FollowMe

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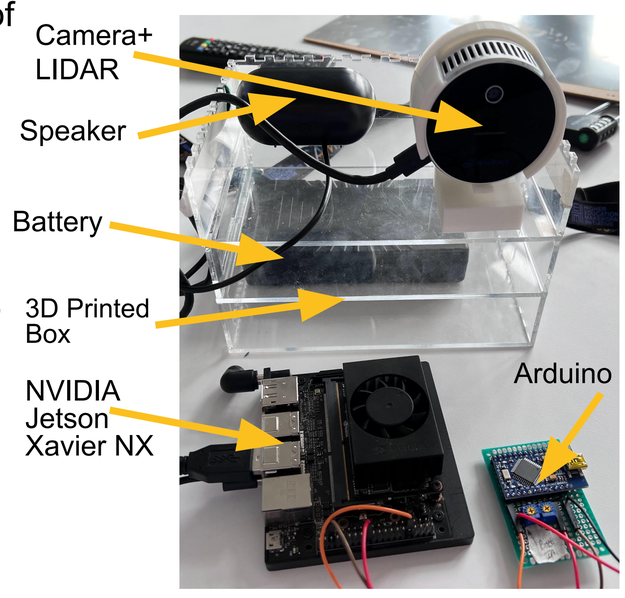
Product Pitch

- **FollowMe** is a blind aid system detecting and identifying obstacles in front of blind people. Specifically for walking in indoor, flat hallways.
- **Use Case:** Blind people have trouble using walking sticks to navigate surroundings because they have little confidence of what and where are in front of them. Followme is an accessible, affordable solution.
- **Design Highlights:** Built upon LIDAR and camera, it combines real-time object detection and depth calculation to output auditory guidance for users.
- **Requirements**: Battery life > **2 hours** and weight < **5lb** for smooth user experience. To ensure safety, must have less than **200ms** of response time and **80%** overall detection accuracy. To be affordable, must be < **$600**.
- **Testing Results:** Successfully meets our goal with **85%** accuracy, **230ms** latency, **2.5h** battery life, and **2.8lb** weight. It uses an NVIDIA Jetson and Intel Realsense Camera which can be replaced with cellphone.

System Description

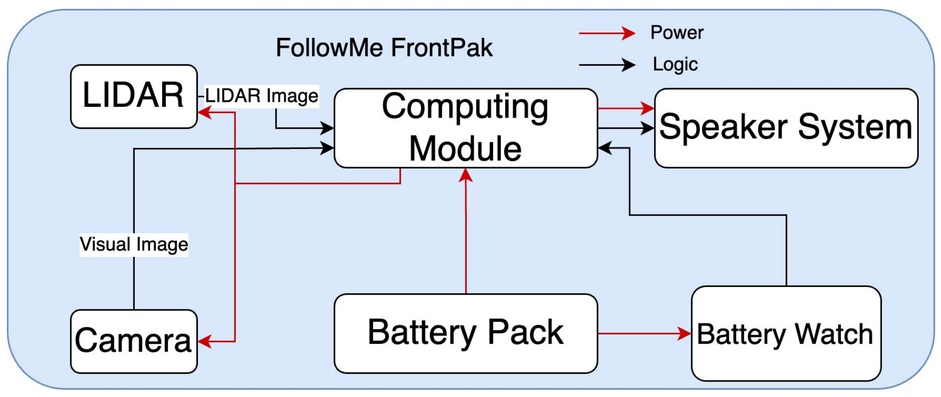


Software: A pre-trained **YOLOv5** Nano as base object detection model for detecting people, as well as a self-trained **YOLOv5** Small model that specializes in recognizing hallway-specific objects such as doors, chairs, windows, and desks.
A **distance calculation algorithm** based on the depth map from LIDAR. It estimates the closest point of the object.
A **filtering algorithm** to improve accuracy by detecting unstable YOLO outputs and whitelisting object classes.

Hardware: three-layered box housing battery at the bottom, NVIDIA Jetson and Battery Watch in middle and Speaker-Camera on top. The battery watch is made with Arduino and 2 potentiometer as Voltage Divider.

