General thoughts on Space Spider autonomous free flyer robot.

Our team (Space Spiders) is really excited about this project because we strongly believe that it is a practical and doable solution for many different problems. One of the most prominent of them is the damage of the outer part structure of space ships and other space objects.
Let us go into details of the main challenges of the project and our approach in trying to solve them.

Moving on different points in space is an intriguing problem!

Considering between many possibilities, we come down on two or maybe three more feasible ways to solve it. From our analyse, moving in the form of inertia have to be one of major ways to cover big distances as much as possible, in order to be able to save energy as much as possible. In our project, the robot is conceptualised to stay outside of the spaceship most of the time. So, reliability, long service time as much as possible, and long power systems, are top priorities in this project. Standing still and locked in one precise position without spending energy is what our solution is trying to solve. We believe gecko feet is a perfect solution together with spider legs anatomy.
It seems a lot of attempts are made in this direction and this proves it to be a doable solution by current technology:
https://www.space.com/24392-wall-crawling-gecko-space-robot-video.html
http://news.mit.edu/2009/stickybot-092509
http://www.4erevolution.com/en/nasa-gecko-robot-spatial/

Our solution consists of a three-petal shaped leg. When we try to pull the leg from the centre of the leg, the forces cause a stick general force that keep it on the surface, similar to what happens in nature with Gecko foot. When we need to move the foot, we pull three tendons and it pulls the petals away from the centre, thus, making it possible for the foot to move from the stick position.

On other hand, this alone is not sufficient to give a full automated solution. So, our project tries to cover another aspect of moving in space (like faster, further and in doing so also spending as low energy as possible). To cover this aspect, long feet inspired by spiders we believe come to help. Not only do they allow us move freely, but they also help the manoeuvrability, maximize the range of difficult terrains the robot can walk on (it is really hard to think of some place that the robot constructed in this way cannot walk on), and also give the range and accuracy the scanner and other onboard sensors and cameras need to operate.
A full stretched leg gives the maximum fixed distance for the 3D LASER scanner working in max area cover/ low resolution regime mode for first and fast routine scanings. On the other hand, moving the angle of the joints of legs can bring the main body of robot as close as we need to the outer layers of the structure of the object we monitor. Their wide range together with soft and

accurate movements make a perfect solution, for these types of missions, in which we strongly believe in.

But it is not over yet…..

By trying to maximize the role of each part and, by so doing, also creating and perfecting our creation as much as we can, we go further. Placing vibration sensors on each leg and monitoring constantly the spaceship with them, we believe it is another interesting idea. When something hits the spaceship, the vibrations generated by the impact, have to move throughout the body. Placing more than two vibration sensors (in our case 6, one for each leg) it makes it an intriguing solution for real time damage position detection (in cases when the object monitored is big, then a number of spider robots can work together, and when one is jumping the others have to be in sensing mode making physical contact with the spaceship. This procedure is easy programable, making a protocol of work for groups with more than one spider monitoring simultaneously).
In cases when damage and position is detected and calculated, the robot automatically sends alarm signals to space crew, to nearest station, or to the earth if possible, and also start to move to impact site. Jumping and moving from inertia together with classical propulsive system, helps in this part. At this phase, going the fastest we can, has to be the priority in designing the robot. Implementing an electric propulsion system (being ion or plasma jet technology) is given priority. Our design has 3 electric jet propulsion combined with vector thrusting to give flexibility in jumps and space movements in any direction. We believe that for a similar robot to be practical and effective in solving its duties, **a combined moving solution** must be taken in consideration.
https://en.wikipedia.org/wiki/Ion_thruster
https://en.wikipedia.org/wiki/Plasma_propulsion_engine
An interesting idea to boost agility are M-blocks or Cubli projects:
https://www.youtube.com/watch?v=S5-BmLsRemk
https://www.youtube.com/watch?v=6aZbJS6LZbs
Or other similar solutions that implement internal angular momentum changes for changing directions of the whole system. However, we have not enough time during competition to further develop this idea. Still we find it intriguing and with potential worth exploring.

Another intriguing use of the legs is their ability to take different shapes and functions.
Trying to maximize its range of missions, we try to implement a modular approach, for example one or more than one feet extremities can be modular and can be replaced with tools, sensors or robotic arms depending on needs. In this way the robot can gain repair capabilities being remote controlled by operator wirelessly.
In other cases when contacting distant places is needed, positioning its legs and taking an parabolic dishes form, similar to the satellites, can help boost reception and transmission range, acting as a middle point repetitor for the spaceships and other objects.
When remote controlled, its group of cameras help create a VR and 360 degree of view to remote operator being inside spaceships or in some other places.

A suite of sensors can be very useful on the robot body measuring temperature leakage from ship structure, in the form of infrared monitoring, gas escape from damaged structure, and radiation levels.

Since all the functions are intentionally biased on electricity, a high energy battery must be implemented on the device (for example Li Ion or more exotic derivatives), together with solar panel in the main body. When in standby mode (radar mode) similar to when spiders wait for their pray attentively listening for vibrations on their web, the robot is in low power operation (it holds a fixed position which does not require active elements) listen for vibrations (the only form of loss of energy) and recharge from the sun or from piezo elements standing near heat points of spaceships is beneficial.

The portable 3D Lidar laser module serves for scanning and comparing it to an already stored 3D mapping by default in memory, and constantly comparing it to the resulting live scan map.
https://www.creaform3d.com/en/metrology-solutions/handheld-portable-3d-scanner-goscan-3d
https://www.nasa.gov/centers/ames/research/3D_vision_lab/robot_scanner.html
https://www.nasa.gov/centers/ames/research/technology-onepagers/high-speed-3d-scanner.html

Any difference in findings triggers alarms and reporting, or repair actions depending on situation. Assisted by visual camera technology boosted by high resolution chips and high quality zoom camera lenses, make a perfect coverage of the monitoring problem. Optical stabilized systems help the view in difficult situations.

Trying to repair small damages with sprays seems another fascinating idea.
https://www.youtube.com/watch?v=Lfd7_p4SVBU

We think it is a very interesting design because of its flexibility and adaptation to lot of different missions, and if we look carefully, even though it looks quite futuristic, all the components are doable by today standard technology. Processing power is now cheaper than ever and with progression of manufacturing in 7 nm nodes and behind it is also very efficient in power consumption. Software with AI learning is making tremendous progress on the other hand. High efficiency, powerful brushless or coreless electric motors or steppers are easier to obtain than ever, state-of-the-art wireless communication, and the sensors are getting cheaper and smaller. It looks that all the pieces needed are there ready to work together for creating something really unique.

We have tried to cover the main functions, making 3D renders help visualize our project, and some of them are published in our official Nasa contest page under progress tab.
https://2018.spaceappschallenge.org/challenges/can-you-build/design-based-nature-fusion/teams/space-spiders/stream
Main page project with 3D renders

https://2018.spaceappschallenge.org/challenges/can-you-build/design-based-nature-fusion/teams/space-spiders/project

Contest Powerpoint:

https://drive.google.com/open?id=1X12X4n5lTlo0vkFsW1D7iipOhBSi1OuD

Thank you all!