C.A.P.E.R.

Compact Animated Parrot with Enhanced Responsiveness

Group 12

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1. Project Description

1.1 Project Description

The early forms of mechanically animated figures arose from the innovations of European clockmakers. Utilizing the same technology seen in clocks and music boxes, these clockmakers would design complex mechanical imitations of living creatures. These figures called "automatons" could carry out complex movements with repeatability and accuracy; performing such tasks as playing a musical instrument, writing, or drawing. Prime examples include the Prague Astronomical Clock, constructed in 1410 (Şengelen, 2022), or David Roentgen's dulcimer-playing Marie Antionette automaton (Stein, 2016). By the 1700s, it was common to find such technology in a more domestic setting, such as cuckoo clocks or music boxes.

The journey towards contemporary robots began to unfold in the early 20th century. The automatons from centuries past operated solely mechanically, using springs, gears, and a complex series of camshafts and connecting rods (MacNeal & MacNeal, 2022). This was a huge limiting factor, as movements had to be physically "programmed" by the carving of each individual cam lobe. There wasn't any method that allowed for efficient reprogramming of the movement patterns in these soon-to-be-obsolete machines. Electricity changed all this; programming individual movements was now easier than ever before, allowing engineers to program and reprogram with far less time and effort. One of the first significant milestones occurred at the 1939 New York World's Fair when attendees were introduced to Elektro and Sparko; an electrical man and dog duo created by Westinghouse. These figures, often hailed as the first modern robotic characters, demonstrated a remarkable set of capabilities using electricity, with Elektro capable of speaking over 700 words, and even smoking a cigar (Marsh, 2023).

Moving forward 25 years, Walt Disney and his company set out to develop this concept; electronically animating lifelike figures for entertainment purposes. Initially inspired by a small bird automaton, Disney realized that he could bring his animated characters to life, and display them at his Disneyland park for all to see (Staff, 2017). One of his initial forays was the "dancing man" figure in 1951; a small rod-manipulated puppet that would dance automatically using mechanical means. From this point onward, his company invested many years in developing this topic, and it wasn't until 1961 that it was finally revealed to the public. Disney coined a new term for this technology, calling it the "audio-animatronic"; a term he would eventually copyright and trademark. The first official audio-animatronics debuted in Disneyland in 1963, with the opening of "Walt Disney's Enchanted Tiki Room". This attraction featured many animated tropical birds, plants, and tikis, all using a combination of electric signals and pneumatic actuators. One of Disney's most impressive animatronics debuted at the 1964 World's Fair; a full-scale figure of Abraham Lincoln. Hereafter, animatronics became increasingly common at Disney Parks; including attractions such as the "Carousel of Progress", "Pirates of the Caribbean", "Haunted Mansion", and many others (*The History of Animatronics*, n.d.).

The 1970s and 1980s saw the peak of animatronic technology, with animatronics appearing outside the walls of Disneyland and in other various entertainment venues. Two of the most famous chains that used animatronics were Chuck E. Cheese's Pizza Time Theater and Showbiz Pizza Place. Both locations featured their own renditions of animatronic bands at all of their locations (*The History of Animatronics*, n.d.). However, it was around this time when the popularity of animatronics began to slowly decline. This period, known as “The Video Game Crash of 1983”, directly resulted in the bankruptcy, merging, and even demise of many non-Disney entertainment venues (Beren, 2023).

Aside from entertainment venues, it is important to note the significance of the film industry, and how pivotal its role was in the life of animatronics. The 1970s witnessed groundbreaking work, such as the pneumatic shark in "Jaws" (1975) and elements of the Xenomorph costume in "Alien" (1979). Rick Baker, a luminary in cinematic animatronics, significantly advanced creature effects with films like "An American Werewolf in London" (1981). For the film "Jurassic Park" (1993), Stan Winston Studios built the largest animatronic ever created; a 9-ton, 20-foot Tyrannosaurus-Rex nicknamed “Rexy”. This record was surpassed in 2001 with the even larger Spinosaurus, weighing in at 25,000 pounds (*Stan Winston School of Character Arts*, n.d.). Conversely, the “Jurassic Park” franchise also demonstrated the power of Computer Generated Graphics, and its ability to outright replace practical effects. Upon this discovery, the use of animatronic props in film also started to decline. Of course, this didn’t mark the end just yet. In 2022, Jim Henson’s Creature Shop recently constructed all the animatronics and mascots for the “Five Nights at Freddy’s” film, inspired by the immensely popular 2014 video game (Graves, 2023).

1.2 Current Projects: Small Scale Open Source Animatronics

Spazzi: A Solenoid Powered Dancebot (BeatBots)

Spazzi, featured in Make: magazine, is a dancebot driven by solenoids and controlled by an Arduino microcontroller. It uses three solenoids to achieve eight distinct positions, enabling it to dance to music or inputs when commands are varied over time via software such as Max/MSP or Pure Data. This project demonstrates how limited movement repertoires can produce complex behaviors.

Electric Parrot Project at MIT Media Lab (Massachusetts Institute of Technology)

The Electric Parrot Project at MIT Media Lab was an endeavor aimed at designing a robot capable of engendering empathy through its interactions and behaviors. Active from January 2015 to August 2016, the project sought to explore the boundaries between technology and emotional connection by constructing a novel zoomorphic robot. This robot was not just about simulating the physical appearance of a parrot but was designed to create its own life story by experiencing the world, being changed by these experiences, and communicating these experiences back to humans. The goal was to demonstrate that by giving the robot an implicit life story, it could invoke empathy in human interactions, potentially being used for empathy intervention.