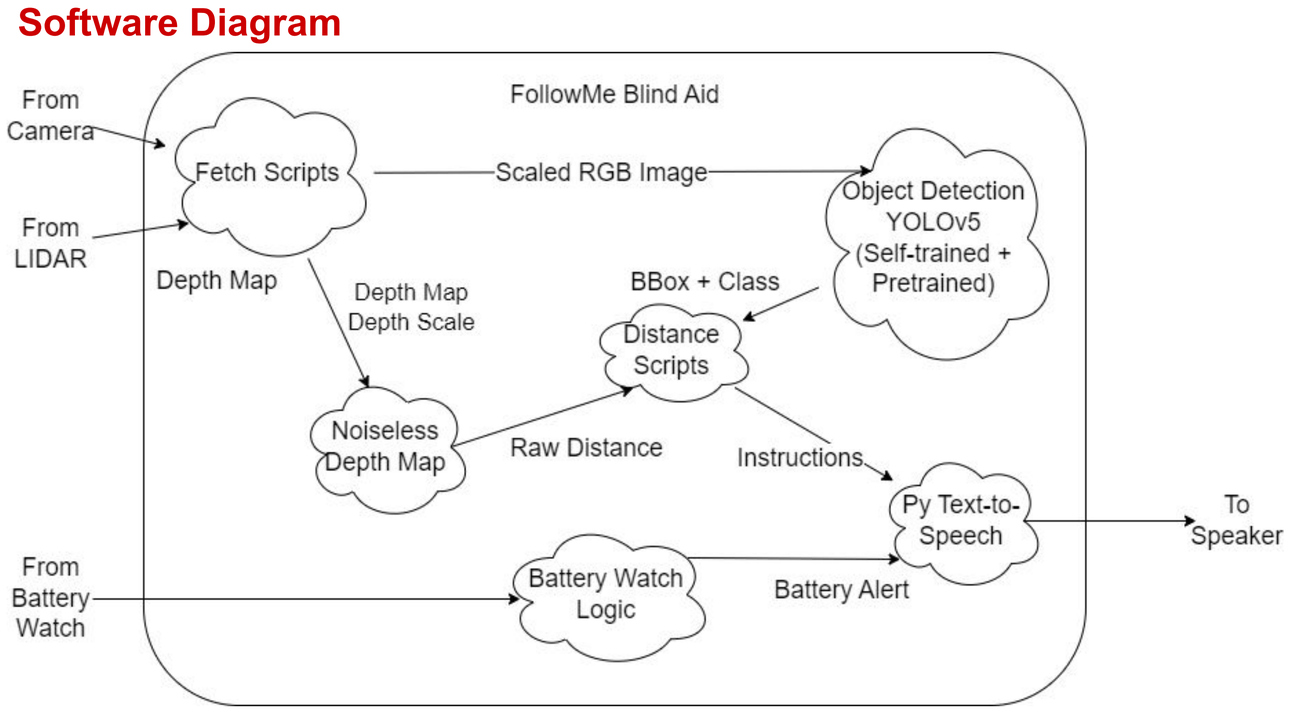
System Architecture

Hardware Diagram



The computing module is NVIDIA Jetson. After the sensors (LIDAR and Camera) collects images and depth maps, the computing module will run model and control script to trigger voice warning to the speaker. Battery pack and battery watch power the system with low-battery warning.

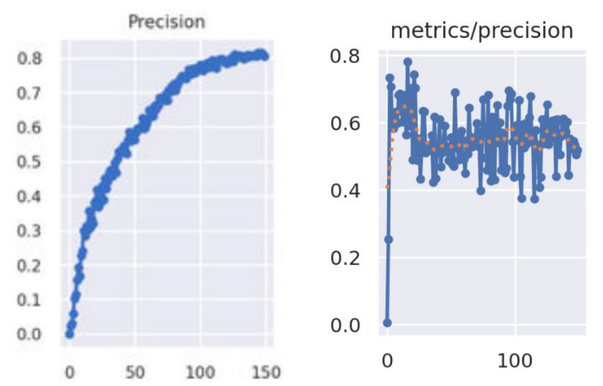
Software Diagram



After preprocessing sensor's outputs, YOLO outputs bounding boxes and labels, and distance calculation script processes closest object's distance. Voice warning is then triggered based on fine-tuned thresholds.

