Designing Ubiquitous and Interactive Computing Devices Final Project Write-up

RoboNeko: An Interactive Companion Robot Cat

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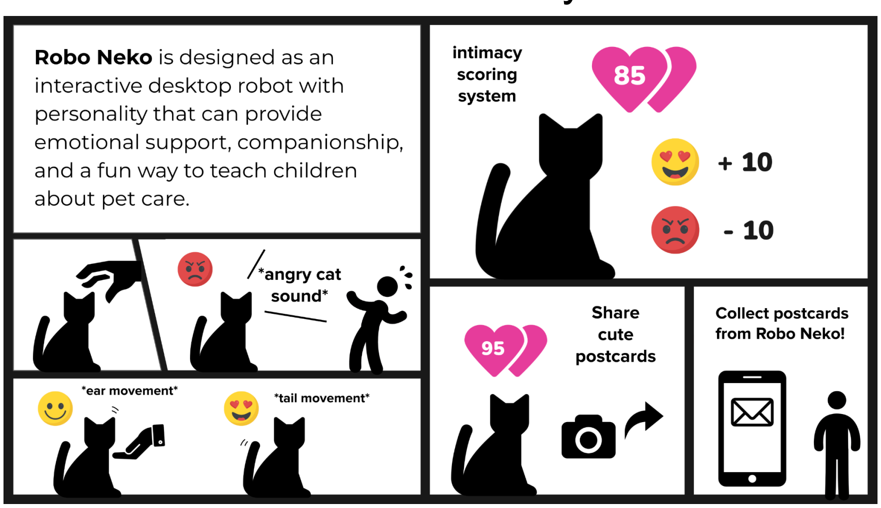
Introduction

In a world increasingly driven by fast-paced digital interactions, many people, especially children and the elderly, find themselves in need of companionship that is emotionally supportive yet low-pressure. RoboNeko is our response to that need: a small, expressive robotic cat designed to offer meaningful interaction through simple, tactile engagement. Inspired by nostalgic digital companions like Tamagotchi and Travel Frog, RoboNeko combines the emotional warmth of a pet with the simplicity and accessibility of a toy.

Unlike traditional robotic pets, RoboNeko introduces a gamified intimacy system and personalized petting preferences, making each interaction feel unique and emotionally resonant. Users build a relationship with RoboNeko by discovering how it likes to be pet—gaining trust and unlocking rewards like themed digital postcards. Through its responsive physical movements, sounds, and evolving personality, RoboNeko encourages empathy, patience, and emotional connection.

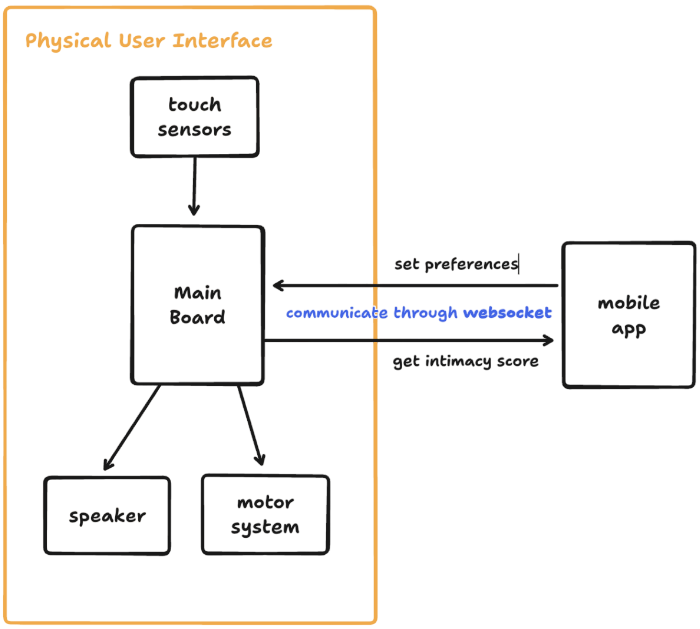
Our project blends playful design, social robotics, and emotional computing into a compact, low-maintenance companion that brings joy to users of all ages. Whether teaching children about pet care or providing comfort to those experiencing loneliness, RoboNeko aims to reimagine how we connect with technology and with ourselves.

