HAPTIC PROXIMITY MODULE

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01. ABSTRACT

'Low vision' (LV) is a common form of vision impairment that involves irreversible vision loss, significantly reduced vision but not total blindness and hence still usable vision, which affects 246 million people globally. The project developed an open-source haptic proximity module (HPM) costing approximately $100, which can enable LV users to engage with their direct environment through vibration feedback as a measure of closeness. This endeavour contributed to the discourse on wearable assistive technology while incorporating off-the-shelf components to create an accessible open source device. After conducting a study of LV, its effects on an individual's functional independence and on the available assistive technologies, the project's findings show that people with LV are still reasonably independent within the home, but outside the home this independence begins to deteriorate due to a lack of vision assistance. The available products are expensive and narrow in application. Hence there is a lack of cheap and readily available haptic devices that could extend a LV user's perception of their immediate surroundings. This project explored how these findings can be used within a design process to achieve the outcome of improving the functional independence of the LV population within their surroundings through the design of a low cost HPM, shared through an open source network.

Keywords: Low Vision, Low Cost Assistive Technology, Open Source, Haptic feedback, Proximity Detection

02. INTRODUCTION

Low Vision impacts 246 million people globally. One of the most common forms of Low Vision is Age-Related Macular Degeneration (AMD) which causes vision impairment in older people when their central vision deteriorates. This makes reading, close work and recognising faces more difficult (Vision Australia 2012)

Haptic Proximity Module (HPM) can be considered an overarching concept under which various devices were realised. In the case of this project, two such devices were created and one tested: the Strip Board Module 03 (STB 03) and the Etched Circuit Board and Housing. The technology and functions employed in the final two iterations of the HPM are the Arduino Nano devices and programming environment, the ultrasonic range finders which work on the basis of sending out a sound pulse and listening for an echo to measure distance, a vibration motor for providing the haptic feedback, linear single gang potentiometers to control the maximum limit for range detected and motor output, a tact switch to pause the function of the circuit, and 6v batteries to power the circuit.

There are some existing technologies present which help; it has been shown that multi-modal feedback is highly effective in reducing the time taken to complete simple computer functions (Jacko, Barnard et al. 2004), but how can this translate into the realm of mobility and other aspects of independent living? While magnification tools are useful, they are generally cumbersome and ineffective when dealing with printed text on home appliances (Riazi, Boon et al. 2010). Magnification technology such as non-CCTV video magnifiers can improve the reading speed, comprehension and comfort for a low-vision user, while positively increasing the user's experience when tested by Jordan's pleasurability framework (Harrison 2004).

Tactile vision systems exist as low fidelity ('Low-Fi' being a form of prototyping that uses low cost, readily available materials and methods of manufacturing) prototypes - Project HALO (Polymythic 2010) & TVSS (Bird, 2009) - and the more refined, Brain Port (Bach-y-Rita and Kaczmarek 2002). They engage the mind's ability to adapt to loss in vision by relying on the sense of touch and show how the point of human-machine interface becomes invisible as the user becomes an expert in the device, i.e. logs more time and experience using the device. Project Halo and Low-fi Skin Vision both validate the idea that a sensory substitution device can be made with minimal conditions and cost to guide behaviour. Compared to the BrainPort system that has been estimated to cost $10,000 if made commercially available.

The research phase of this project set out to answer the research question:

"How are the lives of people with LV affected by their vision impairment and how does this affect their functional independence?"

This included an enquiry into the type of care services available, their own individual experience and the assistive technologies currently available on the market. What was discovered was that within a slow changing environment, such as the home, people were capable of maintaining their independence. Once they moved out of this environment, their limited field of vision, being unable to keep up with the rapid changes occurring outside, would cause a decrease in confidence and subsequently independence as they would need to rely on others for help to discern any fast changing elements.

The design phase of the project, employed Low-Fi prototyping for the development and testing (both laboratory and real-world) of a haptic proximity module – a module that helps a person with low vision impairment feel objects in their direct surrounding through vibration, relative to the sensor's location on the body. Through this attempt to replicate Project HALO, there was an expected bridging of the knowledge gap in the areas of simple electronics, coding and soldering skills.

Successful user testing solidified the validity of the STB 03 and provided opportunities for examination of the basic functions built into the device and reflections for further development. This testing took place in two forms, 'real-world' and 'laboratory' conditions. Real-world testing took place in the home of a LV user while laboratory tests were conducted within a controlled and empty space with a blindfolded user.

03. LITERATURE REVIEW

This project engages with two main themes, low vision – a form of vision impairment – and low cost prototyping. Understanding the subsequent themes related to them is crucial in building a foundation of knowledge to advance the project, while helping to situate any development amongst existing projects. Most interesting of these is Project HALO as it embodies all elements of the current project's aims: low cost, Lo-Fi and a contribution to low vision users.

03.1 General Themes

Low Vision (LV)

Low vision is a form of vision impairment that involves irreversible vision loss. Most importantly, it is significantly reduced vision but not blindness; low vision is still usable vision (Patricia O'Connor and Keeffe 2007) . It is a visual impairment that impacts 246 million people world-wide (World Health Organization 2012) and has other impacts on the individual's quality of life (QoL). It is defined by the World Health Organization in two aspects:

- Low vision is visual acuity of less than 6/18 and equal to or better than 3/60 in the better eye with best correction. [NB: Normal vision is defined as visual acuity of 6/6] (World Health Organization 2012).
- (Low Vision Services or Care) "A person with low vision is one who has impairment of visual functioning even after treatment and/or standard refractive correction, and has a visual acuity of less than 6/18 to light perception, or a visual field less than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task for which vision is essential." (World Health Organization 2012)

How well a person with low vision can see is not fully determined by their degree of vision loss. Various factors independent of the eye's physiology influence quality of sight, in other words, an individual's quality of sight is impacted upon by other factors outside of actual vision loss. To put it into a day-to-day context, a person with limited distance vision, poor near vision, and/or restricted visual fields may have difficulty learning by imitation, understanding non-verbal communication, integrating senses (e.g. visual/auditory, visual/tactual etc.), being independently mobile, recognising people, objects or actions, maintaining personal care and hygiene, preparing food and eating, making and taking care of clothes, reading, performing general functions in poor light, finding objects, etc. (Patricia O'Connor and Keeffe 2007).

A person's mobility and independence can thus be very significantly affected by low vision. Despite their ability to sense sound, smell and haptic information about their physical surrounding, often their visual information and cues are blurred or incomplete. Degrees of lighting and familiarity with a location can have a serious bearing on their mobility (Patricia O'Connor and Keeffe 2007).

Age-related Macular Degeneration (AMD)

Age-related macular degeneration (AMD) is another common term use when talking about Macular Degeneration (MD), a progressive and painless group of degenerative retinal eye conditions that cause progressive loss of central vision, while leaving the peripheral or side vision intact. It affects people over the age of 50 and is often associated with ageing, but inherited forms can affect younger people as well.

MD specifically affects the Retinal Pigment Epithelium (RPE), a layer of cells that both acts as a barrier between and separates the retina from the choroid, a vascular layer. The main role of the RPE is to nourish the retina and clear away waste products. However as MD progresses, these waste products from the retina build up underneath the RPE and can lead to a build-up of drusen, a waste product that appears as yellow spots (Macular Degeneration Foundation 2012).

The later stages of MD consists of vision loss due to the RPE cells dying, or failing to separate the choroid out of the retina, known as Dry and Wet MD respectively. Dry MD is a gradual loss of vision and makes up for a third of all late-stage MD, but these people are still susceptible to Wet MD. Wet MD is a more severe form of the disease and can happen suddenly from rapidly growing vessels that grow into the retina and leak blood, leading to scarring and vision loss (Macular Degeneration Foundation 2012)

Sensory Substitution

Sensory substitution is precisely that, substituting one sense with another. It can occur across sensory systems or within a sensory system, touch-to-sight and touch-to-touch respectively. Historically the most successful sensory substitution system is Braille. Information that is usually acquired through the visual sense from reading is acquired through the fingertips which touch the raised up configurations of dots used to symbolize letters of the alphabet (Bach-y-Rita and S 2003). It can be argued that reading itself is a form of sensory substitution because it is an unnatural occurrence in which auditory information is represented visually. Auditory-vision (seeing via ears) and tactile-vision (seeing via skin) substitution has been studied and successfully demonstrated. As an example, in the case of Auditory-vision, a 'pixel to frequency' relationship is developed which couples the human retina with an inverse model of the cochlea. This more complicated method requires training to be able to increase the user's performance in locating objects in the distance (Bach-y-Rita and S 2003).

Multi-Modality

"Modalities" is a term that is used to differentiate between different flows of information by describing the types of interaction or communication taking place. Having origins in semiotics, the term "modalities" can be linked back to "mode" which means "manner of acting or doing" (Delbridge, Bernard et al. 1992). This helps to create a language with which to talk about interaction specific to the mode and subsequently inform our understanding. For instance, take the five senses of sight, smell, hearing, taste and touch. Any one of these senses can be prefixed with the term "sensory modality" to better describe it in the context of modality, for example sensory modality of touch – meaning to engage the mode of touch. In Human Computer Interaction (HCI) discourse, more specific terms have been developed and become commonplace when discussing and understanding these modes of interaction.

The major modalities include: Vision (seeing), Audition (hearing) and Haptic (touch/tactition and proprioception, which are the sense of pressure and spatial perception of one's body, respectively). Some modalities allow for other modalities to be recognised, for example the linguistic modality and other non-verbal/sign-based information can be found within auditory and visual modalities. When there is any combination of the main modalities (vision, audition and haptic etc.) taking place during an interaction, that interaction can be considered "multi-modal". Multi-modal interactions enable humans and technologies to multi-task between each other, much like a human interacting with his/her natural environment where there are many simultaneous sensory inputs (Bongers 2004).

Assistive Technology (AT)

The Independent Living Centres Australia defines assistive technology as follows: "Assistive Technology is a term for any device, system or design, whether acquired commercially or off the shelf, modified or customised, that allows an individual to perform a task that they would otherwise be unable to do, or increase the ease and safety with which a task can be performed." (Independent Living Centres Australia 2012).

Assistive technology can be considered a type of “orthosis” for the human being, that is, it is an artificial aid that assists a human being regardless of whether he/she is experiencing some form of impairment or not (Gaukrodger and Lintott 2007). Types of Assistive Technology (SCAT Program 2012) include:

- Aids for Daily Living: devices that help with independence and daily life.
- Augmentative Communication: assists people with speech and/or hearing disabilities to communicate.
- Mobility Aids: assist with movement within a person’s environment.
- Seating and Positioning: devices that provide body support to help people complete and perform a range of daily tasks.
- Computer Access Aids: devices or tools that assist in the use of a computer.
- Environmental Controls: systems that help people to control various appliances, switches, or appliances which are activated by pressure, eyebrow movement or breath.
- Home/Workplace Modifications: structural adaptations that remove or reduce physical barriers.
- Prosthetics and Orthotics, such as artificial limbs.
- Recreation aids: devices to enable participation in sport, social and cultural events.
- Sensory Aids for the Vision/Hearing Impaired: aids such as magnifiers, Braille and speech output devices, large print screens, hearing aids, visual alerting systems, telecommunications devices.

Augmented Reality (AR)

“Augmented reality (AR) replaces parts of the environment with computer generated components” (Gaukrodger and Lintott 2007). A field which is comprised of sensing, computing and rendering, these computer generated components allow for the improvement of information flows, both in quantity and quality, from the environment that they are placed in.

When applying AR, the relationship between the perceiver and the action space is important to take note of, i.e. how it is being operationalized. If the augmented environment is displayed via a computer monitor or TV screen, it can disrupt this spatial relationship and separate the user’s actions from the display of those actions. In comparison to this cheaper method, there is the more expensive and difficult method of Spatially Augmented Reality, whereby the augmented surface is projected into the real environment. However this is the most useful form of AR as an assistive technology, as the perception space and action space is unified (Gaukrodger and Lintott 2007).

03.2 Assistive Technologies of Interest:

03.2.1 Commercially Available:

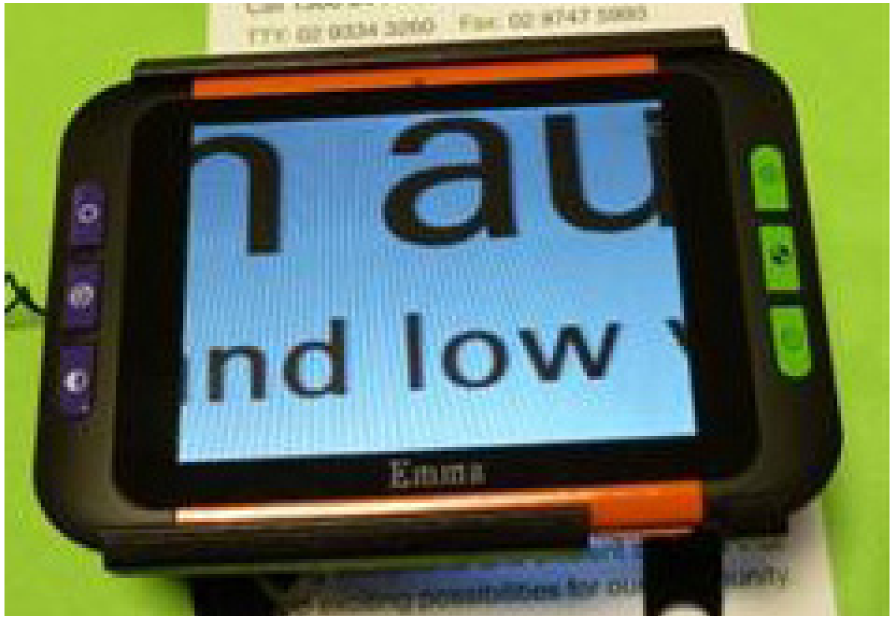
These are assistive technologies that can be purchased from specialty stores, such as the Vision Australia Store, or even from general household retailers.

Magnification: A range of magnification technology is available, ranging from glass or plastic magnifiers (optical) to CCTV systems (video). The cost of this can range from $30 dollars for a cheap magnifier to $200+ for a more expensive optical magnification system. The video magnifiers start at $115 and can go up to $850.

Lighting is usually a matter of placement and brightness. Most lamps can be used as assistive technology for the sight impaired, and the colour and brightness of the light is what is most important.

Tactile: These are usually raised surfaces that can be attached to another surface on demand. They come in pre-packaged bumps or liquid that sets to form a shape raised off the surface.

Liquid Level Sensor from Vision Australia Store, item code: ES7271



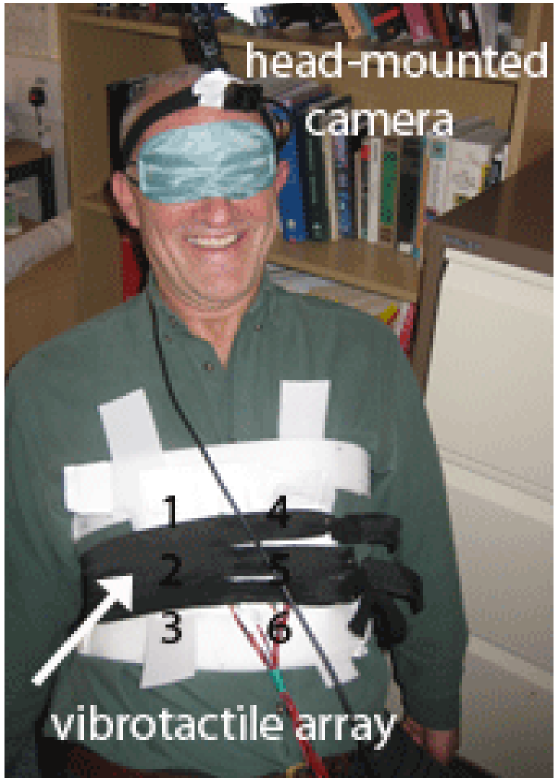
EMMA Handhelp Video Magnifier from Vision Australia Store, item code: ESVM1003

03.2.2 Research Projects

03.2.2.1 Tactile Vision Sensory Substitution (TVSS) – Bird, Marshall & Rogers 2009

This project consists of a Lo-Fi prototyped tactile vision sensory substitution system (TVSS). It claims that "a Low-Fi rapid prototyping ... is particularly effective for building embedded interactive systems" (Bird, Marshall et al. 2009). The device consists of a camera which generated images that were fed into an array of vibration motors that were placed against the stomach area of the user over clothing. The 10th iteration of the prototype consists of a 5x4 Vibrotactile array.

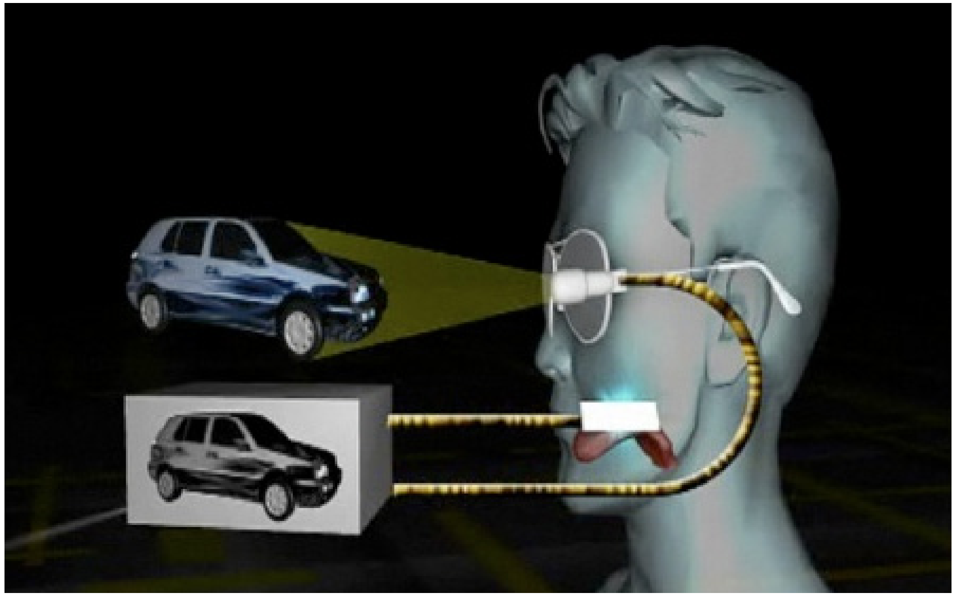
This prototype was tested on 100 participants at a local science fair. Participants were blindfolded, and then they put on the Vibrotactile array while an overhead camera captured live action of a ball rolling towards the participant's hand, where they were required to catch it with a brightly coloured gloved hand. Most participants were able to catch the balls while using the TVSS but it required some getting used to. This prototype had to be tested in a specific and well controlled environment, implying that it is not yet ready to move out of the laboratory into the real world. What is most interesting is that it may be a prototype that can be replicated by others, making it possible for them to build and subsequently adapt their own TVSS system.



Head mounted camera and vibrotactile array on the torso [http://www.esenseproject.org/e-sense%20web%20images/chris-pilot.png]

TVSS system being tested during a ball sensing user test [http://www.esenseproject.org/e-sense%20web%20images/ballBattingFeb09.png]

BrainPort device being worn [http://www.scientificamerican.com/media/inline/device-lets-blind-see-with-tongues_1.jpg]



How BrainPort works [http://www.gadgetreview.com/wp-content/uploads/2010/03/Brain-Port-Device.jpg]

03.2.2.2 "Tongue Placed Tactile Output Device" – Paul Bach-y-Rita & Kaczmarek 2002

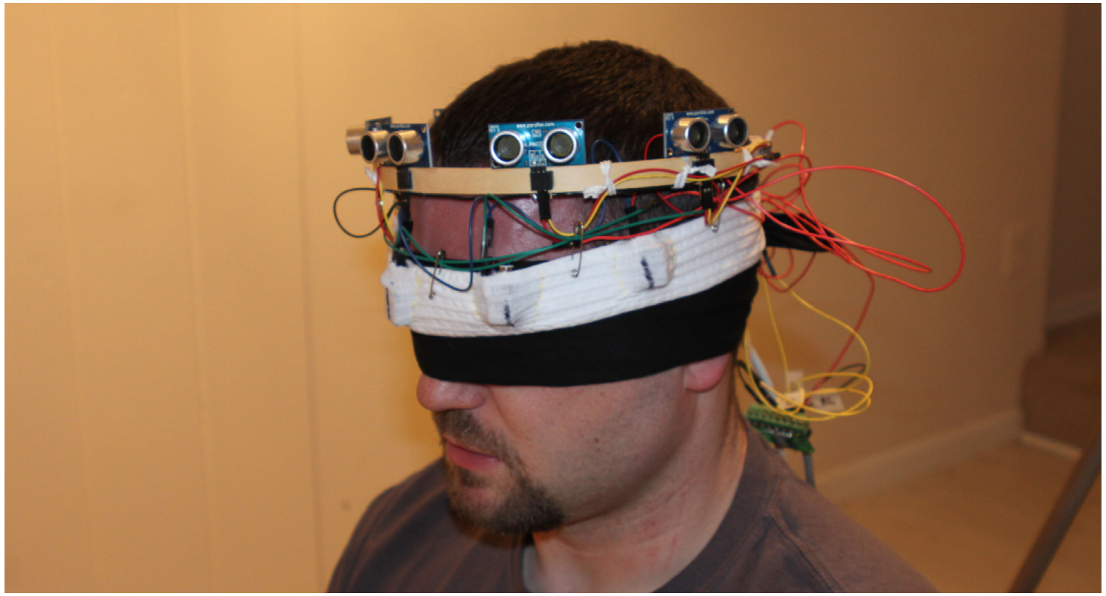
This is a human machine interface (HMI) that takes advantage of the tongue's sensitivity to lower levels of voltage when applying a direct electrical stimulation. This Electrotactile system has proved to be far more convenient and effective than a mechanical Vibrotactile system in terms of physical size and energy consumption. With the tongue having a high number of nerve endings, it allows for a higher resolution electrotactile stimulator, which means that images can be converted and sensed at a higher resolution.

Past studies of this system have shown that, with training, perceptual judgments of depth, as occurring in normal vision, can be achieved through these tactile images. It offers an alternative HMI for sighted individuals too, and will assist where rapid reaction times are required.

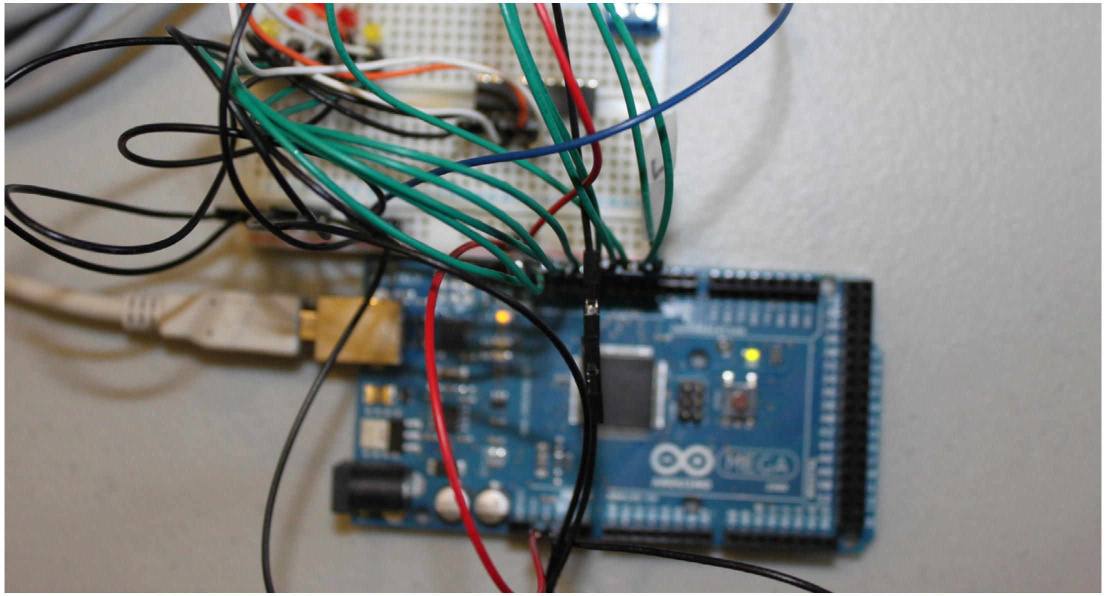
03.2.2.3 Project HALO: Haptic Assisted Locating of Obstacles – polymythic, 2010

Project HALO uses a ring of ultrasonic range-finding sensors worn around the head with an array of vibration motors, also worn around the head, to help a visually impaired person navigate and avoid obstacles in a space. It is an open source Low-Fi rapid prototyped project that was found on the Instructables website. Its main aim is to utilise inexpensive components and sensors to build an assistive technology.

It seems that most of the development time was given to writing and developing the code to connect the sensors to the output. On observing a video demonstration of the device, it was clearly apparent that a person is able to wear this device and navigate around an enclosed (and somewhat controlled) space without hitting anything. What is significant is that, being placed on the head, the sensors are able to capture objects that come close to that height. How it would handle a room full of low objects such as furniture is yet to be established. The person moved through the room slowly at almost a creeping pace. This project seems to be one that could be replicated.



Project HALO headband [http://www.instructables.com/files/orig/FKR/M312/GHFK7PY4/FKRM312GHFK7PY4.jpg]



Arduino and wiring for Project HALO [http://www.instructables.com/files/orig/FTE/EX6P/GHHIM8XZ/FTEEX6PGHHIM8XZ.jpg]

04. METHODOLOGY

In brief, research is one way of obtaining answers to certain questions regarding a specific field (Kumar 1996). To undertake a research study implies that the process (a) is being undertaken within a framework of a set of philosophies; (b) uses procedures, methods and techniques that have been tested for their validity and reliability and (c) is designed to be unbiased and objective.

04.1. Qualitative Method in Design Research

Qualitative Research within the social sciences is defined as a method of inquiry aimed at achieving an in-depth understanding of human behaviour in society and the reasons behind that behaviour. (en.wikipedia.org/wiki/Qualitative_research, accessed 1 Nov2012) It produces data which is rich and nuanced, concrete and vivid and open-ended (Graebner, Martin and Roundy 2012:278). Creswell (2003: 181-183) lists eight characteristics of qualitative research: it “takes place in natural settings...uses multiple methods that are interactive and humanistic...is emergent rather than tightly prefigured...is fundamentally interpretive...views social phenomena holistically...is sensitive to (the researcher’s) personal biography and how it shapes the study...uses complex reasoning that is multi-faceted, iterative, and simultaneous...uses one or more strategies of inquiry”.

Qualitative Research’s role in the context of Design Studies consists of learning about the people who would use the products and their daily life situations, through the observation of what they say and do, and through an engagement with their lives first hand. And it seems that in design, Qualitative Research has evolved from an "at-a-distance" to a "more involved" method for the researcher. There are three main methods:

04.1.1 Focus Groups

In the commercial sphere, focus groups are a well-established method of obtaining ideas, opinions, and conceptual understanding from certain groups or individuals that the company is targeting for its products. This method has undergone continual change as researchers seek to be directly connected to the participants – in the past focus groups were undertaken by a professional moderator, who might not give much personal feedback on the actual group they had just worked with (Ireland 2003).

04.1.2 Ethnography

As design became more socially oriented in the early 20th century, though such concepts as Henry Dreyfuss' "design" being more people orientated – that it should both help and delight people – so field research became the key to successful industrial design (Plowman 2003). Ethnography – a style of research that engages in several methods of data collection, such as in-depth interviewing, participant observation, collecting data from personal document and discourse analyses of native languages – entered design in the 1980s when Xerox PARC (Palo Alto Research Center) engaged in the use of Anthropologists to help conduct ethnographic research. However this research at Xerox PARC into Human Computer Interaction (HCI) can be seen as only selectively utilising sociological and anthropological methods as they had been socially decontextualized – social phenomena like social inequality, gender, class and power relations were not considered (Plowman 2003). Ethnographic methods that have been relevant to design include (Ireland 2003):

- Field ethnography: a researcher spending time observing a person or group as they engage in their daily lives. Ideal in early exploratory stages but this method takes time.

- Digital ethnography: a variation where digital tools, such as digital cameras, PDAs, laptops or virtual collaboration sites, are used to record, transmit, edit and present the data collected.

- Photo ethnography: the participant is given a still or video camera to document his/her everyday life or a specific area of it and is asked to write notes so as to help describe it. This is effective when the presence of an ethnographer would drastically alter the participant's behaviour, or his/her presence is not appropriate or cost-effective.

- Personas: these are scenarios or profiles created to inspire and guide designs that have come about from researching real people.

04.2 Selected Methodologies

There are two main methodologies that this project has employed: ethnography and low-fi rapid prototyping. These two have been selected because they are suitable to the nature of the enquiry, time and budget constraints, further design development and final output.

04.2.1 Study Phase: Ethnography

Ethnography, in the general context of the social sciences, is a style of research that engages in several methods of data collection, such as in-depth interviewing, participant observation, collecting data from personal documents and discourse analyses of native languages (Brewer 2000).

It may be seen as 'big' or 'little' ethnography. Where 'big' ethnography is more the adoption of the perspective of qualitative research rather than the concrete way of doing it and 'little' ethnography is linked to actual 'field research' or one particular way of doing qualitative research. In reality 'little' ethnography is more than a way of collecting data, as it involves judgments about: the object of the research, the researcher's role in that setting, and the data to be collected. These are all derived from a theoretical and philosophical premise which makes 'little' ethnography more than a protocol for conducting research and collecting data (Brewer 2000, p. 18). As Brewer, explains, the elements of ethnographic research are:

- Maintaining the everyday context of studying people's behaviour instead of a condition manufactured by the researcher.
- Keeping observation at the core of data collection, whilst still engaging with other techniques.
- Flexibility in data collection so to avoid the prior imposition of categories on what people say and do.
- The scale is small and focused on a single setting or group.
- Data analysis involves the attribution of meanings to human actions, which are described and explained.

This project seeks to engage "little" ethnography whereby in-depth interviews will be conducted with two main groups of people: people living with AMD or a similar Low Vision impairment, and the professionals that partake in the delivery of information and care to allow the first group to maintain a level of independence in daily life that is within their capabilities.

04.2.2 Design and Build Phase: Low-Fi Prototyping

Low-Fi prototyping requires very few skills, allowing designers to test devices early and often. If any skill needs to be learned it can be easily done through self-driven study and practice using readily available tutorials online. By completing as many prototype-test-refinement cycles as possible before the final design is implemented, this process allows for testing to occur at a very early stage while minimising the use of materials.

It requires the designer to engage in user testing earlier on and consistently over a set time period (Bird, Marshall et al. 2009).

This methodology has the participatory design model embedded into it. Through a panel of users, user testing is conducted with a facilitator to guide users and encourage any discussion or thoughts they have regarding the prototype, much like a focus group. This process is conducted periodically over the development of the product, creating an opportunity for rich data and opinions from users to be gathered. With this data and information, the product can be refined further to make progress. In comparison to 'summary evaluation' of completed products, low-fi prototyping creates opportunities for users to be more open to suggesting changes and providing feedback earlier on, and as users' focus is not only confined to the 'fit and finish' of the product, they have greater opportunity for input (Rettig 1994).

05. METHODS

05.1 Research Method

An ethnographic process to collect qualitative data: audio-recorded face-to-face interviews with people living with AMD and the professionals supporting them.

05.2 Setting for the Study

Interviews were conducted in the natural/home/work environment of participants' where possible. There was the possibility for a neutral or third place to be organized, but this need did not eventuate/ and this was required in x cases. All interviews were voice recorded.

05.3 Research Instruments

The research instruments included: audio and paper recording equipment required for the interview, prepared cue cards for thematic conversation and interview questions.

05.4 Sample Size and Design

The sample was kept small, aiming at 6 to 10 participants, as time was limited, and consisted in total of x participants. The sample was generated through current networks and newly established relationships with organisations and people who are involved with AMD/LV; this includes professionals and people with AMD/LV.

05.5 Data Processing Procedures

After all the conversations and interviews had been conducted, the information was compiled using the following procedure. All audio recordings were transcribed and returned to participants for review so that they were able to verify the information or request any corrections or deletions.

05.6 Workshops

Over the course of Semester one, participation in Workshops was crucial to building better understanding in certain areas of interactive systems and design.

05.7 Prototyping and Technology Development

Development was done rapidly with quick and readily available components. The aim was to achieve the building of a prototype within one day. In actuality, the prototype was built in x days./ OR this goal was achieved.

05.8 Ethical Practice

Plain Language Statement: Before participants were interviewed formally they were given a Plain Language Statement that explained the nature of the research; gave contact details of the individual conducting the research and their supervisors; explained that they would be audio-recorded; their information would be kept confidential and that they were not obliged in any way to take part in the interview or research and could withdraw at any stage.

Consent Form: A consent form was provided to the participants prior to the interview taking place and it required that if they agreed to take part in an interview then they must print their name, confirm everything that is asked of them as listed, sign and date the form.

05.9 Interviews

Script:

An interview script was created to guide the interviewer. This text outlined a clear introduction statement, entry to the questions and a conclusion to the interview. It also explained the importance for the interviewer to clarify the name of the participant for cataloguing purposes and also reminded them that they were under no obligation to answer any question they do not feel comfortable answering.

Questions:

Two sets of questions were developed to suit the two main groups of participants. For the professional group, there were questions based around their roles and tasks, relationship to clients, and any thoughts they might have on the process of supporting LV clients. For the group of people with AMD or LV, there were questions regarding task oriented activities within and outside of the home, the state of their vision, reflections on any treatment and their thoughts regarding their independence.

05.10 Problems and Limitations

Study Phase:

The use of themed interviews is very valuable to interrogate and review the research question. As the researcher lacks experience in conducting ethnographic interviews there may have been lost opportunities for gathering more data, which a more experienced ethnographer would have capitalized on. Involving more participants would also have been ideal but this would potentially cause the schedule to exceed its allocated time. Hopefully through the use of a Pilot test of the interview, and the researcher's growing experience, these limitations were minimized.

Design Phase:

The design phase brought with it a range of challenges that had to be overcome; these were due to the limitations of the author's technical skill and ability in regards to electronics. Much of this was a learning curve, and with every attempt to master the understanding of a component the limitation was removed. There was a concern that problems may occur when these limitations were reached and the framework to work through these limitations could not to be accessed or understood in order to move on. To tackle this, a good serving of time was allowed and disciplined time management was exercised. Weekly goals and deadlines helped to advance the knowledge of the author and allowed for moments of review and reflection before moving on to the next phase.

