EE2-PRJ Year Two Project

Group 12
Knock Pattern Recognition Device
Interim Report

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Content Page

1. Abstract

Locking and unlocking doors are simple tasks for most people. However, as reported by the Department for Work and Pensions, there are millions of people in world today who have dexterity impairment and need assistance from others to even use a key.

Thus, this project seeks to enable the disabled with an intuitive yet secure method to use their doors. After analysing and evaluating different design concepts, the group has decided to implement this with a knock pattern recognition device mounted on the door. This approach has been determined to be simple, safe, ergonomic, and suitable in current market conditions. The top level design is completed, both hardware and software prototyping processes are underway.

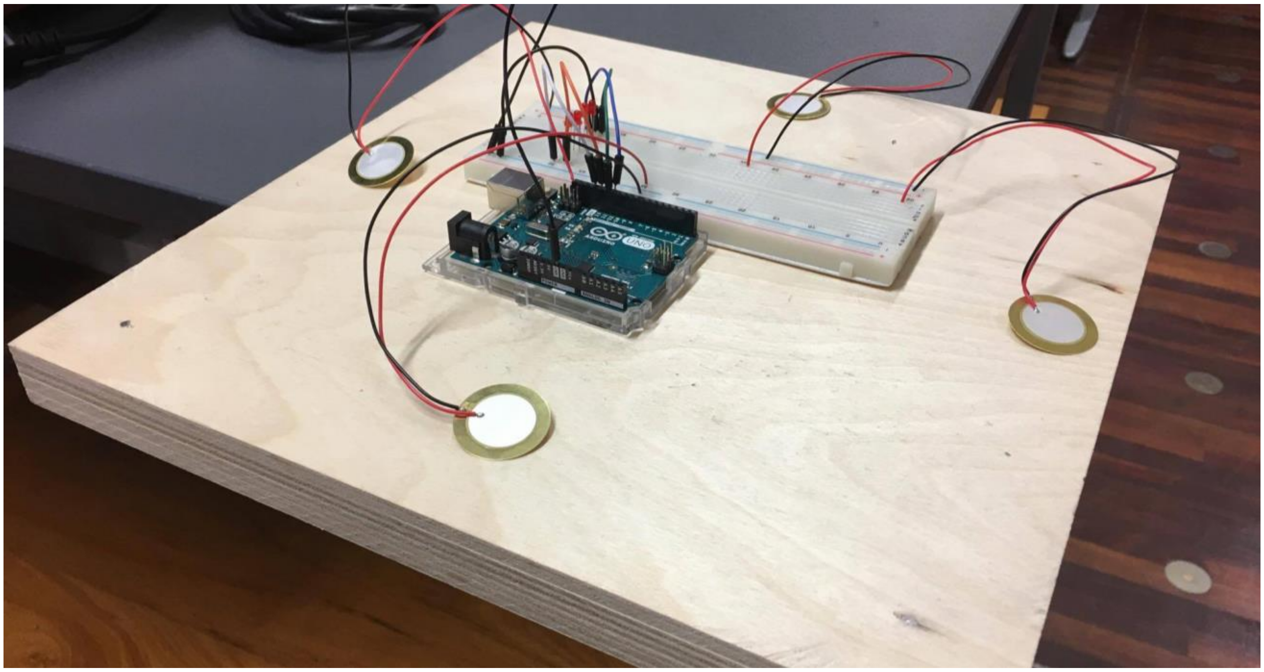


Figure 0 - Prototype (Concept 2) Mounted Behind a Door

2. Introduction

2.1 Technical Problem to be solved

There are millions of people in world who have dexterity impairment. Dexterity Impairment is the limitation of motion and reaction of arms, hands or even fingers due to illness or injury. As a result, these people experience problems and difficulties on using common methods of unlocking doors, such as the use of a key. The idea is to implement a new method that will enable those people address this issue properly and effectively. It can also be used as a solution to ordinary and everyday problems such as losing or broken keys. In this project, the aim is to build a pattern recognition device that can sense an input and compare with the save memory and determine whether the two are the same and react to it accordingly.

2.2 Social Context

Dexterity is ranked as the third disability around the world. Specifically, in the UK, about 3.4 million of the population suffers from a sort of dexterity problems which is equivalent to the 28% of the disabled people, according to a survey conducted by the Department for Work and Pensions in 2013/14 [1].

Further detailed investigation produced some interesting results that relates the age of the people with dexterity impairments.

