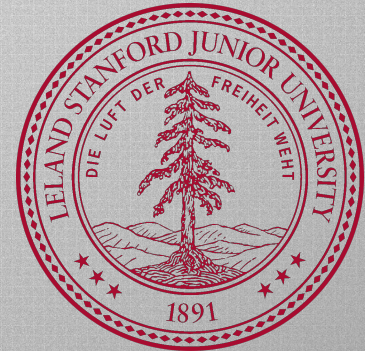


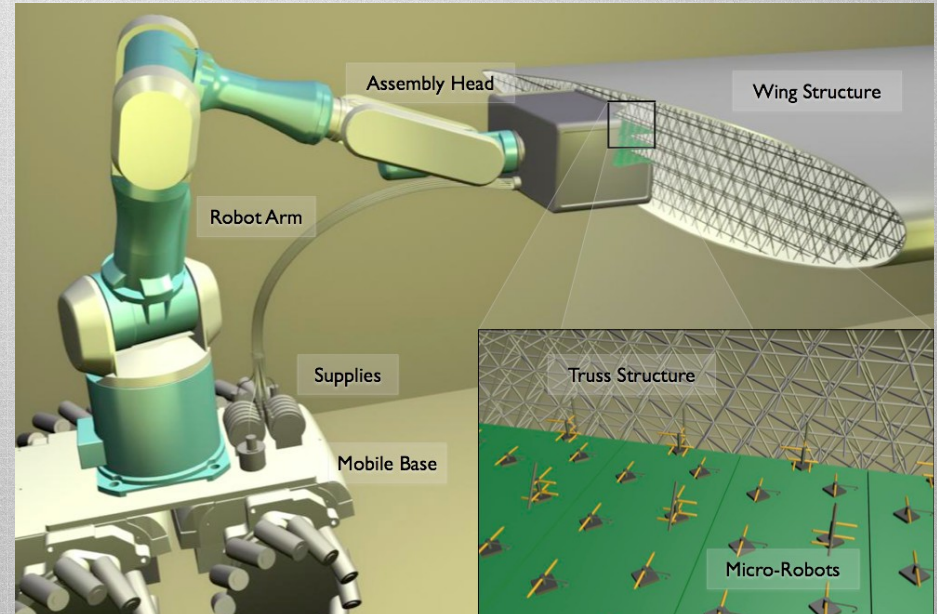
Micro-Factories for Smart Manufacturing

Simulation and Path-Planning Platform

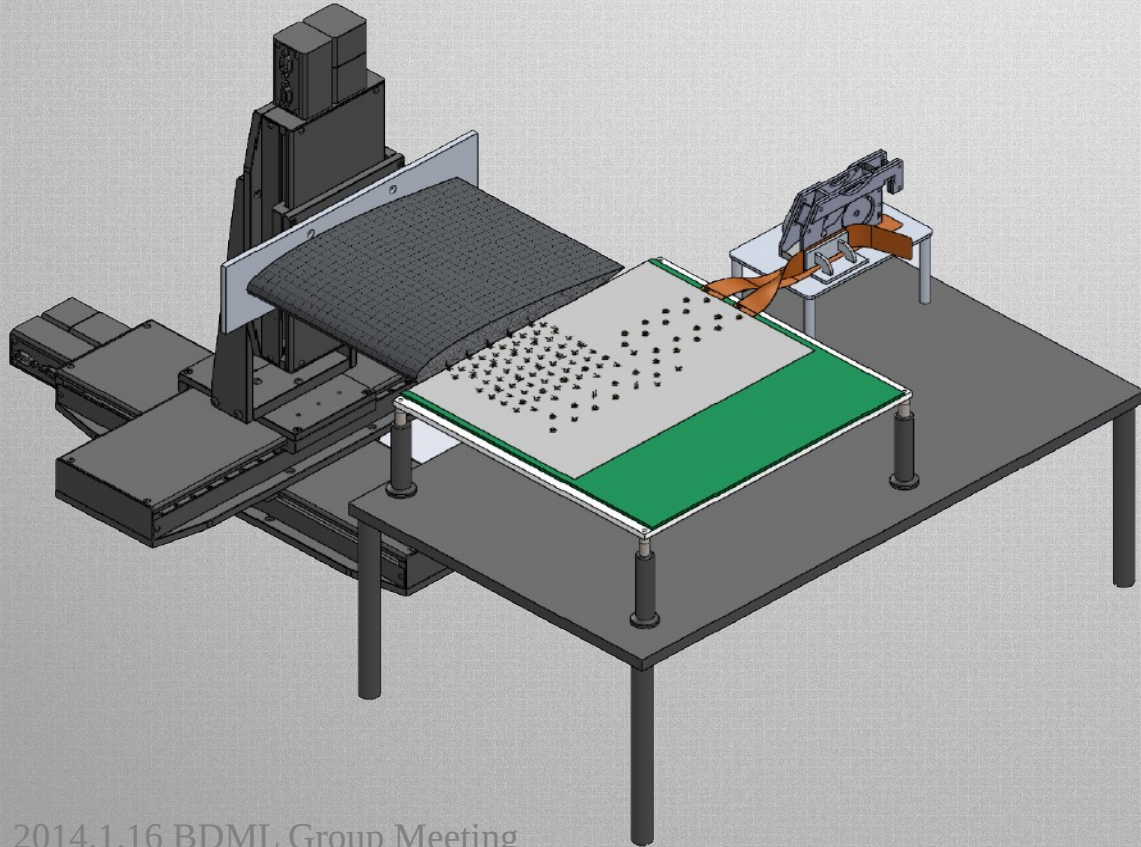


Long-term objective

- Micro robots, macro products
- Parallel manufacturing
- Micro-automation

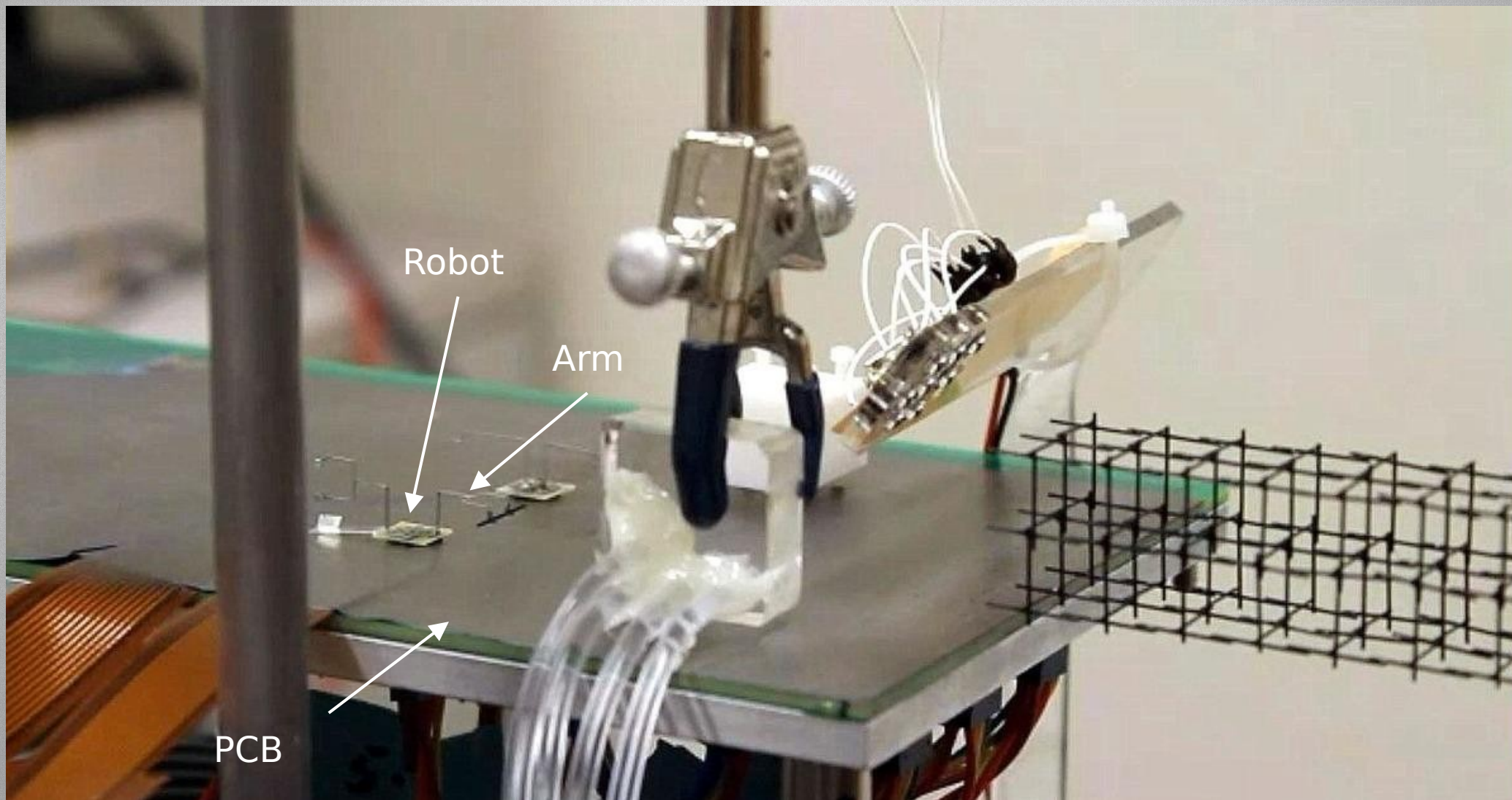


Short-term objective



- Moving stage, stationary robots
- Truss structure with skin
- Manufacturing cells

