Voice-Controlled Autonomous Robot

ELECOMP Capstone Design Project 2026-2027

Sponsoring Company:

Amazon Web Services (AWS)

410 Terry Avenue North, Seattle, WA 98109
Website: https://aws.amazon.com
AWS Public Sector: https://aws.amazon.com/government-education/

Company Overview:

Amazon Web Services (AWS) is the world's most comprehensive and broadly adopted cloud platform, offering over 200 fully featured services from data centers globally. Millions of customers—including the fastest-growing startups, largest enterprises, and leading government agencies and universities—use AWS to lower costs, become more agile, and innovate faster. AWS provides a deep portfolio of services spanning compute, storage, databases, analytics, machine learning and generative AI, Internet of Things (IoT), robotics, and edge computing.

AWS is deeply committed to education and workforce development. Through this ELECOMP Capstone sponsorship, AWS aims to give URI's senior Electrical and Computer Engineering students hands-on experience building real-world systems powered by generative AI—mirroring the architectures that power modern intelligent products.

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Project Motivation:

Generative AI is reshaping how people interact with machines, yet most engineering graduates leave school having only used AI tools—not having built systems on top of them. This project is designed to close that gap. It gives URI's ELECOMP seniors direct, hands-on experience building an intelligent physical system that fuses embedded hardware with cloud-hosted generative AI, developing precisely the interdisciplinary skills employers are urgently hiring for.

- **Real-world relevance and workforce readiness.** LLM-driven task planning for edge devices is one of the most in-demand patterns in the industry today. Students will graduate fluent in the architecture powering the next generation of intelligent products—from voice-controlled assistants to autonomous systems in manufacturing, logistics, healthcare, and consumer robotics.
- **Full-stack, interdisciplinary engineering.** This project spans the full mechatronics stack: PCB and power design, sensor integration, real-time control firmware, cloud-based AI reasoning (Amazon Bedrock), speech processing (Transcribe/Polly), and a real-time web dashboard (Amplify). It bridges electrical engineering and computer engineering, letting ELE and CPE students each contribute their strengths.
- **Lasting institutional value.** The robot is a compelling, highly demonstrable showcase for the Spring Summit, department recruiting, and future capstone recruitment. It provides a reusable platform that URI can build on in future projects.
- **Edge-cloud hybrid architecture.** The project demonstrates a modern pattern where a resource-constrained edge device handles real-time safety and control locally while offloading heavy AI reasoning to the cloud—a design increasingly adopted across industry.

Publication & open-source opportunity: Students will have the opportunity to co-author a technical blog post with their AWS mentors documenting the project and its results, with the goal of publishing it on the AWS website (e.g., the AWS Public Sector or Architecture blog). The resulting solutions can also be open-sourced so that other universities and organizations can adopt and benefit from the students' work—amplifying the impact of the capstone beyond URI.

Anticipated Best Outcome:

A working autonomous mobile robot that accepts spoken natural-language commands, interprets and plans multi-step tasks using a cloud-hosted LLM, and executes physical actions—navigating while avoiding obstacles, capturing and interpreting images, and reporting results back verbally. The best outcome is a robot that reliably executes at least five distinct command types end-to-end and is demonstrable live at the Spring Summit, backed by a real-time mission-control dashboard.

Project Details:

The team will design and build an autonomous mobile robot controlled through natural-language voice commands. A user speaks a high-level instruction (e.g., "go to the window and tell me if the blinds are open"); the robot streams the audio to the cloud, where Amazon Transcribe converts speech to text and Amazon Bedrock (an LLM) interprets the intent and decomposes it into an executable sequence of actions. The robot executes those actions—navigating while avoiding obstacles, capturing images, analyzing its surroundings—and reports back verbally via Amazon Polly. A web-based mission control dashboard provides live status, a camera feed, a map of the robot's path, and command history.

This project demonstrates a modern **edge-cloud hybrid architecture**: the resource-constrained robot handles real-time control and safety locally, while offloading heavy AI reasoning (language understanding, task planning, visual scene interpretation) to the cloud.

