BlossomNav: a Hardware Setup and Software Suite for Mobile Socially Assistive Robots

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Objective

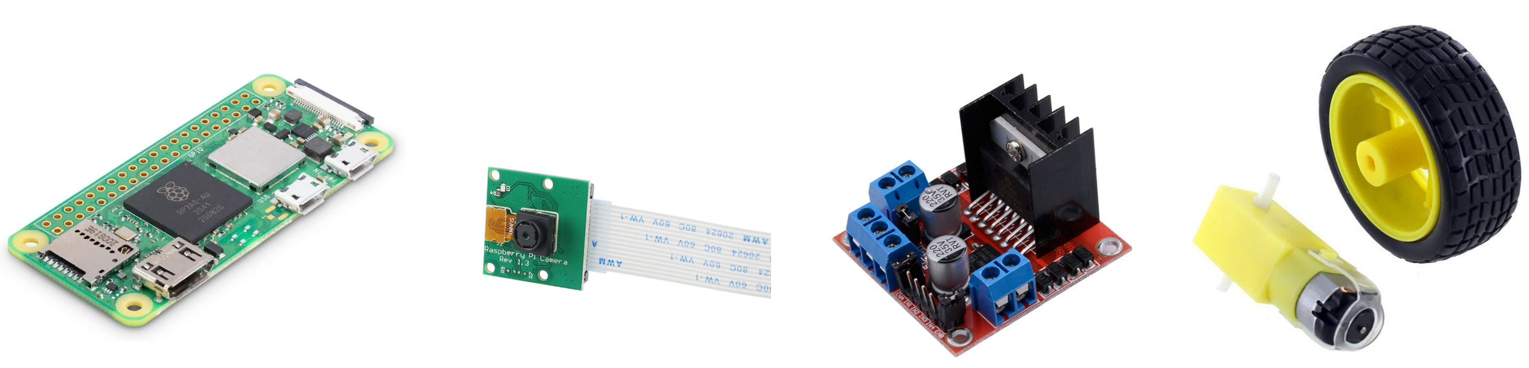
Socially assistive robotics (SAR) aims to provide emotional, cognitive, and social support through robotic interactions. Despite the potential benefits, research and development in highly mobile SAR are limited, and existing solutions are often expensive and complex. In this project, we aim to create hardware setup and software suite for SAR that is more affordable and user-friendly.