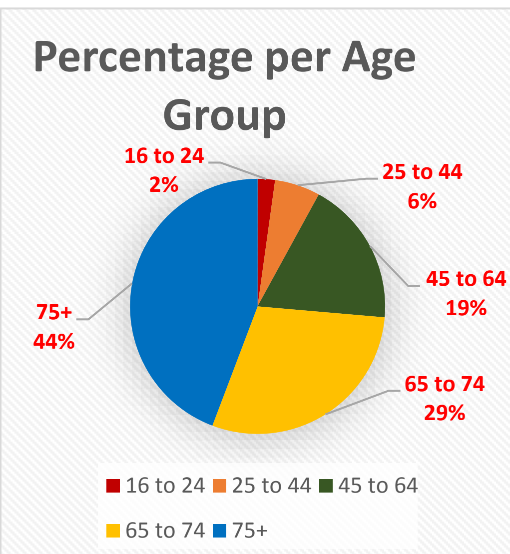


Figure 1 - Graph of Dexterity Problems related with age

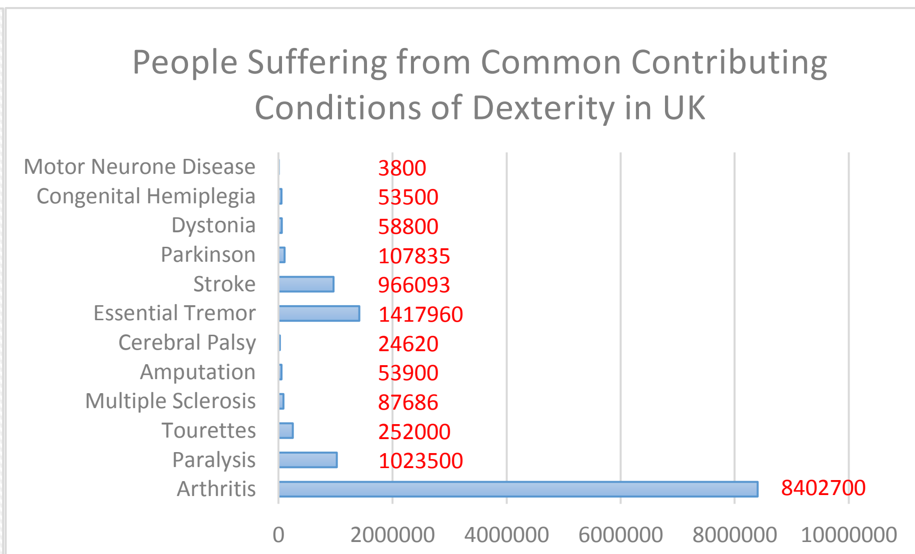


Figure 2 - Common Contribution Conditions related with Dexterity Problems in UK

From figure 1, it can be easily deduced that elderly people are more likely to suffer from dexterity problems, as almost 3 out of 4 people are aged 65+. This is due to the fact that dexterity impairments result from several conditions that mainly occur in older ages. Figure 2 provides data of the number of people that suffer from such conditions in UK. Clearly, arthritis is the main contributing condition since more than 8 million people suffer from a form of it. Moreover, approximately 3.5 million people have been subjected to a kind of stroke, experienced essential tremor and are partly or fully paralysed. A high percentage of those people are prone to dexterity problems and therefore the impact of those conditions is significant and crucial.

Dealing with the challenges faced by the disabled population remains one of the greatest and most pressing challenges in the current time. According to the Disabled Living Foundation, there are over 6.9 million disabled people of working age in the UK, which represents 19% of the working population [2]. Overall, there are over 10 million disabled people in Britain, comprising 15% of the population [3]. The effects are devastating. Quality of life can be greatly affected, and only half of disabled people of working age are in work, compared to 80% of the general population [4]. The effects can be particularly pronounced for those with motor impairments, as they require support from others for often even the most basic of everyday tasks. This state of affairs is not only a profound tragedy for the individuals involved, but also for wider society and the economy. Often, their disability will prevent disabled people from engaging in society as much as they would like to, and society is deprived of unique and important contributors. The ideas and innovations that could be presented by these people remain unable to be formed. Being able to live an independent life free of impediments is a key factor in increasing quality of life, and access to buildings is one of the key difficulties faced. Easing this process would ease a significant obstacle for disabled people's lives.

The effect on the economy is twofold; the costs of providing care and social security are significant, with £41 billion spent per year on incapacity, disability and injury benefits, totalling around 16% of the UK's total welfare spend, and 5.6% of total government spending [5]. This represents a huge cost to the taxpayer, which is a problem in today's financially constrained times. Secondly, their earning potential is almost totally curtailed by them being out of work, which has a significant effect on the UK economy. In many cases, relatively minor improvements in assistive technology, and accessibility improvements to the home, transport and workplace can have a transformative effect in a disabled person's ability to live a more independent and fulfilled life. The commercial opportunities available to those who are able to meet these needs are massive. It is estimated that in 2008 the total market for disability equipment was £1.46 billion [6]. The market is growing tremendously fast as well. Sales have increased 92.6% in the last 10 years and total market size increased by 9.2% last year [7]. In short, there has never been a better time to enter the market, while there is still considerable scope for innovation, and before the market inevitably becomes consolidated.

Governments of developed countries around the world are placing greater focus on disability issues than ever before. The U.S. Department of Labour recently moved to equate disability with race and gender under Affirmative Action laws. Likewise, Canada recently passed legislation focussed on implementing and enforcing accessibility standards with respect to goods, services, employment and the "built environment." Any company seeking growth cannot have no respond to this huge potential market otherwise it loose esteem with increasingly vocal disabled customer base.

2.3 Market Research

The most convenient and safe locks existing on market are RFID locks and coded locks. Compared to RFID locks, the knocking pattern lock provides much more convenience, as it does not need a physical key or RF card. However, ordinary knocking pattern lock does have drawbacks, a loud knocking sound makes this system susceptible to a replay attack.

Being socially and environmentally responsible, the group's concept is to develop products that solve people's real daily concerns. In the meantime, the group desires to use creativity and technology to provide convenience to disadvantaged groups. Many companies are seeking an opportunity to break into this surging market. Although currently there are no similar products to ours in the market, there must be some strong and aggressive competitors in the future. The low manufacture cost of the proposed product will allow mass production and it is possible to sell it at a very competitive price, which gives any potential competitors little space of having a pricing campaign.