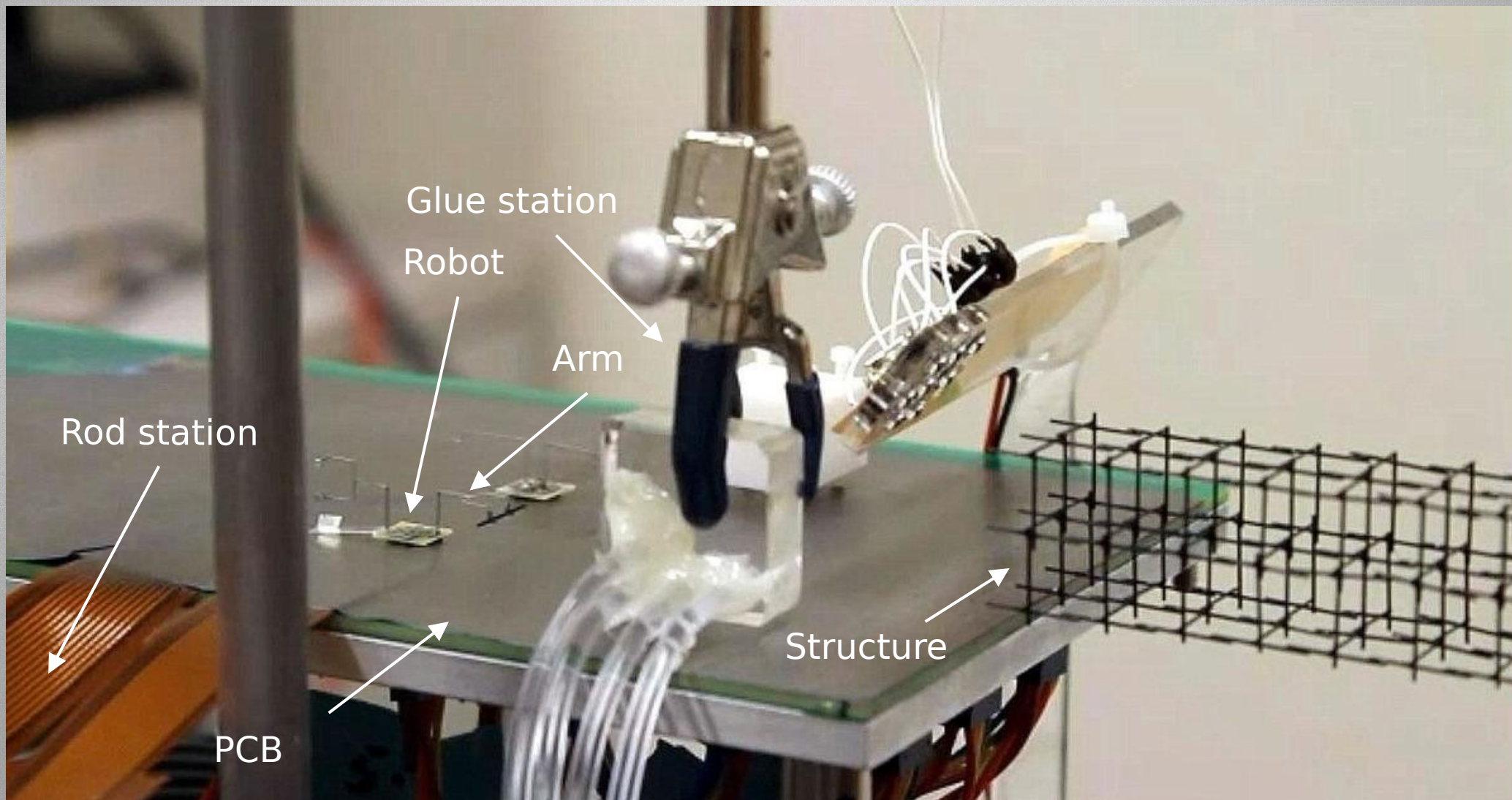
<https://www.youtube.com/watch?v=uL6e3co4Qqc>



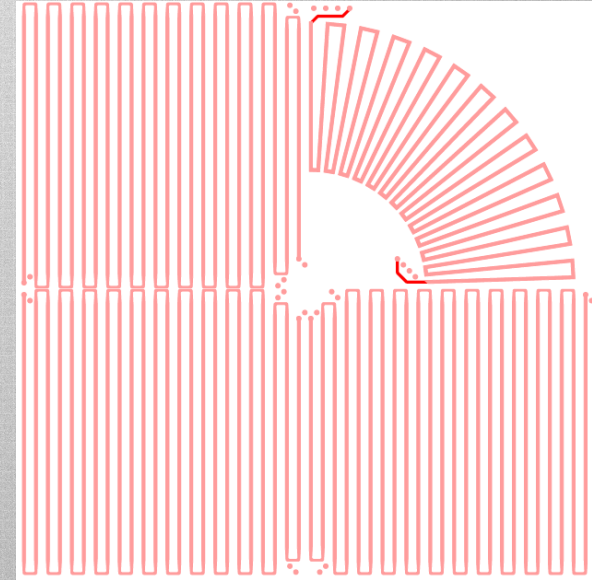
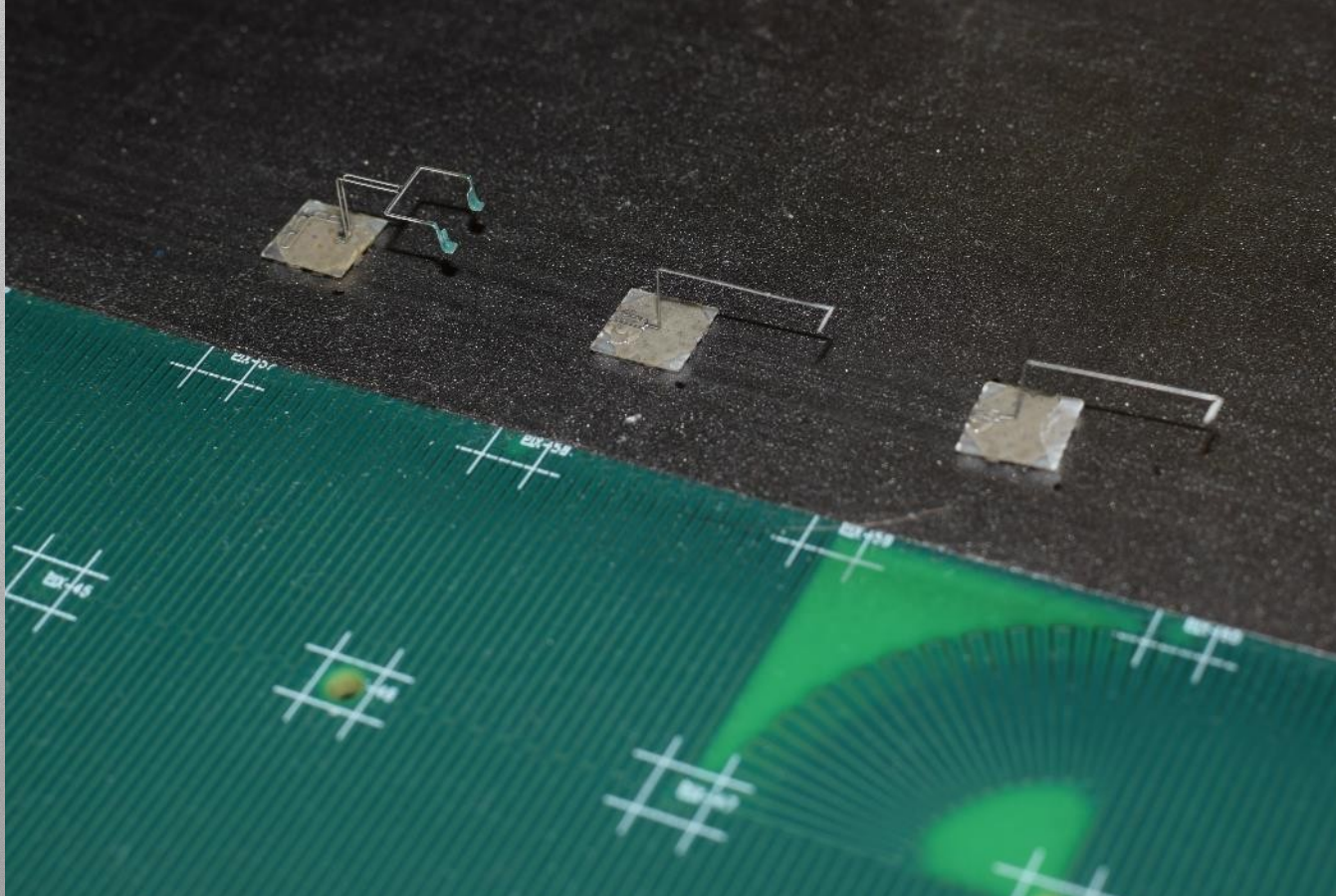
Robot