06. OUTCOMES

06.1 Workshops

Interaction Frogger Method Card Workshop

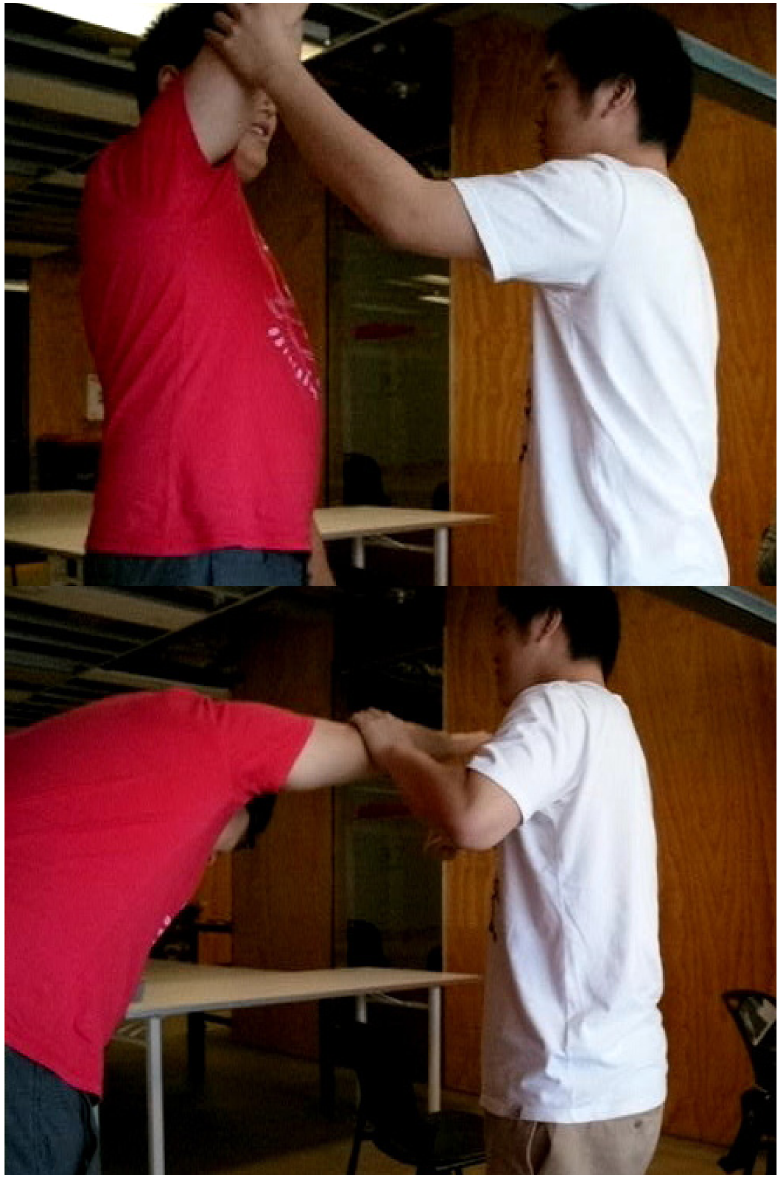
This workshop [re]introduced me to the Frogger Framework (Wensveen, Djajadiningrat et al. 2004), specifically through the use of "Interaction Frogger Method Cards" – developed by Brandon Yeup Hur and Frank Feltham.

The cards were used to address and breakdown the elements of an object, either analogue or digital (comparisons made where possible) and the kind of actions required to use the device, down to every switch, knob and button. People were split into pairs and assigned one object to breakdown and understand. The cards acted as a guide while the pairs acted out and role played the "user" and the "object". Ideas such as coupling, mapping, affordances, feedforward and feedback were examined in the first instance. Groups presented their findings on how they understood their user/object interaction and were then critiqued and asked to explain further.

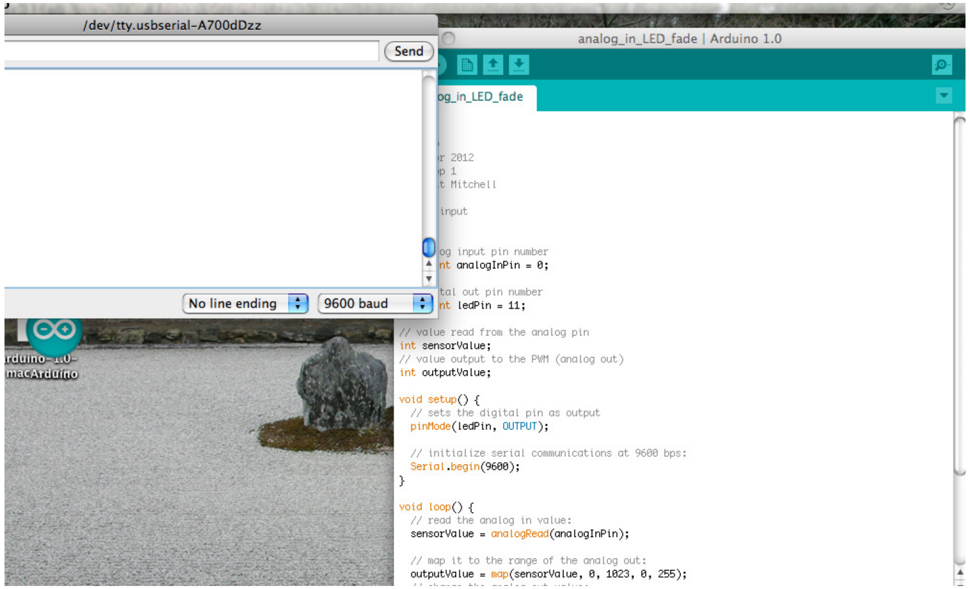
The next stage of the workshop was to take our objects and select one of the ideas within the frogger framework and change its relationship between user and object. In the case of my pairing, we were given the electric toothbrush to analyse and understand. Initially we struggled to grasp how to engage with this new method of learning but with some guidance we were soon able to break down the actions required from a user and the inherent mechanics and controls of the object. This led to an examination and comparison of an analogue toothbrush to the electrical toothbrush. It was clear to see that what changed, apart from the removal of all electronic elements, was how the user engaged with the device and manipulated it. Where the electric toothbrush only required a placing of the rotating and oscillating head, the analogue toothbrush required back-and-forth, up-and-down movement constantly in order to actually clean the teeth.

In the final stage of the workshop, we took one element of the electric toothbrush and changed it. We selected to change the coupling of the control button that acted as an ON/OFF switch and Function selection switch – which controls the type of head movement and oscillation. We decided to completely decouple the ON/OFF/FUNCTION switch and randomise the selection of function and powered state. The user would not know what head movement would occur when the button was pressed. The possibilities were: ON and Oscillate left and right, ON and Oscillate up and down, and OFF completely. We believed this created a unique interaction for the electric toothbrush as the user would have no idea what was coming next. Whether it would encourage a joyful, annoyed or indifferent response would be totally up to the user.

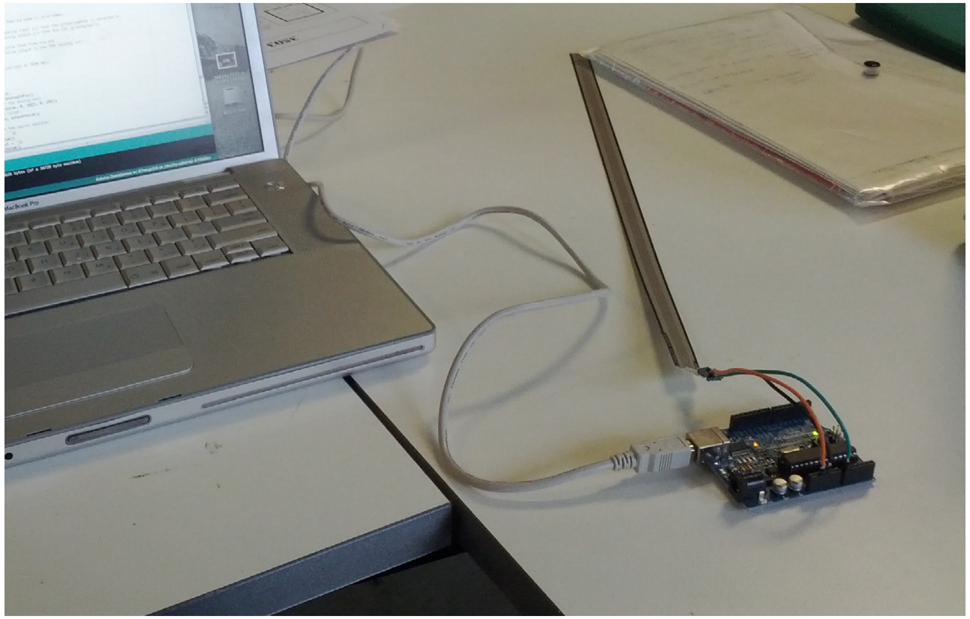
Overall this workshop really established for us what the Frogger Framework is precisely, and gave us tools of analysis built around this framework to address and deconstruct the nature of an object, so to manipulate the kind of interactions objects could create.



Pretending to be an electric tooth brush



Arduino programming environment



Arduino and pressure sensor

Electronics/Arduino Workshop

One of the key parts of interactive systems is having an understanding of how to breakdown and reassemble electronic components and coding language to manipulate and create custom sensors and solutions. The Arduino workshop was held on 26 March 2012 and was a gentle reintroduction into the world of hacking circuits, electronics and programming code. We built circuits that controlled a LED and its rate of blinking. This required an understanding of the elements of an electronic circuit and the programming language of Arduino and Processing. Both of these coding software systems have inbuilt examples and libraries that made a very good starting point for programming an Arduino controller.

06.2 Interviews

Group interview - Not for Profit Vision Organisation: “Sarah”“Geraldine”, “Dean”

The interview was conducted on 25 May 2012 at this organisation’s head office in Melbourne, Australia. Sarah is an Orthoptist (a university –trained allied health care practitioner who specialize in disorders of eye movements and diagnostic procedures related to disorders of the eye and visual system [insert source http://www.retina.com.au/what-orthoptist]), Geraldine is an Occupational Therapist (OT) and Dean is the manager of the Independent Living Group, Sarah and Geraldine work under Dean’s management. The following is a summary of the data gathered from this interview.

Dean’s group helps people with vision loss and impairment by establishing a care plan so that they can continue living with a realistic amount of independence. To access the services available in this group you must be referred. There are a few ways of being referred: self-referral, by family, by eye care specialists, through another associated health provider. Generally Dean sees people who have been referred from eye care specialists, usually when they are unable to function without assistance due to the loss in vision. Generally they are people above 75 years of age and from the total of all the people he sees, over 80% have AMD. When they first meet him, they go through the “CIT CAT” process, CIT being “Common Intake Tool” and CAT being “Common Assessment Tool”. This is where they are asked both general and specific questions to work out their level of eye health and vision, capabilities based on vision and other health levels and what goals they would like to achieve. It is from there that they are able to develop an Individual Service Plan (ISP) and move on to the different services available within the group. They remain clients indefinitely and an ISP is developed based on deterioration in their vision that leads to a specific or general change in their situation. There may not be a need for a new ISP after the initial one has been completed for a long period of time, such as a year or more.

Sarah begins with a 1 hour consultation with the new client, and her work differs from that of a community optometrist, in that she establishes their functional vision and needs and does not look at medical interventions or general eye health. She helps clients establish strategies on how to achieve their goals based on the usable vision that they have and also helps clients to understand the situation arising from their eye condition. This includes examining issues such as past treatments, why these may not have worked, what kind of expectations they have, what are the potential limitations of the treatment, and what they want to do and indeed can do within a realistic framework. Generally people come in with specific needs based on their situation and needs. After she has been through the consultation she will introduce clients to assistive technologies that are available through the organisation’s store.

The products that are on sale at this organisation have gone through a rigorous examination and testing procedure by all the different vision professionals in the organization, who assess them for suitability for the potential needs of people with vision loss or impairment. Companies do approach them with products to sell to their market but they must satisfy the criteria of the organisation before they are sold within the organisation's Store. They have a once a year "Tech-Expo" where all the different companies that create assistive technologies for the visual impaired participate. It is open to the public and gives an opportunity for people to see what is new.

The organization sets up groups for people with vision loss to take part in, both face-to-face and over the phone via a "telelink" service. Usually there are about 8 people to each group and the groups run for 8 weeks at a time. They meet to discuss their situations or problems, a designated topic of the week or to listen to a guest speaker. It is a good opportunity for people with vision loss to connect with one another and share their experiences. People are placed in these groups based on their desire to join or on recommendation. Geraldine currently runs a Quality of Living group and is occasionally a guest speaker in the groups in her role as an Occupational Therapist. Clients will see Geraldine after they see the Orthoptist and she will go through their CIT and CAT to see how she can help them. She will show them self-care techniques on how to adapt to their change in vision, such as listening to the sound when filling a cup, or suggesting certain tools, such as raised surfaces, for their kitchen or around the home. At first the client may not adopt the new technique or technology as they feel they are able to continue living independently but Geraldine gives them the tools and information regardless, in case they have a change of mind. She will take clients through the OT kitchen which has a range of tools and devices to help someone adapt a kitchen to their current visual impairment and suggest strategies to overcome any difficulties.

"Laura"

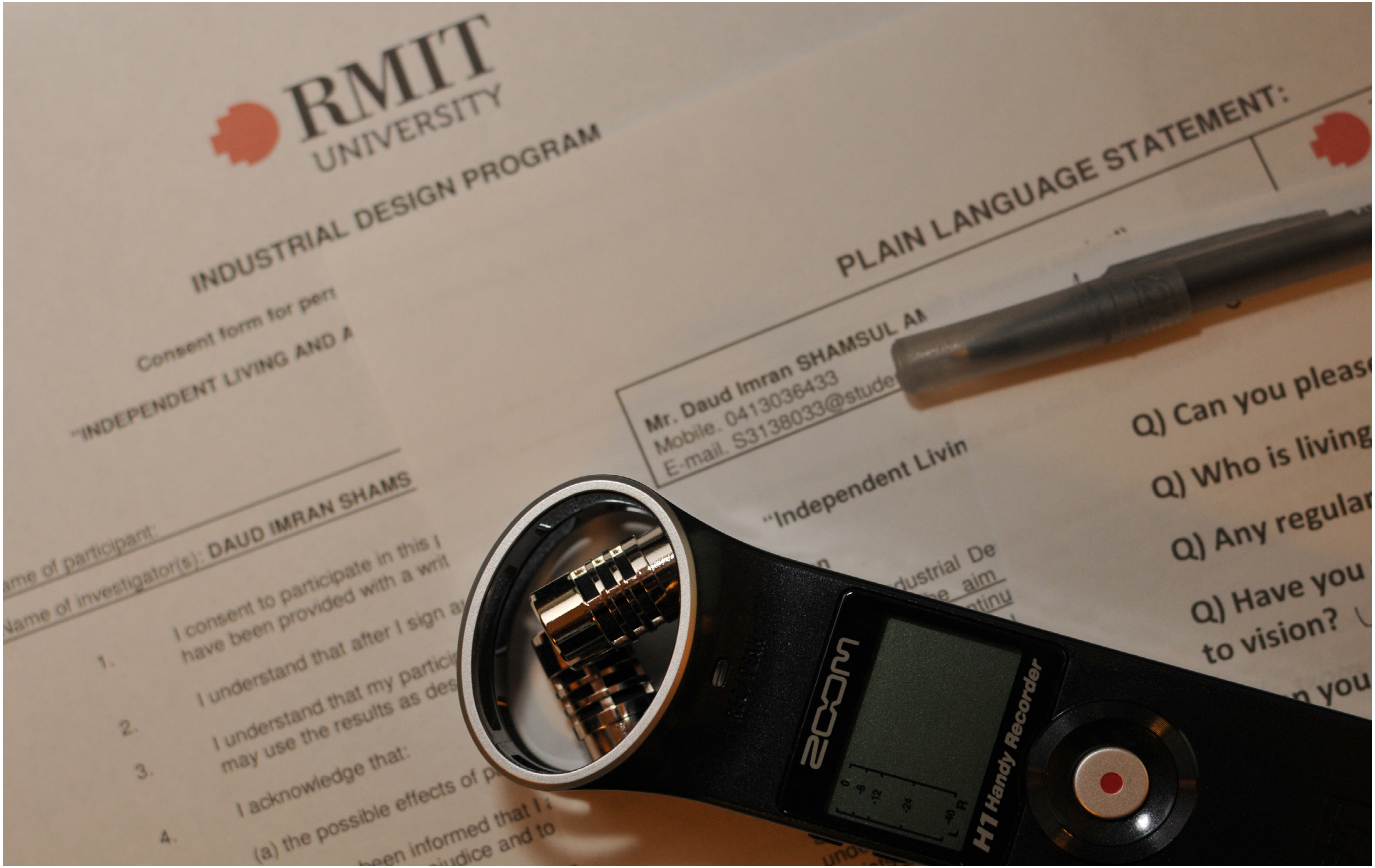
The interview was conducted on 23 May 2012 at her home. Laura is 81 years of age and has both wet and dry AMD in the left and right eye respectively. She visited Vision Australia in the beginning, when her vision changed and was prescribed glasses and took the opportunity to buy a few items from their store. In2004 she noticed a change in her vision and was told by her daughter to immediately seek a medical opinion. Over the past 8 years she has had a total of 31 injections of various drugs to help hold her vision. It is interesting to note the range of expenses that these treatments bring, in some cases she was out of pocket for $3,000 for an injection, on top of any consultation fees. At present she goes on a monthly basis to have injections. To her memory, she has not taken part in any support groups nor been recommended to join any by Vision Australia. She is social in the context of her leisure activity, which is lawn bowls. There she uses a "bowling arm" to help her bowl, as a combination of physical limitations and technique issues prevent her from bowling with her hands. Her vision does not affect her ability to bowl. She is very driven to do things independently and doesn't feel that her deteriorating vision gets in the way of that. However the operation of a vehicle is an area of her life where she is slowly losing independence, as she is unable to drive at night, during poor weather and bright afternoons with long shadows – as the rapid change of contrast is difficult to adapt too quickly. Her home is kept clean with the assistance of a professional cleaner and her garden is taken care of by a professional gardener. Odd jobs around the house are completed by her son-in-law. This living situation speaks more of her age rather than of any vision loss. Apart from these areas she is seemingly capable of functioning independently. Her front steps have had a white stripe painted on the edge of them to help her see where they are – high contrast is helpful for her and this is an area where her vision impairment causes her difficulty. In regards to technology she is very savvy, apparently taking to technology like "a duck to water" when she first used a computer in 2000. She operates a Nokia mobile phone with ease and has been using an Apple iPad. There is now a push from her family to transition to an Apple iPhone. She doesn't feel that this will be a problem to use because she is already familiar with the Apple mobile operating system.

"Olivia"

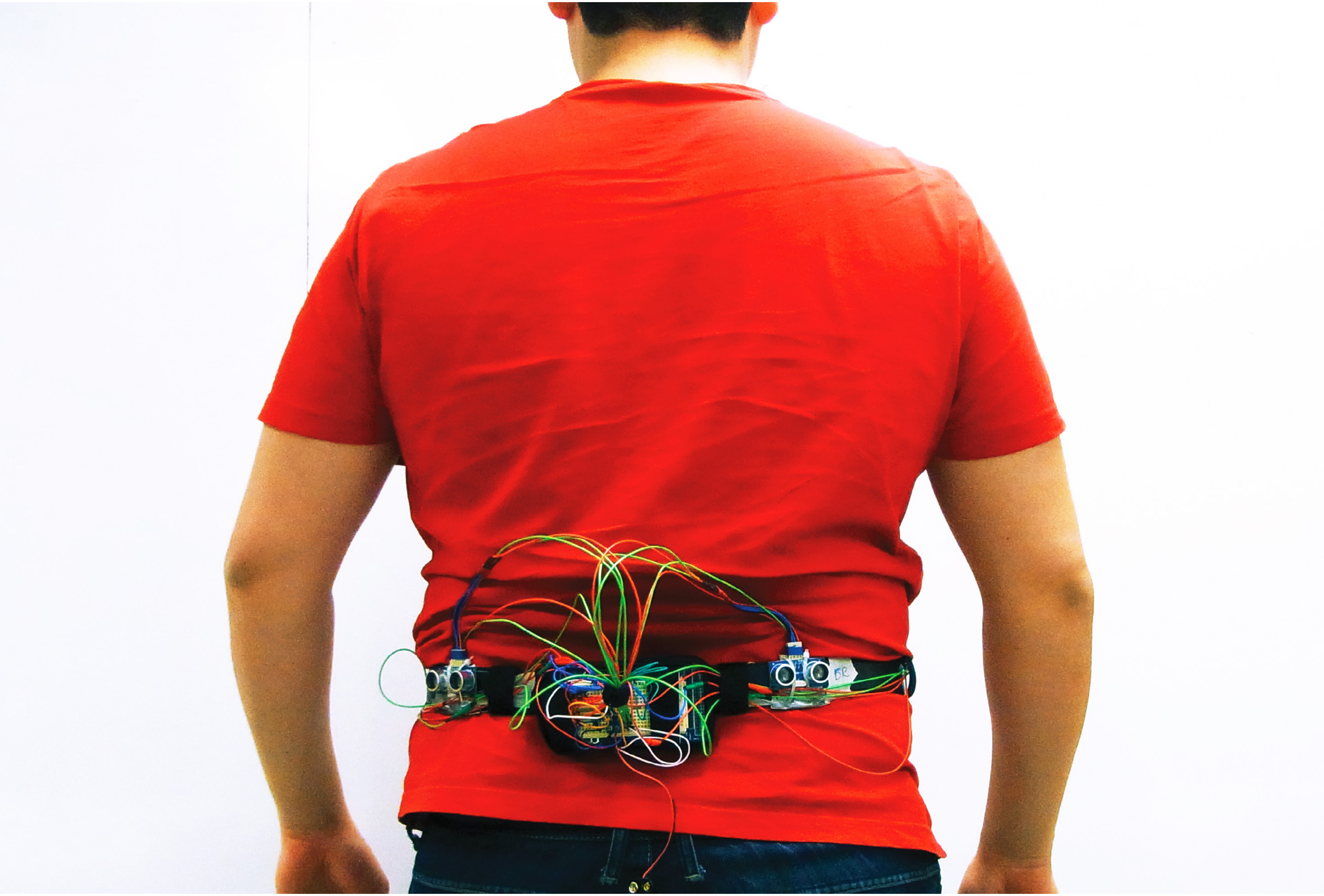
The interview was conducted on 02 June 2012 at her home. Prior to the interview I had provided her with my list of questions, to which she provided answers. Olivia has a low vision disorder called "Birdshot Choroid Retinopathy"; it is an Auto-Immune disorder that occurred in December 2001 after she went through a period of chemotherapy. She lives at home with her husband, Hugh, and is visited by friends and family often. Since the beginning of her visual impairment, she "couldn't wait" to visit Vision Australia and learn more about what they had to offer. She often frequents their library to borrow talking books (audio books) that she plays on her DAISY player – 'DAISY' stands for Digital Accessible Information System [http://www.daisy.org]. She has also made many visits to their store and been to past Technology Expos that have been run by Vision Australia. Once she became a client of Vision Australia she was enrolled in an 8 week "Quality of Living" group where she learnt a lot from other clients and the professionals and specialists that were brought in. She was selected to take part in a Peer Training and Support group, which she enjoyed very much but was disappointed when it didn't lead to anything further. Vision Australia also sent out an Occupational Therapist to help adapt her home environment to suit her vision impairment, who suggested lamps over her working spaces, and little things like raised surfaces and rubber bands on shampoo bottles to help her differentiate shampoo from conditioner. In regards to medical treatment she has sought out many treatments, ranging from tablets, such as steroids, to "heavy duty immune suppressants". For a period of 5 years she received injections in her eye and overall has had 27-30 injections across both eyes. The injections used to hold her vision well but the time taken to recover from a procedure was longer than the length of time her vision would hold, so she ceased injections altogether. As a result, her independence has become restricted and she is unable to drive, and in more recent times is far less confident when leaving the home. She can feel anxious when catching a train into the city. In contrast to her loss of confidence outside of the home, she feels that she is far more independent within the home and more capable, to the extent that she can "throw dinner parties". She is become more fearless when it comes to asking for directions and locations when out in public, crossing roads is very difficult and unless there is an auditory signal from the pedestrian crossing she is unable to tell when it is safe to cross. She remains very active in her life, having taken two writing courses, written two books, had worked in published in a women's magazine and on a bill board, is taking part in three to four choirs on a regular basis, and doing volunteer work at a nearby hospital in the oncology ward, where she speaks to patients in a non-religious capacity. She also composes "Photo stories" on her home computer, which are a combination of image, text and music. Her level of computer literacy is very good and she is confident to use the software needed to create Photo stories and extract music from online sources. She is able to use the computer thanks to the "Magnifier" function in-built into her operating system, Windows XP. She utilises the computer heavily for enlarging text-based things, such as recipes and the music for her choral commitments. What is interesting to note is that she does not utilise optical character recognition (OCR) software but rather gets the text dictated to her by her husband. In regards to her choral singing, in most cases she has to memorise the lyrics and music because she is unable to rely on her vision to remind her of the music. Subsequently her memory has improved since the decline of her vision. She feels that a device like an Apple iPad, or other tablet will help her with her leisure and functional activities, as she will be able to resize text of recipes or music. Personal injury is quite a negative outcome from her loss of vision, luckily it is only minor, such as cuts, burns and scrapes when cooking. To reduce these injuries she has taken to wearing rubber gloves when she cooks. To extend further on functional tasks, using the telephone is problematic for her, as reading the numbers '3', '5' and '8' can be difficult and easily confused. She has since had many conversations with the wrong number. This is something that can reduce one's confidence but is also manageable through the use of larger sized phone numbers; however this requires an initial effort to convert phone numbers into a larger print. When she initially lost her vision she had also developed a desire to write and it became a big goal for her. She feels she has accomplished this goal and has had the technology to help her achieve it, as she is able to type on a computer and review the enlarged text. At the end of the interview she suggested the following question for me to ask future interviewees, "What are some of the things/devices/procedures that you have found helpful for low vision?" I have since taken that into consideration and will be applying that question in the future.

"Hugh"

The interview was conducted on 02 June 2012 at his home, and it went very quickly. As I had provided Hugh with a copy of the questions prior to the interview he was very clear about how he might answer. This is both a positive and a negative thing. In the case of Olivia, she was able to prepare well-thought-out responses that had great detail, but I believe with Hugh it confirmed that he didn't have the same depth of response and I lost the "element of surprise" , in the sense that asking a question in the moment may provide a more natural response. Hugh is 73 years old and lives with his wife, Olivia, in their home. Their main kind of visitor is social and they do not have people from Vision Australia or support groups coming to the home. His relationship with Vision Australia is mainly through his wife who has a Low Vision disorder. They visit Vision Australia for their library, store or the Technology Expo they run once a year. He has Wet AMD, or "the bad one", as he describes it, in the left eye and his vision is deteriorating at a gradual rate. He first discovered this about three to four years ago and has been seeking medical treatment in the form of quarterly eye checks and injections as they are needed, usually every 9 to 12 months. So far after the injection has run its course, there will be deterioration in the eye and he will require another injection to hold the deterioration at that point. He says that the only time he has had a problem with his vision is in poorly lit situations and when reading small text, such as a newspaper, in poor light. In the latter case he requires a magnifier to help enlarge the print. He is also having difficulty driving at night because of the high contrast and brightness of the other car's headlamps. He says it is "a chore" to drive at night now. He is still very active in choirs and is part of 3 different groups. At home he manages to take care of all the functional tasks as his vision does not hinder him from doing any of these things. As of late he is recovering from back surgery, this has been a physical barrier but is quickly on the mend and he is quite active within his limits of healing.



Components of an ethnography, PLS, consent form, voice recorder, questions & pen



Belt Study being worn

06.3 Belt Study

The belt was an attempt to replicate Project HALO (http://www.instructables.com/id/Haptic-Feedback-device-for-the-Visually-Impaired/) through the use of multiple clusters of sensors and motors through one Arduino Mega 2560. I began preparing for this in June 2012 by ordering every component I assumed I would need plus extras. Overall it was a successful failure, as the belt unit failed but the learning from that process has helped me find success in the subsequent development of modules.

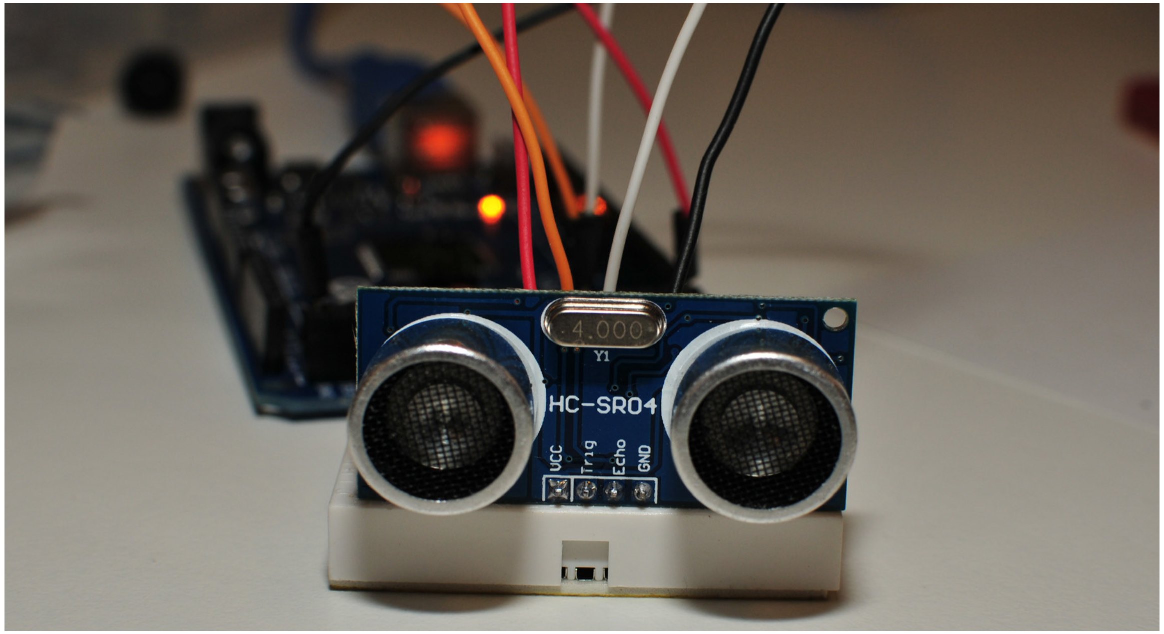
06.3.1 Initial Exploration: experimenting and discovering Proximity sensors and Arduino

After received my electronics I set out to make the Arduino and ultrasonic sensor work together. This required me to download the correct libraries for the Arduino environment and subsequently install them – at first difficult but once I referred to the Arduino.org knowledge base I was able to install them. I began to play with the ultrasonic sensor to understand how it worked. This involved using sample code from online tutorials and breadboards to plug and play with the Arduino Mega and ultrasonic sensor. This process was a success as I was able to see, through the Serial Monitor of Arduino, the changing values of the sensor as it happened. This process of breadboarding allowed me to test and bridge the trigger and echo pin. This also was a success.

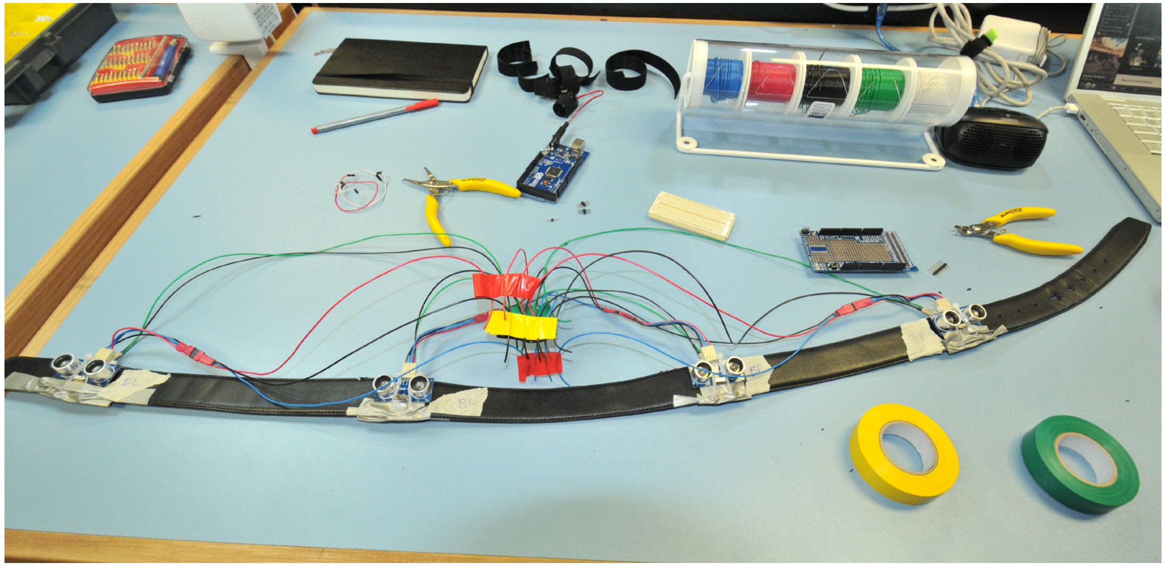
Upon discovering that the ultrasonic sensor could be bridged, I attempt to replicate the instructables device. By following the step by step instructions on instructables.com, I set up my circuit as best possible by following the diagram provided and details within the code regarding which Arduino pins to use. This was a total failure and I struggled to make sense of the code provided. Anders, a friend of mine, helped to re-write the code to suit one or more sensors. This code helped me to further test multiple combinations of motors and sensors leading me into the breadboard phase.