Other lock systems in the market use smartphones as a key to homes, verifying identity via Bluetooth or uses smartphone apps to save security information. While it is convenient that a physical key is not required, there are some major concerns. As technology develops the concern for privacy increases as well. Digital security systems are prone to hacking and the number of crimes related to hacking bank accounts or smartphone information have increased over time. In the U.K. Cybercrimes are hugely under reported, causing the full extent of the impact to remain unknown. In 2015, the Office of National Statistics included cybercrimes to the annual Crime Survey for England and Wales. It is estimated that there were 2.46 million cyber incidents and 2.11 million victims of cybercrime in the UK in 2015. However, the actual number of reported cybercrimes are far less than estimated, with only 16,349 cyber-dependent crimes reported and around 700,000 cyber-enabled crimes reported during the same period of time [8]. If more houses implement this method of security, hacking crime would increase since hacking other people's phone could potentially grant access to their houses as well. To prevent new methods of crime in the future, the project will keep all information private to the user only.

3. Design Specification

The design specifications of the project are defined as below:

Criteria	Expected Result
1. Function	Provides an alternative method to unlock doors that is reliable, secure, and easy to use for the handicapped.
2. Budget	Within a budget of 100 pounds.
3. Product life span	Useful in five years, preferably extended to ten years through upgradability of product.
4. Customers	People with dexterity problem, which will roughly be 3.4 million people in the UK. In addition to those who seek to have an experience entering doors that is more polished and fashionable.
5. Competition on the market	The closest product available on the market are RFID locks, which also do not require a physical key. However, this means that the customer will have to replace their current lock and the new one may not fit perfectly. Also, RFID locks are more expensive to implement in general.
6. Size adaptation	The idea should still have some level of feasibility when it is implemented at a much larger or smaller scale.
7. Durability	The construct should be robust and tough, using materials that fit in the budget.
8. Ergonomics	After researching [9], it is better to avoid any mechanism that requires the user to grip or pinch to reduce the dexterity demand as much as possible. Since the design may include a way for the user to change the passcode, a push button will be used for the device to switch to the change passcode mode.
9. Security	The lock must be placed or installed in a way such that it does not compromise the security.
10. Time limit	Prototype must be built by the end of the spring term.

Table 1 - Design Specification

4. Concept Designs

4.1 Concept Design 1

Principle: Using a Microphone with an amplifier as a sound sensor.

This is the simplest design concept where only one sensor (a microphone) is used to detect the knocking pattern. The microphone converts the knocking sounds into electrical signals, which is amplified by an amplifier chip then transferred into Arduino. An amplifier would ensure that knocks from people with muscle weakness can be detected.

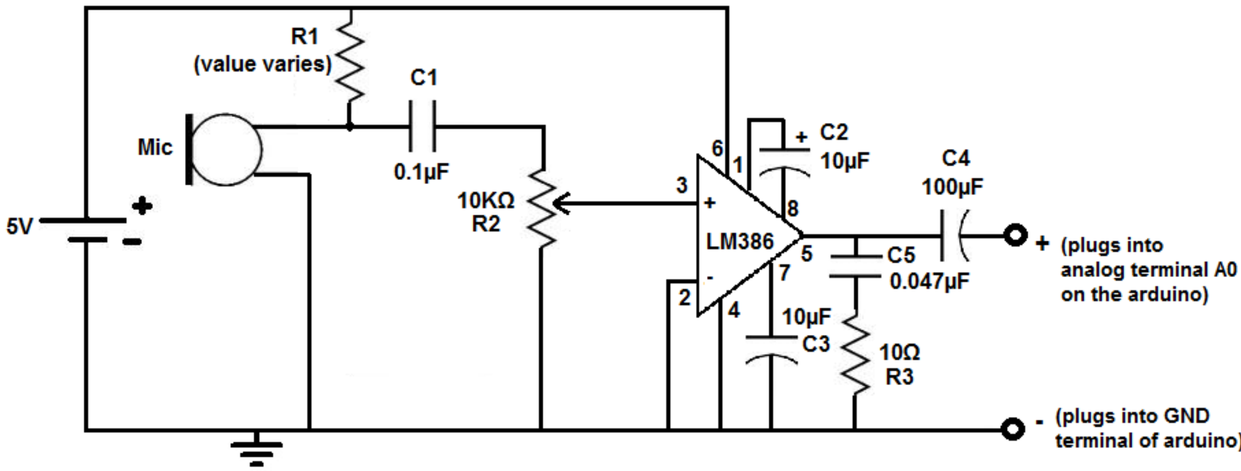


Figure 1 - Circuit diagram for sound detection concept 1

Each component works as follows, the resistor R1 determines how much voltage the microphone receives according to its datasheet [10]. The capacitor C1 removes the DC component of the signal which is used to power up the microphone leaving the AC component, the sound signal. The potentiometer R2 controls the current that enters the amplifier which is also the volume of the signal. The amplifier pins 1 and 8 controls the gain from 20 to 200. According to the amplifier circuit [11]:

$$Gain = \frac{2 \times 15000}{150 + 1350} = 20$$

And if a capacitor C2 is added between pins 1 and 8, it bypasses the 1350Ω resistor so the gain becomes:

$$Gain = \frac{2 \times 15000}{150} = 200$$

As for other capacitors, C3 removes oscillations to improve stability; C4 removes the DC component from the amplifier output; C5 acts as a current bank, it charges when there is an excess current in the output and discharges when the current is low.

Signal processing will be implemented by code in the Arduino micro controller [12]. The knock pattern will be set in the code and the knocks will be converted into signals which would have higher voltage than a threshold set in the code. If the input signal matches pattern set, the output of the Arduino will unlock the door.

