ScentBot

FINAL PRESENTATION | SS23 ECE Capstone

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Electrical & Computer ENGINEERING

Use Case & Requirements

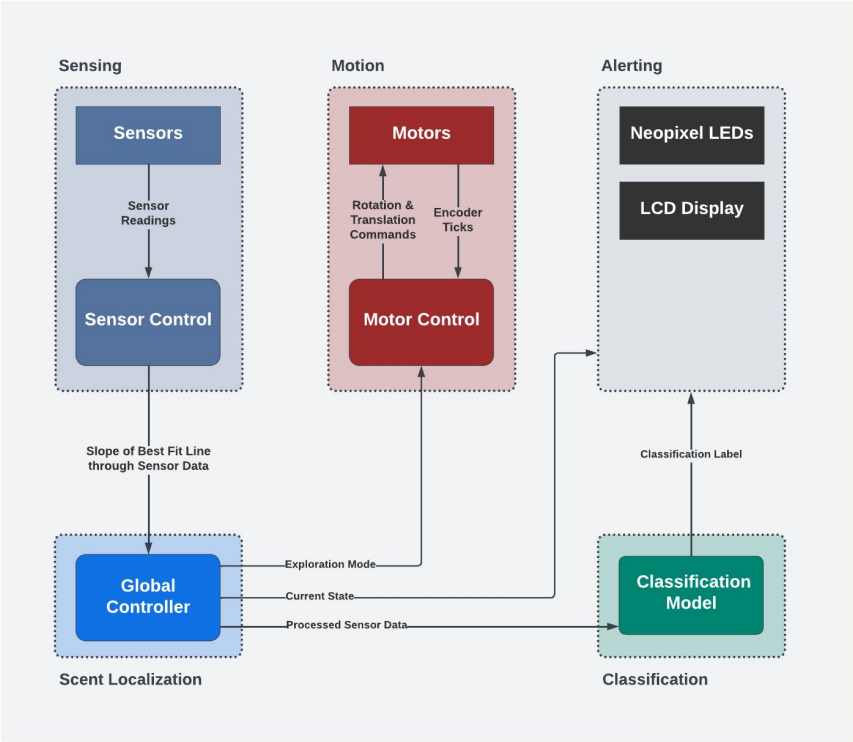
ScentBot is a mobile scent classification system that can **map** and **locate** the source of odor to help prevent hazards.

#01 **Accurately classify different scents**	#02 **Collision-free navigation and location detection**	#03 **Accessibility**
Classification Accuracy (TPR): > 95%	Computation time < 1.5s per step for data collection, routing and inference	Cost effective scent module (< $150)
False negative rate: < 1%	Robot can detect scent from > 0.5m radial distance	I2C compatible sensors for easy interfacing
Collect training data in at least 3 different indoor temperature and humidity environments	Convergence time to scented object < 3 minutes	Clear visual indicator of the hazard type to the user

