



# COZMO QUBE CONSTRUCTION

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# PROJECT IDEA:

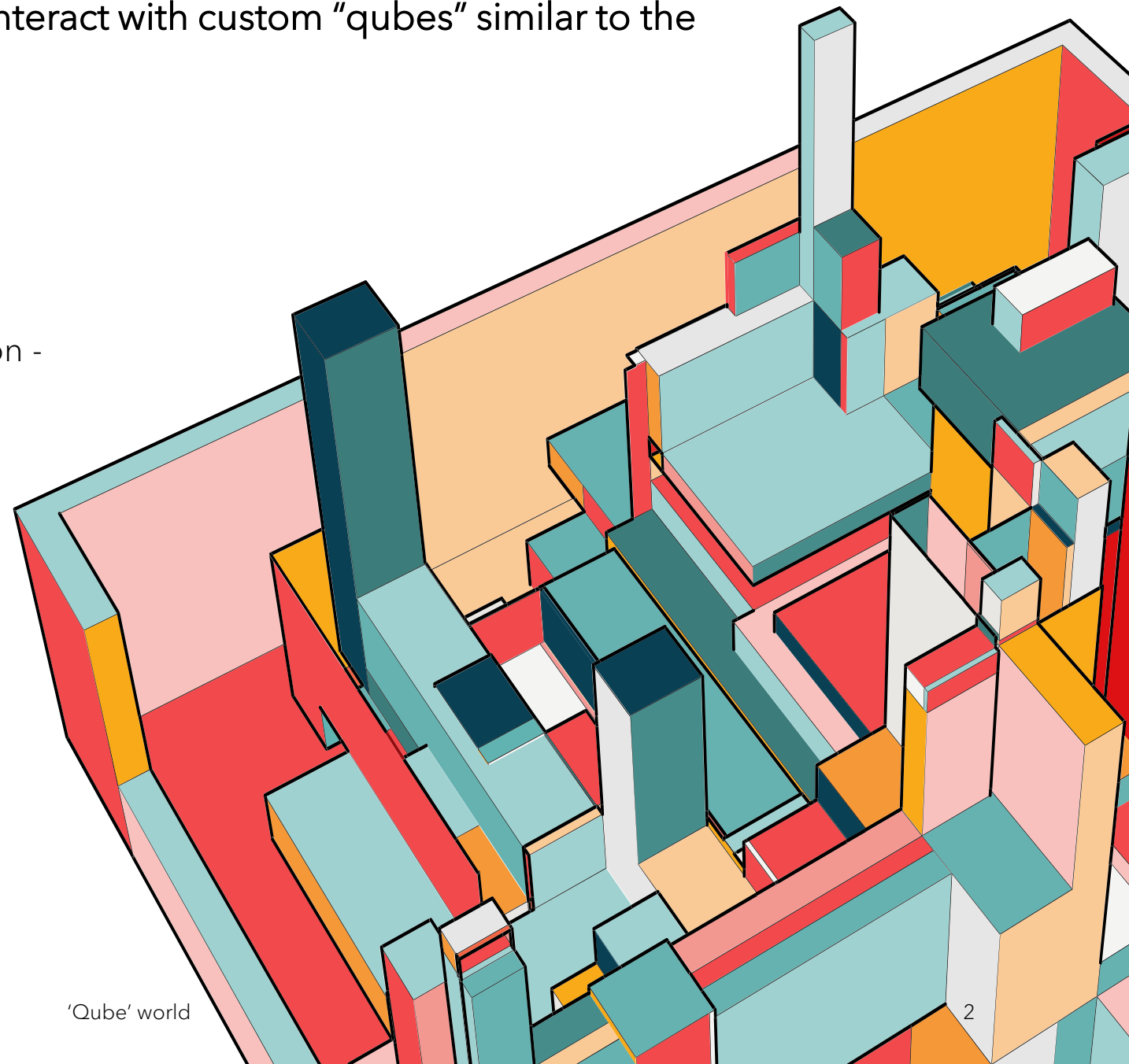
Can cozmo interact with custom "qubes" similar to the light cubes?