1.3 Motivation

Just as automatons became obsolete and antiquated, traditional animatronics are soon going to follow suit. The next generation of entertainment-oriented robots will require the newest technology for any chance to succeed. The downside to this is the high cost of production and installation of modern animatronics. It would cost companies hundreds of thousands of dollars to upgrade their facilities to accommodate these new figures, and many companies cannot foot the bill. This is our motivation for CAPER; to create a low-cost, low-profile, robotic parrot, suitable for permanent installation in facilities with a smaller economic footprint.

1.4 Objectives & Goals

CAPER integrates modern AI and movement control systems for improved human interaction, being able to carry out simple conversations with the user. Voice activation and speech detection will prompt the AI program to generate appropriate movement and audio data in real-time. The raw electrical movement impulses will be translated into motion, and synchronized with the audio; it will look like you're *actually* talking to a parrot. If a less advanced response mode is desired, CAPER will also feature more traditional control methods; real-time manual movement control, and prerecorded movement sequencing.

While mainly focusing on improved human interaction, affordability and ease of use are also critical factors. We must consider the ramifications of overcomplication and expense; preventing installation in facilities with limited space or power resources. We don't ever want this to be the case. Developing user-friendly interfaces that don't require specialized knowledge, further widens the appeal of CAPER to include non-engineer users. Simplifying the design and using less material will reduce development, installation, and maintenance costs, making it a practical option for smaller venues, schools, and hobbyists. This approach not only widens the market but also allows for educational exploration into robotics.

Finally, the CAPER project is a response to the growing need for ethical and positive applications of robotics; aimed at moving away from potential negative uses like militarization and job displacement. We strive to take the next step in entertainment-based practical effects, and once again stimulate interest in the field of animatronics; this time, using new technology.

1.4.0 Short-Term Objectives Overview

What will CAPER do?

As mentioned before, CAPER will generate physical and auditory responses based on user voice input; but how will this be done? How will our design differ from what's being done by other companies? The answer lies in the physical design of both the robotic figure and controllers. The entire system of CAPER involves three main stages. Firstly, the generation of audio and movement response based on various user inputs. Secondly, the translation of raw data from the inputs into usable high-power voltage streams to animate the parrot. Lastly, the mechanical conversion of these voltage streams into movement. Therefore, we will have three respective subsystems: a voice response circuit board, an input/output movement board, and the parrot figure itself. All of the low-level peripheral circuits we'll need, will be consolidated into one of the three main subsystems. This "partial-consolidation" allows for easy installation of each main system individually, and eliminates the worry of over-complicated maintenance and troubleshooting. These three systems are explained in greater depth below:

The CAPER Parrot Figure
CAPER will showcase four movements: beak opening/closing, vertical head tilt, vertical body tilt, and lateral tail/wing tilt. Each movement will be carried out electrically, but without the use of ultra-precise position or speed monitoring. The binary "on/off" style of movement control makes programming more timely, efficient, and understandable, without jeopardizing the "realism" of the movement. The internal frame of the robot along with all the devices and physical extremities, will be completely concealed by the exterior "skin" of the parrot. The figure will stand upright, fixed atop a pedestal for permanent mounting. Wires will run out the bottom of the figure for connection to a separate control unit.

The CAPER Input/Output Control Board (IOCB)
This custom-designed PCB will contain a low-level microprocessing chip and all of the necessary peripheral circuits needed to animate CAPER. It will be enclosed in its own discrete enclosure separate from the figure, allowing for remote control. Most of the control board will be hidden, with only the necessary buttons, switches, and I/O ports visible from the outside. The IOCB will feature four distinct operation modes and will decipher two classes of inputs.

The CAPER Voice Response Board (VRB)
This pre-built edge computing development kit will have all the needed computing power to allow CAPER to give lifelike voice and movement responses to user interaction. Movement data will be sent to the IOCB, while audio will be sent to external speakers.

Classes of input:
- **Single Line Serial Communication over UART:** Using MIDI protocol, data can be transmitted from an external controller in the form of a UART bitstream. Received messages will be decoded and translated by the IOCB. Therefore, all four of CAPER's movements can be controlled by a single serial communication channel.
- **Parallel Digital Inputs:** The IOCB will have four digital inputs corresponding to each of the four movements.

