Mission to Mars: Conquer Sub-collections with Aerial Vehicle Navigation

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Introduction

The original terrain sample finding and collecting scheme in Swarmathon initializes a central base as the rovers' only starting point and the final collection zone. This strategy works decently for a small terrain. However, as the terrain gets larger and the targets become more scattered, the efficiency of this tactic decreases due to long disoriented travels and a high chance of collision near collection zone. As the Mars mission progresses, the number of sample targets collected increases and efficiently returning them to the main zone becomes a difficult task. Using the concept "Divide And Conquer" expedites the process of retrieving and delivering. Rovers are allocated around the central base along with pre-filled sub-collection zones which are to be deployed around the landing site.

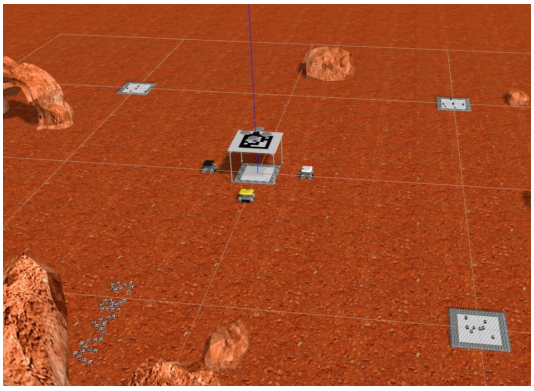
The mechanism can be applied in many scenarios. For example, imagine each rover is placed in a random location with some arbitrary distance from the main center, each rover is only capable of knowing how to return to the sub collection zone from any location within their assigned area. Each of them starts the collection task and temporarily drop the targets at their initial sub collection zone. Each of these distributed collections become a larger unit for the next round of collecting. Recursively, another group of rovers conquers the filled sub-collections by delivering the targets from further area to next locations closer to the main base and finally to the ultimate base where the spacecraft takes off and drives back to Earth.

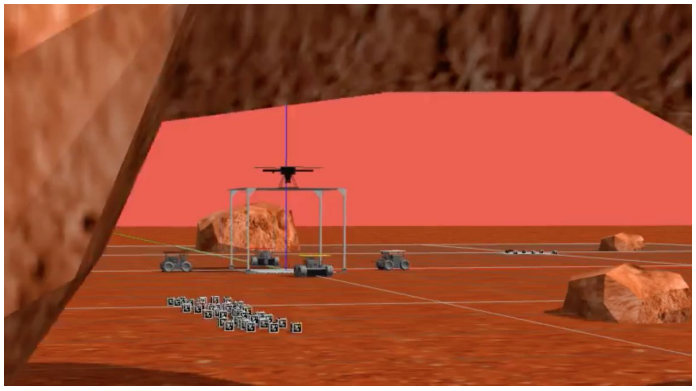
In this mission, an aerial vehicle is recruited to help the rover crew for navigation. We use hector quadrotor in our implementation. Hector quadrotor broadcasts location information to the rovers, allowing them to be aware of their position relative to others and to the sub-collection zones. This information enables them to coordinate and decide on how to execute collection tasks such as choosing which sub-collection zone to use. The assigned sub-collection is not constant as it changes every time a broadcast is received from the hector quadrotor. This updated information helps rovers optimize their path to a sub-collection zone so that collective contribution is maximized. Another factor is when a rover completes its sub collection zone's deliveries, it can seek the nearest unfinished sub collection zone. At this point, hector quadrotor's broadcast can be counted on to improve the overall performance of the cooperating system.