Project: Build any 2d structures from magnetic Qubes that Cozmo can interact with similar to the lightcube

State Machine workflow: Qube Detection -  
> Dock Cube -> Placement of qube,  
repeat (safety checks in between)



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# SUBPROBLEMS

## Subproblem: Qube design

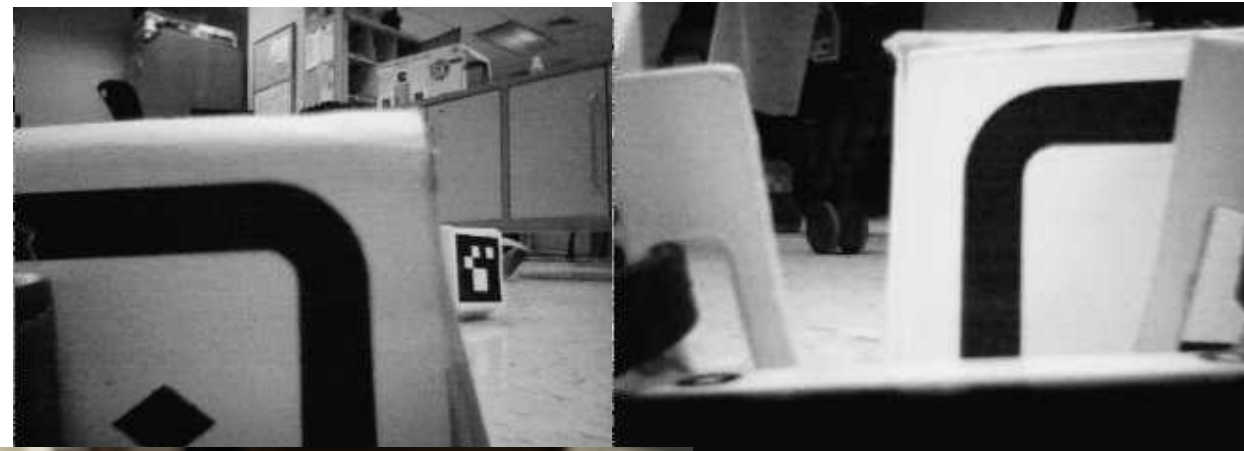
-> Solution: Qubes have magnets in the center at, cozmo has magnets on each lift post; pearson correlation between image after drive to cube and corner of marker to determine success of dock

## Subproblem: Qube macrostructure assembly

->Solution: Qubes alternate magnetic poles; FSM alternates poles during retrieval; represent structure as a "stack" of sequential moves

## Subproblem: Accuracy of Cozmo's SDK object coordinates for the 'Qubes' is lacking

-> Solution: ArUco 'Qubes'!