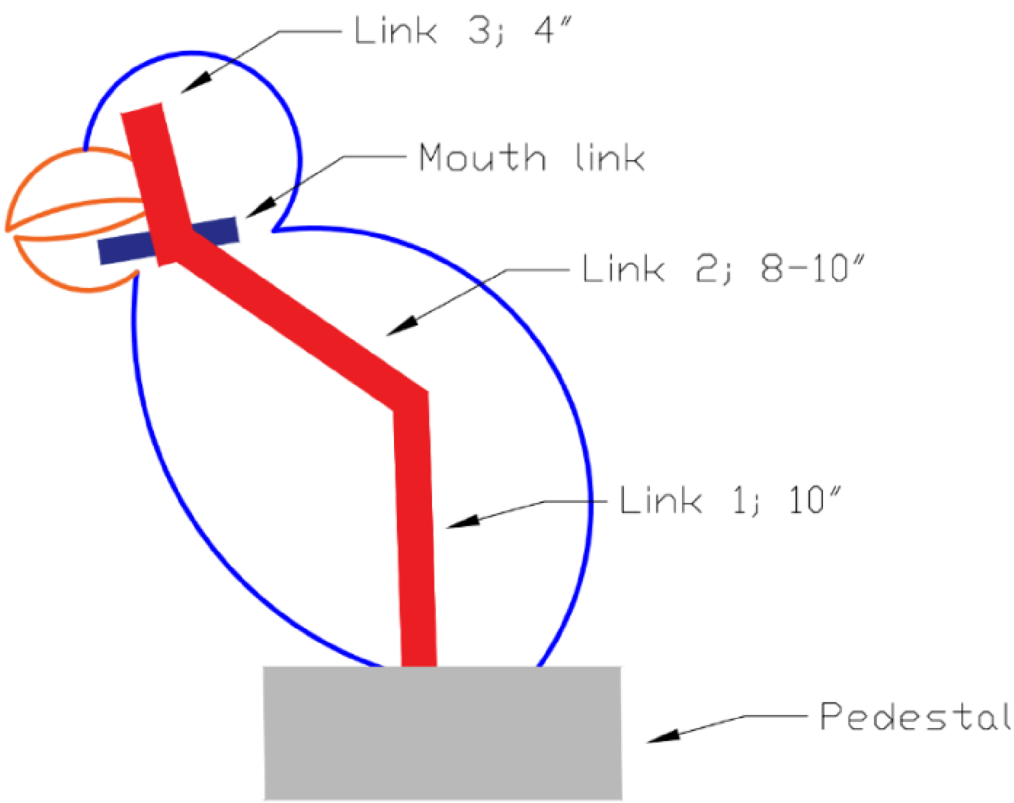
CAPER Operation Modes
- **Fully-Manual Live Operation:** Using the parallel digital inputs, CAPER can be manually operated using push buttons. CAPER features four movements, therefore there will be four buttons. Pressing a button will activate the corresponding joint movement, and depressing the button will return that joint to its resting state. In this mode, CAPER essentially behaves like an electric ventriloquist's dummy.
- **Partial-Manual Live Operation:** Using the parallel input for the mouth actuator, the user can plug a microphone into the IOCB and control CAPER's mouth with their voice. With an adjustable gain knob, the user can tune the sensitivity of the microphone for better accuracy. The remaining three movements can still be operated with the corresponding push buttons, or be moved automatically using the Partial-Manual mode. By flipping a selector switch mounted on the enclosure of the IOCB, the user can activate a subroutine within the IOCB's program, that randomizes the head, body, wing, and tail movements, allowing for complete hands-free operation of CAPER.

- **Pre-recorded Sequence Operation:** CAPER can be operated like a traditional animatronic using an external playback device. Using any easily attainable digital audio workstation (DAW), the user can pre-program a sequence of movements on their computer using MIDI, and transmit the data stream into CAPER's UART input. Once a sequence of movements has been recorded by the user, that exact sequence can be played back repeatedly. Most DAWs allow for simultaneous playback of MIDI streams and audio streams, meaning you can synchronize CAPER's movements with the audio, and play them both at the same time. (The audio can be sent to external speakers).
- **Automatic Live Operation:** CAPER can listen and respond using a synthetic voice to users in with its speaker and move in time with the voice response. Neither the movement nor the content of voice response given are pre-programmed in this operational mode.

1.4.1 Stretch Goals & Objectives

In future versions, CAPER could see its lifelike nature increase with the inclusion of sensors to capture more of its environment without substantially increasing the cost. The output of those sensors could be used to create responses to touch, lighting, and the presence of humans, making both voice and movement feedback more dynamic and unique. Another possible upgrade could be an improvement to the control system by adding battery support, allowing CAPER to be operated in a greater variety of environments. Further still, more movement vectors are also a possible upgrade. Coupling that with the new sensors could give CAPER an almost uncanny dose of realism to its movements, allowing for use not only as entertainment but also in education. It is even possible to make the figure user-customizable!

1.5 Physical Design



1.5.0 Physical Design Overview

CAPER's design will incorporate two distinct physical structures for its implementation.

- The Main Body (MB) will be the parrot-shaped robot that contains all the various systems needed for movement
- The Auxiliary Control Unit (ACU) will be a box that contains all computation systems and be responsible for controlling the robot's movements. It will be connected to the MB by wire.

1.5.1 The Main Body (MB)

CAPER's cornerstone component group will be the robotic parrot apparatus that is operated by the control system, referred to as the Main Body (MB). The MB will contain all the systems needed to turn the signals from the control unit into movement.

The movements available to the MB are:

- Beak open/close
- Head tilt up/down
- Body tilt up/down
- Wing & Tail flap in/out

This central frame in the MB will support all the links, linkages, and electrical devices inside CAPER, and will resemble a 3-link, 2-revolute-joint robotic arm. The first link will extend vertically from the bottom pedestal, where the following two links will diagonally extend outward like a boom, giving CAPER the parrot-like posture. The gravitational force of the links' weight while in their resting positions will be counterbalanced by small coil springs; energizing the solenoid actuator will retract the link into its opposition position, countering the forces of the springs and gravity. Once fully assembled, the frame will be completely concealed by CAPER's skin; the outermost "parrot costume" constructed of malleable synthetic materials. Fully assembled, the figure will stand at approximately 1.5 feet (45.72cm) tall, fixed atop a pedestal for permanent mounting.

1.5.2 Auxiliary Control Unit (ACU)

The MB will not have the necessary internal spacing to accommodate for any of its control systems. The ACU will contain all PCBs needed for all of CAPER's modes, as well as its power supply. The resulting container will need to be large enough to not only contain all devices but also accommodate for the plugging in of external devices. No mechanical stresses are expected here so the design will be made of cheaper 3D printed material.

1.6 Control Hardware

1.6.0 Hardware Overview

To achieve its comprehensive functionality, CAPER will necessitate the incorporation of multiple computational boards. The Input/Output-and-Control Board (IOCB) will be responsible for the critical operations of movement, power management/control, and input management. In contrast, the conversational capabilities, enabling CAPER to recognize spoken words and respond through its onboard speaker, will be facilitated by the Voice Response Board (VRB). Communication across these boards is streamlined and unidirectional; UART will relay movement data to the main board for decoding, while audio data is transmitted directly to the speaker for immediate output.

