Distributed Bike Locking System

Proposal

Introduction

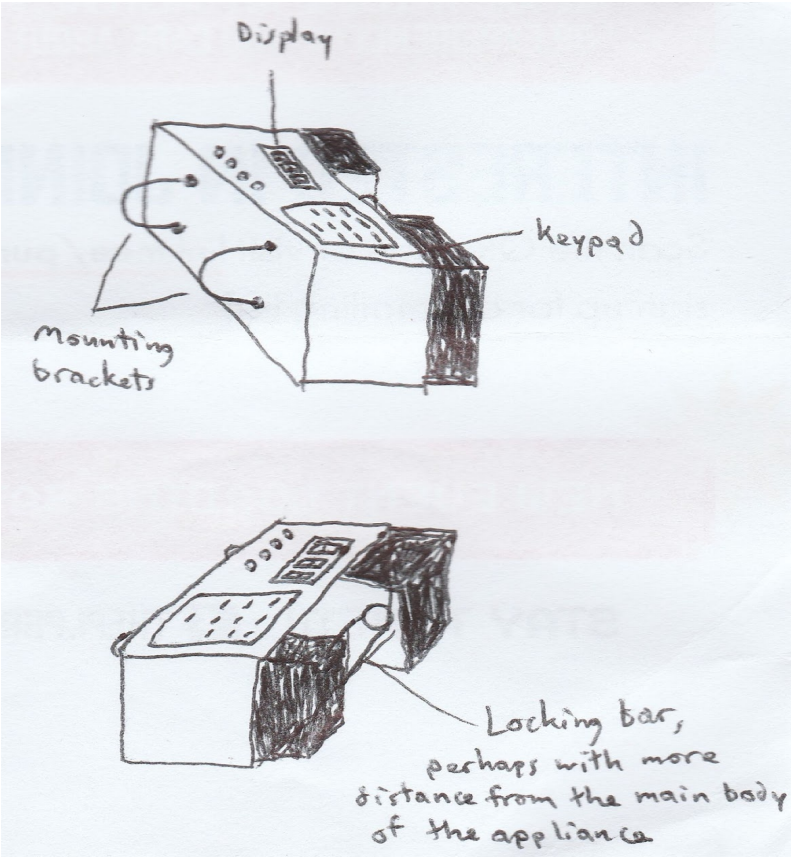
- **Problem:**

  Bike theft has always been a big issue in this world. They are always stolen every 30 seconds. Almost two million bikes are stolen every year resulting in a loss of over $350,000,000. Although there are individual bike locks, thieves are able to cut these locks with tools such as the bolt cutters. This shows that bikes are able to be stolen even when the bikes are locked by the stands. Also, there are times when people forget to bring their locks with some sense of urgency. This also can be a problem where they need a way to keep their bikes safe after coming back from their events which can include school, work, play, etc.