Planned Interactions and Storyboard



High-Level System Design

RoboNeko is composed of three main components: a 3D-printed physical interface, internal hardware embedded within the robot cat, and a dedicated companion mobile application. Below is a system overview of our design. The high-level architecture diagram shows that the input of the main board is touch sensors, and the outputs are a speaker and a motor system. Moreover, the main board communicates with the mobile app through WebSocket, supporting the functionalities of rewarding users with postcards and editing the cat's petting preferences.



Supplies

Supply Name	Amount
8-Channel PWM or Servo FeatherWing Add-on For All Feather Boards	1
Servo Motors	4
FeatherWing Tripler Mini Kit - Prototyping Add-on For Feathers	1
Speaker	1
Microsd Card	1
Music Maker Featherwing w/ Amp	1

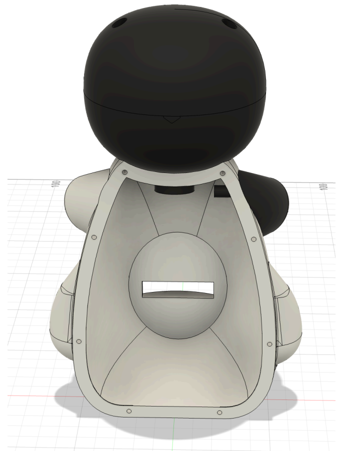
Conductive PLA Filament	1
Battery	1

Components Deep Dive

Physical User Interface

RoboNeko, as a companion social robot, is designed with a visually appealing appearance to encourage users to form an emotional connection with it. To align with the theme of sending postcards to users, the cat carries a camera around its neck. The design consists of multiple separate components, including two movable parts (the hands and tail) and five conductive touch-sensing areas (the ears, chin, belly, and back). These parts are printed individually and assembled after wiring for their specific functions.

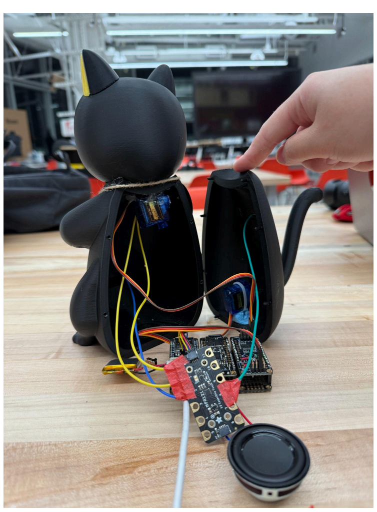
While RoboNeko's physical user interface needed to be aesthetically cute to invite interaction, it also had to house the entire system to achieve an all-in-one design. Therefore, most of RoboNeko's body is hollow, serving as an enclosure for the control board, motors, speakers, and battery. Initially, we also planned to include openings for the power switch and charging port. However, the placement of the board and internal wiring could not be finalized until the physical prototype was printed. This revealed the need for further design iterations to improve the user experience, especially in powering the device without opening the case.

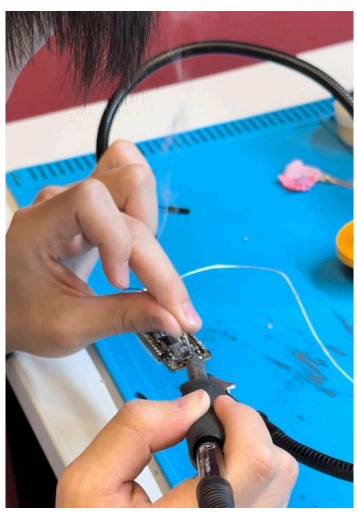


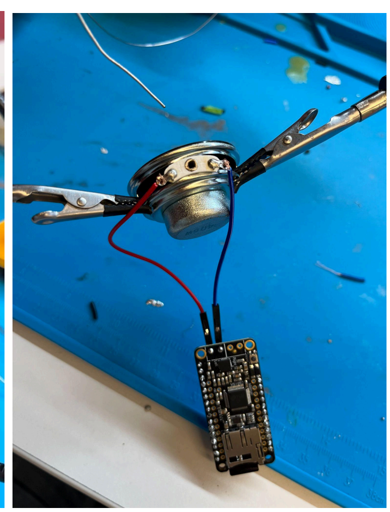
Wiring & Board Development

We stacked the ESP32 Feather board with the Music Maker FeatherWing and the Servo Motor Controller board. The capacitive touch sensor is connected to the main board via I2C communication. Two servo motors, attached to the hand and tail, are triggered by input from the five capacitive touch-sensitive parts. These touch-sensitive components are 3D-printed using conductive PLA filament, and wires are soldered directly to them.