When brought into class Dr. Scott Mitchell reviewed and modified the code (insert code) to simplify it further. This was done by removing the stepped trigger points for the sensor and motor cluster, with a direct mapping of sensor to motor. This code was tested on different numbers of sensor/motor clusters – starting with one and growing to four. I had mixed success with anything above two clusters. In an attempt to debug, I replaced the motors with red light emitting diodes (LEDs) to see if there would be a change in brightness as the detected distance varied. I used four sensors and LEDs. This process showed me that there was a successful mapping of each individual sensor to motor. I then proceeded to begin building a belt with four clusters of sensor/motors. It began by building a wearable belt with one Arduino, motor and sensor. This was done "quick and dirty" with a range of jumper cables and duct tape. It was successful and showed a strong relationship between distances detected and output vibration. I moved on to the four cluster belt powered by one Arduino mega. Overall this process failed as the relationship between sensor and motor at each cluster did not exist. I believe this was a failure in the code and the Arduino was not able to manage all four clusters at once. Even through a debugging process where I only attached one cluster I was still having some problematic issues.

What was gained in this phase was learning basic soldering technique, creating custom connectors and wiring harnesses and overcoming a fear of electronics. Once clearly established as a failure, I moved on to the next phase of creating a modular cluster.



Working out how to use the Ultrasonic Sensor HC-SR04



Sensor and Motor clusters being re-wired with a custom wiring loom

06.4 Module Development

Developing a module was crucial in this project. Its purpose was to simplify the process I had been through with the belt and lead to a device that could easily be replicated and multiplied as it was needed. Overall it was a success, both in the process of learning new techniques, skills and the actual function of a module. The end result was a module that was shared on instructables.com.

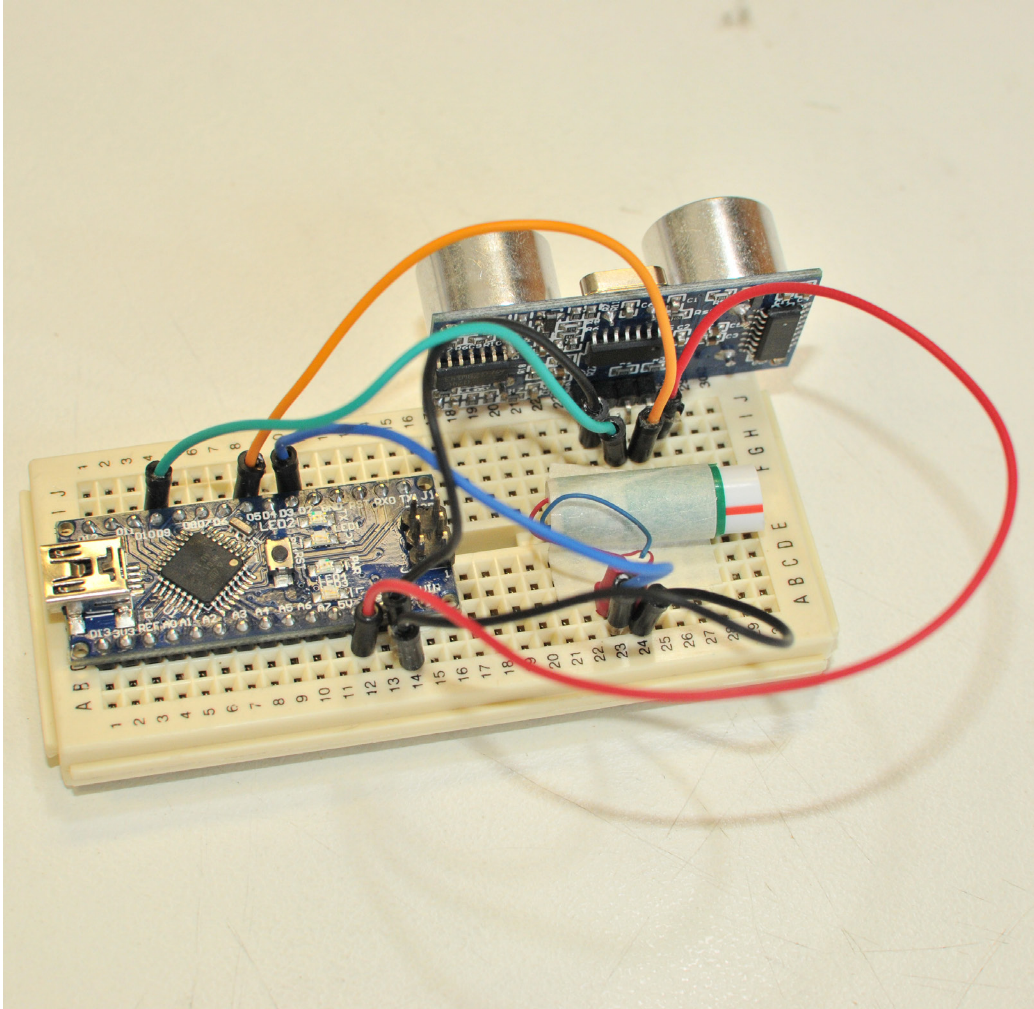
06.4.1 Coding:

Goals: Have code that was simple and bug-free with added features for other people to play with and develop further.

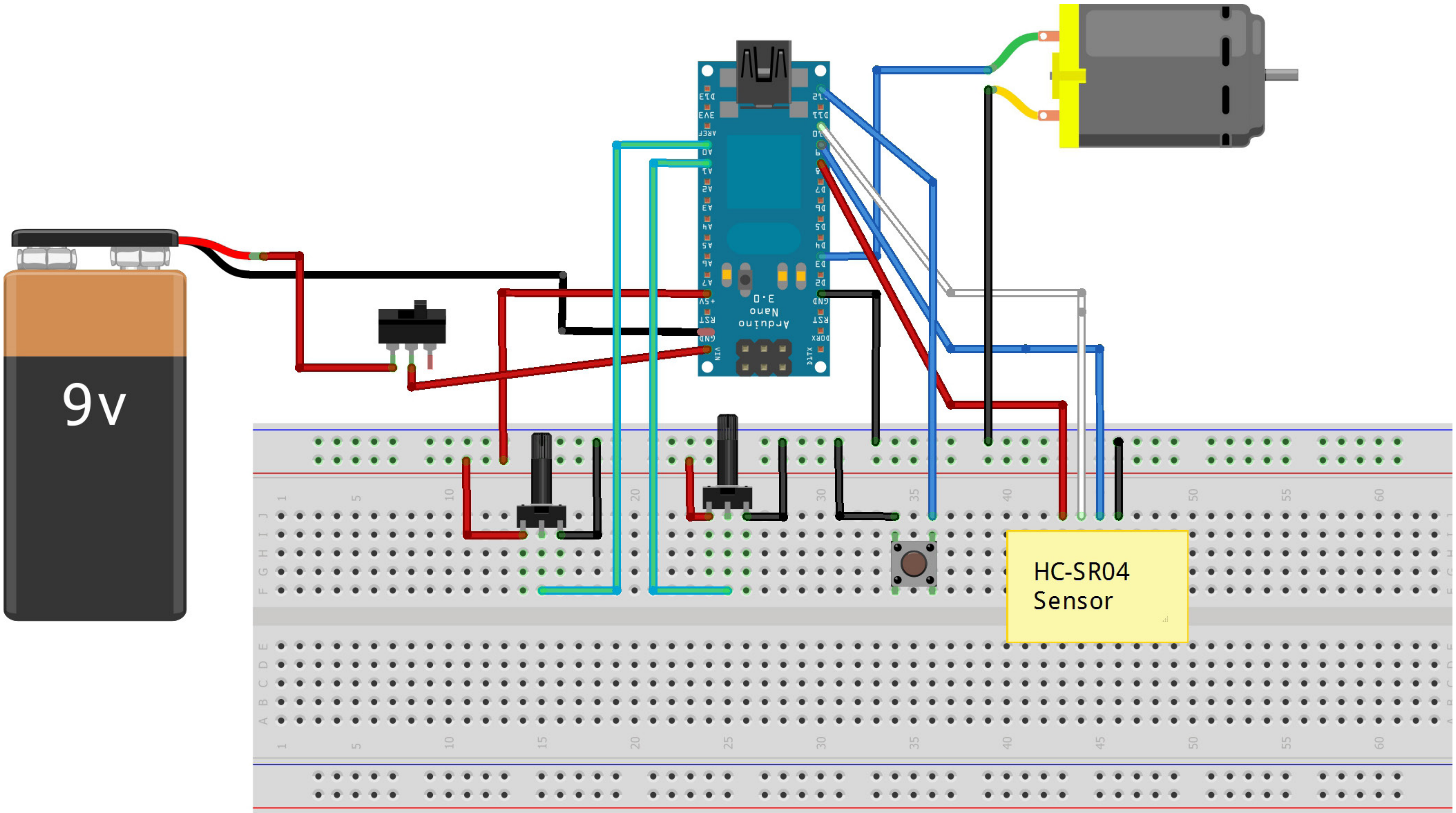
Attempts: There were two main attempts at developing the code to better suit the context of a module. The first attempt was to create added functionality such as potentiometer to control distance and a pause button. The second attempt was to integrate a potentiometer that controlled the maximum power output of the motor. Both were successful.

06.4.2 Build:

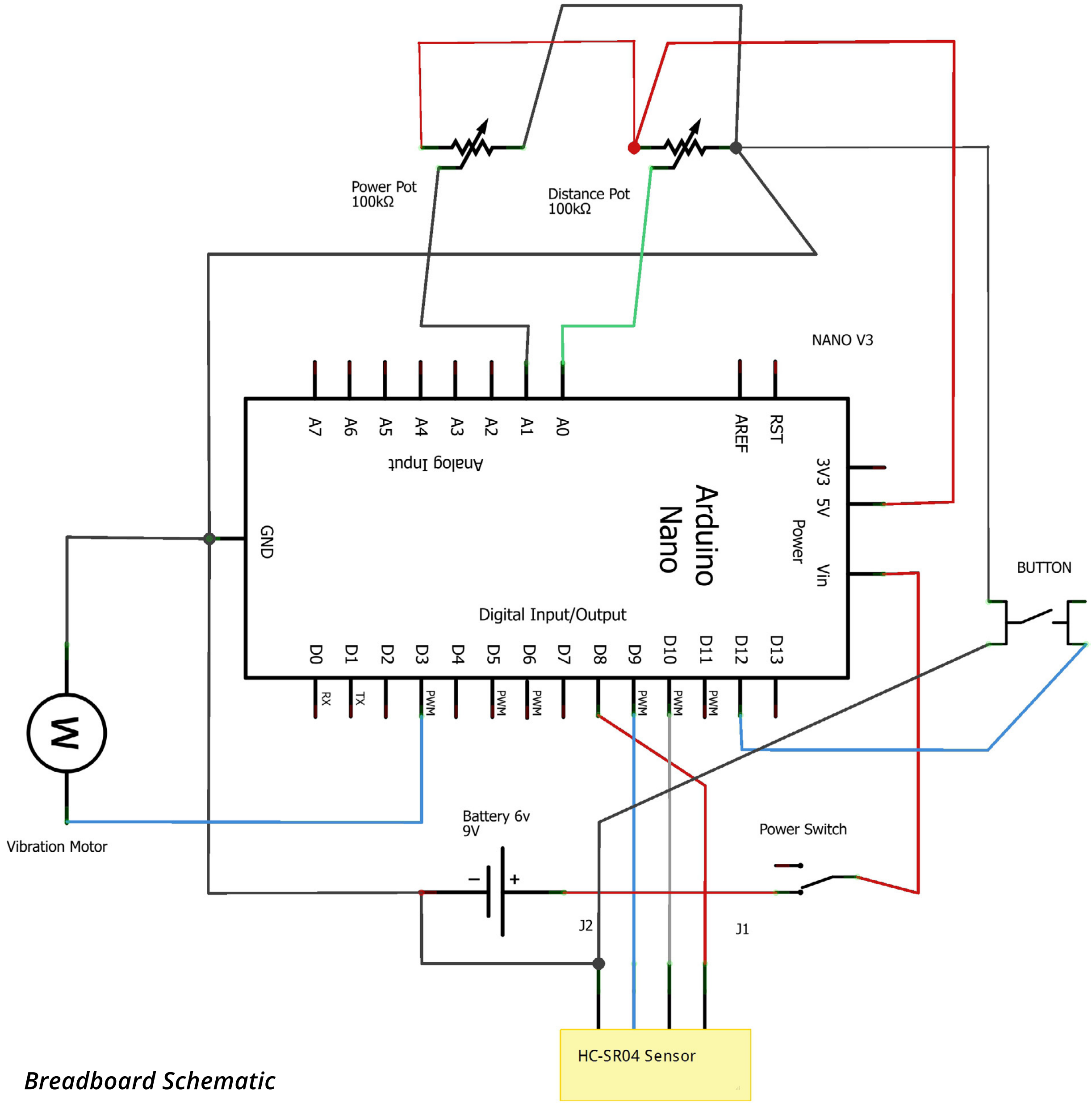
Goals: to build a module that could be shared in an online open source platform that included custom circuitry and housing to suit the 'off-the-shelf' parts.



First version of the Breadboard prototype



Breadboard layout diagram



Breadboard Schematic

06.4.3 Iterations

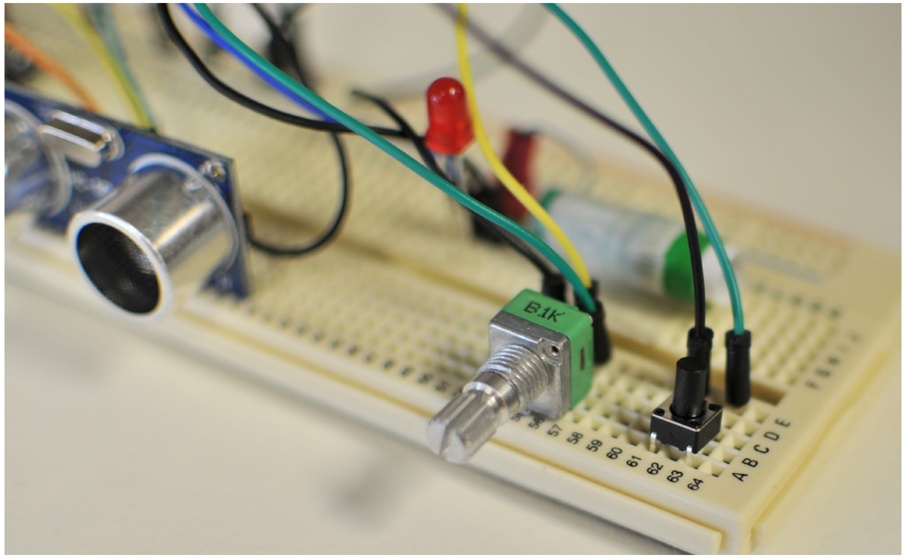
Overall, there have been six iterations of the module from breadboard to final strip board (version 3) and custom circuit board modules. The final strip board module has been used for open source sharing and has been a total success; unfortunately the custom circuit board module with additive manufactured housing is not in a position to be distributed into the open source community.

Breadboard:

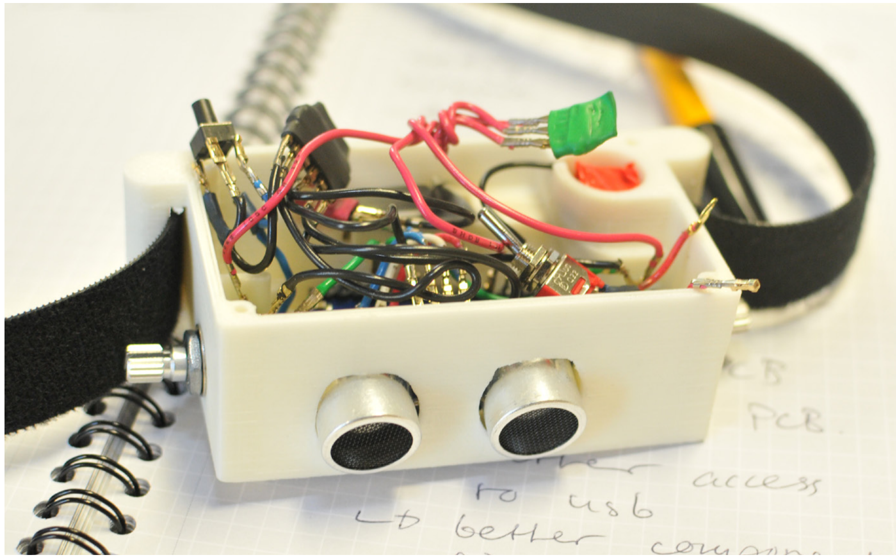
This iteration was to establish functionality within the code before committing to soldering. It was flexible and adaptive if we needed to modify or isolate problems. It was also a fallback testing bed for any modifications to the code.

Housing 01:

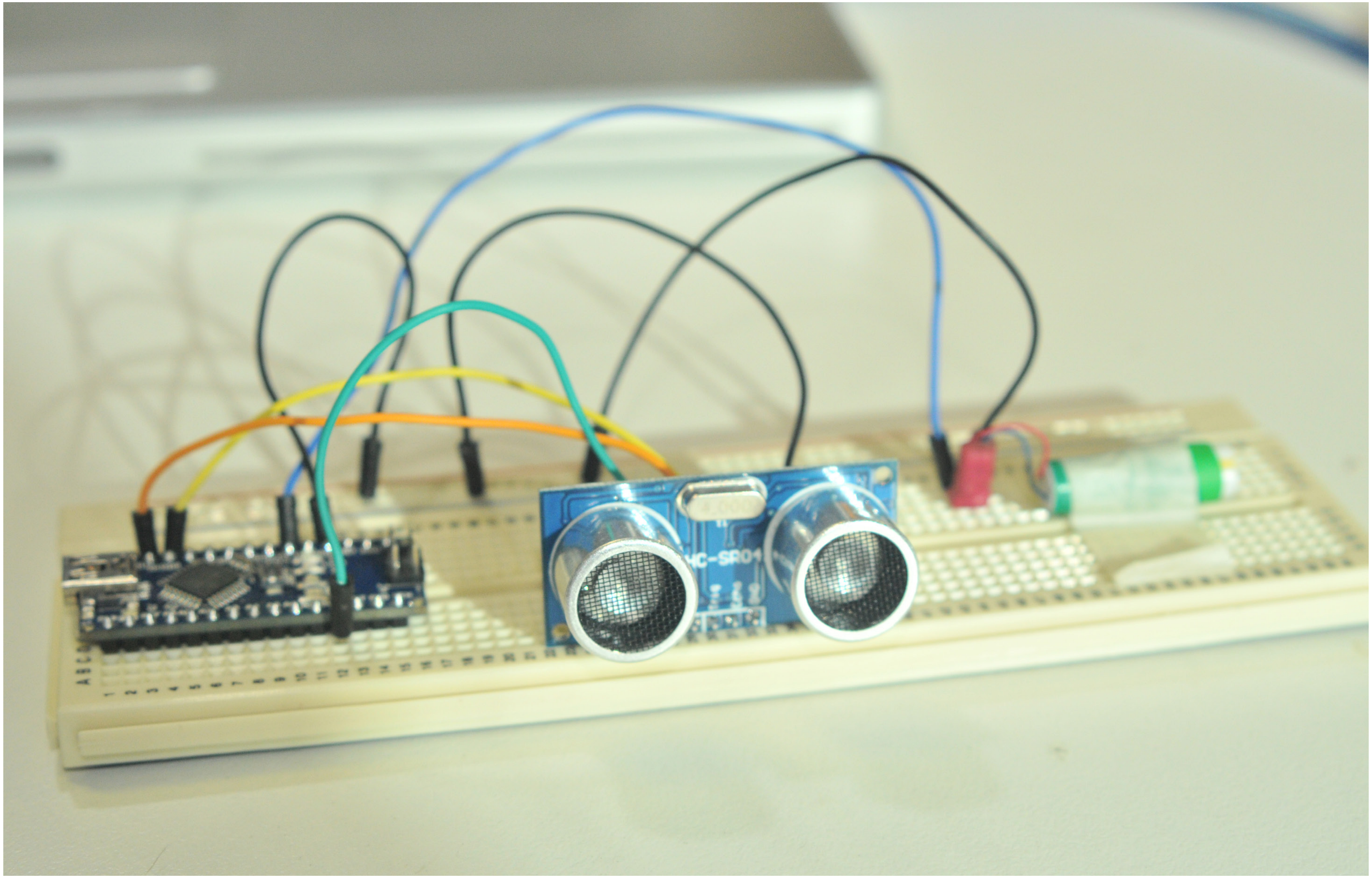
This module iteration was a 3D printed (additive manufacturing) ABS housing that had all the components fitted within it. The idea was to create custom wiring looms to connect it together. This inevitably failed as when you begin to shrink the distance between components, the size of connectors and lack of flexibility of wires become very big problems. Upon accepting this failure I quickly moved on to strip boards which would allow me to connect all components onto the one circuit board for a tidier arrangement.



Potentiometer and Pause button on the breadboard circuit



Housing 01 with custom wiring loom - it failed to fit but was the first wearable module



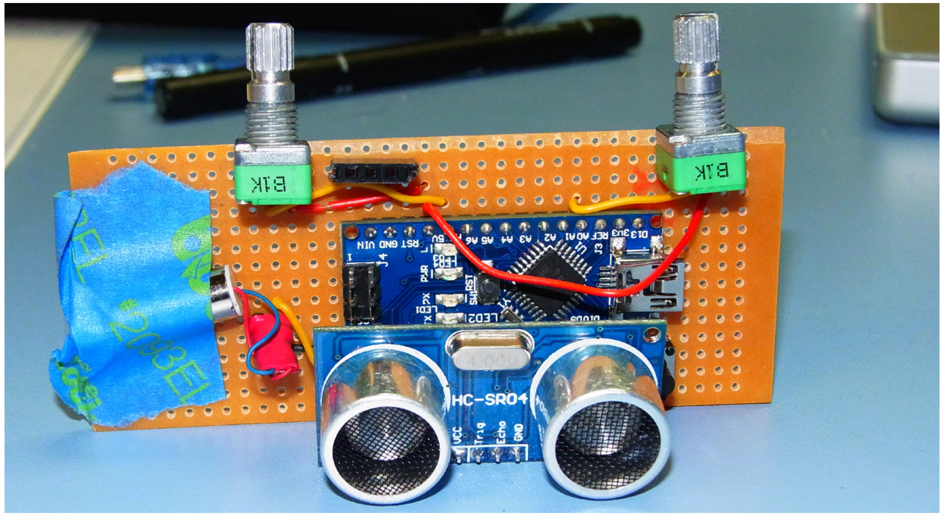
Initial Breadboard with no extra functions, just motor and ultrasonic sensor

Strip Board 01:

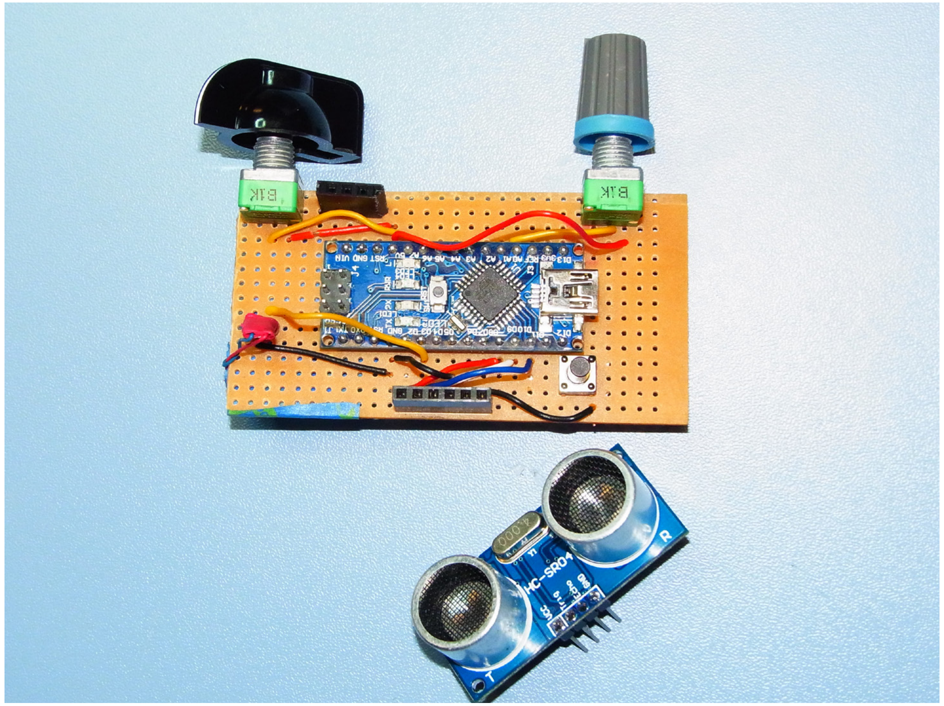
My first attempt at this was done out of frustration resulting from the past failure. It incorporated the two potentiometers, Arduino, pause button and ultrasonic sensor via a 1x4 female header, it also had a 1x2 female header for any battery power. Being the first successful proof of the concept I was able to move on to redesigning the layout of the strip board.

Strip Board 02:

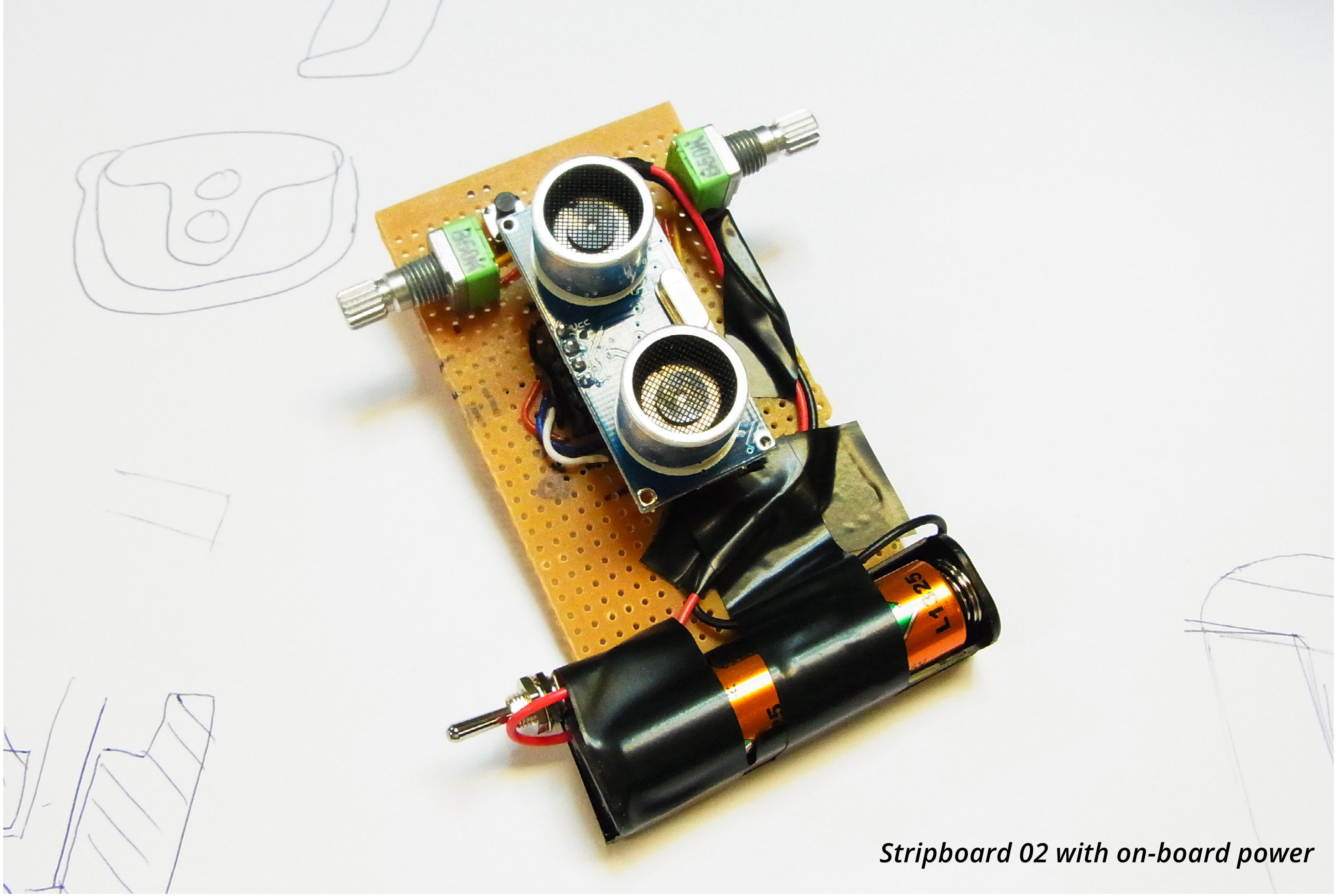
This iteration built was on the Strip Board 01 and rearranged the components into a 'T' shape in an attempt to shrink the size of the board. It had battery power soldered in with a toggle switch in place to cut the power on demand. The battery holder was designed for one AA battery but was instead used to hold two 6v half AA batteries. Running the batteries in series created 12V in to the Arduino. This was enough to power the Arduino but due to the nature of the Arduino's voltage regulator, this may have depleted the batteries much faster. Dr. Scott Mitchell suggested that I run the batteries in parallel to further extend the battery life.



Stripboard 01 with motor mounted on the front



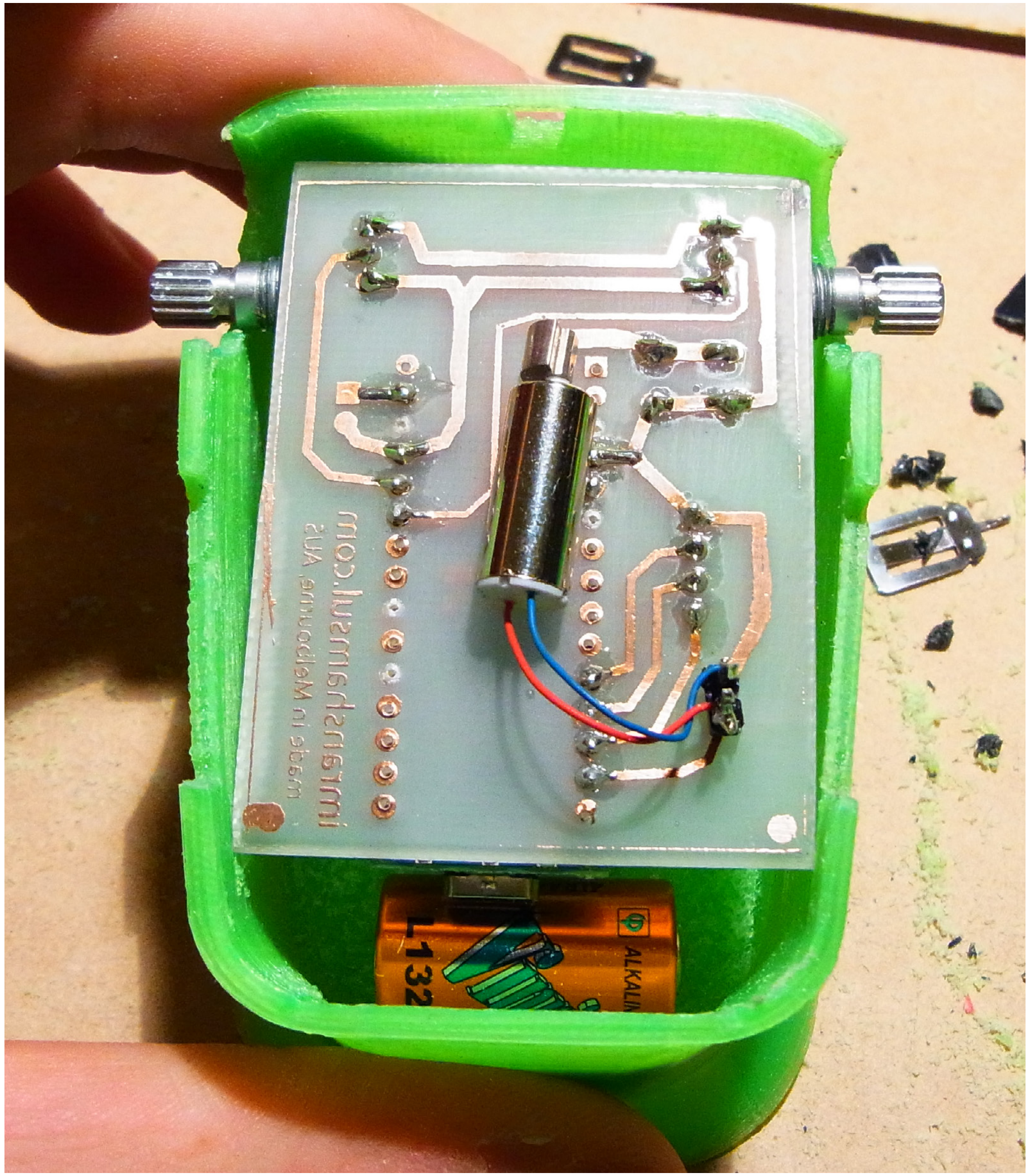
Stripboard 01 with sensor removed to reveal Arduino and jumper cables



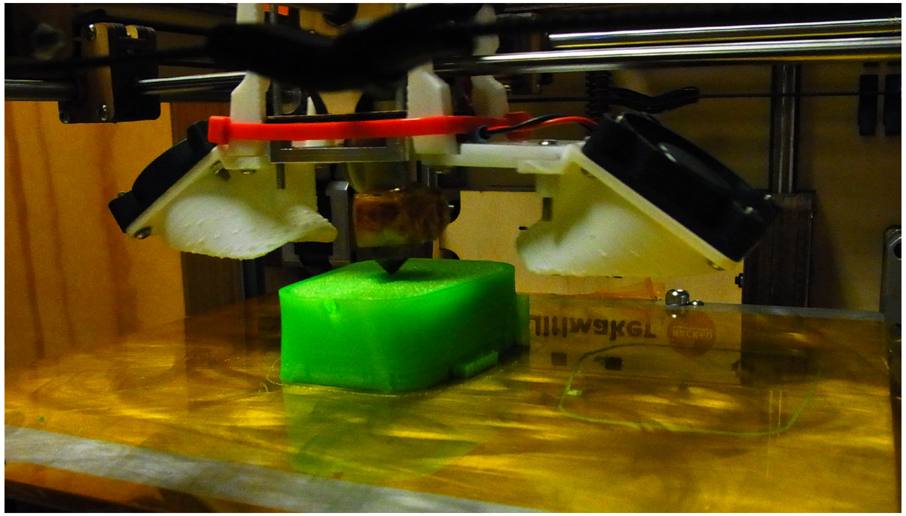
Stripboard 02 with on-board power

Etched Circuit Board (ECB) & Housing 02:

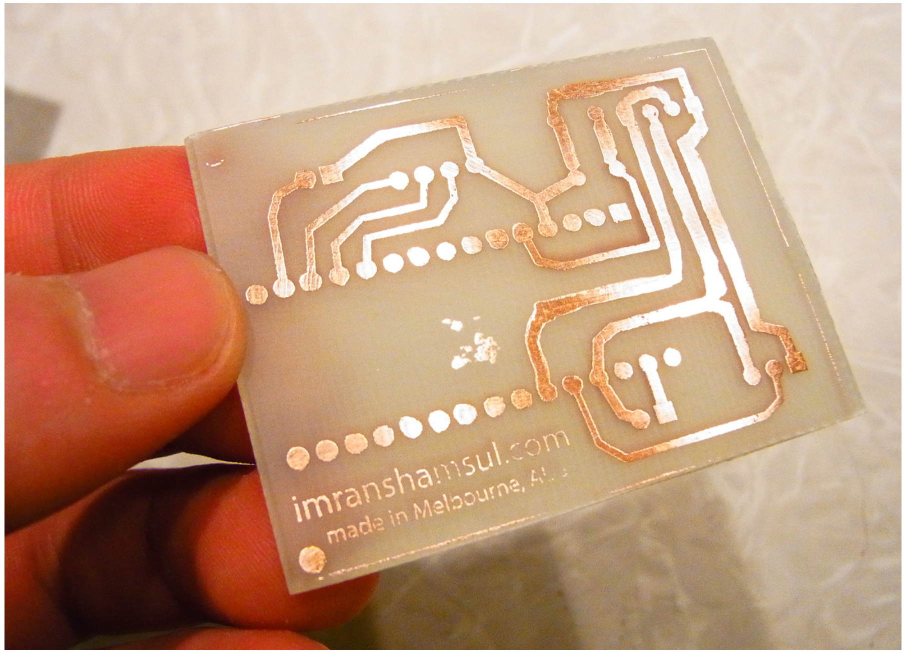
The ECB incorporated the lessons learnt from the first housing attempt and the strip board modules. It followed the layout of Strip Board 02 but did not require any jumper cables as it was all-in-one. The layout of the copper layers were designed on Fritzing (from Fritzing.org) an open source circuit development program. Fritzing allowed me to create and manipulate the layout of this ECB for test printing. At first I sought to get this manufactured properly through specialist printed circuit board (PCB) manufacturers within Victoria, Australia but the cost were too high. One quote was asking for over $500 for ten custom-made PCBs and the others failed to have the turnaround time I was after. While the process to create the ECB was a great learning experience, it was also very confronting as I had to deal with volatile and sensitive elements in the process – from the iron-on transfer of the circuit layout to getting the right chemical mixture for etching prepared (include images of process). This process was a success and I was able to move on to drilling out the holes for the pins and soldering components on. Once the circuit was complete with all components soldered on I was able to load the Arduino code onto the Arduino. Initially I had loaded code with errors but once corrected the whole circuit worked as intended. The next issue came when I attempted to fit the new circuit board into the housing I had 3D printed; not all the components fit well and required some reworking.