The entire control hardware suite will be powered by standard US wall voltage (120V@60Hz) via a cable to a standard receptacle wall outlet. Wall power will be bumped down and rectified to DC via an on-board power supply.

1.6.1 The Input/Output-and-Control Board (IOCB)

This board is to house enough I/O and computing power to drive CAPER's movements and allow it to respond to its environment in a lifelike way without compromising on response time. The IOCB will require an MCU that meets the following criteria:

1. **Microprocessor**: Feature a microprocessor strong enough for adequate data processing capabilities.
2. **UART Input Stream Processing**: Support processing of a UART input stream for voltage-stable serial communication.
3. **Power Supply for Digital Pins**: Provide power and be able to read from multiple digital pins with a voltage tolerance to accommodate digital signaling needs.

Power requirements for the boards' microelectronics cannot exceed what can be drawn from a wall outlet to ensure that CAPER can be operated from nearly anywhere. The board is to be housed in a separate case and connected with cables; this will make CAPER controllable from a distance like the animatronics of old. Basic decision logic for IOCB code in Figure 1.4

IOCB Peripheral Circuits:

Several distinct circuit groups will be housed on this board alongside the MCU, as seen in Figures 1.2, and 1.3 as the blue blocks:

- The Push Buttons: (4), Toggles all four respective movements manually
- Mode Selector Switch (1): Toggles automatic movements
- The Ham Radio "Vox" Circuit: Will generate pulses when voice is present
- The MIDI Optocoupler: An opto-isolator for voltage/ground stability for MIDI signal
- Bootstrap Loader: Allows for USB compatibility, debugging of MCU
- Power Supply/Regulators: Higher Voltage Power Supply, Low Voltage Regulators
- Actuator Relays

Push Buttons

Four physical push buttons will be connected to parallel pins on the IOCB. Pressing the button will transmit an electrical impulse and control one movement. Therefore there will be a mouth, head, body, and wing/tail button. Pressing each button will move the respective joint. Depressing the button will return the joint to its resting state.

Mode Selector Switch

A single, active-high switch, will be connected to its own pin on the IOCB. Operates similar to the push buttons; used for mode selection on the IOCB.

The Ham Radio "Vox" Circuit

A series of operational amplifiers and a bipolar junction transistor, wired to make a voice-activated switch, for hands-free mouth actuator movement and VRB voice detection. The design of this circuit will be similar to that of the Vox circuit commonly seen in ham radios. Audio from an external microphone will pass through multiple amplification stages and a half-wave rectifier. This remaining upper sideband signal can toggle a BJT switch connected to +Vcc. If working properly, the circuit will switch on whenever there's audio present.

MIDI Optocoupler
Transmitting over UART can be electrically unstable due to the separation of ground buses on the MIDI source and the IOCB. The use of an opto-isolator circuit links the electrical signals using light rather than physical connectivity, negating any voltage faults between the two grounds. Using a voltage source local IOCB, the MIDI bitstream will exit the opto-isolator as a stable digital signal, with all data bits uncorrupted.

Power Supplies and Voltage Regulators
The main voltage powering the entire assembly will be from external power supplies. Since CAPER's solenoid actuators require substantial current, they will be supplied directly from the high voltage supply. Lower voltages needed by the MCU and IOCB peripherals will be supplied from on-board low voltage regulators.

Actuator Relays
Relays will be used to receive low-power output signals from the IOCB and switch on to supply higher-power streams to the inside solenoid actuators.

1.6.2 The Voice Response Board (VRB)
The IOCB incorporates substantial computational resources but falls short of the specifications necessary for generating lifelike voice and movement responses. To address this, the Voice Response Board (VRB) will necessitate a chipset that offers superior processing speed, enhanced memory capacity, and greater I/O bandwidth. These enhancements are critical for supporting the sophisticated systems essential for real-time conversational interactions. Key specifications for the VRB chipset include:

- **Power Supply for Digital Pins**: Must supply power to and enable reading from at least two digital pins. This feature is vital for interfacing with non-USB devices.
- **Memory**: A significant amount of RAM is required to facilitate the swift execution of scripts and AI-driven responses.
- **USB Ports**: At least two USB 3.0 ports are necessary for enhanced UART communication speeds.
- **Clock Speed**: Essential to support the intensive processing demands of voice interaction.
- **Data Storage**: Capability to support suitable of storage space to accommodate extensive data and AI models.

The ability to produce realistic speech and interactive responses hinges on the selection of an AI model and the computational capabilities of the VRB. These outlined specifications represent the foundational requirements for the board's performance.

1.7 Software

1.7.0 Software Overview

CAPER's design requires a set of two distinct software packages. One to control the movements and hardware, and another for the robot's more advanced features. Both these systems can function independently and will be linked via serial.

1.7.1 Unified Conversation Mode (UCM)

The UCM will function as the core of CAPER's lifelike behavior, necessitating a design that prioritizes computing power and responsiveness. The software suite enabling the UCM will feature:

1. **Response Time**: The UCM will process and respond to user voice inputs within 4 seconds, ensuring a smooth conversational flow.
2. **Speech Quality**: Responses will be clear and fully intelligible.
3. **Maximum Word Error Rate (WER)**: The system aims for a maximum WER of 20% to ensure at least 80% accuracy in recognizing spoken words.
4. **Response-Relevant Movement Commands**: To add an element of expressiveness, responses will be accompanied by movement commands for CAPER, such as beak adjustments to mimic speech dynamics, adding thematic flair to interactions.
5. **Conversational (Stretch Goal)**: As a stretch goal, the system will aim to generate responses that consider previous prompts, facilitating a more natural and engaging conversation.