4.2 Concept Design 2

Principle: Using an array of piezo sensors to detect the pattern. [13]

This allows detection of position and strength of the knocking pattern. With the aid of a signal processing software it should also be able to detect rhythms in the pattern.

The component used are four piezoelectric elements, a few passive components, and the received analogue signal will be ready for a microprocessor.

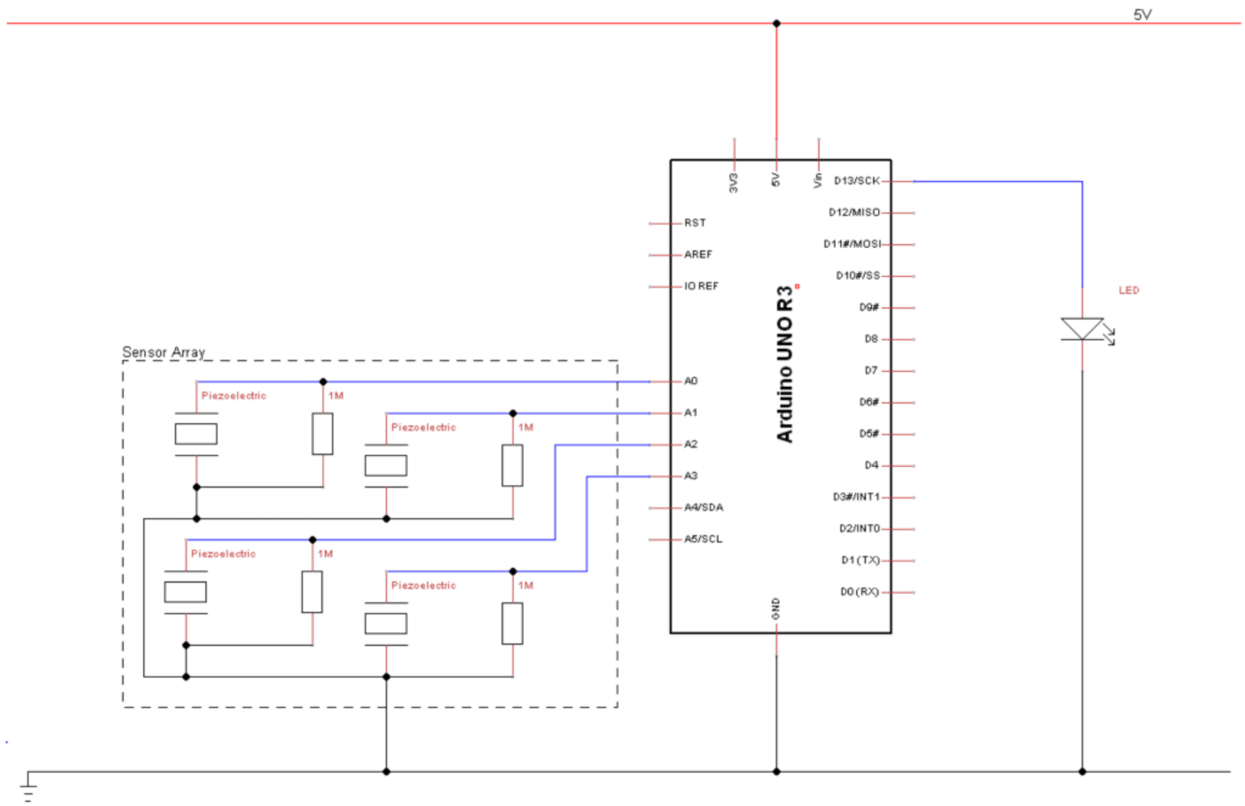


Figure 2 - Concept Design 2

A piezoelectric crystal can vibrate and generate sound when a voltage is applied. In this design however, the component is used in the reverse. When the wood of which the piezoelectric element is mounted on is hit by a knock, the crystal will be deformed by the vibration. This deformation then produces a voltage across the 1MΩ resistor. The resistor is also connected to the analogue input pins of a microcontroller, thus allowing this voltage to be used as the input signal for the processor.

Being arranged in a two by two array means the processor can have four individual voltage readings to work with. When each element is arranged in a way so that they are far enough apart, by comparing the voltage spikes on each element, it will be possible to detect knocks coming from a three by three grid.

4.3 Concept design 3

Principle: Knocking detection system using capacitive sensor.

A capacitive sensor can sense the electrical capacitance of a human hand. The sensor setup requires a medium to high value resistor, a capacitor, a piece of wire and a small piece of aluminium foil.

Initially, when the RC circuit is not touched, it oscillates at a frequency given by the equation $f = \frac{1}{RC}$.

If the touch sensor is touched by a finger, then the body capacitance is connected in parallel to the sensor's capacitance. The overall capacitance of two capacitors connected in parallel is increased, and this causes the oscillating frequency to decrease.

A microcontroller will monitor the frequency and compare it to a certain threshold to decide if a finger is in contact. In this project, three pieces of aluminium foils are installed on the outer side of a door. Users can unlock a door by touching those foils in a particular pattern identical to previous setting. Having three foils provides greater complexity as users can touch multiple foils simultaneously. After all, users can program the unlocking pattern in any way they want.

When oscillations transfer from foil to receive end on a microcontroller. There is always a time delay determined by the time constant, defined by R*C, where R is the resistor value, C is capacitance at the receive pin plus human finger capacitance. Appropriate delay can stabilize sensor readings, making the whole system more reliable. However, too much delay is undesirable, as this project requires a fast unlocking experience.

