit: How does answering this question leverage your interests and abilities?

James: I’m interested in the design of robotic devices that have the ability to positively impact society, and I believe that if we can successfully design a simple and manufacturable device that autonomously plants seeds, our robot could have a very positive impact. For example, our robot could be used in reforestation efforts, but also

be low cost so that it is accessible to countries that are the most negatively impacted by deforestation.

Cree: This project leverages my interests by working with a device that can benefit others. I am also interested in foldable robotics as a whole. I am always interested in finding different and creative ways to solve problems. My abilities are leveraged with some manufacturing and fabrication techniques that can be applied to this project. I enjoy working with my hands and applying the foldable application is part of what I want to do with my degree.

Katie: Answering this question helps leverage my interests in the design of robotic devices that can help benefit society. I am interested in the idea of foldable robotics, especially in finding more innovative ways to solve problems and in finding simple yet more effective ways to help the environment. The fabrication of our project will also leverage my abilities through the manufacturing of a foldable robot that is able to autonomously plant seeds.

Daniel: This project leverages more of my interests rather than skills, which I hope to get better at as the project continues. I am interested in researching the field of robotics when it comes to most applications, but especially when it comes to helping out either people or the environment. Due to this project being important to the future as robotics will continue to be even more widespread, creating a degradable nature in robotics is vital to the Earth's ecosystems.

7. Topic Fit: How does the question use foldable robotics techniques to answer it?

Our research question includes the requirement that possible designs apply the "concepts of foldable robotics," though this statement alone does not demonstrate that our question was selected to be conducive to designs using foldable robotics. However, the biodegradability constraint and the application to seed spreading together suggest that foldable robotics is highly applicable to this problem. The biodegradability required by our design means that our design cannot include common materials used in robotics, most notably common metal materials used for robotic structures and electronics. Foldable robotic devices aim to use compliant materials that can be used for both the links and joints of robotic mechanisms, and many of these materials (e.g., paper) are biodegradable. The application of our design to seed spreading was selected

so that the biodegradability of the design is desirable, since then a robot spreading seeds does not need to be recovered after it has completed its task, and will not cause environmental harm. Foldable robots can also have the benefit of being highly manufacturable, and this characteristic would be desirable for a robot that is intended to be left in the environment after it completes its task.

References

- [1] A. Gollakota and M. B. Srinivas, "Agribot – A multipurpose agricultural robot," *2011 Annual IEEE India Conference*, Hyderabad, 2011, pp. 1-4, doi: [10.1109/INDCON.2011.6139624](https://doi.org/10.1109/INDCON.2011.6139624).
- [2] E. Fortes, "Seed Plant Drone for Reforestation", *Bridgewater State University*, 2017, Accessed: 29- Jan- 2021, [Online]. Available: https://vc.bridgew.edu/cgi/viewcontent.cgi?referer=https://scholar.google.com/&httpsredir=1&article=1033&context=grad_rev.
- [3] P. Kumar and G. Ashok, "Design and fabrication of smart seed sowing robot", *Materials Today: Proceedings*, 2020, Accessed: 31-Jan-2021, [Online]. Available: <https://doi.org/10.1016/j.matpr.2020.07.432>
- [4] S. Prajapati, S. Rai, M. Mali, M. Kumar, and A. Kumar, "AUTOMATIC TREE PLANTING ROBOT," vol. 8, no. 3, p. 6, 2020.
- [5] S. Miyashita, S. Guitron, M. Ludersdorfer, C. R. Sung and D. Rus, "An untethered miniature origami robot that self-folds, walks, swims, and degrades," *2015 IEEE International Conference on Robotics and Automation (ICRA)*, Seattle, WA, 2015, pp. 1490-1496, doi: [10.1109/ICRA.2015.7139386](https://doi.org/10.1109/ICRA.2015.7139386).