Rear view of Housing 02 with ECB



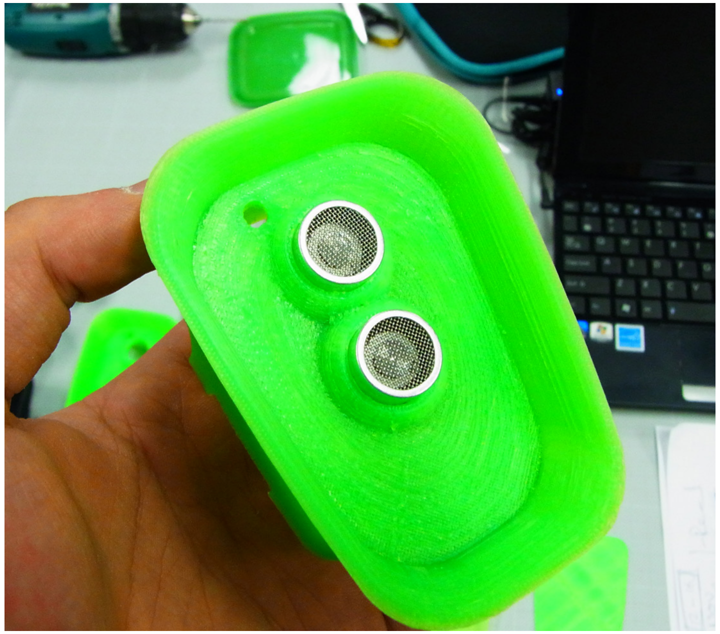
Housing 03 being 3D printed on an Hacked Ultimaker



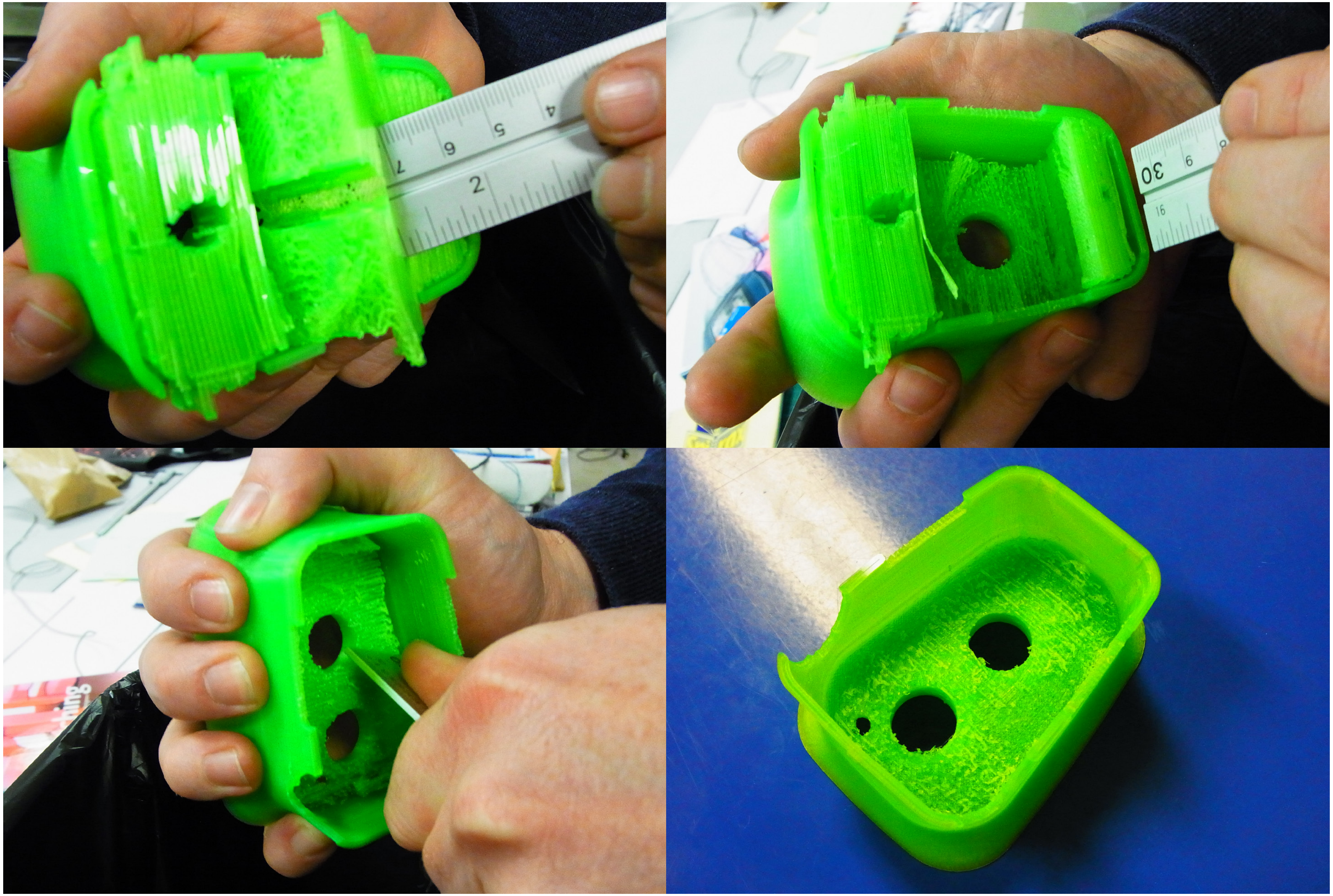
Etched Circuit Board after cleaning and drying

Housing 03:

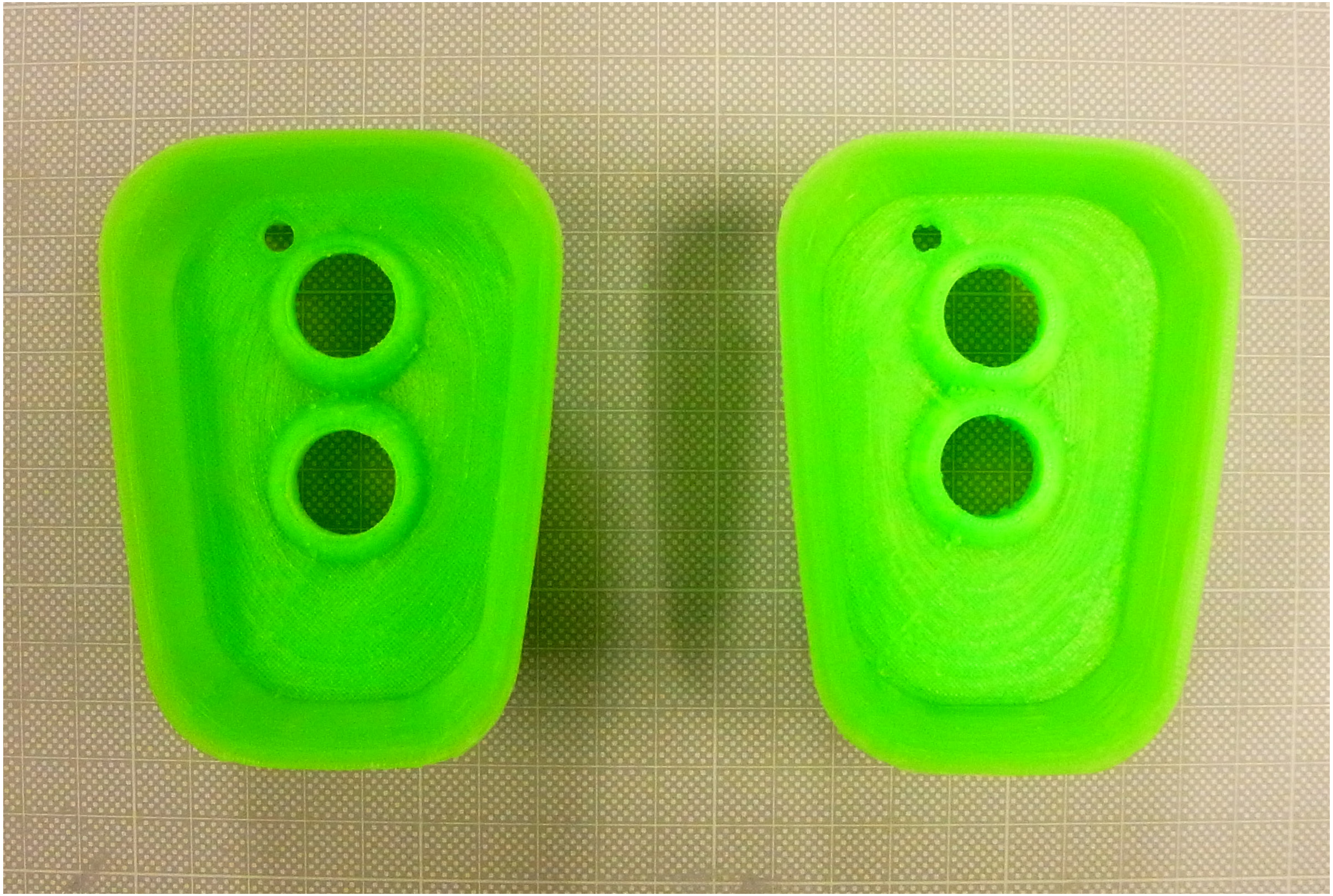
A final and third housing was printed due to the cheap ultrasonic sensors failing to work as expected with my Arduino and circuit. The only resolution was to move on to a more expensive sensor which was far more reliable and accurate. With this new sensor, both the strip board module and ECB module were far more robust and functional. This updated print was to suit the more expensive ultrasonic sensors and was edited to resolve some build issues when printed.



Housing 03 with SRF04 ultrasonic sensor



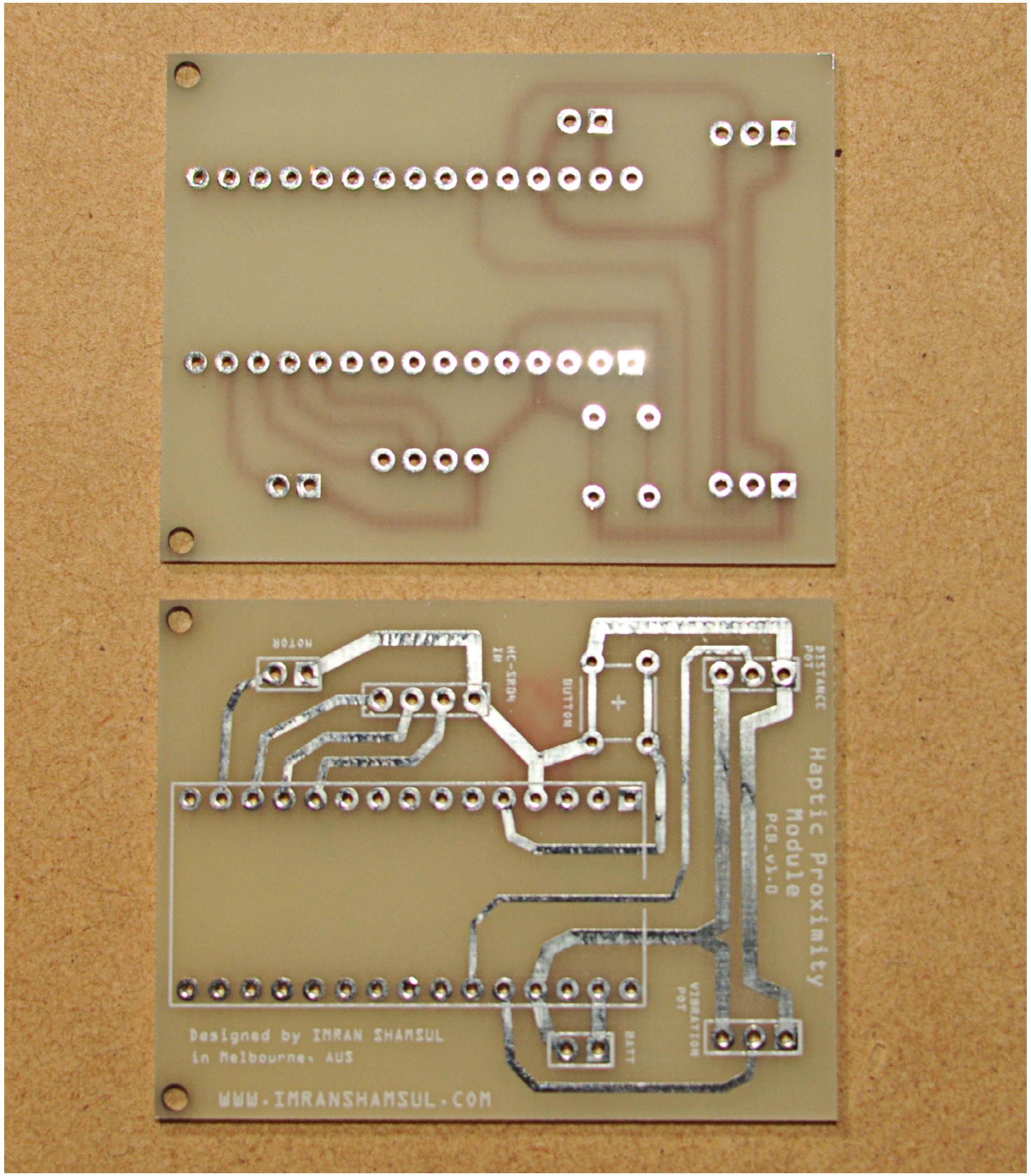
Cleaning up support material from the inside of Housing 02



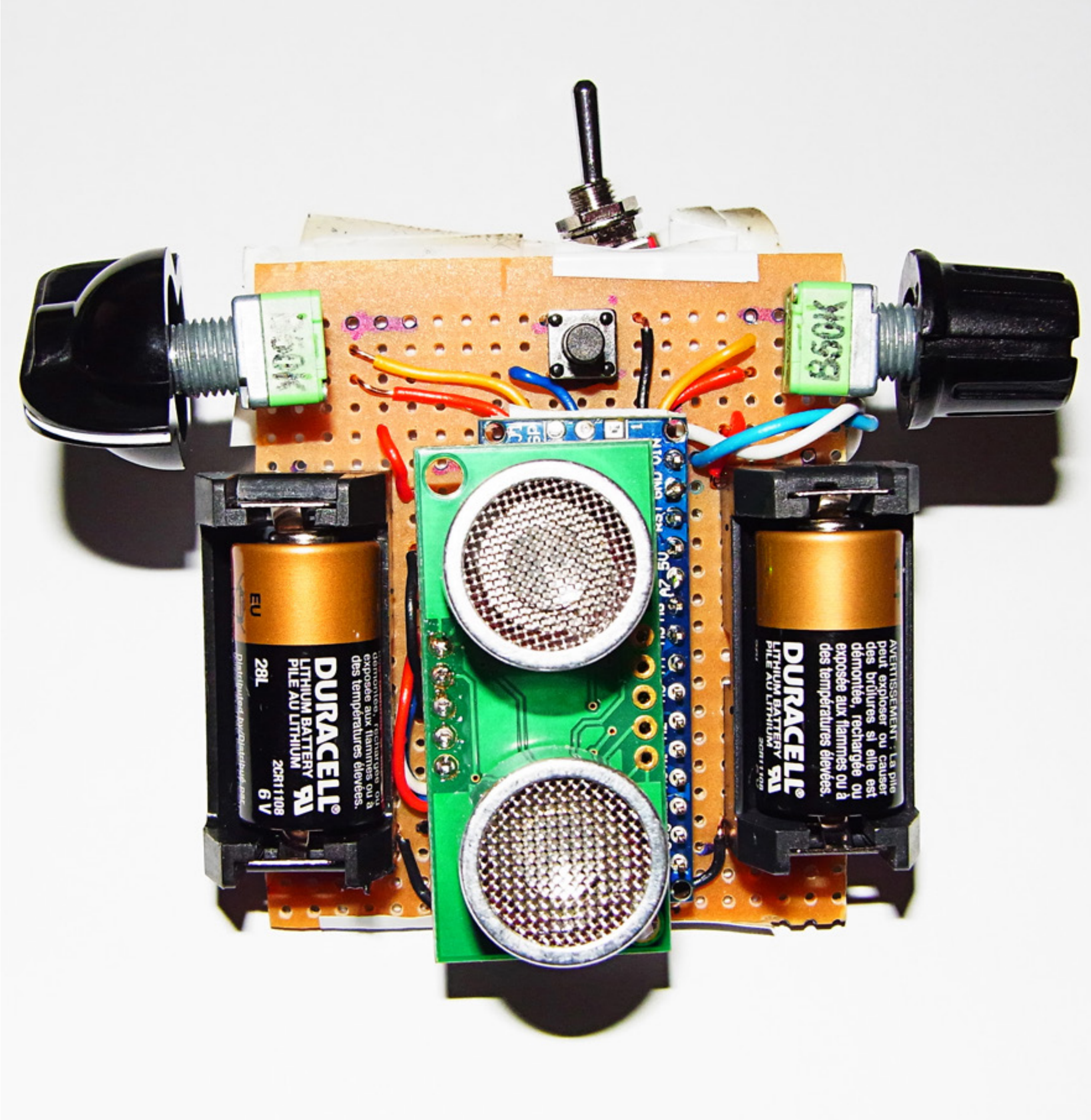
Comparison of Housing 02 (left) and Housing 03 (right). The space between holes suit the different ultrasonic sensors

Small Batch Prototyped Circuit Board:

Quotes: After seeking quotes from five manufacturers, I received a range of costs and production time-lines. In the end I decided to go with Futurlec.com.au as they were the cheapest and seemed to be the best value. However they took two weeks to confirm the file before providing a final invoice for the total amount. There were issues with the payment process and overall communication problems during the whole process. The prototypes Printed Circuit Board (PCB) arrived on the 5th of November at 3pm.



Front (bottom) and rear (top) of Prototypes Circuit Board

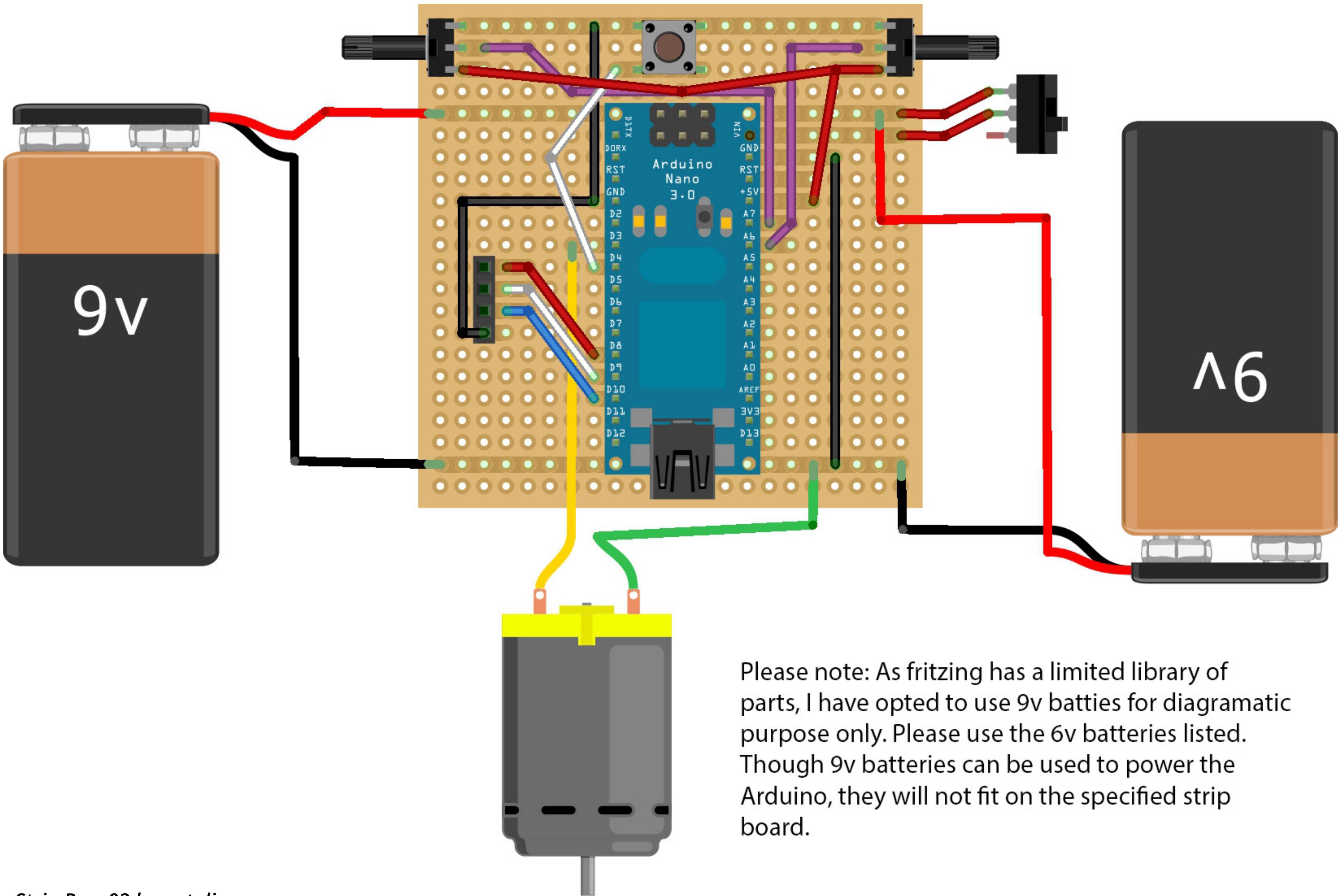


Stripboard 03

Strip Board 03:

This was built as a robust, problem free module. Its main purpose is for user testing and step-by-step instructions on Instructables.com. It has been successful in providing a real working device that meets its intentions. The module development process has been terrifying, frustrating and completely rewarding; it has brought me to the point of having to confront fears regarding my own skills and abilities, tested my mind's ability to think in a way suitable to solder together a circuit and frustrated me through failures in code and hardware. Overall the outcome has been positive. The range of skill sets I have learnt has assisted me with each phase of development, subsequently driving the project forward. 3D printing the housing has brought me back in touch with CAD software and the way of thinking suited to that and additive manufacturing. I am now able to see where the module could be further developed and improved during the building process.

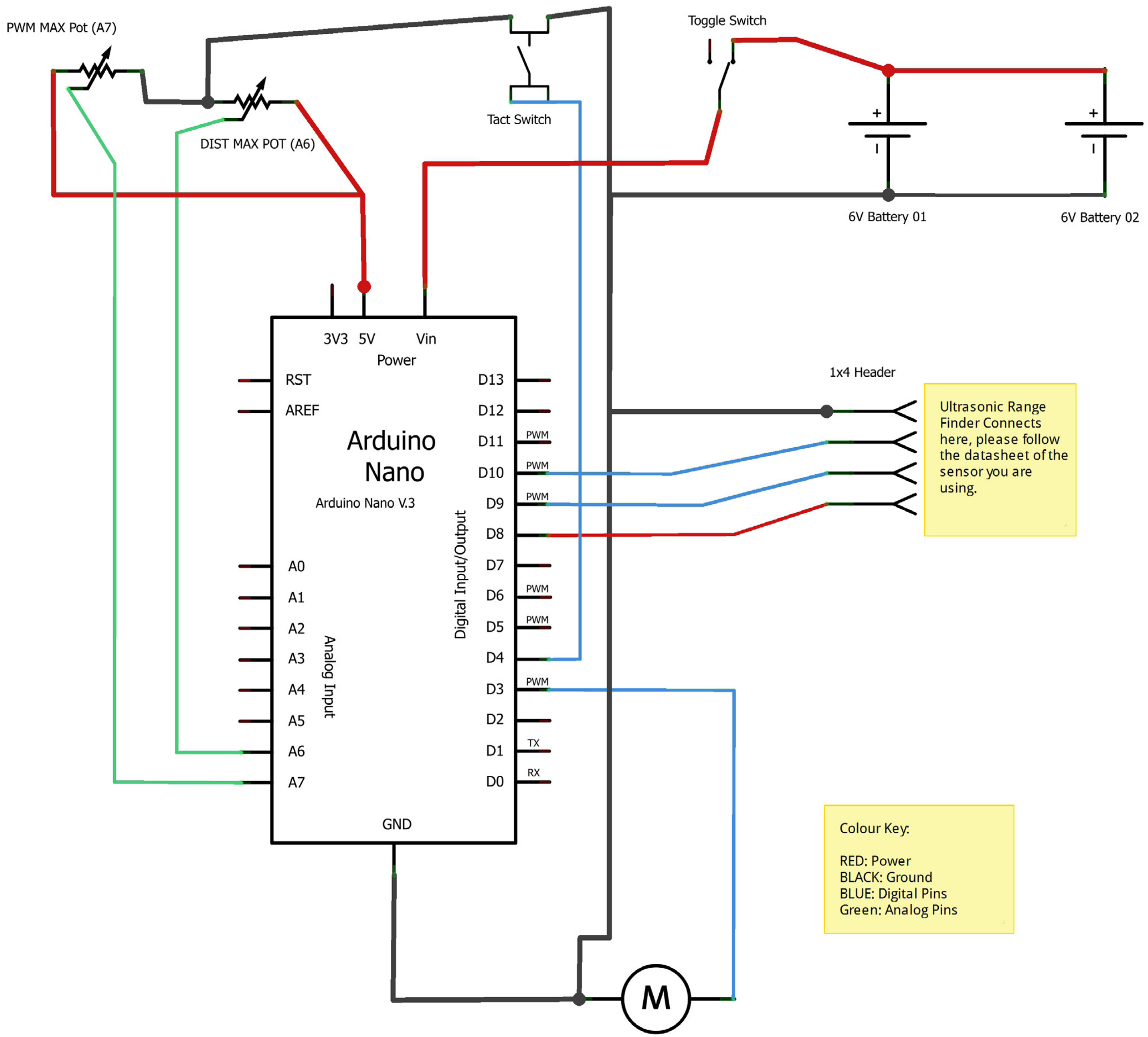
PTIC PROXIMITY MODULE



Please note: As fritzing has a limited library of parts, I have opted to use 9v batties for diagramatic purpose only. Please use the 6v batteries listed. Though 9v batteries can be used to power the Arduino, they will not fit on the specified strip board.

Strip Boar03 layout diagram

OUTCO



Strip Boar03 Schematic

06.5 User Feedback and Testing

06.5.1 Initial User Feedback: ECB & Housing 3, Strip Board Module 03

On the 25th of October 2012, I met with Olivia from the initial ethnographic study conducted in June to seek feedback on the devices I had created and the 3D prints. In regards to the 3D prints, her thoughts were that the process was interesting and the colour of the material was gender neutral and also high contrast, which helped her recognise the device on most surfaces.

When testing the vibration feedback of the device, she placed it initially on her waist, while sitting, to see how it felt and then stood up and held the device just above the knee on her leg and commented how she bumps into things with her legs. She said the vibration was suitable and not overpowering, just the right amount.

When talking about the size of the device she said it is potentially too large and would be more suitable if it was smaller. If it were to be worn on the legs the current size would be too big, and the question of miniaturising the circuit was raised. I suggested that the next phase of this project was to minimise the electronics into a singular circuit and the housing would follow.

On a side note, the idea of a smaller device was raised by lecturer Dr. Scott Mitchell, stating that he had a 'badge/brooch sized' device in mind.

When speaking about wearing the current housing and device as something around your neck – the colour and size would potentially communicate to people around you as a signifier of a person with vision impairment, Olivia suggested that some people may prefer it to resemble something such as a mobile phone.

When reviewing the control of the device Olivia was happy with the size of the control knobs on the Strip Board Module 03 and was able to understand the nature of the two controls and operate them to adjust the distance sensing and vibration level.

06.5.2 User Test 01: Strip Board Module 03

On the 27th of October 2012 a user test was conducted on level 6 of building 88 at RMIT University Melbourne. A willing participant, Oscar, was blindfolded and the device was strapped to his leg below his knee. He was asked to sit down on a chair, blindfolded, in a large empty space. There were objects on wheels ready to be moved once he was seated. I quickly set up an obstacle course for him to venture around, and once this was done I instructed Oscar to stand up and begin walking forward slowly. Unfortunately the sensor was not switched on and Oscar quickly discovered the table as he touched it with his hands. This was quite a surprise. Once this issue was sorted out, Oscar began to walk around the room feeling for obstacles with his hands and with the module on his leg. This was done by sweeping the leg left and right to scan the area.

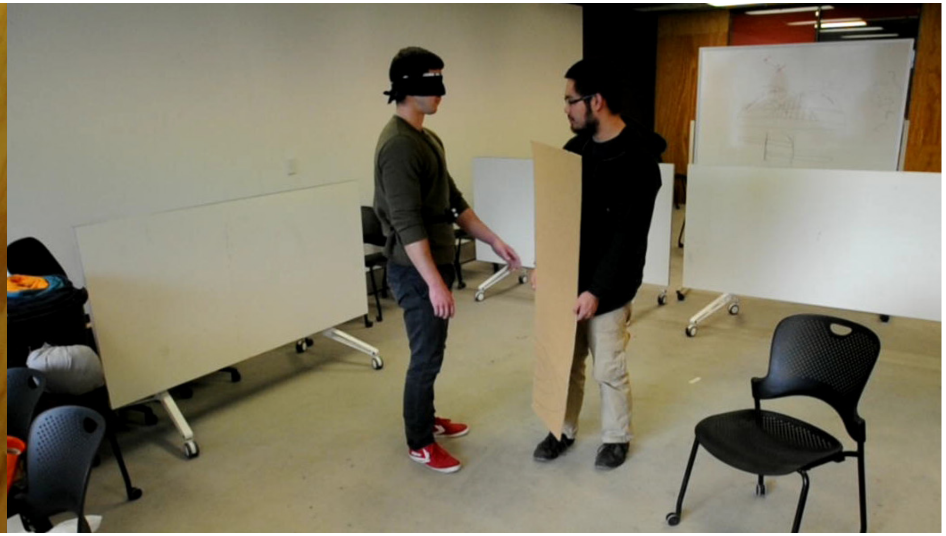
Next Oscar attempted to navigate around the floor of the building where the user test was being conducted to find his way back to his seat. I believe that having a familiar knowledge of the floor assisted him with this process but nevertheless, he was able to detect and avoid obstacles using the module mounted to his leg.

The next test involved Oscar having the module strapped to his waist over a t-shirt and jumper, with him being blindfolded. An area in the original open space was cordoned off with tables that had been flipped up to create a vertical wall below chest height. The helper and I moved around the space with large cardboard sheets to block Oscar as he moved through the space. The only instruction given to him was to stand up and begin wandering through the space, trying to avoid objects without using his hands. Oscar successfully did this and was able to build a mental image of the room layout; this is a testament to Oscar's visual mapping skills but still is positive in the sense that the module was able to help him do this while blindfolded. He had calibrated the sensor to begin detecting objects in the line of sight of the sensor at about arm's length. This helped him to have enough time to detect and engage objects and provided him with confidence and peace of mind with the device.