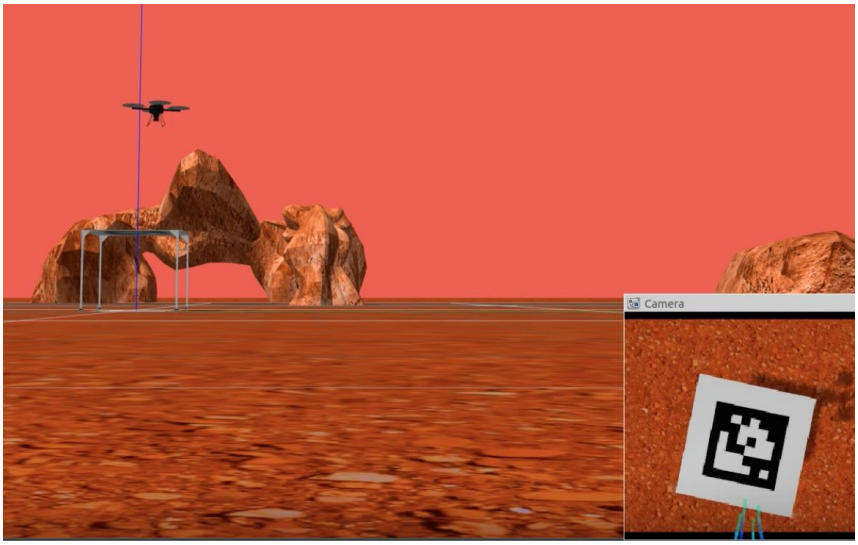
The additional features to the current Swarmathon design are intended to inspire the future Swarmathon innovation. For instance, nowadays, the unmanned aerial vehicle (UAV) is developed and utilized in the robotics field for different purposes. One of the studies is Mars rover and helicopter cooperation. The aerial vehicle plays a very significant role in mapping, localization and risk prediction. Swarmies can take advantage of a UAV's vision to enhance their pose estimation.

Mission Implementation

Implementation: https://github.com/sammilei/MissionToMars-Swarmathon-PCC-CSPU.git
Demo video: https://youtu.be/aDgJCkAqRDo

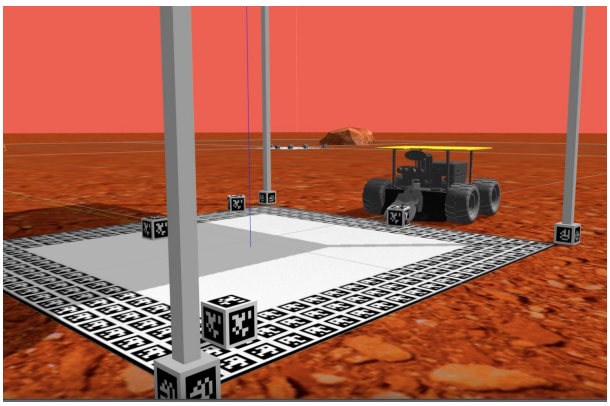






To improve upon the 2018 NASA Swarmathon base simulation that uses a single central collection zone, we implement four more collection zones as sub-bases at each corner of the arena, where each zone is pre-filled with the cubes that were gathered from the last completed mission. These four sub-bases serve as target locations that rovers attempt to pursue. From these sub-bases, the rovers will load and deliver the cubes one at a time to the main base, and the whole process repeats till the cubes have been exhausted. Mission complete.

Above the main base, a launch pad is built for the hector quadrotor to take off and land. The launch pad is supported by four pillars next to the corners of the base and it utilizes a large April tag to assist the hector quadrotor landing. To prevent the rovers from colliding with the pillars and to help them identify the main base, each pillar of the launch pad is elevated by a cube where each visual side is attached with an identical April tag.



Hector quadrotor will take off from the launch pad, hover for a few minutes above the arena and land to gain each rover's current location periodically. The way to locate each rover is by reading the ID tags on top of each rover. Rovers will use that coordinate information to recalculate the mapping error. Once the quadrotor publishes the global location of each rover, the coordinator among the rover crew replans the travel and fetch job for each rover.

Unfortunately, some of the features designed haven't been fully implemented yet. For example, the hector quadrotor is still controlled manually and it is not sending signals to the rovers. They remain as the future exciting challenges.