Smart Door Lock

DESIGN DOCUMENT

Team 10
Client: Diane Rover
Advisers: Diane Rover, Xinyao Li

Members:
James Gossling - Hardware Design
Hailey Lucas - Embedded System Design
Jackson Lopata - Mechanical Design
Eric Reusch - Software System Design
Isaac Stich - Embedded System Design
Christian Williams - Embedded System Design
Frankie Mago - Machine Learning Algorithm Design

sdmay22-10@iastate.edu
https://sdmay22-10.sd.ece.iastate.edu/
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Executive Summary

Development Standards & Practices Used

- IEEE P2089- Standards for Age Appropriate Digits Services
- IEEE P2660.1- Recommended Practice on Industrial Agents: Integration of Software Agents and Low Level Automation Functions.
- IEEE P2817 - Guide for Verification of Autonomous Systems.
- IEEE P2840 - Standard for Responsible AI Licensing Standard for Responsible AI Licensing
- ANSI Grade 3- Standard/safety requirements for locks
- BHMA Residential Security Grade- Standard/safety requirements for locks
- Legal standards for recording with/without someone's consent
- privacy standards for saving/distributing user audio data
- Wifi/Bluetooth communication standards

Summary of Requirements

- Use embedded system that is small enough to fit on a door lock (not pi, Arduino mega etc)
- Stay within the physical bounds of the microcontroller (memory, cpu speed, etc)
- Be able to lock/unlock within 5 seconds of confirmation
- Easy access to data sets / easy creation of data sets
- Use tools and skills learned from the coursera embeddedML course
- Use machine learning to pick up a specific person saying a specific word
- Get the machine learning algorithm accuracy to at least 90%.

Applicable Courses from Iowa State University Curriculum

- CPRE 288
- CPRE 488
- COMS 327
- COMS 474/574

New Skills/Knowledge acquired that was not taught in courses

- Arduino hardware functionality
- Arduino software functionality
- Knowledge of setting up hardware/systems (Arduino->peripheral setup)
- Edge Impulse functionality

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Team

1.1 Team Members

James Gossling, Jackson Lopata, Hailey Lucas, Isaac Stich, Eric Reusch, Christian Williams, Francis Mago

1.2 Required Skill Sets for Your Project

- Knowledge of hardware and electrical systems, knowledge of software concepts. knowledge of cyber security concepts
- Knowledge of embedded systems programming
- Knowledge of Machine Learning concepts
- Microcontroller experience

1.3 Skill Sets covered by the Team

Software: Jackson Lopata, James Gossling, and Eric Reusch

Computer: Hailey Lucas and Christian Williams

Electrical: Isaac Stich and Francis Mago

1.4 Project Management Style Adopted by the team

Agile/Scrum

1.5 Initial Project Management Roles

Scrum Leader: Isaac Stich

Product Owner: James Gossling

Record Keeper: Hailey Lucas

Individual Contributors: James Gossling, Isaac Stich, Jackson Lopata, Francis Mago, Christian Williams, Hailey Lucas, Eric Reusch

2 Introduction

2.1 Problem Statement

We want to produce an embedded system that utilizes machine learning that has real world applications and solves physical problems, and decide whether the project could be integrated into the ISU curriculum.

To solve this problem we have chosen to design a voice operated 'Smart Door Lock.'

2.2 Requirements & Constraints

Incorporate machine learning to an embedded system

When the programming user says their keyword, the door (un)locks; only the programmed voice works

Users must agree to having voice recorded with purchase of lock

Appropriate technical complexity for an ISU course

Easy for the user to program a keyword/easy install

Machine learning accuracy of 90% on voice and keyword recognition

Use embedded system that is small enough to fit on a door lock (not Pi, Arduino Mega, etc.)

Stay within the physical bounds of the microcontroller (memory, CPU speed, etc.)

Be able to lock/unlock within 5 seconds of confirmation

Easy access to data sets/easy creation of data sets

Use tools and skills learned from the Coursera Embedded ML course

2.3 Engineering Standards

Use IEEE standards when applicable

- IEEE P2089- Standards for Age Appropriate Digits Services
- IEEE P2660.1- Recommended Practice on Industrial Agents: Integration of Software Agents and Low Level Automation Functions.
- IEEE P2817 - Guide for Verification of Autonomous Systems.
- IEEE P2840 - Standard for Responsible AI Licensing Standard for Responsible AI Licensing
- IEEE P7001 - Transparency
- IEEE P7002 - Data Privacy

ANSI Grade 3- Standard/safety requirements for locks (Strength & Durability)

BHMA Residential Security Grade C- Standard/safety requirements for locks (Strength, Durability, Finish)

Legal standards for recording with/without someone's consent

Privacy standards for saving/distributing user audio data

Wifi/Bluetooth communication standards

2.4 Intended Users and Uses

Property owners/renters can use this system to secure internal and external doors

Safe makers can integrate this system into their safes.

Locksmiths can sell these locks to customers.

Security and insurance companies can recommend and/or sell these to clients.

2 Project Plan

2.1 Project Management/Tracking Procedures

We will be using agile, because it will be much easier to respond to changes in requirements with this approach.