For the ears and chin, the wires are routed through the head to connect with the touch sensor board. For the belly and back, we created openings in the outer shell to guide the wires from the exterior to the interior. Additionally, a speaker is connected to the Music Maker FeatherWing, allowing RoboNeko to make happy and angry sounds, which were stored on an onboard SD card.







Board Development

The main board (ESP32-S2) is programmed using the Arduino framework. The code can be found at the [GitHub repository](). The system receives the signals from the touch sensors, triggers the motor servos and speaker, and communicates with the mobile app client through a web socket. To achieve this, the program maintains the following variables: touchSensorMap, preferenceMap,preferenceToAction, and intimacyScore.

Variable	Description	Example

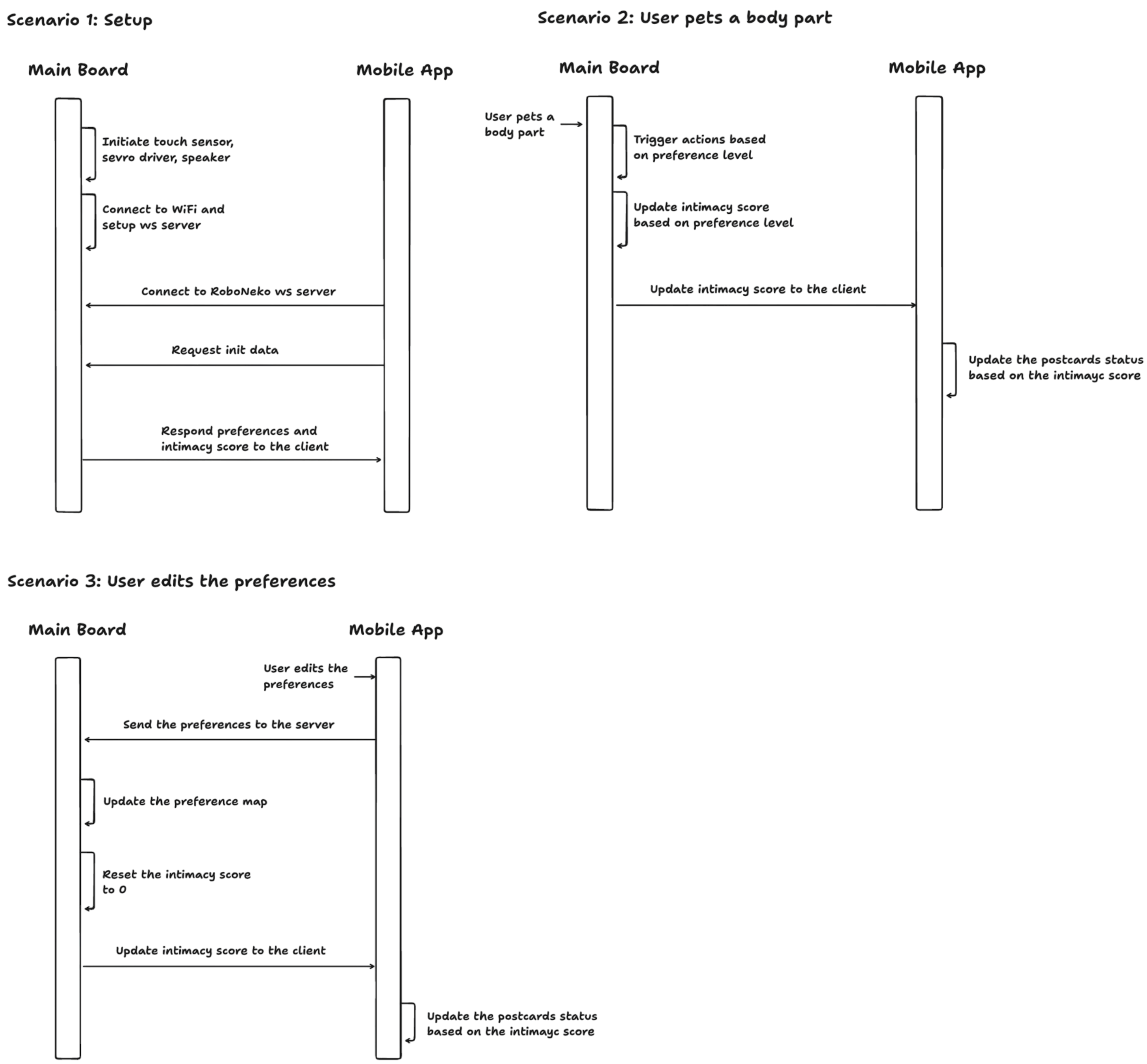
touchSensorMap	Map touch sensor number to a pettable body part on RoboNeko, including head, ears, belly, and back.	`{`
		`6: "head",`
		`0: "ear_left",`
		`1: "ear_right",`
		`2: "belly",`
		`8: "back"`
		`}`

