Projecting Robot Navigation Paths: Hardware and Software for Projected AR

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HRI 2022 – Mar 8, 2022

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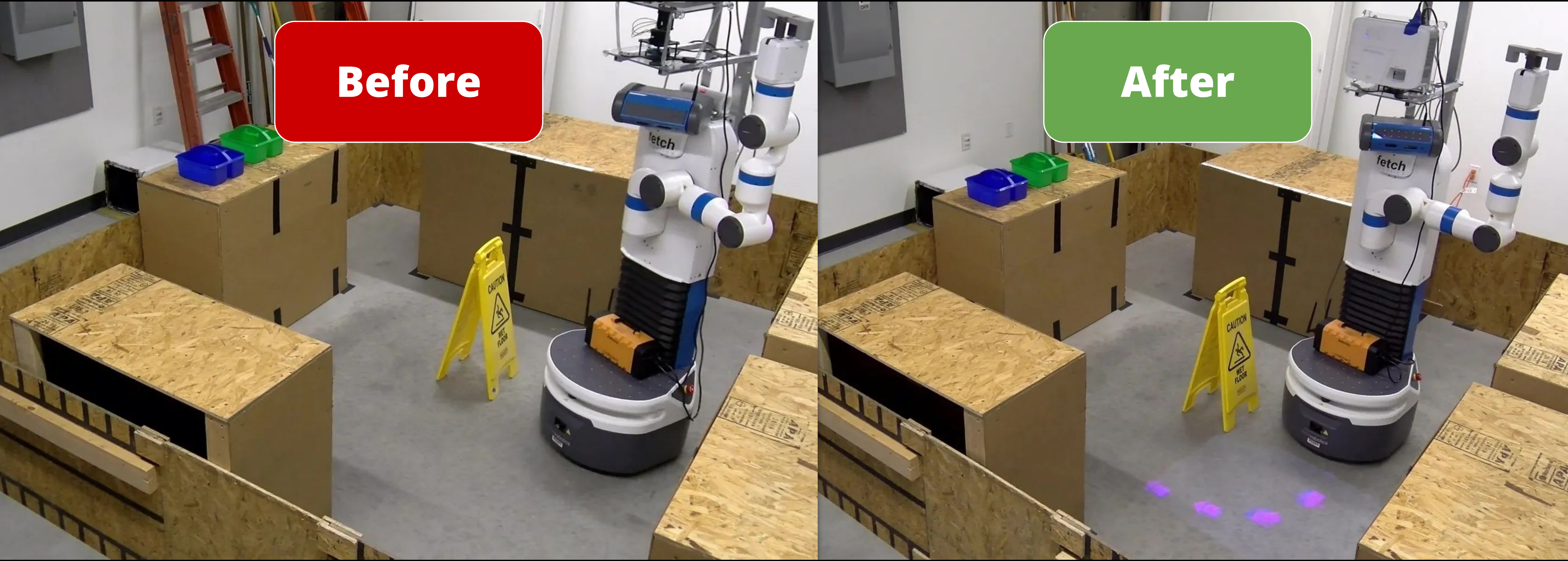
Motivation: Where Are They Going?

Zhao Han, Jenna Parrillo, Alexander Wilkinson, Holly A. Yanco, and Tom Williams, "**Projecting Robot Navigation Paths: Hardware and Software for Projected AR**", *Short Contribution, 2022 ACM/IEEE International Conference on Human-Robot Interaction*. bit.ly/hri22

Projecting Robot Navigation Paths



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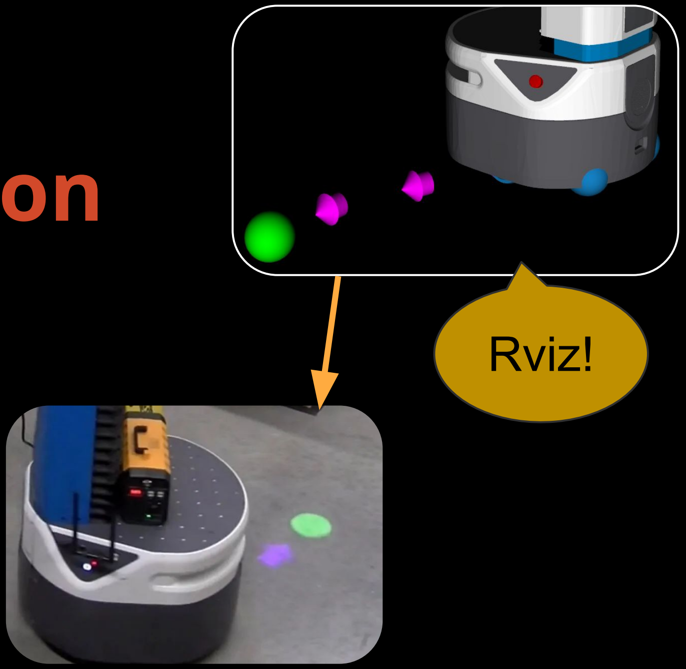
Goal of this Code Paper