We will use Gitlab for project management, Google Drive for documents, and Discord for communication and logistics.

2.2 Task Decomposition

-Finish Coursera course
-Research hardware
-Acquire hardware
-Research similar software implementations (Alexa, Google, etc.)
-Gather data
-Design locking mechanism
-Software design
-Implement algorithm on Edge Impulse
-Implement software
-Test software
-Implementation testing
-Complete course assignments

2.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Milestone	**Metric**
ML algorithm detects a specific person saying a keyword (ML version 0.1)	90% accuracy
ML algorithm differentiates between different people saying the keyword (ML version 0.2)	90% accuracy per person

ML algorithm can detect a given user's voice and their user-defined keyword (ML version 0.3)	90% accuracy
microcontroller moves motor to unlock door on correct keyword recognition (ML version 1.0)	Motor switches consistently within 5 seconds of receiving keyword

fig 1

2.4 Project Timeline/Schedule

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.2) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development model. For Agile, a sprint schedule with specific technical milestones/requirements/targets will work.

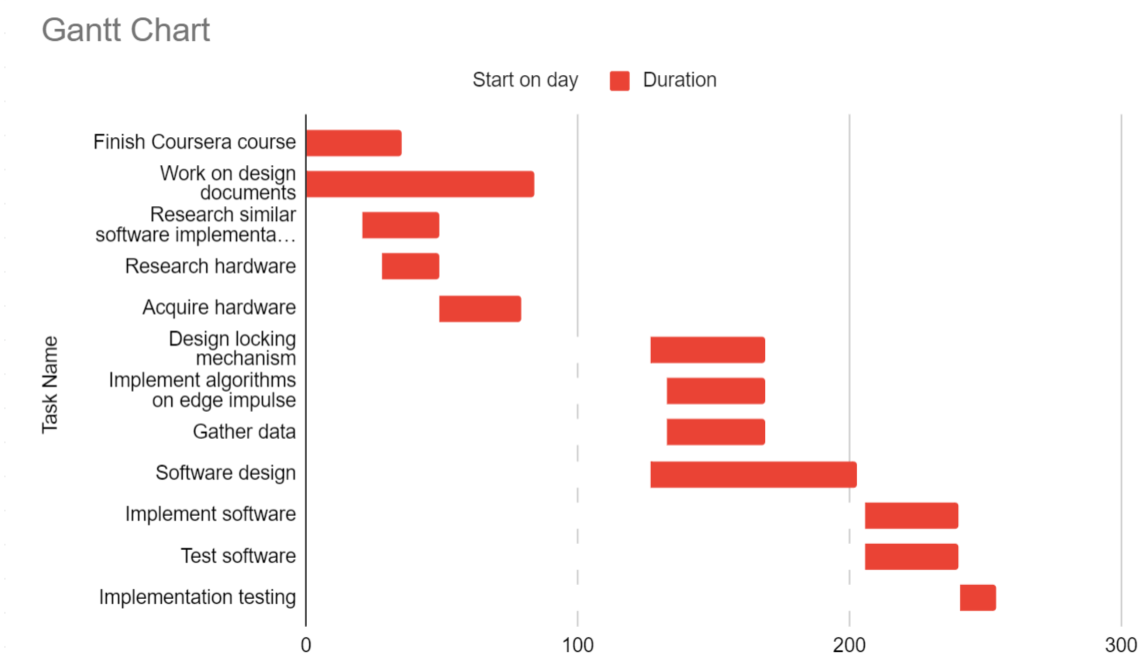


fig 2.

2.5 Risks And Risk Management/Mitigation

Agile projects can associate risks and risk mitigation with each sprint.

-Finish Coursera course

Not everybody finished on time. Risk: 0.1

-Research hardware

Unsure of what hardware to use. Risk: 0.2

-Acquire hardware:

Hardware may not be available due to supply chain shortages. Risk: 0.4

-Research similar software implementations (Alexa, Google etc)

Specific implementation details are unavailable. Risk 0.3

-Gather data

Unable to gather enough data for training. Risk: 0.6

Mitigation: Use available audio resource packages from google or other companies that have pre-recorded keywords to train our model

The data is biased. Risk: 0.7

Mitigation:

1. Gather more data.
2. Gather more data from more people with underrepresented characteristics.

3.Use more audio resource packages as more data.

-Locking mechanism design

The design does not work as intended and needs to be redesigned: Risk 0.3

-Software design

The design does not work as intended and needs to be redesigned: Risk 0.3

-Implement algorithm on edge impulse

Accuracy is not as high as we want it to be. Risk 0.5

Mitigation: Redesign different aspects of the algorithm (nodes, layers), gather more data, gather more diverse data

-Implement software

We don't have enough time to implement all the planned software features: Risk 0.4

-Test software

We don't have enough time to implement full test suites: Risk 0.4

-Implementation testing

We don't have enough time to implement full test suites: Risk 0.2

-Complete course assignments

We don't have enough time to finish all course work: Risk 0.1

2.6 Personnel Effort Requirements

Task	Person-Hours
Finish coursera course	10
Research hardware	10
Acquire hardware	5
Research similar software implementations	10
Gather data	100
Design locking mechanism	30

Software design	60
Implement algorithm on edge impulse	50
Implement software	60
Test software	60
Implementation testing	20
Complete course assignments	

fig 3.

