BE 5140 - Rehab Engineering and Design

12/15/2023

LUCK-E: A Life Uplifting Companion Kitten for Emotional Well-Being

Group 2: Anh Nguyen, Camila Zhan Jin, Shuyan He, Ashwin Suvarna

Description of the Patient and their Needs

Mr. Li is a 63-year-old Chinese adult male living in Philadelphia who is facing a variety of physical and mental challenges, including hypertension (high blood pressure), mixed hyperlipidemia (high fat levels), gum diseases, chronic back pain, and early onset intellectual disabilities which result in mood disorder and depression throughout the day. Due to these health deficits, he requires a 24 hour caretaker. Although Mr. Li has limited language and processing abilities, he has a middle school level of education from China, can speak both Cantonese and English, and is capable of answering yes/no questions, completing basic math problems, and writing Chinese characters. Spending most of his time with caretaker In his downtime, Mr. Li enjoys watching Chinese movies, particularly drama/martial arts, and anime shows. He also has an appreciation for nature and bird watching in particular, but his back pains hinder his ability and enthusiasm for any physical activities. His daughter, who serves as his legal guardian, manages his care and wishes for him to stay connected with friends, family, and the world. To address his day-to-day activities, a social robot companion with multiple support behaviors and one survival behavior (battery life alert) is required to remind him to stay on task with his hygienic, medical, physical, and emotional needs.

Assumptions Made to Flesh Out Case

- Mr. Li's mental disability is caused by a birth defect and not by a childhood fever
- He has gradually developed hypertension, mixed hyperlipidemia as an adult, and several gum diseases as an elderly adult
- He uses assistive technology for movement (given his age and health conditions)

- Mr. Li is required to stay updated with his hygiene, medication, and physical and emotional health 7 days a week
- “Physical Activity” requires going for walks outside
- A caretaker will be available to carry LUCK-E for Mr. Li when needed
- Mr. Li likes cats, as they also enjoy nature and bird-watching

Disability Curve

Mr. Li's initial overall functional status began at 80%, assuming that his mental disability was caused by a birth defect and not a childhood fever. As Mr. Li gets older, he has gradually developed some health conditions such as hypertension and mixed hyperlipidemia which lowered his overall disability curve. As an elderly adult, he has also developed several gum diseases that resulted in a drastic yet steady drop in his functional percentage. Over time, he has also developed chronic back pain that has further reduced his functionality curve. We assume that given his age and health conditions, he uses assistive technologies (e.g. a walker) that have improved his overall functionality which reached a plateau over a short period of time.

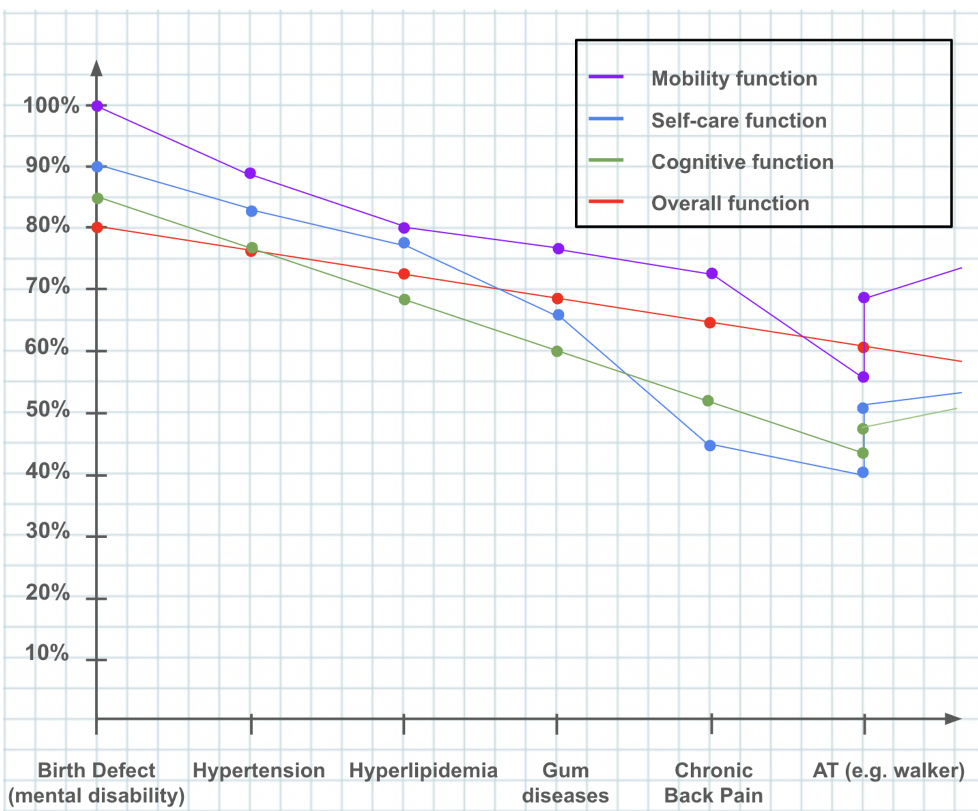


Fig.1 Disability curve of Mr.Li, showing his mobility, self-care, cognitive, and overall function over time.

HAAT Model

Human	Activity	Context	Companion Robot
• 63 year old, Chinese male • Lived in Philly for 32 years • Hypertension • Mixed hyperlipidemia • Gum disease: teeth and bone loss • Will require dentures • Chronic back pain • Mental retardation • Mood disorder and depression • Needs 24 hr care taker • Childhood fever or birth defect might have cause mental disability • Completed middle school in China • Speaks Cantonese and English • Limited verbal language/processing (Y/N questions) • Limited mental capacity • Physically able to some minor back pain	• Write Chinese characters and labeling things • Does not exercise much (should be encouraged to walk more) • Enjoys nature and watching animals (eg. birds) • Enjoys watching Chinese movies • Stay better connected with the world, family, and friends who speak Cantonese • Likes dancing	• Lives near Philadelphia Airport and Wild Refuge Park • Has caretakers • Mostly at home • Goes to YMCA to dance • Outdoors to watch animals • Family: daughter (mid 30s as legal guardian)	• System to support remind/reward him to take medication and to complete dental and general hygiene • Companion to calm him down when he acts up from his mood disorder/depression • Help him stay connected to the world and family • Survival behavior so that it alerts to battery life • Encourages him to walk more • Resemble a cat • screen/projector on the stomach • Dispenser for his medication • Receives what he says and responds (in Cantonese and/or English) • Video call capabilities • Affordable • Lightweight/portable

Design Priorities

Mr. Li needs a social robot companion with multiple support behaviors that keep him company and help him stay on task with his daily hygienic, medical, physical, and emotional needs. Therefore, we have classified the design priorities into two groups:

Primary Priority: focuses on Mrs. Li's principle needs to center around creating an interactive companion with multiple reminders and alert systems.

- Reminder/reward system for hygiene and medication
- Companion to calm him down from his mood disorder and depression
- Stay connected with family and friends
- Battery life alert
- Screen display

- Medication dispenser
- Activity reminder

Secondary Priority: focuses on additional features that increase user-friendliness and the interactivity between Mr.Li and the social robot

- Dual language (Cantonese and English) capabilities
- Affordability
- Lightweight/Portability
- Maintain a conversation with Mr. Li

State of Art Analysis

In order to help maintain his physical routines as well as document his emotional status, Mr. Li would benefit from a cost-effective, low-maintenance, high-tech therapeutic robot capable of keeping track of his needs. There are many existing state-of-the-art devices available on the market that could potentially aid in Mr. Li's life, such as the Kismet (Appendix, Fig.1), which provides expressive facial features which react to human speech, the Tico (Appendix, Fig. 2) which is fit with a large monitor touchscreen for interactive purposes, the simply designed and lightweight Jibo (Appendix, Fig. 3), as well as the Paro (Appendix, Fig. 4), the soft plush seal fit with reactionary animal movements. While each of these robots may fit the individual requirements, their overall functional drawbacks in the context of Mr. Li's environment prevent them from providing optimal life improvement. The greatest disadvantage of these robots in Mr. Li's case is their overall cost. Due to their sophistication and universality in design, purchasing these devices would place an unnecessary burden on Mr. Li.