1.7.2 Conversation Module Overview:

The UCM will require the following systems to function effectively:

1. **Automatic Speech Recognition (ASR):** This program works to turn spoken word into text
2. **AI-based Text Completion:** This programs works to find ways to complete the input text data in a way that produces a response
3. **Text-to-Speech (TTS)**: The final stage involves converting the generated text responses into spoken words.

1.8 Constraints & Required Specifications

1.8.1 Constraints

- Time – Senior Design II takes place in the Summer semester. This is about 4 weeks less to build a working prototype than the typical Fall/Spring semesters. This project cannot have every feature we want to include due to time constraints.
- Costs – $1300 is the maximum estimated total, though prices can vary depending on the availability of parts and distributors.
- Quality – Balance between quality versus expenses. The goal is to keep CAPER as affordable as possible while providing the highest quality outputs.
- Legality – Intellectual property rights.

1.8.2 Required Specifications

These are the specifications chosen regarding current objectives and constraints. The highlighted specifications are the ones that were selected for the focus of the demonstration.

Table 1.1: Specifications

Specifications	
Movement Capability	Solenoids should be able to move the joints in a way that makes the parrot life-like with fluid motions such as head tilt, mouth movements when speaking, wing flapping, etc. Head – 45 degrees; tilt up and down Mouth – 50 degrees; open and close Body – 30 degrees; tilt up and down Wings & Tail– 45 degrees each; flap in and out
Interactive Modes	The selector switch will be used when the MIDI is inactive. The position of the switch will declare the mode the parrot is in. Turning the switch on would activate randomized movements for the head, body, and tail flap. Turning the switch off would activate total manual control using button inputs.
Dimensions	Around 1.5 ft tall. Maximum 2ft
Durability	Able to last at least two years with minimal required maintenance
Weight Limit	Maximum of 15 pounds.
Power Consumption	Maximum 40W
Cost Maximum	$1300
Response time to user input in push buttons	2 seconds
Voice Recognition	The parrot should be able to recognize when its name is called and respond accordingly with 80% accuracy.
Audio Response	Parrot should respond in a realistic manner with intelligible speech and 80% accuracy. Parrot should be easily understandable by the user.

1.9 Diagrams

Main Block Diagram

Everything within the red outline is housed in the PCB and all require an external power supply (see individual subsection diagrams)

- Blue = peripheral circuits
- Pink = external devices
- Green = microprocessor chip

****all components are to be acquired*

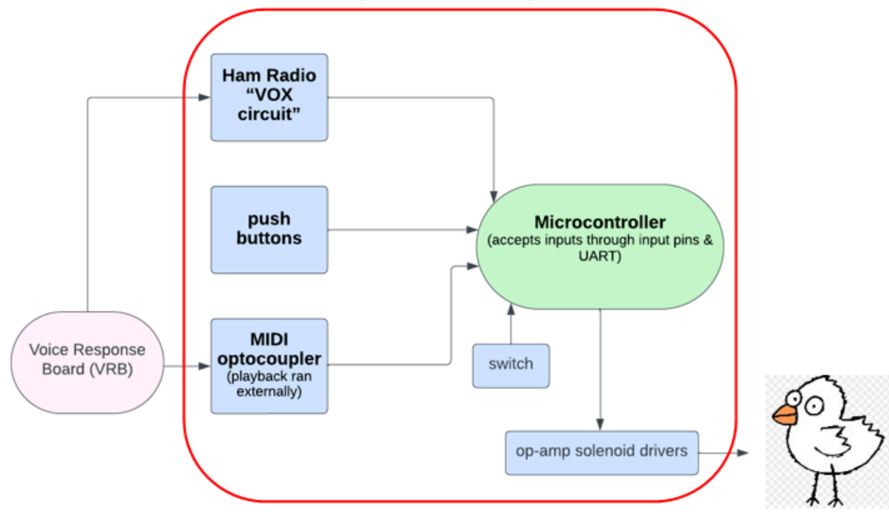


Figure 1.1: Main Block Diagram

Input Control Board Block Diagram

Blue = on PCB; requires power supply

Green = microprocessor inputs

Pink = external devices (may require separate power supply)

Blocks within red outline → VOX circuit (see main diagram)

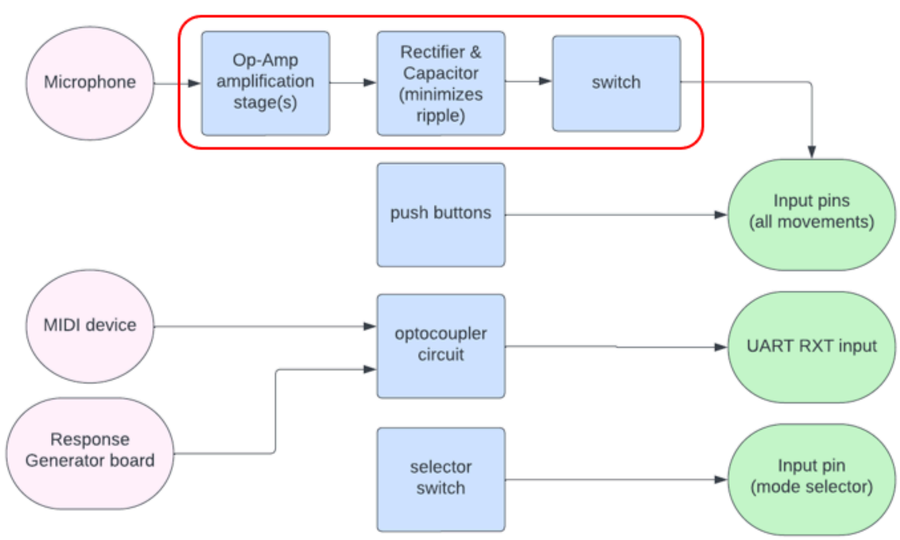


Figure 1.2: Input Control Board Block Diagram

Output Control Board Block Diagram

Blue = on PCB; requires power supply

Green = microprocessor outputs

Pink = external devices (may require separate power supply)

