When the user boots up KED, the main program launches threads. The number of threads and their functions can be seen in figure (n). One thread builds the CNN for facial recognition, and it takes around thirty seconds for the CNN to be fully built. Once the CNN if fully built, the main menu is displayed. Along with the main menu, a window opens that displays the camera feed. In the background, KED is measuring accelerometer data, and a facial recognition system. From the main menu, the user can unlock the door manually, change settings, and manage keys. KED is also constantly scanning for a face. If KED detects a face, several actions happen. On the camera feed, a rectangle is displayed around the face detected. In the background, the face detected is sent to through the CNN. If the face detected is a recognized user, the door is unlocked. Also, the recognized user’s face is displayed in the camera feed.

KED is two different modules, the RPi and the Atmega. The RPi manages the Key Database, the Random Key Generator, the Security Settings, Camera, and the Facial Recognition. The Atmega communicates with the accelerometer, and the motor. The RPi and the Atmega both communicate to each other via UART.

The RPI runs the main program which controls and manages components connected to it. The components it manages mostly act independently.

The Key Generator generates random keys that act as passcodes to the door. The time and date the key was created is also saved and assigned to the respective keys.

The Key Database manages the keys created. The user can view the keys created and delete keys manually. Keys are automatically deleted after a certain amount has passed since the key’s creation.

The Camera sends a live feed to the RPi which is displayed on screen. It is also where face detection occurs.

The Facial Recognition is activated when the camera detects a face. This component takes a frame from the camera when a face is detected. This frame sent through the CNN to determine if it is a recognized face.

The Atmega controls the rest of the peripherals. It communicates with RPi via UART.

The Key Generator generates passcodes at the length of 5 digits. The time and date the key was created is also saved to the key. The date and time are found by using a python package called datetime. An expiration date is also given to the key upon creation. Keys created are saved into a key list file. The expired key checker will constantly go through this key list to find any expired keys. Any expired keys are deleted off the key list.

The camera is attached to the RPi via (USB or RPi Camera). In order to display the camera’s live feed, the python package, OpenCV, is used. Using OpenCV, the main program opens a window for the camera feed. Along with live feed, OpenCV is used for face detection, but not used for facial recognition. It uses Haar Casscades in order to determine if a face is detected. A rectangle is drawn around peoples’ faces on the camera feed to indicate that a face has been detected.

The facial recognition takes in a frame from the camera when the camera detects a face. The frame is cropped and resized, so that frame is only the detected face. The detected face is sent through the CNN and formatted for image comparison. The formatted image is compared to an image of a registered user using cosine similarity. If the similarity is underneath a specific threshold, the face detected is considered recognized, and the door is unlocked. Also, the recognized person’s name is displayed on the camera live feed.

The Atmega is used to communicate with the motor and the accelerator. The type of motor KED uses is a stepper motor which are controlled by using discrete phases. The Atmega reads in accelerometer data using I2C. Both the Atmega and the RPi are in communication using UART. The connections between Atmega and RPi can be seen in figure (). The Atmega sends accelerometer data to the RPi which is displayed on screen. The RPi sends commands to the Atmega to rotate the motor. 