M.A.R.I.A.: Multi-Agent Robotic Intelligent Assembly

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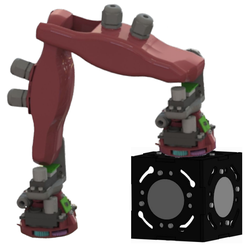
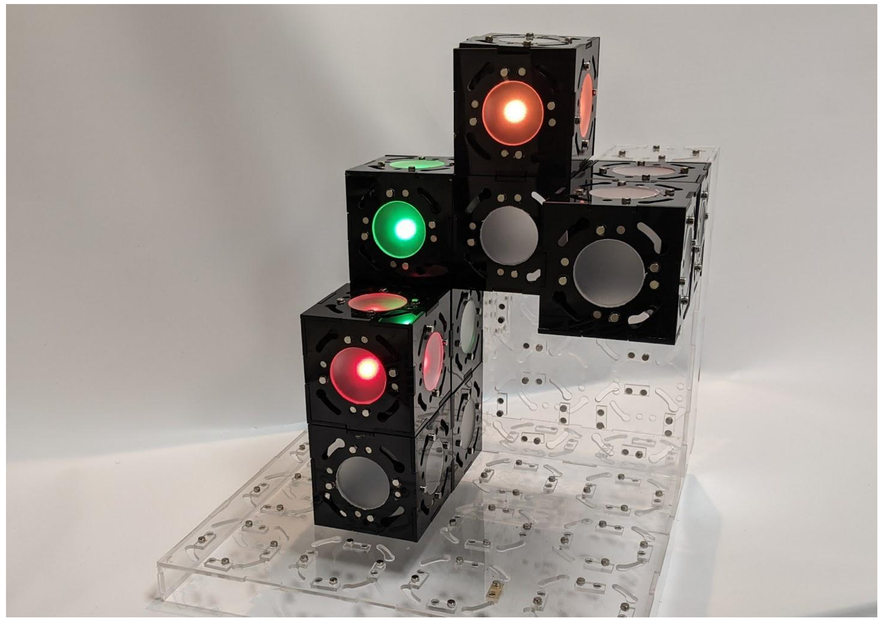
Construction can be optimized by using robotic workers to create structures from smart materials. The prior creation of a construction agent, a robotic inchworm, laid the groundwork for our team to focus on the development of smart building blocks which utilize visual light communication(VLC) and a decentralized planning algorithm. Using a decentralized algorithm allows each agent to act independently with simple rules, creating emergent behavior to build a desired structure using the structure itself as the primary organizer of construction.

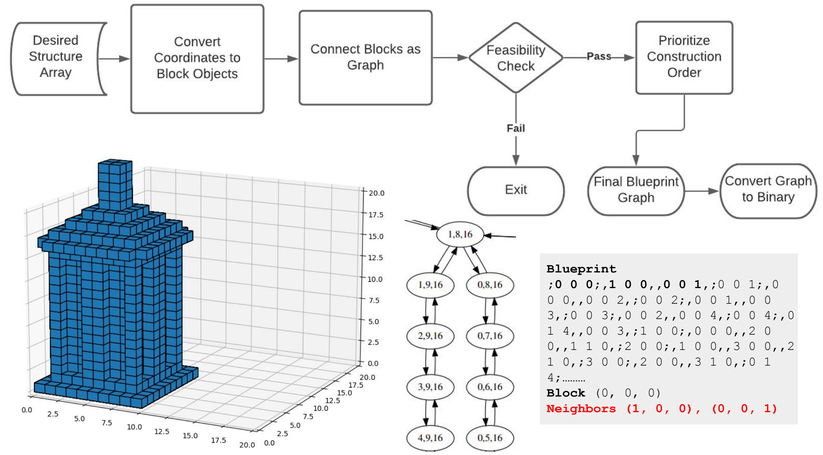
System Design

SWARM SYSTEM
Inchworm construction agents, designed by the previous team, build structures together using intelligent blocks. These blocks organize construction, as opposed to the builders themselves, utilizing the connected nature of the structure to form an information highway.