2.7 Other Resource Requirements

Microcontroller
Motor
Microphone
Power source
Lock
Phones
Audio files
Possibly HPC cluster time

3 Design

3.1 Design Context

3.1.1 Broader Context

Area	Description	Examples
Public health, safety, and welfare	How will our project keep people and property safe?	Increased security of buildings since keys can be copied, but a person's voice saying a specific password cannot be copied nearly as easily. Increased safety because you won't be locked out of your house if you lose your physical key.
Global, cultural, and social	How will our product protect people's privacy as well as safety?	May not be usable in areas where stored biometric data is not allowed.

		People may be reluctant to use it since it utilizes A.I. and stores their biometric data.
Environmental	How will our product affect resource consumption?	Increased power usage in homes. Potential water/resource consumption with adding our design onto existing lock in production.
Economic	How will our product affect the economy as a whole? How will our product affect the financial situation of its users?	Keeps people's homes safe and secure, less break ins and so less insurance claims, possibly leading to lower premiums. Increased power usage of homes. More expensive than traditional locks.

fig 4.

3.1.2 User Needs

- Building owners/renters need an easier way to lock and unlock their doors using their voices.
- Locksmiths/Safe Companies need new products to sell and to increase ease of use and security.
- Insurance Companies need to lower the risk of a payout as much as possible, so they could add incentives for their clients to use these locks.
- Security Companies need ways to increase the security of the properties and products that they are securing.

3.1.3 Prior Work/Solutions

- Coursera Embedded Machine Learning course (https://www.coursera.org/learn/introduction-to-embedded-machine-learning)
    - Advantages:
      Faster spin up time, lots of documentation and examples on hand, tools to help workflow available have completed a simple project that is similar to what we are making
    - Shortcomings:
      The project was simple so added complexity will need to be done without help from the course
- August Lock company makes smart door locks, including voice activated locks (https://august.com/)

3.1.4 Technical Complexity

1. We have a microcontroller element which will control a system of hardware (mic, motor/actuator, battery)
2. We will be acquiring data for and training machine learning model(s)

3. We will have to design a physical interface between the locking motor and the lock itself
    a. Torque and RPM requirements
        i. Different motors, voltages, gear chains
    b. Positional requirements

Training machine learning models to work with an individual's voice meets, and sometimes exceeds, the current market solution.

3.2 Design Exploration

3.2.1 Design Decisions

1. Choice of standalone system, not dependent on a network or other computing devices
2. Choice of using edge impulse for data acquisition, model training, and model deployment
3. Custom or off the shelf lock

3.2.2 Ideation

If we did a distributed system we thought about the different potential connectivity methods:

Wifi
Bluetooth
RF
USB/serial.

If the system would be standalone, connected to other locks, connected to a mobile app and/or a base station/hub.

3.2.3 Decision-Making and Trade-Off

Simplicity vs. functionality.

		Options							
Criteria	Weight	Standalone		Interconnected		Mobile app		Base Station	
		Score	Weight	Score	Weight	Score	Weight	Score	Weight
Able to implement in 1 semester	1	1	1	4	4	2	2	3	3
Able to explain upon ML model	2	3	6	4	8	2	4	1	2
Security	3	1	3	2	6	4	8	3	9
Lock/ unlock quickly	4	1	4	2	8	3	12	4	16
Easy for customer to set up	5	1	5	4	20	2	10	3	15
Totals: Lowest is best			**19**		46		36		45

fig 5.

3.3 Proposed Design

We have all completed the Embedded Machine Learning Coursera course, which means we've done a project on keyword spotting. This was implemented and tested on an Arduino board, which may potentially be used for our final design.
Began research on hardware considerations.

3.3.1 Design Visual and Description

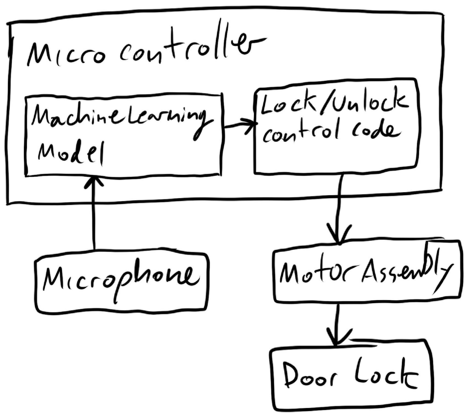


fig 6.

The microcontroller contains the machine learning code and lock/unlock code which controls the motor assembly. The microcontroller has a microphone and motor assembly wired to it. The microcontroller samples from the microphone, sends the data to the machine learning model, and based on the Machine Learning Model's output, the lock/unlock code will execute and turn the motor. The motor assembly will physically lock or unlock the door depending on what state the lock was in previously.