The following picture illustrates another possibility how this system could work. Instead of a microcontroller, it uses a frequency to voltage converter and a comparator, which compares the converted voltage with a fixed DC threshold. [14]

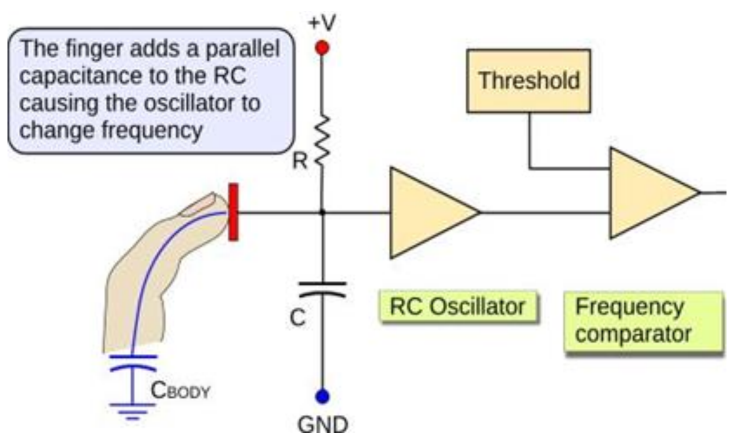


Figure 3 - Concept Design 3

Improvements on stability of the system can be made by using a manufactured touch pad instead of aluminium foils. Small sized sensor such as the ‘Standalone Momentary Capacitive Touch Sensor Breakout - AT42QT1010’, has a comparator equipped on it, thus it can send a digital output signal directly from its pins to microcontroller. [15]

5. Discussion

5.1 Comparing Table

Each of the three designs stated above are evaluated using the design criteria stated in section 3.

Concept Design No.1	Concept Design No.2	Concept Design No.3
Principle		
Microphone	Piezoelectric Sensor	RC Touchpad
Performance		
6 Able to detect complex audio input. Accuracy heavily dependent on quality of microphone.	**8** Able to detect position and intensity. Accuracy dependent on material of door and mounting locations of piezo sensors. The direct mounting provides clarity, increase tolerance to noise, thus negate this effect somewhat	**7** Able to detect touching pattern There is always a time delay determined by the time constant, defined by R*C, appropriate delays are desired but too much delays lead to slow response of the lock.
Cost of Components		
7 £3 Microphone £1.5 LM386 Chip £20 Arduino £7 Microcontroller £8 Power Supply £5 Miscellaneous £44.5	**8** £2 Piezo Sensors £20 Arduino £7 Microcontroller £8 Power Supply £5 Miscellaneous £42	**6** £18 Touchpads £20 Arduino £7 Microcontroller £8 Power Supply £5 Miscellaneous £58
Product life span		
8 Capacity exceeds current requirement - great potential for upgrading	**5** Heavily software based - any upgrade requires dedicated equipment to reprogram the microcontroller	**5** This system can be widely used in any place (e.g. cars, cabinets) where low to no force human touch sensing is needed. Great encryption with simple programming code, but little space for future upgrading since the input interface is fixed
Durability		
7 Hidden away thus hard to be damaged accidentally. Condenser microphones can withstand physical impact	**7** Hidden away thus hard to be accidentally damaged. Simple circuits - easy to maintain and repair	**6** RC touchpads are relatively easier to be damaged compared to the other two designs, since they are assembled outside the door.
Security		
6 Low profile - can be easily hidden away since the installation can be entirely behind the door Low complexity due to lack of input locations.	**8** Low profile - can be easily hidden away since the installation can be entirely behind the door Complex pattern - can use position, intensity, and rhythm as a part of the passkey	**7** A variety ways of password coding leads to good security. Touchpads can be easily noticed from outside and could be destroyed by offenders.

Size Adaptation		
8 Can be attached on existing doors. However, a mature product may need developing a particular type of electromechanical lock.		**5** Installation needs the destruction of current door lock.
Ergonomics		
7 Sensitivity can be altered at a wide range to account for different extent of dexterity.	**8** Intuitive design, people are already familiar with knocking on different parts in a grid.	7 Little force required to trigger the system. People wearing gloves or having disability on their finger may have difficulties to press the touchpads.
Time Limit		
All three concepts can be prototyped by the end of Spring Term. The designs are all relatively easy to build and test with a circuit on a breadboard. This does also allow more time to improve the design through more testing and design improvements.		
Technical Feasibility		
More research on signal processing and pattern recognition algorithms will be carried out. However initial analysis does suggest a technically feasible project. Additional testing and experiments will be made to reach a conclusive feasibility evaluation.		
Final Score		
49	**52**	**43**

Table 2 - Rationalization of Selected Design

Conclusion

To summarise, concept 2 has the highest pattern complexity thus it is the most secure. Yet it still has the most simplistic and user-friendly design. Therefore, concept 2 is chosen as the project design.

5.2 Innovations

Popular security measures such as incorporating a timestamp into the message, and using a series of one-time passwords are tedious and really confuse users. In other words, they are hard to use and are against ergonomics. People want security, but no one would like to have getting access to his house as complicated as logging into his bank account.

Building from a simple knocking pattern detector, the proposed design has unique security measures using an array of piezo sensors, detecting both pattern and position. This grid system introduces an additional layer of information in the knocking process. This extra dimension in signal provides more complexity and security than an ordinary knocking lock or a RF key. A similar product popular in the market is a password lock. However, not only does it cost much more than the proposed design, but it also fails to provide the best security assurance. A 4-digit T9 password lock has 6,561 combinations. Assuming a knock or a pause lasts at least 0.5 second, an ideal 5 seconds long array knocking detector has a complexity 9,000,000,000 combinations. It must be noted that in reality it would not be possible to knock that fast, and a certain fuzziness has to be allowed for consistent unlocking. Yet this is still more secure than an average password lock.