- **Detail empirical evidence**
  - Directional projections – arrow, gradient bands, or lines – were all proven effective and improved perception
- **Share a robot-agnostic implementation**
  - ROS – works on more robots
  - rviz – no computer graphics library needed
  - Hardware setup details
    - Robot, projector and power



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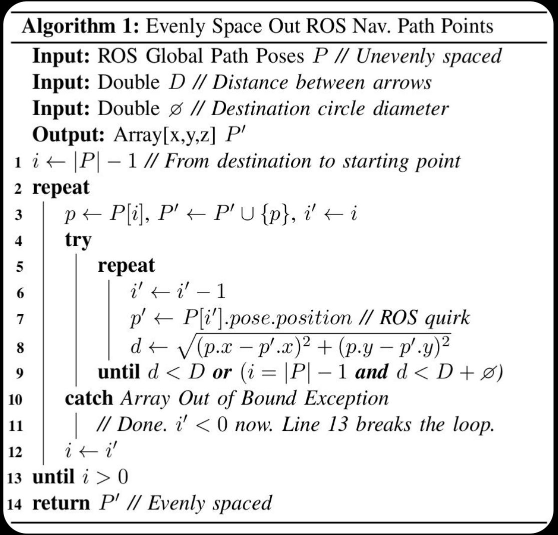
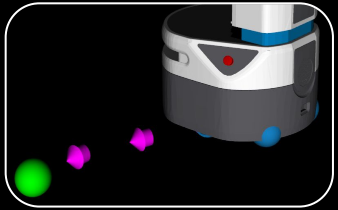
Main Features

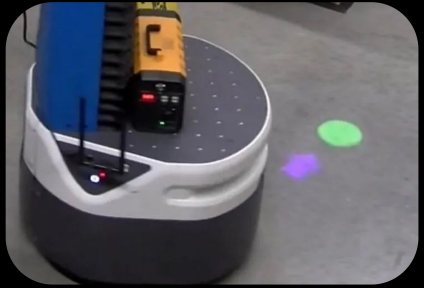
- **Arrows for paths**
  - Evenly spaced
- **Circle for destination**

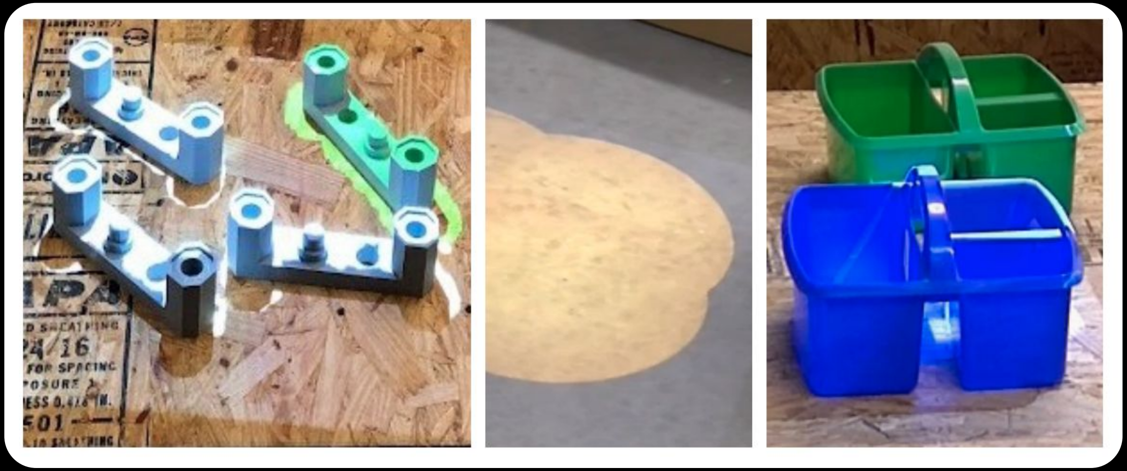
- **Generalizability**
  - Any rviz visualization: Point cloud, spheres, cubes, and more
- **Extra evaluation**



```
Algorithm 1: Evenly Space Out ROS Nav. Path Points
   Input: ROS Global Path Poses $P$ // Unevenly spaced
   Input: Double $D$ // Distance between arrows
   Input: Double $\varnothing$ // Destination circle diameter
   Output: Array[x,y,z] $P'$
 1 $i \leftarrow |P| - 1$ // From destination to starting point
 2 repeat
 3     $p \leftarrow P[i]$, $P' \leftarrow P' \cup \{p\}$, $i' \leftarrow i$
 4     try
 5         repeat
 6             $i' \leftarrow i' - 1$
 7             $p' \leftarrow P[i'].pose.position$ // ROS quirk
 8             $d \leftarrow \sqrt{(p.x - p'.x)^2 + (p.y - p'.y)^2}$
 9         until $d < D$ or $(i = |P| - 1$ and $d < D + \varnothing)$
10     catch Array Out of Bound Exception
11         // Done. $i' < 0$ now. Line 13 breaks the loop.
12     $i \leftarrow i'$
13 until $i > 0$
14 return $P'$ // Evenly spaced
```