preferenceMap	Record each body part's preference levels, ranging from 0~3, and they are allowed to change by the app. The higher the preference level, the more RoboNeko enjoys being pet on that body part.	`{`
		`"head": 0,`
		`"ear_left": 2,`
		`"ear_right": 2,`
		`"belly": 1,`
		`"back": 3`
		`}`

preferenceToAction	Define the actions response by RoboNeko under each preference level. Now we have four different actions: angry sound, tail move, hand move, and meow sound.	`{`
		`0: ["anygrySound"],`
		`1: ["tailMove"],`
		`2: ["handMove"],`
		`3: ["meowSound"]`
		`}`

intimacyScore	An integer that is initialized to 0. When the body parts are pet, the value will increase by its preference level.	`30`

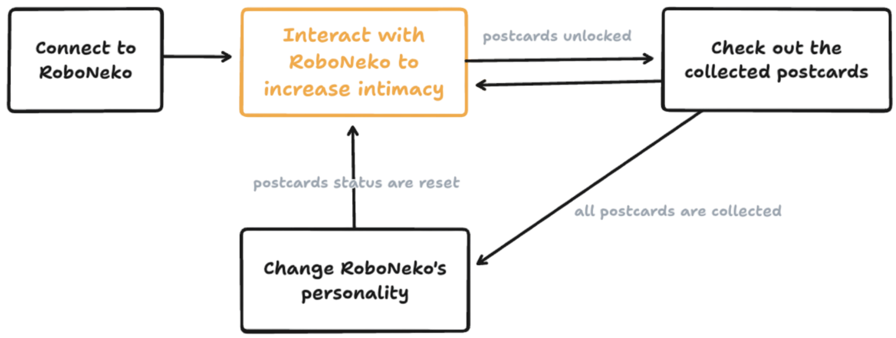
Here are the sequence diagrams of essential scenarios:



Mobile Application

We developed a mobile companion application to enhance user engagement and enrich the interaction experience. The mobile application was developed using React Native with the Expo framework and tested on both an iOS simulator and an iPhone 14 Pro. Most of the visual assets were generated using ChatGPT-4o, guided by style reference images and custom prompts, followed by manual refinement. The code can be found in the GitHub repository.

User Flow



Once RoboNeko is powered on, users can connect the companion app by entering its IP address in the settings popup. They can then begin interacting with RoboNeko by petting different body parts to increase intimacy. As previously noted, RoboNeko has preferences for where it likes to be pet. In addition to triggering different behavioral responses, intimacy scores increase based on these preference levels, which can be customized or reset in the "Catsonality" screen. As users build intimacy, the system rewards them by unlocking digital postcards in the "Postcards" screen.

Features

<table>
<tr><th>Description</th><th>Feature Screenshots</th></tr>
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Home Screen

- Cat icon button: navigate to "Catsonality" Screen
- Gear icon button: open settings popup modal
- Postcards button: navigate to "Postcards" Screen

Settings Popup Modal

Enter the WebSocket IP of RoboNeko and press the "Save" button. The indicator under the input will turn red to green and show "Connected".