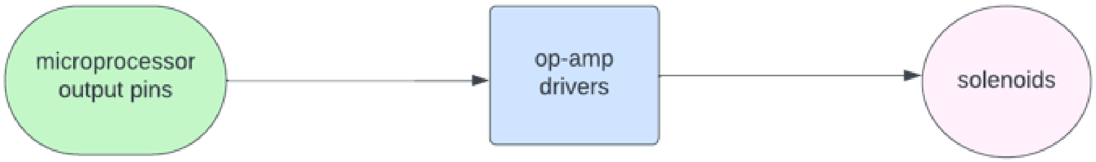


Figure 1.3: Output Control Board Block Diagram

Microcontroller Software Logic

- ❖ Blue = I/O pins as seen by the **code/program**
- ❖ Orange = hardware & external devices
- ❖ Green = pseudocode in the debugging program

****all components are to be acquired*

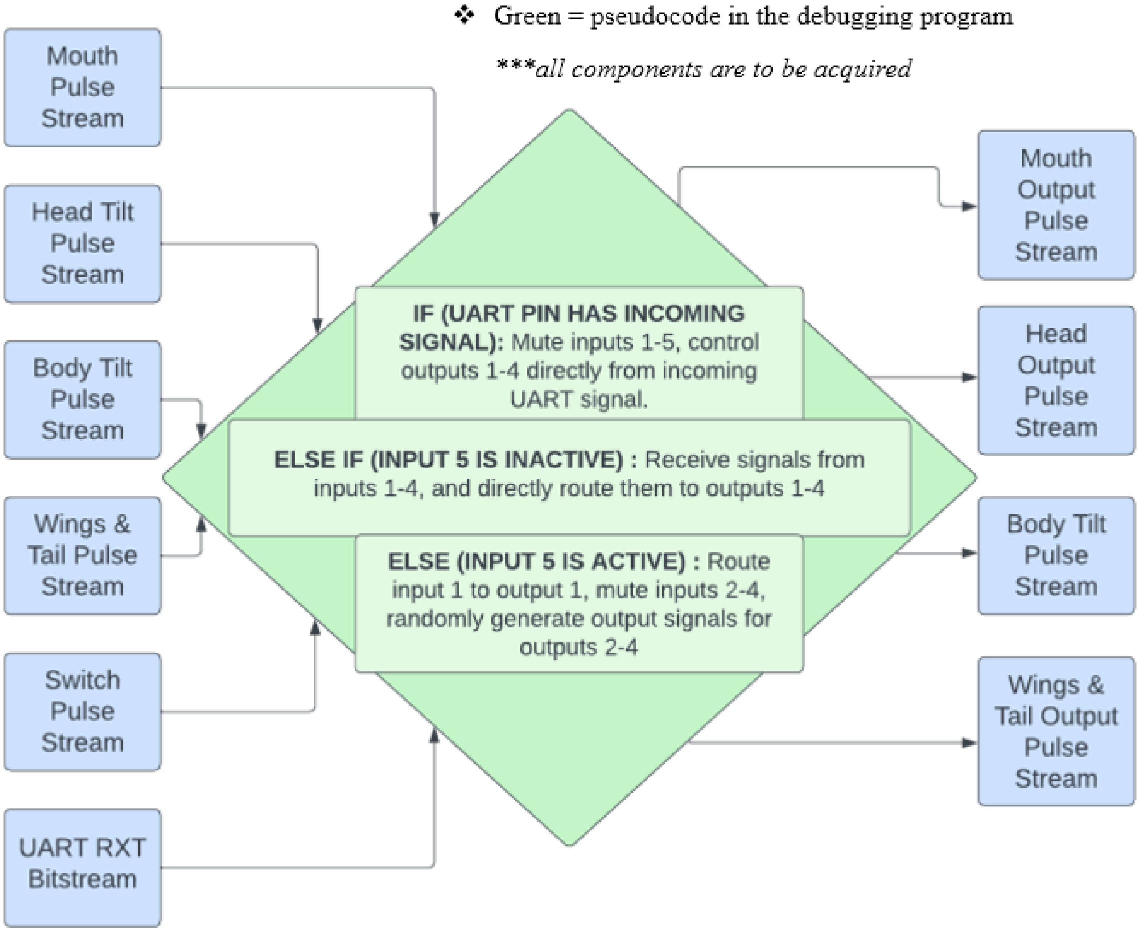


Figure 1.4: Microcontroller Software Logic

Sensor and Conversational Module Data pipeline

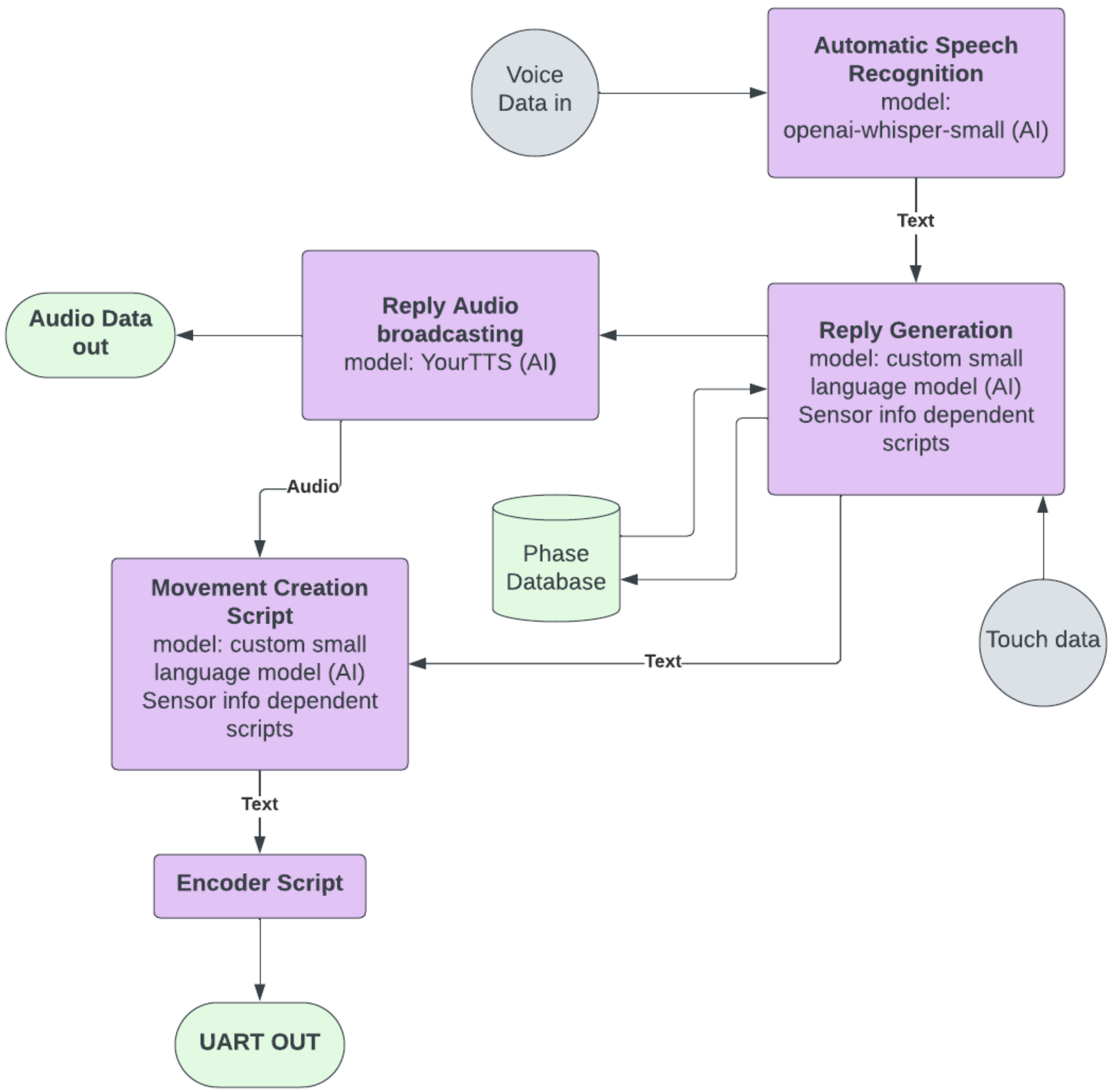
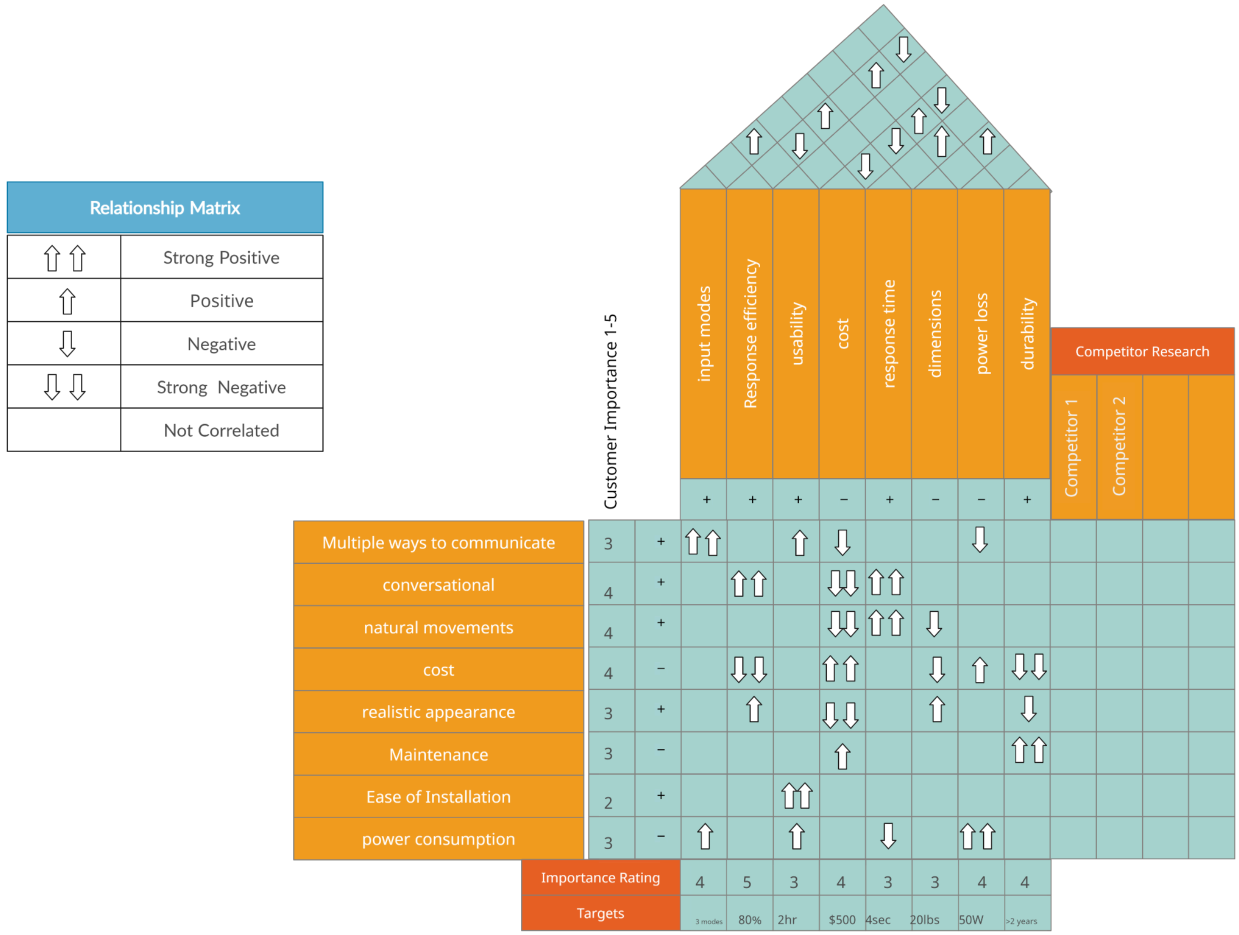