Arm

PCB

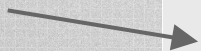


Locomotion mechanism

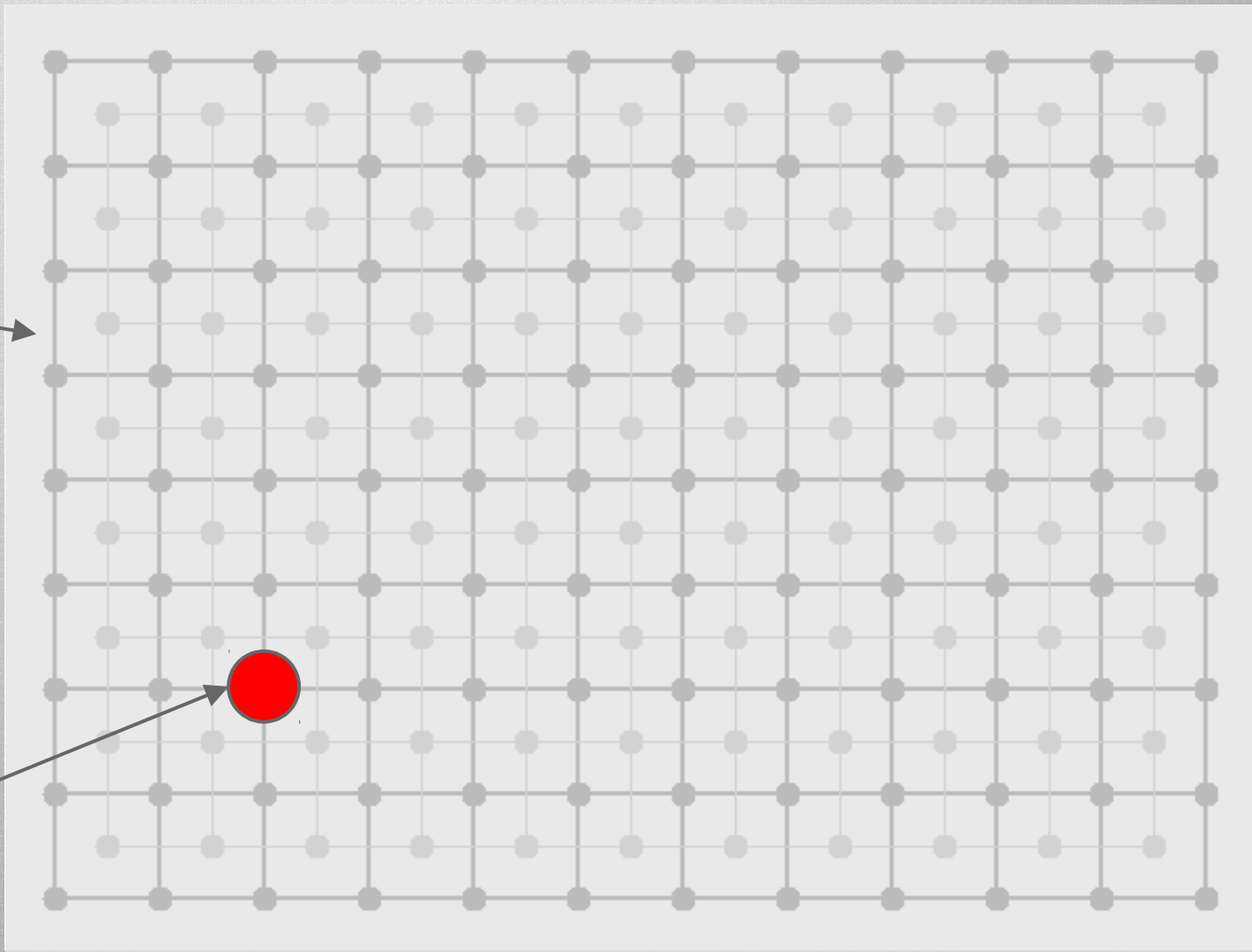
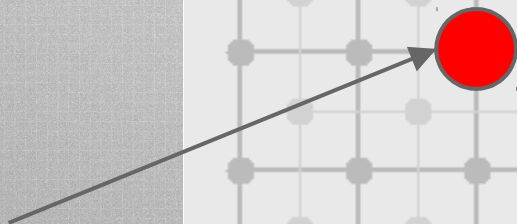


Locomotion mechanism

PCB



“Robot”



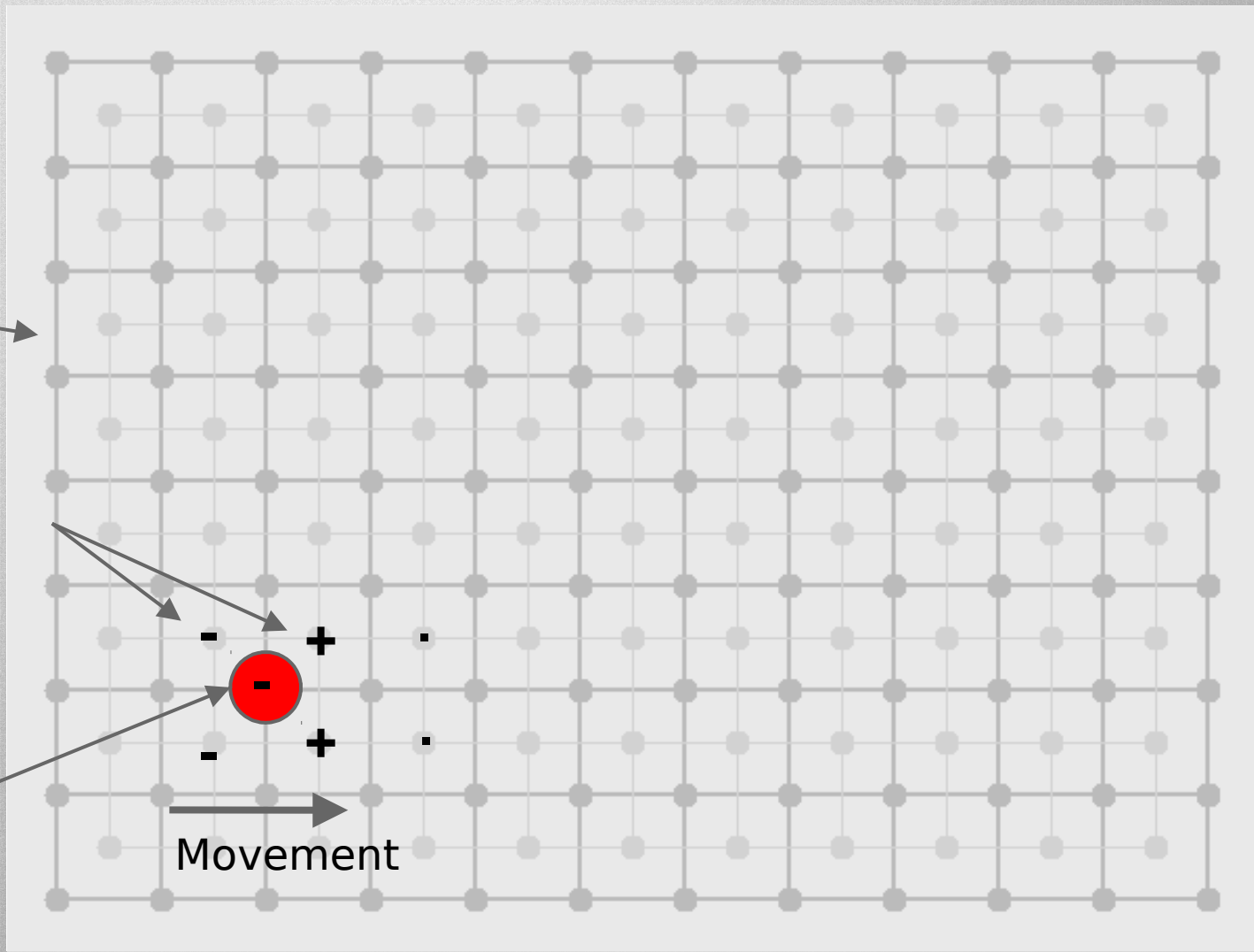
Locomotion mechanism

PCB

Applied magnetic fields

“Robot”