A robot companion equipped with a range of supportive behaviors and a crucial survival function is essential to help Mr. Li maintain focus on his mental health, hygiene, medication, and physical activity. Developing a HAAT Model identified a variety of social robot requirements specific to Mr. Li that would be crucial to the final design. In addition to an audiovisual tactile-responsive system that would help him complete daily tasks, as well as animatronic features of a beckoning lucky cat, the device would also need to be able to maintain these behaviors throughout the entire day on its battery life. With all of these considerations in mind, multiple intermediate design options were developed based on existing design principles and tensions, all while keeping Mr. Li's particular needs in mind throughout the process.

Intermediate Design Process

Inspired by the Paro design (Appendix, Fig. 4), we opted for a soft plush robot approach. We came up with several designs such as a panda-shaped robot as pandas are a symbol of peace and luck in Chinese culture, a parrot design that resonates with Mr. Li's bird-watching hobbies, and a lucky cat that aligns with Chinese cultural aesthetics. After careful consideration, we ultimately decided to choose the lucky cat because of the profound cultural significance that lucky cats hold in China, where they are seen as powerful symbols of good fortune. The chosen design honors Mr. Li's cultural background and provides a robotic companion with a touch of tradition and positivity.

During the initial brainstorming stages of the social robot, the focus was primarily on function and meeting Mr. Li's highest priority needs. Based on his current lifestyle and conditions, it was imperative that the robot would be capable of providing Mr. Li with a more structured lifestyle through audiovisual aids. Those same aids would also need to be able to keep track of his progress and emotional health so that he is able to stay consistent with his daily activities of brushing twice a day, followed by showering, taking medication, and performing physical activity at least once a day. Once this routine was determined, implementation of a touchscreen display on the robot was agreed as the best solution for Mr. Li to be able to receive alerts as well as directly interact with the robot, so as to avoid disinterest. Since touch screens require a significant amount of processing power which cannot be handled by the Arduino alone, a Raspberry Pi 4 with 4GB RAM was purchased and integrated into the design to complement this deficit. In order to ensure the robot can be carried around (rather than tethered to an outlet for power), a PiSugar S Plus portable battery was purchased.

While the Pi would help run the displays of each reminder on the screen, an Arduino UNO would be utilized to activate several servo motors and sensors to bring the robot to "life". Our goal was to enhance the interactivity of the cat robot by incorporating features like touch responsiveness, waving arms, and a collar. For touch interaction, we envisioned sensors placed on the head that would enable the cat to react to touch. To simulate body movement, we opted for servo motors, leveraging their rotational capabilities. The challenge was determining where to place the actuators—eyes, mouth, and ears were all considered. Ultimately, we settled on the ears, as the natural movement of flapping ears in cats signifies happiness or attentiveness, creating a playful dynamic between the robot cat and Mr. Li. In terms of petting, we initially had the idea of using a force sensor activated by squeezing, but we found that a touch sensor mimicked petting better.

Arms also hold profound symbolic importance in lucky cats, where the raising of the right arm signifies protection and the raising of the left arm signifies fortune. Inspired by the cultural meaning behind the arms of the lucky cat, we envisioned incorporating a meaningful function into both arms. For the right arm, we decided to integrate a medication dispenser under a fish-shaped cover which aligns with the concept of protection, offering Mr. Li a sense of security and health when taking his medication. Inspired by the automatic hand sanitizer dispensers, we aimed to create a medication storage system for pills that would open upon sensing the presence of a hand. To achieve this, servo motors were used with a blocker to maintain the dispenser in a closed position. Upon activation, the dispenser would rotate 90 degrees briefly for 1 second and return to its original position to close the dispenser. To trigger the servo motor, we initially opted for an ultrasonic sensor due to its ability to measure distance. The servo would turn on and rotate when a hand is detected at a minimum distance of 8 cm from the sensor. For better accuracy, we substituted the ultrasonic sensor with a time-of-flight distance sensor.

The left arm of our lucky cat acts as an interface between the Arduino and Raspberry Pi components. Originally we aimed to use it as a medication reminder for Mr. Li. We reconsidered its functionality to maximize interaction and engagement. Recognizing the symbolism associated with the cat's raised right arm representing fortune, we decided that having the cat wave its left arm multiple times a day would offer a delightful and meaningful interaction with Mr. Li. For the Arduino component, we implemented a servo motor mechanism that carries out a 90-degree rotation, lifting the arm upward and returning to its initial position. This motion is repeated twice every time a reminder or questionnaire is displayed on the Raspberry Pi's screen. This synchronization between the left arm's movement and the Raspberry Pi's functions enhances the overall user experience. To seamlessly integrate the Arduino with the Raspberry Pi, we established a serial communication system between the two components, ensuring efficient coordination and communication (Appendix B).

Lastly, we had the idea of adding a collar to the robot so that it resembles a real cat. We wanted to use the ornament hanging from the collar as a battery display system that will notify Mr. Li to change the battery when it is running low. To achieve this, the Arduino will read the input voltage and turn on a green LED in the collar when there is a high battery and turn on the red LED when the battery is running low. This battery status display ensures that Mr. Li remains informed and can promptly replace the battery, preventing any unintended abandonment of the robot due to a perceived malfunction.

To enhance our design process, we implemented a systematic approach by developing a comprehensive chart featuring three primary modules: the Arduino components, the Raspberry Pi, and the outer shell of our robot. Within each module, we outlined the tasks and their corresponding behaviors (Appendix A, fig. 8).

Design Considerations

There are several design considerations that we used throughout the design process. Given that Mr.Li has limited verbal language and processing capabilities, we made sure our device is *simple and intuitive to use* (Universal Design Principle 3). All the functionality that we considered is automated, eliminating the need for Mr. Li to undergo a setup process or learn intricate procedures. Mr. Li only has to carry out familiar actions such as petting the robot as he would with a real pet, and placing his hands near the medication dispenser for easy access to pills. We also included *perceptible information* (Universal Design Principle 4) by adding a large touchscreen with buttons for interaction, visual presentation of the reminders, and different modes for different types of reminders. To minimize the *tolerance for error* (Universal Design Principle 5), we placed the screen and sensors far away from each other, minimizing the chance of misusing the features and discouraging unconscious actions. Given Mr. Li's chronic back problems, we want to create a robot that requires *low physical effort* (Universal Design Principle 6) which allows Mr. Li to maintain its neutral body position without the need for excess physical effort. Some design tensions that we considered are including, but not limited to, identity vs ability, complexity vs simplicity, and fashion vs discretion. When it comes to identity vs ability, we chose the lucky cat due to its significance in Chinese culture. Given that Mr. Li is originally from China, it became particularly significant for us to develop a social robot that not only serves as a companion with diverse abilities but also accentuates his identity, fostering a sense of connection and comfort in his interactions with the robot. In the context of *complexity vs simplicity*, we really wanted to use technology. Given Mr. Li's limited verbal and learning capabilities, our goal was to incorporate technology and complex features utilizing both Arduino and Raspberry Pi and create a simple-to-use and user-friendly interface, ensuring that Mr. Li's interaction with the robot remains simple. Regarding *fashion vs discretion*, our objective was to achieve a close resemblance to a lucky cat, as illustrated in our initial design concept (Appendix A, Fig. 7). The intention was to avoid an odd appearance and instead cultivate a discreet aesthetic. We deliberately selected skin colors in shades of gold, white, and black which were chosen not only for their fashionability and visual appeal but also for their symbolic significance, representing happiness, warding off negative energy, and wealth, all of which hold significant importance for Mr. Li.