3.3.2 Functionality

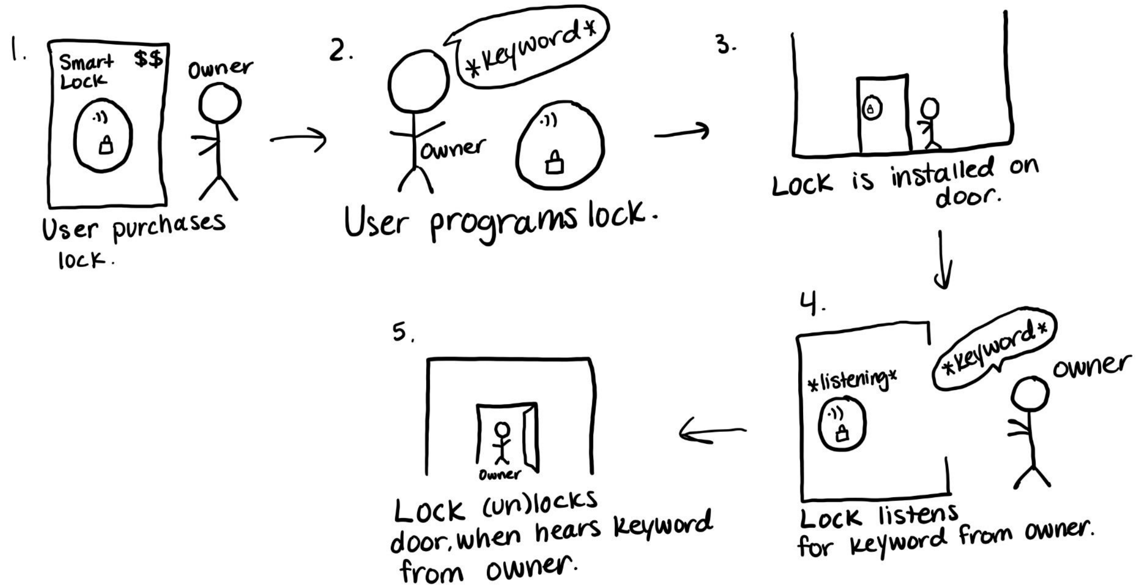


fig 7.

The client receives the lock, and it is installed into the client's door. The lock should function by always listening for a certain keyword of the user's choosing (a password), and when that keyword is uttered by the corresponding user, then a motor switches to either lock or unlock the door.

Our current design satisfies the functional requirements, but it is indeterminate if we satisfy the non-functional requirements until we have implemented our design.

3.3.3 Areas of Concern and Development

Concerns:

Concerns over model accuracy and unbiased data.

Unable to find and modify a lock to meet our needs.

Development:

Begin data collection, model training. How soon can we order materials?
Researching lock
Consulting with other students at ISU, mainly mechanical engineers, to look over the design on the lock.

Dr. Rover has connected us with Dr. Muhammad Handan, and ISU ECE grad as our domain expert to reach out to with questions.

3.4 Technology Considerations

Strengths:

- We will be using some of the smallest available microcontrollers and motors
- We will be using off the shelf hardware
- We will be using an open source machine learning framework (Edge Impulse)

Weaknesses:

- We will have limited CPU speed and available memory
- We will not be creating custom hardware so we will need to work within the limitations of the existing hardware

3.5 Design Analysis

Our prototype keyword spotter worked with ~90% accuracy on training and test data, we believe we can easily build off of this prototype and increase the accuracy even more.

3.6 Design Plan

See Section 5

4 Testing

4.1 Unit Testing

Machine Learning:

- Keyword recognition testing: How accurate the neural network identifies a keyword.

- Keyword spotting accuracy first measured using randomly selected test set data on Edge Impulse to give theoretical accuracy.

Arduino Software:
- Microphone sensor code testing: Use Arduino IDE and serial monitor to check that sampling data is correctly sampled/stored.
- Motor(s) code testing: visually inspect that motor working as it should when the Arduino runs it
- EdgeImpulse library: Using Arduino IDE and serial monitor to check that the model library is working, and returns a result within time limit.

4.2 Interface Testing

Interfaces:
Adafruit microphone library
Stepper motor library
Edge Impulse library

The microphone unit will interact with the Edge Impulse library unit, we will test that the microphone delivers the proper data in the proper format to the Edge Impulse unit. The Edge

Impulse unit will interact with the motor unit, we will test that the Edge Impulse library's return value is properly used to make the motor move or not move. This will be done visually and with the serial monitor on the Arduino IDE.

4.3 Integration Testing

Machine Learning:
- Keyword recognition testing: How accurate the neural network identifies a keyword.
    - Will then test keyword spotting accuracy using real time data (spoken words) once deployed onto a microcontroller.

-Motor calibration and positioning: Ensure that the motor does not over/under rotate the deadbolt axel to make sure that the motor does not burn out and/or wear down gears.

-Simple Keyword test: When the keyword is spoken does the lock open.

4.4 System Testing

We will be saying words and visually confirming that the system acts appropriately to a keyword/non keyword. All the interface and integration tests will be applicable to the system test.

4.5 Regression Testing

After major implementation changes rerun system tests. If we see multiple of these large implementations in the future make a "test rig" to ensure functionality.

