INTRODUCTION
We propose a navigation system for mobile robots in pedestrian-rich sidewalk environments. We developed a group surfing method which imitates pedestrian behavior to support sidewalk navigation in a safe and socially-compliant manner. The proposed system is demonstrated and evaluated in simulation, along with a live demonstration.

SYSTEM
- We consider package delivery as our example task, where the user specifies a delivery destination through a graphical user interface.
- Using the Google Maps API, a list of intermediate GPS waypoints are generated.
- The sidewalk navigation module moves the robot towards the next waypoint using either group surfing or curb following.

GROUP SURFING
The group surfing algorithm takes advantage of natural pedestrian behaviors through imitation. Such behaviors include: walking in lanes, avoiding collisions with other pedestrians or obstacles, waiting at intersections to cross, and not walking into traffic.

LOCAL NAVIGATION AND COLLISION
For local navigation we used the Socially-Aware Collision Avoidance with Deep Reinforcement Learning (SA-CADRL) package. We did not train the policy ourselves, but used the results made publicly available[1]. The SA-CADRL policy, \( S_r \rightarrow a_t \), maps the robot’s state and observations to a velocity control command.

The reinforcement training process induces social awareness through social reward functions, e.g., staying to the right and passing on the left.

DEMONSTRATIONS AND RESULTS
In a simulated sidewalk environment populated with pedestrians, we compared the paths taken by a robot using our system \( (r_{sim}) \), a simulated pedestrian \( (p_{sim}) \), and the shortest possible path along the sidewalk \( (s_{sim}) \).

<table>
<thead>
<tr>
<th></th>
<th>Directional Hausdorff</th>
<th>Average Hausdorff</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r_{path} )</td>
<td>1.9661</td>
<td>0.4726</td>
</tr>
<tr>
<td>( s_{path} )</td>
<td>2.3606</td>
<td>1.2195</td>
</tr>
</tbody>
</table>

Table 1. Comparison of directional Hausdorff distance and average Hausdorff distance between the path taken by a pedestrian and the path taken by the robot, simulated pedestrian, and the shortest possible path along the sidewalk.

As a proof of concept, we implemented our group surfing method in the Powerbot and tested navigation on the same route that the simulated world was modeled after.

FUTURE WORK
- Further testing with different group sizes and sidewalk types to support generalizability of our method.
- The SA-CADRL is trained with simulated pedestrians; using real sidewalk pedestrian data may improve performance.
- Improve selection criteria for the group surfing algorithm.
- Interview external observers and pedestrians to gauge if the system produces socially acceptable behavior.