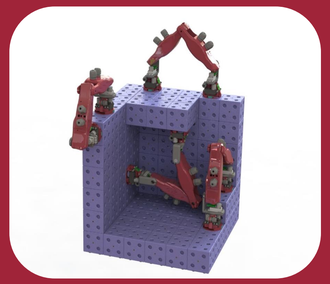

3D Swarm Construction

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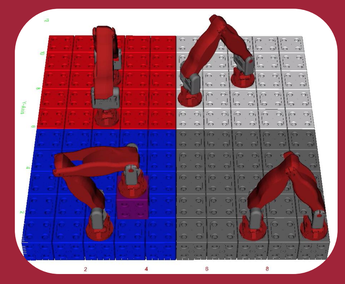


Why 3D Swarm Construction?

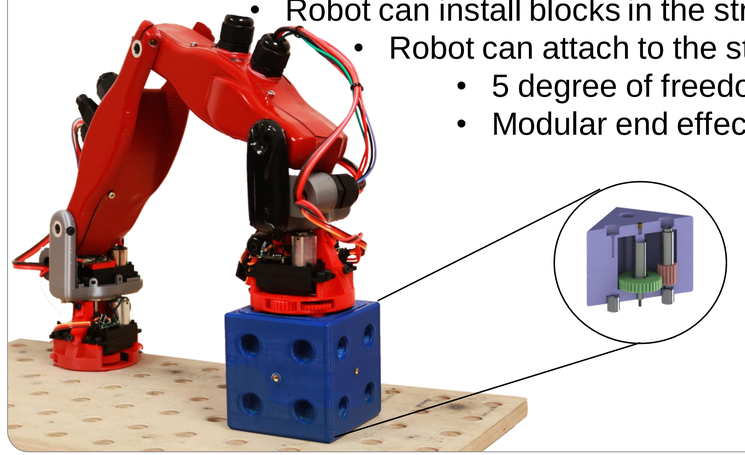
- The automation of construction address the **safety of workers**, especially in hazardous environments where construction may be difficult or impossible.
- Target structures include **temporary shelters for hurricanes, containment zones for nuclear accidents, as well as extraterrestrial habitats for Mars** [1].

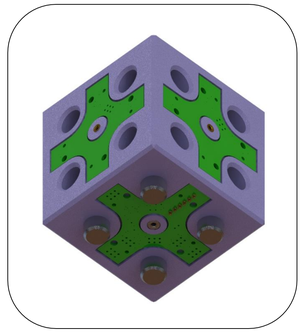
Contribution

- We create an **autonomous 3D collective construction system** in which two types of robots cooperate: construction robots and smart blocks. The latter use integrated electronics to communicate and convey data to robots such as their position.
- We address the research gap that **collective construction has never been performed in 3D with robots that can move in 3D**.
- We formulate a **novel collective building algorithm** that allows robots to collaborate when building structures.

Robot Design

- Robot dimensions scaled to enable traversal of structure
- 30 kg-cm motors rated for static and dynamic torques
  - Robot can install blocks in the structure
    - Robot can attach to the structure
      - 5 degree of freedom robot
      - Modular end effectors



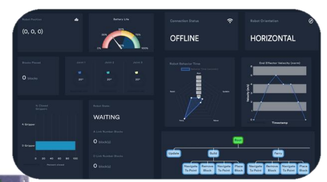


- Smart Blocks use NFC to communicate with each other and the robots
- Communicate state of structure in near real-time

System Architecture

1) Smart Blocks:
Our smart blocks talk to each and share their position with the robots.

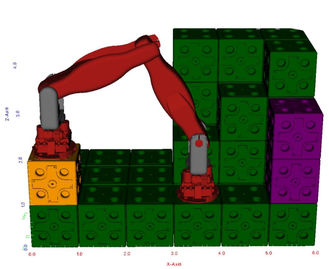
3) Dashboard:
The progress of the swarm can be monitored and evaluated.

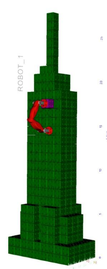


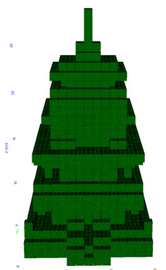
Home Block:
The origin from which block positions are determined.

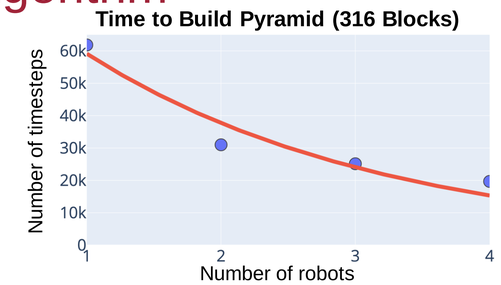
2) Construction Robots:
These robots work together to place/remove blocks using our building algorithm.

Collaborative Construction Algorithm









- An algorithm was developed that allows structures to be built by swarms of our robots. The algorithm prioritizes robots working together by having robots pass blocks to each other. The images shown are structures built with the algorithm.
- In the experiments ran, we found that by increasing the number of robots that are working on a given structure, the amount of time it takes to build decreases.

References

1) Petersen KH, Napp N, Stuart-Smith R, Rus D, Kovac M. A review of collective robotic construction. Science Robotics. 2019;4(28):eaau8479.
2) Jenett B, Cheung K. Bill-e: Robotic platform for locomotion and manipulation of lightweight space structures. 2017:1876.

Future Work and Lessons Learned

- Future work includes reducing the waiting time of robots when building.
- Lessons learned include the importance of good communication.

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