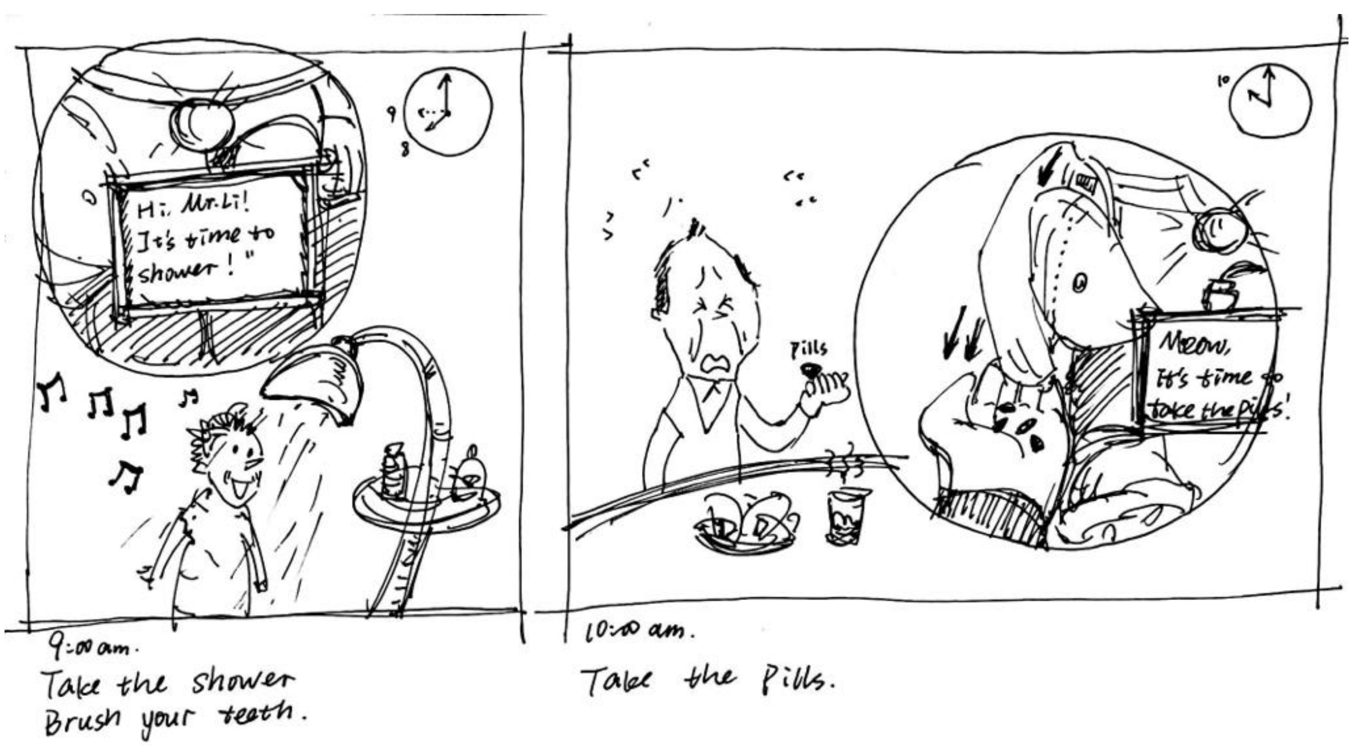
Final Design

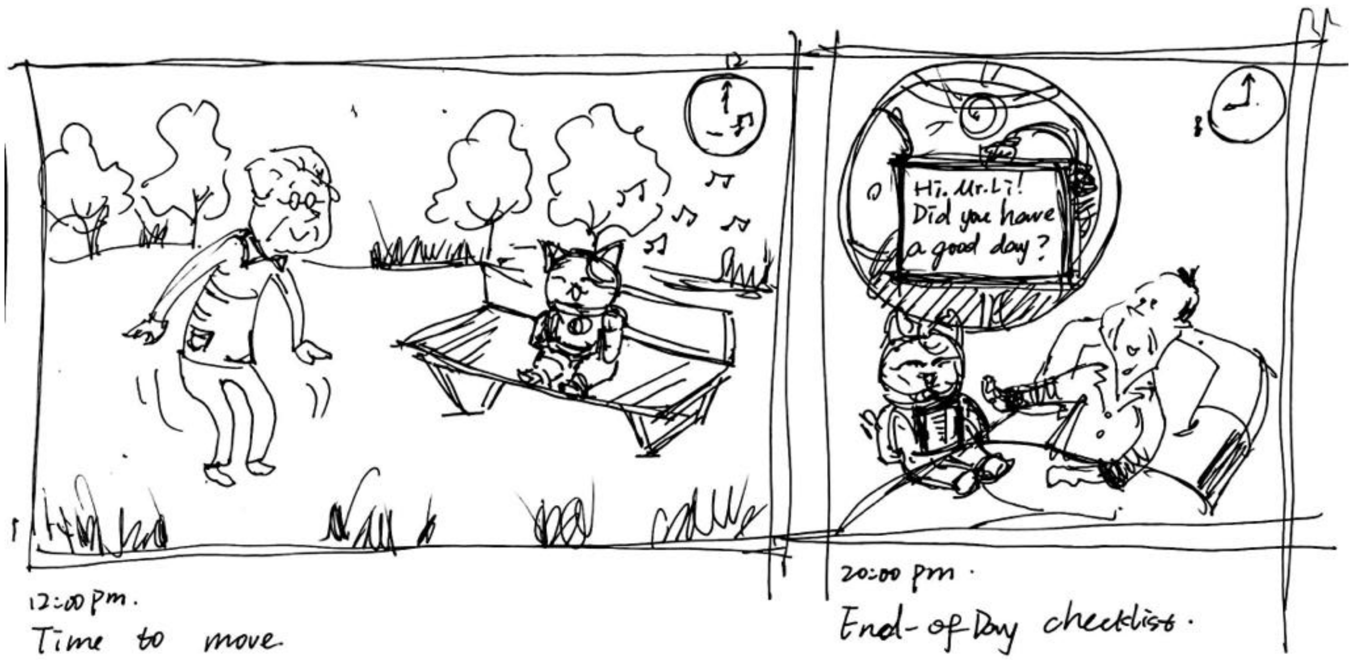
We first crafted the framework for the lucky cat, creating a precise CAD model before utilizing laser cutting for assembly. Subsequently, we employed foam to sculpt the cat's form, securing it to the skeleton with nails, and sewing the components together for stability. Following this, we applied polyester poplin fabric to produce the cat's skin, fixing it to the foam with staples to define each piece's shape. Trimmed and secured with hot melt glue, the end result is a remarkably lifelike cat. While shaping the lucky cat, careful consideration was given to accommodating circuits, wires, motors, sensors, etc., ensuring a discreet integration of the entire functional system. The deliberate choice of a 0.5-inch thick foam aligns with our social robot's objective of providing a gentle and comforting tactile experience for the user.

