Kwadropus Duster Robot

Mobility Arm Team

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The premise

- Octopuses live neutrally buoyant in the water—they don't really sink and they don't really rise up, they can rest in the water without moving up or down. This is similar to how an astronaut floats around in the Neutral Buoyancy Lab when they train for a space walk on the space station. When astronauts are inside the space station in micro-gravity, it is similar to being neutrally buoyant—they don't sink or rise. The air has a lot less mass so it is very difficult to move enough air to 'swim' when on the Space Station.

The Proposal:

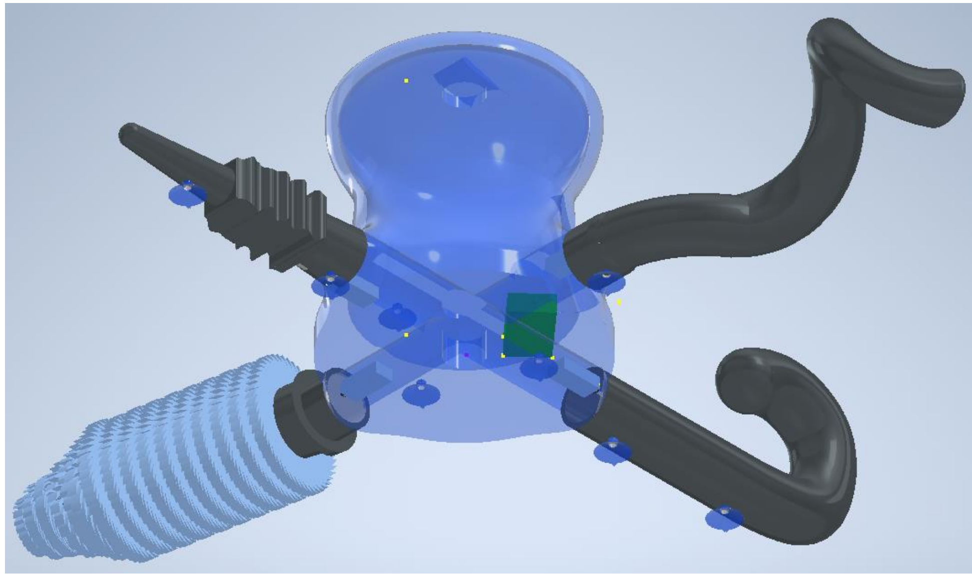
- HUNCH would like to demonstrate the feasibility of an octopus like, soft robot that can crawl around the inside of the Starlab or Axiom Space Stations using flexible arms and suction cups on handrails and flat or curved, smooth surfaces for mobility and uses some kind of duster appendage to remove dust from the walls of the space station. The idea is that it needs to work kind of like a Roomba (but doesn't vacuum up the dirt) for a zero-g environment. An Octopus has 8 arms but HUNCH expects that our dusting robot may only need 4 arms—which makes it more of a Kwadropus. Like an octopus, each of the 3 mobility arms need to be able to act independently to find something to grasp and hold to prevent the Kwadropus from pushing away from the wall. Two suction cups per arm will need to be placed where they will have the most chance of being used. While the 4th arm, a duster arm, is cleaning, at least one of the mobility arms has to be holding the Kwadropus onto a wall or handrail either with a grasping of an object or a suction cup to a surface to keep it from being pushed away from the wall and floating aimlessly. If somehow the Kwadropus does get pushed away from the wall and handrails, the Kwadropus will use some kind of octopus like propulsion to push itself back to the wall.

A Roomba is a small, robotic room sweeper and vacuum cleaner. We are looking for a duster without the vacuum suction.

The Teams

- The **Kwadropus Robot** is divided up into **five different projects** to allow small teams to concentrate on what they are good at and increase each team's chances of success. This is how NASA or any engineering company would develop a new product. Part of each team's responsibility is to be aware of what the other team's requirements are and to stay on their own requirements so everyone continues to work for the same goal and final product.