Movement



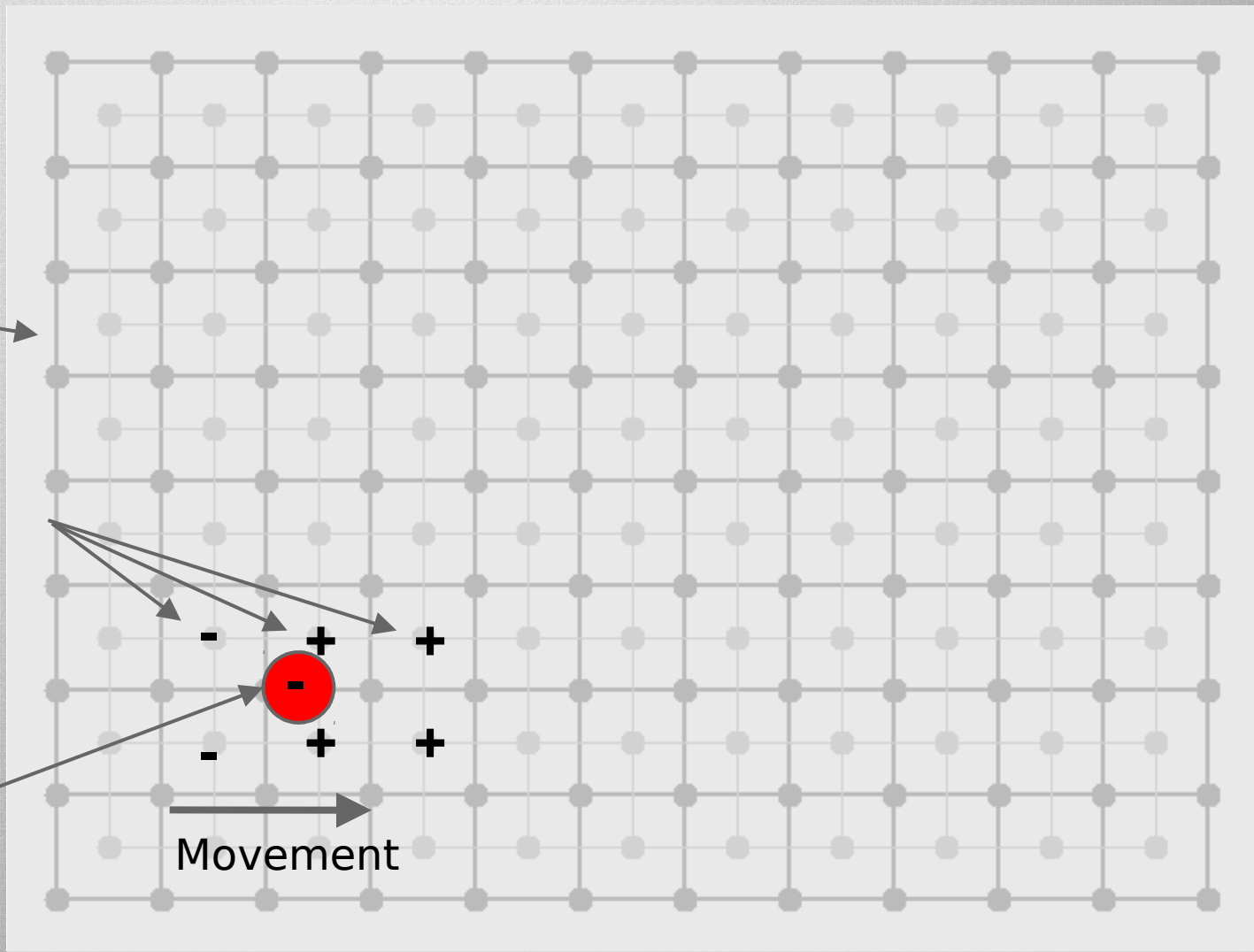
Locomotion mechanism

PCB

Applied magnetic fields

“Robot”

Movement



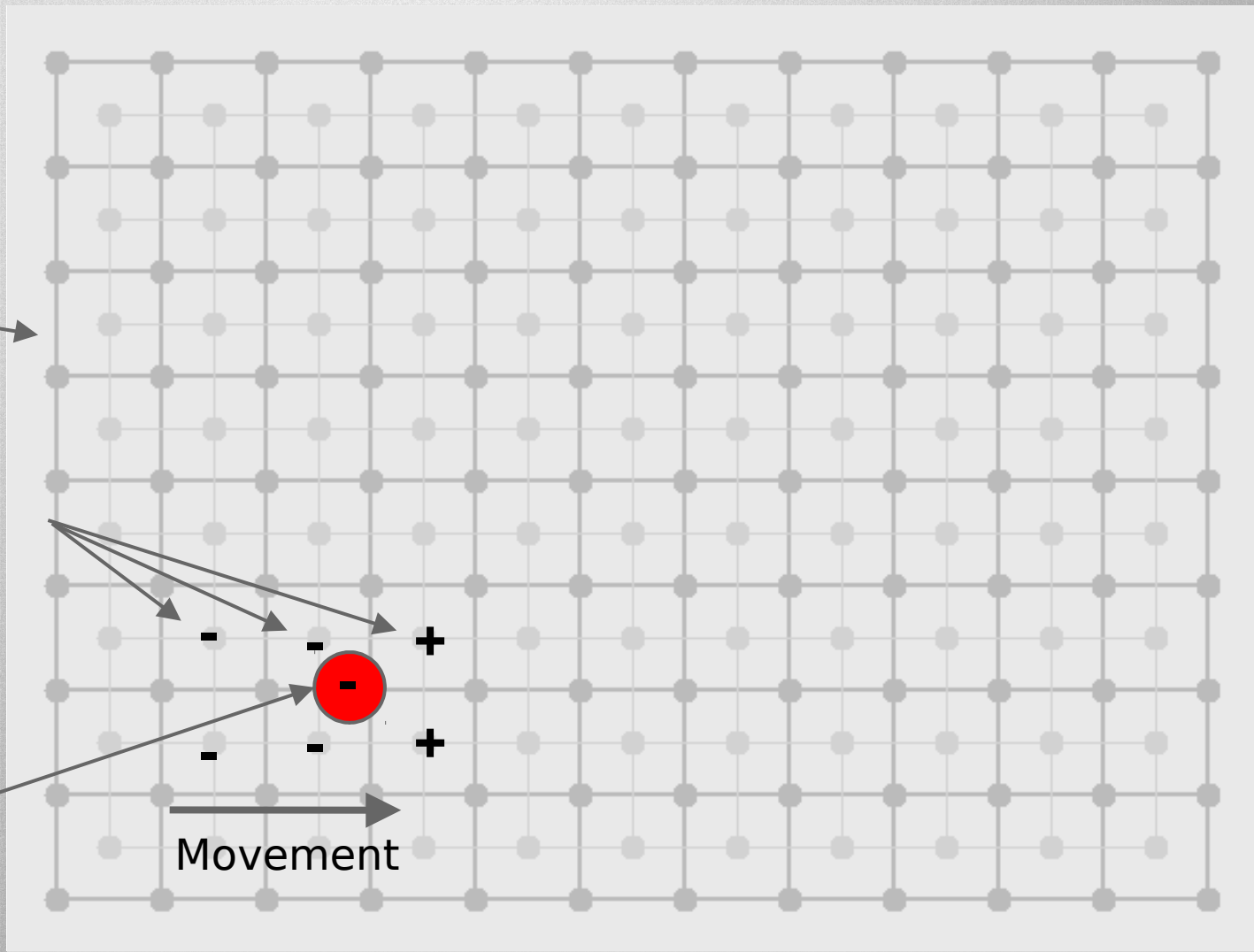
Locomotion mechanism

PCB

Applied magnetic fields

“Robot”

