**AACC ScuttleBot Robotics Project**

**A Technical Report**

**Abstract**

This report details the development of a series of low-cost, student-built ScuttleBots at Anne Arundel Community College (AACC). Part I outlines how our robotics group built and programmed these mobile robots to follow lines using basic sensors and to track and chase a ball using a camera and OpenCV. Part II describes our upcoming plans to expand on this platform with advanced mapping (using LIDAR), improved obstacle avoidance, and AI-based decision-making. The ultimate goal is to provide a robust, hands-on learning experience in robotics, programming, and artificial intelligence for undergraduate students.

**Introduction**

The field of robotics offers students invaluable hands-on experience in mechanics, electronics, and software development. As part of an undergraduate research initiative, a group of AACC students formed a robotics club to build affordable and versatile mobile robots—referred to here as ScuttleBots. These robots serve as a platform for exploring sensor integration, basic artificial intelligence, computer vision, and autonomous navigation.

In the 2023–2024 academic year, the team focused on creating robots that could track a line on the floor using simple infrared sensors and chase an orange ball using OpenCV-based vision algorithms. The key components of each ScuttleBot include:

* **Raspberry Pi** as the main controller.
* **Motor drivers** powering two DC motors.
* **Sensors** for line detection (infrared or light sensors) and vision (a Pi Camera).
* **Basic algorithms** for autonomous navigation (line following) and object tracking (ball chasing).

The following sections are divided into two parts to illustrate both our **accomplishments to date** and our **plans moving forward**.

**Part I: What We Have Accomplished**

**1. Robot Construction and Setup**

* **Hardware**: Each ScuttleBot was constructed using a simple, lightweight chassis. Off-the-shelf motors and wheels (often from hobbyist robotics kits) were mounted to a 3D-printed or laser-cut base.
* **Raspberry Pi Integration**: A Raspberry Pi served as the central computing unit, chosen for its balance of affordability, power, and ease of use with Python.
* **Motor Drivers**: We integrated L298 or similar motor driver boards, enabling independent control of two DC motors.

**2. Line-Tracking Functionality**

* **Sensor Array**: We attached a small array of three infrared sensors beneath each ScuttleBot to detect a dark line on the floor.
* **Control Logic**:
  + A proportional control scheme guided the robot to remain centered on the line.
  + If the central sensor lost track of the line, the robot would rotate slightly until it realigned.
* **Challenges**: Calibrating sensor thresholds was critical; varying floor reflectivity occasionally caused false positives or signal noise.

**3. Ball Tracking with OpenCV**

* **Camera Setup**: We mounted a Pi camera at a slight downward angle to capture the robot’s forward field of view.
* **Centroid Calculation**: Using Python and OpenCV, the code identified the largest orange contour in each frame, calculated its centroid, and translated that into motor commands.
* **Motion Control**: If the ball centroid was to the left, the robot turned left; if it was to the right, the robot turned right. Distance (approx. size of the contour) determined forward or backward motion.
* **Outcome**: The ScuttleBot could autonomously follow an orange ball around a room, offering an engaging demonstration of computer vision fundamentals.

**4. Educational Impact So Far**

* **Hands-On Learning**: Students gained experience in soldering, programming in Python, and working with microcontrollers (Raspberry Pi).
* **Collaboration**: The project facilitated teamwork among students from different STEM backgrounds (e.g., mechanical design, electrical engineering, computer science).
* **Community Engagement**: Demonstrations of the ScuttleBots at campus events helped raise awareness and interest in robotics.

**Part II: What We Plan to Do Next**

**1. Upgrading Sensors and Hardware**

* **Encoders**: We plan to add wheel encoders for more precise motion control, enabling tasks such as accurate point-to-point navigation or exact turning angles.
* **LIDAR**: A 2D 360-degree LIDAR sensor (e.g., RPLIDAR A1M8) will allow real-time mapping of the robot’s surroundings.
* **Improved Chassis**: We may redesign or strengthen the robot base (possibly using aluminum extrusions or custom-cut acrylic) to accommodate the new sensors.

**2. Mapping and Obstacle Avoidance**

* **SLAM (Simultaneous Localization and Mapping)**:
  + We aim to integrate SLAM algorithms so the robot can build a 2D map as it moves.
  + The robot will localize itself in the map and avoid obstacles automatically.
* **Path Planning**:
  + Using the LIDAR-based map, the robot will plan a route from a start point to a target destination.
  + The ability to detect objects (chairs, walls, people) and navigate around them is a key milestone.

**3. Artificial Intelligence Integration**

* **OpenCV Enhancements**: We will further leverage OpenCV for more advanced object detection, possibly identifying not just a colored ball, but also markers or human outlines.
* **OpenAI Services**: Sensor data (LIDAR, camera feeds, encoder readings) will be sent to an AI model. The AI will analyze the data and determine how the robot should respond, effectively bridging machine learning with robotics.
* **Human-Robot Interaction**: We plan to explore simple voice commands or gesture recognition to control the robot, thus introducing another dimension of AI.

**4. Timeline and Funding**

* **Phase 1 (Next Semester)**: Acquire and mount encoders and LIDAR; implement basic mapping and path planning.
* **Phase 2**: Integrate the AI decision-making layer; refine camera-based detection beyond simple color tracking.
* **Phase 3**: Investigate advanced features like multi-robot coordination or advanced 3D mapping if resources and student interest permit.

**Concluding Remarks**

Our ScuttleBot initiative has laid a solid foundation for undergraduate students to gain practical experience in robotics. By starting with simple line following and open-source computer vision for ball tracking, the project has taught valuable lessons in electronics, coding, and teamwork. Looking ahead, implementing LIDAR for mapping and AI algorithms for autonomous decision-making will not only elevate the robots’ capabilities but also significantly enhance the educational value of the project.

This report meets the requirement of documenting our current achievements and future goals for the community college undergraduate research journal. As we continue, we plan to gather performance metrics (e.g., mapping accuracy, successful navigation rates) that will further validate our approach and enrich the research component of this undertaking.

**References**

1. **AACC Mobile Robot Project**. (2025). *Internal Document,* Anne Arundel Community College.
2. **OpenCV Library**. (2023). *Open Source Computer Vision Library*, <https://opencv.org>
3. **RPLIDAR A1M8**. Slamtec. (n.d.). https://www.slamtec.com/en
4. **Raspberry Pi Foundation**. (2025). <https://www.raspberrypi.org>

*(Additional references, such as datasheets, software libraries, or relevant academic papers, can be added as needed.)*

**Figures and Attachments**

* **Figure 1**: SolidWorks design or photograph of the current ScuttleBot (optional).
* **Appendix**: Detailed code snippets or wiring diagrams, if required for completeness.