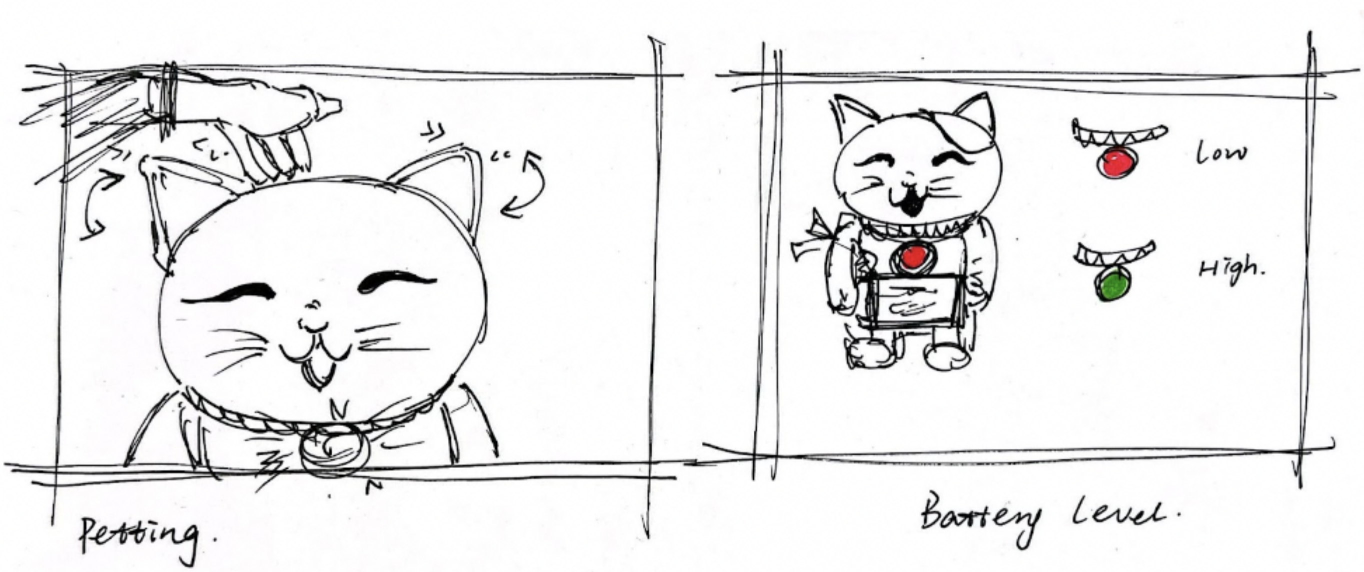
Within the shell, serial processing between the Raspberry Pi 4 and Arduino UNO provides a seamless user interface. This optimal setting keeps Mr. Li and his caretaker informed of his daily requirements via servo motor left arm waving in tandem with audiovisual Tkinter GUI reminders/questionnaires on the touchscreen, and each reminder was coded in Python to promote a different behavior of the robot, displayed both in English and Chinese. The first behavior of the day occurs at 8:00am and again at 7:00pm to remind him to brush his teeth, displaying a “Hi, Mr. Li! It’s time to brush your teeth!” message on the touchscreen while audio from the speaker behind the screen plays the sound of someone brushing their teeth. This same hygiene behavior also reminds Mr. Li to shower at 9:00am with a “Hi, Mr. Li! It’s time to shower!” message followed by the sound of a shower running. At 10:00am, LUCK-E’s next behavior is scheduled to display “Meow Mr. Li! It’s time to take the pills!” followed by a meowing sound. Another behavior is displayed at 12:00pm to remind Mr. Li to get some physical exercise with the display “Hi, Mr. Li. It’s time to move!” followed by the current weather projections in Philadelphia (“Today’s weather in Philadelphia”, “Temperature [deg F]”, “Humidity”, “Description”) collected using weather API integrated into the Python code. At the end of the day (8:00pm), an end-of-day checklist is displayed, comprised of five dichotomous questions (require yes/no answer) and two Likert Scale Questions (require 1-5 scaled answer) which Mr. Li is required to answer. The basic nature of these questions are to confirm whether or not he completed his daily tasks, as well as determine his physical pain level and overall mood. Once he presses “Submit”, the results are then sent to a “patient_responses.csv” file with the exact time they were completed, where his caretaker can then track his progress weekly, monthly, and yearly. Each of these behaviors can be taken off the screen by pressing “OK” once displayed, and they are programmed to set off at different time throughout the day using Linux Terminal Cron Jobs, which can easily be adjusted to best fit Mr. Li’s needs based on his personal schedule. Additionally, in instances where reminders are not displayed on the screen, Mr. Li can easily activate it with a simple touch and an image of a landscape in China, from the region where he spent his childhood and teenage years will be displayed, providing a sense of comfort (Appendix A, Fig. 12).

Besides these behaviors, the design also features additional animated feedback behaviors from the Arduino to Mr. Li's interactions with the cat, such as touch sensor (petting on the head) input with servo motor ear wagging output and ultrasonic sensor (rest hand near LUCK-E's right arm) input with servo motor armpit dispenser output when it is time to take his medication. A battery life alert was also designed around the neck in order to display a clear view for whenever LUCK-E needs to be recharged. Combining the cost of supplies, the greatest being $29.99 for the PiSugar Portable Battery, $52.99 for the 5" screen, and $129.99 for the CanaKit Raspberry Pi 4 (4GB RAM) Starter PRO Kit, the total budget of the robot ranged around $250, though much of the extraneous expenses could be equated to the need for replacement parts during the development phase. This pricing is also significantly lower than that of other social robots which LUCK-E took inspiration from, such as the Paro Seal Robot (appx. $6000 per unit).

Design Storyboard







LUCK-E DEMO VIDEO**:** https://youtu.be/4yg1J_LsbSY

Feature-Benefit Case Statement

- Feature 1: LUCK-E's Looks

We want to create a robot that benefits not just Mr. Li, but also his caretakers, family members, and potentially society. Lots of the current state of the art has a classic robot look and uses hard materials which could create a sense of distance and fear. LUCK-E tackles this problem. The approachable lucky cat's appearance resembles a real cat, giving the user a sense of closeness. The use of foam and polyester poplin fabric, along with secure assembly techniques, results in a visually appealing and comforting tactile experience for the user, Mr. Li. Not only that, this social robot specifically targets lucky cat lovers and the Asian community, which creates a design opportunity for future social robots.

- Feature 2: Daily Reminders

  One of the key features of LUCK-E is that it has scheduled daily reminders for hygiene, activity, and medication. These features serve not only to enhance Mr. Li's well-being but also to benefit his caretakers. The integration of these features ensures that Mr. Li adheres to his daily routine and essential health practices, while simultaneously easing the responsibilities of the caretakers to remind him every day of these tasks.

- Feature 3: End-of-day Questionnaires

  Another feature that benefits the caretaker and Mr.Li's family is the end-of-day checklist which allows Mr. Li's to self-evaluate himself at the end of the day, and let his family and caretaker track his mental, emotional, and physical state over time, providing valuable information on Mr. Li's well-being.

- Feature 4: Petting LUCK-E

  Petting enhances the interaction between LUCK-E and Mr. Li. The movement of the ears when petted, offers Mr. Li a comforting and emotionally enriching experience, creating a sense of companionship similar to interacting with a real pet. This interactive interaction not only benefits Mr. Li but also his caretaker. It serves as a means for him to bond with his caretaker. This shared experience of interacting with the robot creates positive energy and creates a sense of connection.

- Feature 5: Medication Dispenser

  The medication dispenser incorporated into LUCK-E is a crucial component of the overall design. By creating an opening in the mouth for Mr. Li's caretaker to insert medication which Mr. Li can access later by holding out his hand underneath LUCK-E's right arm; the robot allows for a fun and user-friendly interactive experience for everyone involved in the process.

- Feature 6: Battery Life Indicator

  LUCK-E's behaviors require a sufficient amount of battery power in order to run properly. In the same way Mr. Li must gauge his energy level to take care of his health throughout the day, a clear and visible battery life indicator around the robot's neck serves as a user-friendly tool of communication between LUCK-E and Mr. Li. Real-time feedback of the robot's battery level allows Mr. Li to predict when it is time for LUCK-E to recharge: green indicating that the battery is high, and red indicating that the battery is low.

- Feature 7: Cost-Effective Design

  One of the main issues with current social robots is that they are not accessible to most elderly people due to their expensive costs. We carefully selected our components to ensure that LUCK-E can be built for under $250 USD and can be introduced to the market at a relatively low cost.

In summary, LUCK-E is not just a social robot; it's a carefully designed and cost-effective companion that seamlessly integrates technology into Mr. Li's daily life, providing comfort, reminders, and interactive experiences while promoting a structured and healthy routine.

Utility Case Statement

The finalized design model of the LUCK-E social robot represents a unified product, incorporating multiple aspects of Mr. Li's physical and emotional requirements to continue living a healthier lifestyle. However, real-life applications of the device must be considered to determine the device's full effectiveness in meeting Mr Li's needs in the context of his social and physical environment.

The primary concerns of LUCK-E's functionality were that it needed to assess Mr. Li's daily physical and mental well-being while also allowing his caretakers to be able to efficiently track his progress throughout the week/month. In addition, the robot needed to be soft, portable, and affordable, as well as be able to maintain communication with Mr. Li and keep him well-informed depending on his mood at the time. The finalized design model accomplishes many of these requirements, both in terms of functionality as well as overall visual presentation. For softness and structure, the robot shell was designed with a laser cut CAD lightweight wooden skeleton, fit with "skin" and "fur" consisting of an assembly of foam and various textile colors sewn together to resemble a tortoiseshell pattern (black, white, yellow). Whether it required taking LUCK-E around the house or outside on his walks, Mr. Li and his caretaker would have no issues with practical portability.

