

# Can a mobile robot be constructed entirely from degradable materials?

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

- 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 goal is to identify a robotic application in a remote, extreme, or high risk environment where a robot cannot be recovered and poses a negative financial or environmental risk. We want to explore solutions to biodegradable sensors, actuators, and energy sources, identify applications where a biodegradable robot can match or even outperform a conventional robot, and design a disposable robot consisting entirely of degradable materials to accomplish the task while reducing costs and eliminating environmental damage.

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

- What keywords did you use when performing a literature review on your topic?
- What were the four most highly cited references? (Consider using Mendeley or similar to format your citations according to the “Submission Best Practices” document)
- Provide a short summary of each, focusing on whether these papers have already done what you set out to do.

When searching for relevant references, we used keywords like: degradable, biodegradable, disposable, sustainable, and composting robots.

Article [1] perfectly describes the motivation behind our research question and the mindset that we want to approach possible applications and solutions with. The article describes the wasteful practices of the tech industry and a recent push for more sustainable practices which is particularly challenging in the field of robotics. They propose a biodegradable robot that is fully functional but degrades to nothing when left in the environment. The article explores solutions including biodegradable sensors, actuators, and energy sources. Finally, the article explains how a biodegradable would enable new methods and applications that were not possible with conventional robots. We want to consider all of the same things in our own investigation. We want to explore more solutions to biodegradable sensors, actuators, and energy sources and to identify applications where a biodegradable robot can match or even outperform a conventional robot.

Article [2] focuses on a disposable robotic finger design that can pick up unsanitary objects. What makes this product unique is that it's pneumatically driven, using tubes and a commercially available cable chain to minimize costs for disposal. The final product is able to implement a force of 4N at the fingertips and conform to objects that range from a sheet of paper to a small, 30 gram box, while being completely disposable. The one thing about this product is that the materials used, plastics and foam, are not biodegradable. According to the research, switching to biodegradable materials is the next step in the evolution of the pneumatic finger.

Article [3] describes a "folded cellulose-substrate microUnmanned Aerial Vehicle" distinguishes itself from other UAVs by its unique disposable attribute. The concept of a disposable UAV came with the development of Micro Electro-Mechanical Systems (MEMS), which are cheap controllers. It is made up mostly of biodegradable material and is very small and inexpensive to manufacture. The paper used is still very robust, having a 30 MPa tensile strength, and can still be creased to create joints for the system. The UAV uses control surfaces along with its airfoil design to generate enough lift for long range flight, with a large percentage of the aircraft's mass being contributed to the payload. This is feasible due to the small scale of the UAV. The control is made possible using paper circuits, a cheaper and lighter alternative to traditional wires. Trade offs include the fragility of paper, limited size, susceptibility to water, as well as high impact of variabilities that may occur during manufacture.

The design detailed in this report is a nearly entirely bio-degradable UAV that only works in relatively clear skies. They created an airborne, disposable robot, which could be improved upon, but does accomplish most of the problem statement for its specific applications.

The research [4] outlines the feasibility and use of small robotic sensors designed to monitor and transmit data for atmospheric parameters. This is crucial for their proposed idea, to create small robotic sensors that mimic raindrops when deployed from a UAV. The paper researches in depth the motion, physics and dynamics of a raindrop. It also does an in depth analysis on the required electronics and design in order to mimic the research motion of raindrops. In their conclusion they discuss the necessity for disposability and use of biodegradable materials within these rain drop robots. The research demonstrates the possibility that disposable robotics have a use and have accomplished this theoretical work for our team. However, this paper only addresses the feasibility of the raindrop robots, and does not fully accomplish what our team hopes to achieve this semester.

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

- **What makes it important to others?**
- **Why is this idea important now? What prevented it from being answered 10 years ago?**
- **Within what contexts could other people use your results?**
- **What are the potential broader impacts on society?**

This question is important to others because we all share the environment and preserving it now will help preserve it for future generations. It's also important in today's world

because we are just seeing the impact of previous actions that have harmed the environment from decades ago. Not too long ago, actions were made with no thought or proper understanding of how they could alter the environment for the worse. Now that we see the negative impact of excessive waste and hazardous materials, sustainability has become a serious conversation in everyday life.

People using robots intended to be disposed of or robots that cannot be recovered when they fail should consider switching to a biodegradable robot design. Some of the broader impacts on society include promoting an everyday sustainable lifestyle such as composting. Additionally, less harmful effects of a product may actually enable or hasten their adoption.

**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.***

Our question can be answered in a lot of ways and with respect to various realms. Different kinds of solutions can be created, i.e some fully biodegradable solutions versus solutions that focus on making specific elements or electronics biodegradable (or a whole versus partial solution). We have structured our research question to allow the investigation of these different kinds of solutions and contexts. This is necessary to be inclusive of the numerous solutions that currently exist to various problems, but the field is still new and there are unexplored opportunities disposable robotic applications.

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

Our question compliments the current initiative to become more environmentally friendly. This research could potentially inspire other researchers in a different area such as medical or military how they could consider the residual effects of their products. Our research specifically does not want to create any negative impact on the environment and could inspire medical researchers how they could safely deliver medicine with no negative side effects. Could inspire military/security how they could minimize damage but also leave no trace.

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

This research question is particularly interesting to our team because we believe that creating sustainable solutions and improving the wellbeing of the environment should be a focus in robotics.

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

Our problem's material constraints depend on foldable robotics to create high performing robots without traditional joints and mechanisms. Many current disposable robotics require foldable robotic techniques that maximize the unique material properties of disposable/biodegradable. As a team we plan on combining these techniques to answer our research question using these techniques.

# References

- [1] Jonathan Rossiter, Jonathan Winfield, Ioannis Ieropoulos, "Here today, gone tomorrow: biodegradable soft robots," Proc. SPIE 9798, Electroactive Polymer Actuators and Devices (EAPAD) 2016, 97981S (15 April 2016); [https://pdfs.semanticscholar.org/227c/4e820861d8c39ab314afbf1037bfd5da9e4d.pdf?\\_ga=2.33032826.574204144.1612049696-2066131118.16026323110](https://pdfs.semanticscholar.org/227c/4e820861d8c39ab314afbf1037bfd5da9e4d.pdf?_ga=2.33032826.574204144.1612049696-2066131118.16026323110)
- [2] Junya, T., & Nobuto, M. (2020). Disposable robotic finger driven pneumatically by flat tubes and a hollow link mechanism. Journal of Robotics and Mechatronics, 32(5), 958-976. doi:<http://dx.doi.org.ezproxy1.lib.asu.edu/10.20965/jrm.2020.p0958>
- [3] Pounds, P. (2012, December). Paper plane: Towards disposable low-cost folded cellulose-substrate UAVs. In Australasian Conference on Robotics and Automation (pp. 3-5). <https://www.araa.asn.au/acra/acra2012/papers/pap143.pdf>
- [4] S. Bertoldo, C. Lucianaz, M. Allegretti, G. Perona, "Disposable falling sensors to monitor atmospheric parameters," Proc. SPIE 10001, Remote Sensing of Clouds and the Atmosphere XXI, 1000104 (19 October 2016); <https://doi.org/10.1117/12.2241156>