Kwadropus Duster Robot
Propulsion

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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:

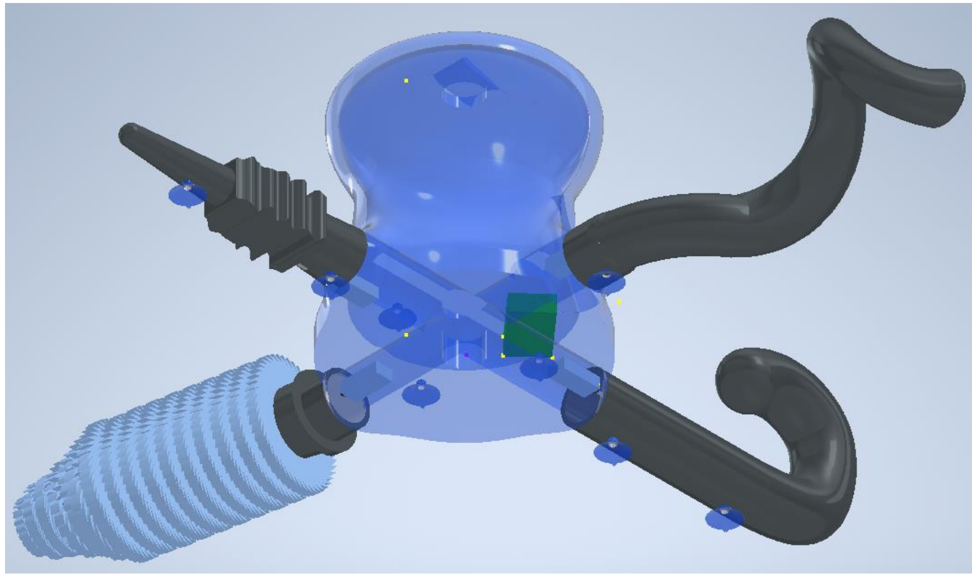
- HUNCH would like to demonstrate the feasibility of an octopus like, soft robot that can crawl around the inside of the Starlab or Axiom Space Stations using flexible arms and suction cups on handrails and flat or curved, smooth surfaces for mobility and uses some kind of duster appendage to remove 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.s

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.

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

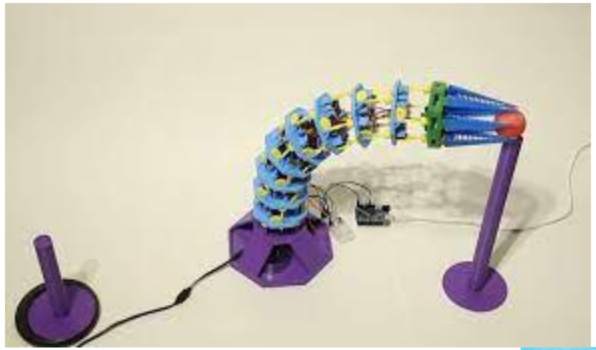
- https://techxplore.com/news/2021-08-omnidirectional-octopus-like-robot-arm-motor.html

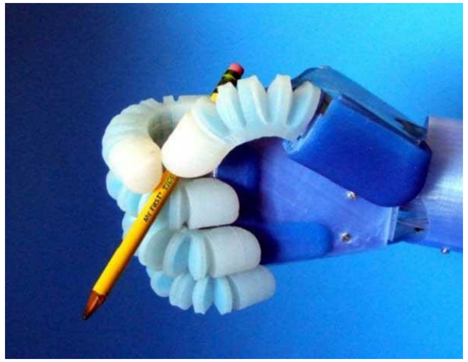
Tips for making soft robotics components