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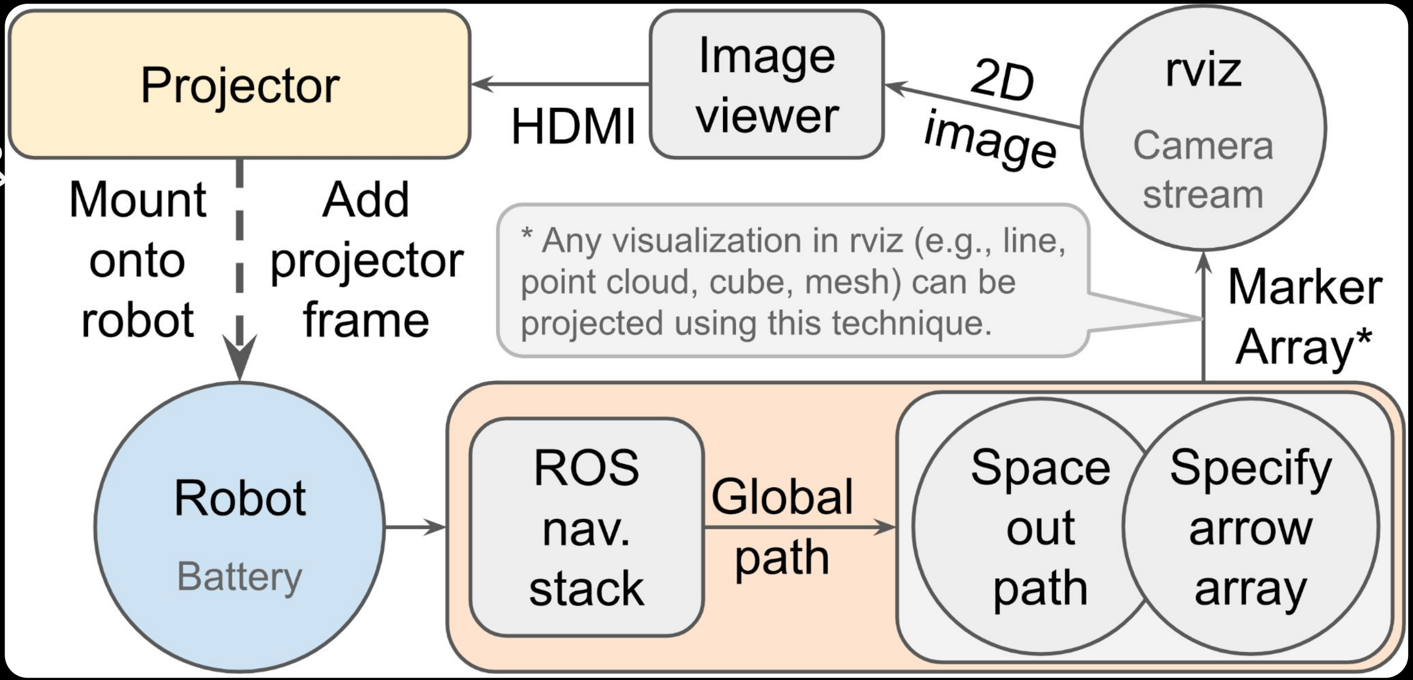
How to Project Navigation Paths

1. **Hardware**
   1.1. Robot with power
   1.2. Mount off-shelf projector & add TF frame
2. **Software** github.com/umhan35/arrow_projection
   2.1. Convert probabilistic global path
   2.2. Subscribe output in Rviz via rviz camera_stream plugin
   2.3. Output rviz camera image



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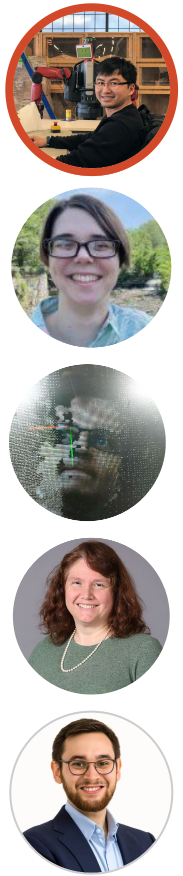

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Main Takeaways

1. **Projecting navigation paths** is a **proven** way to **convey nav. intent**
2. With our code, you can **mount a projector** and **use ROS & rviz** to achieve it (and **any rviz visualizations!**)
3. **Read our paper** for a **hardware setup** and more: **bit.ly/hri22**