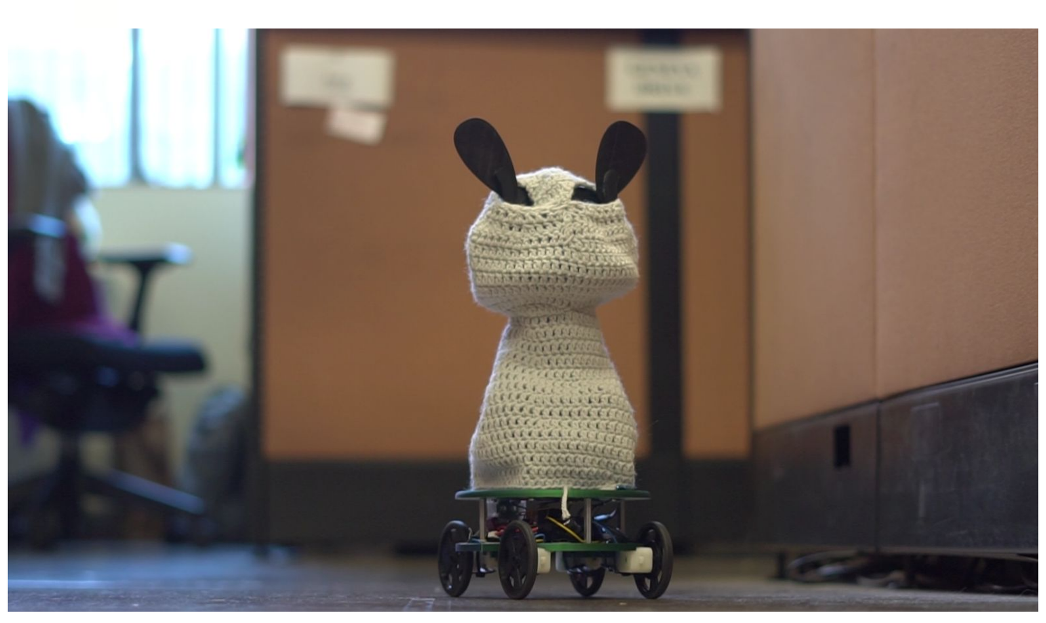
Hardware Setup

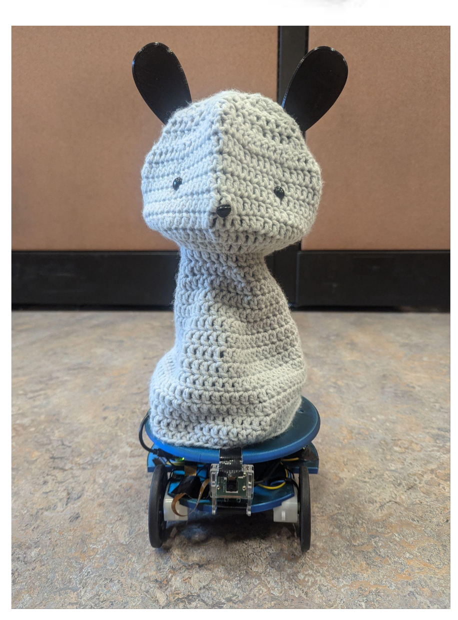
The hardware used to make the robot:

- Raspberry Pi Zero 2 ~ $15
- Raspberry Pi Camera Rev 1.3 - $15
- L298N Motor Drive Controller Board Module ~ $7
- 4pcs Geared Motor DC3V-12V DC for Four-wheel Drive Toy Car/Robotic Body/Aircraft Toys and 4pcs Plastic Tire Wheels ~ $10
- Breadboard Jumper Wires ~ $5
- Urgenex 2000mAh High Performance Li-ion Battery ~$22
- Atom Tech Battery ~ $15

