CareLink

Bringing apart back together.

[CareLink - Product Demo Video]

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For HF766 Final Project - Fall 2020

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Abstract

Our team, Total Modal, convened mid-September 2020 with a mission. We aimed to design a multimodal experience that supports those users who are isolated, especially in this increasingly isolating time of the Covid-19 pandemic, and that creates for them a feeling of connectedness.

Through our device, the CareLink, both those hospitalized and their loved ones are able to communicate in multiple modalities, nurturing a sense of closeness and connection despite their physical distance.

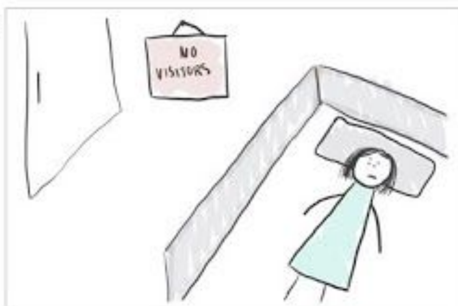
Introduction

People who are hospitalized can be isolated from their families and loved ones, and because of limited communication, suffer from a lack of physical and emotional connection. Similarly, families experience the difficulty of isolation while feeling concerned about their loved ones' healing. This is an ongoing problem that has been exacerbated by the COVID-19 pandemic.

Our design pays particular attention to older users who may be battling serious conditions, feeling weak, and potentially approaching the end of their lives. For those patients who are receiving curative care and are expected to soon or eventually return to their families, the devices allow communication that eases the stress of distance and isolation for both parties and lessens the strain of such isolation on the health of patients. For those patients who are receiving palliative care and are approaching death, the devices may allow some of the final communication between patients and their families - especially given the current conditions of hospitals, in which visitors are not often allowed. This end-of-life period can cause even more stress and fear than would a disease and hospitalization for a younger person, and so connection and communication are even more critical and cherished for such patients and their families. Additionally, due to our target persona and the visual impairments they may be facing, as well as the emotional aspect of touch, we aimed to create a device that does not solely focus on visual features but is multimodal.

The team identified the problem space by converging individual prototype ideas, storyboards, and functional and morphological chart diagrams. We observed a common theme: a focus on facilitating communication between isolated medical patients and their families and loved ones. Centering around this theme, the team began a design process of sketching and combining ideas and diagrams, developing paper and eventually physical prototypes, and iterating towards a functional and usable design. We researched various devices that included some common functionality with our ideas, and our morphological chart (Appendix B) helped us to think through various possible components. One notable component we explored was a device that would glow and light up to show warmth and presence, similar to the "friendship lights" we found available through local online retailers. Ultimately, we decided to focus on other modalities and less on the visual space to make the device more accessible to the population most affected by COVID-19.

Scenario

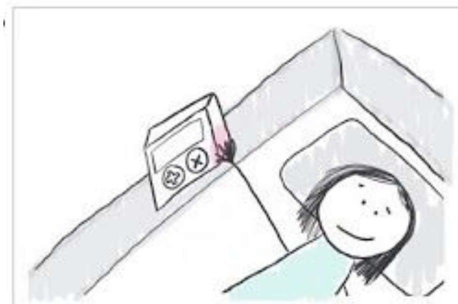


Ruth is a retired teacher in her seventies with three adult children, two of whom live on the other side of the country. Jane, Ruth's youngest daughter, is Ruth's primary caretaker and has been living with her for the past year. They're used to seeing each other, being close by, and communicating their affection with touches and hugs.

Ruth recently contracted COVID-19 and is in the hospital being treated. Fighting her illness requires most of her energy. She misses her family, and feels isolated, confused, and lonely. Back at home Jane worries about her mother constantly and wishes she was allowed to be by her side. She wants to know that Ruth is okay, even if she is just resting. And she wants Ruth to know that she loves her and is thinking about her.

Ruth's medical care team in the hospital provided her and Jane the CareLink, a new technology allowing patients and their loved ones to communicate and stay close. The CareLink patient-side device mounts on the side of Ruth's hospital bed. The device makes it easy for Ruth or her care team to notify Jane and keep her updated on Ruth's status, whether Ruth is in treatment or resting.

Ruth or her care team can indicate when Ruth is resting by pushing the appropriate button on the bedside CareLink.



When Ruth's status is updated to resting, Jane's CareLink device lights up in the same color, indicating that Ruth is currently resting. When Ruth wants to interact with Jane she can send a love signal, a heart, to Jane simply by sliding her finger on the designated touch area of the device.