Movement



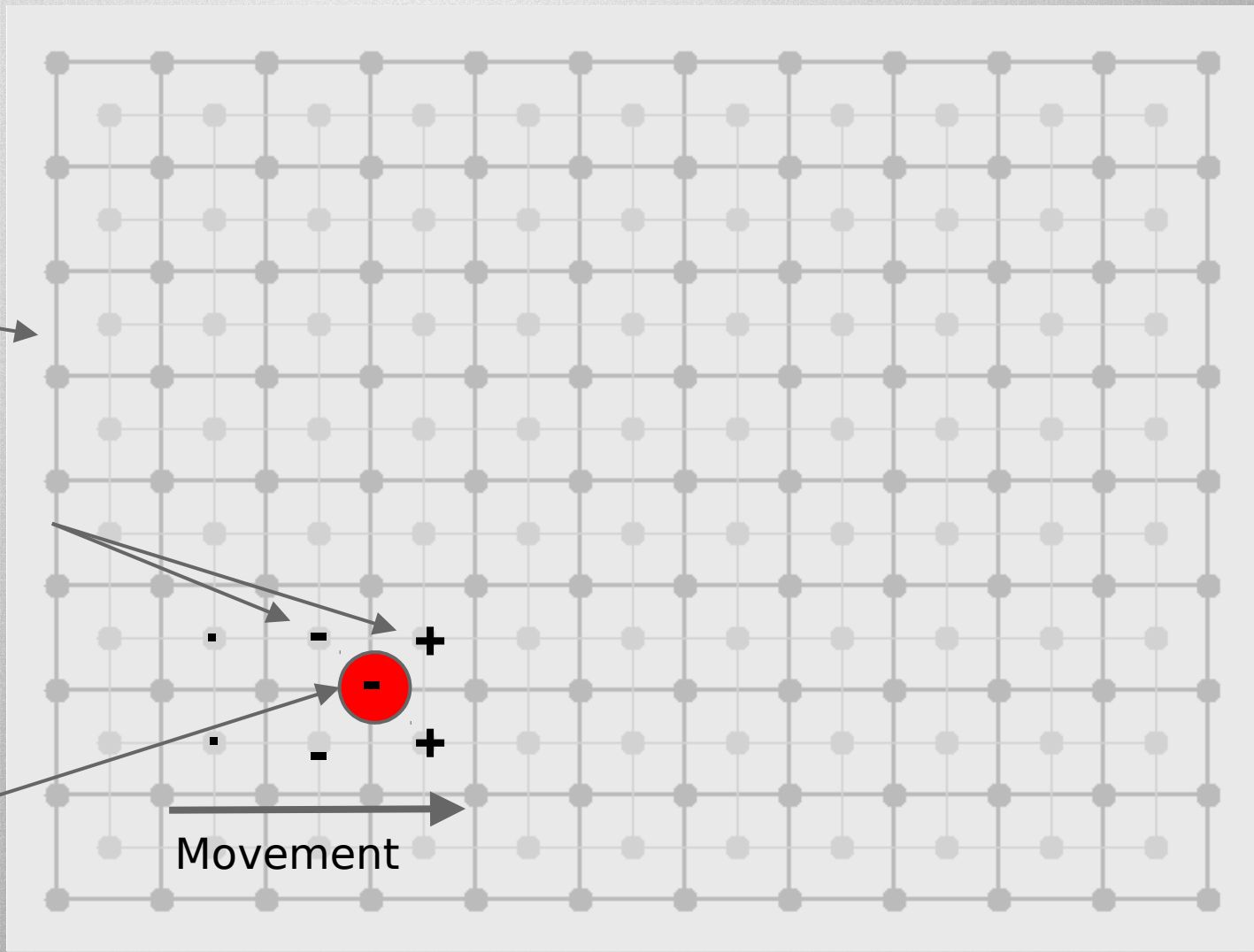
Locomotion mechanism

PCB

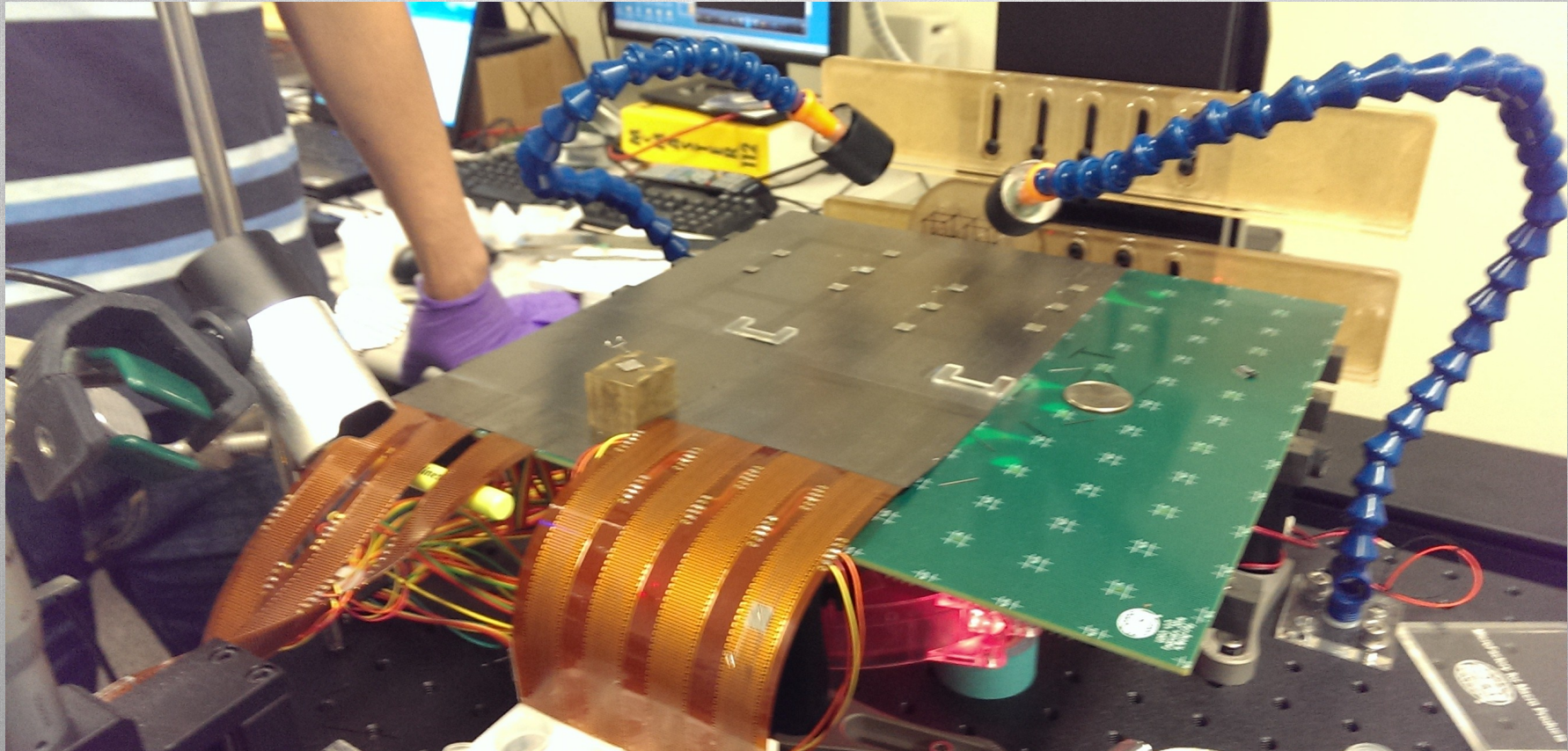
Applied magnetic fields

“Robot”