## Plastic Cubes with Magnets in Center

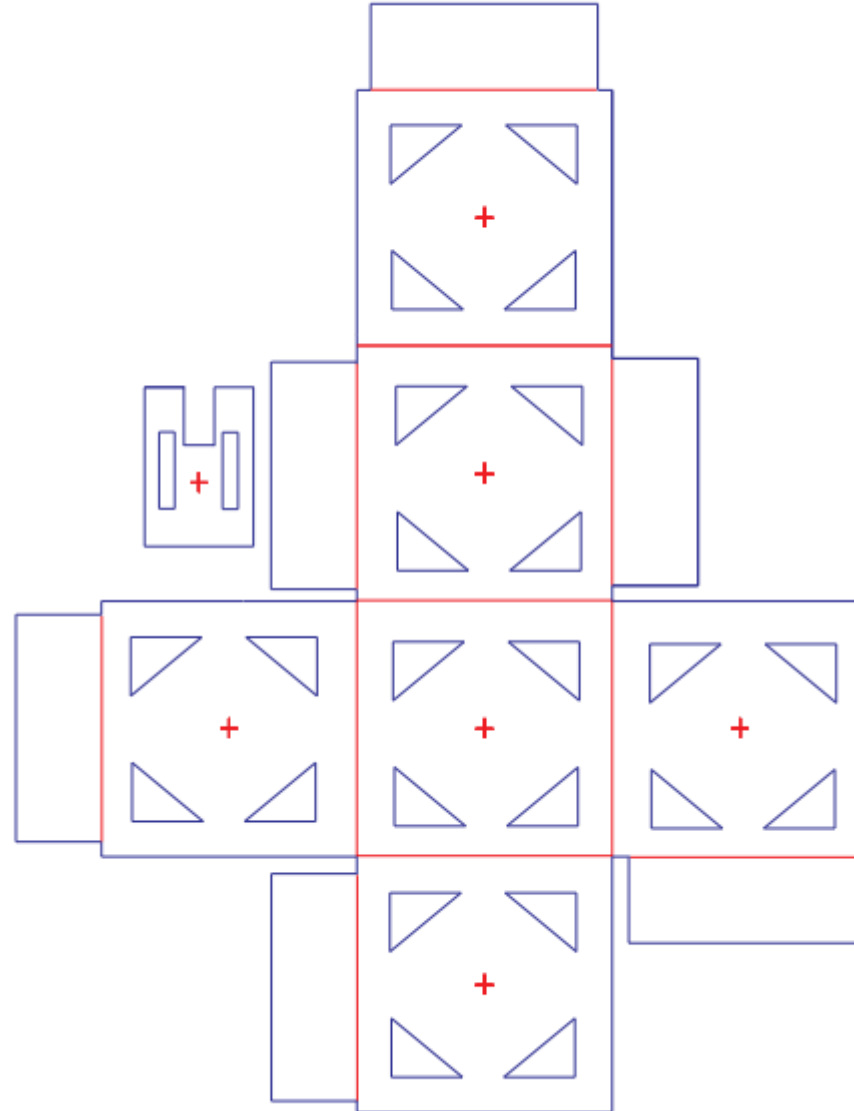
- Qubes alternate poles and cozmo interacts via lift magnetic interaction attachments
- Can be assembled without hot-glue using sticker
- Lightweight design allows easy interaction with cozmo lift magnets and structural integrity of 'Qube' interactions (can actually build structures that stay together!)