Jane receives the love signal on her CareLink device. As her device screen lights up and displays a heart, she knows her mom is thinking about her and reaching out. Jane responds to the signal by sending a heart back to Ruth, which lights up, displays a heart, and vibrates the bedside device.

The vibration and lighted heart display notify Ruth that Jane is attentive and with her right at the moment. Jane and Ruth cherish the feeling of being together in the moment. It’s as if Jane was right by her bedside, holding her hand. Smiling and feeling close to her daughter, Ruth rests and heals up. This closeness helps Ruth and Jane move through this difficult time together.

Operation

The CareLink prototype we developed centers technically on three primary aspects: information output, information input, and inter-device communication.

Information Output

- The LCD screen provides visual feedback to the family and patient when messages are received and sent. It also provides visual feedback through backlight color and notification message when patient status is changed.
- The status indicator keycap is placed on each side and uses different light colors to indicate the current patient status.
- The vibration motor provides a simple haptic feedback pattern to the family and patient when the messages are received and sent. When the message is received, the vibration pattern also matches the heartbeat pattern that is animated on the LCD screen.

Information Input

- Three functional keycaps on the patient side are used for changing patient status (Resting, In Treatment, Available) and status change is reflected on the status indicator and LCD screen.

- The capacitive touch slider on each side allows family/patient to send a predefined message to the other side. It requires a sliding interaction to activate, which eliminates the possibility of activation by accidental touch.

Inter-device Communication

- The infrared emitter sends the signal from one device to another.
- The infrared receiver receives the signal sent from the other device.
- The emitter and receiver are placed on both devices to enable two-way communication.

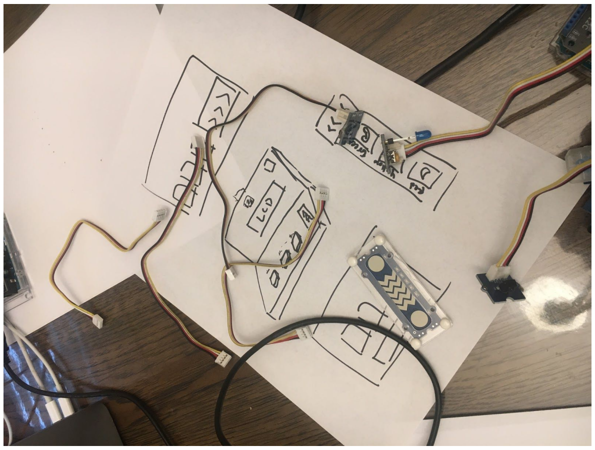
Construction

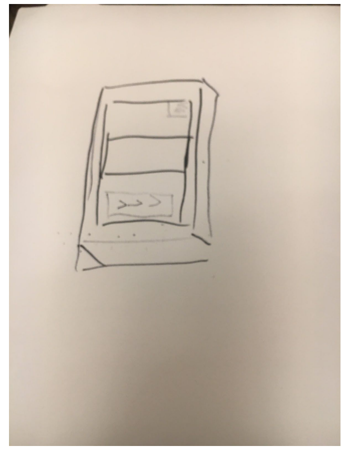
Step One - Planning, Coding, and Testing

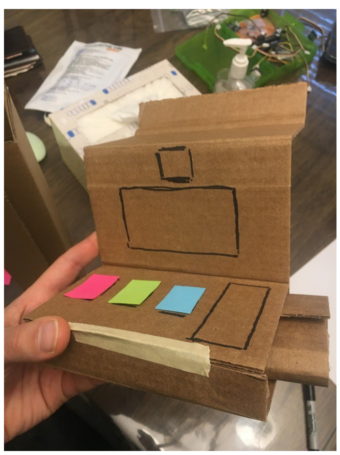
In this initial stage, we deliberated on the best way to work together remotely and focused on building the code that the prototype would require. We learned how to create the infrared connection, and how to make the components work together.