Movement



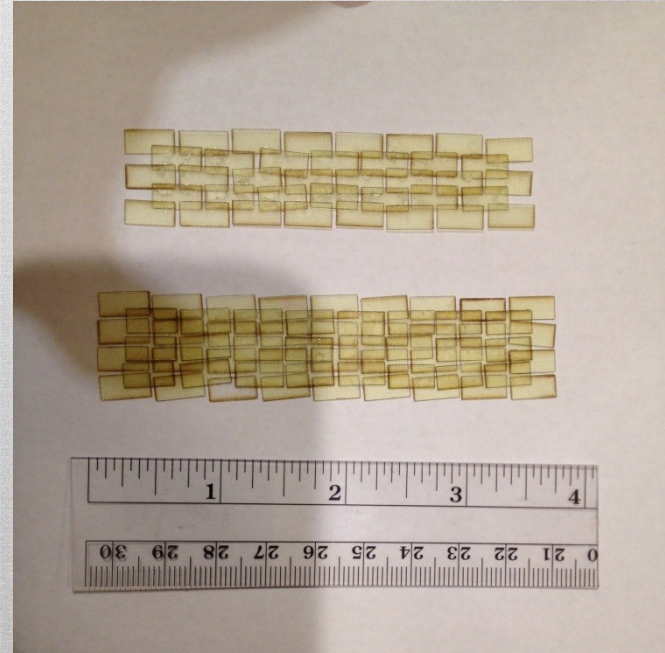
Current Setup



Target Structures

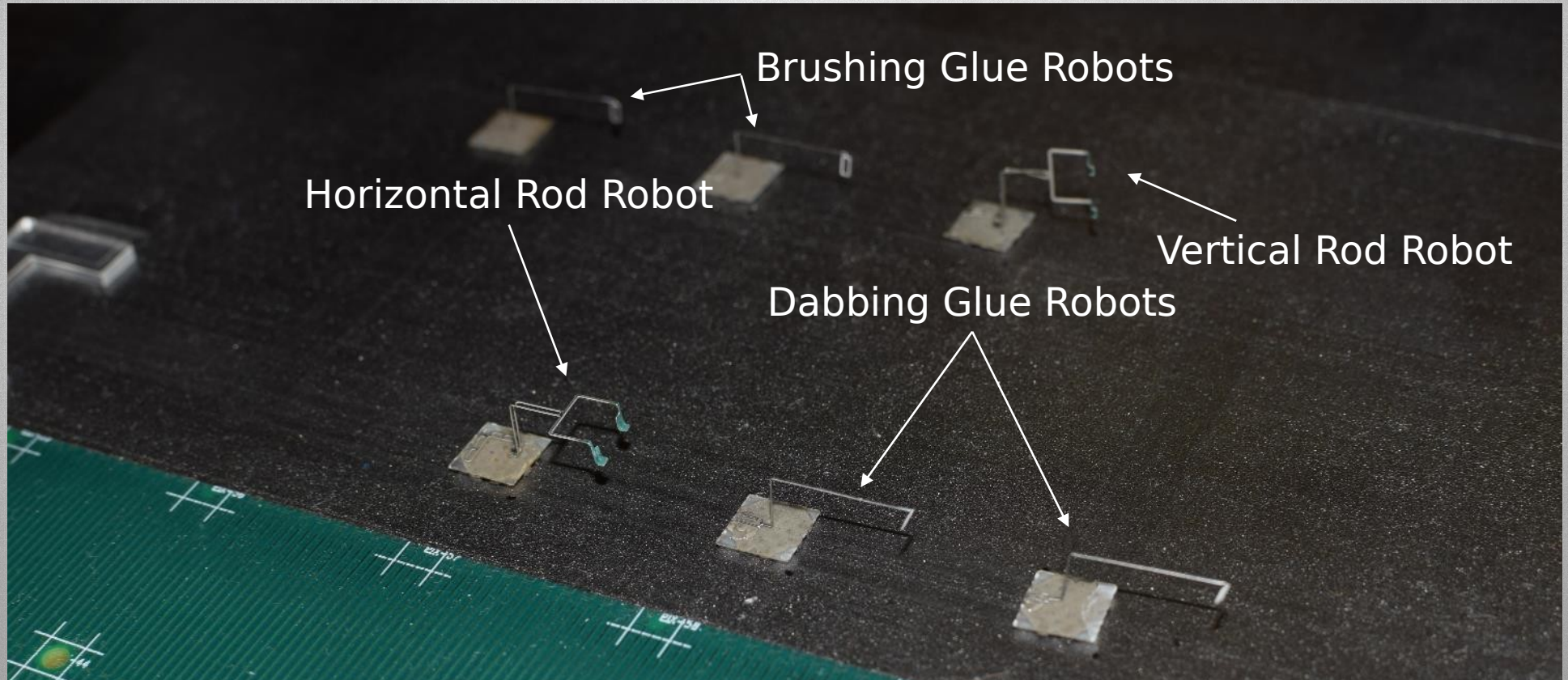


Carbon Fiber Truss

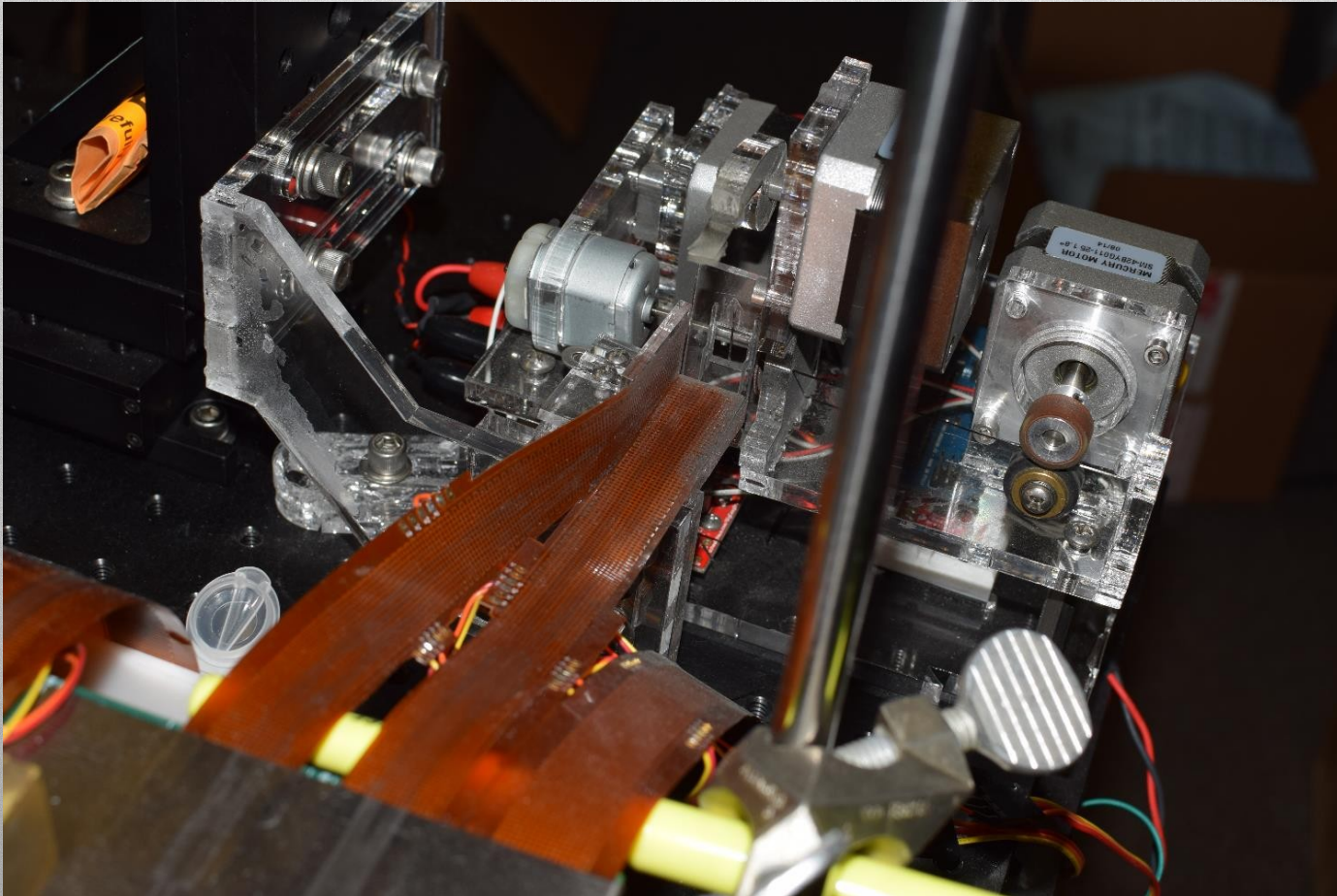


Platelet Skin

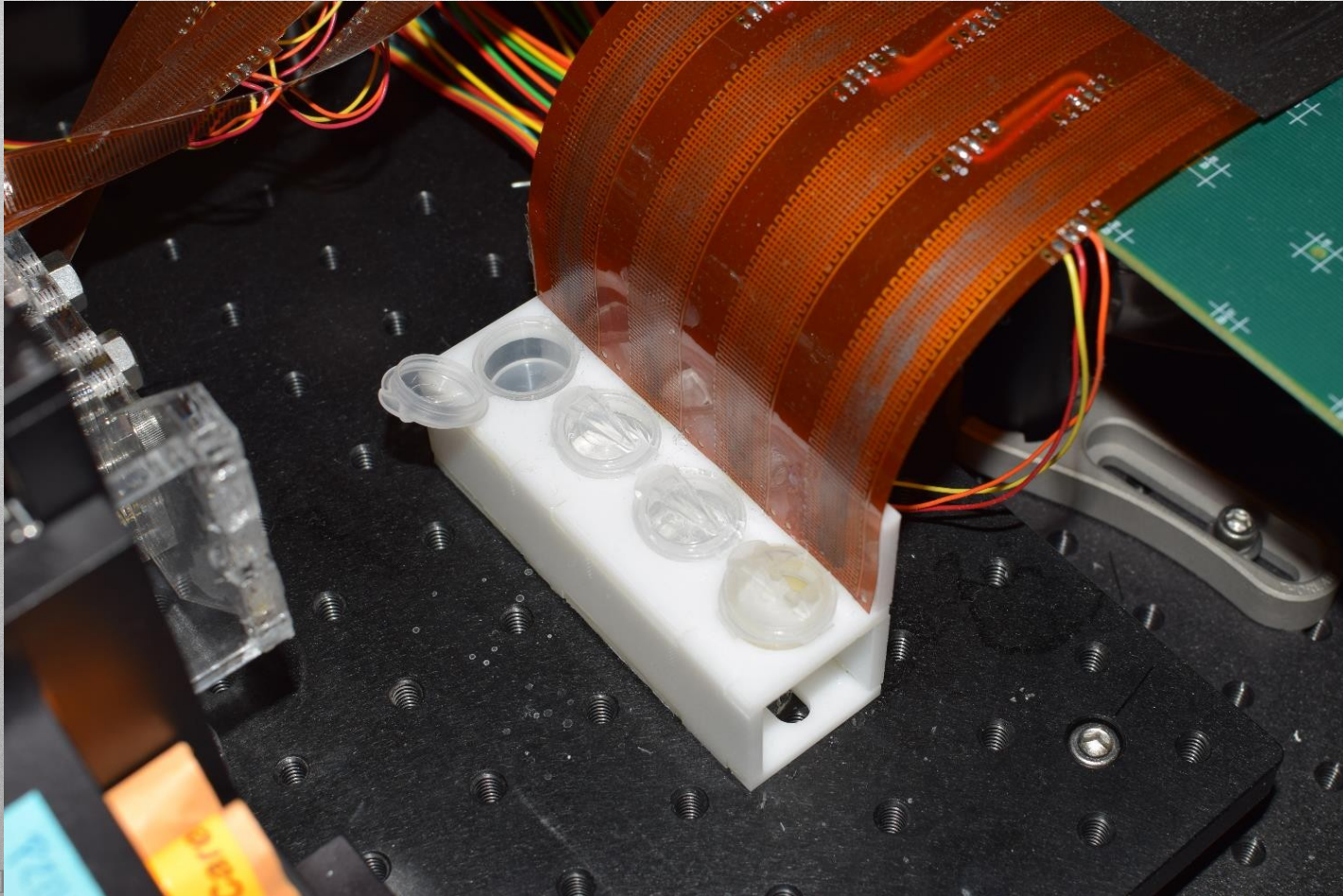
Robot Types



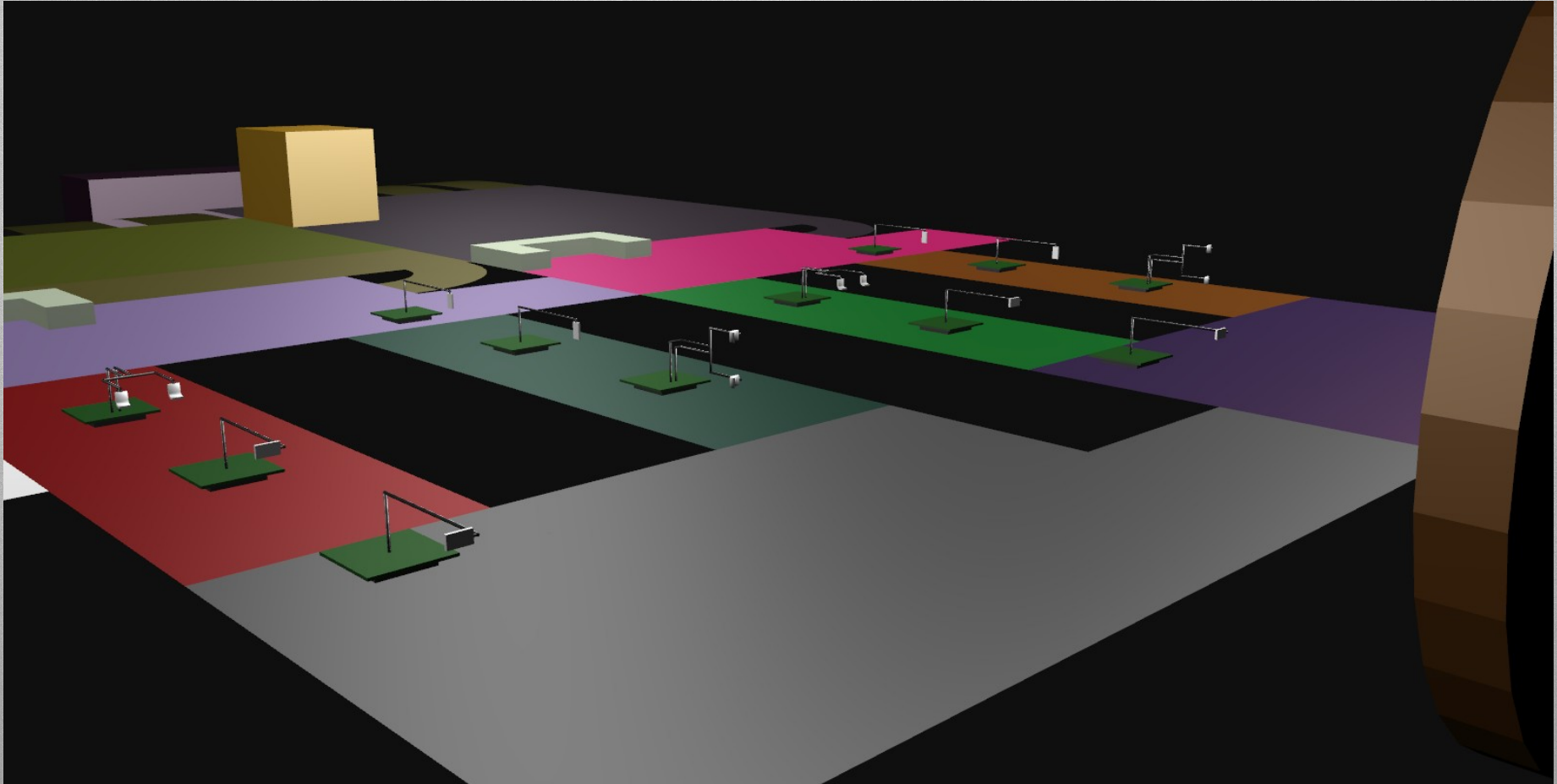
Rod Feed Stations