All other parts were 3D printed. Total price ~ $90



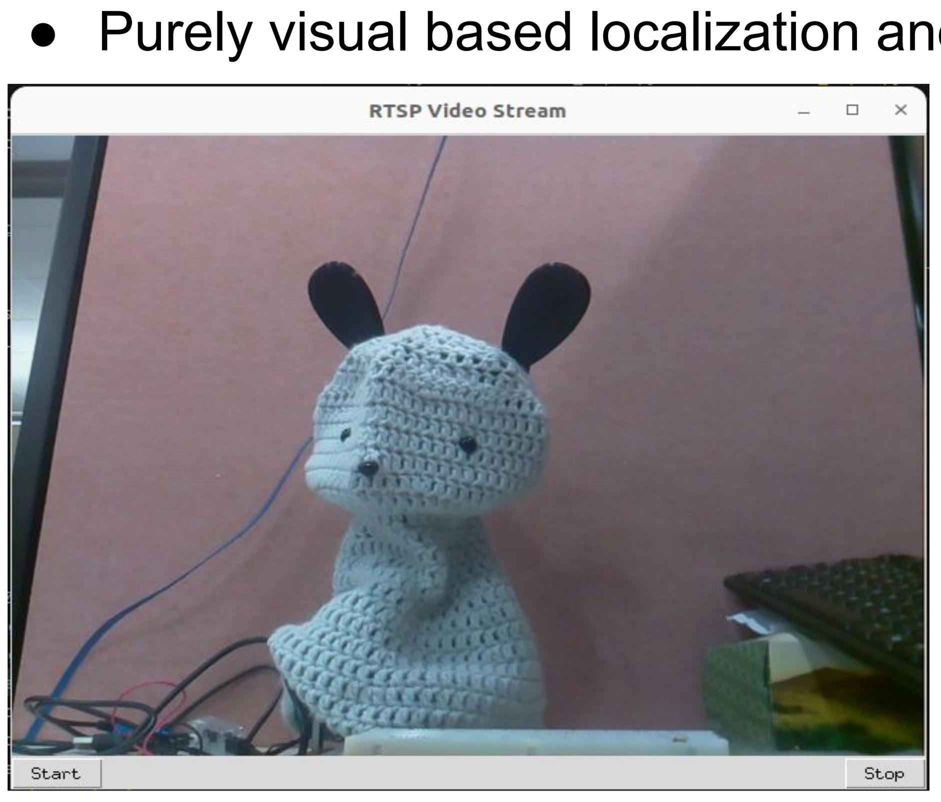


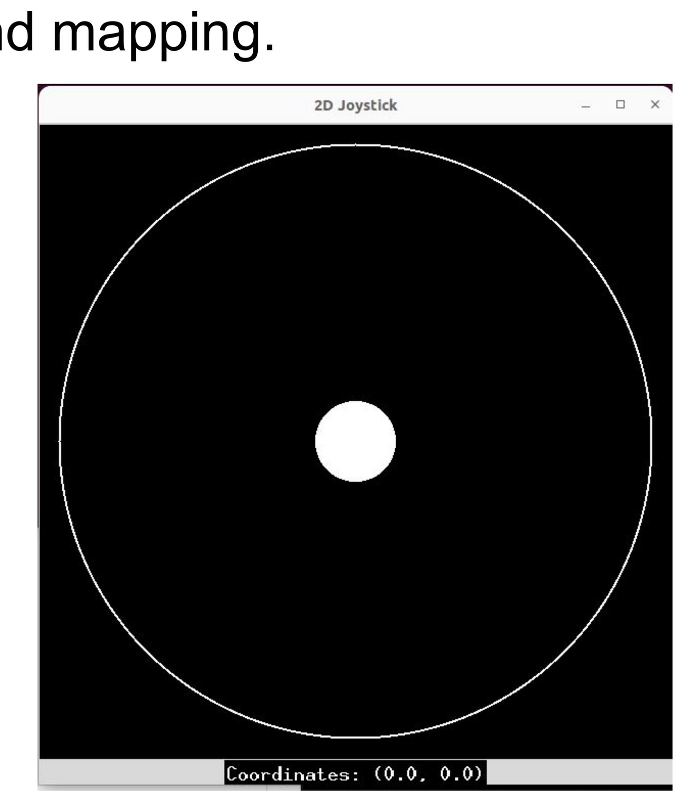


Software Suite

The software suite supports:

- Easy to use app for teleoperating robots.
- Recording teleoperation controls and footage from pi camera
- Skid drive implementation for any robot using raspberry pi and dual-channel H-bridge driver.
- Purely visual based localization and mapping.





Depth Estimation

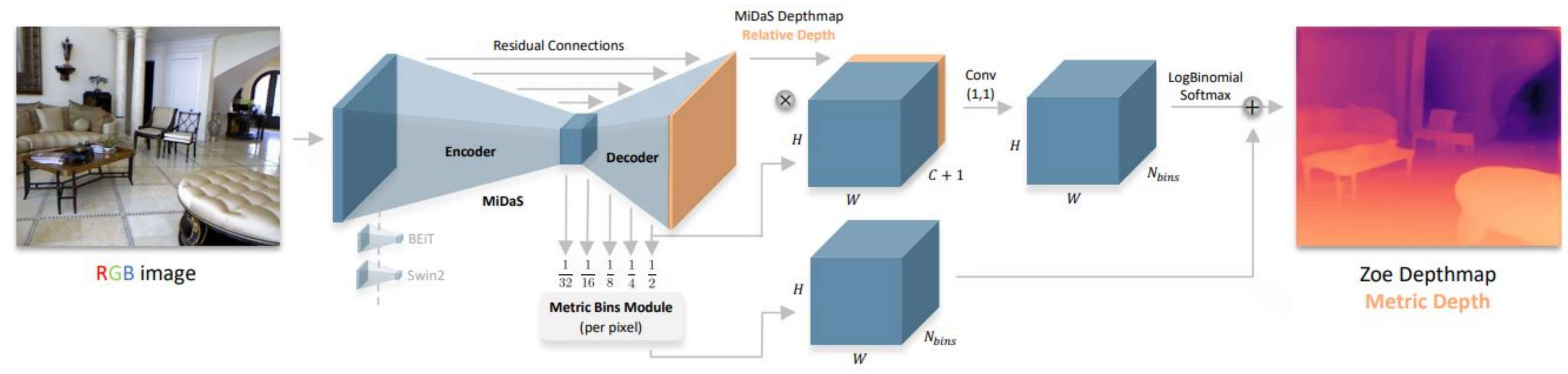
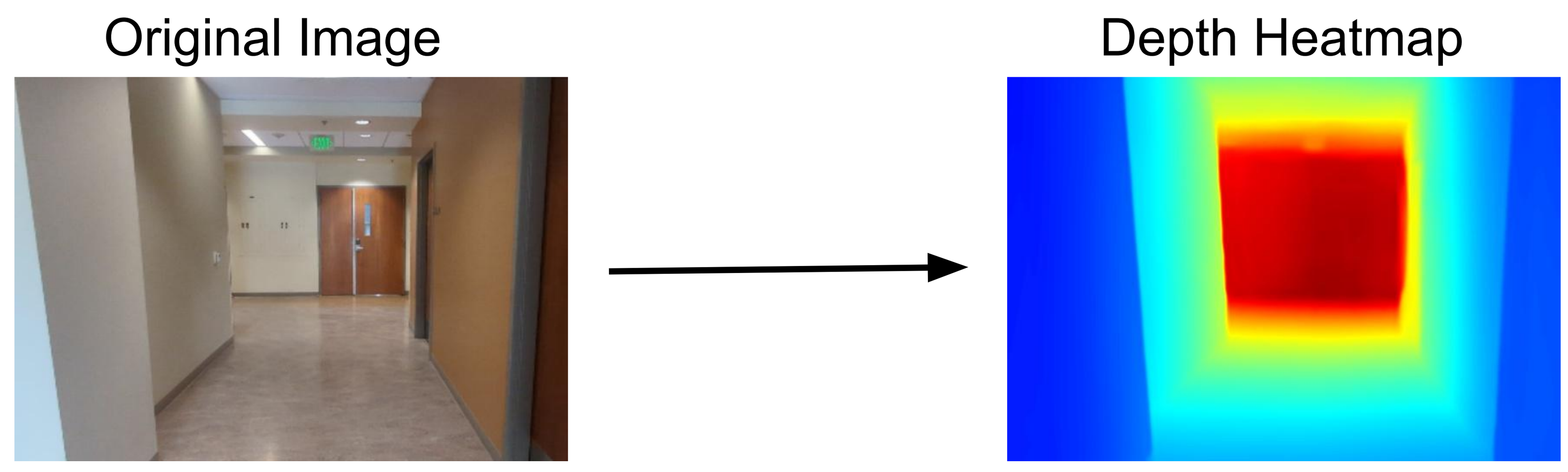