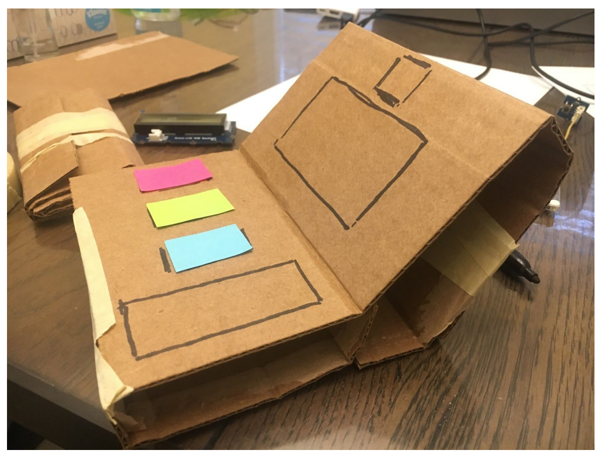
Step Two - Low-fi Prototype and Usability Study

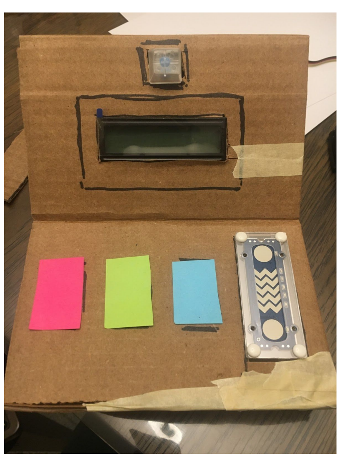
In this stage we compared and combined sketch ideas of the product. We prototyped with cardboard, testing and shaping the form to ensure it captured the intent of the product. We also wanted to be sure the product was ergonomically supportive for users laying down, and for mounting on the side of a hospital bed.