Water/Glue/Solvent Wells

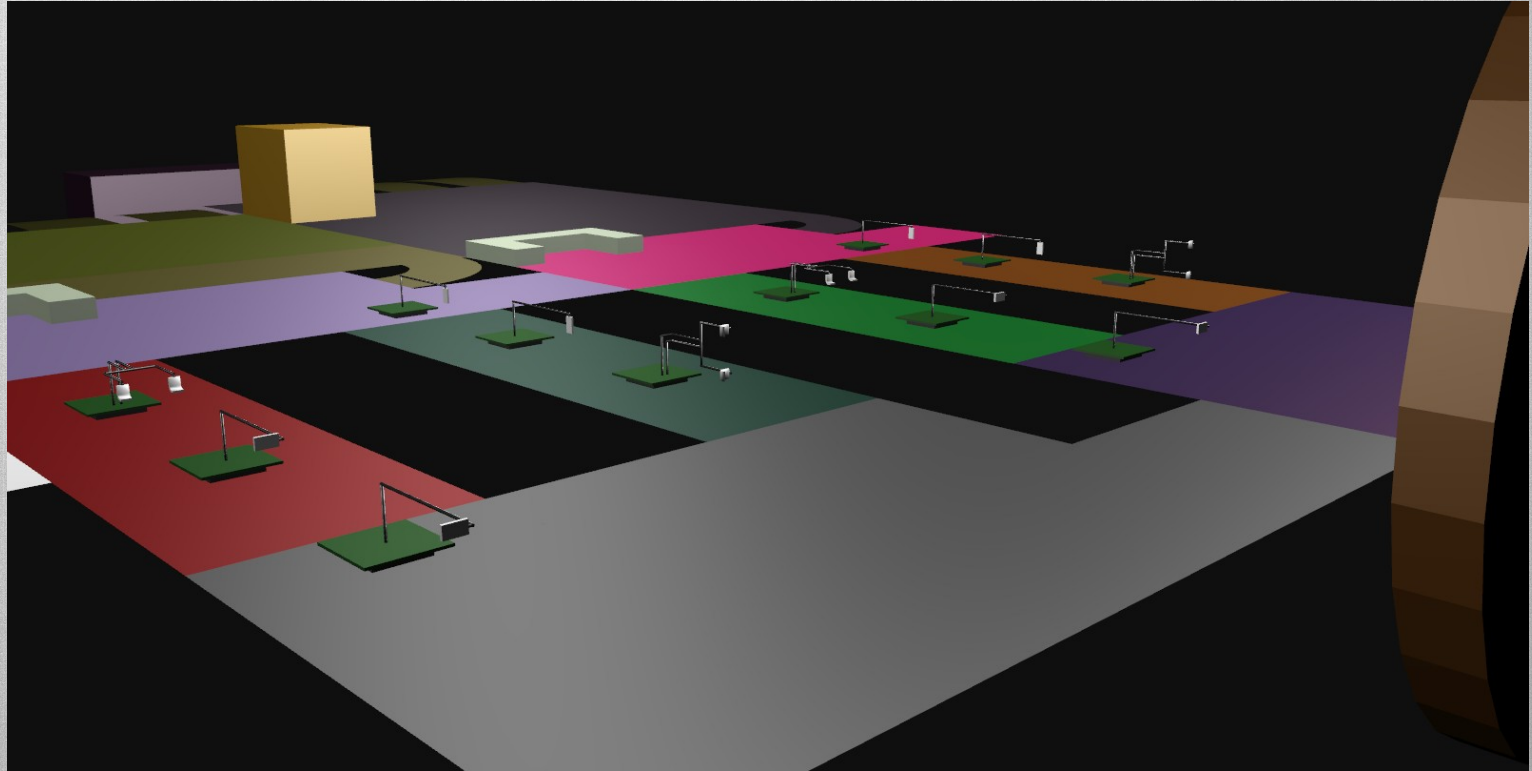


Simulation and Path-Planning Software



Motivation

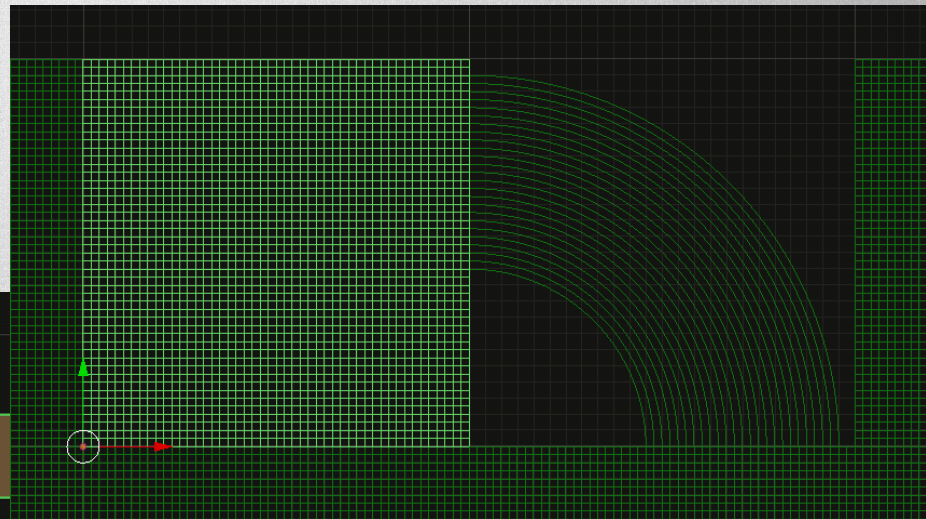
- Reliability
- Iteration
- Automation



Simulation

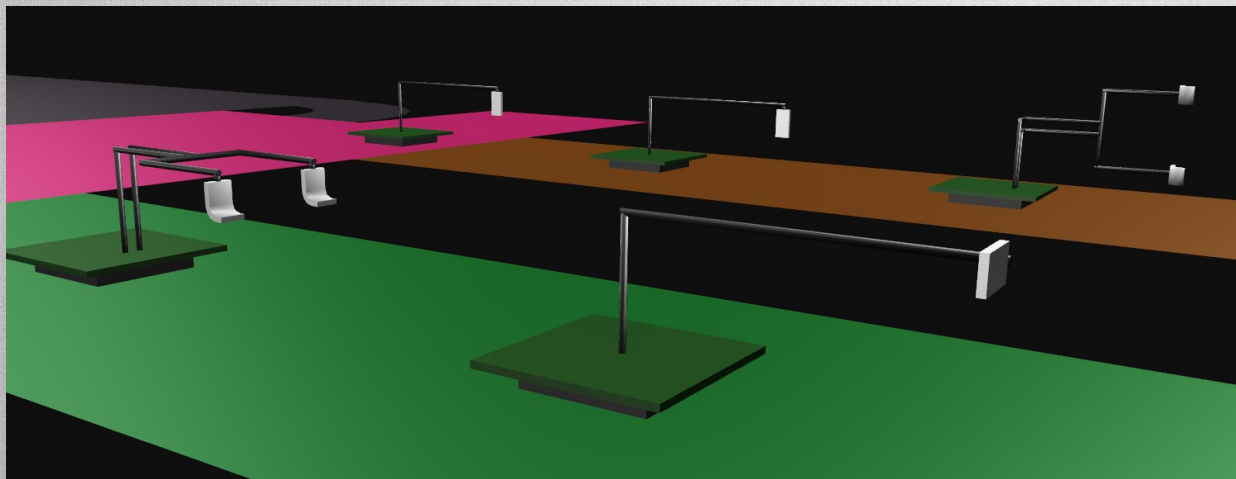
- Written for hardware
- Parser for simulation
- Act as abstraction layer