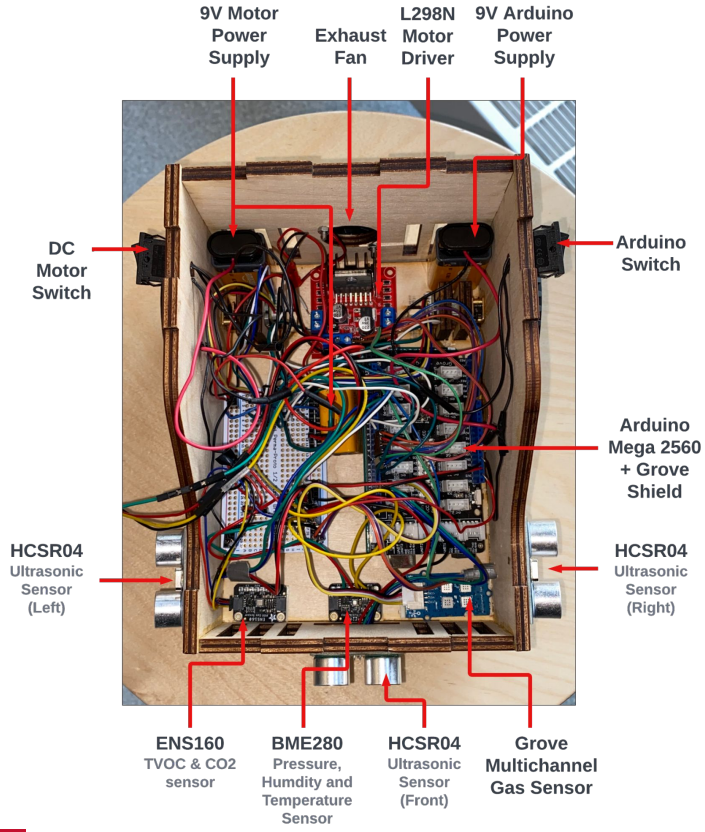
Introduction to ScentBot

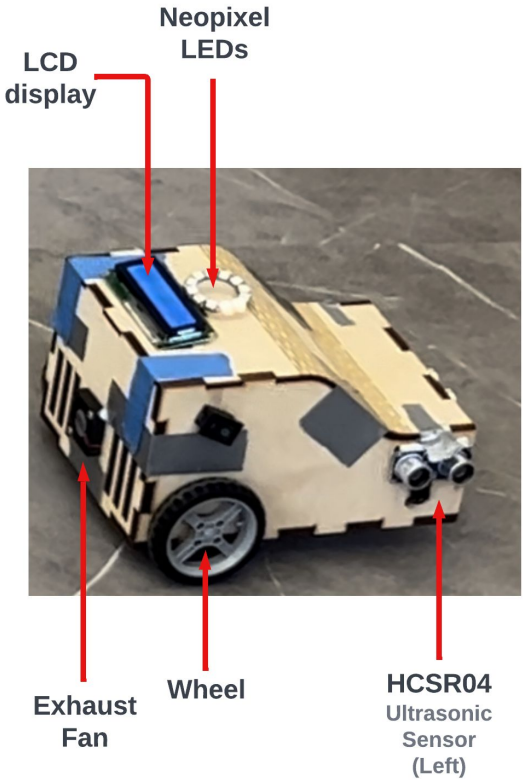
Changes since Design Review

- Entire system hosted locally on an Arduino Mega
- Now detecting two scents: alcohol and paint thinner
- Random exploration approach
- Classification *after* high threshold is determined
- More ultrasonic sensors and displays

