Pseudo GPS for Romi Bots

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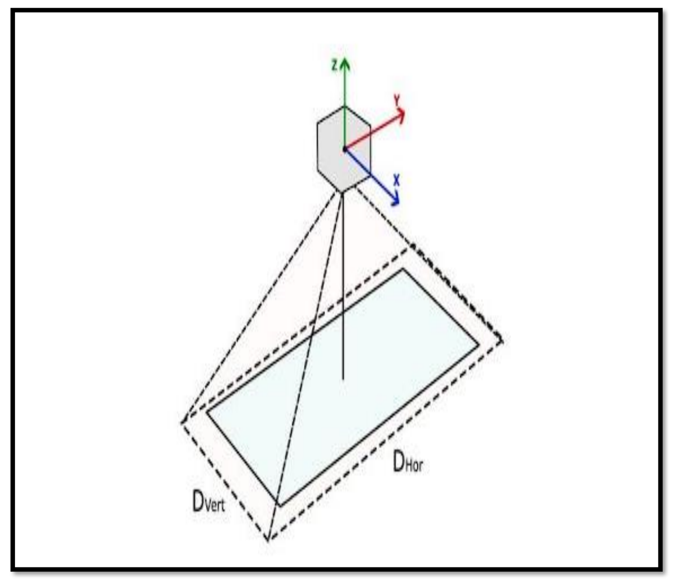
Problem Statement

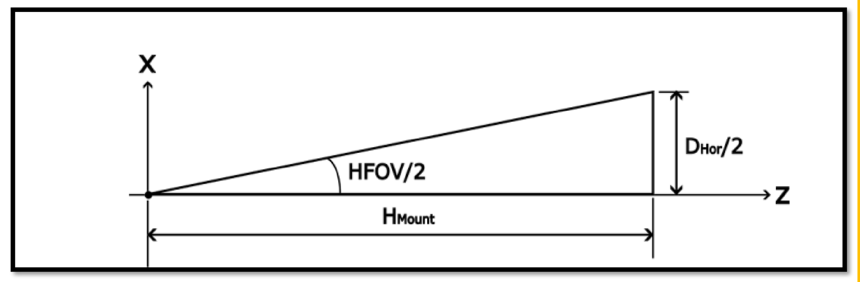
The lack of indoor localization technology limits ME 405 students' ability to gather precise position data on the Romi robot, restricting their development of advanced algorithms.

Objective

The Romi robots in the Cal Poly Mechatronics lab currently can't determine their exact position or orientation using their own sensors. To help develop more advanced technology, ME 405 instructor Charlie Refvem and his students need a system that can provide accurate, real-time location data for multiple Romi robots. This solution will improve how the robots track each other and communicate, ensuring high accuracy, precision, and fast updates over a wide range with minimal delay.

Camera Spec Analysis





Camera /Lens	Resolution [pixels]	HFOV [deg]	VFOV [deg]	Dhor [ft]	Dvert [ft]	Aview [ft^2]	Aview [mm^2]	Apix [mm^2]	Wpix [mm]
Raspberry Pi Camera Module 3	1.19E+07	66	42	8.12	4.80	39.0	3.62E+06	0.30	0.55
Raspberry Pi Camera Module 3 Wide	1.19E+07	102	67	15.44	8.27	127.7	1.19E+07	1.00	1.00

To verify that our camera is capable of tracking within our +- 5mm accuracy target, we can use our Field of View (FOV) specifications provided by the camera manufacturer as well as the known height the system will be mounted to the ceiling to estimate the viewing area of the camera. If the viewing area can fully capture the table, then we can use the digital resolution of the camera as well as the viewing area to determine the number of mm per pixel. If this is less than 5mm, the camera will be suitable for this application.