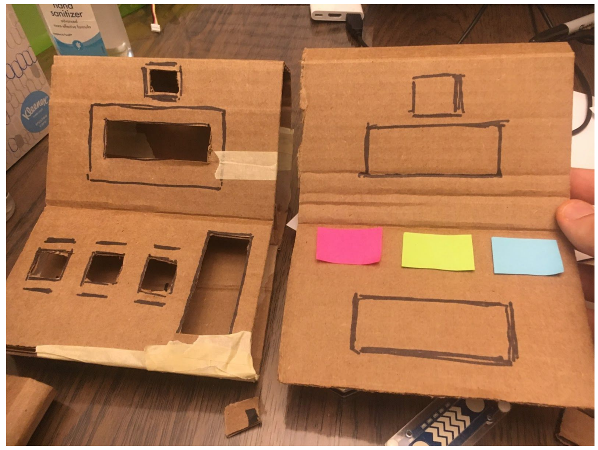


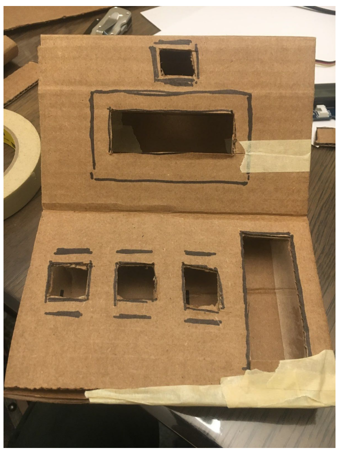


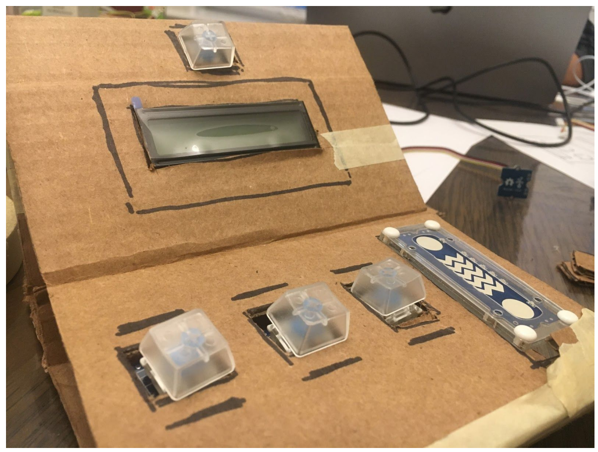




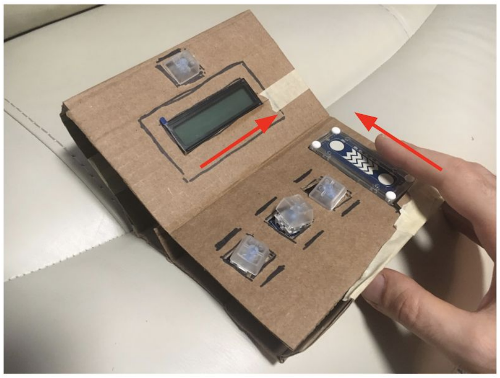




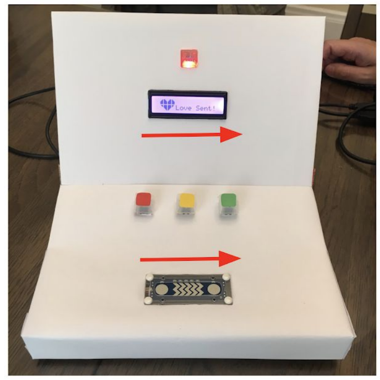




In this stage, we also carried out usability tests. One central finding from the testing was that the touch sensor placement could easily interfere with button use, so the two components had to be well spaced apart to prevent error. A second central finding was that the LCD screen digital message needed to align visuospatially with users' gestural direction in order to match their mental model and prevent error.



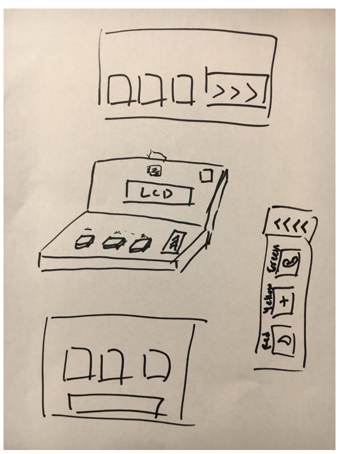
Before

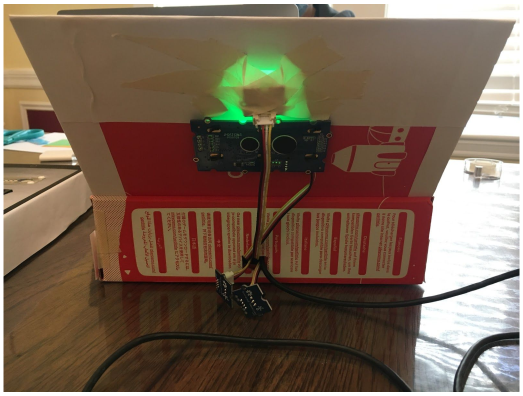


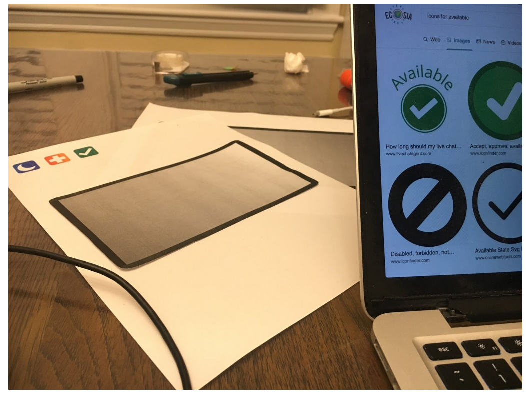
After

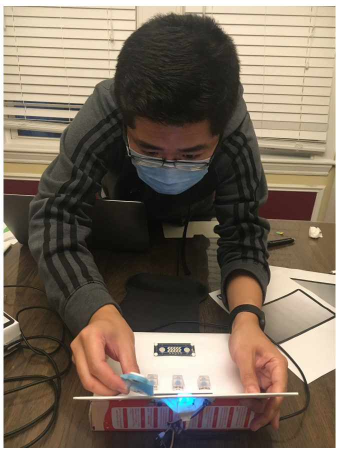
Step Three - Final Prototype

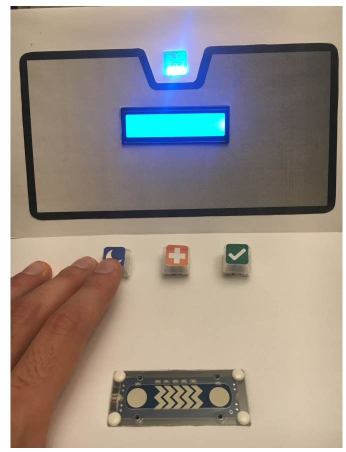
In this stage, we transformed our medium-fidelity cardboard prototype into our final high-fidelity working prototype. We considered methods to improve the size, form, button positions, and screen position of the device. We also developed the aesthetic design of the device by creating CareLink icons and labels, and stylizing the device with more color and shape.