Figure 1: Architecture of the depth estimation model. Diagram is from Shariq Farooq Bhat, Reiner Birkl, Diana Wofk, Peter Wonka, and Matthias Muller in *ZoeDepth: Zero-shot Transfer by Combining Relative and Metric Depth.*



Visual Odometry

Algorithm: Pose Estimation

Input: List of Images, List of Depths, Camera Intrinsics

Output: List of Poses

Function POSEESTIMATION(Im, Dep, K) **is**

  $poseset \leftarrow \{\}$;

  $curr \leftarrow I_4$;

  for $i = 1$ **to** $|Im| - 2$ **do**

    $essentialMat \leftarrow \text{findEssentialMat}(Im[i-1], Im[i])$;

    $distance \leftarrow \text{calculateDistanceBetween}(Dep[i-1], Dep[i], K)$;

    $R, t \leftarrow \text{recoverPose}(essentialMat)$;

    $scaledT \leftarrow \text{t} \cdot distance \cdot 0.001$;

    $pitch, yaw, roll \leftarrow \text{getEulerAngles}(R)$;

    $\Delta D \leftarrow Dep[i] - Dep[i-1]$;

    if $\left(\frac{\sum(\Delta D>0)}{size(\Delta D)} > 0.50\right) \wedge (pitch > 0.10) \wedge (t[2] < 0)$ **then**

      $t \leftarrow t \odot [1, 1, -1]^T$;

    else if $\left(\frac{\sum(\Delta D<0)}{size(\Delta D)} > 0.50\right) \wedge (t[2] < 0)$ **then**

      $t \leftarrow t \odot [1, 1, -1]^T$;

    $curr \leftarrow curr \cdot \begin{pmatrix} R & t \\ 0 & 1 \end{pmatrix}$ // Converting to Open3D format