List of Acknowledgement

- Charlie Refvem
- Dr. Amanda Emberley
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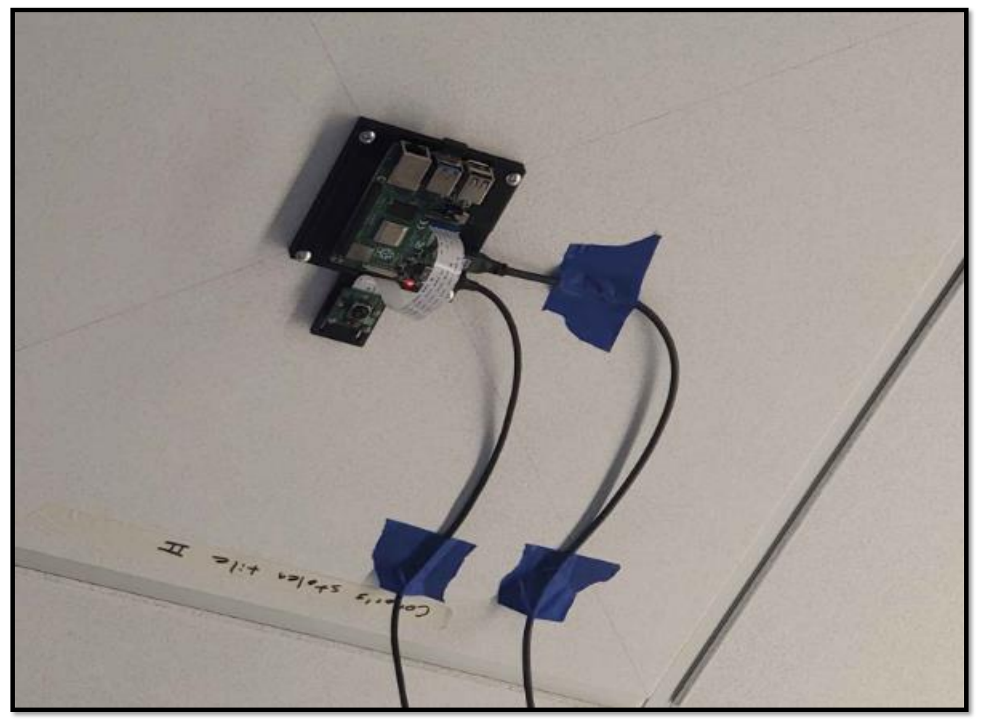
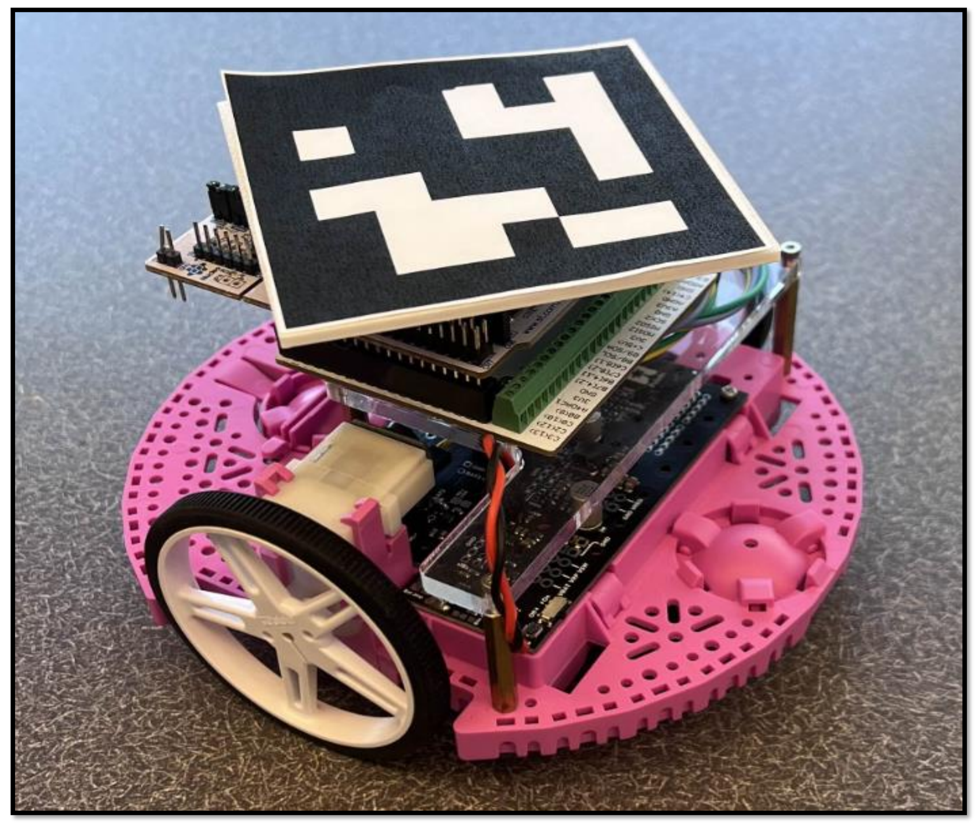
- Dr. Jonathan Ventura

Classroom Setup



The image above shows the camera setup, which will be mounted on the classroom roof. This location ensures the camera can see the entire space, allowing it to easily track the movement of the Romi robots.

