Autonomous Greenhouse with Swarm robots for Mars Exploration

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Abstract: Bhoomi is a swarm robotics platform to build Habitats. Each robot in the swarm is independent and completes functional requirements autonomously. Multiple robots collaborate to complete a complex task. Robots consist of Rover(UGV), Quadcopter(UAV/), Humanoid(Digital twin). VR map model is generated by the Habitat Monitor system for real time visualization and tracking progress of robots. Each robot has a fallback position, for human operators to intervene for complex task processes.

The system will generate layouts for Habitat modules and provide Assistance and monitoring to Martial explorers. Fresh and locally grown food is necessary for Sustenance and survival of crew members. The system will monitor the green house and provide information to Mission specialists.

For the Habitat's Greenhouse Module. Below tools have to be 3D printed

- Metal Cutter/Shearer : To repurpose landing gear shell for walls and compartments
- Exercise Equipment : Weight + Dumbbells
- Photo Frames : Mental Health and sense of belonging to mission and life
- Rubber/Soft Mallet : Bend materials into shape for building compartment
- Wires - Thick filaments to hold items into places
- Cutlery/Garden Tools : Scissors, knife, Screwdriver - Standard head

Process

- 3D printer - Print the items based on Prioritised order received from the Habitat Control System
- Rover to pick the items from the 3D printer and to stack it at the sub-module location.
- Astronaut build the module with logistic support of Rover

Modules retrofitted from I-HAB segment

- Crew Systems: Galley for warming food and dining and Personal Crew Compartments providing private area for sleeping
- Crew Health Performance Subsystem: Environmental monitoring, Exercise area and Medical care
- Docking ports: Two axial ports for attachment to the Gateway, Two ports radially for vehicles
- Phenotype plant growth and requirements by growing in Simulated environment on Earth.

Schedule

- Weekly harvest - Per person requirements calculation
- Sow / Re-planting order and time consumed
- Batches of seeds - Initial usage and seeds creations for long term
- Print - Pots and containers for schedules

- Data Collection
- Edge calculation for hourly/daily/weekly summary
- Logging data to central message queue for Backup / Earth analysis
- Phenotype plant growth and requirements by growing in Simulated environment on Earth
- Build tracking system and forecasting system based on observations and real time setup

System Features

- Vision Module
  - Real Time processing of multiple camera source with processing ondevice and/or central server with video stream.
  - Localisation of video source : vGPS (Visual GPS)
  - Multi camera video analytics
  - Use federated learning from difference devices to provide accurate and real-time information
- Resource Utilization Module
  - Resource utilization for dietary requirements is provided by Bhoomi Habitat controller. Based on the number of Habitants, food sources are replenished with Garuda(UAV drone) carrying out
    - Sowing of seeds,
    - Spraying fertilizers
    - water irrigation through a sprayer module attached to drones in the swarm.
- Clean Solar Array
  - Maintenance Swarm Drones which clean the dust of Solar Array Panels in remote locations autonomously.
  - The rotor wash of the drone's propeller would be directed at the panels to blow away the minute dirt accumulated throughout the day.
  - Using the Vision Position System(VPS) the grids would be assigned to individual drones based on its health parameters.
  - Using 2/3 wide angle camera lens, 360 deg view would be constantly monitored for SLAM.
  - Autonomous drones would be wireless charged during excess peak output to conserve energy for critical systems.
- Navigation Module
  - We propose a novel replication algorithm for exploration and mapping of the habitat. From the Swarm drones, replica's are created at intersection to solve sub-problems and the drones return to the start point/ way point if goal is not reached. Information is stored in graph nodes and the replicated data is updated in individual drones on reaching the waypoint. Memory access is global read for instances and local write on reaching the waypoint. The graph is updated globally with delta information when an instance reaches the waypoint. We propose to test the Hypothesis to solve a Maze and to interpret the efficiency of the algorithm compared to other SLAM methods.
- For Greenhouse Maintenance
  - In this approach, A filled syringe is attached to the underbody of a micro-aerial drone. The plunger is activated to spray the liquid using an electro-mechanical actuator.The target area is set based on the type of plant. Using Computer Vision the individual leaf/stalk is identified and a predetermined quantity is sprayed.

- Usage of insecticide for agriculture has a destructive effect of the soil. The existing method of using a body-mounted hand-pump based system is inefficient in terms of
    - Insecticide quantity used.
    - Square area of land covered

The inefficiency is are dependent of the factors below

- Human error
- Wind direction
- Distance between plants
- Height of plants
- Type of plants viz., large leaf, small leaf
- Spray Nozzle

On a conservative method/approach, the insecticide is sprayed ineffectively over an area due to human error or field of view. The error is could a due to a combination of factors viz.,

- Fatigue
- Region of interest as a small dense area, cumbersome to traverse
- Reduced plant to plant coverage due to height of plants

Execution Plan -

- Total Addressable Market - Extreme climate regions, Research stations, High Altitude locations
- Open Data - Competition and IP protection
- Ease of Use - Data + Software + Service
- Talent Funnel - Local school and university collaboration with internship and sponsorship of competitions
- Sustainability - self-rating Gaganyatri score, energy consumption ratio, SDG goals and community infrastructure for green energy