4.6 Acceptance Testing

Whole System:
- From the spoken keyword, the system accurately detects and identifies the keyword and opens the lock within a set amount of time.
    - Measure the time it takes from the spoken phrase until the lock finishes opening.

Machine Learning:
-Keyword Recognition Testing: How accurately the neural network identifies a keyword and opens the lock.

- Keyword spotting accuracy first measured using randomly selected test set data on Edge Impulse to give theoretical accuracy.
    - Will need an accuracy of >x%
- Will then test keyword spotting accuracy using real time data (spoken words) once deployed to a microcontroller with a lock system attached.
    - Will need an accuracy of >x%

Physical Testing:

-Endurance testing: make sure the lock operates after 1,000 lock cycles. This can be done by writing code that will cycle the lock.

-Lock Testing: Test to ensure the lock is able to open and can accurately and quickly. Once given the command to open the lock needs to open constantly. This can be do simultaneously to the endurance testing

4.7 Security Testing (if applicable)

Test for false positives in our machine learning algorithm:

-Try and activate a keyword with someone who sounds similar

-Try and use a recording of someone's spoken keyword

4.8 Results

Example of a figure we can include to display model accuracy:

Model testing results

ACCURACY

89.42%

	_NOISE	_UNKNOWN	HELLO	STOP	UNCERTAIN
_NOISE	98.3%	0%	0%	0%	1.7%
_UNKNOWN	3%	76.3%	4.3%	5%	11.3%
HELLO	0.3%	1.3%	96.3%	0.3%	1.7%
STOP	3%	4%	0.3%	86.7%	6%
F1 SCORE	0.96	0.84	0.96	0.90	

Feature explorer

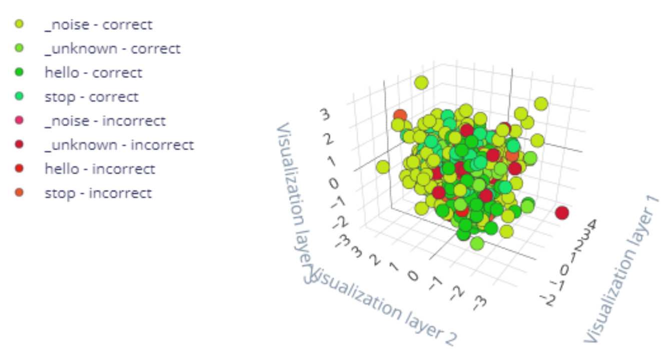


fig 8.

Edge Impulse has this and more graphs to display model characteristics. They will be used to help visualize machine learning testing results.

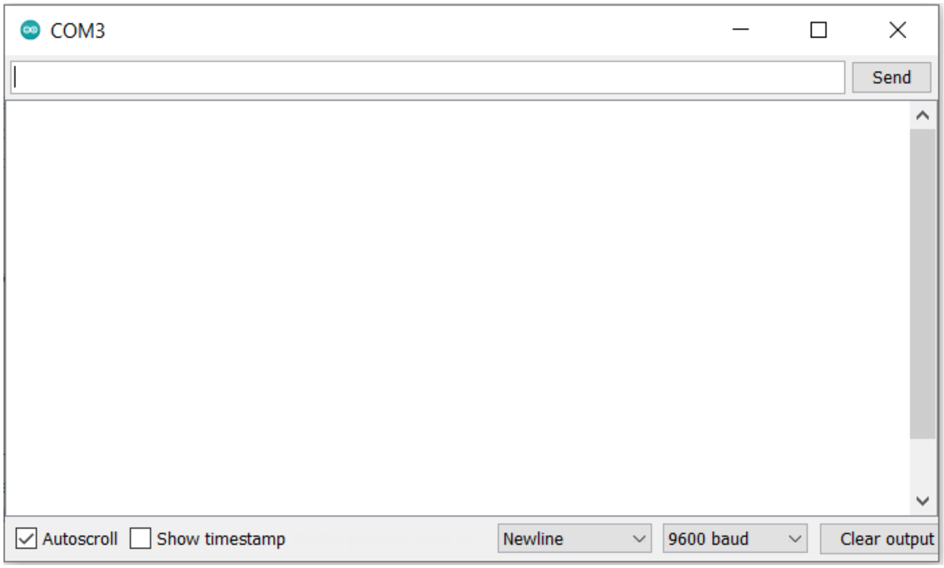


fig 9.

Tests involving the Arduino and any hardware will be either inspected visually or will be inspected using the serial monitor (above) in the Arduino IDE

Summary:
When a chosen user says the password, the system will always lock/unlock for that person using that word in the specified amount of time.
When anyone or any other sound besides the user saying the password is picked up, the system will not lock/unlock the door.

5 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3. If your project has inseparable activities between design and implementation, you can list them either in the Design section or this section.