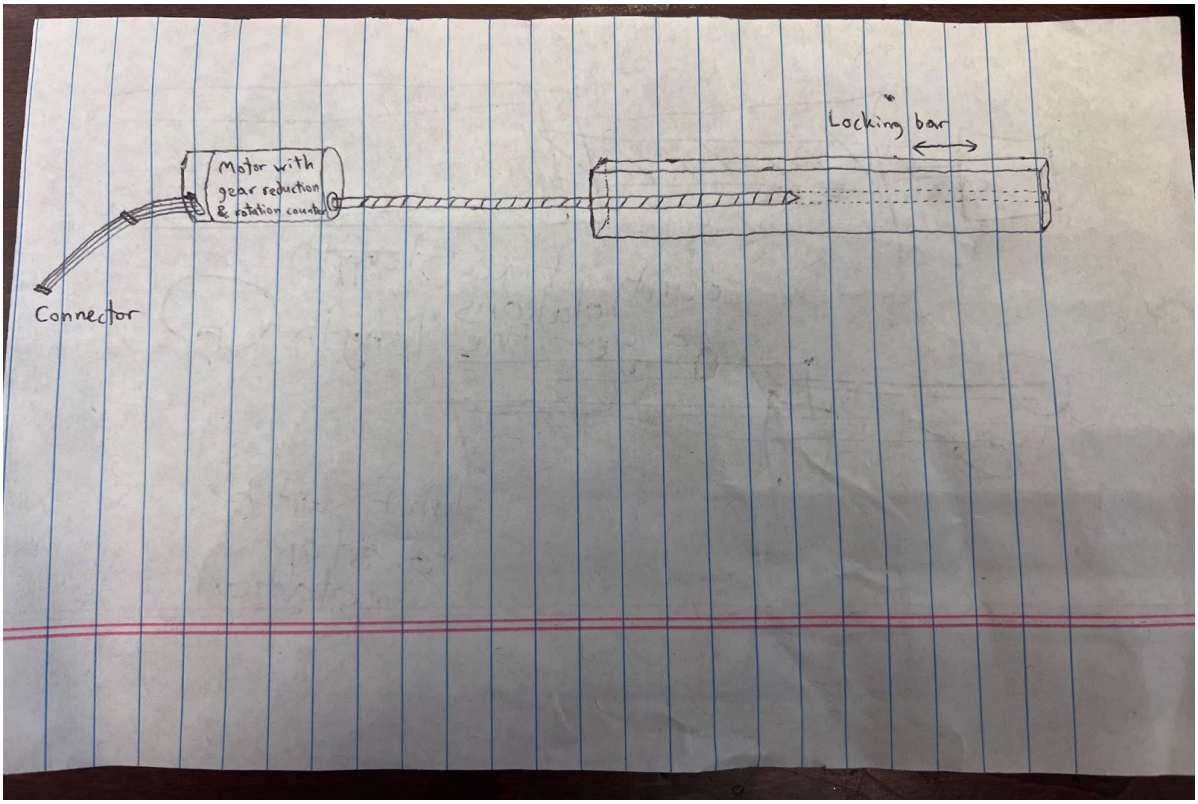
- **Solution:**

  In order to solve the problem of bike theft, we are proposing a distributed bike lock system. This is going to be a group of independent, public, automated, passcode-driven locks that will significantly reduce bike theft. The system will sound a high pitched alarm when any sign of physical theft activity is happening and this will be detected through the use of sensors and buttons. This will take a user input of the number of hours to lock their bike as well as the amount of money from the user for that input amount of time. This keeps their bike firmly locked for that amount of time.