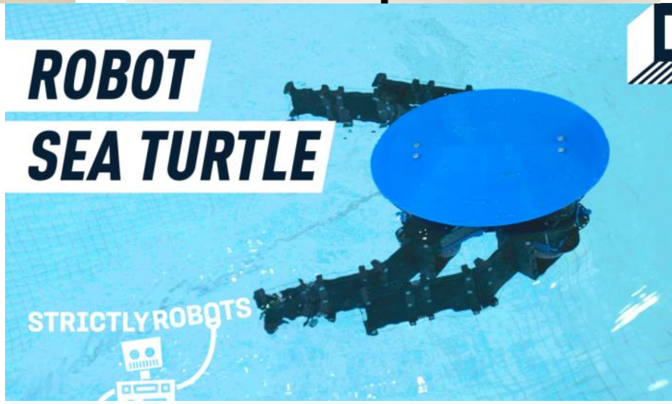
- https://www.youtube.com/watch?v=TyYW9BmMeSs
- https://www.youtube.com/watch?v=GgJt6vIbiso

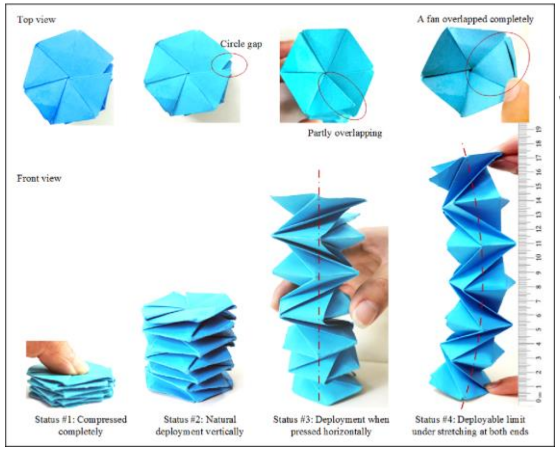
Other related ideas for soft robotics

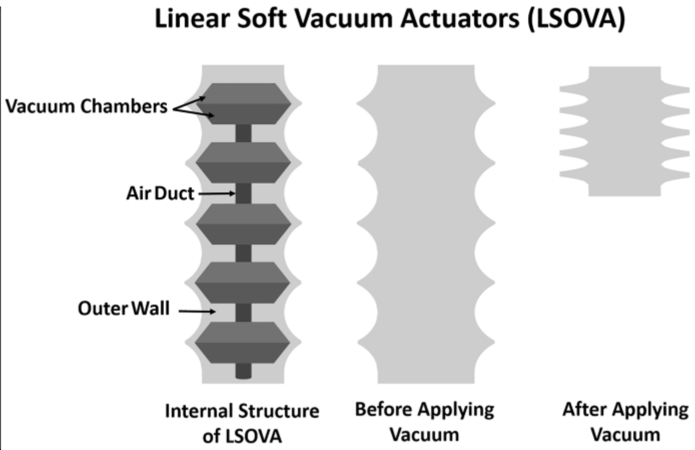
- https://www.universetoday.com/162514/engineers-design-a-robot-that-can-stick-to-crawl-along-and-sail-around-rubble-pile-asteroids/











Propulsion Team

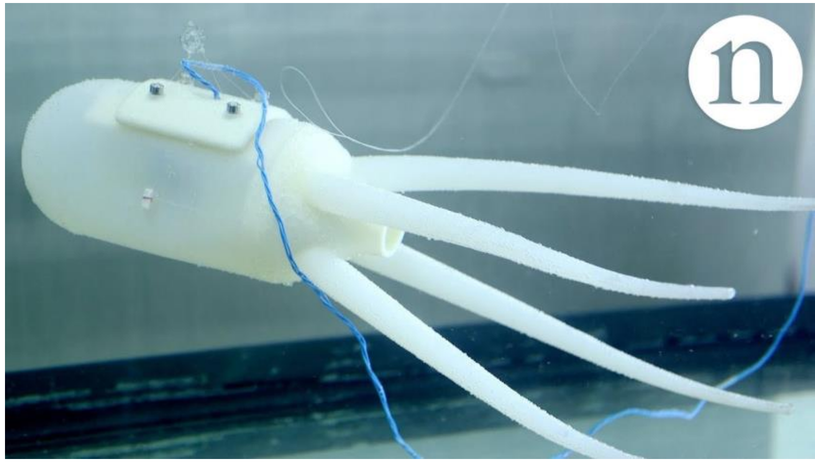
Octopuses use muscles in their mantle to squeeze water out their siphon for short bursts of speed to attack prey, get away from predators or other dangers.
If and when all of the arms loose contact with the wall, the kwadropus will float toward the center of the module. The robot needs to push itself back to the wall and get a grip. An octopus can jet itself around by squirting water in specific directions to get away from danger.
Video of octopus jetting away.
Could our Kwadropus use similar methods to get around? Air has much less mass for propulsion but there is also a lot less friction.
https://cimi.org/blog/octopus-jet-propulsion/

