1. Introduction

- Problem and Solution Overview

  Car dealers deal with a lot of car keys during working hours, and have a central location where they keep keys to the cars on the lot. Unfortunately, employees sometimes misplace the car keys, forget to return them after using them for test drives, or the car keys could even be stolen. Replacing car keys takes time and money, and also poses a security concern.

  To combat all of these issues we are proposing a smarter set of keys and a corresponding key box to house all of these and some of the system's features. The keys would be able to be located by making sounds when looking for them. The key box system would be able to activate, deactivate the keys and give a direction to the key which the user is looking for.
- Visual Aid
- High-level requirements list
  1) Keys that are within certain distance can be tracked easily by sound and direction hints
  2) Keys that are out of the distance range after a specified amount of time and are unaccounted for will be deactivated automatically (for example, if the salesman forgets where the keys are and loses them, there's a chance they were stolen and should be deactivated, but if the car was purchased by a customer, obviously the key would still be gone but should not be deactivated)
  3) Keys are small, so all the implementations on the keys should be small enough for keys to carry.
  4) The ability to handle a large quantity of keys

2. Design

- Block Diagram

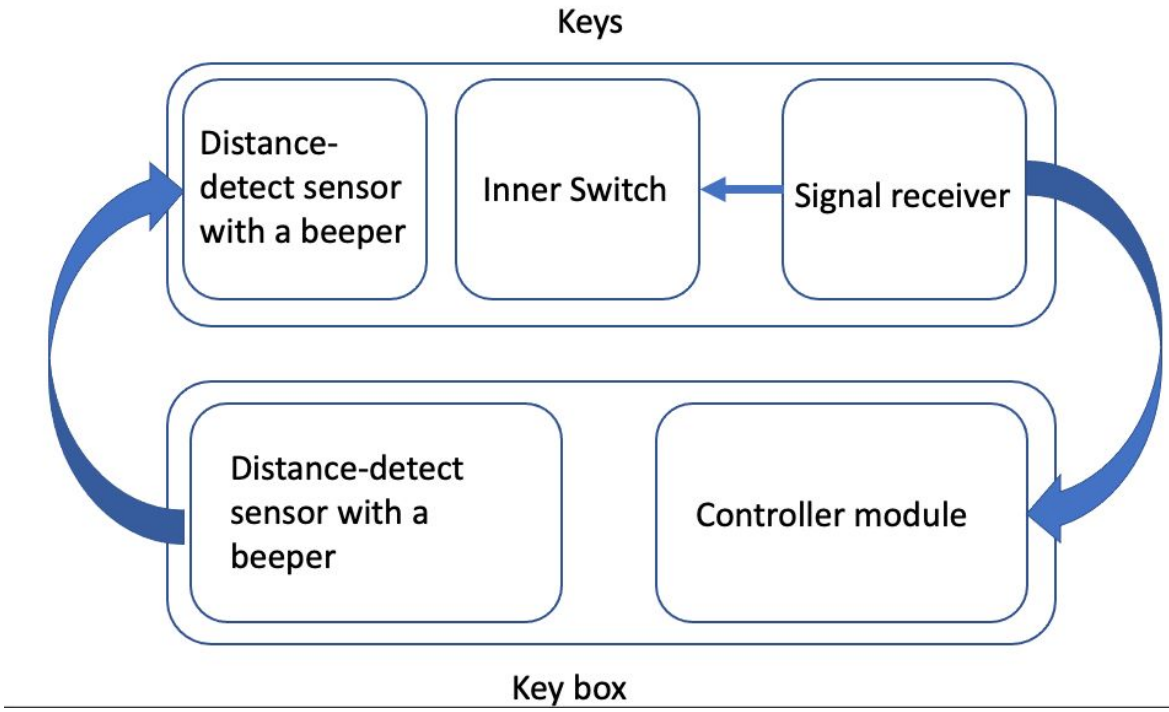

Figure 1. Block Diagram

- Subsystems(need to adjust according to R&V: https://courses.engr.illinois.edu/ece445/guidelines/requirements-and-verification.asp)
    1) Beeper (parts under consideration: Arduino and piezo buzzer(flaws: expensive and large))
       The key box will have beepers with distance sensors, each sensor is responsible for a specific key. Every key will have a beeper with a distance sensor that reacts to the sensor on the key box. When the user is looking for a specific key, the user will press the button that activates the sensor responsible for the specific key, then the beeper on the key and the key box will both make sounds. When the user is moving towards the key, the sound will be larger, indicating that the user is approaching the specific key.
    2) Controller module
       This module controls the activation and deactivation of keys. When the user wants to deactivate a key, a button will be pressed and send out a signal to the signal receiver on the specific key. It will alert the user of active/inactive keys through a simple interface and allow them to track the keys when a key needs immediate attention or when it is stolen/lost.
    3) Signal receiver (Communication module)
       This device receives the signal sent by the control module indicating activation or deactivation of the specific key. We plan to use RF circuits to transmit and receive data without the need of line of sight and considerably higher range for broadcasting of signal compared to other technologies within the scale of the

key casing. Sizing of the casing will have to be adjusted based on the needed range of the RF module.

4) Inner Switch
   The switch will turn off or turn on the key according to the signal received by the signal receiver. This will be the interface between the receiver and the key deactivation module which might be necessary since the deactivation actuators may not operate on the same voltage as the receiver module.
5) Key Deactivation (part of inner switch)
   For cars with physical keys, we could use actuators that extend a metal piece into place that prevents the key from entering the car's key hole. This would mean the key activation module may sit on the key as a jacket-like casing. For keys with no physical keys, the solution would be slightly different. Keys will have an inner switch on each of them that can only be turned up and off by the control module. (or like disabling the key fob's ability to unlock the vehicle so that they couldn't reach the push button start.)

- Tolerance analysis (guide: https://courses.engr.illinois.edu/ece445/documents/tolerance-analysis-guide.pdf)

3. Cost and schedule

1) Cost analysis
   - Labor(For each partner in the project)
   - Parts
     1) RF circuits for signal receivers
     2) Arduino and piezo buzzers for distance-detect sensor with a beeper (may be too large to put on a key)
   - Sum of costs into a grand total
2) Schedule

4. Discussion of Ethics and Safety

5. Citations