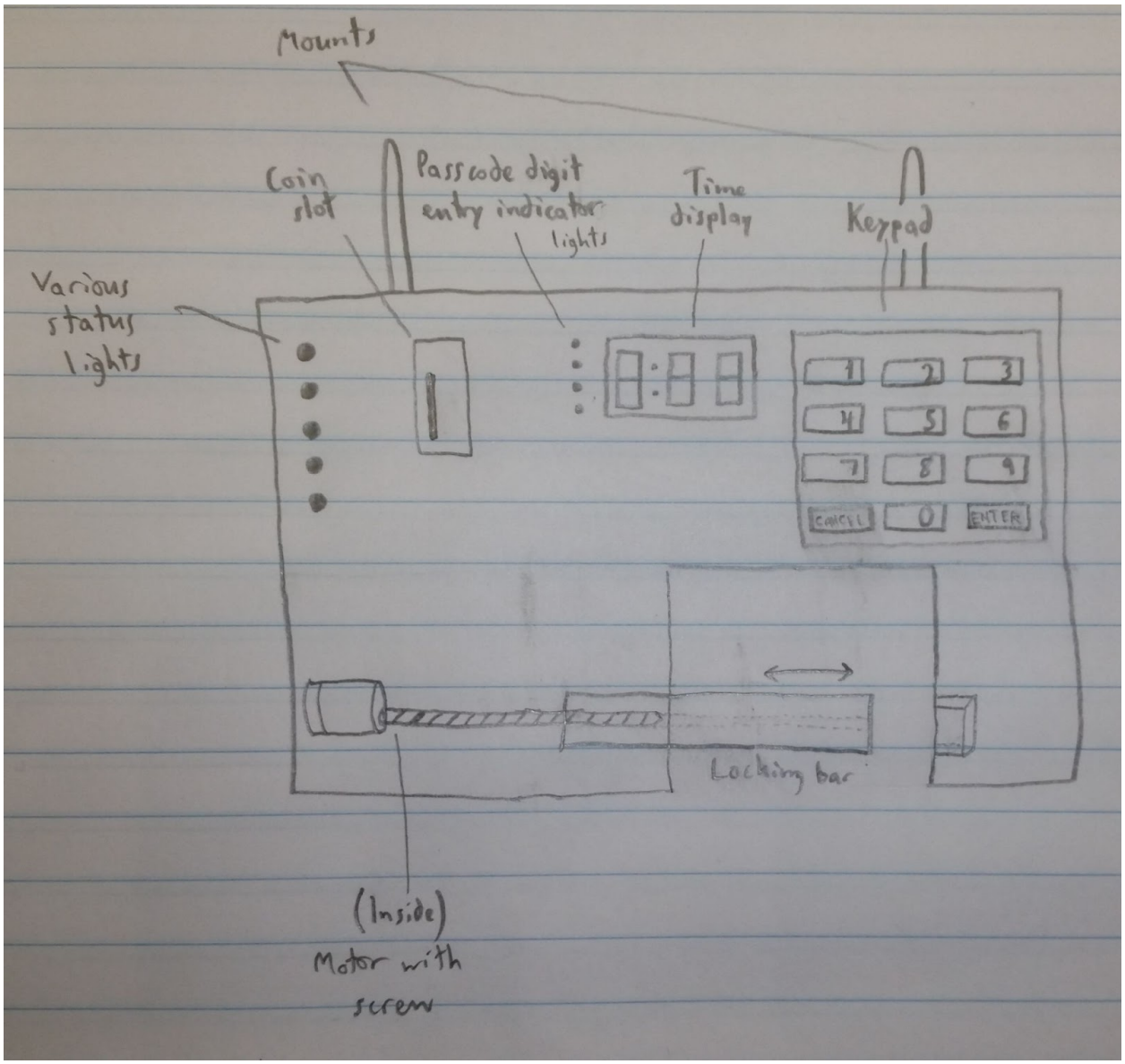
- **Visual Aid:**



Bike lock unit



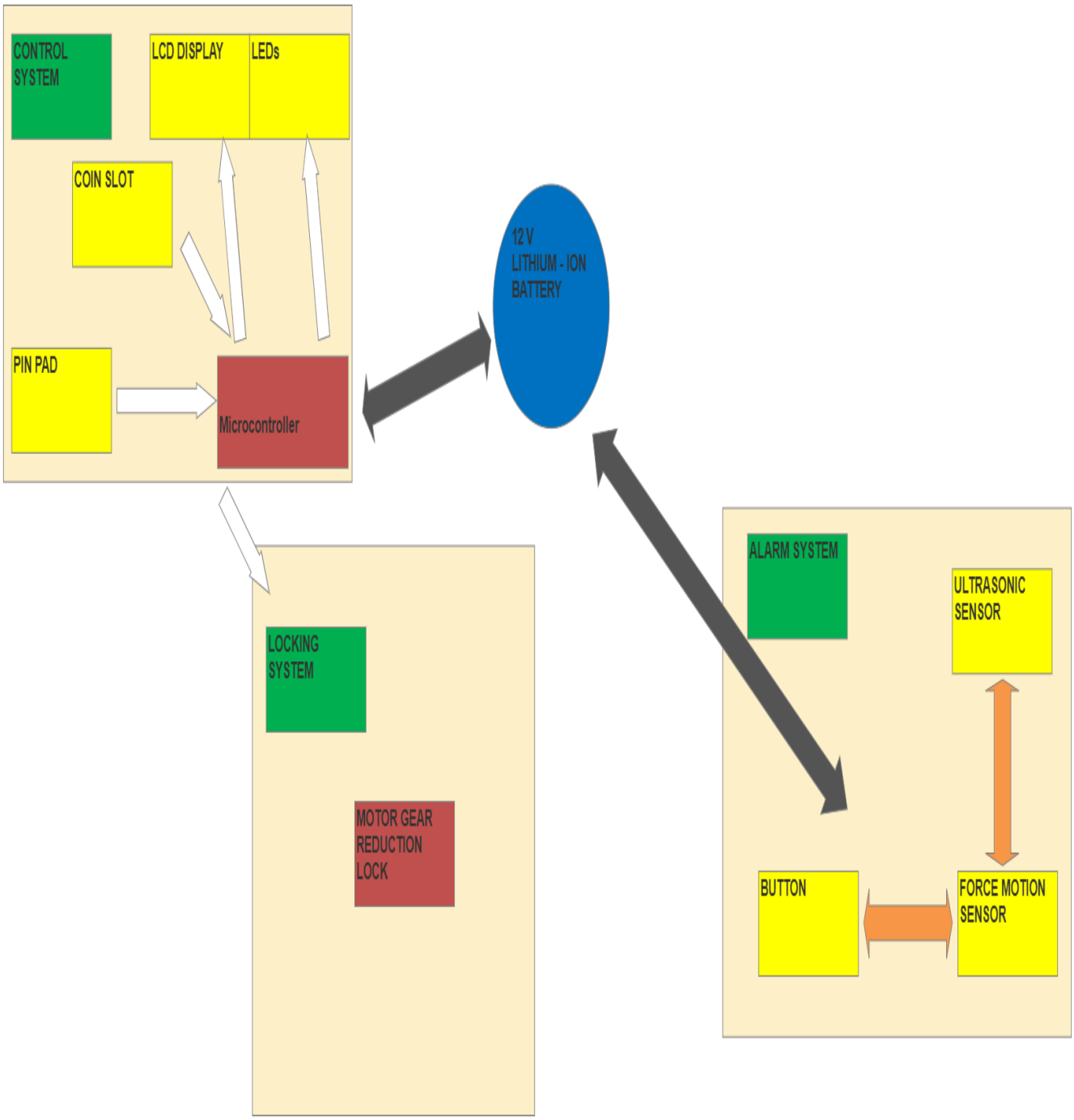
Motor utilized for the bike lock



General interface layout

Design

- **Block Diagram:**



- Subsystem Overview:

- Control Subsystem: Responsible for locking and unlocking the gear motor based lock. Takes user input for the number of hours they want to lock the bike for through the use of the pin pad. Makes the user deposit coins in the coin slot to start the locking of their bike and the required amount is $0.50 per hour. This transfers the signals to the LEDs to keep track of the lock process and the LCDs to display the status of the system eg. four digit pin with *'s, money needed to deposit, the status of the lock
- Alarm Subsystem: Sounds the alarm when there is a thief attempting to steal the bike with a high pitched sound and this is operated by a 12 volt lithium Ion battery-based power source. This is connected with three sensor components and if there is any physical force coming near the sensors, a signal will be sent to the alarm which would sound with a high pitched sound. This is near the lock subsystem.
- Lock Subsystem: Rotates the gear to shift it left or right based on the signal from the microcontroller. This is programmed by the Programmable Interface Controller. It shifts based on the signal from the controller. This makes sure the bike is firmly locked in a way that no thief can try to force the lock to open with any tools or break it.

- Subsystem Requirements:

