# 2D Swarm Assembly of Rigid Objects using Uniform Inputs

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***Abstract*— Imagine hundreds of particles actuated by an external magnetic field to build a component deep inside the human body. If these particles could be small enough to pass through tiny blood vessels, they could be delivered almost anywhere in the body. Though, the tiny size of these particles would limit the amount of force any one particle could exert, large numbers of particles could exert larger forces. These forces could potentially be used to construct objects. Unfortunately, the small size of the particles limits the capabilities of individual particles. This paper considers a subset of this problem. The particles are actuated in 2D by a uniform global external field (e.g. gravitational or magnetic fields), such that they all move in the same direction. This paper provides a controller for multi-part assembly that computes the optimal shortest path for each component for assembly, and steers the swarm to push the component along the path. The algorithm is validated through simulation.**

## I. Introduction

## II. Related Work

pushing control in 2D has a long history (B. Donald, Kevin Lynch, to Shiva)

uniform controls and why

optimal control: dubins car and extentions

## III. Model

## IV. Methods

calculate the shortest path

figure of the 6 candidate Dubins paths for the objects,

calculate collisions, iterate path parameters to search for path

figure of the collisions and the updated path

controller:

figure showing the path, the object, the closest point, the mean and variance of the swarm

## V. Simulation Results

show trace of actual object along assembly

1.) peg-in-hole task (one object is fixed) figure: traces from several starting locations plot: success rate & timing as a function of number of robots plot: success rate & timing as a function of object mass

2.) two-part assembly (two moveable parts) figure: traces from several starting locations plot: success rate & timing as a function of number of robots plot: success rate & timing as a function of object mass

## VI. Conclusion

Extensions to multi-part assembly. Extensions to 3D Hardware implementations

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