    $poseset \leftarrow poseset \,||\, curr$

  return $poseset$

Localization and Mapping

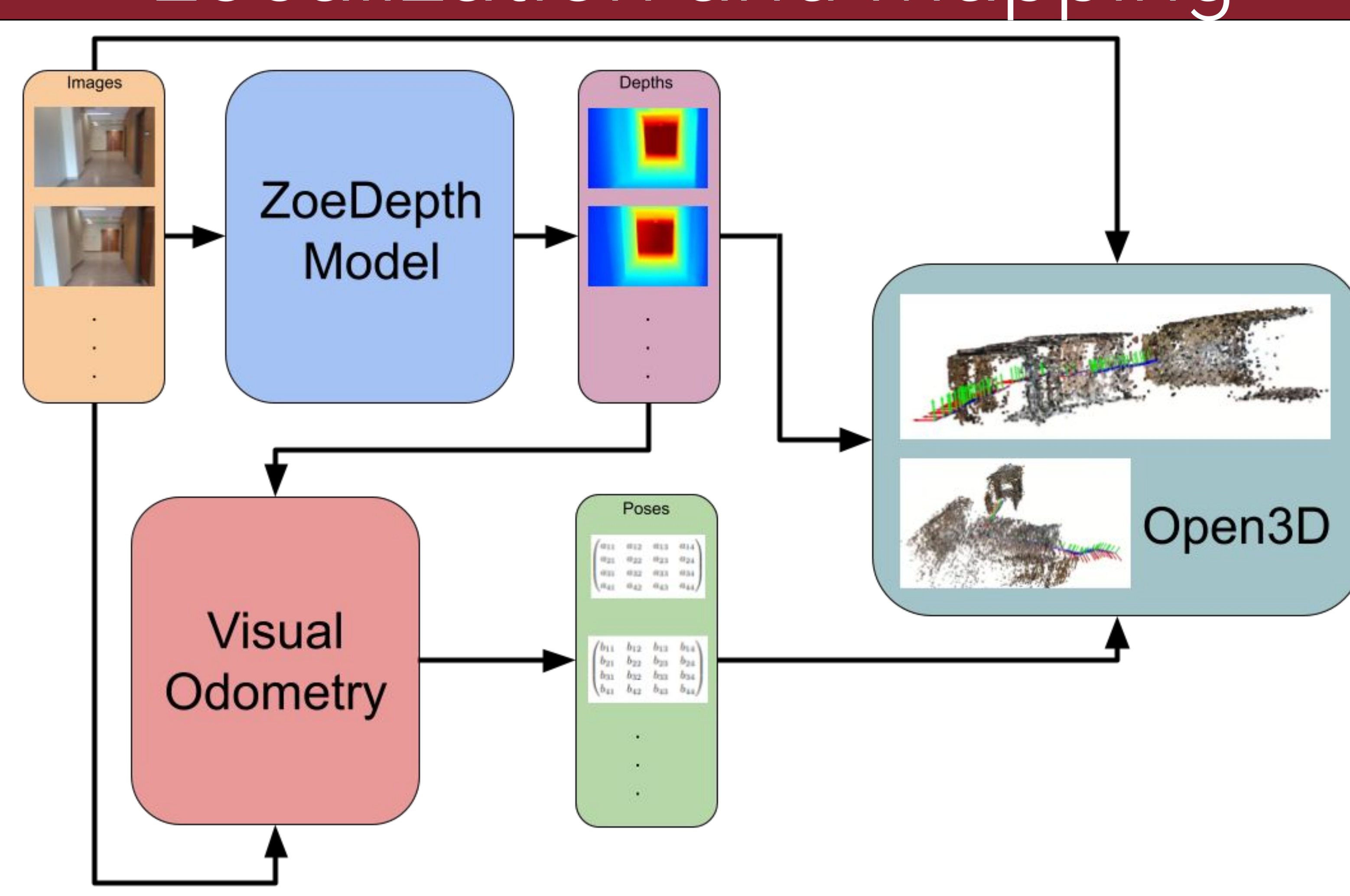


Figure 2: BlossomNav Localization and Mapping pipeline.

Application

BlossomNav with its ability to record user input controls and footage from the camera makes it a good tool for imitation learning. It's price also makes it a great platform for future development in swarm social robotics. Finally, having localization and mapping tools can make it a cheaper, more user-friendly option in research for autonomous and mobile social robotics.

Acknowledgements

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References: [1] S. F. Bhat, R. Birkl, D. Wofk, P. Wonka, and M. Müller, "ZoeDepth: Zero-shot Transfer by Combining Relative and Metric Depth." arXiv, Feb. 23, 2023. doi: 10.48550/arXiv.2302.12288. Available: http://arxiv.org/abs/2302.12288. [Accessed: Jun. 05, 2024], [2] N. Simon and A. Majumdar, "MonoNav: MAV Navigation via Monocular Depth Estimation and Reconstruction." arXiv, Nov. 23, 2023. doi: 10.48550/arXiv.2311.14100. Available: http://arxiv.org/abs/2311.14100. [Accessed: Jun. 10, 2024], [3] Q.-Y. Zhou, J. Park, and V. Koltun, "Open3D: A Modern Library for 3D Data Processing." arXiv, Jan. 29, 2018. doi: 10.48550/arXiv.1801.09847. Available: http://arxiv.org/abs/1801.09847. [Accessed: Jul. 16, 2024]