  - Mobility Arm Team
    - Develop one robotic arm with minimal amount of rigid parts that can pull itself from one location to another using a handrail or other
    - Can rotate to grasp in multiple directions
  - Suction Cup Team
    - Develop a suction cup that can conform itself to a smooth but rounded surface and suction onto it. This could be size related—small suction cups can attach to smaller curves, big suction cups can only attach to fairly flat surfaces.
  - Propulsion Team
    - Develop a propulsion that simulates how an octopus uses a directional jet of water to move itself if it can't grab or grip the wall or handrail.
  - Duster Arm Team
    - Develop a flexible and moving dusting arm that will be able to remove and absorb dust as the robot moves around the module walls without liberating dust into the surrounding volume. (slow may be important)
  - Control Team
    - Develop a method of hive programing similar to an octopus where each arm is able to control itself autonomously—looking for a grip-- but still takes commands from the central brain to clean the room in a random fashion or if the robot is floating away from the wall



- No team should try to do a whole robot—each of these projects requires deeper thinking and prototyping. Two or more teams can put their projects together to help demonstrate how things fit together but that does not mean they will be selected together.
- Because this is the first attempt at this kind of motion, none of these have to act fast. This robot could take an hour to move a few inches. We need to see what kind of motion is possible

General ideas updated to answer several good questions

Nobody has done this before so we are exploring something new.

- As of now, we are attempting to demonstrate the technology and the techniques of how this can be done as individual parts. I'm not too worried about the size of your demonstration as long as your prototype can fit on a table top and show how it works. Once we have terrific ideas from each of the teams, then we will look at how to incorporate all of the ideas into a functional robot.
- The only team that needs to have motors at this point in the development is the control team. If you are able to show your mobility arm or duster arm works by pulling strings or use a syringe to push air in and out of it, that works for me. Later on we can see what kind of motor is needed to pull the string or pump to suck out the air. If you can activate your suction cup with a couple of strings and/or a syringe that will show the idea—motors are ok but not needed.
- This robot will eventually operate on batteries similar to a Roomba. We would aim at it being able to operate for 1 to 2 hours on its own before it has to recharge.
- Expect that the internal temperature of the space stations will be around 71 degrees F.
- It needs to be soft so that it doesn't damage hardware as it moves around. Also since we are aiming at many different space stations, soft robotics may allow for more diversity of movement in a generic environment.
- It is early to know what size the kwadropus duster will be in the end but I think we should aim for a robot that would be around 2 to 2 ½' in diameter and maybe a foot tall. This is our testing robot. Eventually we will make it so it can fit into smaller spaces and get more dust—maybe around 1ft in diameter. Right now I want you to have room to design without having to keep it small—figure out the mechanics first, then we shrink it to the size we need.

- Will the robot have 3 of one kind of mobility arm or will there be multiple

Starting points but not enough information

How does an elephant trunk work

- https://www.businessinsider.com/elephant-trunk-powerful-nose-sniff-out-bombs-2019-1

Anatomy of the tongue

- https://www.google.com/search?q=how+do+tongues+move&rlz=1C1GCEA_enUS939US939&ei=-6YhZM3SFY7DqtsP5q6lgAY&ved=0ahUKEwiNvMPxp_z9AhWOoWoFHWZXCWAQ4dUDCBA&uact=5&oq=how+do+tongues+move&gs_lcp=Cgxnd3Mtd2l6LXNlcnAQAzIFCAAQgAQyCAgAEBYQHhAPMgYIABAWEB4yCAgAEBYQHhAPMgoIABAWEB4QDxAKMggIABAWEB4QDzIGCAAQFhAeMggIABAWEB4QDzIICAAQFhAeEA86CggAEEcQ1gQQsAM6BwgAEIoFEEM6CAgAEIoFEIYDSgQIQRgAUJsIWP0XYIYbaAFwAXgAgAGHAYgBnAeSAQMwLjiYAQCgAQHIAQjAAQE&sclient=gws-wiz-serp#fpstate=ive&vld=cid:aa384407,vid:lATWhP0wJ5c

Robotic turtle—soft parts

- https://mashable.com/video/mit-robot-sea-turtle

Completely Soft Robot

- https://www.technologyreview.com/2016/12/08/155290/meet-the-worlds-first-completely-soft-robot/

Octopus soft arm

- https://onlinelibrary.wiley.com/doi/full/10.1002/aisy.201900041
- https://www.youtube.com/watch?v=8IXncY4L_nc