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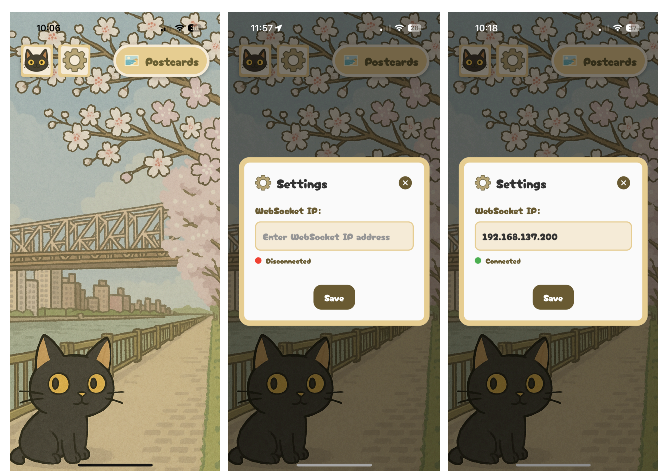

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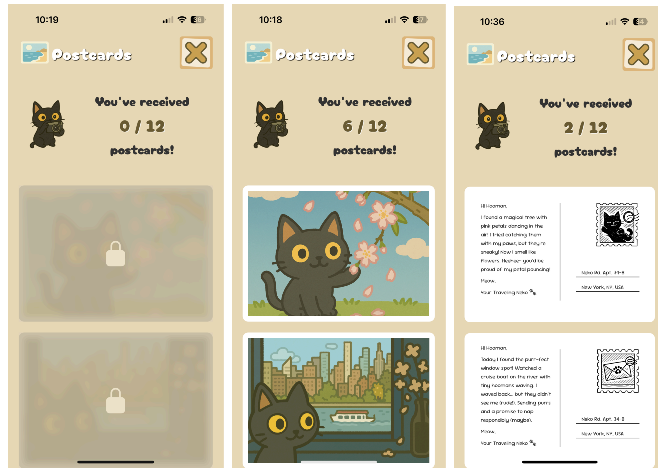
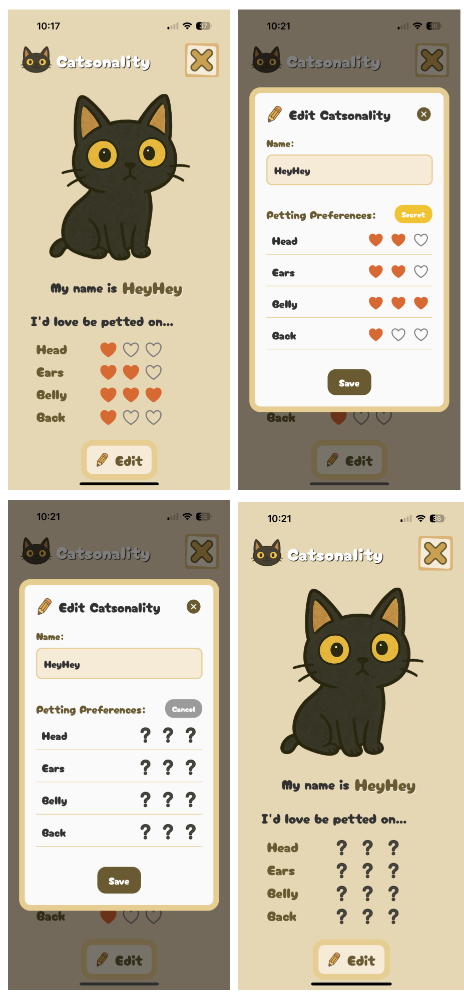
Postcards Screen The system includes 12 Roosevelt Island-themed postcards, each featuring unique text and a custom stamp, designed to simulate RoboNeko sharing its life from its own perspective **[Appendix 1]**. These postcards are initially locked, and users must interact with RoboNeko to unlock them. Once a postcard is unlocked, the user can tap it to flip it over and reveal its content. The intimacy thresholds required to access each postcard are defined within the app but remain hidden from the user to preserve a sense of discovery.	
Catsonality Screen This screen displays the RoboNeko's name and its preferred body part for being pet, scoring from 0~3. The user can click the "Edit" button and modify the petting preferences and name in the popup modal. **Secret Preferences** In the edit popup modal, clicking the "Secret" button changes the heart icon to a question mark, indicating that RoboNeko's preferences will be randomly assigned. Users must then discover these preferences through interaction, creating a more unpredictable and engaging experience.	

