Tala Aoun (taoun2), Apurva Chanda (apurvac2), Aishwarya Rajesh (arajesh4)
ECE 445 - Project Proposal
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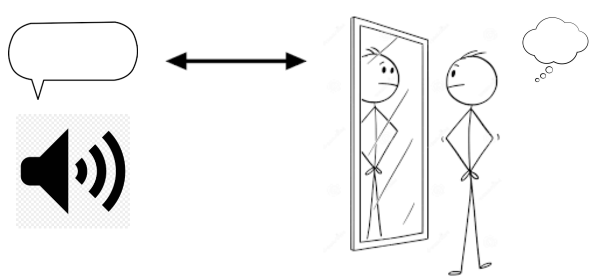
Introduction –

Problem: These past few years have highlighted the need for strategies alleviating mental and physical health issues (Source) especially during COVID-19 (Source). In particular, many who live alone face loneliness and seek comfort/companionship. A potential solution to provide accessible technology to all is an emotionally intelligent mirror that can understand your emotions in real-time and communicate with you. The mirror should also be able to track a user's emotions on a long-term basis to see if any improvements or deteriorations are occurring. Our end goal is to give the user a better understanding of their mental health patterns and be able to take actions to keep themselves healthy.

Solution: The mirror will be able to understand the user's emotions such as happiness, anger, sadness and neutral and respond accordingly to each emotion by reciting comforting words, playing music and sympathizing with the user. Every morning, the user could start his day looking at the mirror which would give him daily affirmations and would boost his mental well-being. On a long term basis, the mirror will store information about a user's mental health that has been gathered from facial expressions and emotions to track a user's progress and see if any improvements or deteriorations are occurring. If a user's emotions are obviously getting worse in the long term, the mirror would be able to provide resources like crisis hotlines or telehealth to help the user. The mirror would alleviate the stress and negative emotions that the user has. In regards to privacy issues, the mirror will be password protected so that each user can have their own profile and data. The mirror will prompt each user to enter their password into a number keypad in order to access their profile.

Visual Aid:



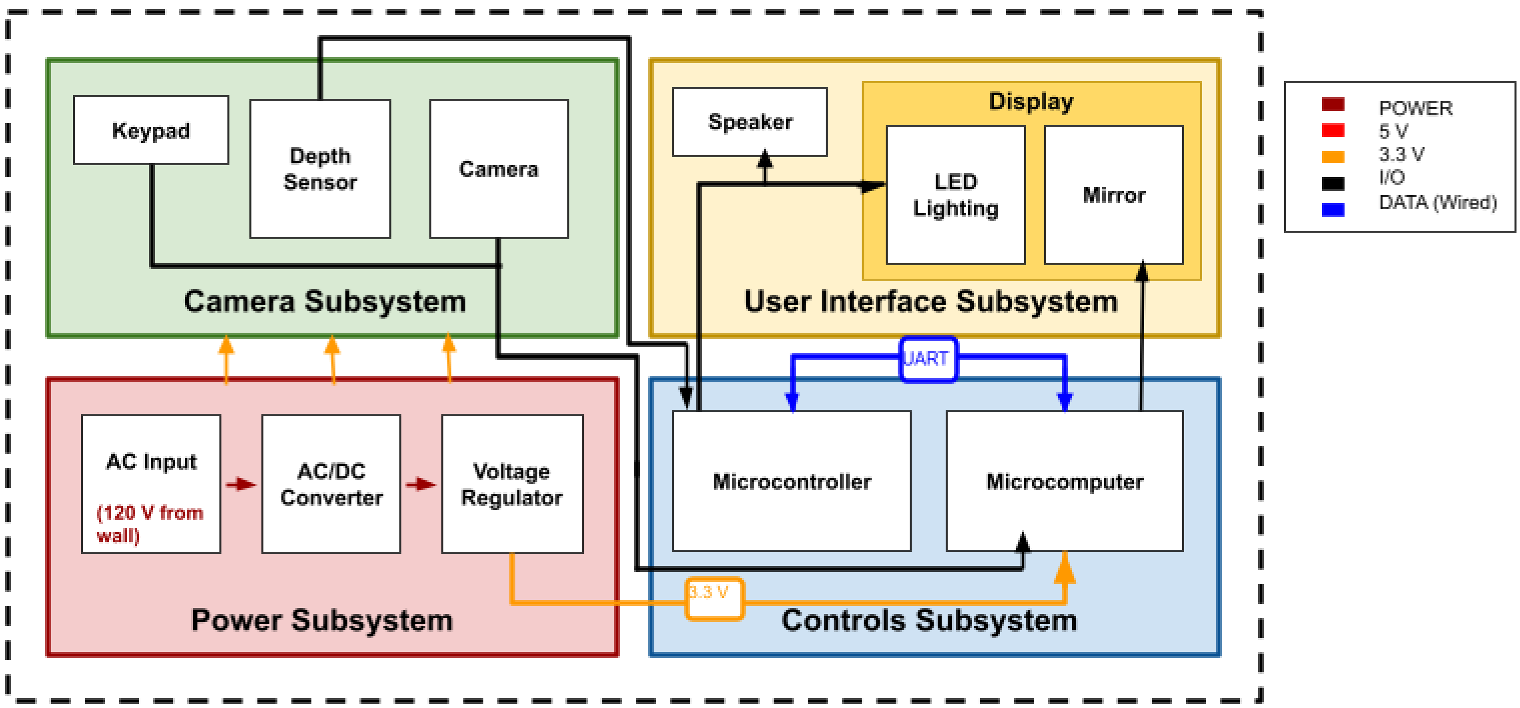
High-Level Requirements List:

1. The mirror will accurately identify if the user's emotion is negative, positive, or neutral 100% of the time and the specific emotion 80% of the time it is used.