Despite the LUCK-E robot being capable of achieving its intended behaviors and a majority of the initial design ideas for Mr. Li, there remain some existing drawbacks with the current prototype. The serial processing between the Raspberry Pi and Arduino UNO is effective for delegating behaviors without potential damage, but only achieves this at the cost of significantly reducing the battery life capabilities of the robot if it ran on the RPi alone (roughly 6.5 hours with the PiSugar portable battery). Also, in order to achieve ear-wiggling feedback and medication dispensation features of the device, the touch and ultrasonic sensors had to remain exposed in order to avoid potential activation interference from fabrics or the overall shell. These glaring design flaws could make portability more difficult due to the possibility of accidentally setting off either of these behaviors simply through mishandling or by bumping into nearby objects. When the reminders are not visible on the Raspberry Pi touchscreen, the layout of the default desktop interface might overwhelm Mr. Li, resulting in early abandonment. The size of the ON/OFF switch on the RPi itself is also minuscule in size, which can lead to battery usage issues and confusion on how to activate or deactivate the robot. Besides these problems in functionality, there also exists the issue of human error when submitting daily reminders within the checklist. Reliance on Mr. Li’s part to be honest with his answers is crucial, as there are no safeguards in place to be able to tell the difference as to whether or not he actually completed his daily activities, or if he is being genuine with the state of his mood.

Feasibility Case Statement

The chosen configuration for LUCK-E is technically feasible, primarily due to the utilization of a combination of sensors, motors, and coding that collectively enhance its functionality. The components that LUCK-E uses – an Arduino microcontroller with corresponding sensors and motors and a Raspberry Pi microprocessor are widely used and shown to be successful in current products in the market. In terms of sensors, LUCK-E integrates specialized touch sensors that respond to Mr. Li's interactions, making the robot's responses intuitive and user-friendly. These sensors contribute to the overall simplicity of the device, aligning with the goal of providing a companion that is easy for Mr. Li to use. Motor subsystems play a crucial role in LUCK-E's feasibility. The integration of servo motors enables dynamic movements such as waving arms and responsive ear motions. This simplicity in motor functionality, coupled with efficient coding, ensures a smooth and engaging interaction for Mr. Li without the need for overly complex mechanisms. The coding aspect is pivotal in achieving a seamless and efficient operation of LUCK-E. The code facilitates the coordination between various components, allowing for intelligent responses to touch, automated reminders, and dynamic movements. The simplicity of coding contributes significantly to the user-friendly nature of the robot.

The absence of overly intricate mechanisms enhances the device's feasibility. LUCK-E's design prioritizes a straightforward mechanical structure, making use of basic yet effective components. This deliberate choice simplifies the fabrication process, ensuring cost-effectiveness and ease of maintenance. The technical feasibility of LUCK-E is attributed to the thoughtful integration of sensors, motors, and coding. This approach not only ensures the robot's effectiveness in providing companionship but also aligns to create a device that is simple, intuitive, and tailored to Mr. Li's unique needs.

Conclusion/Future Directions

The LUCK-E draws inspiration from existing social robots both in fashion and function in order to provide Mr. Li with a companion that can promote him to continue taking care of himself through brushing teeth and showering, encouraging him to take walks outside, and checking in on his emotional health. The design was intended to resemble that of a stuffed lucky cat animal, while also integrating lifelike capabilities of arm movement and ear twitching. Future iterations of this project will implement more applications of the Raspberry Pi’s processing power, while also optimizing for battery usage. Some considerations for the robot include AI-powered bird call recognition using a microphone in order to display different birds in the area while Mr. Li takes LUCK-E on his outdoor walks, facial/object recognition capabilities using a camera hidden behind one of the eyes, and utilizing ChatGPT to reconfigure the cat with conversational capabilities in both Cantonese and English. More general additions to the design would include a larger touchscreen (7” or larger), automated facial expressions, push notification of Mr. Li’s status directly to his caretaker phone, and WhatsApp and Zoom so that Mr. Li can have more direct contact with friends and family. While the LUCK-E succeeds in providing Mr. Li with many new applications for him to stay motivated throughout his life, there is always room for improvement in the design to help Mr. Li continue working towards becoming the best version of himself.

Appendix A

Design Brainstorming Process

- Cultural Design Inspirations
    - Lucky Cat: Historical/Cultural Significance
    - Maneki Neko, or “Beckoning Cat”
        - Originated in Japan (Edo Period)
        - Symbol of abundance and fortune throughout Asia
        - China, Korea, Taiwan, Thailand, Vietnam
    - Left vs. Right Paw Raised
        - Left: brings in customers
        - Right: wealth & good luck
        - Higher raiser paw = greater fortune
    - Color Significance
        - Tri-Colored = good luck, wealth, prosperity
        - White = happiness & purity
        - Black/Red = ward off evil/negative energy
        - Golden = wealth & money
        - Pink = attract love & romance
        - Green = good health & education
- Existing State of Art Inspirations

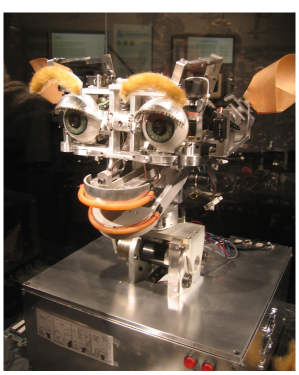


Fig. 1 Kismet: facial features, expressive and reactive to human speech

Fig. 2 Tico: large monitor for touchscreen feedback

Fig. 3 Jibo: small, portable, simple design

Fig. 4 Paro: soft outer shell, adorable, universal design

- Ordered List of Design Concepts
    - Initial Design Concepts

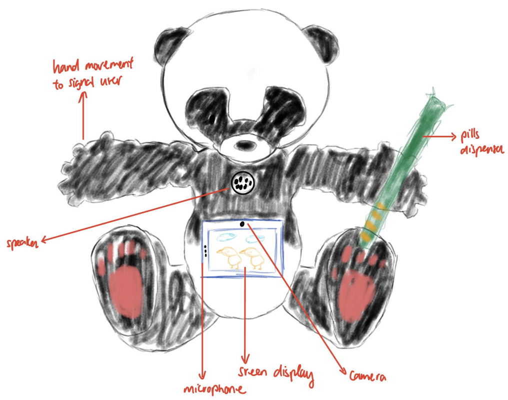


Fig. 5 Panda design that resembles a stuffed toy.

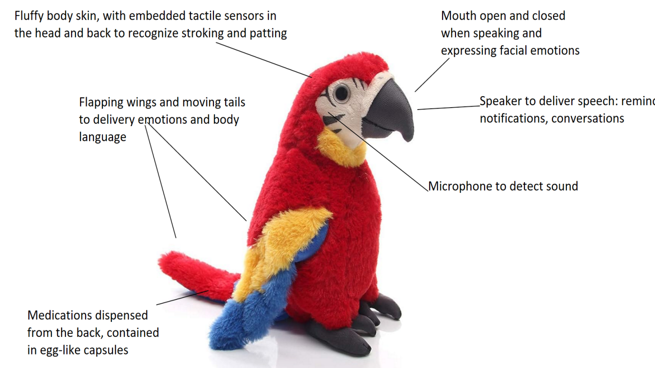


Fig. 6 Parrot design with features that resonate with Mr. Li's bird watching hobbies.