Overall the test was positive, with a few problems relating to the limitation of the height of placement of the device and the discomfort caused by the vibration on the stomach. The device does not detect thing above, below, left or right of the line of sight; its strength is directly in front of it, so sweeping the device across space is important for detecting objects. Once this limitation was understood by Oscar he was able to adapt its usage and navigate as best he could with the sensor and his available limbs. The discomfort of the vibration was due to it causing an effect on his digestion system.

This user test was positive in establishing errors that can take place in a user test. It provided me with more confidence to take the device back to people who have vision impairment and to seek their feedback, as there was a fear of the device failing while being tested by these people. The issue of mounting it on the human body became apparent and this needs to be addressed in future iterations. As a proof of the concept of a object sensor, it was a success and provided helpful information for further development. The next step is to test it in context with low vision users.

Blindfolded user detecting the gap between tables



Detecting the cardboard surface that was randomly located in the space

Detecting a wall

User built a mental map of the space through vibration feedback and touch

Sighted user was blindfolded and seated before user test began. HPM placed above his knee.

06.5.3 User Test 02: Strip Board Module 03

On the 31st of October 2012 I conducted a second user test at the home of Olivia and Hugh, where they both took part in testing and gave feedback on the Strip Board Module 03.

What was interesting was that Olivia was wearing a skirt, so for the device to attach to the leg via Velcro around the leg was not possible. The device was attached to her right ankle as this was the only point unobstructed by the skirt below the waist. It was directly on her skin with no clothing between. This was the best position for her as her peripheral vision deteriorates greatly below her waist level while she is looking forward.

Olivia wore the device for twenty minutes and walked around her kitchen, lounge and other living areas in her home. She attempted to navigate with her eyes closed, but I advised her that this was not necessary as what was important was how she experienced it with her eyes open. Almost immediately after putting on the device (Velcro around the ankle), Olivia was able to detect a blue bucket that had been left in the kitchen and she was able to avoid hitting it. I then proceeded to place a small cylindrical silver rubbish bin in her path, and she was able to momentarily detect it as she moved around the kitchen but then 'loose it' again. The colour of the bin was silver, was this a factor is causing the device not to detect it? Did the bin deflect the ultrasonic signal off in a different direction, and subsequently the device failed to receive the return echo signal, thus not activating the motor vibration? While the previous blue round bucket was detected, this silver rubbish bin was not. I have tested the device with other light reflective surfaces such as glass and mirrors, and in this case, when the object was perpendicular to the sensor, the echo signal was detected without problem, but at angles greater than 45 degrees from the surface, the echo signal seems to be deflected. In the case of the silver rubbish bin, Olivia was not approaching it at a perpendicular angle, or within the sensor's range of function. Therefore I concluded that as sound is being reflected here, not light, the issue was the angle of approach to the rubbish bin, not its surface finish.

Regarding the vibration she was happy with the level of vibration and did not find it troublesome or problematic; she felt it was the right amount. In terms of navigating the home in general, she suggested that having another sensor higher up would have helped also in avoiding objects and walls. She expressed that when there was a long solid wall it was a lot easier to feel it with the HPM placed on the ankle.

Hugh then tried on the sensor around his ankle. It was strapped on over his pants, which was over his socks also. He said that the vibration could have been stronger; I believe this was due to the extra the layers of clothing which absorbed the vibration. He wore the device for a short period of time (5 minutes) and said he immediately understood the mapping, also stating that over time the understanding would probably become more natural for him and for anyone else. He joked that he'd like a system like this installed on his car! (Note: much like rear parking sensors available on cars today but with vibration feedback.)

Overall the user test was immensely positive. Being able to gain feedback from people who experience vision impairment everyday helps put the device into context and reveals both the functional gains to the user and the shortcomings of the device.

06.5.4 Reflections and Scope for Improvement

- How the device is mounted to different parts of the human body over different kinds of clothing is very important. If it cannot be worn well then what point is there to its function, as it may lead to issues, such as physical discomfort, causing frustration to the user.
- Its ability to detect a range of surfaces, flat and curved is important. However a curved surface may lead to a failed detection due to the ultrasonic pulse being deflected and not returning an echo to the sensor, causing a failure to communicate the location of an obstacle in the user's direct path. Otherwise the sensor is very capable of reflecting sound off glass and many other surfaces with a variety of common finishes such as paint. Though, non-common finishes such as special sound absorbing paint used in military applications would be an issue, it does not occur commonly in everyday situation, so it can be dismissed for now as a real problem.
- Access to controls is weak when it is outside of arms reach. 'On-the-fly' changes become difficult and require the user to stop and adjust to suit changing environment or needs. Development potential for the module may include wireless adjustment and calibration of settings, even enabling the user to pause the device from a remote instead of activating controls directly on the device itself. Further development into the wear-ability of the device is important to accommodate for different parts of the body and different items of clothing worn by the user. Detecting objects through clothing in an interesting step but may be problematic depending on the method of object detection.
- Overall usability and maintenance of the device needs further consideration. At this stage if anything goes wrong it is difficult for the user to potentially understand how to fix the problem. It is not particularly straightforward to source the battery or change it in the second and third iteration of the housing.
- One concept that was raised was a suit of modules thus making the whole human body capable of perceiving distance through vibration!

06.6 On-line Open-Source Sharing:

www.instructables.com

http://www.instructables.com/id/Haptic-Proximity-Module-HPM-for-Low-Vision-users/

- Published: 25 Oct 2012
- All-time views: 10,461 @ 4 Nov 2012
- Comments: 15
- Followers 9

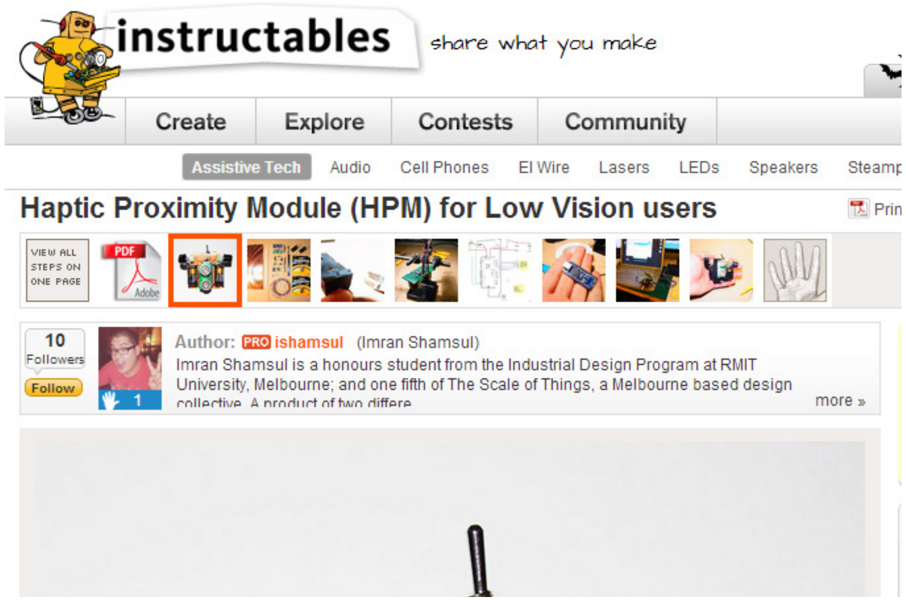
The posting on instructables.com process for easier than I thought. Their website gave me a good platform to add text and images. There were some issues with pressing backspace and then going to the previous page loaded which erased all my work. Luckily this happened only twice. There is a Save As button which I began to press often. I began by establishing all the components required with links on where to purchase them.

The images were prepared and selected and put through a filtering process on Photoshop to bring out the colours, shrink and save the files. The rest of the process was very straightforward as I uploaded images and files that I had prepared and added text, especially since I was taking photos along the way, making the process a lot easier!

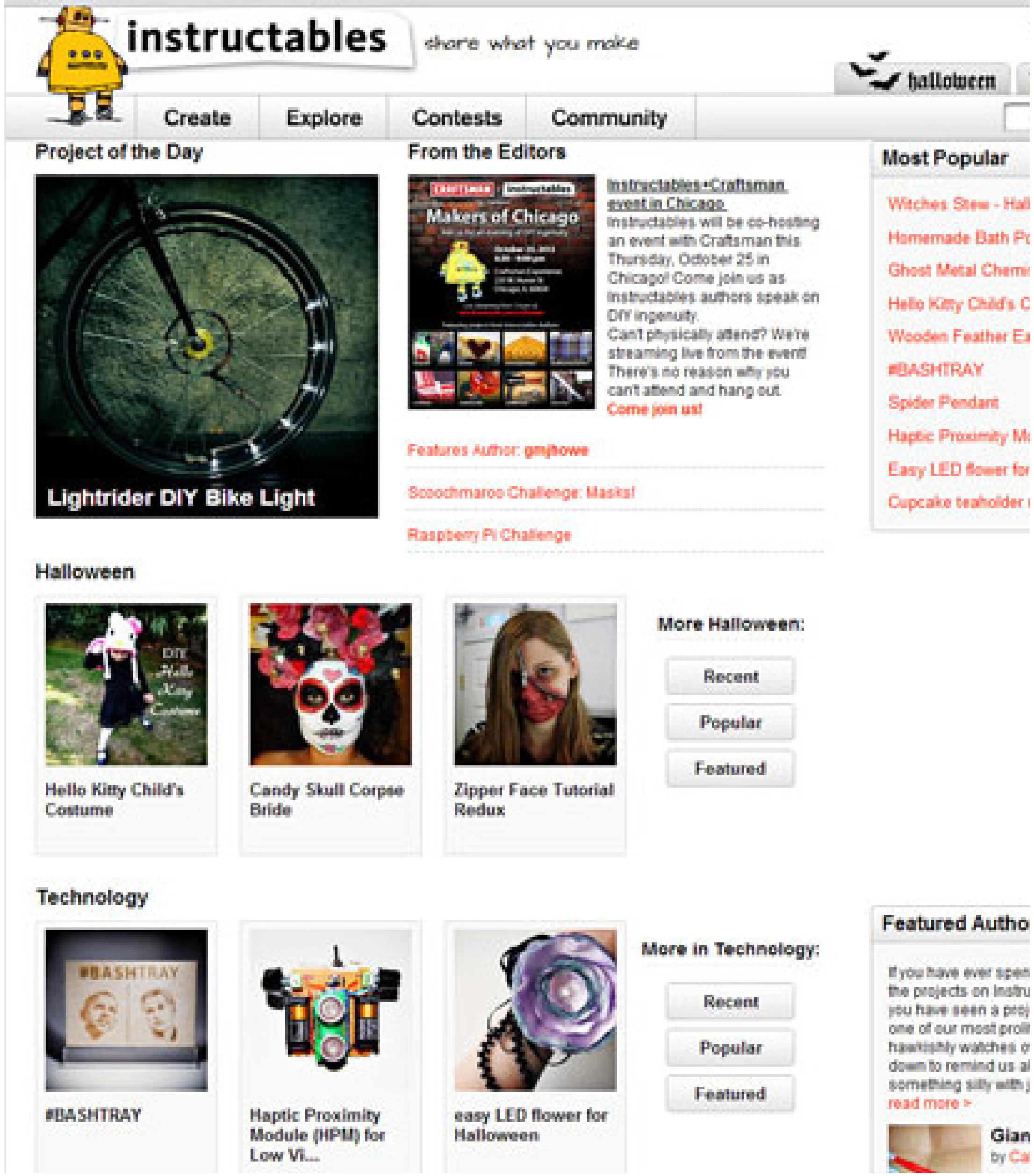
To publish the Instructable how-to, you must categorise your item and then write in any tags that you feel associate with the project. It is a process I am happy about and willing to continue using to share developments of this and other projects.

Within 5 hours of posting the STB03 labelled as just 'HPM' on Instructables it made the front page of instructables.com. I was notified by instructables.com that this had happened via e-mail. Upon checking Instructables I found it on the front page under the technology section.

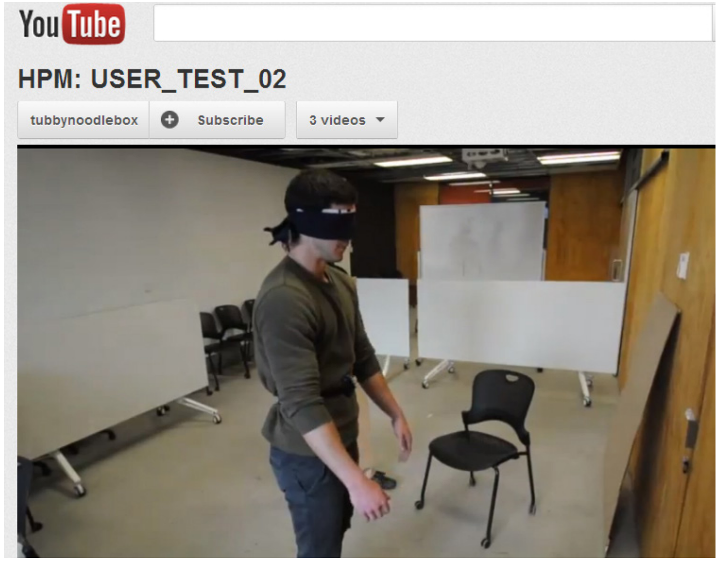
I have since received two emails regarding the project specifically, one about borrowing ideas and the second a request for a kit to be sent to him.



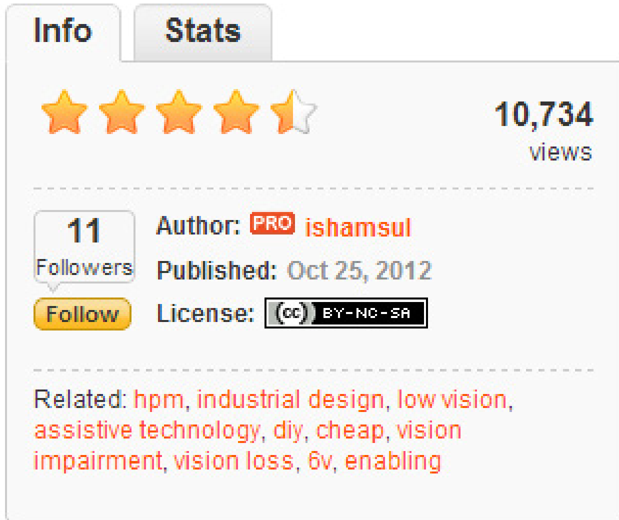
Instructables page,



Step-by-step instructable featured on the front page.



User Test video on YouTube.com

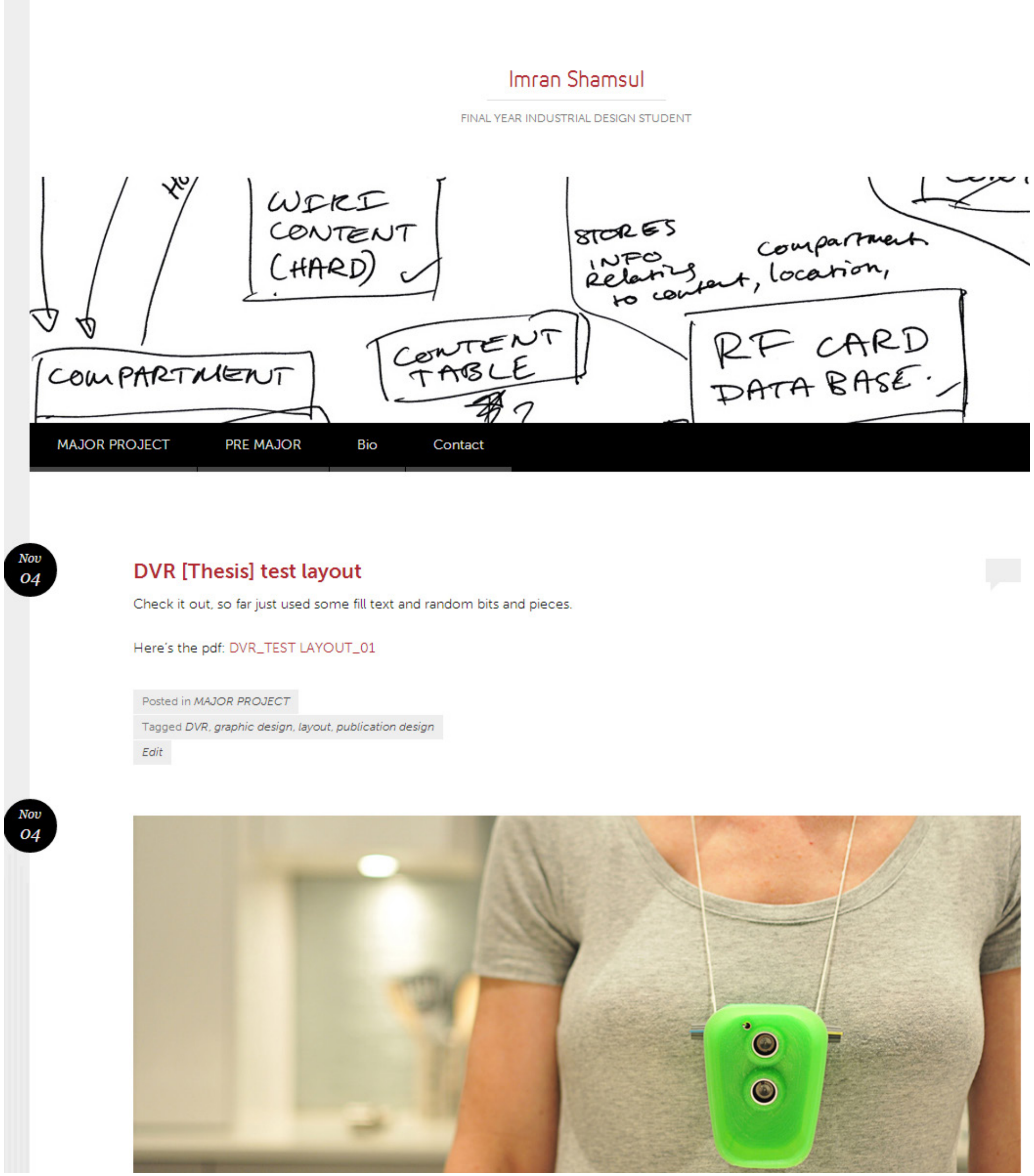


Information box from instructables page

www.imranshamsul.com

- Began: March 2012
- All-time views: 1,371 @ 4 Nov 2012
- Comments: 2
- Followers: 4

Imranshamsul.com has not received as much attention over the life of the blog. However, what it has done is provided a platform for me to place my thoughts and work into one place online. I've noticed, the only time it receives much attention is usually around a deadline or due date, so I am led to believe it is other students in my class that are referring to my blog for information. That in itself is part of the blog's intention, a point of reference for other people too.



Front page of ImranShamsul.com

07. DISCUSSION

07.1 Research Phase:

From the outcomes of the research phase of this project, the interviews have provided an initial insight into the lives of people with AMD or LV. It is interesting to note that the loss of vision for the individuals with AMD has been very gradual, and with the appropriate medical treatment this can be controlled within reason to help maintain a level of visual acuity for an extended period of time, in these cases, between 5 to 8 years. For the more severely affected by vision impairment, there is a greater reliance on one's memory to help around the house and a decreased amount of confidence in relation to the world outside of the home. Fortunately the participants interviewed are reasonably comfortable with technology and willing to engage with it as a tool of assistance for daily function.

Vision Australia is a professional organisation that provides a comprehensive service for people experiencing low vision by taking the time to assess and create individualised solutions for people based on their capabilities, needs, and goals. There is a resounding feeling that everything that is done for their clients must be reasonable in relation to their situation. From the review of literature there was discussion that the referral pathways were not being maximised and people were not having access to services such as those offered by Vision Australia (Patricia O'Connor and Keeffe 2007), but in the case of the services offered in the state of Victoria, it appears that the referral pathways are in place and individuals are being referred to Vision Australia at an earlier stage in their vision loss.

Participants did not think of daily life tasks as anything above and beyond them, and felt that they simply had to get on with them as they had always been doing. It seems other factors relating to age have more of an impact on their functional capabilities than their deteriorating vision. In fact having good mobility helped to compensate for the vision impairment and ensured they were capable of continuing their life independently. In the case of Olivia, she seems reliant on Hugh, her husband, to help her engage with text, such as small news print, recipes and music. She requires him to dictate the text so she is able to type it up and expand it. Olivia was also one to suggest ideas on how to do things and also proposed a question to help in the interview process.

The home is an area in which the participants have been able to control and become somewhat confident to function within. It is the world outside of the home that can cause difficulty and distress for them. For the participants that can still drive, rapid change of light is a problem and has caused them to either avoid or cease driving at night or when the light creates high levels of changing contrast. One participant had great difficulty when attempting to cross roads as her vision was impaired to an extent that she was unable to sense or judge fast moving objects, such as vehicles. Any HPM module at this stage would be able to detect that there was an object within the range of the sensor (up to 200 centimetres) allowing the user to feel any passing car, but as for distinguishing and judging an approaching vehicle, the time taken to sense and then respond to that sensation using the HPM would not be sufficiently safe for a person to use in a road environment. At this stage any HPM would be for stationary and, at best, very slow moving object avoidance outside of the user's field of functional vision.

Throughout the interview process, it became apparent that the interview questions needed adjusting and additional themes added to get the most productive information from the participants. They did however provide a good consistent frame with which to understand and engage with the participants about their vision impairments.

The workshops have provided a solid foundation to develop a set of analytical tools for examining interactions and also technical skills in regards to electronics. The Frogger method cards will be useful when a prototype is being created and elements of it must be broken down for further interrogation.

07.2 Design Phase:

As expected the design phase came with challenges and new opportunities for learning. The main areas of learning were coding, circuit building and design, soldering technique and computer aided drafting for additive manufacturing. The design and build process was a blend of failure and success from failure, through creating two iterations of the belt study and six iterations of the module. The most interesting element was the feedback and reflections from user testing and feedback of the final Strip Board Module 03 (SBM03)

Sharing the process of creating the STB03 on Instructables.com proved to be a positive step in the project as it reinforced the relevance of the project in the public sphere with nearly ten thousand views on the site within the first week of publication; STB03's audience has subsequently grown beyond that of just people within the Industrial Design Program at RMIT, friends and family. Instructables has provided direct contact with two people internationally that have shown specific interest in the project, one student from the University of Southern Mississippi developing a ultrasonic glove and a person requesting a kit to be sent to him in India as his brother has vision impairment at night.

In regards to the learning process and bridging the gap in technical knowledge and skill, this process took far longer than anticipated – even with extra time given to help this. Technical failures became personal roadblocks and required a push of courage to overcome them. Soldering was an important skill to master and took 6 weeks to really build and become a core skill-set. Once this had happened further development on strip board, printed circuit board (PCB) or etched circuit board (ECB) became easier and faster, helping the overall process of module development along.

User testing and feedback was very productive for drawing out new ideas for development pathways and iterations. Sadly these realisations only occurred at the end of the project due to the time-line being blown out due to the increased time required to overcome gaps in knowledge. This meant that further development was not possible.

When compared to Project HALO, the Haptic Proximity Module sits well as a natural progression. On a coding level it approaches the mapping between sensor and motor directly compared to the 'timer and interrupt' method of Project HALO, whereby an event triggered by the sensor interrupts the clock cycle of the Arduino and engages another set of actions. In terms of cost the HPM project is more expensive if you want to have an equal number of sensors as Project HALO.

08. CONCLUSION

In conclusion the research phase has generated a richness of data that has grounded this project in the real world and provided a level platform to build an interactive technology that can be used in the design phase. The ethnographic research was very important in establishing an understanding of how people have adapted to their visual impairment and maintained/adapted their surroundings to continue independent living.

Low-fi rapid prototyping has provided eight iterations in total from the beginning of the design phase – two in the belt study and six in the module development. Time and project management have had a big impact on the success of the final outcome; while it could be refined further, the outcomes that exist at present have been released into the wider world for public consumption and have surpassed any expectation had at the beginning of the project. Overall this has been a successful process with great knowledge building and a resultant working Haptic Proximity Module.

08.1Future Work

The next natural step is minimising the footprint, components and power consumption of the HPM. This will require improved understanding of electronics and available microprocessors. Creating a wireless network of modules being controlled by remote would allow for greater freedom and placement of modules while allowing the users to manage and engage them in real time while moving through their world.

I believe there will be a split, one direction will be an open-source driven device while the other will be deeply refined and customised outside of the reach of do-it-yourself users. – the latter having greater research potential and even commercial opportunities.

09. BIBLIOGRAPHY

1. Bach-y-Rita, P. and K. A. Kaczmarek (2002). Tongue Placed Tactile Output Device. United States, Wisconsin Alumni Research Foundation.

2. Bach-y-Rita, P. and W. K. S (2003). “Sensory substitution and the human-machine interface.” Trends Cogn Sci 7(12): 541-546.

3. Bird, J., P. Marshall, et al. (2009). Low-fi skin vision: a case study in rapid prototyping a sensory substitution system. Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology. Cambridge, United Kingdom, British Computer Society: 55-64.

4. Bongers, A. J. (2004). Interaction with our electronic environment - an e-cological approach to physical interface design. Utrecht, Hogeschool van Utrecht, Faculty of Journalism & Communication.

5. Brewer, J. D. (2000). Ethnography. Buckingham, Open University Press.

6. Delbridge, A., J. Bernard, et al. (1992). The Macquarie Dictionary. Sydney, The Macquarie Library Pty Ltd.

7. Gaukrodger, S. J. and A. Lintott (2007). Augmented reality and applications for assistive technology. Proceedings of the 1st international convention on Rehabilitation engineering \&\#38; assistive technology: in conjunction with 1st Tan Tock Seng Hospital Neurorehabilitation Meeting. Singapore, ACM: 47-51.

8. Harrison, C. M. (2004). “Low-vision reading aids: reading as a pleasurable experience.” Personal Ubiquitous Comput. 8(3-4): 213-220.

9. Independent Living Centres Australia (2012). “Assistive Technology - Independent Living Centres Australia.” Retrieved 09 MAY, 2012, from http://www.ilcaustralia.org/home/assistive_technology.asp.

10. Ireland, C. (2003). Qualitative Methods: From Boring to Brilliant. Design Research: Methods and Perspectives. B. Laurel. Cambridge, The MIT Press.

11. Jacko, J. A., L. Barnard, et al. (2004). Isolating the effects of visual impairment: exploring the effect of AMD on the utility of multimodal feedback. Proceedings of the SIGCHI conference on Human factors in computing systems. Vienna, Austria, ACM: 311-318.

12. Kumar, R. (1996). Research Methodology: A step-by-step guide for beginners. Melbourne, Addison Wesley Longman Australia Pty Limited.

13. Macular Degeneration Foundation (2012). “Macular Degeneration.” Retrieved 09 JUNE, 2012, from http://www.mdfoundation.com.au/resources/1/factsheets/AMD_Booklet.pdf.

14. Patricia O’Connor and J. Keeffe (2007). Focus on Low Vision. East Melbourne, Centre for Eye Research Australia.

15. Plowman, T. (2003). Ethnography and Critical Design Practice. Design Research: Methods and Perspectives. B. Laurel. Cambridge, The MIT Press.

16. polymythic (2010). "Haptic Feedback device for the Visually Impaired [Project HALO]." Retrieved 10 JUNE, 2012, from http://www.instructables.com/id/Haptic-Feedback-device-for-the-Visually-Impaired/.

17. Rettig, M. (1994). "Prototyping for tiny fingers." Commun. ACM 37(4): 21-27.

18. Riazi, A., M. Y. Boon, et al. (2010). Difficulties in reading small print materials on today's home appliances for people with visual impairment. Proceedings of the 4th International Convention on Rehabilitation Engineering \& Assistive Technology. Shanghai, China, Singapore Therapeutic, Assistive \& Rehabilitative Technologies (START) Centre: 1-4.

19. SCAT Program (2012, 15 MARCH 2012). "SCATP Fact Sheets." Retrieved 09 MAY, 2012, from http://www.sc.edu/scatp/what.htm.

20. Vision Australia (2012, 25 AUG 2010). "Age-Related Macular Degeneration Fact Sheet - Resources - Vision Australia Website." Retrieved 18 MARCH, 2012, from http://www.visionaustralia.org.au/info.aspx?page=605.

21. Wensveen, S. A. G., J. P. Djajadiningrat, et al. (2004). Interaction frogger: a design framework to couple action and function through feedback and feedforward. Proceedings of the 5th conference on Designing interactive systems: processes, practices, methods, and techniques. Cambridge, MA, USA, ACM: 177-184.

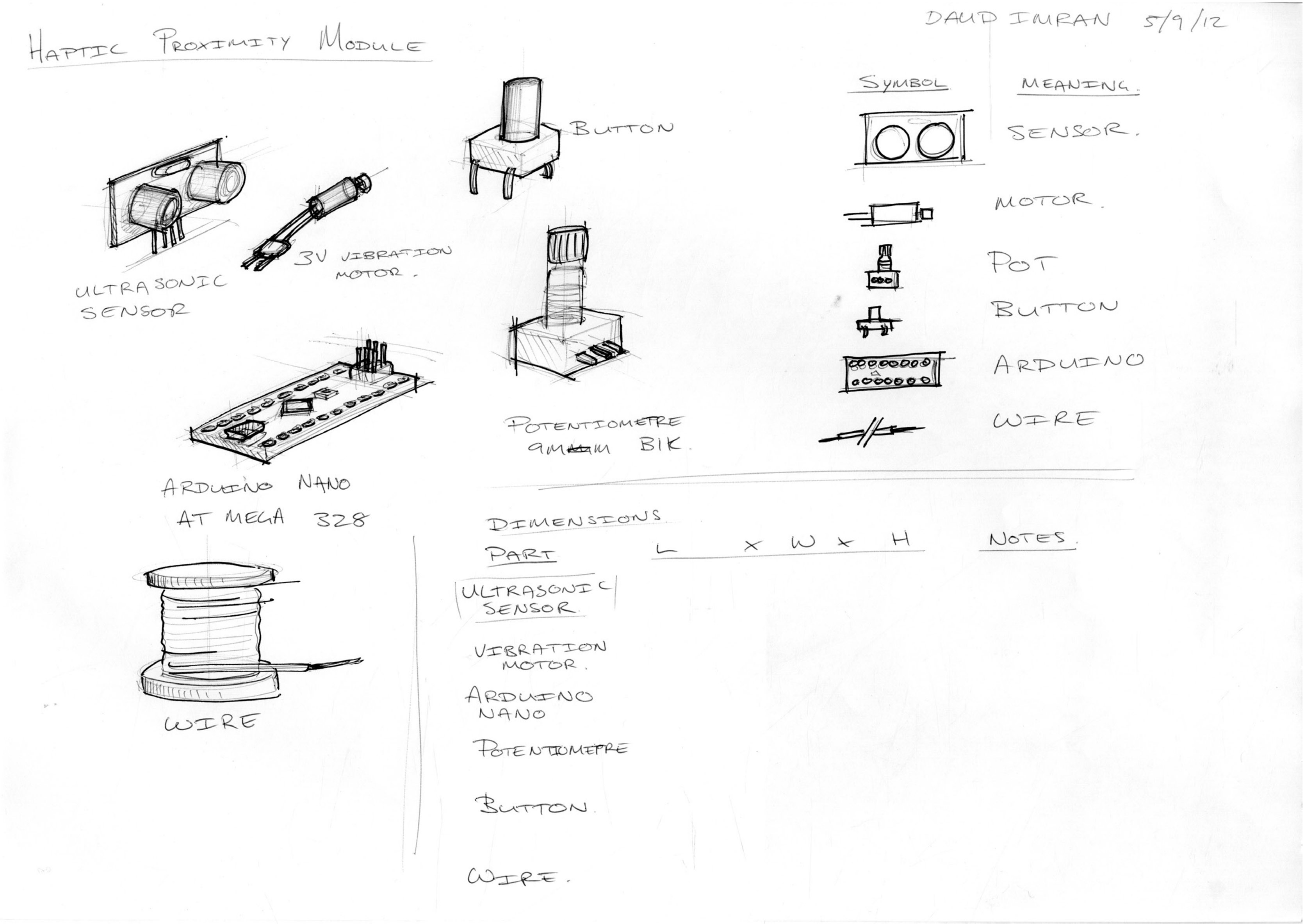
22. World Health Organization (2012). "WHO | Visual impairment and blindness." Retrieved 09 MAY, 2012, from http://www.who.int/mediacentre/factsheets/fs282/en/.