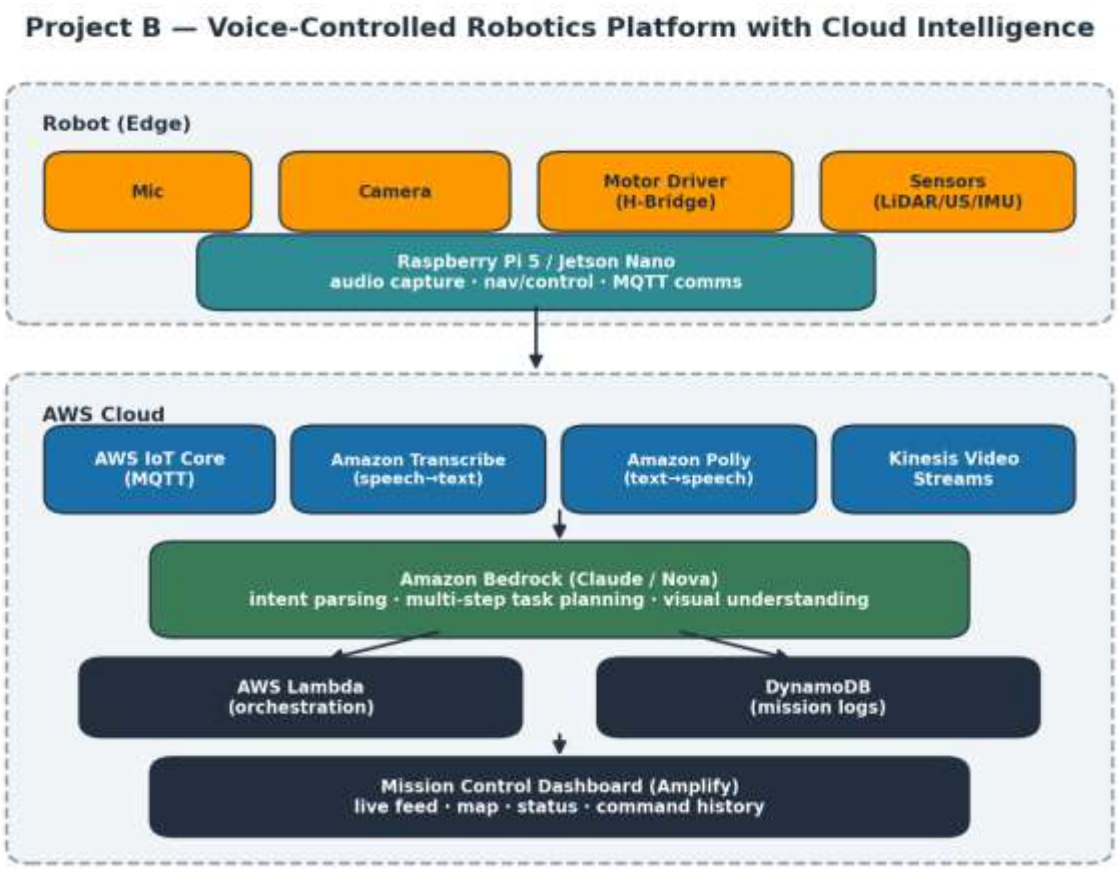

Figure B-1: Voice-Controlled Robot System Architecture.

The project is organized around the following outcomes:

ABO B-1: Mobile Robot Platform with Autonomous Navigation

Hardware / Electrical Tasks:- Design and assemble the robot chassis with differential drive (two DC motors + caster), including motor driver (H-bridge) circuitry - Integrate wheel encoders for odometry and an IMU for orientation sensing - Integrate obstacle-detection sensors (ultrasonic and/or LiDAR) - Design the power subsystem: LiPo battery pack, voltage regulation, and a power-monitoring circuit - (Optional) Integrate a servo-driven gripper/manipulator for pickand-place tasks

Firmware / Software / Computer Tasks:- Program the on-board controller (Raspberry Pi 5 or NVIDIA Jetson Nano) for motor control and sensor acquisition - Implement obstacle avoidance and waypoint navigation using odometry; establish teleoperation over Wi-Fi as an initial milestone

ABO B-2: Voice Command Understanding and Task Planning (Cloud AI)- Capture microphone audio on the robot and stream it to the cloud; integrate **Amazon Transcribe** for speech-to-text - Integrate **Amazon Bedrock** (Claude or Amazon Nova) with a system prompt that decomposes a high-level command into an ordered sequence of executable robot actions (e.g., navigate_to → capture_image → analyze → report) - Integrate **Amazon Polly** for spoken responses; establish robot-to-cloud messaging via **AWS IoT Core** (MQTT); support at least five distinct command types end-to-end

ABO B-3: Visual Understanding of the Environment- Capture camera frames and send them to a Bedrock multimodal model for scene description and object detection - Enable the robot to answer environment questions (e.g., "how many chairs are in the room?", "is the light on?") and fuse visual results into the task-planning loop

ABO B-4: Mission Control Dashboard- Build a web dashboard hosted on **AWS Amplify** showing live robot status (battery, position, current task) - Stream the live camera feed via **Amazon Kinesis Video Streams**; display command history and a map of the robot's path - Store mission logs in **Amazon DynamoDB**; orchestrate cloud logic with **AWS Lambda**

ABO B-5 (Stretch): Multi-Step Autonomous Task Chaining- The LLM decomposes complex commands into multiple sequential sub-tasks executed autonomously (e.g., "check all three rooms and report back which ones are occupied")

Composition of Team:

This project is delivered by a team of **2 Electrical Engineers and 1 Double Major (ELE/CPE)**.