- Control Subsystem: Requires a microcontroller to take user input from the keypad and coin slot, and send output to the status LEDs, numerical display, and motor controller (embedded in the motor). The microcontroller is embedded on a PCB, and it interprets the data from the coin slot and adds the values of the coins to determine when the proper amount due has been paid. It then sends a signal to the motor controller when the right amount of money has been paid, according to the number of parking hours specified by the user. The microcontroller board is connected to a voltage-regulated power source via a plug. The microcontroller is responsible for starting and stopping the lock motor based on the number of revolutions traveled, which is sent as data by the motor controller. The keypad sends a signal to the microcontroller after the 4 digit PIN is typed. Then the microcontroller waits for the input signal from the coin slot. The input will be successfully processed when the user pushes the correct amount of money into the slot. The microcontroller after having the correct amount of money from the user with a 4 digit pin will send a signal to the motor.
- Alarm Subsystem: Sounds the alarm when there is a thief attempting to steal the bike, with a high pitched continuous beep. It is operated directly by a battery, in an analog circuit with no need for intelligent alarm activation as long as the force of a user or their presence signals the sensors. This in turn will send the signal to

the alarm which will sound a beeping noise with a high enough frequency to be unpleasant to the ears. This includes the force/motion sensor to detect any movement of the thief along with the ultrasonic sensor to detect the movement from a particular distance. If both the sensors are able to detect unusual or suspicious activity with strong force or object or hand movement close to the alarm system, then this would trigger the alarm.