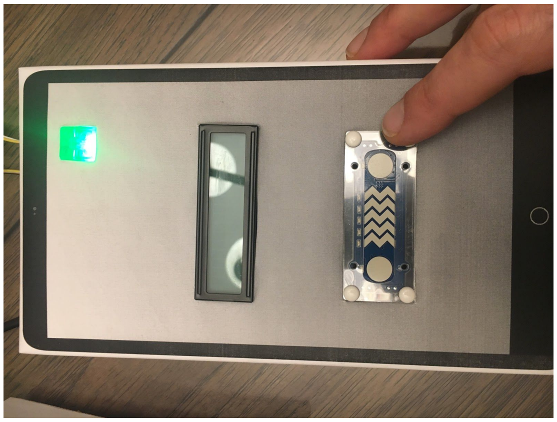



Available





Final Product



Electrical Connections

Family Side

Module	Arduino Pin number
16X2 LCD RGB Backlight Display	I2C (output)
Grove Mechanical Keycap - LED keycap with programmable light	D8 (only uses digital IO pin 9 for LED light - output)
Grove - Capacitive touch slider	I2C (input)
Grove - Vibration Motor	D4 (output)
Grove - Infrared emitter	D3
Grove - Infrared receiver	D2

Patient Side

Module	Arduino Pin number
16X2 LCD RGB Backlight Display	I2C (output)
Grove Mechanical Keycap - LED keycap with programmable light	D5 (available - input) D6 (in treatment - input) D7 (unavailable - input) D8 (Status indicator) (only uses digital IO pin 9 for LED light - output)
Grove - Capacitive touch slider	I2C (input)
Grove - Vibration Motor	D4 (output)
Grove - Infrared emitter	D3
Grove - Infrared receiver	D2

Results and Discussion

This project has been engaging for us in the technical, creative, and intellectual domains, and we're pleased with the work we were able to do. Overall, we feel that we were able to execute our prototype with a high level of fidelity to our original concept intentions. In the process we evolved our vague ideas into a working prototype with major functions that meet the needs of our target persona.

Discussing the Process

What worked?

- The main goal was to find a way for two people to connect through some kind of touch when distance and physical ailments are the main constraints. We were able to accomplish this baseline goal, and along the way, discovered more ideas, questions, and constraints.
- The Arduino and Grove Seeed platform itself served as a limitation. With limited coding and electrical engineering knowledge, we were able to put together a fully functioning prototype, even figuring out inter-device connections.
- Having our team spread across the country served as another limitation. In the current world, due to many factors, a remote workplace is becoming more acceptable. Our team was able to navigate different time zones as well as navigate building a physical prototype when each team member is not physically present. Ways we navigated this included: ordering two sets of hardware for team members to test depending on their location, many hours of Zoom meetings, consistent weekly meetings to stay on the same page and push the project forward. Our team did extremely well in leaning into each other's strengths too. After discovering where we each do well, we each took responsibility for and owned different parts of the project.
- We quickly learned how helpful it is to sketch our ideas and stick to low-fidelity prototyping for as long as possible to get everyone thinking on the same page. After moving through many, many rounds of sketching and talking through our ideas, only then did we proceed to cardboard prototyping.

What didn't work?

- Since the physical prototype had to be housed somewhere, not every team member was able to be present to build the prototype. Our team combatted this by having the other team members tackle other steps in the project process.
- We initially were unsure about which elements from our respective individual prototypes to include in our team prototype moving forward. In the deliberation process we chose to nix certain elements, like temperature sensor components, a child-friendly stuffed animal casing, and more meditative design elements, about which we felt fondly. Though we

agreed that these elements had to be removed for reasons of practicality, we were sorry to lose them from our design, and have tried to suggest in the Future Work section where and how they might be later incorporated.

Discussing the Prototype

What worked?