Chameleon inspired

- https://www.youtube.com/watch?v=trDz4Ukz_VQ

Langley Soft robotics lab

- https://www.youtube.com/watch?v=VuxnPLU_KEs
- https://www.youtube.com/watch?v=iwQRYzLZvGE

Oregami octopus—You will not be able to use magnets like this one because the changing magnetic field would damage the electrical systems in the space station, but there is some really cool thoughts here

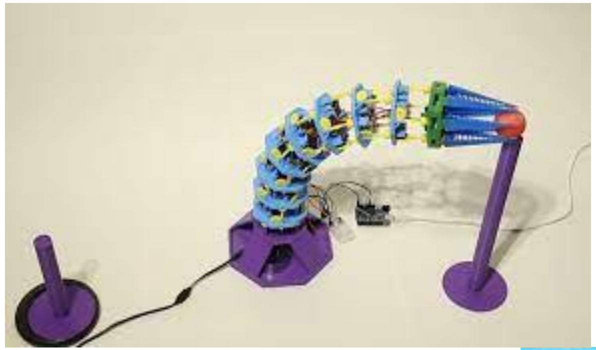
- https://techxplore.com/news/2021-08-omnidirectional-octopus-like-robot-arm-motor.html

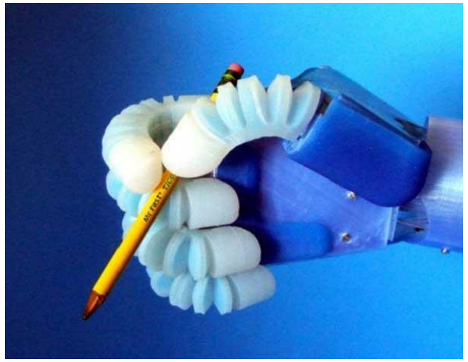
Tips for making soft robotics components

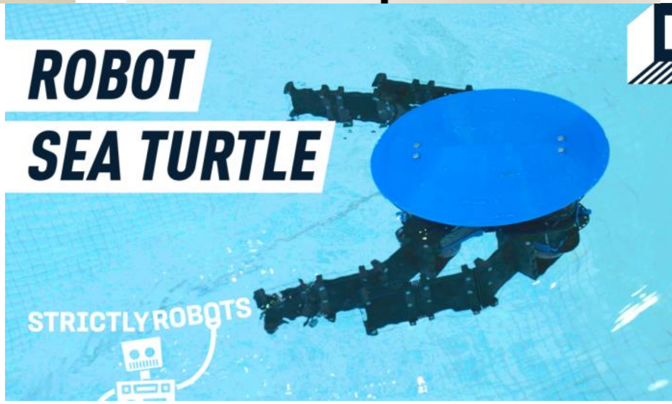
- https://www.youtube.com/watch?v=TyYW9BmMeSs
- https://www.youtube.com/watch?v=GgJt6vIbiso