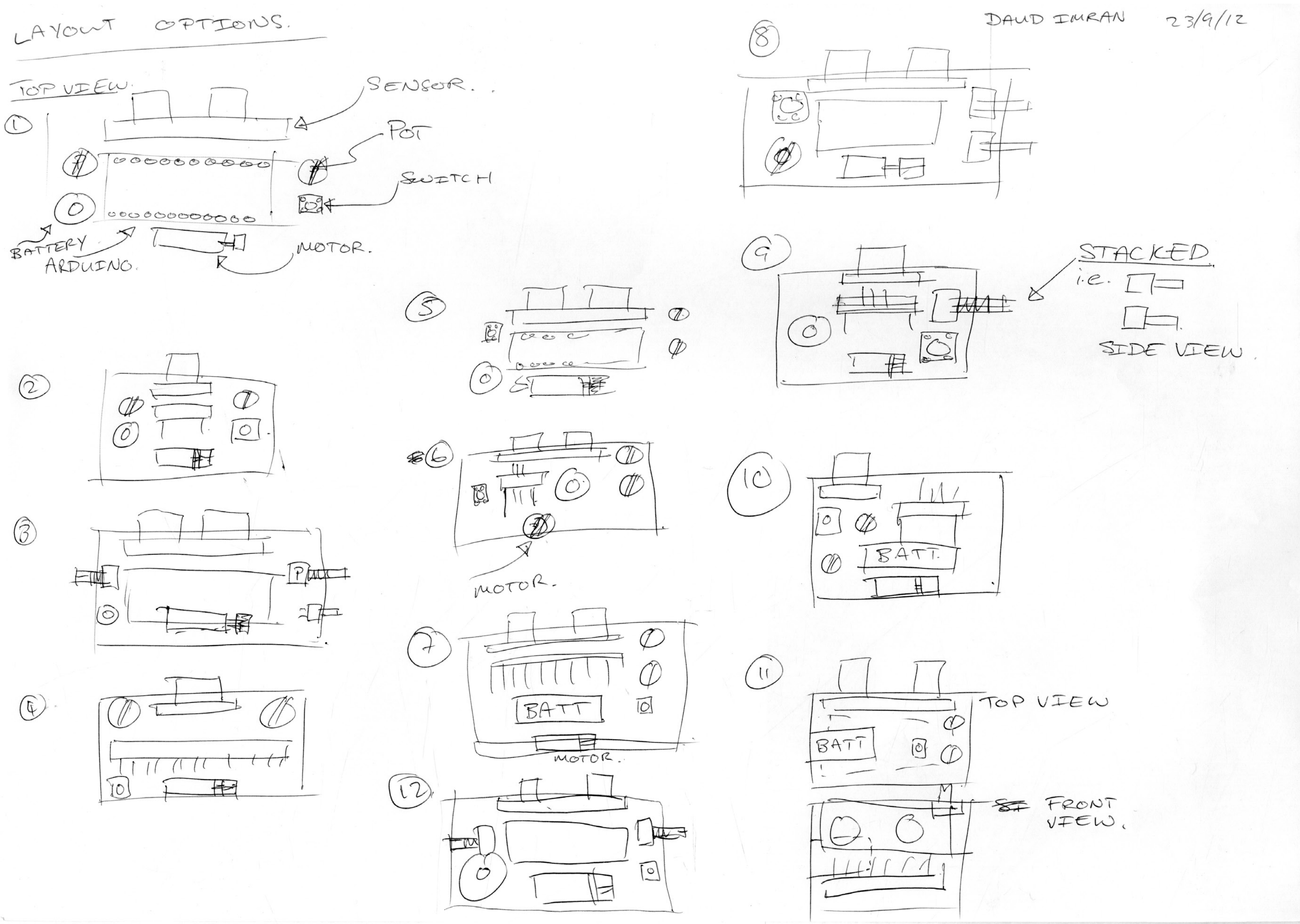
10. IMAGE LIST

11. APPENDIX

1. Sketch pages
2. Interview Package: Consent form, Plain Language Statement, Abstract
3. Interview Questions: Low Vision User/Low Vision Support Professionals)
4. Semester 01 Time line Projection
5. Code variations
6. Instructables PDF

11.1 Sketch Pages




LAYOUT OPTIONS.
DAUD IMRAN 23/9/12
TOP VIEW.
SENSOR.
POT
SWITCH
BATTERY
ARDUINO.
MOTOR.
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i.e.
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MOTOR.
BATT
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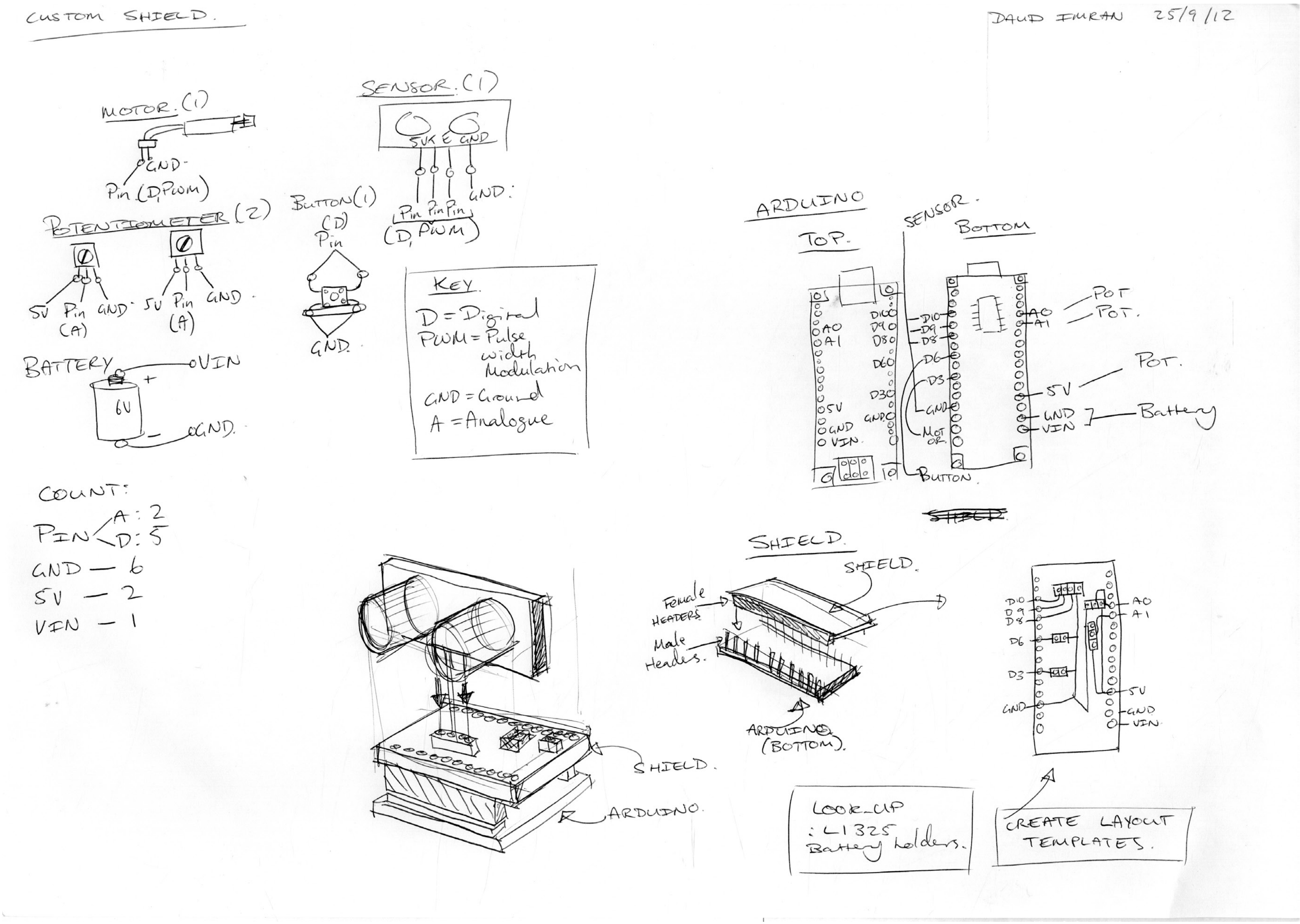
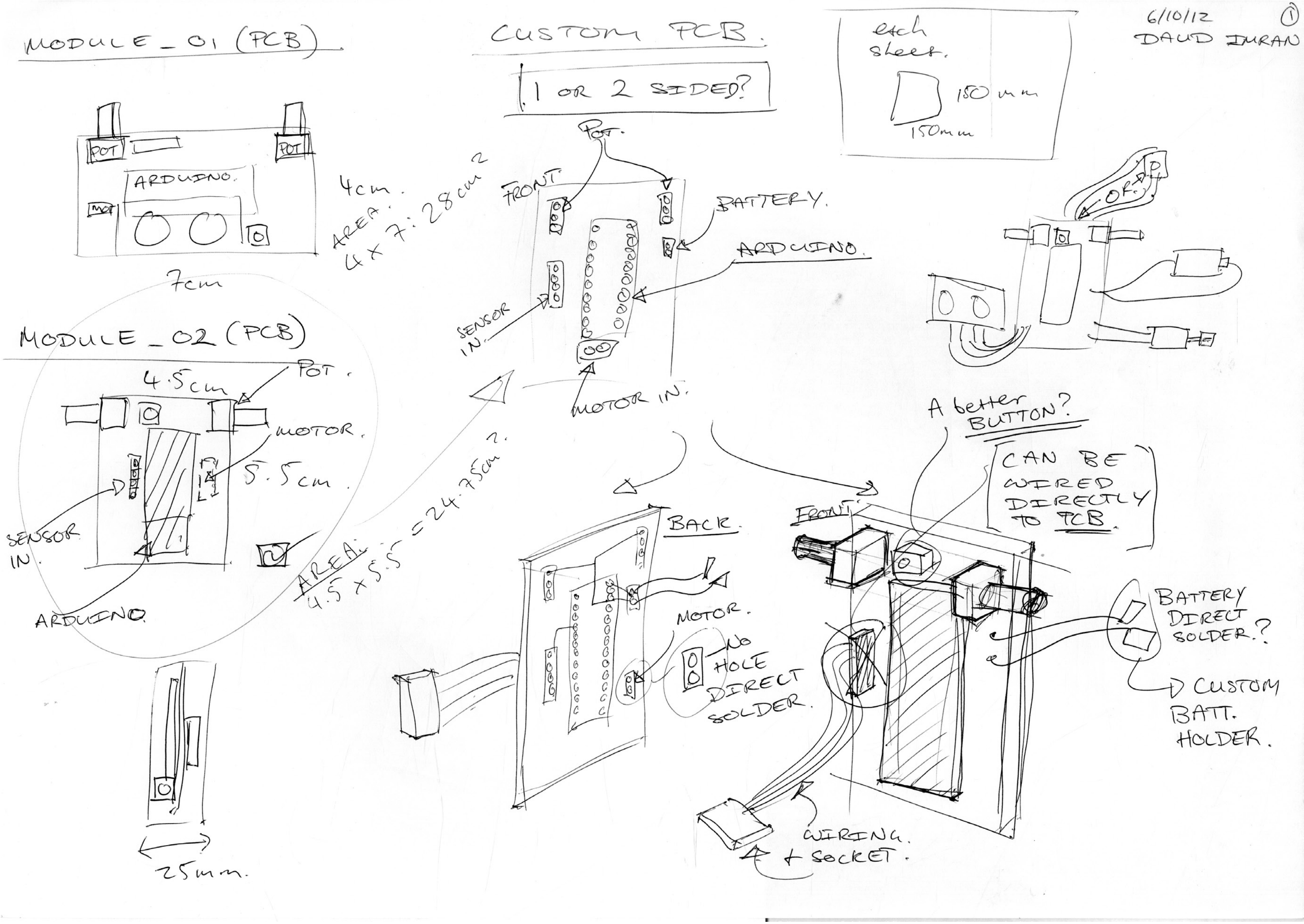
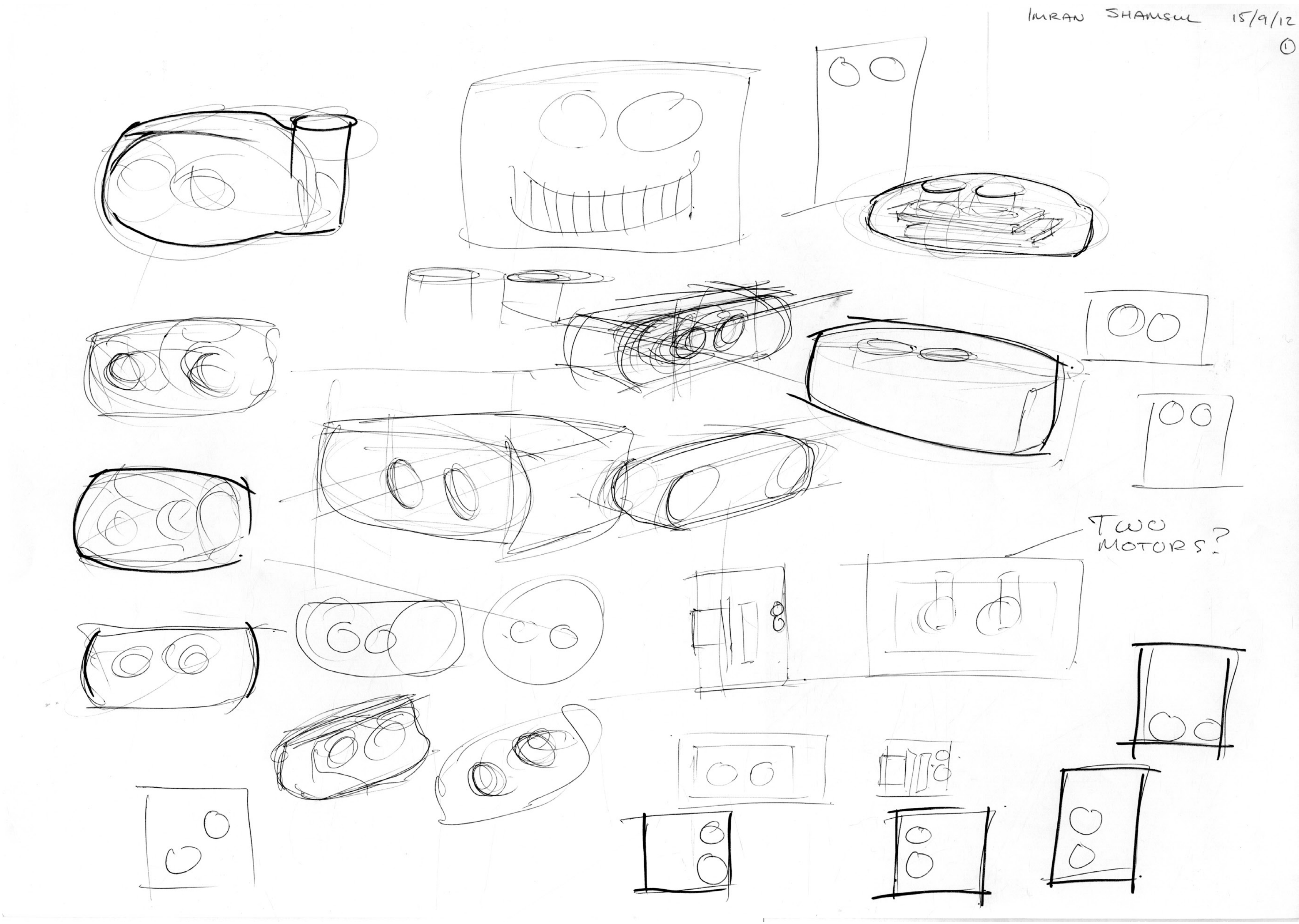
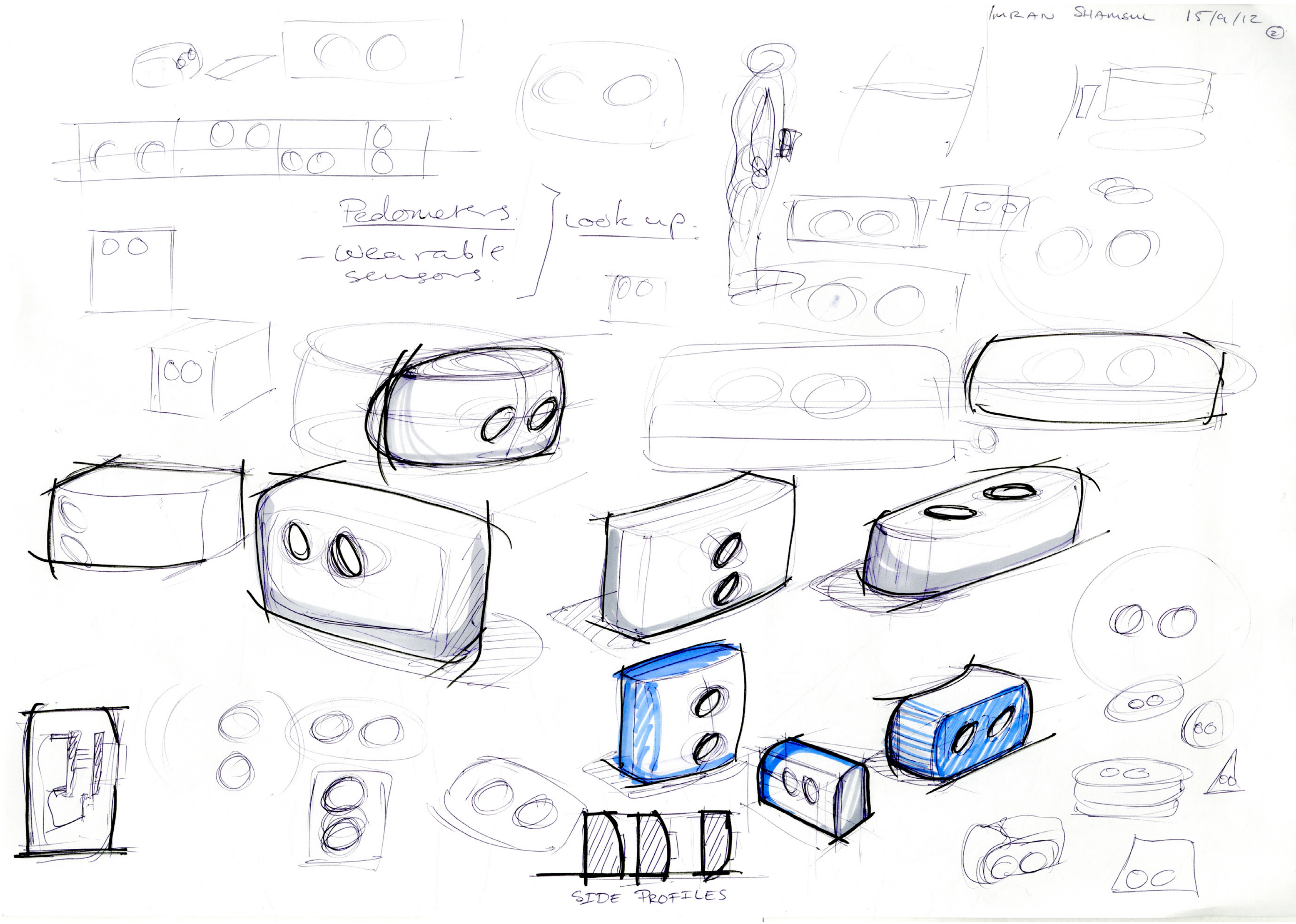
TOP VIEW
FRONT VIEW.


CUSTOM SHIELD.
DAUD IMRAN 25/9/12
MOTOR (1)
GND
Pin (D, PWM)
SENSOR (1)
5V
GND
Pin Pin Pin
(D, PWM)
BUTTON (1)
(D)
Pin
GND.
POTENTIOMETER (2)
5V Pin GND
(A)
BATTERY
VIN
6V
GND.
KEY
D = Digital
PWM = Pulse width Modulation
GND = Ground
A = Analogue
ARDUINO
TOP.
SENSOR.
BOTTOM
POT
Battery
BUTTON.
COUNT:
PIN A: 2
D: 5
GND — 6
5V — 2
VIN — 1
SHIELD.
Female HEADERS
Male Headers.
ARDUINO (BOTTOM).
ARDUINO.
LOOK-UP : L1325 Battery holders.
CREATE LAYOUT TEMPLATES.

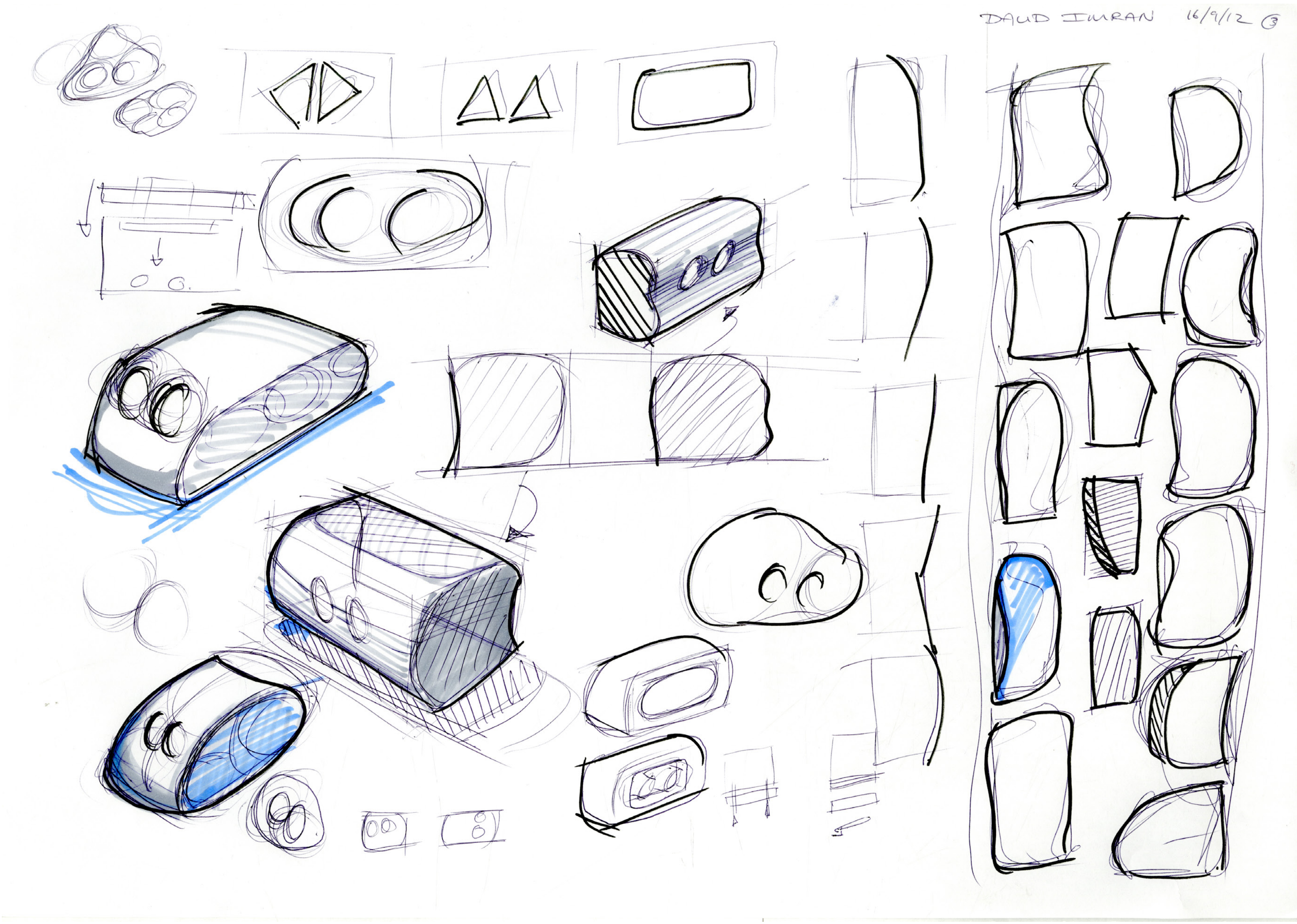

MODULE_01 (PCB)
POT
POT
ARDUINO.
MOT
4cm.
AREA.
4 x 7 : 28 cm²
7cm
MODULE_02 (PCB)
4.5cm
POT.
MOTOR.
5.5cm.
SENSOR IN.
ARDUINO.
AREA.
4.5 x 5.5 = 24.75cm²?
25mm.
CUSTOM PCB.
1 OR 2 SIDED?
POT.
FRONT
BATTERY.
ARDUINO.
SENSOR IN.
MOTOR IN.
each sheet.
150mm
150mm
6/10/12
DAUD IMRAN
OR
BACK.
MOTOR.
NO HOLE DIRECT SOLDER.
FRONT.
A better BUTTON?
CAN BE WIRED DIRECTLY TO PCB.
BATTERY DIRECT SOLDER?
CUSTOM BATT. HOLDER.
WIRING + SOCKET.

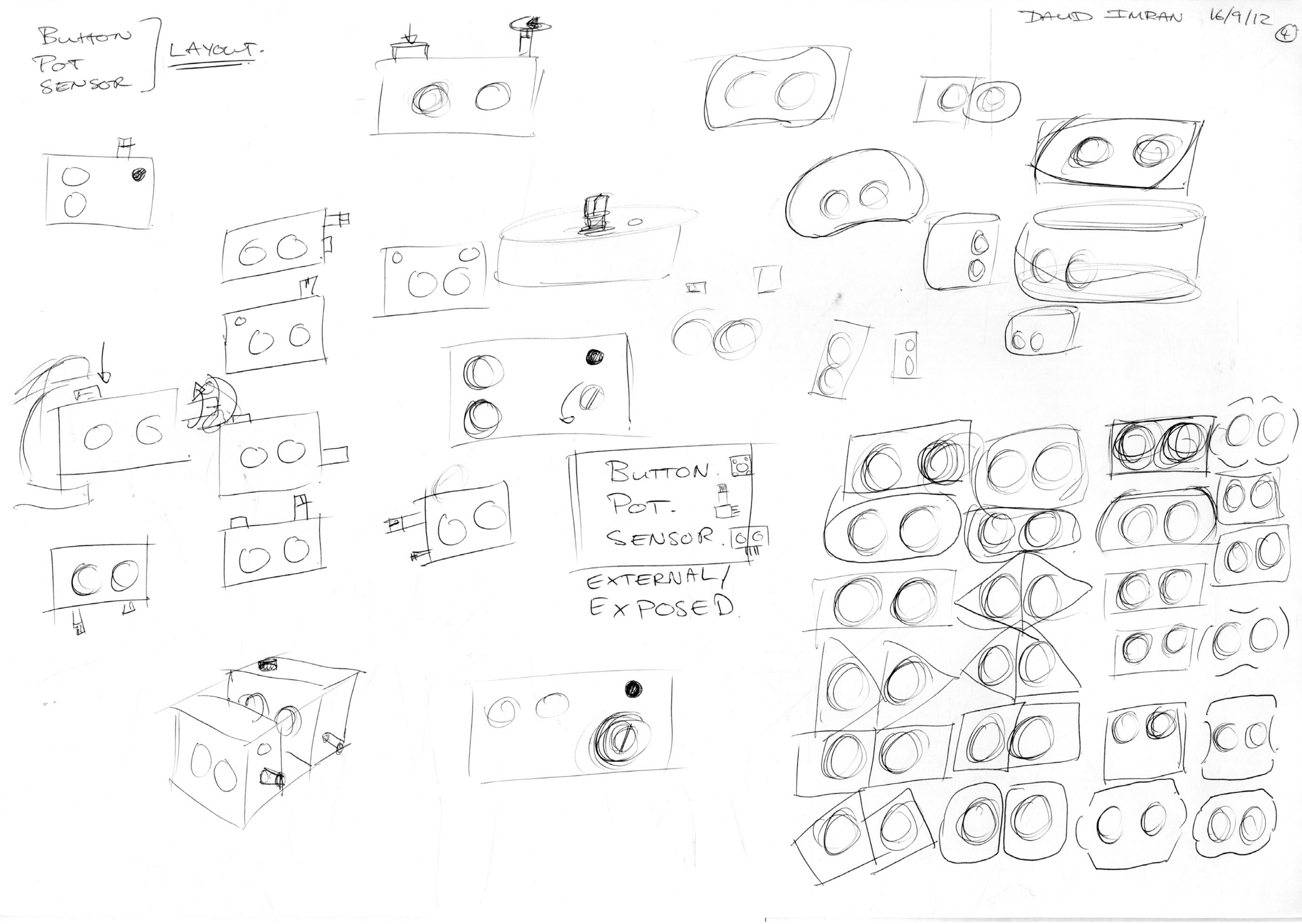
HAPTIC PROXIMITY MODULE



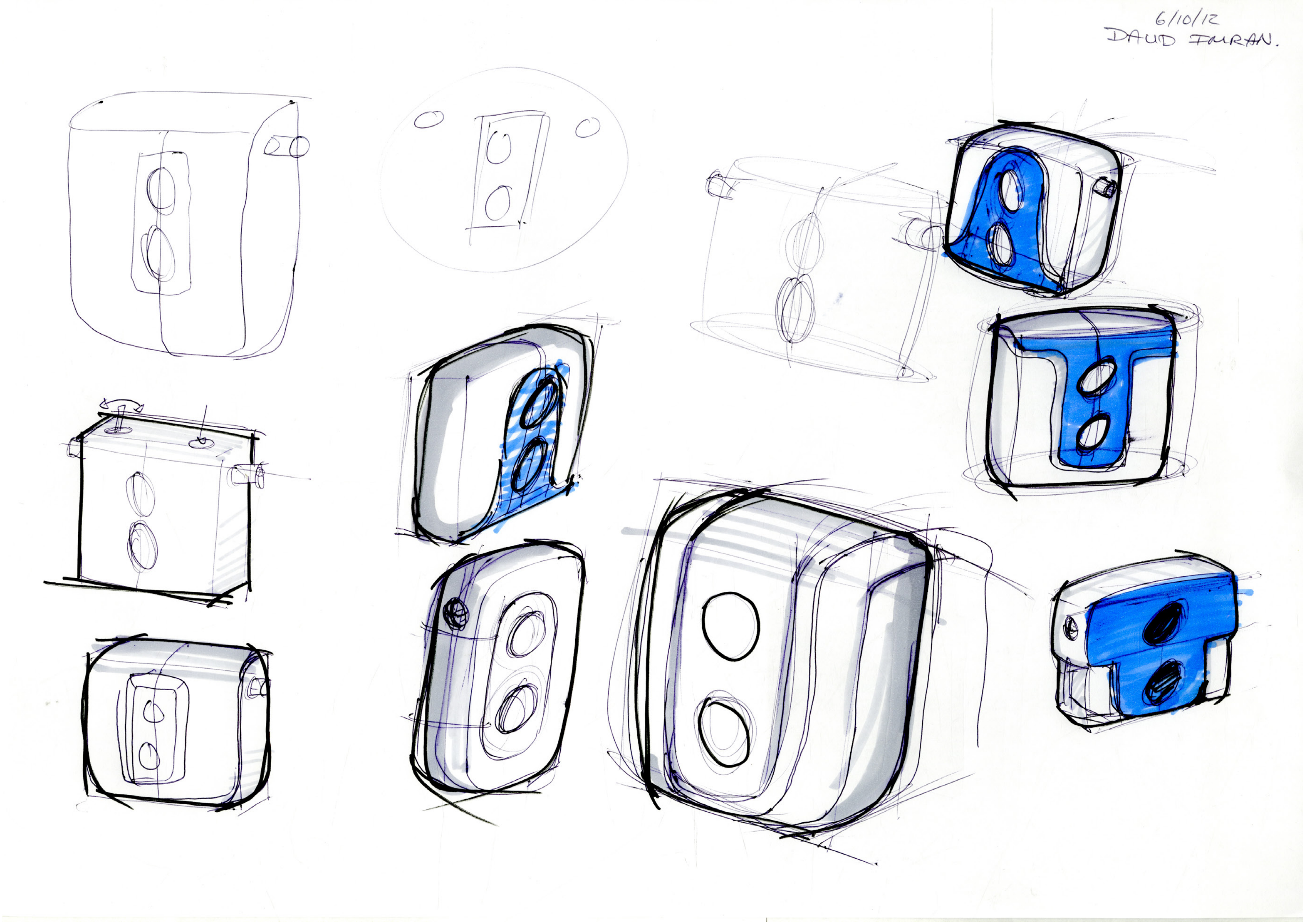

IMRAN SHAMSUL 15/9/12
Pedometers.
– Wearable sensors.
Look up.
SIDE PROFILES

HAPTIC PROXIMITY MODULE




BUTTON
POT
SENSOR
LAYOUT.
DAVID IMRAN 16/9/12
4
BUTTON.
POT.
SENSOR.
EXTERNAL/
EXPOSED.

HAPTIC PROXIMITY MODULE



Button Flow Chart. /Mapping

Imran Shamsul 9/9/12 (1)

ONE × (Button)
ONE × (Potentiometer)

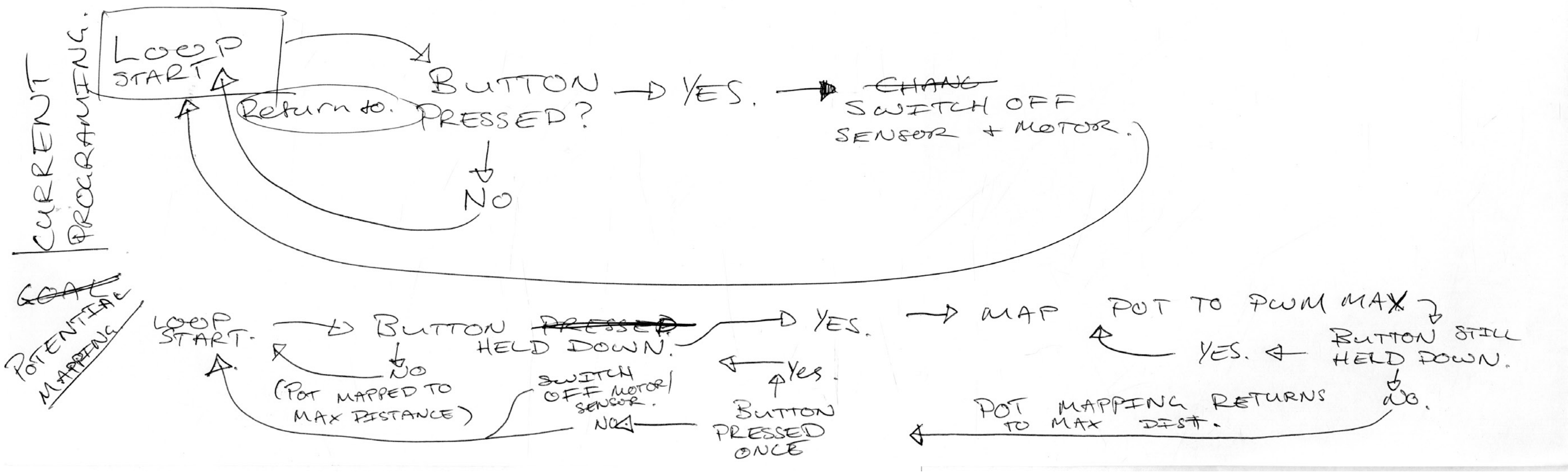
* Do I need an ON/OFF switch for battery?
* How will the unit be powered down?