- As a team, we're all truly excited about the prototype that we created, from its design to its functionality to its potential impact. Though we recognize certain limitations to the prototype born of logistical constraints or our own technical expertise, we are pleased that we were able to develop and demonstrate a compelling and realistically engaging product. Primarily, we're excited about the following aspects:
    - The prototype is fully functional, with the Arduino devices communicating in real-time as planned. With Prof. Ziat's assistance, we were able to troubleshoot numerous issues with the Arduino code around the use of the infrared emitter and infrared receiver. We're all delighted by the fact that the finished prototype genuinely sends messages between two Arduinos, without us having to run code on multiple devices to make it appear as such.
    - Our team aimed to focus the prototype on modalities beyond the visual space. Though we did incorporate visuals, it was more important to us that we incorporated the haptic abilities, allowing family members to share the sense of touch, and vibrations to serve as notifications and amplify the haptic experience. For our target users, visual impairment could be a common limiting factor that we wanted to design around. We also recognized that while there exists technology that can simulate the visual experience of looking at a loved one - e.g. iPhone FaceTime call, or even a photograph - there are fewer technologies that simulate the haptic experience of touching a loved one.
    - The prototype incorporates learnings from form factor testing and is ergonomically informed. While we had many early ideas about the potential shape or style of the prototype, we were chastened once we began designing and recognizing all of the material and logistical constraints the design would face. To that end, we were pleased that we were able to test the usability of the prototype at multiple stages during the design process, incorporate feedback, and design a prototype that negotiated form and function without compromising seriously on either aspect. We feel that the finished prototype is significantly easier to use because of our testing and iterative design.
    - We created a product in a highly relevant space, and for a serious social need. While there are many sectors that would have been interesting and informative to design for, we feel that designing for the medical and healthcare space during Covid-19 was a meaningful and motivating goal.

What didn't work?

- Ultimately, we were forced to make design sacrifices because of project constraints. These constraints most notably included the semester timeline on which we were operating, the individual budgets we had available, and our own current levels of technical understanding and prowess. The constraints in turn limited aspects of our prototype development.
    - The limited range of the infrared emitters and receivers in turn limited the design and demo-ing of our prototype. Because of the short range of the infrared signal, the prototype devices worked most consistently when they were within several feet of each other. As the CareLink is intended to be a long-distance communication device, this rather short distance was an impediment to our demonstrations of the device.
    - Because of the logistical constraints of the Arduino R3 platform around running multiple sets of code, we were not able to make the prototype as fully functional as we would have liked. Specifically, though the devices were able to communicate and receive status changes seamlessly, only one device at a time could send a message, and only one device at a time could receive it. We would have liked to demonstrate greater functionality of both devices sending and receiving messages in uninterrupted sequence, but had to reset and compile the code on devices each time in order to switch their function.
    - We also used the keycaps creatively as buttons and status indicators, making use of their changing LED capabilities. In the future, a better button option would be considered in a larger size with more capabilities.
    - We would have liked to use select plastics, professionally designed and printed labels, and more industrial-appearing casing to house the Arduinos in our finished prototype. Because of access constraints, we had to make do with cobbled-together materials like cardboard and printed paper.
- Though these design sacrifices had an impact on the functionality and appearance of the prototype we ultimately assembled, we're pleased with what we were able to design and construct. We feel, fortunately, that much more did work than didn't work.

Results

As a team, we were ultimately able to meet our original goal of uniting patients with their family members and loved ones using our CareLink prototype. In short, CareLink brings a loved one's touch in real-time to a patient's bedside and concurrently to their family member's mobile device. With the slide of the finger, the push of the button, or the resting of a hand, each side can keep in touch and send their love back and forth using touch and vibrations. It was crucial that we focus not just on the visual space, but also on the haptic touch and feedback space. Most notably, we rendered a device that can be used without requiring the user to have sight. We believe that this final prototype design is more mindful and inclusive of patients of all abilities.

Our team imagined a device that could help ease some of the pain that COVID-19 has created this year. During this time, families have had to work through being separated when a loved one is sick or in the hospital. In a pre-pandemic world, families could visit their loved ones and spend hours with them at their bedside. This is not currently possible, and medical facilities worldwide have had to emphasize safety protocols over connection and outside access. This system, though absolutely necessary for safety, takes a deep, emotional toll on people.

This toll is at its sharpest, and most painful, when those who are hospitalized are nearing the end of their lives. End-of-life is a time when families want to hold their dying loved ones close, holding on to each fleeting moment together. While nothing can soften the grief of losing a loved one, we hope that our device could restore at least a modicum of the connection that dying patients and their families so deeply cherish.

Overall the CareLink aims to alleviate, even in the slightest, the common human pain of loneliness that people are experiencing now more than ever. The device can do so by bringing loved ones together in ways that previously would have been impossible. Due to the commonness of this human experience of distance and loneliness, we believe the CareLink could have an impact beyond the pandemic and the hospital setting. It could be used to improve communication in nursing homes, in hospice home-care, and even in long-distance relationships. In the following section, we highlight ideas for future work to improve and further develop the CareLink and thereby extend its impact.