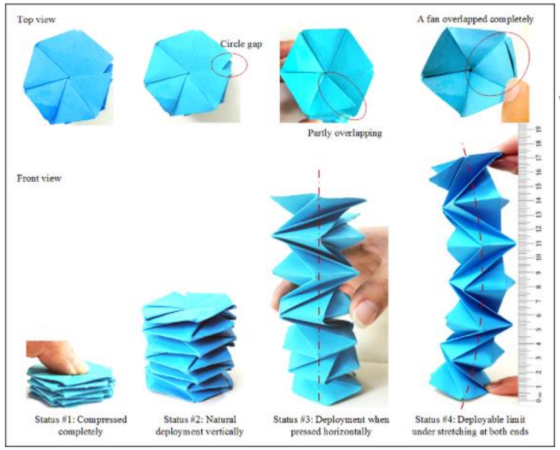
Other related ideas for soft robotics

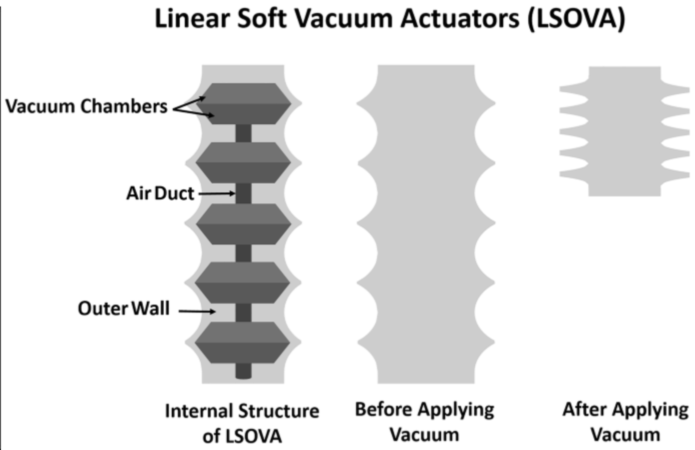
- https://www.universetoday.com/162514/engineers-design-a-robot-that-can-stick-to-crawl-along-and-sail-around-rubble-pile-asteroids/