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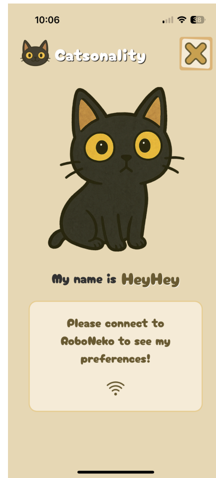
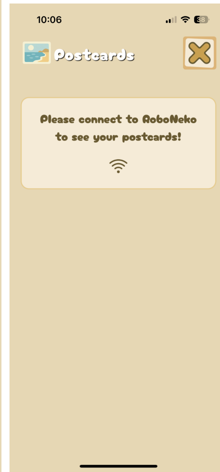
<td>Disconnected Mode

When the app is not connected to the web socket server, users cannot access and edit preferences or view postcards to prevent unexpected status and behaviors.</td>
<td>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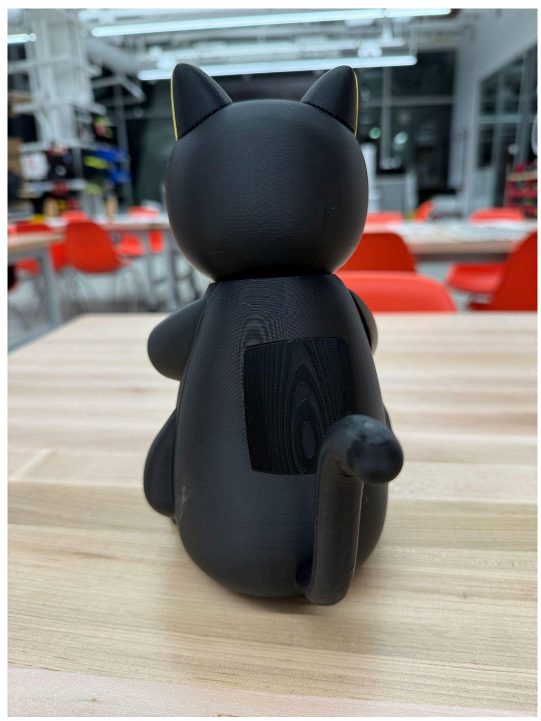
Final Builds

Video

RoboNeko-demo.mov

https://drive.google.com/file/d/1PeYxYGWQ7CluYhgMN0gPheGK9jN9ld7c/view?usp=sharing

Discussion

Our goal in developing RoboNeko was to explore how physical interaction, personality-driven behavior, and a sense of reward could create an emotionally engaging robotic companion. We assumed that users would find joy and connection in discovering RoboNeko's preferences through touch and that responsive, pet-like behaviors would make the experience feel both playful and meaningful. We also expected that embedding a real-time camera would enhance the illusion of autonomy by allowing RoboNeko to "send" snapshots of its life to users.

Some of these assumptions were validated. Notably, our implementation of touch interaction exceeded expectations. We initially used copper foil for testing touch functionality due to its simplicity and flexibility. Once the sensing mechanism was confirmed to work as intended, we switched to conductive PLA, which provided better integration with the 3D-printed form and improved durability. This transition validated our design strategy for embedding tactile feedback directly into the robot's physical structure. Additionally, we used AI to generate custom stamps, postcard visuals, and written content in the black cat's playful and mysterious tone under various interaction scenarios. This added a fun and engaging narrative layer to the experience, reinforcing the emotional connection between users and RoboNeko.