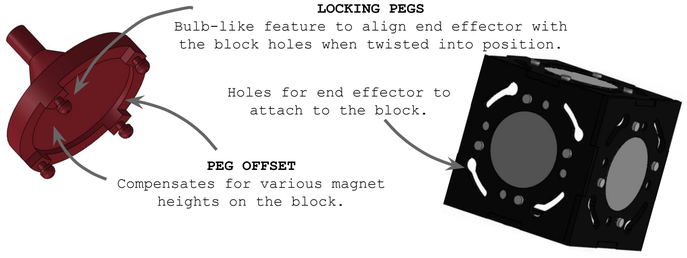


Structure Design



FEASIBILITY CHECK
Proposed designs are first ran in simulation. The system is limited by certain rules governing **how far blocks can overhang** and **how much weight they can support**. If a structure is analyzed and found to be feasible, each block has their list of neighbors prioritized in a desired building order based on these constraints and the final blueprint graph is produced. This graph is converted to binary for transmission by the blocks.

Step 1: Retrieve New Block



LOCKING PEGS
Bulb-like feature to align end effector with the block holes when twisted into position.

Holes for end effector to attach to the block.

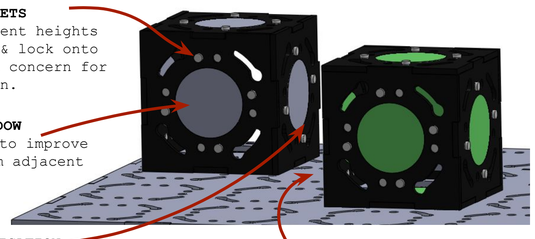
PEG OFFSET
Compensates for various magnet heights on the block.

Step 2: Place Block Within Structure

PEGGED MAGNETS
Magnets at 2 different heights used to self align & lock onto other blocks without concern for orientation.

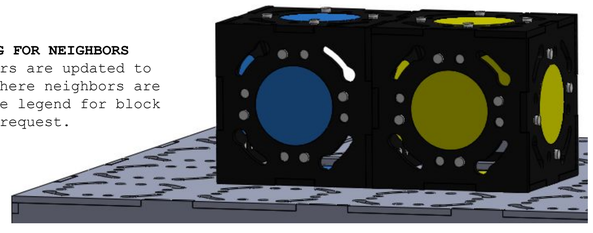
FROSTED WINDOW
Diffuses LED light to improve sensor reading from adjacent block.

BLOCK COMMUNICATION
Color sensor looks for change in light value to indicate a message being sent.



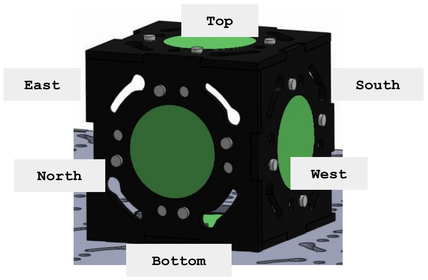
SENDING DATA
Sensor in block face detects darkness, indicating a neighbor was placed. Starts sending color message.

LOOKING FOR NEIGHBORS
Face colors are updated to indicate where neighbors are needed. See legend for block request.



Color Code for Requested Neighbor Block

Top	North	South
Bottom	East	West

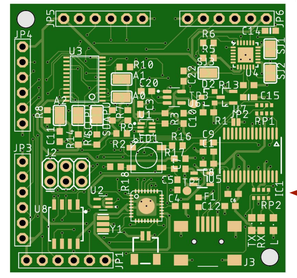


Step 3: Transmitting the Blueprint

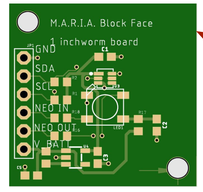
LIGHT COMMUNICATION
A new block must receive the blueprint to begin requesting neighbors. Flashing lights, which encode 4 bits of data per flash, deliver the blueprint to a listening neighbor.

Binary Messaging Colors			
0000	0001	0010	0011
0100	0101	0110	0111
1000	1001	1010	1011
1100	1101	1110	1111

CUSTOM PCB
Each block face can sense color and flash their LED to give a new neighbor the blueprint.



PARENT BOARD
Each block contains one parent board that manages the transmitted graph. Contains an ATMega328P, multiplexer, IMU in addition to an LED and color sensor.



CHILD BOARD
Appears on 5 of the 6 faces of the smart blocks. Contains an LED and color sensor.

Lessons Learned

- Remote work hinders integration
- Developing a novel solution requires substantial research
- Asynchronous and decentralized communication takes careful tuning

Future Work

- End Effector
- Inchworm Mobility & Design
- Communication Scalability

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