Machine Learning Implementation:

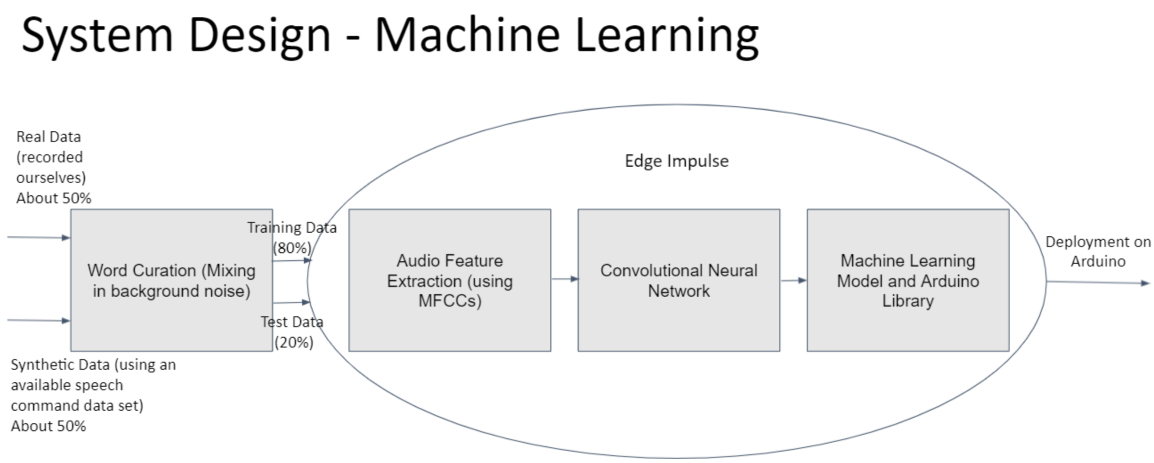


fig 10.

We will implement the machine learning model on the Arduino using data collected ourselves and data available online in available data sets. The data will then be uploaded into Edge Impulse, an online tool, and then a model will be trained and extracted for deployment on the Arduino.

Software Implementation:

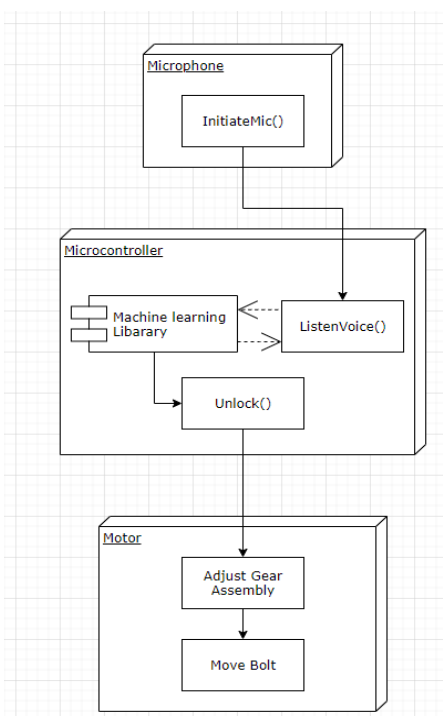


fig 11.

We will be using an Arduino for the bulk of software in the smart door lock. External sensors such as the microphone will utilize libraries to interface with the Machine Learning library supplied by

Edge Impulse. The Arduino programming language will be used for all interactions with hardware such as engaging the gear assembly and moving our lock's bolt.

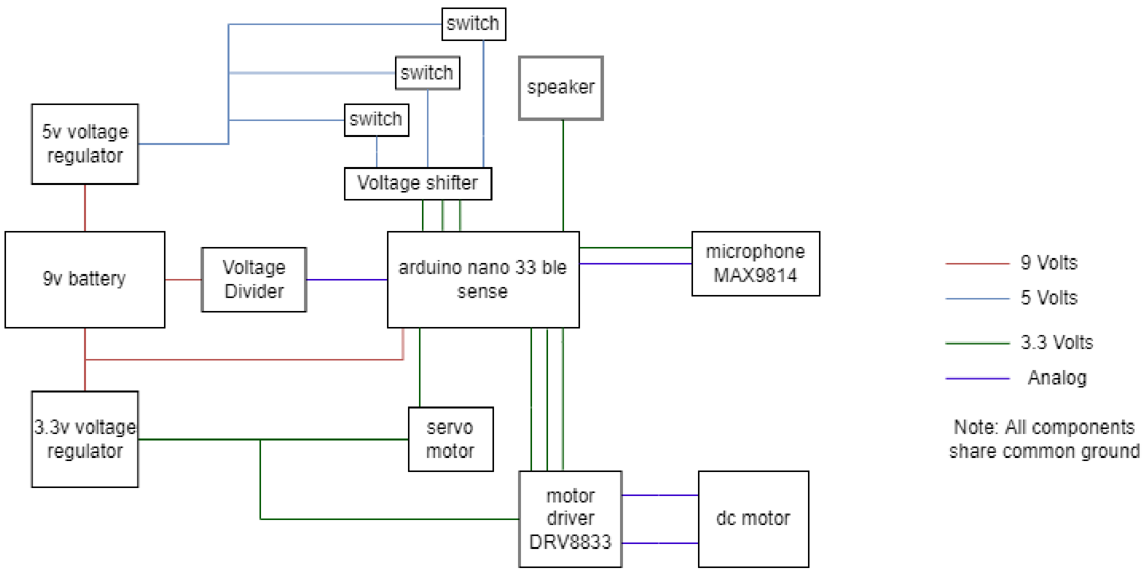


fig 12.