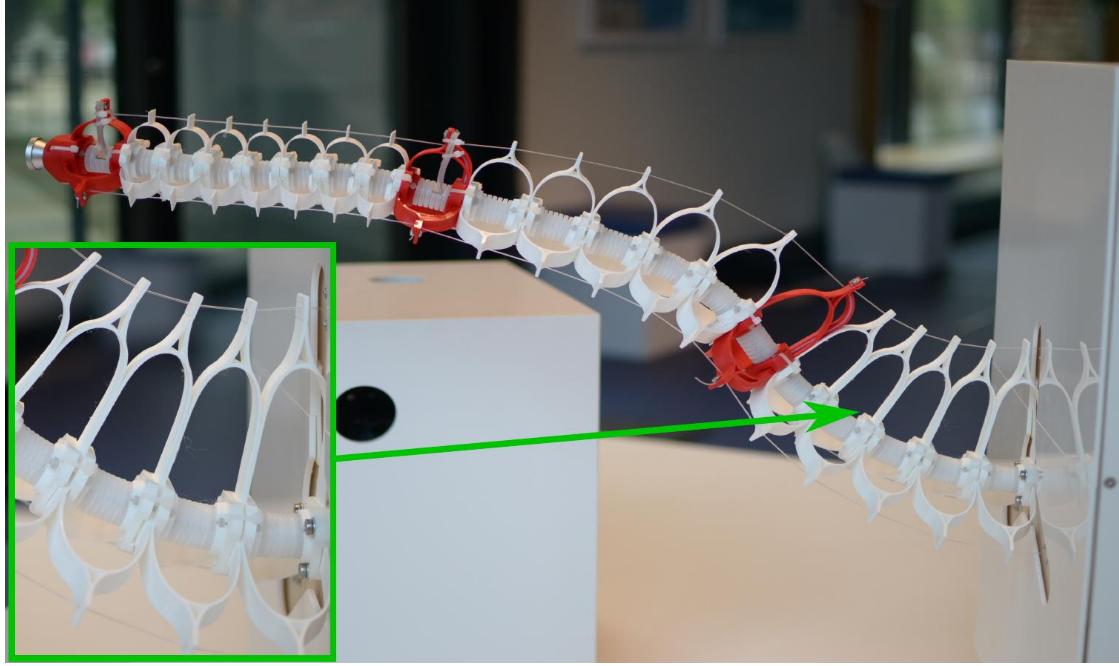




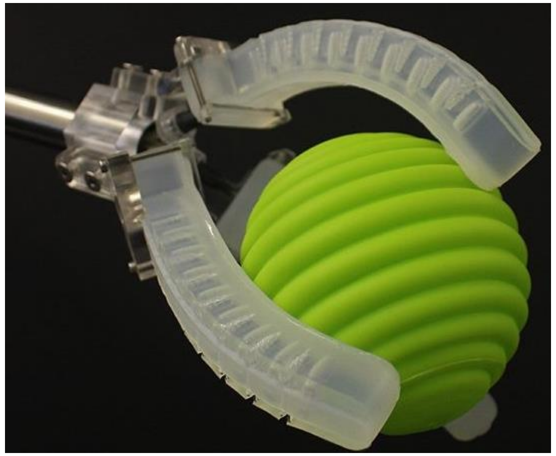


Arm Team

- Octopuses only have arms, no tenticles. Arms have suckers throughout the whole length of the appendage. Tentacles like those seen on squid only have suckers on the ends.
- Octopus arms don't have any bones or rigid components. They are a combination of several muscles that are more similar to a person's tongue or an elephant's trunk than an arm or leg. Each octopus arm can act independently exploring or searching for food or assisting with mobility. If an octopus arm is cut off, it will wriggle and move for up to 5 hours on its own. During that time it can respond to both pain and food. The octopus can also regenerate that arm over a few months. We don't expect any of this for an octopus Robot. What we are interested in is how flexible of an arm can be made using as few rigid parts as reasonable.
- How do snails and slugs move along
- Muscles of an octopus work similar to an elephant trunk or a persons tongue.
- Toys that may lend ideas and options
  - Use coiled memory metal to extend when hot and coil back up when cool to approximate octopus tentacle.
  - Use party favor that goes straight when blown into end contracts back to a coil to approximate motion of tentacle.
  - Use a snap bracelet with pneumatic or hydraulic tubing to approximate motion of tentacle
- There will be 3 arms for mobility. Each arm will need to be able able to extend and contract 12 inches and sense contact with an object. It will incorporate at least two suction cups somewhere on the arm but the arm team will not develop the suction cup only where the suction cups will go on the arm and allow for connections to the suction cup



Shark bodies are mostly cartilage, like your ears or nose. Semi rigid parts can give more flexibility and allow for more motion.



Flexible parts made rigid with air pressure. Could also be use vacuum for motion and power

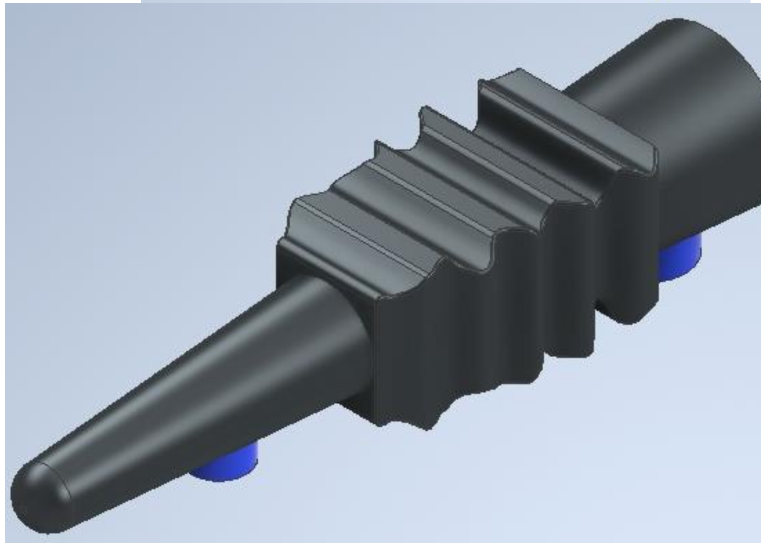
Ideas to look at?

This is like the finger traps. I used them
when working for an electrician and
pulling wires through the walls. It has
great spring action that could be
helpful for grabbing onto objects.

Check this out!!!! This is really exciting.
The inchworm style of motion is more
useful than I had imagined.
https://www.msn.com/en-us/money/other/raw-video-squishy-robotic-worm-slithers-inside-aircraft-engines-for-maintenance/vi-AA1hedfC?ocid=socialshare

Wrapping around not drilling through

Should we use one style of mobility arm for all of the arms or
should we use 3 different style of arms? Not determined
yet—you will help decide. There are other methods you can
suggest besides what is represented here.



ISS Handrails

Our goal is to make a robotic duster for the space stations of the future not the ISS, however, the handrails they use on the new space stations will probably be very similar to those on the ISS. There are lots of handrails all over the ISS and though some of them operate differently, they all fit on to seat track and are smooth and comfortable on the hand. There may also be other things attached that the robot may grab onto that isn’t a handrail.