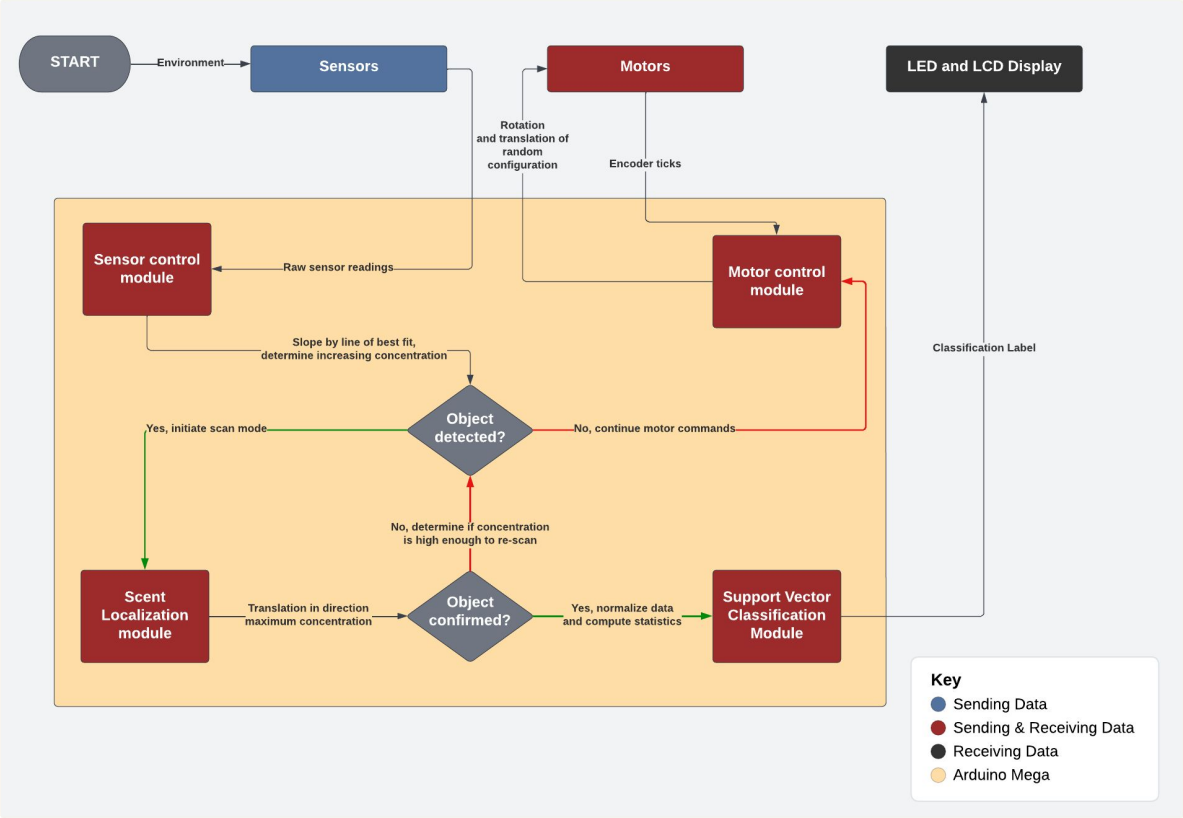


Introduction to ScentBot

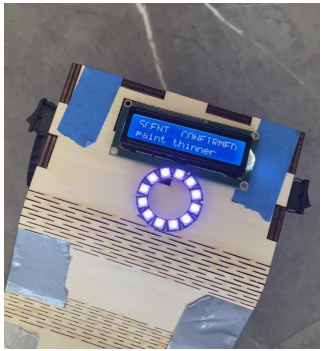


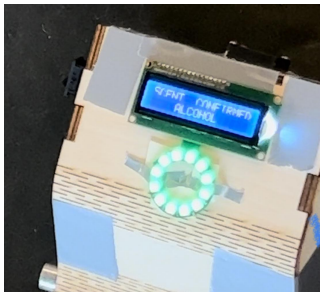


System Specification Diagram



Complete Solution

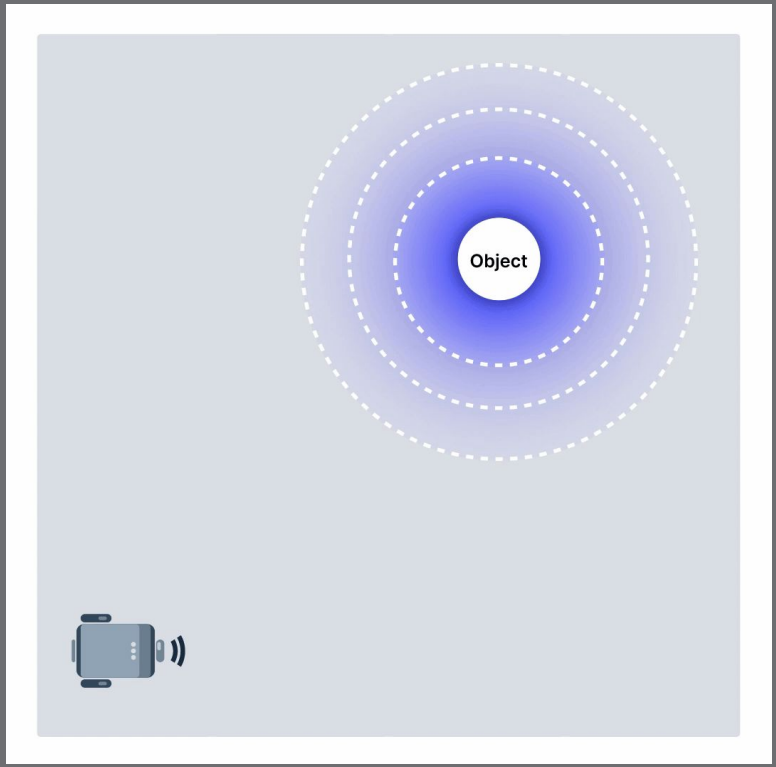




Classified object through visual indicator

Testing Plan

- Test Arena: 2m x 2m
- Test setup: one object, one of two scents
- Robot will randomly explore the space and follow the increasing scent probability to the object
- Environment - Techspark
    - Concrete flooring with walls
    - Single scented object
    - Single scented object + 2 obstacles
- For preliminary tests, we compared the average of 24 runs (1 run = confirmed scented object under 3 min) with our metrics