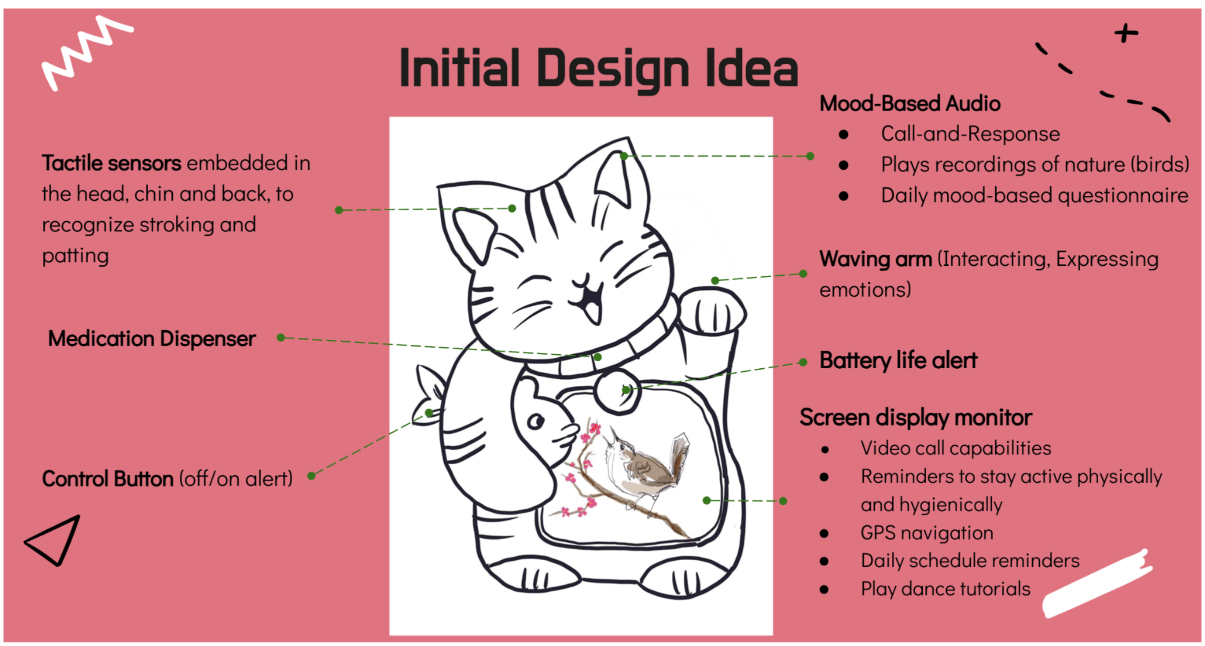
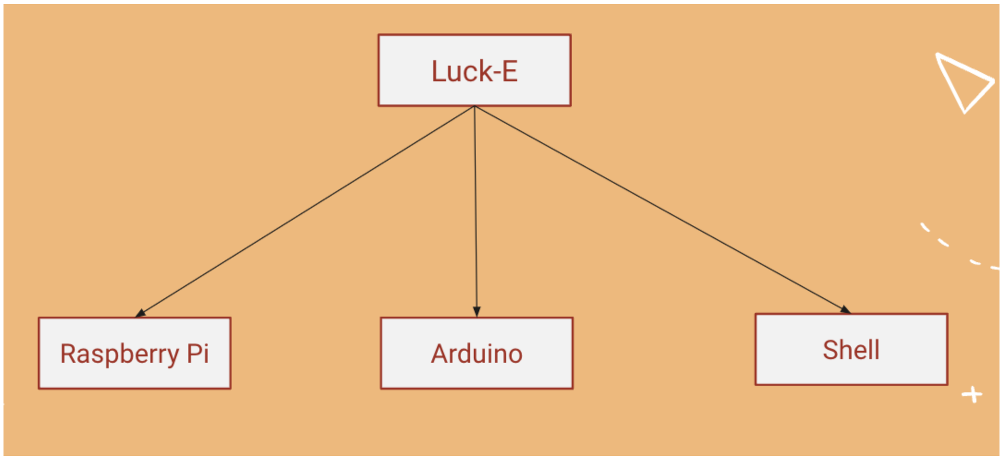
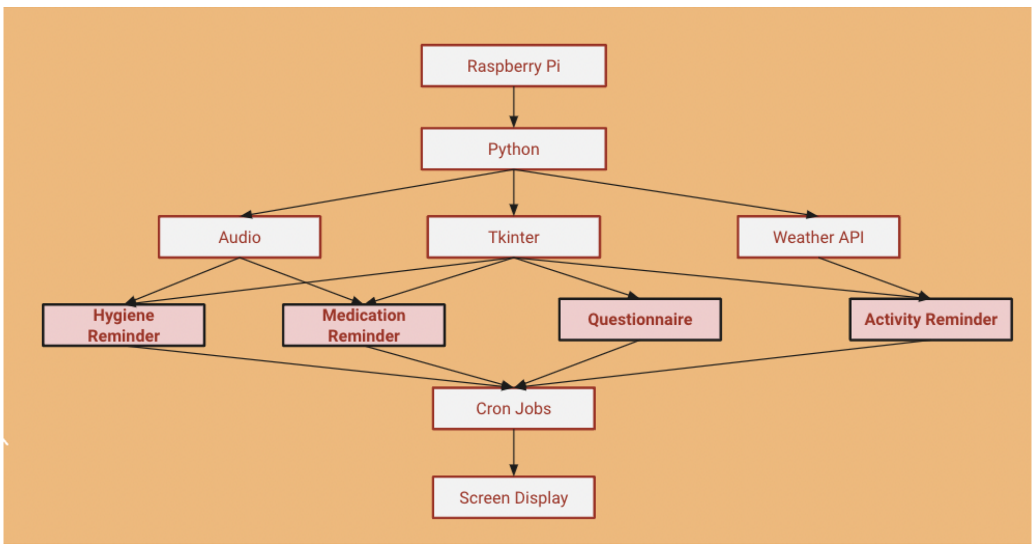


Fig. 7 Lucky Cat design that aligns with Chinese cultural aesthetics.

    - Design Process Chart:


Luck-E
Raspberry Pi
Arduino
Shell


Raspberry Pi
Python
Audio
Tkinter
Weather API
Hygiene Reminder
Medication Reminder
Questionnaire
Activity Reminder
Cron Jobs
Screen Display

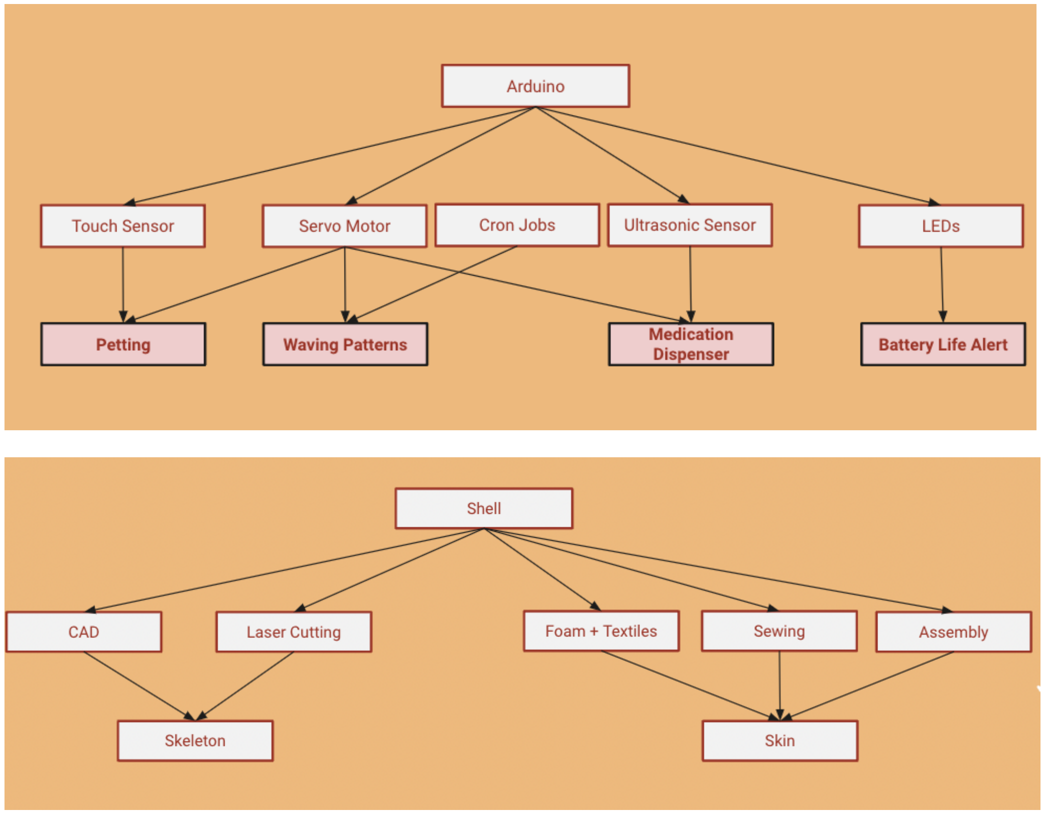


Fig. 8 Design process chart

Final Design: LUCK-E

Fig. 9: Final Prototype

Behaviors

- Daily Schedule
  - 8:00am - “Brush your teeth!”
  - 9:00am - “Shower time!”
  - 10:00am - “Take your medication!”
  - 12:00pm - “Time for outdoor exercise! Here is the current weather!”
  - 7:00pm - “Brush your teeth!”
  - 8:00pm - End of Day Checklist
  - Left arm lifting during onset of every activity reminder
- Linux Terminal Cron Jobs Setup: See README.md in this Github repo: https://github.com/czhanjin/Project2/blob/master/README.md
- Medication reminder and Automated medication dispenser
  - Daily reminder to take medication
  - Arm gestures to get Mr. Li’s attention