Figure 1.5: Sensor and Conversational Module Data Pipeline

1.10 House of Quality



2. Administrative Content

2.1 Finances

This project is not being sponsored by anyone, and everything is being paid out of pocket, split equally, between the four team members. Initial estimates are in the table below. Since not every component is concretely decided on, the estimated costs will increase later on in the project once all components are selected. Some items may be obtained for free from the campus labs, which would alleviate some costs. All costs were rounded up due to the possibility of needing multiple of each component for testing. The maximum budget is about twenty percent more than the estimated budget, assuming that the most expensive option for the voice response board is chosen, so there is wiggle room for trial and error. Still, it is preferable to keep this project as affordable as possible and stay well below $1300.

- Goal budget: below $1300
- Estimated total: $1055

2.2 Bill of Materials

This is the tentative bill of materials. The voice response board has a large price range due to uncertainties due to how far we want to go with the AI. To be updated as more research is conducted.

Table 1.2: Bill of Materials

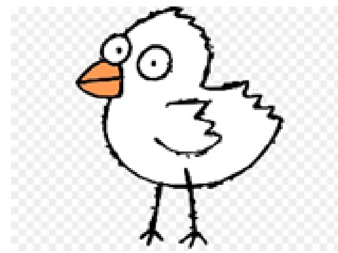
Part	Estimated Cost	Quantity
microcontroller	$5	1
Voice response board (VRB)	$200-700	1
12 V power supply	$20	1
op-amps	$10	8
camera	$50	1
Microphone	$0 (already acquired)	2
Touch sensor	TBD	TBD
Board enclosure	$25	1
Relays	$20	4
Voltage regulators	$20	4
Buttons & switch	$15	4, 1
Miscellaneous materials (to build robots)	$100	TBD
Internal skeleton (wood & metal)	$30	TBD
Solenoids	$10	4
PCB material	$50	TBD

2.3 Distribution of Worktable

The table below shows how the tasks have been divided between the members. Each member has an overlapping task to promote collaboration and teamwork. All members are aware of and involved in every aspect of the project even without having the assigned task.

Table 1.3: Distribution of Worktable

Task	Primary	Secondary
AI implementation	Paco	Kellen

Sensors	Kellen	Sarah
Embedded systems	Kellen	Billy
Circuits	Billy	Sarah
PCB design	Sarah	Paco
Organization	Sarah	
documentation	Paco	
Construction	Kellen	
Project lead	Billy	

2.4 Project Milestones

This team formed over winter break and began brainstorming just before the start of the spring semester in preparation for Senior Design I. For the milestones, the cells in blue are in reference to project documentation and the cells in pink are in reference to project design. The tentative deadlines are in the table below, but we plan on completing the report much earlier to get ahead on Senior Design II. We plan to order our PCB early to have extra time for testing and assembly.

Table: 1.4: Senior Design I Project Milestones

Task	Description	Anticipated competition date	Duration
Senior Design I Documentation			
Discuss project ideas	Member meeting to discuss project ideas	Already completed	1 week
Choose Project	Member meeting to finalize project choice → animatronic → ER	Already completed	1 week
Advisor/ Reviewer selection	Choose and email reviewers → Dr. Piotr Kulik, Dr. Vikram Kapoor, ____	2/9/24 (in progress, 2/3 professors chosen)	2 weeks

Work on Divide & Conquer	Member meetings regularly to work on the paper together + discuss future aspects. Sections have been divided between members	2/2/24 (in progress)	2 weeks
Chan Discussion	Discuss the project + specifications with Dr. Chan	2/8/24	30-minute Zoom call
All component selection	Tentative BOM + decide on all main components needed for the hardware	3/3/24 (in progress)	4 weeks
Additional Research	Finalize research and sources for the final report	3/3/24 (in progress)	4 weeks
60 page milestone	The halfway point of the report	3/27/24	4 weeks
System Design	Making the overall schematic of the project	3/27/24	4 weeks
Final Document	Completion of the 120-page final document.	4/24/24	4 weeks
Breadboard Prototype(s)	Completion of the breadboard prototype	4/24/24	4 weeks
PCB design & order materials	Completion of PCB design + ordering all materials; complete BOM	4/30/24	3 weeks

Task	Description	Anticipated competition date	Duration
Senior Design II Documentation			
PCB testing	Assembling PCB + testing all parts to ensure they work properly	TBD	TBD

Integration	Test and integrate individual systems	TBD	TBD
Finalize documentation	Completed documentation of the entire project	TBD	TBD
Final project PowerPoint	Complete final presentation PowerPoint + practice final presentation	TBD	TBD
Final presentation		TBD	TBD

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