Different pieces of hardware will require different amounts of power, so we will be using voltage regulators and level shifters in order to supply the correct voltage to our entire project. The voltage divider will be used to read the remaining battery charge. All hardware functionality will be controlled via the Arduino Nano.

6 Professionalism

6.1 Areas of Responsibility

Area of Responsibility	Definition	NSPE Cannon	IEEE	Difference(s)
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.	To maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations	While both NSPE and IEEE mention that we should take technological tasks in our area of competence, IEEE goes into detail how we should be improving our competence and only take tasks if qualified under the right

				conditions. NSPE also mentions to avoid deception, unlike IEEE.
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	to reject bribery in all its forms	The main difference here is that in IEEE it is mainly focused on bribery whereas NSPE is more about just being responsible and trustworthy with money.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	To be honest and realistic in stating claims or estimates based on available data.	The NSPE code of ethics makes sure to point out the aversion to potentially deceptive acts. While IEEE's code puts more focus on making sure the audience you present your findings to realizes your assessments are based on only *available* data.
Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.	To avoid injuring others, their property, reputation, or employment by false or malicious action To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to	The 1st element of the IEEE code of ethics mirrors the NSPE code talking by specifically saying "health, safety, and welfare of the public." The IEEE goes on to strictly warn against actions that are intended to hurt others, as well as includes

			disclose promptly factors that might endanger the public or the environment	the environment in this category. The NSPE covers more specific examples of how to handle safety, well-being, and health.
Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	To seek, accept, and offer honest criticism of technical work. to acknowledge and correct errors and to credit properly the contributors of others To avoid injuring others, their property, reputation, or employment by false or malicious action	NSPE cannon doesn't really go into depth with how an employee should respect the property, ideas or information or even define what would qualify as faithful.IEEE does with specifying the work which would include the ideas and information and even reputation and employment is added which is more than the NSPE.
Sustainability	Protect environment and natural resources locally and globally.		To improve the understanding of technology, its appropriate application, and potential consequences. To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might	N/A

			endanger the public or the environment.	
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.	To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;	IEEE does not talk about acting lawfully whereas NSPE does. Through IEEE Code of Ethics someone could act unlawfully if doing so would prevent damage to public or environment. NSPE code does not talk about responsibility to the public or environment, only to not tarnish the reputation of the profession.

fig 13.

6.2 Project Specific Professional Responsibility Areas

Area of Responsibility	How it applies?	How well are we performing?
Work Competence	We are competent throughout our design process by carefully planning and working through problems to the best of our technical experience. We are also constantly increasing our technical competence by researching every week on different aspects of the project we are less familiar with, like Machine Learning. Continuously working and learning is keeping us on time schedules, and recording proper documentations on progress every week helps us stay organized and professional.	High: We are constantly planning and updating our progress every week, while updating our design along with our documentation. Our skills are expanding as we are learning about more tools, skills, and ideas that we can apply to the project.
Financial Responsibility	Ensures that in the making of	High: We have not spent any

	the lock we are not wasting money. I don't see us being bribed but just in general we will be making this to the best of our ability while maintaining responsible financial planning.	money but we have begun planning out parts and budgeting for required materials. But we have been looking at options to determine the most economical materials.
Communication Honesty	Ensure that our inter-team communication and external communication of goals and data usage are in accordance with what we specify in presentation and reports.	High: Inter-team communication is very strong, using Slack, Discord, and Webex for frequent check-in with our sponsor. External communication is being covered by the creation of our website and final presentation prep.
Health, Safety, Well-Being	Making sure that our lock has the necessary strength, both physically and in terms of software, to prevent break-ins to a user's house.	High: Using an already manufactured lock that will be up to lock standards for a mechanical lock. Creating a strong machine learning algorithm that will block attempts to unlock that is not the in-person voice of the user.
Property Ownership	We are helping to protect our user's property	High: Our lock will help keep user's property safe and not allow unauthorized people access.
Sustainability	Making sure the lock does not draw extra power when not necessary. Mainly using PLA plastics for construction of housing about internal parts.	Medium - We are getting a motor driver that has sleep functionality built in. We will be using rechargeable batteries within the system to reduce waste. The PLA plastics that we are using can be broken down in 3 month in a controlled environment, but takes anywhere from 100 to 500 years to break down in a landfill.
Social Responsibility	We need to be responsible with our user's privacy and data	High: we will not be permanently storing user's audio data, audio data will not leave the microcontroller

fig 14.

6.3 Most Applicable Professional Responsibility Area

Social Responsibility: Privacy concerns are very important and our users need to trust us with their audio data and privacy. Our project will not permanently store user's audio data and it will not transfer their audio data anywhere from the microcontroller. The microcontroller will only store the data in RAM long enough for the machine learning library to perform its function, then it will be overwritten on the next iteration.

7 Closing Material

7.1 Discussion

The goals that we are going for in this project are to create a useful lock that utilizes a machine learning algorithm to do voice recognition. One of the goals for our machine learning algorithm is to get an accuracy of 90%.