- Meowing sounds
- Dual English and Chinese Interface

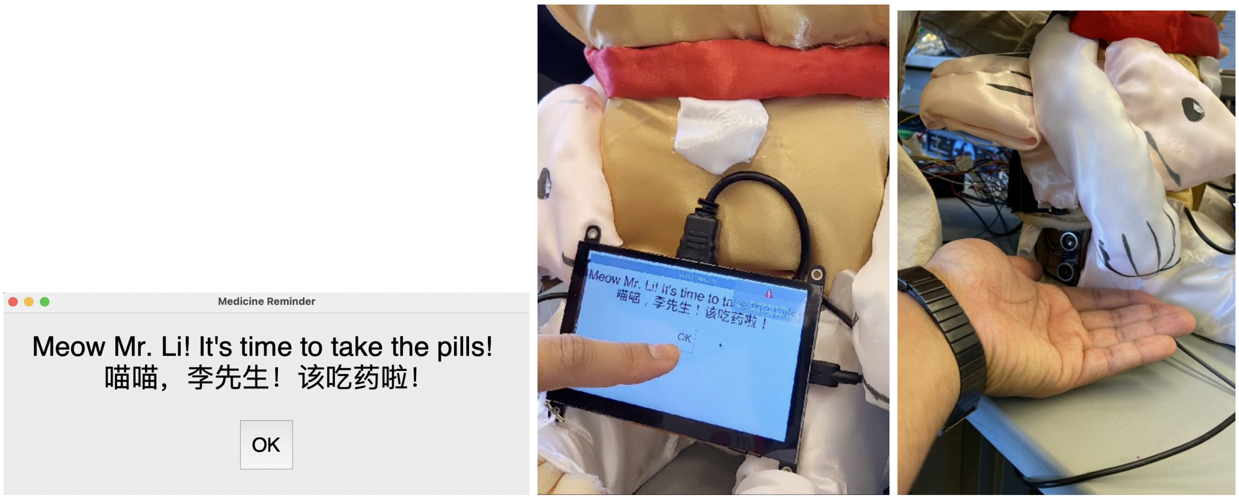


Fig 10.1: Medication reminder

- Activity Reminder
  - Daily Reminder to exercise
  - Real-time weather forecast
  - Temperature, humidity, weather description
  - Icon associated with current weather
  - Arm gestures to get Mr. Li's attention
  - Dual English and Chinese interface

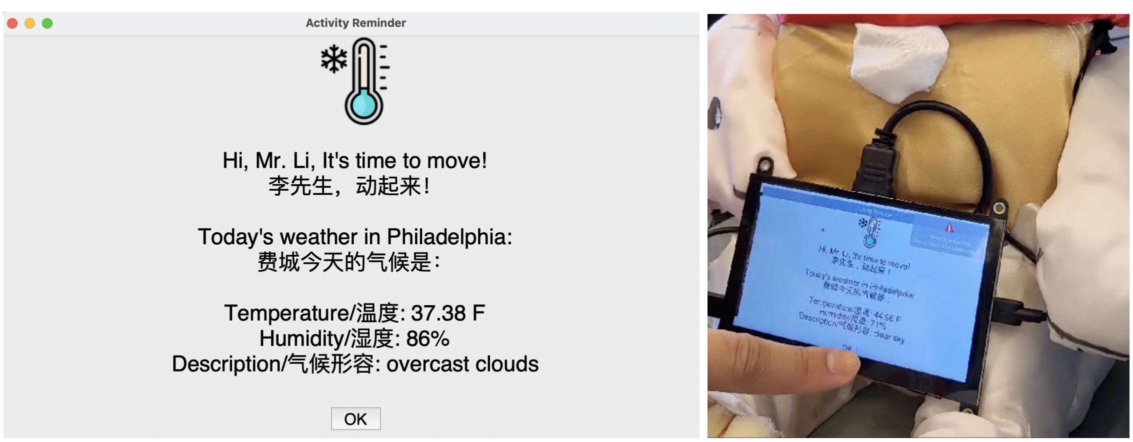


Fig 10.2: Activity reminder

- Hygiene Reminder

- Daily reminder to shower and brush teeth
- Shower audio and teeth brushing audio
- Arm gestures to get Mr. Li’s attention
- Dual English and Chinese interface

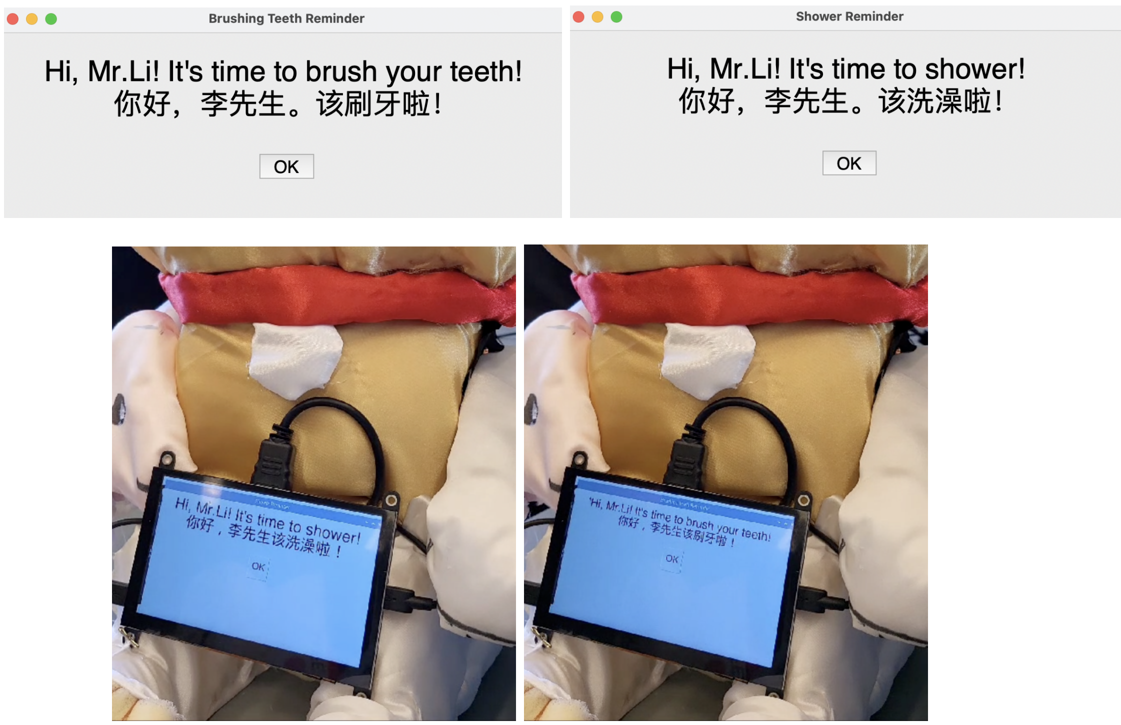


Fig 10.3: Hygiene reminders

- Daily mood-based questionnaire

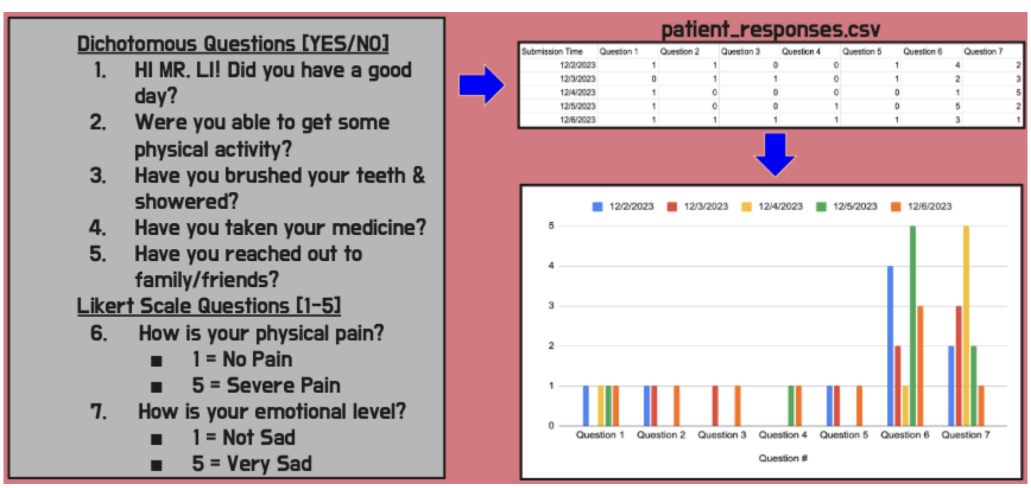


Fig 10.4: Daily questionnaires

- Battery Life Alert: Red and Green LEDs that show battery life
  - Red LED = Low-battery
  - Green LED = High-battery