System Evaluation

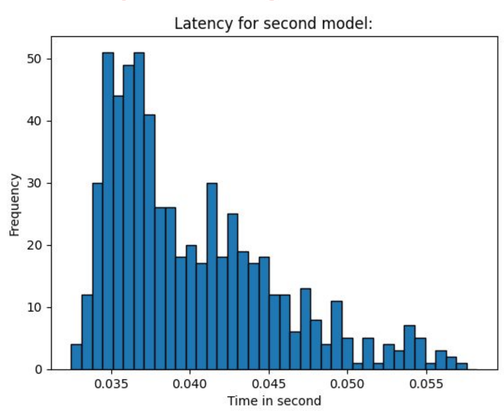
Accuracy Testing

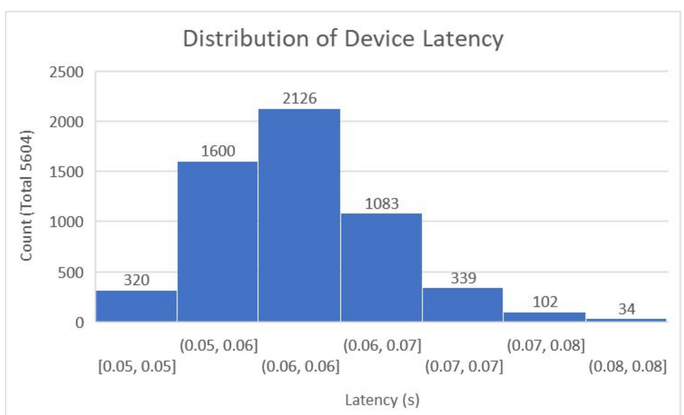


Visualization

Results: For self-trained model, precision is 0.76, recall rate is 0.7. Combined with the 95% accuracy pre-trained model, the overall system's accuracy is 0.85 by real-world user tests.

Latency Testing





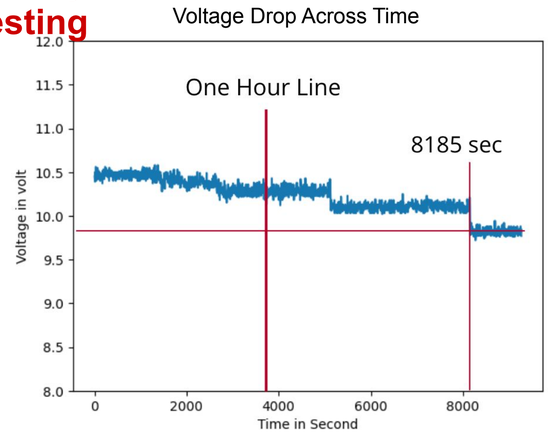
Results: The latency of hardware is about 60ms, and the average latency of the neural model to be around 40ms. The worst-case latency is 230ms.

Trade-off Studies

ML Model	Speed	Accuracy
Hough Transform	CPU Memory Intensive	Bad for complex
Segmentation	**~10s**	Too Detailed
FRCNN	**500ms**	**0.9**
YOLO	**200ms**	**0.76**

Key tradeoff between accuracy and inference speed. YOLO model, a single stage detector, balances the tradeoff by directly recognizing extracted features from raw images.

Battery Watch Testing



Results: The battery life of the system is around 2.5 hours. Within one hour, the voltage is relatively stable.

Conclusions & Additional Information

- **FollowMe** meets our goal with **85%** accuracy, **62ms** latency, **2.8lb**, **2.5h** battery life.
- **Summary**: Self-trained YOLO + Battery watch + LIDAR depth measurement script.
- **Highlights**: User-centric blind aid promoting blind people's public welfare
- **Future work**: incorporate GPS navigator like SLAM into the design that recognizes blind people's voice input and guides to the destination.
- **Lessons Learned:**

As product managers, we learned user-centric design, iterative design, and the importance of carefully scoping designs.

As engineers, we learned how to analyze tradeoffs and make robust systems that adapt to changes.

https://course.ece.cmu.edu/~ece500/projects/f23-teama5/

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