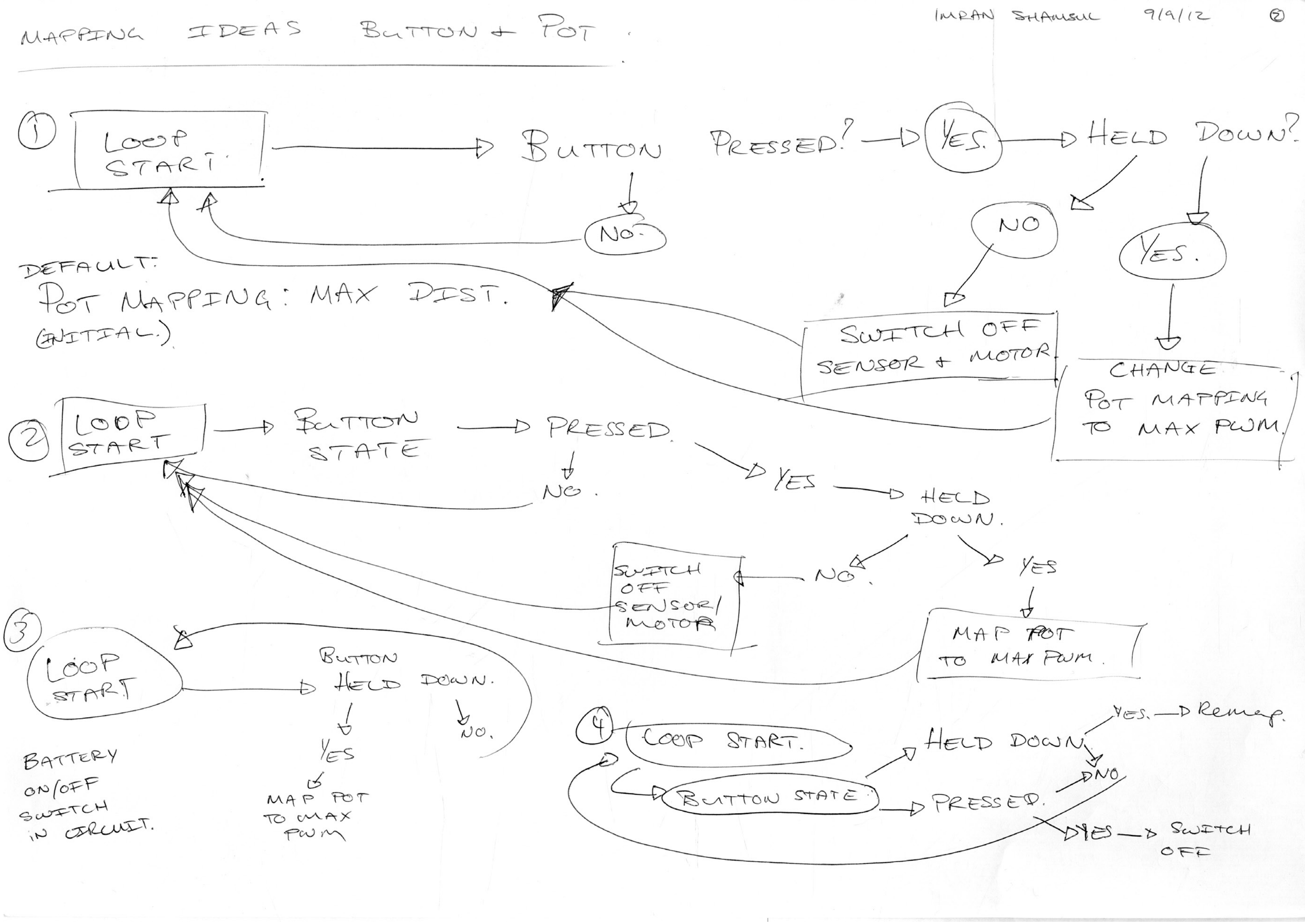
Mapping.

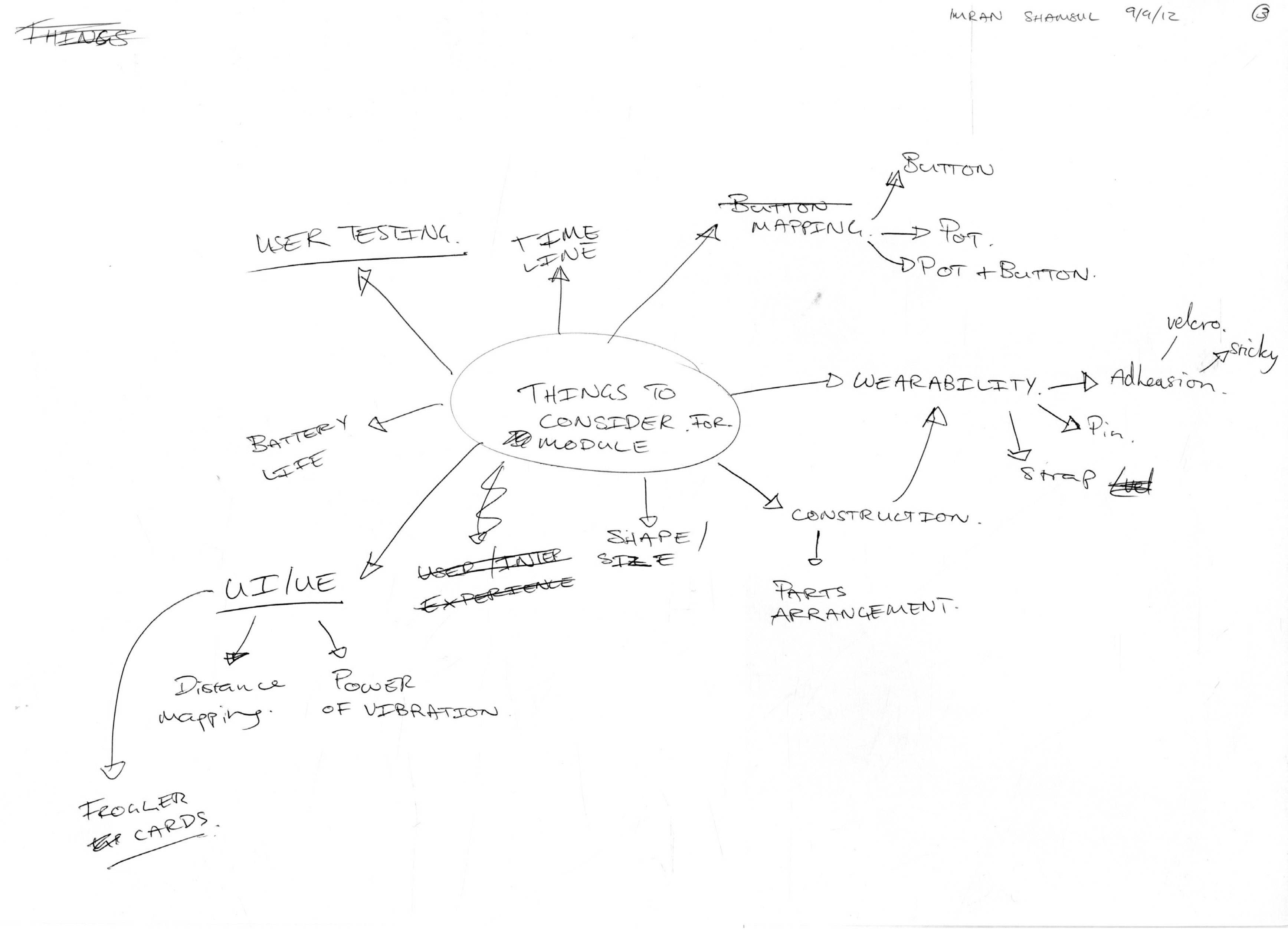
Pot — set ~~vibration intensity (PWM max)~~
→ distance/range max

Button — switch off/on sensor + motor by cutting/allowing power through.

Button + Pot. — set vibration intensity (PWM max).




IMRAN SHAMSUL 9/9/12 ②
MAPPING IDEAS BUTTON + POT
① LOOP START
BUTTON PRESSED?
YES.
NO.
HELD DOWN?
NO
YES.
SWITCH OFF SENSOR + MOTOR
CHANGE POT MAPPING TO MAX PWM
DEFAULT:
POT MAPPING: MAX DIST.
(INITIAL.)
② LOOP START
BUTTON STATE
PRESSED.
NO.
YES
HELD DOWN.
NO.
YES
SWITCH OFF SENSOR/ MOTOR
MAP POT TO MAX PWM.
③ LOOP START
BUTTON HELD DOWN.
YES
NO.
MAP POT TO MAX PWM
BATTERY ON/OFF SWITCH IN CIRCUIT.
④ LOOP START.
BUTTON STATE
HELD DOWN
Yes. Remap.
NO
PRESSED.
YES SWITCH OFF


IMRAN SHAMSUL 9/9/12
THINGS TO CONSIDER FOR MODULE
USER TESTING.
TIME LINE
BUTTON MAPPING.
BUTTON
POT.
POT + BUTTON.
WEARABILITY.
Adheasion.
velcro.
sticky
Pin.
Strap
CONSTRUCTION.
PARTS ARRANGEMENT.
SHAPE / SIZE
USER / INTER EXPERIENCE
UI/UE
Distance mapping.
POWER OF VIBRATION
FROGLER CARDS.
BATTERY LIFE

IMRAN SHAMSUL (04)
9/9/12

Time line.

Mon. 10 ~~OCT~~ SEPT.

(1) Book - FONTS/P.styles/Layout.
- confirm printers, details.
- Paper stock finalise.
Text + image.

7. Module - 3D print casing.
- CODE

~~THESIS~~
DVR - Re-Draft. Due (17/9)

MON 17 SEPT

(2) USER TESTING.

7 MODULE - 3D PRINT.
- CODE
- Development.

DVR - INDESIGN.
- WRITING.
- COMPILE IMAGES.
- confirm paper stock
- test images.

MON 24 SEPT

(3) MODULE - MODIFY + print 3D.
- USER TESTING.

7 DVR. - INDESIGN.
- WRITING.
- ORGANISE IMAGES.

MON 01 OCT

(4) MODULE - user testing.
DVR. - writing.

7

MON 8 OCT

(5) DVR - Finalise Draft.
- Editing.
- Buy paper stock.

7 Poster - begin poster design.
User feedback.

MON 15 OCT

(6) DVR - Printers - submit too.
- Binding.
- Buy

7 Poster printing.
OPEN SOURCE - WRITE INSTRUCTABLES

MON 22 OCT

(7) DVR. - loose ends
- pick up printing.

7 POSTER. - loose ends.
- print.

Final Presentation - prep.
finalise.

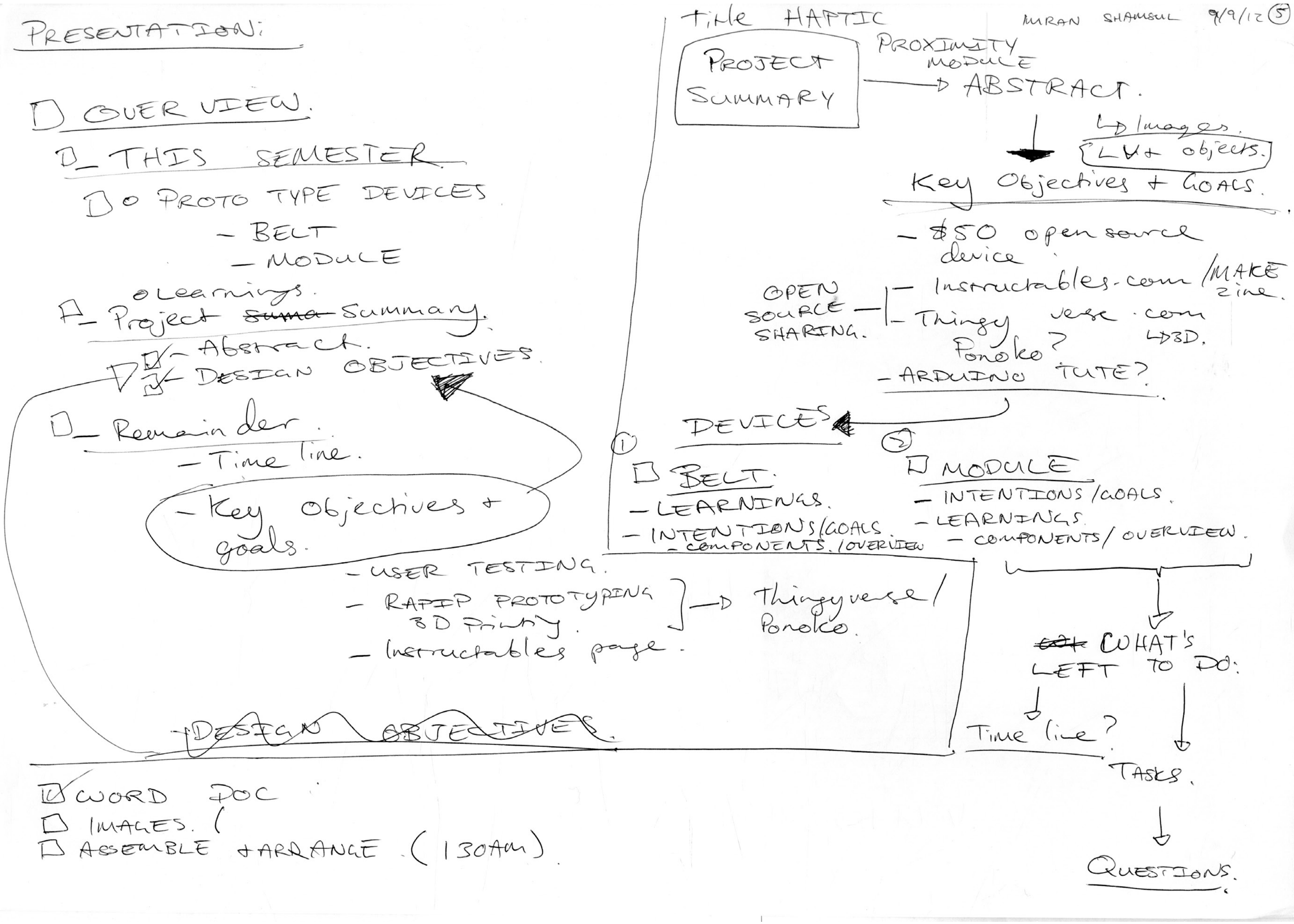
MON 29 OCT.

3 Exhibition prep. → THURS 01 NOV.
Finalize loose ends.

MON 5 NOV.

WED. 7.
THURS. 8

- Practice presentation.
- Finalise/loose ends.


PRESENTATION:
OVER VIEW.
THIS SEMESTER
PROTO TYPE DEVICES
– BELT
– MODULE
Learnings.
Project Summary.
– Abstract.
– DESIGN OBJECTIVES.
Remainder.
– Time line.
– Key objectives + goals.
– USER TESTING.
– RAPID PROTOTYPING 3D Printing.
– Instructables page.
Thingyverse/ Ponoko.
DESIGN OBJECTIVES.
WORD DOC
IMAGES.
ASSEMBLE + ARRANGE (1 30AM)
Title HAPTIC
IMRAN SHAMSUL 9/9/12
PROJECT SUMMARY
PROXIMITY MODULE
ABSTRACT.
images.
objects.
Key Objectives + GOALS.
– $50 open source device
OPEN SOURCE SHARING.
– Instructables.com /MAKE zine.
– Thingy verse.com
3D.
Ponoko?
– ARDUINO TUTE?
DEVICES
1
BELT.
– LEARNINGS.
– INTENTIONS/GOALS
– COMPONENTS./OVERVIEW
2
MODULE
– INTENTIONS/GOALS.
– LEARNINGS.
– COMPONENTS/ OVERVIEW.
WHAT'S LEFT TO DO:
Time line?
TASKS.
QUESTIONS.

11.2 Interview Package

INDEPENDENT LIVING AND AMD: Multimodality as a Tool for Independence

Abstract:

The purpose of this research is to establish better understanding of how people with Age-related Macular Degeneration (AMD) maintain independence, and how multimodality is able to create an outcome that can continue independence while providing a positive user experience.

AMD causes severe vision impairment in older people, occurring when central vision deteriorates. Thus making reading, close work and recognising faces more difficult (Australia, 2012). There are technologies present to help; it is shown that multimodal feedback is highly effective in reducing the time taken to complete simple computer functions (Jacko et al., 2004). While magnification tools are useful, they are generally cumbersome and ineffective when dealing with printed text on home appliances (Riazi, Boon, Dain, Bridge, & Riazi, 2010), there exists non-CCTV video magnifiers, which can improve the reading speed, comprehension and comfort for a low-vision user while positively increasing the user's experience when examined by Jordan's pleasurability framework (Harrison, 2004).

The question arises; how can multimodal technology be used to continue supporting independence for people living with AMD while providing a positive user experience?

As there is a need to establish a first-hand understanding of what people with AMD do to maintain their level of independence, adopting an ethnographic research method will help to engage the research questions, specifically through face-to-face interviews, and provide a good method to observe, in context, the use of any object or system that is designed and developed around multimodality.

Significance can be found through the evaluation of an individual's independence, available support technology, and examining all outputs with the outcome of independent living in mind.

Keywords: Age-related Macular Degeneration (AMD), Multimodality, Independent Living, Positive User Experience, Ethnography

Bibliography:

Australia, V. (2012, 25 AUG 2010). Age-Related Macular Degeneration Fact Sheet - Resources - Vision Australia Website Retrieved 18 MARCH, 2012, from http://www.visionaustralia.org.au/info.aspx?page=605

Harrison, C. M. (2004). Low-vision reading aids: reading as a pleasurable experience. *Personal Ubiquitous Comput., 8*(3-4), 213-220. doi: 10.1007/s00779-004-0280-0

Jacko, J. A., Barnard, L., Kongnakorn, T., Moloney, K. P., Edwards, P. J., Emery, V. K., & Sainfort, F. (2004). *Isolating the effects of visual impairment: exploring the effect of AMD on the utility of multimodal feedback*. Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems, Vienna, Austria.

Riazi, A., Boon, M. Y., Dain, S. J., Bridge, C., & Riazi, A. (2010). *Difficulties in reading small print materials on today's home appliances for people with visual impairment*. Paper presented at the Proceedings of the 4th International Convention on Rehabilitation Engineering \& Assistive Technology, Shanghai, China.

Daud Imran SHAMSUL AMRI s3138033@student.rmit.edu.au

PLAIN LANGUAGE STATEMENT:

Mr. Daud Imran SHAMSUL AMRI (honours student)
Mobile. 0413036433
E-mail. S3138033@student.rmit.edu.au

RMIT UNIVERSITY

"Independent Living and AMD: Multimodality as a tool for independence"

Introduction

I am a current Industrial Design honours student and I would like to invite you to participate in my research project. The aim of the study is to interrogate how people with Age-related Macular Degeneration (AMD) continue living independently and where multi-sensory information can be used to help so to create positive user experiences. This project has been approved by Mr. Frank Feltham (supervisor), Pre Major & Major Project Coordinator, Industrial Design Program at RMIT University.

What will I be asked to do?

Should you agree to participate, you would be asked to contribute in a face-to-face interview to further understand how people with AMD live independently and how the role of multi-sensory information assists in this and how it may provide positive user experiences. With your permission, the interview would be audio-recorded so that I can ensure that I make an accurate record of what you say. When the audio recording has been transcribed, you would be provided with a copy of the transcript, so that you can verify that the information is correct and/or request deletions. I estimate that the total time commitment required of you would not exceed 60 minutes.

How will my confidentiality be protected?

Your responses will be kept confidential in a storage device that will be kept in a locked cabinet. The data will be kept for 1 year before being destroyed. If any information from the research is published examples will be codified and you will be referred to by a pseudonym.

Will participation prejudice me in any way?

Please be advised that your participation in this study is completely voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

Where can I get further information?

Should you require any further information, or have any concerns, please do not hesitate to contact me on the number given above. Should you have any concerns about the conduct of the project, you are welcome to contact Mr. Frank Feltham (supervisor), Industrial Design Program, RMIT University, Melbourne, on PH: 03 9925 5388, or E-Mail: frank.feltham@rmit.edu.au.

How do I agree to participate?

If you would like to participate, please indicate that you have read and understood this information by signing the accompanying consent form and returning it in the envelope provided or in person at the time of the interview. If mailed, the researcher will then contact you to arrange a mutually convenient time for you to complete the interview.

RMIT UNIVERSITY

INDUSTRIAL DESIGN PROGRAM

Consent form for persons participating in a research project

"INDEPENDENT LIVING AND AMD: Multimodality as a Tool for Independence"

Name of participant: ____________________

Name of investigator(s): **DAUD IMRAN SHAMSUL AMRI**

1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.
2. I understand that after I sign and return this consent form it will be retained by the researcher.
3. I understand that my participation will involve an ***interview*** and I agree that the researcher may use the results as described in the plain language statement.
4. I acknowledge that:

   (a) the possible effects of participating in the ***interview*** have been explained to my satisfaction;

   (b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;

   (c) the project is for the purpose of research;

   (d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;

   (e) I have been informed that with my consent the ***interview will be audio-recorded and I understand that audio-records*** will be stored at RMIT University and will be destroyed after one year;

   (f) my name will be referred to by a pseudonym in any publications arising from the research;

   (g) I have been informed that a copy of the research findings will be forwarded to me, should I agree to this.

I consent to this ***interview*** being audio-recorded — □ **yes** □ **no** (please tick)

I wish to receive a copy of the summary project report on research findings — □ **yes** □ **no** (please tick)

Participant signature: ____________________ Date: ____________________

11.3 Interview Questions

INTERVIEW QUESTIONS: LOW VISION USER

Q) Can you please tell me your age?

Q) Who is living in the household?

Q) Any regular visitors or council workers?

Q) Have you made any visits to Vision Australia, Seminars or Groups relating to vision?

1. Can you recall when you noticed a change in your vision?

2. Are you currently seeking or considering any treatment for this?

3. How do you feel this impacted on your independence?

4. Do you have a paid occupation and/or do you do volunteer work?

5. Are you involved with any groups, collectives or Societies?

    5.1. [yes] can you tell me about your contributions to these groups?

6. Now without evaluating if the activity is positive or negative, could you please describe an activity that you do for leisure?

    6.1. What are the aids for this activity, for instance an object or device?

    6.2. Can you describe to me how it works?

    6.3. Is the device easy to use or does it cause you frustration?

    6.4. What do you feel can be improved about it?

    6.5. What are the positives/negatives about this activity?

7. As before, without evaluating if the activity is positive or negative, could you please describe an activity that is functional, such as around the home?

    7.1. What are the aids for this activity, for instance an object or device?

    7.2. Can you describe to me how it works?

    7.3. Is the device easy to use or does it cause you frustration?

    7.4. What do you feel can be improved about it?

    7.5. What are the positives/negatives about this activity?

8. Are there any other specific things in regards to leisure or functional activities that are important for you to do?

I'm going to ask some questions about tasks and activities in general:

9. Overall what is a task that is easy for you to do?

10. Are there tasks where you need assistance, what are they?

11. Can you give me an example of what tasks have caused you the most problems?

11.1. How did you develop a system to complete these tasks?

These questions are more about your independence:

12. Have you made changes within your home to assist you with living independently?

13. When your vision changed did you set out to continue achieving any particular goals relating to leisure or function?

13.1. Is that really important to you?

14. How have you gone with achieving those goals?

15. Are you experiencing anything else which impacts on your independence?

[Yes, continue]

15.1. How do you feel about this?

15.2 Have you taken any measures to help improve it?

INTERVIEW QUESTIONS: LOW VISION PROFESSIONALS

Introduction:

Before we being, for the purpose of cataloguing the recording, may I kindly ask that you please state your name, or other preferred names?

[Response...]

Thank you.

I just want to inform you that if at any point you don't feel comfortable answering any questions, please just say so and we can move on.

Questions... [Refer to question sheet]

[End:]

That is all the information and opinion that I wish to gather from you today for the project.

I am very grateful that you've been generous with your time and provided answers to these questions, Thank You!

General:

1. Can you please describe your role within Vision Australia?

1.1. How long have you worked in this role?

1.2. Have you had any other roles within the organisation prior to this?

1.3. Do you mainly work with people living with Macular Degeneration (MD)?

More about the people with Age-related Macular Degeneration (AMD):

2. How much time do you spend developing and implement a system to maintain independence?

3. Can you explain your process/method of how you deliver assistance?

4. What is the learning curve like for these people?

5. What has surprised you about the people you have assisted?

Independence:

6. What levels of independence are people at when they seek and receive your professional assistance?

7. Do you see an improvement in their level of independence during/after your assistance?

8. What goals relating to independence do you help them establish, or they approach you with?

8.1. Are these goals achieved?

8.2. How long does it take for this to happen?

Group support:

9. Are there groups or sessions for people with AMD to come together and meet?

10. If no, do you think they would benefit from group support?

10.1. If yes, do you encourage the people you assist to take part in groups?

10.2. How do they engage with the group?

10.3. How important do you think the group structure is to their overall independence and wellbeing?

Completing Tasks for people with AMD:

11. From your observation, are there improvements in their completion of day-to-day and leisure tasks?

11.1. Could you expand on what tasks are involved?

11.2. Do you find that people begin to use their other senses to help?

12. How strongly do the other senses contribute to supporting their independence?

13. In your observation, what is the most common task people need assistance with?

13.1. What assisting technology/product do you suggest they use?

14. Have the people with MD expressed a want or need for a system/product/technology, that is yet to exist or be available, that can help them with the tasks they're struggling with?

15. From what you have observed, how do people manage the implementation of assisting technologies or products?

16. What role do you think consumer technology such as computers or tablets/iPads have in helping people with MD maintain independence?

17. How important are human beings, animals for support in comparison to objects/devices?

18. Do you think people with MD should work with companies that manufacture support products so to help make products that are more suitable to their needs?

17.1. Are you aware of any companies which already do this?

19. In your experience, have all these technologies and products been positive in maintaining a good level of independence?

20. Do you have any final thoughts or observations regarding AMD and Independence?

11.4 Semester 01: Time-line Projection

			Task										
	Wk. No.	Week (Mon - Sun)	Interview Preps	Interviews	DVR	A0 Poster	Transcribing Interviews	Returning Transcriptions	Editting Transcription	Review Data	Research Journal	Design Phase	Wrap Up
0	12	~~21/5 – 27/5~~											
0	13	~~28/5 – 3/6~~											
1	14	~~4/6 – 10/6~~											
2	15	11/6 – 17/6											
3	16	18/6 – 24/6											
4	17	25/6 – 1/7											
5	18	2/7 – 8/7											
6	19	9/7 – 15/7										Review 01	
7	1	16/7 – 22/7											
8	2	23/7 – 29/7										Review 02	
9	3	30/7 – 5/8											
10	4	6/8 – 12/8										Review 03	
11	5	13/8 – 19/8											
12	6	20/8 – 26/8										Review 04	
13	7	27/8 – 2/9											
14	8	3/9 – 9/9										Review 05	
15	9	10/9 – 16/9											
16	10	17/9 – 23/9										Review 06	
17	11	24/9 – 30/9											
18	12	1/10 – 7/10										Review 07	
19	13	8/10 – 14/10											
20	14	15/10 – 21/10										Review 08	
21	15	22/10 – 28/10											
22	16	29/10 – 4/11											
23	17	5/11 – 11/11											
24	18	12/11 – 18/11											
25	19	19/11 25/11											
26	20	26/11 – 2/12											

11.5 Code Variations

_120724_pingtut_07.ino

```
// these arrays are looped through, make sure your pin and motor match.
// so mypin[1] should corrispond to mymotor[1] and so on
int myPins[] = {2};
int myMotors[] = {13};
int howmany = 1;

void setup() {
  // initialize serial communication:
  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimetres:
  long duration, cm;


// loop through the pins array, noting theat we've set the limit to 5
int i; // define "i" this is used as a count variable
// start a count loop, since you know how many sensors there are, hard code this in the i < NUMBER OF SENSORS bit
for (i = 0; i < howmany; i = i + 1) {
  // print out what pin
  //  Serial.println(myPins[i]);

  // The PING))) is triggered by a HIGH pulse of 2 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  // check the pin pMyPin[i]
  pinMode(myPins[i], OUTPUT);
  digitalWrite(myPins[i], LOW);
  delayMicroseconds(2);
  digitalWrite(myPins[i], HIGH);
  delayMicroseconds(5);
  digitalWrite(myPins[i], LOW);

  // The same pin is used to read the signal from the PING))): a HIGH
  // pulse whose duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(myPins[i], INPUT);
  duration = pulseIn(myPins[i], HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

//  Serial.print(inches);
//  Serial.print("in, ");
// inches are for americans, they silly.
  Serial.print(myPins[i]);
  Serial.print("-");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

//  if(cm < 100){
    analogWrite(myMotors[i],returnfeedback(cm));
//    delay(returndelay(cm));
//    analogWrite(myMotors[i], 0);
//  } else {
//   analogWrite(myMotors[i], 0);
//  }
} // end of the pin loop

  delay(200);
}

// change to formul
int returnfeedback(int cm){
  int motorPWM = map(cm,200,0,0,255); //variable map formula relationship
  motorPWM = constrain(motorPWM, 0, 255);
//  if (cm < 5){ // distance
//     return 255; // strength
//  } else if (cm < 10){
//     return 220;
//  } else if (cm < 20){
//     return 190;
//  } else if (cm < 40){
//     return 160;
//  } else if (cm < 80){
//     return 130;
//  } else if (cm < 100){
//     return 100;
//  } else {
//     return 0;
//  }
  Serial.print("motorPWM = ");
    Serial.println(motorPWM);

 return motorPWM; //serial print pwm


}


long microsecondsToCentimeters(long microseconds)
{
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}
```

_120813_in_class_01.ino

```
// these arrays are looped through, make sure your pinb and motor match.
// so mypin[1] should corrispond to mymotor[1] and so on
int myPins[] = {2,3,4,5};
int myMotors[] = {13,12,11,10};
int howmany = 4;
int maxDistance[] = {50,50,50,50};
int maxPower[] = {255,255,255,255};

void setup() {
  // initialize serial communication:
  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimetres:
  long duration, cm;


// loop through the pins array, noting theat we've set the limit to 5
int i; // define "i" this is used as a count variable
// start a count loop, since you know how many sensors there are, hard code this in
the i < NUMBER OF SENSORS bit
for (i = 0; i < howmany; i = i + 1) {
  // print out what pin
  //  Serial.println(myPins[i]);

  // The PING))) is triggered by a HIGH pulse of 2 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  // check the pin pMyPin[i]
  pinMode(myPins[i], OUTPUT);
  digitalWrite(myPins[i], LOW);
  delayMicroseconds(2);
  digitalWrite(myPins[i], HIGH);
  delayMicroseconds(5);
  digitalWrite(myPins[i], LOW);

  // The same pin is used to read the signal from the PING))): a HIGH
  // pulse whose duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(myPins[i], INPUT);
  duration = pulseIn(myPins[i], HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

//  Serial.print(inches);
//  Serial.print("in, ");
// inches are for americans, they silly.
  Serial.print(myPins[i]);
  Serial.print("-");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

//  if(cm < 100){
    int motorPWM = map(cm,maxDistance[i],0,0,maxPower[i]); //variable map formula
relationship
  motorPWM = constrain(motorPWM, 0, 255);

    analogWrite(myMotors[i],motorPWM);

    Serial.print("motorPWM = ");
    Serial.println(motorPWM);

    delay(200);
}

//    delay(returndelay(cm));
//    analogWrite(myMotors[i], 0);
//  } else {
//   analogWrite(myMotors[i], 0);
//  }
 // end of the pin loop

//  delay(200);  uncomment if needed
}

/*
// change to formul
int returnfeedback(int cm){
```

```
  int motorPWM = map(cm,maxDistance[],0,0,maxPower[]); //variable map formula relationship
  motorPWM = constrain(motorPWM, 0, 255);
//  if (cm < 5){ // distance
//     return 255; // strength
//  } else if (cm < 10){
//     return 220;
//  } else if (cm < 20){
//     return 190;
//  } else if (cm < 40){
//     return 160;
//  } else if (cm < 80){
//     return 130;
//  } else if (cm < 100){
//     return 100;
//  } else {
//     return 0;
//  }
  Serial.print("motorPWM = ");
    Serial.println(motorPWM);

 return motorPWM; //serial print pwm


}
*/

long microsecondsToCentimeters(long microseconds)
{
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}
```

```
_120724_pingtut+07.ino// these arrays are looped
through, make sure your

pinb and motor match.
// so mypin[1] should corrispond to mymotor[1] and
so on
int myPins[] = {2};
int myMotors[] = {13};
int howmany = 1;

void setup() {
  // initialize serial communication:
  Serial.begin(9600); // this just means you can output
to the serial panel
}

void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimetres:
  long duration, cm;


// loop through the pins array, noting theat we've set
the limit to 5
int i; // define "i" this is used as a count variable
// start a count loop, since you know how many
sensors there are, hard code this in the i < NUMBER OF
SENSORS bit
for (i = 0; i < howmany; i = i + 1) {
  // print out what pin
  //  Serial.println(myPins[i]);

  // The PING))) is triggered by a HIGH pulse of 2 or
more microseconds.
  // Give a short LOW pulse beforehand to ensure a
clean HIGH pulse:
  // check the pin pMyPin[i]
  pinMode(myPins[i], OUTPUT);
  digitalWrite(myPins[i], LOW);
  delayMicroseconds(2);
  digitalWrite(myPins[i], HIGH);
  delayMicroseconds(5);
  digitalWrite(myPins[i], LOW);

  // The same pin is used to read the signal from the
PING))): a HIGH
  // pulse whose duration is the time (in microseconds)
from the sending
  // of the ping to the reception of its echo off of an
object.
  pinMode(myPins[i], INPUT);
  duration = pulseIn(myPins[i], HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

//  Serial.print(inches);
//  Serial.print("in, ");
// inches are for americans, they silly.
  Serial.print(myPins[i]);
  Serial.print("-");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

//  if(cm < 100){
    analogWrite(myMotors[i],returnfeedback(cm));
//    delay(returndelay(cm));
//    analogWrite(myMotors[i], 0);
//  } else {
//   analogWrite(myMotors[i], 0);
//  }
} // end of the pin loop

  delay(200);
}

// change to formul
int returnfeedback(int cm){
  int motorPWM = map(cm,200,0,0,255); //variable map
formula relationship
  motorPWM = constrain(motorPWM, 0, 255);
//  if (cm < 5){ // distance
//     return 255; // strength
//  } else if (cm < 10){
//     return 220;
//  } else if (cm < 20){
//     return 190;
//  } else if (cm < 40){
//     return 160;
//  } else if (cm < 80){
//     return 130;
//  } else if (cm < 100){
//     return 100;
//  } else {
//     return 0;
//  }
  Serial.print("motorPWM = ");
    Serial.println(motorPWM);

 return motorPWM; //serial print pwm


}


long microsecondsToCentimeters(long microseconds)
{
  // The speed of sound is 340 m/s or 29 microseconds
per centimeter.
  // The ping travels out and back, so to find the
distance of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}
```

