Voice Over for RA-L video

This video shows parallel self-assembly of 2D tile structures using uniform control inputs. Tiles of different colors stick together.

All tiles are actuated simultaneously by a global control input that pushes in the clockwise sequence of right, down, left, and up. The factory generates multiple copies of the desired part. For this example, the goal configuration is shown at left.

Each clockwise sequence assembles another part.

These parts are called polyominos

Our algorithm first determines if a polyomino can be constructed by adding one tile at a time; if so it generates a build sequence for the tiles in the part, otherwise it returns that the polyomino cannot be built by additive construction. Such polyomino must be made by different methods.

We built a reconfigurable, gravity-based model and a milli-scale magnetically actuated system to demonstrate parallel assembly. In the gravity-based model, gravity is the global input that manipulates the red and blue sliders. These sliders connect magnetically – the red sliders have magnetic south out and the blue magnetic north.

In the milli-scale prototype, alginate particles are actuated by a global magnetic field to assemble into a 2d structure. In this case the structure is a four-particle square. A custom magnetic control stage generates a magnetic drag force by moving a permanent magnet. The assembly workspace is built on a silicon wafer. Channels were formed from SU-8 photoresist filled with Dionized Water and 10% Tween 20. All microrobots used for these experiments were loaded alginate paramagnetic hydrogels, otherwise known as artificial cells.

The global input is the clockwise <u,r,d,l> sequence.

Friction from the walls is the largest challenge when maneuvering through the factory.

To overcome this friction, the control input is pulsed. The pulsed control input does cause some of the microrobots to temporarily move backwards, but they reach their destination by the end of each control sequence.

Some unfortunately consequences are represented by other tiles or alginate microrobots moving in opposite direction for a short period, but following the <u,r,d,l> sequence, they once again move back into the proper location.

0 s ~ 7 s in video : the first alginate microrobot comes out the hopper.

7 s ~ 10 s in video : two alginate microrobot come down to assemble together.

10 s ~ 14 s in video : alginate tiles come together.

14 s ~ 22 s in video : the 2-tile polyomino is moving to the next assemble location.

22 s ~ 42 s in video : the 3-tile polyomino is created

42 s ~ 1:03 s in video : the 4-title polyomino is shown