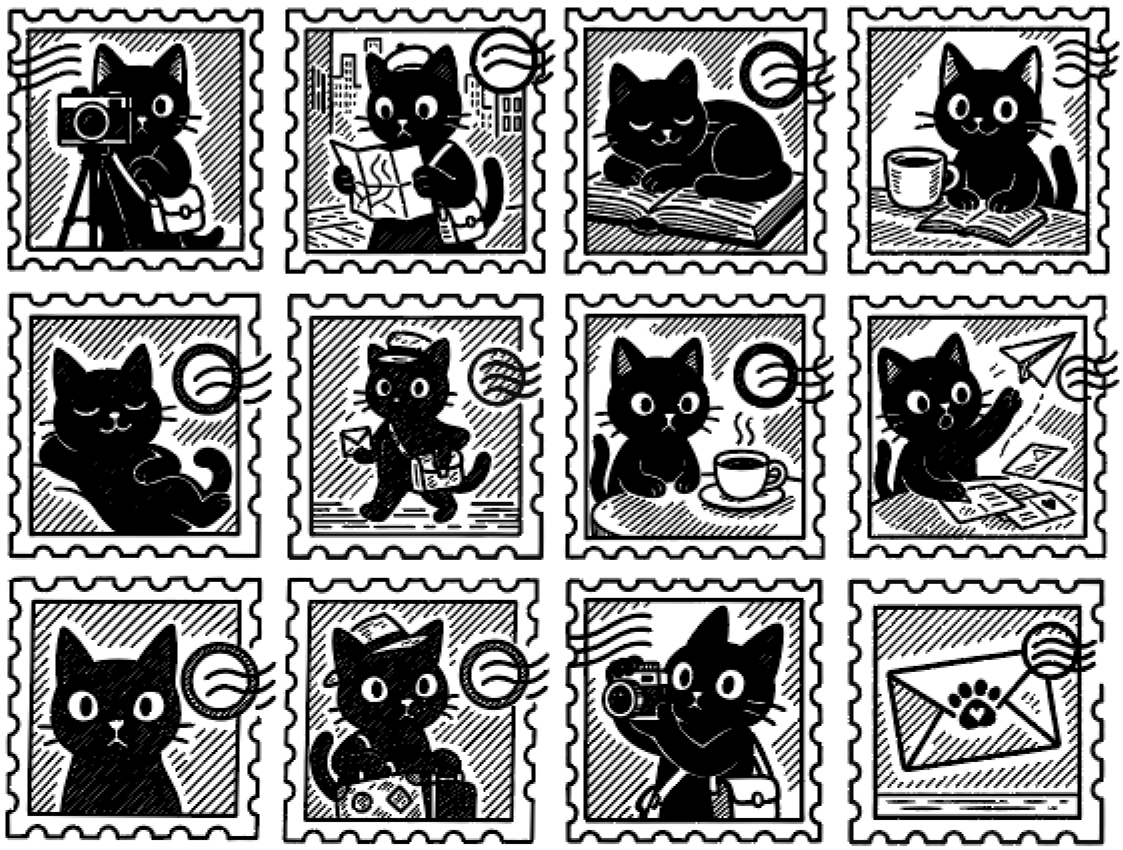
However, several technical challenges led us to revise our original plans. The camera board faced persistent connection issues, which made it unreliable for capturing real-time photos. As a result, we pivoted to using a set of pre-designed postcards. While this still allowed us to convey RoboNeko's "perspective," it limited the system's dynamic responsiveness and reduced the feeling of spontaneity we had hoped to achieve.

We also faced difficulties with the motor system. The wiring between servo motors and joints proved to be unstable during movement, occasionally preventing parts like the ears, tail, or hand from responding correctly. Additionally, some movements were not well accounted for in the physical design—for instance, the hand sometimes collided with the cat's camera due to insufficient clearance. These issues highlighted the need for more precise movement planning and iterative testing. We had initially intended to include head movement as well, but due to spatial constraints in internal space, we had to abandon this feature.

Through this process, we learned the value of designing with hardware limitations in mind and the importance of physical prototyping at an early stage. Iterative testing is crucial not just for refining functionality but also for ensuring the integration of moving parts in confined spaces. We also recognized the importance of flexibility in design—being able to adapt when certain components fail or don't meet expectations. Despite the challenges, RoboNeko succeeded in delivering a playful, emotionally engaging experience.

Appendices

Vibe Designing with ChatGPT - Stamps



Vibe Designing with ChatGPT - Postcards


POTATO CHIPS
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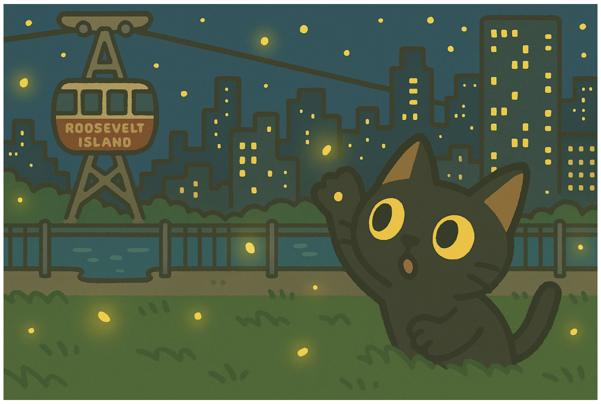
ROOSEVELT
ISLAND