RFID and password locks can only be adapted in limited places. RFID locks are mostly used in offices, meanwhile password locks are mostly installed on home doors. The pattern recognition design can be adapted in, but not limited to, offices and home entrances. It has the potential to be developed further into several branch products which can be used in children's bedroom, old people's homes or even cars. In addition, it does not require pressing buttons or using a key. It is extremely friendly to the disabled, especially for those suffering from hand disabilities. For the convenience of those using wheelchairs, the sensors can be installed on the same height as the user, with no adjustment needed on the original door locks.

In conclusion, the proposed array piezo knocking system has an intuitive user interface, a relatively low cost and highest level of security. All these merits make the design a novel but meaningful product which does meet the market's demand.

6. Conclusion and Future Work

After weighing up the pros and cons of each proposal, concept 2 (using an array piezoelectric sensors) has now been chosen as the basis of the design for the final product. If any new ideas and designs are found during the construction process, these will be evaluated and compared to the current design using a process similar to that used already to obtain the working concept. Prototyping components have been obtained, and a process of testing and refinement of the design will now commence. Initially, the circuit wiring will need to be checked to see if it is correct. When this is the case, software will need to be written to control the device. This will probably be written in the Arduino environment using its own programming language (based on C). A different language may be considered if more advanced features are desired.

This will probably be the most complex and challenging part of the design, because most of the features of the design are implemented in software, such as the signal processing and the lock controls. The software will need to analyse data from each of the piezo sensors to identify where on the knock area is being struck, as well as the velocity. This will require a fair amount of research, coding and debugging, so it is expected to take a significant amount of time.

Once this stage has been completed, and a functioning prototype has been produced, a device that resembles the final product more closely will be constructed. This will include a knock area of the desired materials, feel and size, permanent, robust electronics and their housing, proper wiring connected to the mains system, and a fully-functioning electrical lock, enclosed at least in a slab of wood, if not an actual door. This will be dependent on cost and the ability to obtain a suitable medium.

Of these steps, the initial hardware construction and prototyping is already well underway, and should take one or two weeks. Initial design of the computer code should be underway by this time, [Appendix 4] with delegation of the relevant sections and modules to begin soon, once the final circuit designs are finalised. This should take around three weeks to complete. The remainder of the project should come together fairly smoothly after this, and should take around two weeks. This should leave one to two weeks of leeway for analysis and debugging to take place, as such things never go entirely according to plan and there are always unforeseen difficulties. Also, the final report will need to be written, for submission on 13th March. This will be gradually written as more technical details become available after this report is submitted. The demonstration of the final project will take place on 21st March, and this is the final deadline the group is working towards. [Appendix 2]

7. References

[1] Family Resources Survey by the Department for Work and Pensions in 2013/14 (Table 4c): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437481/family-resources-survey-2013-14.pdf

[2] Disability Rights Commission, July 2008

[3] Family Resources Survey (FRS) Disability prevalence estimates 2007/8

[4] Office for National Statistics - Labour Force Survey, Jan - March 2009

[5] Illustration of government budget: http://visual.ons.gov.uk/welfare-spending/

[6] Key Note Market Report 2006, 'Equipment for the Disabled' (ISBN 1-84168-8975)

[7] Plimsoll Portfolio Analysis (Disabled Equipment) First Edition 2009, Dec 2008), pp.2.1 – a and b.

[8] Cyber-crime data in 2015 http://www.nationalcrimeagency.gov.uk/publications/709-cyber-crime-assessment-2016/file

[9] Inclusive Design Toolkit by Umesh Persad and Sam Waller: http://www.inclusivedesigntoolkit.com/betterdesign2/UCdex/dex.html

[10] Datasheet for LM386: http://www.ee.ic.ac.uk/pcheung/teaching/DE1_EE/Labs/LM386.pdf

[11] LM386 Audio Amplifier Gain Calculation: http://www.petervis.com/electronics%20guides/LM386%20Audio%20Amplifier/LM386%20Audio%20Amplifier%20Gain%20Calculation.html

[12] How to Connect a Microphone to an Arduino: http://www.learningaboutelectronics.com/Articles/Arduino-microphone-circuit.php

[13] Similar Ideas: https://programmingelectronics.com/how-to-make-a-secret-knock-detector-to-trigger-anything-with-only-an-arduino-and-a-few-cheap-components/; http://www.instructables.com/id/Secret-Knock-Detecting-Door-Lock/; http://workshopweekend.net/arduino/projects/secret_door_knocker; https://www.arduino.cc/en/Tutorial/Knock

[14] How Touch Buttons work: http://pcbheaven.com/wikipages/How_a_Touch_Button_works/

[15] Standalone Toggle Capacitive Touch Sensor Breakout - AT42QT1012: https://www.adafruit.com/products/1375

8. Appendix

8.1 Minutes of Meeting

Meeting: 1

Date: 9/12/2016 **Time:** 13.00 **Location:** Computer Labs

Meeting Called by: Whole group

Type of Meeting: Introduction Meeting.

Facilitator: James and Joshua

Note taker: Constantinos

Attendees James, Joshua, Eric, Loizos, Constantinos, Kevin, Jack.

Agenda Topic Introduction.

Discussion

Introduction meeting was about meeting with each other. James and Joshua introduced idea and concept.