Modeling the map



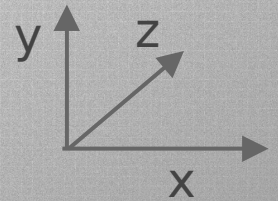
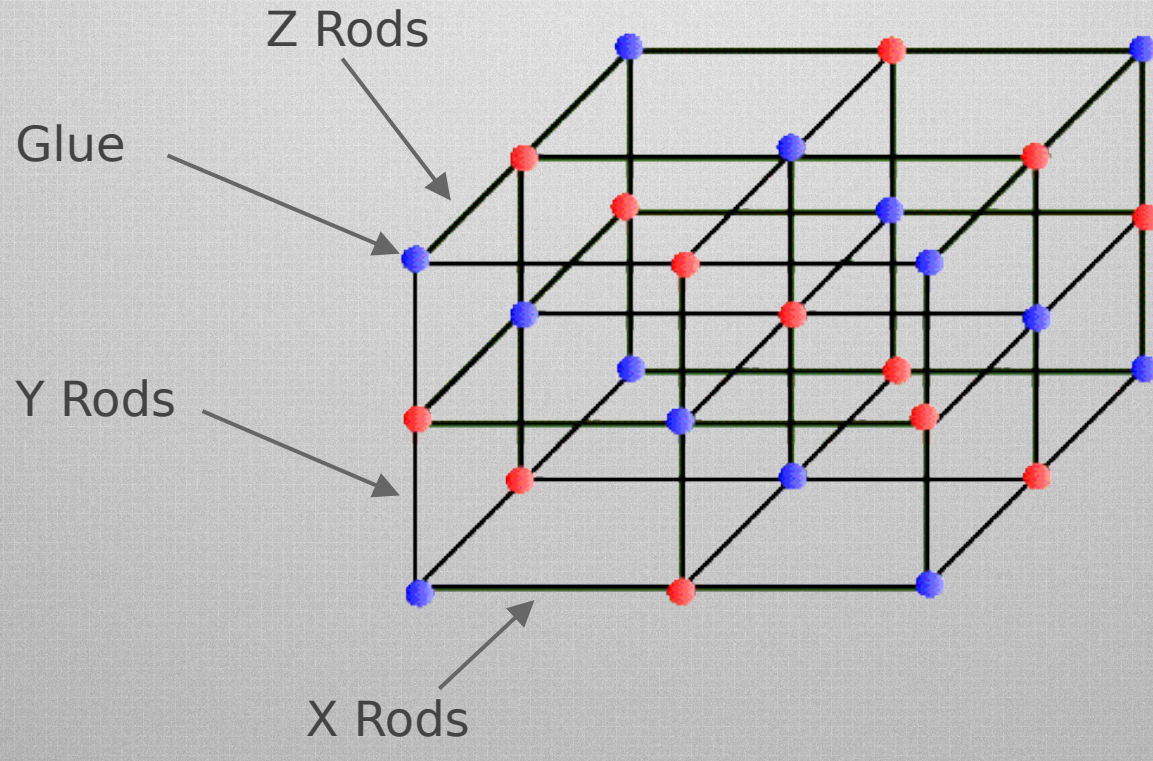
- 0.5 mm steps
- 251k nodes
- 846k edges
- 10"x8" nominal
- Auto-merge

Modeling robot movements

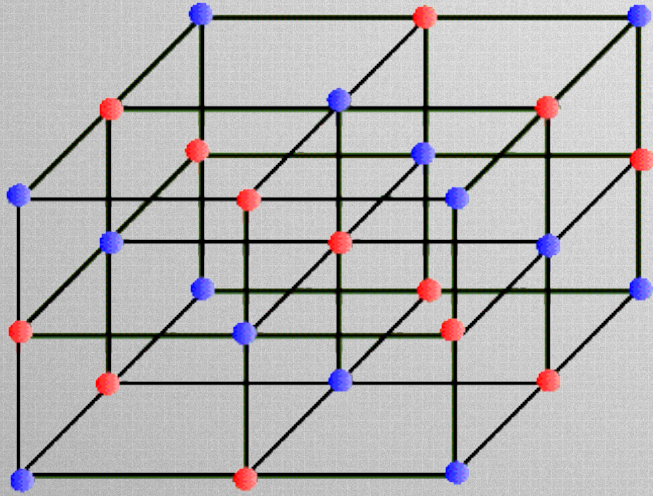


- Labeled edges
 - Zone, direction
- Rotation
- Shortest-path

Modeling the structure



Creating Jobs



**Target
Structure**



Job 1: Y Rod from (0, 0) to (0, 1)
Job 2: X Rod from (0, 0) to (1, 0)
Job 3: Y Rod from (1, 0) to (1, 1)
...

Job Queue

Task Allocation

Job 1: Y Rod from (0, 0) to (0, 1)

Job 2: X Rod from (0, 0) to (1, 0)

Job 3: Y Rod from (1, 0) to (1, 1)

...



Step 1: Get an available Y bot

Step 2: Get a rod from a Rod Station

Step 3: Get glue from a Glue Station

Step 4: Drop off the rod and apply glue

Task-level routines

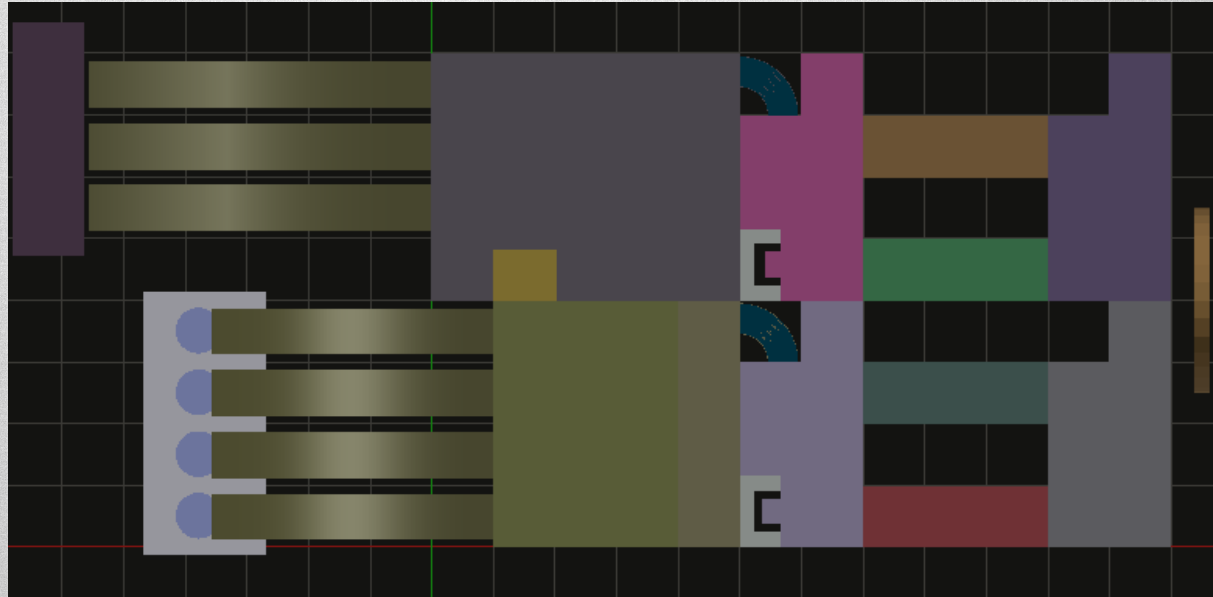
```
1  #First step is to get glue
2  <units1&2_getglue_v
3  <alignall
4
5  #buffer advance and get rods
6  <units1&2_buffer_advance
7  <alignall
8  <units1&2_gettree
9
10 #buffer advance and put glue
11 <units1&2_buffer_advance
12 <units1&2_buffer_advance
13
14 rate(80)
15 simscript(unit1_tree_putglue, unit2_tree_putglue)
16
17 #buffer advance and put rod
18 <units1&2_buffer_advance
19 rate(100)
20 simscript(unit1_tree_putrod, unit2_tree_putrod)
```

- Written for hardware
- Parser for simulation
- Act as abstraction layer

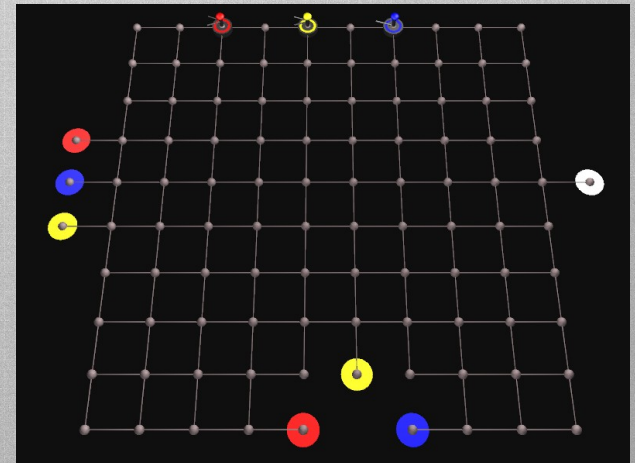
Simulation Goal

- Structure → tasks
- Tasks → routines
- Routines → visualization
- Testbed for iteration, optimization, trajectory generation

Future?



- Forget routines, automate it all
- Non-linear, discontinuous control problem
 - Shortest-path heuristics
 - Controllability constraints



Future?

- Structure makespan
- Map density
- Parallelization



Q & A

Micro-Factories for Smart Manufacturing

Simulation and Path-Planning Platform