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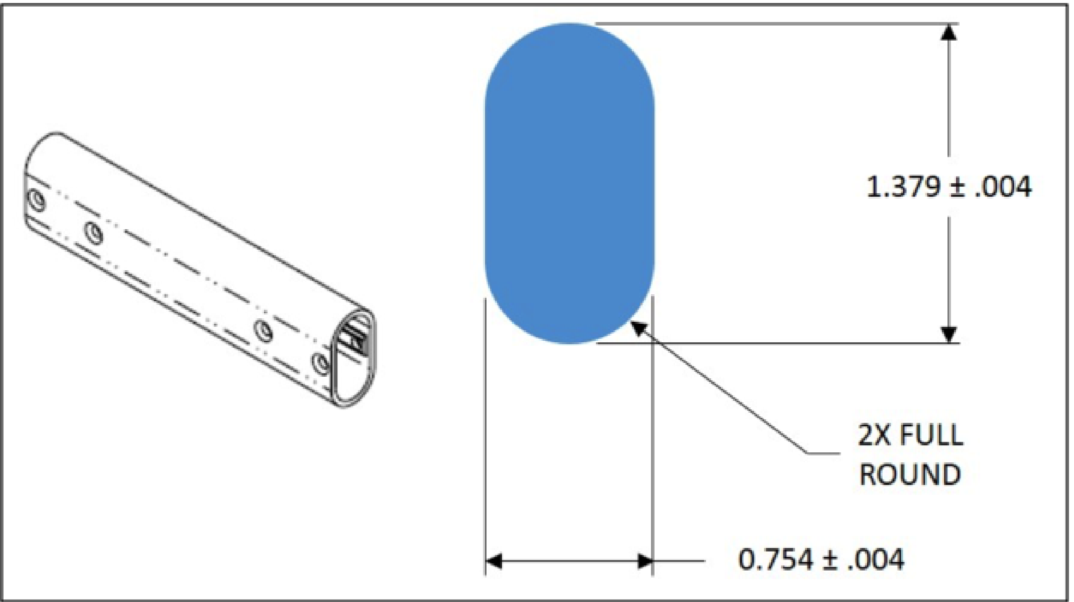
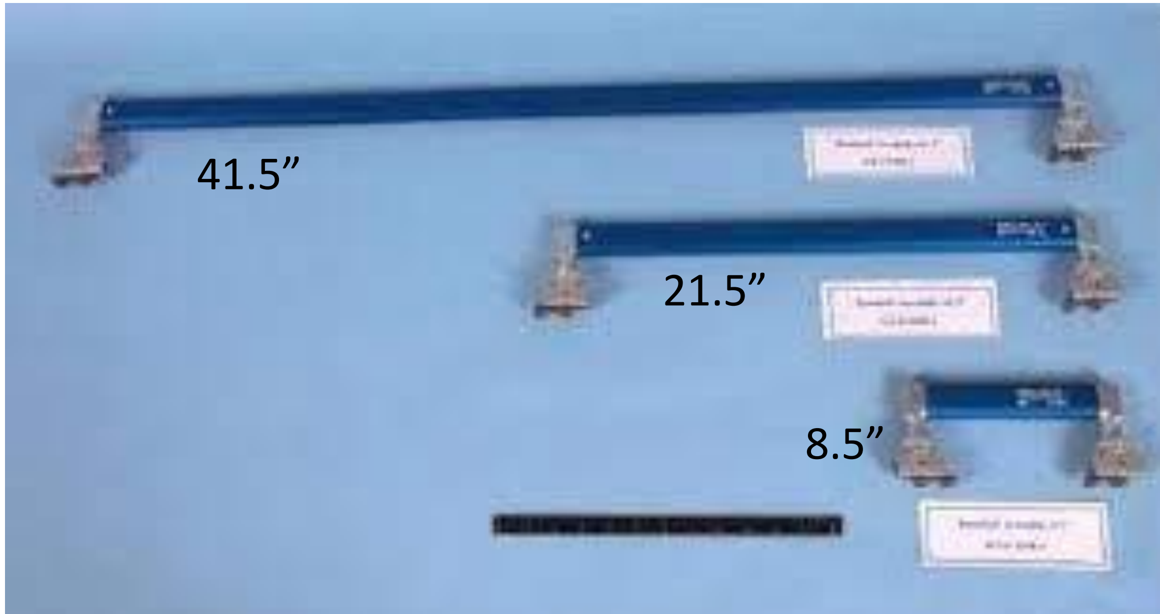

1.379 ± .004
2X FULL ROUND
0.754 ± .004


41.5”
21.5”
8.5”