

Supplement to Shaping a Swarm With a Shared Control Input Using Boundary Walls and Wall Friction

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Abstract—Includes algorithms and equations too lengthy for main paper, but potentially useful for the community.

I. CALCULATIONS FOR MODELING SWARM AS FLUID IN A SIMPLE PLANAR WORKSPACE

Two workspaces are used, a square and a circular workspace.

A. Square Workspace

This section provides formulas for the mean, variance, covariance and correlation of a very large swarm of robots as they move inside a square workplace under the influence of gravity pointing in the direction β . The swarm is large, but the robots are small in comparison, and together cover an area of constant volume A . Under a global input such as gravity, they flow like water, moving to a side of the workplace and forming a polygonal shape. The workspace is

The range of possible angles for the global input angle β is $[0, 2\pi)$. In this range of angles, the swarm assumes eight different polygonal shapes. The shapes alternate between triangles and trapezoids when the area $A < 1/2$, and alternate between squares with one corner removed and trapezoids when $A > 1/2$.

SquarePlotPositions.pdf

B. Circle Workspace

II. ALGORITHM FOR GENERATING DESIRED y SPACING BETWEEN TWO ROBOTS USING WALL FRICTION

Algorithm 1 GenerateDesired y -spacing(s_1, s_2, e_1, e_2, L)

Require: Knowledge of starting (s_1, s_2) and ending (e_1, e_2) positions of two robots. $(0, 0)$ is bottom corner, s_1 is rightmost robot, L is length of the walls. Current position of the robots are (r_1, r_2) .

Ensure: $r_{1x} - r_{2x} \equiv s_{1x} - s_{2x}$

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1:  $\Delta s_y \leftarrow s_{1y} - s_{2y}$ 
2:  $\Delta e_y \leftarrow e_{1y} - e_{2y}$ 
3:  $r_1 \leftarrow s_1, r_2 \leftarrow s_2$ 
4: if  $\Delta e_y < 0$  then
5:    $m \leftarrow (L - \max(r_{1y}, r_{2y}), 0)$   $\triangleright$  Move to top wall
6: else
7:    $m \leftarrow (-\min(r_{1y}, r_{2y}), 0)$   $\triangleright$  Move to bottom wall
8: end if
9:  $m \leftarrow m + (0, -\min(r_{1x}, r_{2x}))$   $\triangleright$  Move to left
10:  $r_1 \leftarrow r_1 + m, r_2 \leftarrow r_2 + m$   $\triangleright$  Apply move
11: if  $\Delta e_y - (r_{1y} - r_{2y}) > 0$  then
12:    $m \leftarrow (\min(|\Delta e_y - \Delta s_y|, L - r_{1y}), 0)$   $\triangleright$  Move top
13: else
14:    $m \leftarrow (-\min(|\Delta e_y - \Delta s_y|, r_{1y}), 0)$   $\triangleright$  Move bottom
15: end if
16:  $m \leftarrow m + (0, \epsilon)$   $\triangleright$  Move right
17:  $r_1 \leftarrow r_1 + m, r_2 \leftarrow r_2 + m$   $\triangleright$  Apply move
18:  $\Delta r_y = r_{1y} - r_{2y}$ 
19: if  $\Delta r_y \equiv \Delta e_y$  then
20:    $m \leftarrow (e_{1x} - r_{1x}, e_{1y} - r_{1y})$ 
21:    $r_1 \leftarrow r_1 + m, r_2 \leftarrow r_2 + m$   $\triangleright$  Apply move
22:   return  $(r_1, r_2)$ 
23: else
24:   return GenerateDesired $y$ -spacing( $r_1, r_2, e_1, e_2, L$ )
25: end if

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Fig. 1. A swarm in a