ANDERS_120730_01.ino

```
//Written by Anders from Anders.com.au

// these arrays are looped through, make sure your
pinb and motor match.
// so mypin[1] should corrispond to mymotor[1] and so
on
int myPins[] = {6}; // map the pins for the Ping Sensors
int myMotors[] = {9}; //map the pins for the Vibration
motors
int howmany = 1;  //number of sensors and motors

void setup() {
  // initialize serial communication:
  Serial.begin(9600); // this just means you can output to
the serial panel
}

void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimetres:
  long duration, cm;


// loop through the pins array, noting theat we've set
the limit to 5
int i; // define "i" this is used as a count variable
// start a count loop, since you know how many
sensors there are, hard code this in the i < NUMBER OF
SENSORS bit
for (i = 0; i < howmany; i = i + 1) {
  // print out what pin
  //  Serial.println(myPins[i]);

  // The PING))) is triggered by a HIGH pulse of 2 or
more microseconds.
  // Give a short LOW pulse beforehand to ensure a
clean HIGH pulse:
  // check the pin pMyPin[i]
  pinMode(myPins[i], OUTPUT);
  digitalWrite(myPins[i], LOW);
  delayMicroseconds(2);
  digitalWrite(myPins[i], HIGH);
  delayMicroseconds(5);
  digitalWrite(myPins[i], LOW);

  // The same pin is used to read the signal from the
PING))): a HIGH
  // pulse whose duration is the time (in microseconds)
from the sending
  // of the ping to the reception of its echo off of an
object.
  pinMode(myPins[i], INPUT);
  duration = pulseIn(myPins[i], HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

//  Serial.print(inches);
//  Serial.print("in, ");
// inches are for americans, they silly.
  Serial.print(myPins[i]);
  Serial.print("-");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

  if(cm < 100){
    analogWrite(myMotors[i],returnfeedback(cm));
//    delay(returndelay(cm));
//    analogWrite(myMotors[i], 0);
  } else {
   analogWrite(myMotors[i], 0);
  }
} // end of the pin loop

  delay(200);
}


int returnfeedback(int cm){
  if (cm < 5){ // distance
    return 255; // strength
  } else if (cm < 10){
    return 220;
  } else if (cm < 20){
    return 190;
  } else if (cm < 40){
    return 160;
  } else if (cm < 80){
    return 130;
  } else if (cm < 100){
    return 100;
  } else {
    return 0;
  }
}

long microsecondsToCentimeters(long microseconds)
{
  // The speed of sound is 340 m/s or 29 microseconds
per centimeter.
  // The ping travels out and back, so to find the distance
of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}
```

BELT_03_120828_01.ino

```
// H.A.L.O. Project
// Haptic Assisted Locating of Objects
// steve@polymythic.com
// www.polymythic.com
// Steve Struebing
// 12_2_2010 - Changing the motor scheme
// 12_10_2010 - Changed pulsein in ping library
// 12_10_2010_v6- using analogWrite() for intensity rather than digital out
// 12_10_2010_v7- modifying range algorithm

// *******************************************
// INCLUDES
//http://www.parallax.com/dl/docs/prod/acc/28015-PING-v1.3.pdf
//
#include <Ping2.h>  // Modified Parallax Ping Library

// *******************************************
// CALIBRATION VARIABLES
// INTERPULSE_LANTENCY (milliseconds) - Defines the period of time between when 
one ping
// fires and the next fires.  This should allow for the sound to travel to
// its furthest detectable echo distance so that the next sensors RX will not
// pick up splash from the previous ping's TX.  This may/will result in
// a lower than real distance result from the next sensor.
#define INTERPULSE_LATENCY_DURATION 25

// MOTOR_PULSE_DURATION (milliseconds) - Defines the duration that the motor will 
pulse
// This is a constant at the moment, and the MOTOR_VIBRATION_FACTOR will
// shorte between the pulses of the motor
#define MOTOR_PULSE_DURATION 250

// RESCHEDULE_THRESHOLD_CONSTANT - Note: This may be replaced by 
"debouncing?" the motor
// This is the threshold over which the distance is large enough to trigger a
// reschedule event.  If too small, there may be a lot of rescheduling, and if
// it is too large, then there may not be enough granularity.
//#define RESCHEDULE_THRESHOLD_CONSTANT 20.83

// MAXIMUM_DISTANCE_CONSTANT (inches) - This is is the range over which we will
// not schedule any events.  If the range is greater than this value, we will not even
// bother with it.
#define MAXIMUM_DISTANCE_CONSTANT 48

//#define INTENSITY_STEP 63

// MOTOR_DISTANCE_GAP_FACTOR (millis per inch) - 1000 milis / MAXIMUM_
DISTANCE_CONSTANT = milis per inch
// NOTE: This is an important constant.  If the value is too low, then
// the motors will constantly be firing and rescheduling the next start
// which may elapse before any motor stop happens.  This will result
// in always on motors.
// This was calculated at distance of 48 inches (1000 / 48)
// @todo- this should be derived from the MAXIMUM_DISTANCE_CONSTANT
//#define MOTOR_DISTANCE_GAP_FACTOR 20.83
#define MOTOR_DISTANCE_GAP_FACTOR 250

#define MAX_GAP ((MAXIMUM_DISTANCE_CONSTANT/12) * MOTOR_DISTANCE_GAP_
FACTOR)

// PING_MS_DELAY - THIS HAS BEEN MOVED INTO THE PING2 LIBRARY
// Note: This caused some debugging because the pulseIn() command used in the 
normal
// library defaults to 1 second.  This is way outside what we can handle.  According
// to the PING)) datasheet, the maximum time to wait (tIN_MAX) == 115us.  We will 
use
// 150 just for some buffer.
//#define PING_MS_DELAY 150

// *******************************************
// INPUT PINS
// - PING Input Sensors
#define INPUT_LEFT_SENSOR_PIN         3
#define INPUT_LEFT_CENTER_SENSOR_PIN  4
//#define INPUT_CENTER_SENSOR_PIN       5
#define INPUT_RIGHT_CENTER_SENSOR_PIN 5
#define INPUT_RIGHT_SENSOR_PIN        6

// Enumeration for sensor input array
enum sensor_input {
  left_sensor,
  left_center_sensor,
```

```
  center_sensor,
  right_center_sensor,
  right_sensor,
  max_sensor_index
};

// ****************************************
// OUTPUT PINS
// - MOTOR Output Pins (PWM)
#define OUTPUT_LEFT_MOTOR_PIN         13
#define OUTPUT_LEFT_CENTER_MOTOR_PIN  12
//#define OUTPUT_CENTER_MOTOR_PIN       10
#define OUTPUT_RIGHT_CENTER_MOTOR_PIN 11
#define OUTPUT_RIGHT_MOTOR_PIN        10
#define OUTPUT_DEBUG_PIN              8
/*
// - DEBUG Output Pin (LED)
#define OUTPUT_CENTER_MOTOR_PIN       13
*/
// Enumeration for motor output array
enum motor_output {
  left_motor,
  left_center_motor,
  center_motor,
  right_center_motor,
  right_motor,
  max_motor_index
};

// Create the array of input PING))) sensors
Ping2 inputSensorArray[max_sensor_index] = {INPUT_LEFT_SENSOR_PIN,
                              INPUT_LEFT_CENTER_SENSOR_PIN,
//                              INPUT_CENTER_SENSOR_PIN,
                              INPUT_RIGHT_CENTER_SENSOR_PIN,
                              INPUT_RIGHT_SENSOR_PIN};

// Create the array of output vibration motors based on pin constants selected
int outputMotorArrayPins[max_motor_index] = {OUTPUT_LEFT_MOTOR_PIN,
                              OUTPUT_LEFT_CENTER_MOTOR_PIN,
//                              OUTPUT_CENTER_MOTOR_PIN,
                              OUTPUT_RIGHT_CENTER_MOTOR_PIN,
                              OUTPUT_RIGHT_MOTOR_PIN};

// Create the array of input sensors based on pin constants selected
int inputSensorArrayPins[max_sensor_index] = {INPUT_LEFT_SENSOR_PIN,
                              INPUT_LEFT_CENTER_SENSOR_PIN,
//                              INPUT_CENTER_SENSOR_PIN,
                              INPUT_RIGHT_CENTER_SENSOR_PIN,
                              INPUT_RIGHT_SENSOR_PIN};

// Create the schedule data members
unsigned long motorStartTimeSchedule[max_motor_index];  // this is the clock time
(determined by millis() ) when we should start a motor
unsigned long motorStartNextTimeSchedule[max_motor_index];  // this is the clock
time (determined by millis() ) when we should start a motor
unsigned long motorStopTimeSchedule[max_motor_index];   // this is the clock time
(determines by millis() ) when we should stop a motor
unsigned long motorStopNextTimeSchedule[max_motor_index];  // this is the clock
time (determined by millis() ) when we should start a motor
unsigned int  motorStopTimeGap[max_motor_index];        // this is the gap of time (in
milliseconds) between a motor stop and start
unsigned int motorIntensity[max_motor_index];          // What PWM value to pulse the
motor with

boolean isMotorPulsing[max_motor_index];               // this tracks if the motor is
currently pulsing
boolean isInRange[max_motor_index];                    // this sensor has detected we are
in range
boolean isMotorScheduled[max_motor_index];             // this motor has a start time
we can iterate off of since the last unscheduling

// The onboard LED (PIN 13) will alternate on and off at each sweep through the
sensors to give a sense of tempo
boolean led_Value = true;


// This method is called on time to initialize values for the motor schedules to 1
second
void initializeMotorSchedules()
{
  // Get the current time
  unsigned int currentTime = millis();
```

```
  // Initialize all motor values
  for (int x=0; x<max_motor_index; x++)
  {
    // Initialize the values for all motors
    motorStartTimeSchedule[x] = 0xFFFF;  // max value for ulong
    motorStartNextTimeSchedule[x] = 0xFFFF;  // max value for ulong

    motorStopTimeSchedule[x] = 0x0;  // min value for ulong
    motorStopNextTimeSchedule[x] = 0x0;  // min value for ulong
    motorStopTimeGap[x] = 0xFF;  // max value for uint
    motorIntensity[x] = 0;
    isMotorPulsing[x] = false;
    isInRange[x] = false;
    isMotorScheduled[x] = false;
  }
}

int pingAndAdjustSchedule(int motorToSchedule)
{
  // Fire the sensor
  inputSensorArray[motorToSchedule].fire();
  int currentInchesRange = inputSensorArray[motorToSchedule].inches();

   // Record the current time
   unsigned long initialTime = millis();

  // Calculate the new gap we should have based on current range
  int new_gap = calculateRangeInFeet(currentInchesRange) * MOTOR_DISTANCE_GAP_
FACTOR;

  // The sensors will sometime inadvertently return a range of 0.000 inches.
Disregard this reading)
  if (currentInchesRange == 0)
  {
    return 0;
  }

  // This event was not large enough to trigger a reschedule event
 if (abs(new_gap - motorStopTimeGap[motorToSchedule]) < RESCHEDULE_
THRESHOLD_CONSTANT)
  {
    return 0;
  }


  // This event was beyond our range, let's schedule out to "end of time"
  if (new_gap >  MAX_GAP)
  {
    isInRange[motorToSchedule] = false;
    return 0;
  }
  else // Hey, we're in range!!
  {
    isInRange[motorToSchedule] = true;
  }


  // If we are coming in range, we are scheduling our first event
  if (isMotorScheduled[motorToSchedule] == false)
  {
    // Schedule our first motor event
    motorStartTimeSchedule[motorToSchedule] = initialTime + new_gap;
    motorStopTimeSchedule[motorToSchedule] =
motorStartTimeSchedule[motorToSchedule] + MOTOR_PULSE_DURATION;

    motorStartNextTimeSchedule[motorToSchedule] =
motorStopTimeSchedule[motorToSchedule] + new_gap;
    motorStopNextTimeSchedule[motorToSchedule] =
motorStartNextTimeSchedule[motorToSchedule] + MOTOR_PULSE_DURATION;

    motorIntensity[motorToSchedule] = calculateIntensity(currentInchesRange);

    isMotorScheduled[motorToSchedule] = true;

    //DEBUG
    Serial.print("Scheduling ");
    Serial.println(motorToSchedule, DEC);
    fireAndPrintSensor(motorToSchedule, false);

  }
  // We are at shorter range than previously
```

```
  else if ((new_gap < motorStopTimeGap[motorToSchedule]) &&
(isMotorScheduled[motorToSchedule] == true))
  {
    // Adjust the new start and stop times based on the new gap value
    motorStartNextTimeSchedule[motorToSchedule] =
motorStartNextTimeSchedule[motorToSchedule] - (
motorStopTimeGap[motorToSchedule] - new_gap);

    // Update our end time
    motorStopNextTimeSchedule[motorToSchedule] =
motorStartNextTimeSchedule[motorToSchedule] + MOTOR_PULSE_DURATION;

    // Update the intensity
    motorIntensity[motorToSchedule] = calculateIntensity(currentInchesRange);

    // Update the new value of the gap time
    motorStopTimeGap[motorToSchedule] = new_gap;
  }
  else if (new_gap > motorStopTimeGap[motorToSchedule] &&
(isMotorScheduled[motorToSchedule] == true))
  {
      // Adjust the new start and stop times based on the new gap value
      motorStartNextTimeSchedule[motorToSchedule] =
motorStartNextTimeSchedule[motorToSchedule] + (new_gap -
motorStopTimeGap[motorToSchedule]);

      // Update our end time
      motorStopNextTimeSchedule[motorToSchedule] =
motorStartNextTimeSchedule[motorToSchedule] + MOTOR_PULSE_DURATION;

      // Update the intensity
      motorIntensity[motorToSchedule] = calculateIntensity(currentInchesRange);

      // Update the new value of the gap time
      motorStopTimeGap[motorToSchedule] = new_gap;
  }

  return 1;
}

int executeMotorAndReschedule(int motorToExecute)
{
  unsigned long time = millis();

  // We are past the start time schedule activate the motor, our motor is pulsing, and
we are scheduled
  if ((time >= motorStartTimeSchedule[motorToExecute]) &&
(isMotorPulsing[motorToExecute] == false) && (isMotorScheduled[motorToExecute]
== true))
  {
    // Activate Motor
    // NOTE: Rather than high, this could be a PWM value to denote the intensity of the
motor as well
    analogWrite(outputMotorArrayPins[motorToExecute],
motorIntensity[motorToExecute]);
    //digitalWrite(outputMotorArrayPins[motorToExecute], HIGH);


    isMotorPulsing[motorToExecute] = true;

    // Reschedule next Start Time
    motorStartTimeSchedule[motorToExecute] =
motorStartNextTimeSchedule[motorToExecute];
    motorStartNextTimeSchedule[motorToExecute] =
motorStartTimeSchedule[motorToExecute] + motorStopTimeGap[motorToExecute] +
MOTOR_PULSE_DURATION;

  /*
    // DEBUG:
    Serial.print("Activating Motor On Pin: ");
    Serial.println(outputMotorArrayPins[motorToExecute], DEC);
  */
    return 1;
  }

  if ((time >= motorStopTimeSchedule[motorToExecute]) &&
(isMotorPulsing[motorToExecute] == true))
  {
    // Dectivate Motor
    analogWrite(outputMotorArrayPins[motorToExecute], 0);
    //digitalWrite(outputMotorArrayPins[motorToExecute], LOW);
    isMotorPulsing[motorToExecute] = false;
```

```
    // We are out of range, and and we've turned off the motor.  Let's mark it as 
unscheduled
    if ((isInRange[motorToExecute] == false) && (isMotorScheduled[motorToExecute] 
== true))
    {
      isMotorScheduled[motorToExecute] = false;
      motorIntensity[motorToExecute] = 0;

      //DEBUG
      Serial.print("Unscheduling :");
      Serial.println(motorToExecute, DEC);
      fireAndPrintSensor(motorToExecute, false);

    }
    else
    {
      // Reschedule next Stop Time
      motorStopTimeSchedule[motorToExecute] = 
motorStopNextTimeSchedule[motorToExecute];
      motorStopNextTimeSchedule[motorToExecute] = 
motorStartNextTimeSchedule[motorToExecute] + MOTOR_PULSE_DURATION;
    }

  }
  return 1;
}

void outputTest(int outputIndex)
{
  // Test all of the outputs (motors or LEDS)
    //digitalWrite(outputMotorArrayPins[outputIndex], HIGH);
    //analogWrite(outputMotorArrayPins[outputIndex], 255);
    //delay(1000);
    //digitalWrite(outputMotorArrayPins[outputIndex], LOW);
    //analogWrite(outputMotorArrayPins[outputIndex], 0);

}

int calculateIntensity(int rangeInches)
{
  // This is terrible code.  Magic numbers, and logic that could be error prone.
  if (rangeInches <=12)
  {
    return 255;
  }
  else if (rangeInches <=24)
  {
    return 128;
    //return 50;
  }
  else if (rangeInches <=36)
  {
    return 64;
    //return 20;
  }
  else if (rangeInches <=48)
  {
    return 32;
    //return 5;
  }
  else
  {
    return 0;
  }
}

int calculateRangeInFeet(int rangeInches)
{
  int value = (rangeInches / 12) + 1;

  return value;
}

void fireAndPrintSensor(int sensorNumber, boolean fireSensor)
{

  // If we have been told, then fire the sensor
  if (fireSensor == true)
  {
    // Fire the sensor
    inputSensorArray[sensorNumber].fire();
```

```
  }

  // Display the range information
  Serial.print("************ SENSOR ");
  Serial.println(sensorNumber, DEC);
  Serial.print("   Inches:");
  Serial.println(inputSensorArray[sensorNumber].inches(), DEC);
  Serial.print("   Feet:");
  Serial.println(calculateRangeInFeet(inputSensorArray[sensorNumber].inches()),DEC);
  Serial.print("   Gap in Milliseconds:");
  Serial.println(motorStopTimeGap[sensorNumber]);
  Serial.print("   Intensity:");
  Serial.println(motorIntensity[sensorNumber]);
  Serial.println();
}

void setup()
{
  // Initialize the motors as output pins
  for (int index=left_motor;index<max_motor_index;index++)
  {
    pinMode(OUTPUT, outputMotorArrayPins[index]);
  }

  // Initialize the motors as output pins
  for (int index=left_sensor;index<max_sensor_index;index++)
  {
    pinMode(INPUT, inputSensorArrayPins[index]);
  }

  // Configure debug LED
  pinMode(OUTPUT_DEBUG_PIN, OUTPUT);

  // Initialize the serial output.
  //*******************************************************************
*********************
  //WARNING:  This is slow and can be hinder the performance of your system.
  //So if you gotta debug, send few characters as infrequently as possible
  //*******************************************************************
*********************
  Serial.begin(115200);

  // Initialize the schedules to default values;
  initializeMotorSchedules();
}

void loop()
{
 // Toggle the onboard LED to get a pace of the iterations
  digitalWrite(OUTPUT_DEBUG_PIN, led_Value);
  led_Value = !led_Value;

  // For each sensor, schedule it
  for (int x=0 ; x<max_sensor_index; x++)
  {
    // DEBUG Block - Test the key functions
    //fireAndPrintSensor(x, false);
    //pingAndAdjustSchedule(2);
    //executeMotorAndReschedule(2);
    //delay(1000);
    //outputTest(x);

    // Schedule this sensor
    pingAndAdjustSchedule(x);

    // Check all motors to see if they should be run.  Note: The executeMotors function
could be changed to run all motors, but
    // this is for more control at the moment to debug individual motors
    for (int y=0; y<max_motor_index; y++)
    {
      executeMotorAndReschedule(y);
    }

  }
  // Delay for the pulse response to clear out
  delay(INTERPULSE_LATENCY_DURATION);

}
```

MODULE_120829_01.ino

```
// these arrays are looped through, make sure your pinb and motor match.
// so mypin[1] should corrispond to mymotor[1] and so on
int myPins[] = {3};
int myMotors[] = {9};
int howmany = 1;
int maxDistance[] = {100};
int maxPower[] = {255};

void setup() {
  // initialize serial communication:
  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimetres:
  long duration, cm;


// loop through the pins array, noting theat we've set the limit to 5
int i; // define "i" this is used as a count variable
// start a count loop, since you know how many sensors there are, hard code this in
the i < NUMBER OF SENSORS bit
for (i = 0; i < howmany; i = i + 1) {
  // print out what pin
  //  Serial.println(myPins[i]);

  // The PING))) is triggered by a HIGH pulse of 2 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  // check the pin pMyPin[i]
  pinMode(myPins[i], OUTPUT);
  digitalWrite(myPins[i], LOW);
  delayMicroseconds(2);
  digitalWrite(myPins[i], HIGH);
  delayMicroseconds(5);
  digitalWrite(myPins[i], LOW);

  // The same pin is used to read the signal from the PING))): a HIGH
  // pulse whose duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(myPins[i], INPUT);
  duration = pulseIn(myPins[i], HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

//  Serial.print(inches);
//  Serial.print("in, ");
// inches are for americans, they silly.
  Serial.print(myPins[i]);
  Serial.print("-");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();

//  if(cm < 100){
    int motorPWM = map(cm,maxDistance[i],0,0,maxPower[i]); //variable map formula
relationship
  motorPWM = constrain(motorPWM, 0, 255);

    analogWrite(myMotors[i],motorPWM);

    Serial.print("motorPWM = ");
    Serial.println(motorPWM);

    delay(200);
}

//    delay(returndelay(cm));
//    analogWrite(myMotors[i], 0);
//  } else {
//   analogWrite(myMotors[i], 0);
//  }
 // end of the pin loop

//  delay(200);  uncomment if needed
}

/*
// change to formul
int returnfeedback(int cm){
```

```
  int motorPWM = map(cm,maxDistance[],0,0,maxPower[]); //variable map formula
relationship
  motorPWM = constrain(motorPWM, 0, 255);
//  if (cm < 5){ // distance
//     return 255; // strength
//  } else if (cm < 10){
//     return 220;
//  } else if (cm < 20){
//     return 190;
//  } else if (cm < 40){
//     return 160;
//  } else if (cm < 80){
//     return 130;
//  } else if (cm < 100){
//     return 100;
//  } else {
//     return 0;
//  }
  Serial.print("motorPWM = ");
    Serial.println(motorPWM);

 return motorPWM; //serial print pwm


}
*/

long microsecondsToCentimeters(long microseconds)
{
  // The speed of sound is 340 m/s or 29 microseconds per centimeter.
  // The ping travels out and back, so to find the distance of the
  // object we take half of the distance travelled.
  return microseconds / 29 / 2;
}

v
```

SCOTT_120904_02.ino

```
/* Code Developed by SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.
edu.au

for Imran Shamsul www.imranshamsul.com imran.shamsul@gmail.com

 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on
when svet)
 - Button to switch motor on and off

 Functions to include:
 - Button, when motor off, sensor off.
 - Power Sensor via Pin


 */

#include “Ultrasonic.h”

Ultrasonic sensor1(10,9);
const int MOT1 = 3;
const int distPotPin = 0;
const int button1Pin = 6;

const int sensor1Power = 8; // sensor power pin

const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

int motorPWM, distPot, distControl;
long cm;
boolean motorState = true;
boolean button1Up = false;

int maxPower = 255; // PWN power Max 255, min 0


void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(button1Pin, INPUT);
  digitalWrite(button1Pin, HIGH);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  // check the button
  if(digitalRead(button1Pin)){
    button1Up = true;
  }
  else {
    if(button1Up){
      motorState = !motorState;
      button1Up = false;
    }
  }

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


  if(motorState){
    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);

    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,2,0,maxPower); //variable map formula
relationship
    //motorPWM = map(200,maxDistance,0,0,maxPower); //variable map formula
relationship
    motorPWM = constrain(motorPWM, 0, 255);


  }
  else {
    analogWrite(MOT1, 0);
```

```
    digitalWrite(sensor1Power, LOW);
  }

  Serial.print(cm);
  Serial.print("cm Max ");
  Serial.print(distControl);
  Serial.print("cm motorState:");
  Serial.print(motorState);
  Serial.print(" PWM ");
  Serial.println(motorPWM);

  // delay(50);
}
```

Final Code: MODULE_FINAL_25SEPT12.ino

```
/* Code Developed by
SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.edu.au
 &
Daud Imran SHAMSUL AMRI www.imranshamsul.com / imran.shamsul@gmail.com

 DATE: 25 SEPT 2012


 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on
when set)
 - Power Sensor via Pin
 - Button, when motor off, sensor off.
 - second pot to control PWM output



 */

#include "Ultrasonic.h"

#include "Button.h"

Ultrasonic sensor1(10,9); // Ultrasonic(int TP, int EP);
const int MOT1 = 3; //D3 PWM
const int distPotPin = 0; //A0 distance pot
const int pwrPotPin = 1; //A1 power pot
const int sensor1Power = 8; // D8 PWM8

//distance min and max
const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

//power min and max
const int minPower = 0;
const int maxPower = 255;

int motorPWM, distPot, distControl;  //don't get this??
int outputPWM, pwrPot, pwrControl; //am I missing this??
long cm;

boolean motorState = true;

Button button1 = Button(12,PULLUP);  //button control



void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  if(button1.uniquePress()){
    motorState = !motorState;
  }

  button1.isPressed();

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


 //check the power pot
  pwrPot = analogRead(pwrPotPin);
  pwrControl = map(pwrPot,0,1024,minPower,maxPower);


  if(motorState){
    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,minDistance,minPower,pwrControl); //variable
map formula relationship
    motorPWM = constrain(motorPWM, 0, 255);
```

```
    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);
  }

  else {
    analogWrite(MOT1, 0);
    digitalWrite(sensor1Power, LOW);
  }


  Serial.print(cm);
  Serial.print("cm Max ");
  Serial.print(distControl);
  Serial.print("cm motorState:");
  Serial.print(motorState);
  Serial.print(" pwr control::");
   Serial.print(pwrControl);
 Serial.print(" PWM ");
  Serial.println(motorPWM);

  // delay(50);
}
```

Final Code: PCB_CODE.ino

```
/* Code Developed by
SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.edu.au
 &
Daud Imran SHAMSUL AMRI www.imranshamsul.com / imran.shamsul@gmail.com

 DATE: 22 OCT 2012

 Code for custom design pcb.
 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on when set)
 - Power Sensor via Pin
 - Button, when motor off, sensor off.
 - second pot to control PWM output



 */

#include "Ultrasonic.h"

#include "Button.h"

Ultrasonic sensor1(9,10); // Ultrasonic(int TP, int EP);
const int MOT1 = 11; //D11 PWM
const int distPotPin = 6; //A6 distance pot
const int pwrPotPin = 7; //A7 power pot
const int sensor1Power = 8; // D8 PWM8

//distance min and max
const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

//power min and max
const int minPower = 0;
const int maxPower = 255;

int motorPWM, distPot, distControl;
int outputPWM, pwrPot, pwrControl;

long cm;

boolean motorState = true;

Button button1 = Button(2,PULLUP);  //button control



void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  if(button1.uniquePress()){
    motorState = !motorState;
  }

  button1.isPressed();

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


 //check the power pot
  pwrPot = analogRead(pwrPotPin);
  pwrControl = map(pwrPot,0,1024,minPower,maxPower);


  if(motorState){
    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,minDistance,minPower,pwrControl); //variable
```

```
map formula relationship
    motorPWM = constrain(motorPWM, 0, 255);

    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);
  }

  else {
    analogWrite(MOT1, 0);
    digitalWrite(sensor1Power, LOW);
  }


  Serial.print(cm);
  Serial.print(“cm Max “);
  Serial.print(distControl);
  Serial.print(“cm motorState:”);
  Serial.print(motorState);
  Serial.print(“ pwr control::”);
   Serial.print(pwrControl);
 Serial.print(“ PWM “);
  Serial.println(motorPWM);

  // delay(50);
}
```

Final Code: STRIP_BOARD_CODE_01.ino

```
/* Code Developed by
SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.edu.au
 &
Daud Imran SHAMSUL AMRI www.imranshamsul.com / imran.shamsul@gmail.com

 DATE: 02 OCT 2012

 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on
when set)
 - Power Sensor via Pin
 - Button, when motor off, sensor off.
 - second pot to control PWM output



 */

#include “Ultrasonic.h”

#include “Button.h”

Ultrasonic sensor1(9,10); // Ultrasonic(int TP, int EP);
const int MOT1 = 3; //D3 PWM
const int distPotPin = 0; //A0 distance pot
const int pwrPotPin = 7; //A7 power pot
const int sensor1Power = 8; // D8 PWM8

//distance min and max
const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

//power min and max
const int minPower = 0;
const int maxPower = 255;

int motorPWM, distPot, distControl;
int outputPWM, pwrPot, pwrControl;
long cm;

boolean motorState = true;

Button button1 = Button(12,PULLUP);  //button control



void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  if(button1.uniquePress()){
    motorState = !motorState;
  }

  button1.isPressed();

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


 //check the power pot
  pwrPot = analogRead(pwrPotPin);
  pwrControl = map(pwrPot,0,1024,minPower,maxPower);


  if(motorState){
    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,minDistance,minPower,pwrControl); //variable
map formula relationship
    motorPWM = constrain(motorPWM, 0, 255);
```

```
    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);
  }

  else {
    analogWrite(MOT1, 0);
    digitalWrite(sensor1Power, LOW);
  }


  Serial.print(cm);
  Serial.print("cm Max ");
  Serial.print(distControl);
  Serial.print("cm motorState:");
  Serial.print(motorState);
  Serial.print(" pwr control::");
   Serial.print(pwrControl);
 Serial.print(" PWM ");
  Serial.println(motorPWM);

  // delay(50);
}
```

Final Code: STRIP_BOARD_CODE_02.ino

```
/* Code Developed by
SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.edu.au
 &
Daud Imran SHAMSUL AMRI www.imranshamsul.com / imran.shamsul@gmail.com

 DATE: 05 OCT 2012

 Code for stripboard circuit board, verticle "T" shape.
 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on
when set)
 - Power Sensor via Pin
 - Button, when motor off, sensor off.
 - second pot to control PWM output



 */

#include "Ultrasonic.h"

#include "Button.h"

Ultrasonic sensor1(9,10); // Ultrasonic(int TP, int EP);
const int MOT1 = 3; //D3 PWM
const int distPotPin = 6; //A6 distance pot
const int pwrPotPin = 7; //A7 power pot
const int sensor1Power = 8; // D8 PWM8

//distance min and max
const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

//power min and max
const int minPower = 0;
const int maxPower = 255;

int motorPWM, distPot, distControl;  //don't get this??
int outputPWM, pwrPot, pwrControl; //am I missing this??
long cm;

boolean motorState = true;

Button button1 = Button(12,PULLUP);  //button control



void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  if(button1.uniquePress()){
    motorState = !motorState;
  }

  button1.isPressed();

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


 //check the power pot
  pwrPot = analogRead(pwrPotPin);
  pwrControl = map(pwrPot,0,1024,minPower,maxPower);


  if(motorState){
    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,minDistance,minPower,pwrControl); //variable
map formula relationship
    motorPWM = constrain(motorPWM, 0, 255);
```

```
    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);
  }

  else {
    analogWrite(MOT1, 0);
    digitalWrite(sensor1Power, LOW);
  }


  Serial.print(cm);
  Serial.print("cm Max ");
  Serial.print(distControl);
  Serial.print("cm motorState:");
  Serial.print(motorState);
  Serial.print(" pwr control::");
   Serial.print(pwrControl);
 Serial.print(" PWM ");
  Serial.println(motorPWM);

  // delay(50);
}
```

Final Code: STRIP_BOARD_CODE_03.ino

```
/* Code Developed by
SCOTT MITCHELL, PhD. RMIT University scott.mitchell@rmit.edu.au
 &
Daud Imran SHAMSUL AMRI www.imranshamsul.com / imran.shamsul@gmail.com

 DATE: 23 OCT 2012

 Code for stripboard circuit board, verticle "T" shape.
 Code functions include:

 - Pot to control max distance (min distance set to 2cm so motor will not power on
when set)
 - Power Sensor via Pin
 - Button, when motor off, sensor off.
 - second pot to control PWM output



 */

#include "Ultrasonic.h"

#include "Button.h"

Ultrasonic sensor1(10,9); // Ultrasonic(int TP, int EP);
const int MOT1 = 3; //D3 PWM
const int distPotPin = A6; //A6 distance pot
const int pwrPotPin = A7; //A7 power pot
const int sensor1Power = 8; // D8 PWM8

//distance min and max
const int minDistance = 2;  //dist in CM dont go below 2
const int maxDistance = 200;  //dist in CM

//power min and max
const int minPower = 0;
const int maxPower = 255;

int motorPWM, distPot, distControl;  //don't get this??
int outputPWM, pwrPot, pwrControl; //am I missing this??
long cm;

boolean motorState = true;

Button button1 = Button(4,PULLUP);  //button control



void setup() {
  pinMode(MOT1, OUTPUT);
  pinMode(sensor1Power, OUTPUT);
  digitalWrite(sensor1Power, HIGH);

  Serial.begin(9600); // this just means you can output to the serial panel
}

void loop()
{
  if(button1.uniquePress()){
    motorState = !motorState;
  }

  button1.isPressed();

  // check the distance pot
  distPot = analogRead(distPotPin);
  distControl = map(distPot,0,1024,minDistance,maxDistance);


 //check the power pot
  pwrPot = analogRead(pwrPotPin);
  pwrControl = map(pwrPot,0,1024,minPower,maxPower);


  if(motorState){
    cm = sensor1.Ranging(CM);

    motorPWM = map(cm,distControl,minDistance,minPower,pwrControl); //variable
map formula relationship
    motorPWM = constrain(motorPWM, 0, 255);
```

```
    analogWrite(MOT1, motorPWM);
    digitalWrite(sensor1Power, HIGH);
  }

  else {
    analogWrite(MOT1, 0);
    digitalWrite(sensor1Power, LOW);
  }


  Serial.print(cm);
  Serial.print("cm Max ");
  Serial.print(distControl);
  Serial.print("cm motorState:");
  Serial.print(motorState);
  Serial.print(" pwr control::");
   Serial.print(pwrControl);
 Serial.print(" PWM ");
  Serial.println(motorPWM);

  // delay(50);
}
```

11.6 Instructables step-by-step.pdf