Testing Specifications and Performance

Requirement	Metric	Performance
Accurate hazard classification	Classification accuracy (%): > 95%	**100%** classification accuracy for scented object
Safe navigation	Number of collisions with object	Made contact with obstacle **21%** of the time
Efficient navigation & low latency	Convergence time (s) < 180 s (3 min)	Average convergence time: **89.6s**
Maximum detection distance	First detection distance >= 0.5m	Can detect object from an average distance of **0.325m**
Accessibility	Cost of sensor module (US $) < $150	Cost of sensor array: **$66.89**

Trade-offs

Approach

- Random exploration vs. planned path
- Choosing scents for classification (safety vs. functionality)

Hardware

- Microcontroller (memory space vs. size/weight)
- Cameras vs. proximity sensors
- Sensor selection (cost/accessibility vs. sensitivity)

Trade-offs (Continued)

Software

- Classification: cloud computing vs. edge computing (functionality vs. time)
- Machine learning model selection and parameter tuning (accuracy vs. model size)
- Obstacle detection (safety vs. time)
- Detection & scanning algorithm - tuning constants (accuracy vs. time)
- Controller: positional feedback vs. speed controller
- Localization: odometry vs. SLAM

Project Management

Task No.	Task Title	Owner	Progress	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7		Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Finals Week
					1/30 - 2/5	2/6 - 2/12	2/13 - 2/19	2/20 - 2/26	2/27 - 3/5	3/6 - 3/12	3/13 - 3/19	3/20 - 3/26	3/27 - 4/2	4/3 - 4/9	4/10 - 4/16	4/17 - 4/23	4/24 - 4/30	5/1 - 5/7
1	**Deliverables**																	
i	Project Abstract	All	Done															
ii	Project Proposal	All	Done															
iii	Website Setup	All	Done															
iv	Proposal Presentation	Caroline	Done															
v	Design Review	All	Done															
vi	Design Review Presentation	Aditti	Done															
vii	Design Review Report	All	Done															
viii	Ethics Assignment	All	Done															
ix	Interim Demo	All	Done															
x	Final Presentation	Eshita	In progress															
xi	Final Report	All	Not started															
xii	Final Demo	All	Not started															
xiii	Final Video	All	Not started															
xiv	Final Poster	All	In progress							S								
										P								
2	**Sensing System**									R								
i	Research Sensors and Microcontrollers	All	Done							I								
ii	Ordering Sensors & Parts	All	Done							N								
iii	Sensor System Assembly	Eshita & Caroline	Done							G								
iv	Data Routing (ioT)	Eshita	Done															
v	Dataset Generation	Eshita & Caroline	Done															
vi	Classification Algorithm	Eshita	Done															
vii	Testing with integrated classification	All	In progress															
3	**Robot Navigation & Control**																	
i	Research Commercial Mobile Robots	All	Done							B								
ii	Ordering Parts	All	Done							R								
iii	Robot Assembly	Aditti & Caroline	Done							E								
iv	Computer Vision Segmentation	Aditti	Done							A								
v	Odometry	Aditti	Done							K								
vi	Path Planning (Scented)	Caroline	Done															
vii	Path Planning (Unscented)	Aditti	Done															
viii	Testing	All	In progress															
5	**System Integration & Verification**																	
i	Field Design & Construction	All	In progress															
ii	Hardware Integration	All	In progress															
iii	Software Pipeline Integration	All	In progress															
iv	Testing with 1 Scented Object	All	In progress															
v	Testing with Multiple Scented Objects	All	Dropped															
6	**Slack**																	

Work left:

Further testing with unscented obstacles

Conclusion

Lessons learned:

- Scent detection is hard (but possible)
  - Airflow and environment challenges for sensors
  - Temperature and weather dependencies
  - Classification algorithms suitable for multiple scents
- Robot wheel and tuning speed is hard
- Design and integration of components is tricky

Proud to have developed ScentBot as a self-contained robot in 13 weeks!