## Cozmo SDK gives coordinates

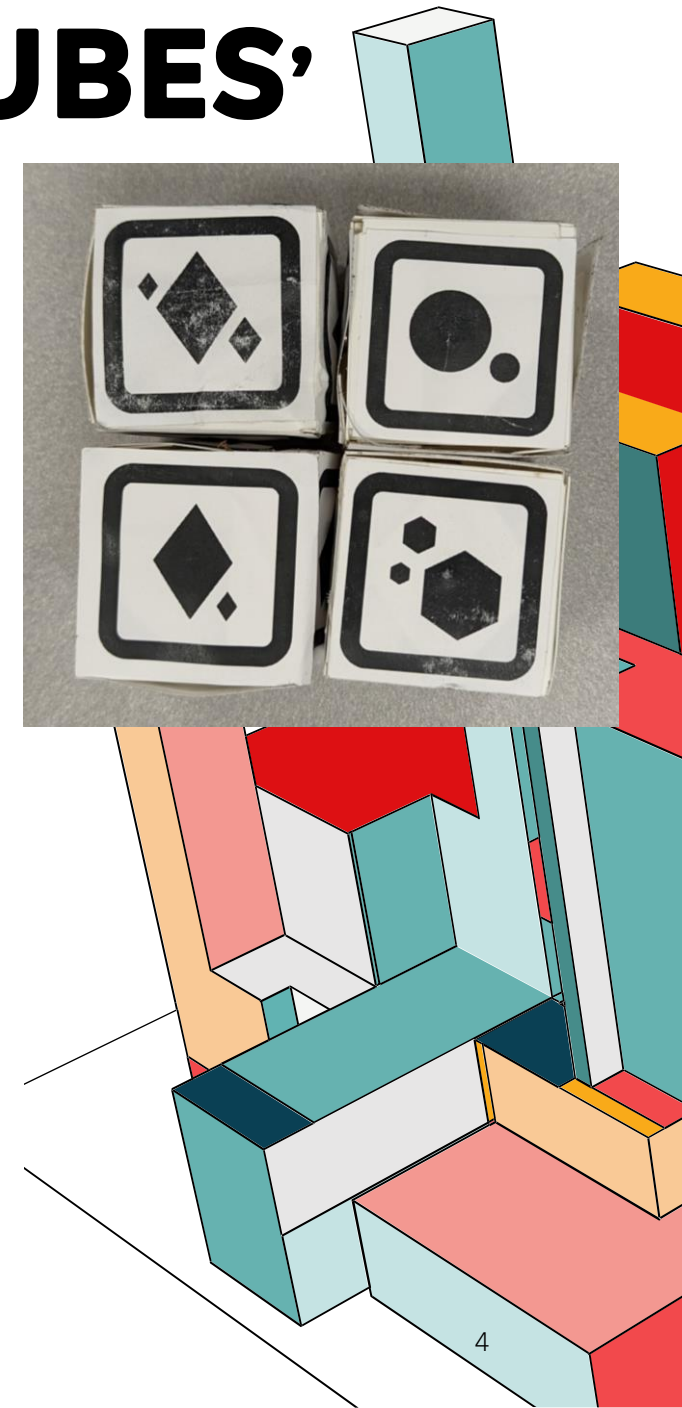
- custom marker object interface is good but inaccurate
- need aruco markers to calibrate location during construction

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# 'QUBES'



'Qube' world



4

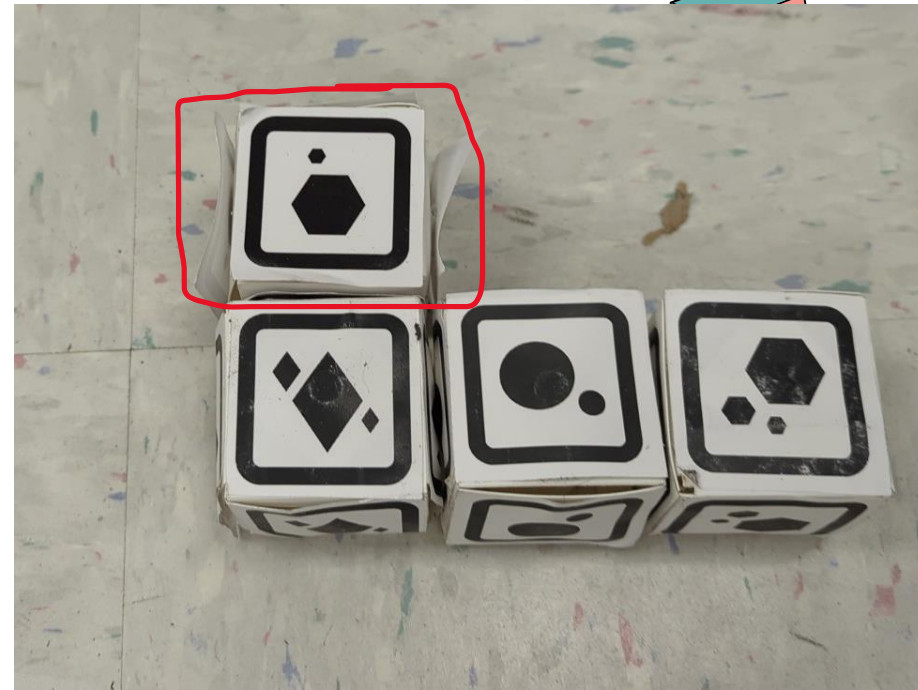


# REPRESENTING THE STRUCTURE

The structure is represented as a “stack”, implemented as a list, of two-tuples (number of qubes, compass direction) with the last element representing the starter ‘qube’.