2. After 30 days of consistently negative emotions recorded on a user's profile, the profile will be flagged, because the user is exhibiting a downward trend in terms of their mental health. It will be flagged and resources like therapists and support groups in the area (within 25 miles) will be provided. For those without nearby resources, online alternatives will be offered.
3. The mirror will be able to identify one of the basic seven human emotions in under 10 seconds according to the goal accuracy levels above.

Design –

Block Diagram:



Subsystem Overview and Subsystem Requirements:
Camera Subsystem:
The User Detection subsystem contains the depth sensor, the camera and the number keypad. The depth sensor will be used to provide input to the microcontroller. The depth sensor will be able to distinguish the user from his surroundings. To do this, we will use the OpenCV library in Python to implement the Histogram of oriented gradients (HOG) algorithm to identify the important parts of the photo and remove the extraneous parts. The camera will provide the live picture of the user's face to the microcomputer which will be used to determine what emotion the user is feeling. To classify and identify the emotion, we will try implementing one of the

following emotion detection algorithms: Support Vector Machine (SVM), Nearest Neighbor (kNN), or Random Forest (RF), and choose depending on performance and feasibility. In order for every user to have their own profile, the user will be prompted to enter their password into a number keypad and the mirror will authenticate that. The user detection subsystem will only provide information to the integration subsystem and will never receive any data from other subsystems. It will interact with the power system to stay running.

Controls Subsystem:
The microcomputer and the microcontroller will be considered one subsystem that we will call the controls integration subsystem. Therefore the user detection system will only interact with the integration subsystem and will only be providing input to it, never receiving information from any subsystem. We will most probably use the UART communication protocol to connect the two components with the rest of the subsystems. The user detection subsystem is the basis of our project since it will be providing all the information we are going to be analyzing to determine a user's emotional state. The picture from the camera must be at least 40 px in order for the person's face to be analyzed. The integration subsystem will interact with all other subsystems both sending data and receiving it.

User Interface Subsystem:
The display subsystem contains the mirror, the LED lighting and the speaker. In order to display all the information and interface with the user, there will be a mirror attached on a wall. The mirror is the main component of our project and will be used to interact with the user. The mirror will prompt the user to enter their password into the number keypad. The speaker will be used to communicate with the user. To reduce overall power consumption from the external wall source, we will include LED lighting to better see and receive visual input from the user. The display subsystem will receive input from the integration subsystem but it will never provide data to any other subsystem. It will interact with the power system to stay running.

Power Subsystem:
In order to have the whole project functioning, the power subsystem will connect to all the other subsystems through various physical connections. From the wall, the AC input will be directed to an AC to DC converter to switch the type of current. There will be a power loss of about 5-20%, so the diode and capacitor will be chosen accordingly. If we choose to add a regulator, though not technically necessary, we would use a switching or linear voltage regulator to get the voltage amounts we need for different subsystems. Finally, we would use an USB port to connect to the controls system to power all the components.

Tolerance Analysis:

An aspect of this project that poses a risk is the physical layout of our system components on the mirror, particularly the camera. The angle that the camera is placed on the mirror, whether it's mounted above it, at eye level, or elsewhere, will affect the accuracy of emotion detection. If the camera is placed above the mirror at a bad angle, then it might not be able to get a full picture of the user's face and it may incorrectly analyze the user's emotions. When detecting human features, it's ideal to be 30 degrees above eye level. However, 30 degrees above eye level is highly dependent on the person's height, a variable out of our control. To combat this issue, we are using a camera that can rotate while mounted to be at the ideal height for the user. Our mirror will "speak" to the user and let them know if their camera is at the right angle prior to analyzing their emotion.

Ethics and Safety –

After reviewing the IEEE Code of Ethics and the ACM Code of Ethics, we do not think our project will raise any ethical concerns. We do want to point out that we are dealing with people's mental health information which must be kept confidential under all circumstances (refer to ACM Code of Ethics and Professional Conduct Section 1.7). To prevent any privacy issues, security on each user's profile will be of utmost importance and we will have the user complete an authentication process before storing the information, to ensure that no other user can see their health history. As an additional security measure, we will give them the option to delete their photos after the 30 day period where we provide resources, so users have the option to store their data for a longer period of time or delete it entirely. Because we are storing and analyzing mental health patterns over time, we have a moral duty to provide resources and any help we can if we notice someone struggling. We will keep these concerns in mind as we design our final product. In terms of safety, we do not anticipate any significant safety issues for ourselves as the lab team or end users. We are not using significant voltage or battery power in our project nor are our end users putting themselves at risk by using the product. The end users will be looking into the camera on our mirror and hearing its response; the hands-off approach to our product lends itself to minimal safety issues.