For this project, preference will be given to seniors enrolled in the PCB Design Course, taught by Mike Smith.

Skills Required:

Students entering this project should have, or be prepared to develop, the following skills. All 3 Technical Directors will provide guidance and enablement on the cloud- and AI-specific areas.

- **Programming:** Proficiency in Python and JavaScript/TypeScript; familiarity with Git and collaborative development
- **Cloud & Generative AI:** Interest in (and willingness to learn) Amazon Bedrock, prompt engineering for LLM task planning, and AWS IoT and serverless services (IoT Core, Lambda, Kinesis Video Streams, DynamoDB)
- **Embedded systems:** Microcontroller/single-board-computer programming (Raspberry Pi/Jetson), sensor interfacing, real-time control
- **Electrical/hardware:** Circuit design, motor driver and power-supply design, PCB layout, and instrumentation

AI Usage:

The AI Use Policy for this project is defined in Appendix A at the end of this proposal. Technical Directors: complete the checklist in Appendix A to indicate which AI uses are permitted on this project. Any item left unchecked is not allowed.

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

The anticipated best outcomes create economic impact along several dimensions:

- **Talent pipeline.** The project produces graduates fluent in Amazon Bedrock, edge-cloud IoT, serverless, and AI—skills in acute demand across AWS and its customers and partners. This strengthens the hiring pipeline for AWS and the broader cloud economy.
- **Reference architectures and reusable assets.** The robot's LLM task-planning stack is a reusable reference implementation. Published as a blog and/or open-sourced, it lowers the cost for other institutions and customers to adopt the same pattern, accelerating AWS service adoption.
- **Brand and community impact.** A co-authored AWS blog post and a live Spring Summit robot demonstration raise AWS's visibility in higher education and provide compelling proof points reusable across the education field. The open-source solution extends the economic benefit to the wider community.

Broader Implications of the Best Outcome on the Company's Industry:

Beyond AWS, the outcomes have implications for the cloud, AI, and education-technology industries:

- **Edge-cloud AI for robotics**. The robot demonstrates how cloud-hosted LLMs can augment resource-constrained edge devices for natural human-robot interaction—an architecture increasingly relevant across manufacturing, logistics, healthcare, and consumer robotics.
- **Democratizing intelligent robotics**. By open-sourcing the solution and documenting it in a public AWS blog, the work lowers the barrier for smaller universities and organizations—those without dedicated robotics labs—to build their own LLM-powered robots, broadening participation in applied AI.
- **Workforce transformation**. Producing engineers who can build intelligent edge-cloud systems on generative AI (not merely use AI tools) helps the industry close a critical skills gap, informing how engineering curricula and industry-academia partnerships evolve to prepare the next generation of AI-fluent engineers.

Appendix A: AI Use Policy – Voice-Controlled Autonomous Robot

Allowed

Students may use AI tools for

- ☒ brainstorming support
- ☒ concept development
- ☒ literature and publicly available documentation review
- ☒ software development
- ☒ debugging
- ☒ data analysis
- ☒ test development
- ☒ non-proprietary paragraph editing
- ☒ non-proprietary single-slide formatting
- ☒ preparation of project deliverables

Not Allowed

- Note taking or transcription of meetings
- Using AI in violation of university policies, applicable laws, or course-specific rules identified by the capstone instruction team and project-specific rules identified by the technical directors.
- Entering proprietary, confidential, personally identifiable, security-sensitive, or otherwise restricted information into an AI system without authorization.
- Submitting AI-assisted work without understanding, reviewing, verifying, and appropriately disclosing its use.
- Submitting entire documents or presentations to an AI system for editing or formatting.
- Any unchecked items from the allowed list above.

Requirements

- If any use is allowed, AI tools may only be used to enhance, but not replace, students' technical reasoning, engineering judgment, and understanding. Students must be able to explain, justify, and defend all submitted designs, code, analyses, test results, documentation, and conclusions.
- During the first two weeks of the project, the student team shall work with the Technical Directors to: identify any proprietary or confidential information that may be involved in the project; determine what information may or may not be shared with AI systems; identify the AI tools, models, accounts, and configurations approved for project use; and document any project-specific restrictions or approval requirements.

- Students shall transparently document the uses of AI using the URI CYPHER AI Usage Marking guidelines (https://web.uri.edu/cypher/ai-marking/). A workshop is planned for September to familiarize students with these guidelines.
- Students retain full professional responsibility for all design decisions, analyses, implementations, testing, documentation, presentations, and final deliverables, regardless of whether AI tools contributed to the work.