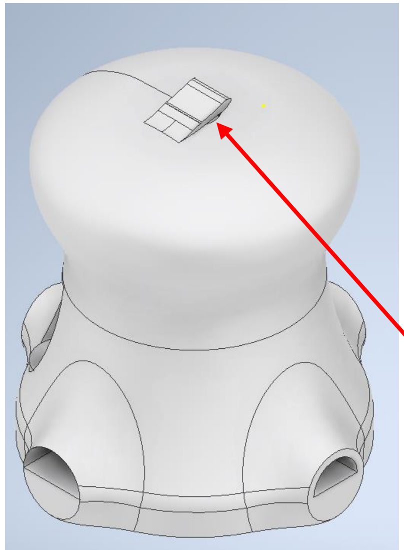
https://zackandscottkarmachameleons.wordpress.com/2016/04/22/octopus-inspired-underwater-propulsion/comment-page-1/

https://ocean.si.edu/ocean-life/invertebrates/cephalopods

If the kwadropus has a mass of 2 kg what kind of propulsive force is needed?
It doesn't need to move fast.
How directional does it need to be?
Can a motor and band be used to squeeze a plastic bottle to pulse the air?
Does there need to be some kind of valving to recharge the bulb with air?

Does the exit nozzle for the air needs to be directional so the Kwadropus can steer at least a little in some way?
Could it be done with valves or ports that open up or by moving the opening like you might with a nozzle for a balloon.
Could it be done with one or multiple fans? (That would be much less like the motion of an octopus.)





Flapper valves to control the exit airflow and the entrance airflow?

Testing

- In the microgravity of a space station, there will be very little force needed to move an object. I really don't know how much mass the Kwadropus may have when it is completed, I think you could expect it to be around 10 kg. We are also not looking for high speed so the amount of force needed to move the robot back to the wall should be relatively small. You may be able to attach 10 kg of weight to your propulsion system and then hang it from a string and see how much it is able to push the mass when activated.
- How can a bottle or bladder be squeezed and released using a motor?
- Does the bottle need help returning to the original shape after being squeezed?
- How fast does the air need to be pushed to be effective for the 10 kg robot?
- Does the size of the opening for the air make a difference?
- How much air is needed to push 10 kg?
- Would a fan be better?
  - Would the torque from the fan cause the robot to turn?
  - Would it take longer for the robot to get pushed back to the wall?
  - I'd like to stay with emulating an octopus but it may not be realistic.
- How quick can the kwadropus grab onto the rack face?
- If the response time to not being on a rack face is quick, the kwadropus will need little propulsion and little control to get back onto the rack face.
- If the propulsion is too forceful of a push, the kwadropus may bounce off the rack face before it can grab on. It would be good if the propulsion is relatively gentle. It may require several
- What if the kwadropus tumbles from a kick? Don't worry about this yet. Keep it simple at first.
- What is the method of expelling air?
- Is it easy to automate?
- What is the method of refilling the air supply?
- Is it easy to automate?
- Does the bottle/bag refill quickly?
- Does the bottle/bag refill from the same location it exhausts from or a different inlet?