7.2 Conclusion

In working on our project we have completed Planning and Have finished Designing the project. We have begun the process to acquire our hardware and we are hoping to have that request completed by the end of the semester. We also completed the coursera course that was asked to be completed by our mentor. All of the goals that we set out to accomplish were completed in the required time. The only constraints we had was time and this was just due to other class work.

7.3 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

J. Lin, K. Kilgour, D. Roblek and M. Sharifi, "Training Keyword Spotters with Limited and Synthesized Speech Data," ICASSP 2020 - 2020 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), 2020, pp. 7474-7478, doi: 10.1109/ICASSP40776.2020.9053193.

7.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

Arduino Nano 33 BLE Sense Datasheet - https://docs.arduino.cc/hardware/nano-33-ble-sense

7.4.1 Team Contract

Team Members:

1. Hailey Lucas

2. Isaac Stich
3. Eric Reusch
4. Christian Williams
5. James Gossling
6. Jackson Lopata
7. Francis Mago

Team Name: Team10

Team Procedures:

1. Client meeting Monday at 1:30 pm
   TA meeting Monday at 5:00 pm
   Team meeting Mondays directly after TA meeting on Monday
2. Discord and Slack
3. 6 step decision making process
4. Meeting Minutes recorded by record keeper on Discord

Participation Expectations

1. Attendance expected, or communication prior to meeting about absence
2. Work on individual expected tasks, if there are questions be sure to ask them and update Scrum Leader with weekly progress reports (verbal).
3. Updates in weekly meetings, if unable to attend a meeting send a memo in Discord.
4. Adhere to the group's decision put forth in meetings, regardless of personal feelings. Commit to keeping up with deadlines and tasks, however long that may be per week.

Leadership

1. Issac Stich- Scrum Leader, James Gossling - Product Owner.
2. Agile/Scrum ideology
3. Agile/Scrum ideology (Scrum Leader will track individual contributions)

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team:

Name	**Skills**
Jackson Lopata	Embedded system, C, FreeRTOS
James Gossling	C/C++, real-time systems, hardware/software interfacing
Isaac Stich	Embedded Systems, VLSI Design
Francis Mago	Integrated circuits, Embedded Systems

Hailey Lucas	Embedded Systems, Machine Learning, C, Java
Christian Williams	Embedded Systems, C, Java
Eric Reusch	C/C++, Java, Command line networking

fig 15.

2. Agile/Scrum ideology
3. Mediation with Scrum Leader and group discussion

Goal-Setting, Planning, and Execution

1. Learn about machine learning in embedded systems (take coursera course), Plan and design project to work on next semester.
2. Agile/Scrum ideology
3. Agile/Scrum ideology

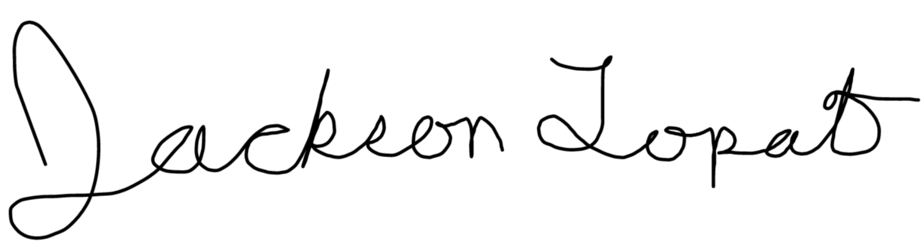
Consequences for Not Adhering to Team Contract

1. Work as a team to deal with minor infractions.
2. If a problem persists then go to TA or Professor

Team Signatures

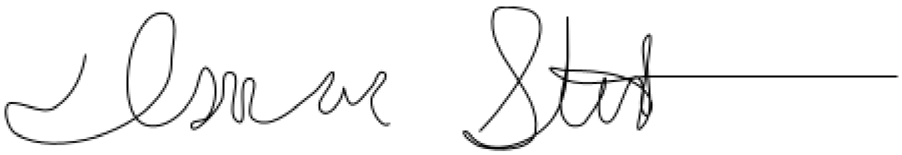
James Gossling - 9/13/2021

Jackson Lopata - 9/13/2021

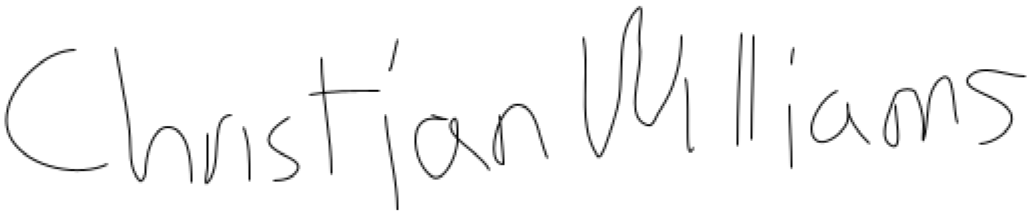


Francis Mago - 9/13/2021

Isaac Stich - 9/13/2021



Christian Williams - 9/13/2021



Hailey Lucas - 9/13/2021

Eric Reusch - 9/13/2021