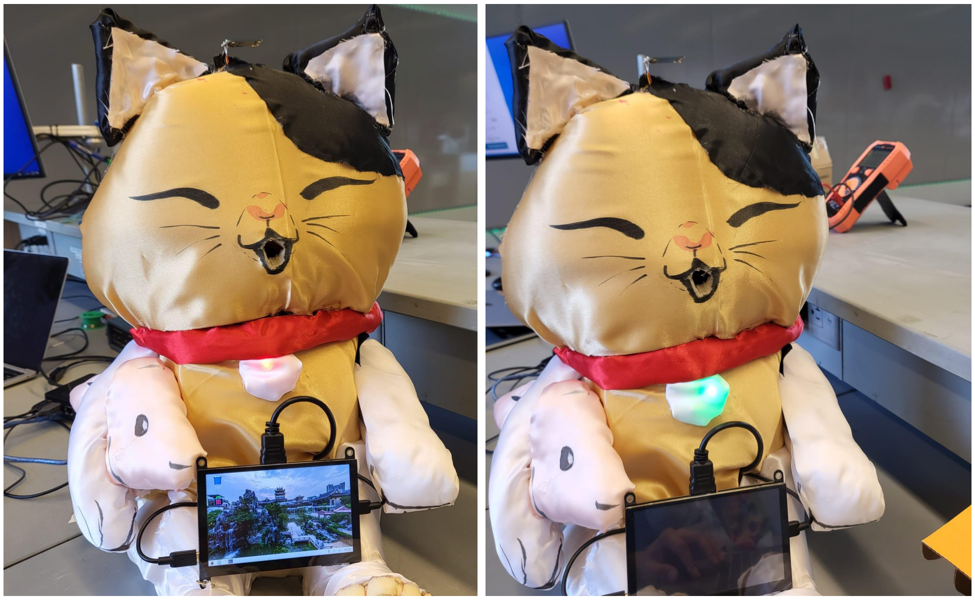


Fig 10.5: Battery life alert

- Petting LUCK-E
  - Feedback from petting LUCK-E's head
  - Movement of ears

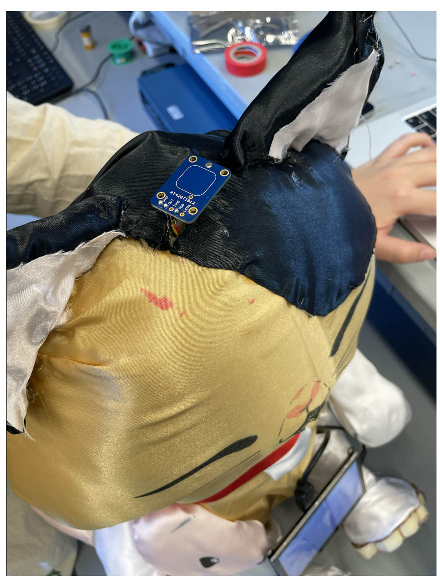


Fig 10.6: Petting using touch sensor and motors at ears

Appendix B

Python codes and Arduino codes

Github repo: https://github.com/czhanjin/Project2

- Control Servo: https://github.com/czhanjin/Project2/blob/master/control-servo.py
- Outdoor Activity Reminder: https://github.com/czhanjin/Project2/blob/master/Activity_reminder_final.py
- Medicine Reminder: https://github.com/czhanjin/Project2/blob/master/Medicine_reminder_final.py
- Shower Reminder: https://github.com/czhanjin/Project2/blob/master/Shower_reminder_final.py
- Teeth Brushing Reminder: https://github.com/czhanjin/Project2/blob/master/Teeth_reminder_final.py
- End-of-Day Questionnaires: https://github.com/czhanjin/Project2/blob/master/luckycat_dailyquestionnaire.py
- Arduino C++ script: https://github.com/czhanjin/Project2/tree/master/Cat_dec13

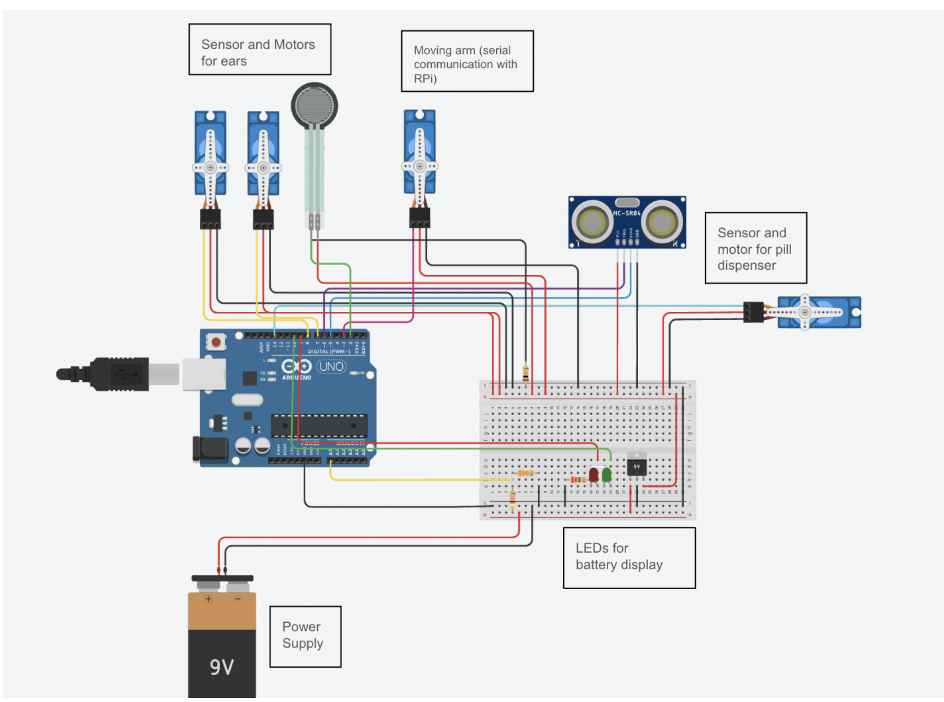


Fig 11: Simulated circuit (touch sensor and TOF distance sensor are replaced by Force sensitive resistor and ultrasonic sensor)

Fig 12: Default wallpaper on Raspberry Pi screen

References

- Broekens, J., Heerink, M., & Rosendal, H. (n.d.). Assistive social robots in elderly care: A review . https://ii.tudelft.nl/~joostb/files/Broekens%20et%20al%202009.pdf
- Vandevelde, Cesar & wyffels, Francis & Vanderborght, Bram & Saldien, Jelle. (2017). DIY design for social robots
- https://www.megadroid.com/Robots/necoro.html
- https://sites.socsci.uci.edu/~wmmaurer/courses/anthro_money_2006/maneki.html#:~:text=Generally%20representing%20good%20fortune%20and,symbol%20to%20many%20business%20owners.
- https://medium.com/@punamkhokhar/maneki-neko-the-lucky-cat-a5a7ec1272e6
- Awesome 5 Inch IPS Touchscreen For The Raspberry Pi 4! HDMI & Built In Speaker
- Raspberry Pi Rain Radar & Weather Dashboard
- Face Recognition With Raspberry Pi + OpenCV + Python
- Use Sound and Machine Learning to Identify Birds with a Raspberry Pi - BirdNET-Pi
- https://youtu.be/HUL5Ii0dD7E?si=JrGqEY5iAMZ0UrIw
- https://youtu.be/yDPQfj4bZY8?si=wMVaEv20aWqNL0V7

- https://youtu.be/jU_b8WBTUew?si=OFztqurpouG-sPxA
- https://roboticsbackend.com/raspberry-pi-arduino-serial-communication/