Future Work

Considering time, resources, and technical constraints, we were only able to bring the most important functions of our design vision to life. In the design process we had many other ideas of how the prototype could be developed in the future. What follows are some of the ideas we would most like to incorporate in a future product iteration of the CareLink.

Hardware

- The inter-device communication could be operated through Wi-Fi, to eliminate the distance restriction of infrared and the competing infrared signals.
- A larger LCD screen on the patient side could be added to make it easier for the patient to view the incoming messages.
- An ergonomic casing could be added to provide a better user experience for patients while laying down.
- A larger touch surface could allow patients to touch a greater area and not have to be so precise since mobility and dexterity may be restricted.

- The auditory modality could be more incorporated in the device, via:
    - A designed overlay matching with the haptic feedback, to provide richer sensory feedback.
    - A text-to-voice component that would read the LCD screen message content aloud, so the patient would not need to look at the screen or rely on visuals at all.
- Different, larger buttons could be used, or buttons could be customized so that they cover more surface area and are easier to push and distinguish between. They could also be distinctly textured such that sight is not required.

Software

- The touch slider could send different messages with different interaction patterns. For example, messages would be different when the patient slides from left to right and from right to left. There could also be more built-in interaction if there were a larger screen; for example, one tap could communicate a different message than two taps.
- The visual display could also be developed to show a heartbeat and combine it with sounds, vibrations, and other interactions. The device could vibrate in a subtle heartbeat pattern when both patient and family rest their hand on the touch sensor at the same time - an aspect that would incorporate one of our original design concepts.

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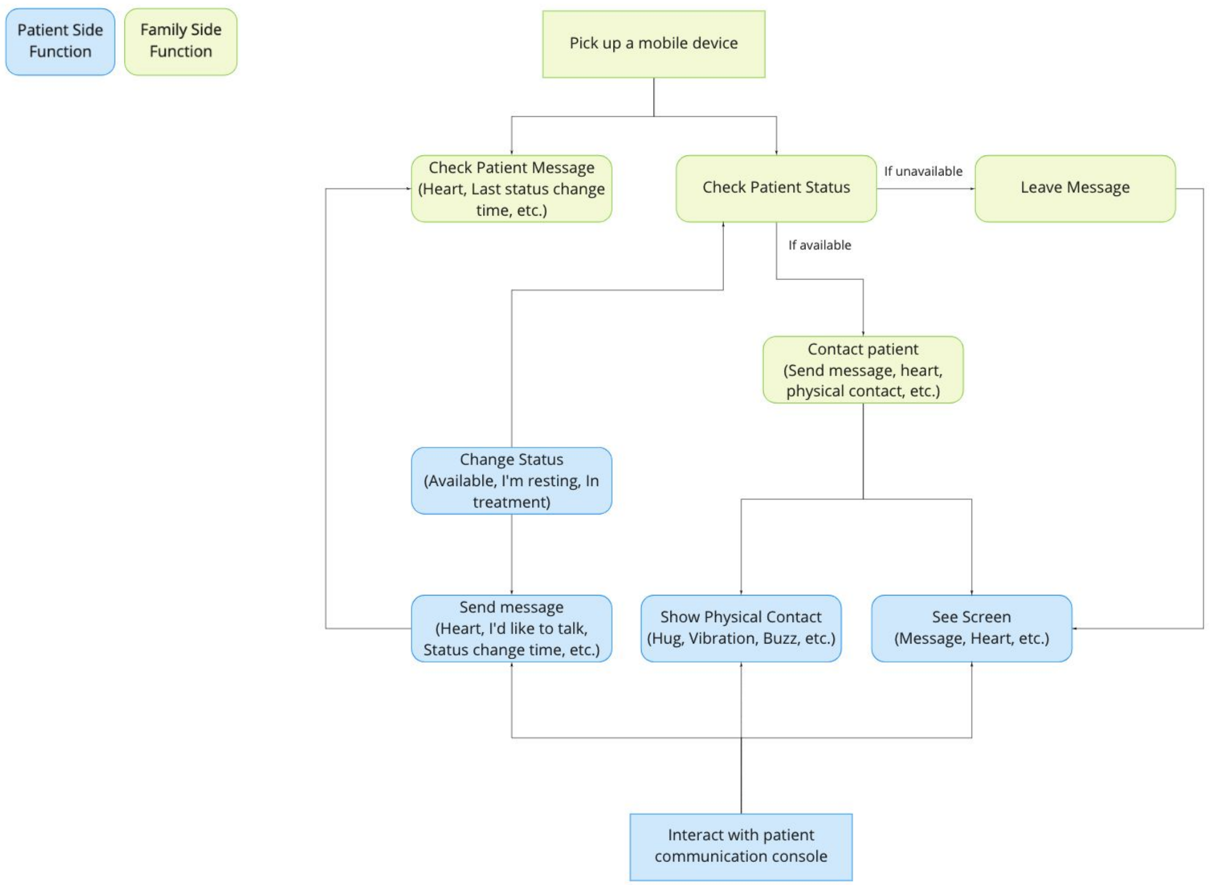
Appendices