- Lock Subsystem: Rotates the screw to shift the bar left or right based on the signal from the microcontroller. This makes sure the bike is firmly locked in a way that no thief can try to force the lock to open with any tools or break it. The Alarm Subsystem is also near the lock and this is the best way to ensure no tool or force comes near the lock to steal the bicycle. This is operated with the use of the control subsystem. The lock is activated when the control system successfully receives and processes the input signals from the keypad and the coin slot. Overall, the lock subsystem is reliant on the control subsystem.

- Tolerance Analysis:

The possible risks of the system that can interfere with the completion are with the signals from the microcontroller to the motor-driven locking bar. This can be a problem with the time the motor takes to get the signal from the microcontroller, and also the time it takes for the motor to lock the bike. Another problem is with how well the motor locks the bike and the way it is unlocked. This is because the motor needs to stay firm in one place for the bike to be locked. We also need to make sure we have the clipped terminals (secured wiring) especially for the coin slot. The coin slot will not process the money properly and it can drop the coins in random places which can also increase the chances of money theft. The signal relays are important in that they have to be programmed properly with the Programmable Interrupt Controller. This includes taking signals from both the keypad and the coin slot and then outputting them to the LEDs and the LCD screen. Both the successful keypad 4-digit input, and the right amount of coins in the coin slot to start locking the bike with the motor, need to be taken into consideration.

Ethics & Safety

Each unit of the Distributed Bike Locking System is not a particularly hazardous device. It does not use high voltage, and only contains one moving part that is visible from the outside. With the ACM Code of Ethics and Professional Conduct in mind, discrimination, fairness, respect, and privacy are in no way called into question by our design, simply because of the nature of the device. Anyone can use it, information is not shared, and the procedure for using it is made clear by the status lights and the writing next to them on the exterior of the device.

The only issues that might arise during use of the device are honesty and physical safety. The device must accept coins without error or failure, especially since there is no coin return mechanism as there is on many vending machines. If there is a lapse in the functionality or communicative ability of the coin slot, however brief, it could have the effect of stealing from the user, with a coin or several coins not counted. In the design, we will have to ensure that all connections to the coin slot are secure, shock-resistant, and not prone to corrosion. Clips for connection plugs will ensure that connections will not come apart without deliberate human intention, and small amounts of conductive grease on electrical contacts will keep them free of rust. If there is any other problem, however, the device will need to have on the exterior the contact information of the managing or owning party, so that the dissatisfied user can have maintenance staff sent out from the (presumably nearby) building. This will be laser-engraved or somehow printed or inscribed on the exterior by the dealer when ordered by a client, and provision of appropriate contact information (such as a phone number) by the client will be a condition for the sale of the unit or units. The owner of the bicycle racks and lock appliances must have a custodian familiar with the device, to remedy any potential problems when necessary.

As far as physical safety, there are two risks. The first is that the device will be both loose and bulky, and so can slide down the two-foot-tall bicycle rack tube and potentially land on the user's foot if the user accidentally lets go of the device while using it. It will need to be held up by hand during user interaction, although depending on the shape of the rack, the installer of the appliance may be able to mount it tightly, if possible without compromising its ability to be used with any bicycle. Rubber stops may also be necessary to prevent significant shock due to dropping, or from careless release after termination of parking. A decal can be attached to the outside of the device saying "dropping may cause personal injury" or something to that effect. The second physical risk, and perhaps the more dangerous one, is accidental insertion of the user's finger into the locking bar receptacle, opposite the place where the bar comes out. The motor has a great amount of torque, so any object that gets in the way of the locking bar when in motion will probably not stop the motor, even if that means that the bar stops and the motor breaks out of its mounts inside the appliance. Some sensor could be employed to

stop the motor if something got in the way of the locking bar, but we decided that it would be simpler to apply a decal to the exterior saying “keep fingers away” or something similar, and flash an LED continuously until the bar finishes its movement. The device is not exactly poor-judgment-proof, but there arises the need for safety decals, and the durable construction of the device may help to differentiate it favorably from any possible alternatives that the user may find. Generic “Warning” and “Danger” stickers are available commercially. The motor is not nearly powerful enough to need to meet National Electrical Manufacturers Association standards, as their minimum is 200 horsepower.

During development of the appliance, the only hazards are electric shock, overloading circuitry from incorrect wiring, and injury from the strong motor. To avoid these, care must be taken in wiring, and nothing overlooked. Understanding the hazards is perhaps the most crucial element of this, and it is important not to underestimate the dangers that will become apparent as we work on it.