Conclusions:

We decided to wait for the supervisor's meeting so we can consider his advice. Also we decided as a group and each person individually to research during Christmas break. ~~Create~~

Action Items:	Person Responsible:	Deadline:
Contact Supervisor	Joshua	End of 1st term
Create One drive file	Eric	–

Time of Meeting: 30mins **Next meeting:** As soon as Supervisor responds

Meeting: 2

Date: 13/1/2017 **Time:** 13.00 **Location:** Computer Labs

Meeting Called by: Group

Type of Meeting: Routine (Weekly Meetings every Friday at 13:00)

Facilitator: –

Note taker: Constantinos

Attendees James, Joshua, Eric, Louis, Constantinos, Kevin, Jack

Agenda Topic ~~Company~~ Product ~~Ideas~~ Discussion, Report

Discussion

Block diagram was presented. We decided on roles of each member and had a preliminary discussion for report.

Conclusions:

We decided that Eric would ~~[illegible]~~ be the leader of the group and that Kevin would be the Webmaster. Supervisor meeting was arranged as he didn't respond to our email before Christmas

Action Items:	**Person Responsible:**	**Deadline:**
Arrange supervisor meeting	Joshua	13/1/2017
Webmaster	Kevin	18/1/2017 Meet with Dr Clarke

Time of Meeting: 30 mins **Next meeting:** Supervisor meeting 16/1/2017

Meeting: 3

Date: 16/1/2017 **Time:** 13:30 **Location:** 10th floor Room 1015

Meeting Called by: Dr Krystian Mikolajczyk (Supervisor)

Type of Meeting: Supervisor Meeting.

Facilitator:

Note taker: Constantinos

Attendees Joshua, James, Jack, Kevin, Eric, Constantinos

Agenda Topic Discussion on project in general

Discussion Reasons for project security matters, cost, software design, report writing, deployed block diagram of device

Conclusions: The supervisor introduced the idea of using microphones rather than piezo sensors which we must discuss further on another meeting. He also raised several concerns regarding cost and security.

Action Items:	**Person Responsible:**	**Deadline:**
Research Microphone idea	Eric, Jack, Kevin	20/1/2017

Time of Meeting: 30' **Next meeting:** 20/1/2017

Meeting: 4

Date: 20/1/2017 **Time:** 13:00 **Location:** Computer labs

Meeting Called by: Group meeting

Type of Meeting: Routine

Facilitator: -

Note taker: Constantinos

Attendees Joshua, James, Jack, Kevin, Loizos, Eric, Constantinos.

Agenda Topic Report

Discussion Went over marking scheme and guidelines provided and discussed which part of report would be suitable for each person.

Conclusions: Report was split into three parts where several members are responsible for each part. A deadline was set for following friday for all parts to be completed

Action Items:	Person Responsible:	Deadline:
Introduction of report	Loizos, Constantinos	27/1/2017
Main body of report	Jack, Eric, Kevin	27/1/2017
Conclusion of report	James, Joshua	27/1/2017

Time of Meeting: 30' **Next meeting:** 27/1/2017

Meeting: 5

Date: 27/1/2017 **Time:** 13:00 **Location:** Computer Labs

Meeting Called by: Group meeting

Type of Meeting: Routine

Facilitator: -

Note taker: Constantinos

Attendees Joshua, James, Jack, Kevin, Eric, Lazos, Constantinos

Agenda Topic Report

Discussion Most of report was completed as everyone delivered their part. Some finishing details are left and so we can combine report parts together.

Conclusions: A meeting on Monday was suggested to put finishing touches and send report for feedback.

Action Items:	**Person Responsible:**	**Deadline:**
finish conclusion	James	30/1/2017
Combine parts	Lazos/Eric	30/1/2017
Move files from one drive to google drive	Eric	-

Time of Meeting: 30' **Next meeting:** 30/1/2017

Meeting: 6

Date: 30/1/2017 **Time:** 13.30 **Location:** Computer labs

Meeting Called by: Group

Type of Meeting: Report review

Facilitator: –

Note taker: Constantinos

Attendees James, Joshua, Constantinos, Jack, Lazos, Kevin, Eric

Agenda Topic Report check.

Discussion We went over report to check if it was fine.

Discussed a C.V on website and how to make it

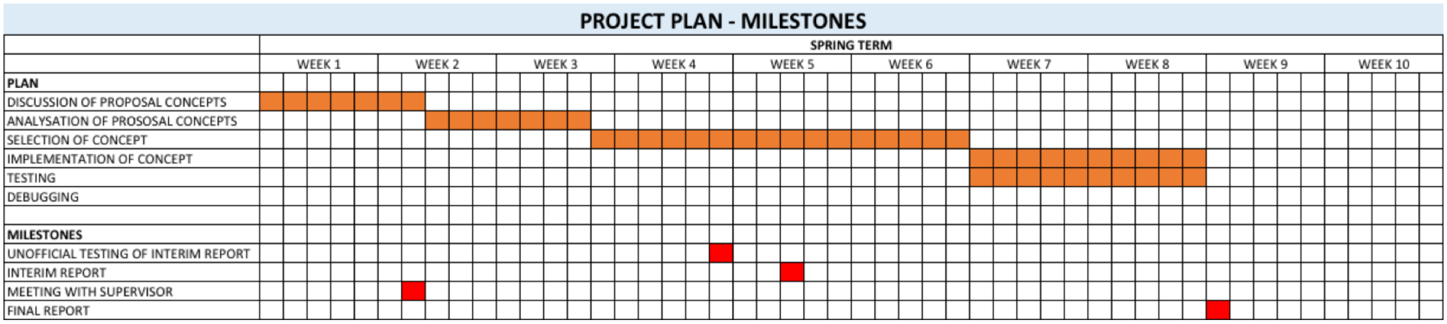
Conclusions: Send report for feedback by Wednesday.