Functional Analysis Chart

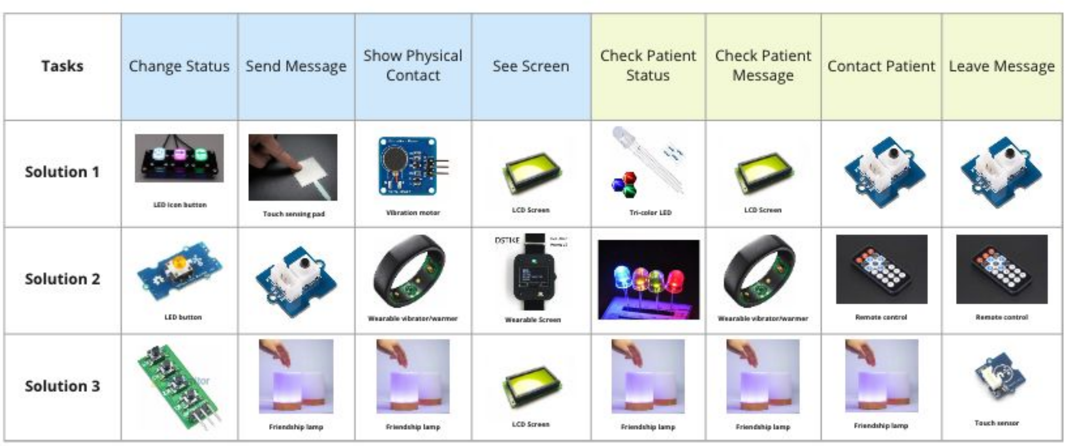


Morphological Chart

Morphological Chart

Function	Solution 1	Solution 2	Solution 3	Solution 4	Solution 5	Solution 6	Solution 7
Change Status				LED icon button	LED button	Remote control	
Send Message			Remote control	Touch sensing pad	Friendship lamp	Voice recognition	
Show Physical Contact				Vibration motor	Buzzer	Wearable vibrator/warmer	Friendship lamp
See Screen	LCD Screen	Phone mount	Tablet Stand	Embedded Screen		Wearable Screen	
Check Patient Status	Tri-color LED			LED Icon Light	Friendship lamp		
Check Patient Message	LCD Screen	Mobile app	Wearable Screen	Vibration motor	Buzzer	Wearable vibrator/warmer	Friendship lamp
Contact Patient			Remote control	Touch sensor	Friendship lamp	Voice recognition	
Leave Message			Remote control	Touch sensor	Voice recognition		

Preferred solutions



Tasks	Change Status	Send Message	Show Physical Contact	See Screen	Check Patient Status	Check Patient Message	Contact Patient	Leave Message
Solution 1	LED icon button	Touch sensing pad	Vibration motor	LCD Screen	Tri-color LED	LCD Screen		
Solution 2	LED button		Wearable vibrator/warmer	Wearable Screen		Wearable vibrator/warmer	Remote control	Remote control
Solution 3		Friendship lamp	Friendship lamp	LCD Screen	Friendship lamp	Friendship lamp	Friendship lamp	Touch sensor

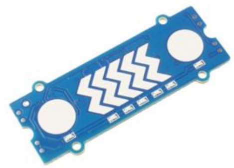
List of Electronics

Grove - 16X2 LCD RGB Backlight Display

Grove - LED buttons

Grove - Mechanical Keycaps

Grove - Capacitive Touch Slider Sensor



Grove - Vibration Motor

Grove - Infrared Emitter

Grove - Infrared Receiver

List of Other Hardware

We did not use any further hardware.