Romi with ArUco Marker



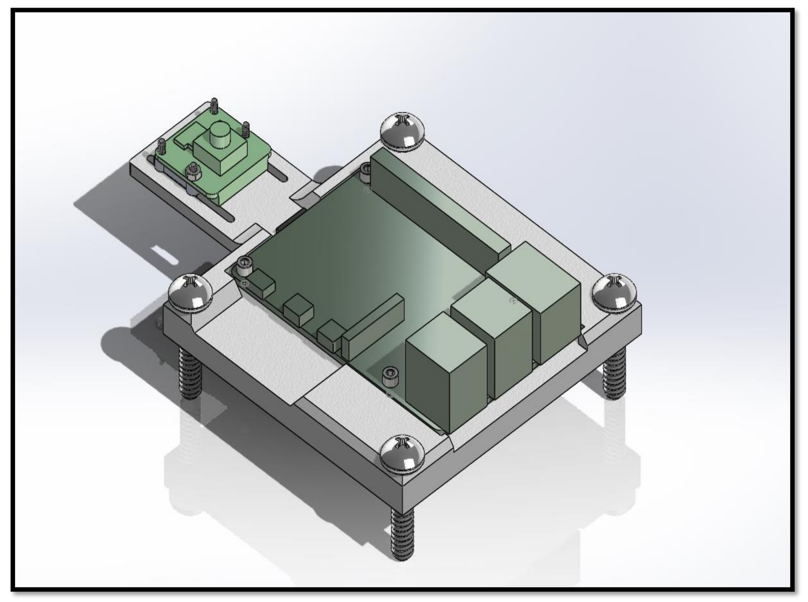
The image above shows a Romi Robot with an ArUco marker attached to the top. This marker helps us track the robot's location and movement, making it easier to monitor its actions and interactions in real-time.

Conceptual Idea

The project involves using an overhead camera to monitor a lab table. The camera captures images, which are processed by a microcontroller to track objects relative to a defined origin on the table. Custom libraries will reference objects like the Romi bots and obstacles, with computer vision tools like the ArUco markers to improve object recognition.

Object localization are handled through OpenCV, which detects object contours and calculates their coordinates relative to the grid's origin. The system uses ArUco markers placed on the Romi bots or obstacles for precise identification and orientation, improving localization accuracy. The system continuously captures video for real-time monitoring, with detected objects localized and used for movement control to avoid obstacles.

Final Design



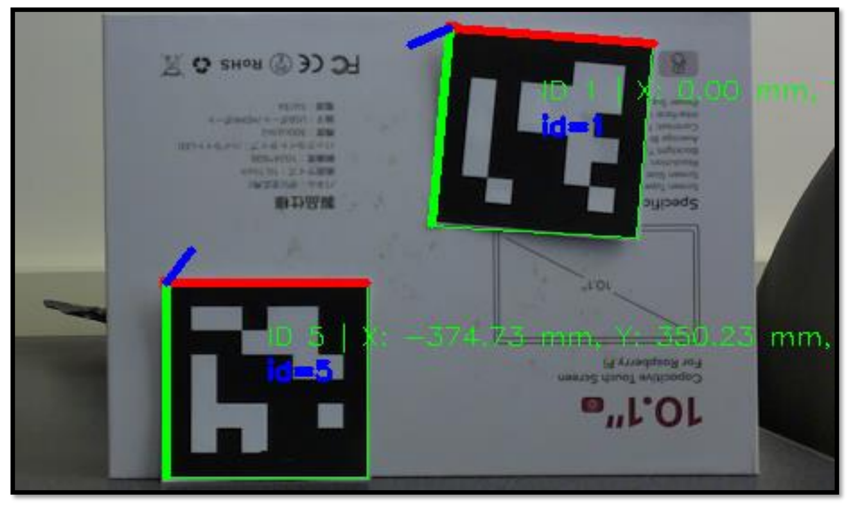
Our final design securely holds the Raspberry Pi and Pi Camera in place. The 3D-printed mount is designed to be easily attached to a ceiling tile using toggle bolts, ensuring a stable and adjustable installation.

Testing for Position and Orientation

Distance Test @ Constant Heights — Markers placed on Romi (z = 0mm)		Computer	Actual
Run 1	x [mm]	7	0
	y [mm]	392	361
Run 2	x [mm]	89	90
	y [mm]	2	0
Run 3	x [mm]	139	137
	y [mm]	46	42
Run 4	x [mm]	35	30
	y [mm]	236	242
Run 5	x [mm]	455	443
	y [mm]	248	255

Distance Test @ Constant Heights — Markers placed on Romi (z = 105mm)		Computer	Actual
Run 1	x [mm]	310	296
	y [mm]	95	85
Run 2	x [mm]	192	178
	y [mm]	339	330
Run 3	x [mm]	232	225
	y [mm]	144	150
Run 4	x [mm]	208	195
	y [mm]	231	220
Run 5	x [mm]	141	135
	y [mm]	232	215

Distance Test @ Various Heights		Computer	Actual	z [mm]
Run 1	x [mm]	86	81	15
	y [mm]	369	370	
Run 2	x [mm]	605	590	113
	y [mm]	202	190	
Run 3	x [mm]	536	534	50
	y [mm]	378	380	
Run 4	x [mm]	24	35	113
	y [mm]	53	60	
Run 5	x [mm]	117	122	50
	y [mm]	460	463	



This test demonstrates how ArUco markers can be used to track positions in space. One marker is set as the origin, while other markers are tracked based on their coordinates, calculated from the camera's view using pixel data. In this test, the markers remain stationary to show how their positions can be accurately identified and mapped.