Implementation currently supports any structure where only one ‘qube’ is connected to one other ‘qube’. Could be expanded to represent multiple ‘qubes’ attached to one ‘qube’, however there are lots of collisions to consider

[(2, 'east'), (1, 'south'), (1, 'starter')]



# ARUCO 'QUBES'

**Can be placed anywhere in the environment to add accuracy to cozmo's sense of location**

ArUco 'qubes' in the environment helped drive 'qubes' to the precise locations of other qubes

**Can be used in any cozmo task to provide better precision in navigating worldmap**

Since these arUco 'Qubes' don't trigger 'collides' events, they can be pushed around so be careful to navigate around them explicitly in the code (run a check for each move that navigates around the aruco qube)

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The 'board' for Qube Construction requires an arUco qube at each corner (300mm from cozmo) and an arUco qube between front side and back side of 'board'





# WHAT THIS MEAN FOR FUTURE COZMO

## More objects to interact with

Quality qubes that can be recreated and offer more diversity to current light cube objects



## Cozmo games: can be used for a physical communication between cozmos

### cozmos

One cozmo can interact with another or instruct action to another cozmo by building some structure

## Build many unique structures

The handling of structures as a list of directional moves can be expanded to build any possible 2d structure of magnetic qubes





# CURRENT LIMITATIONS/IMPLICATIONS OF PROJECT

## Limitations:

### Lots of qubes = Lots of GoalCollides

Navigating the 'board' is a computationally expensive computation and many qubes means many goalcollides pathpose events.

### Takes a long time to assemble

5-10 minutes  $\geq$  3 qube structures

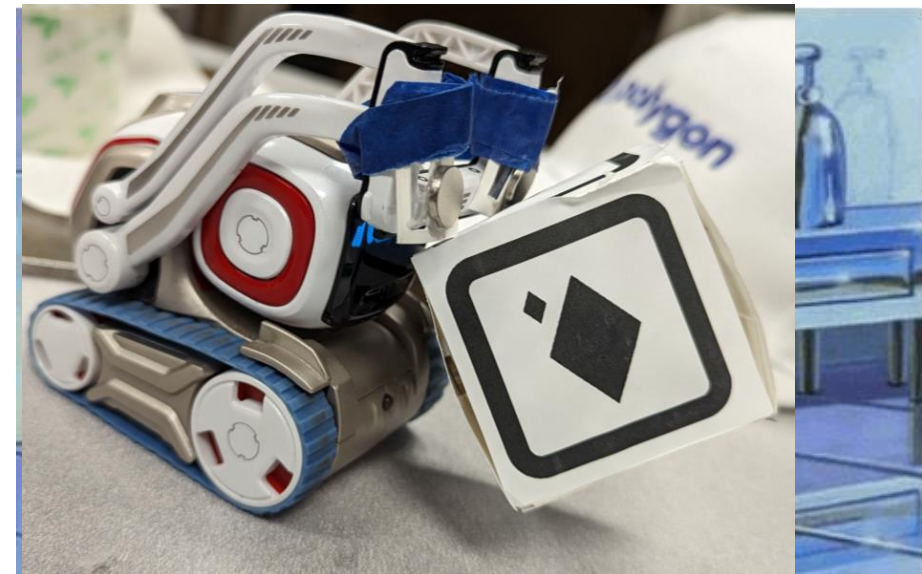
### Can endlessly just tour qubes

Collision events signal Cozmo to slightly move and try again; this can loop, leaving cozmo touring the cubes

## Implications:

### In general: construction robotics

Stack representations of construction structures and reference aruco "qubes" is a meaningful solution to construction problems in robotics; since the moves are sequential this could be applied elsewhere as a methodology for brick-and-mortar construction robots



FUTURE!