Action Items:	Person Responsible:	Deadline:
finalise report	Lazos, Joshua, Eric	1/2/2017

Time of Meeting: 20'

Next meeting: 3/2/2017

8.2 Project Plan



8.3 Spending

Part Number	*Description*	*Unit Price*	*Quantity*	*Total Price*
Onecall 1675548	ABT-441-RC Piezo Element	£0.447	4	£1.788
EEDStore LC0035	6mm laser-grade birch plywood	£2.98	2	£5.96
Total Budget Spent				*£7.748*

8.4 Arduino Code

```
#define pinSensorA 0
#define pinSensorB 1
#define pinSensorC 2
#define pinSensorD 3

#define pinLedA 13
#define pinLedB 12
#define pinLedC 11
#define pinLedD 10

#define pinReset 9

/* Pin Arrangement
A----AB----B
------------
------------
AC---X----BD
------------
------------
C----CD----D
*/

#define directThreshold 200
#define sideThreshold 100
#define centreThreshold 50

/*------------------------------------------------
-----------------------FSM------------------------
--------------------------------------------------
--------------------------------------------------
--LOCKED_IDLE ==> 1stKNOCK ==> 2ndKNOCK =..\------
-------^-------------|------------|--------|------
-------|-------------|------------|--------|------
-------|-------------V------------V--------V------
-------|============================== LASTKNOCK -
-------|-------- WRONG KNOCK --------------|------
-------|-----------------------------------|------
-------|-----------------------------------V------
-------\========================== UNLOCKED_IDLE -
--------------- RESET ----------------------------
--------------------------------------------------
------------------------------------------------*/

int state;

#define LOCKED_IDLE 0
//A way to define all knocks as one single state?
#define KNOCK_1 1
#define KNOCK_2 2
#define KNOCK_3 3
#define KNOCK_4 4
#define KNOCK_5 5
#define KNOCK_6 6

#define KNOCK_FINAL 98
#define UNLOCKED_IDLE 99

//------------------------------------------------
//--------------------START-----------------------
//------------------------------------------------

void setup() {
```

```
	Serial.begin(9600);

	state = LOCKED_IDLE;

	//Pattern to knock
	int CodeArray = [5, 5, 5];

	pinMode(pinSensorA, INPUT);
	pinMode(pinSensorB, INPUT);
	pinMode(pinSensorC, INPUT);
	pinMode(pinSensorD, INPUT);

	pinMode(pinLedA, OUTPUT);
	pinMode(pinLedB, OUTPUT);
	pinMode(pinLedC, OUTPUT);
	pinMode(pinLedD, OUTPUT);

}

void loop() {

	//Read input
	int knockA = analogRead(pinSensorA);
	int knockB = analogRead(pinSensorB);
	int knockC = analogRead(pinSensorC);
	int knockD = analogRead(pinSensorD);


	/* Reference
	1----2----3
	-----------
	-----------
	4----5----6
	-----------
	-----------
	7----8----9*/
	int heardPattern = 0;
	if(knockA >= directThreshold) {
		heardPattern = 1;
	}else if(knockB >= directThreshold) {
		heardPattern = 3;
	}else if(knockC >= directThreshold) {
		heardPattern = 7;
	}else if(knockD >= directThreshold) {
		heardPattern = 9;
	}else if(knockA >= sideThreshold && knockB >= sideThreshold) {
		heardPattern = 2;
	}else if(knockA >= sideThreshold && knockC >= sideThreshold) {
		heardPattern = 4;
	}else if(knockB >= sideThreshold && knockD >= sideThreshold) {
		heardPattern = 6;
	}else if(knockC >= sideThreshold && knockD >= sideThreshold) {
		heardPattern = 8;
	}else if(knockA >= centreThreshold && knockB >= centreThreshold && knockC >= centreThreshold &&
knockD >= centreThreshold) {
		heardPattern = 5;
	}

	//FSM
	switch state{

		case LOCKED_IDLE:
			digitalWrite(pinLedA, LOW);
			digitalWrite(pinLedB, LOW);
			digitalWrite(pinLedC, LOW);
```

```
			digitalWrite(pinLedD, LOW);
			if(heardPattern == true){
				state = KNOCK_1;
				digitalWrite(pinLedA, HIGH);
			}
			break;

		case KNOCK_1:
			if(heardPattern == true){
				state = KNOCK_2;
				digitalWrite(pinLedA, LOW);
				digitalWrite(pinLedB, HIGH);
			}
			break;

		case KNOCK_2:
			if(heardPattern == true){
				state = KNOCK_FINAL;
				digitalWrite(pinLedB, LOW);
				digitalWrite(pinLedC, HIGH);
			}
			break;

		case KNOCK_FINAL:
			if(heardPattern == true){
				state = UNLOCKED_IDLE;
				digitalWrite(pinLedC, LOW);
				digitalWrite(pinLedD, HIGH);
			}
			break;

		case UNLOCKED_IDLE:
			if(heardPattern == true){
				state = LOCKED_IDLE;
				digitalWrite(pinLedA, HIGH);
				digitalWrite(pinLedB, HIGH);
				digitalWrite(pinLedC, HIGH);
				digitalWrite(pinLedD, HIGH);
			}
			break;

		default:
			state = LOCKED_IDLE;
			break;
	}
}
```