Chapter 1

Introduction

Sociometric Badge is a set of wearable social sensors developed by Boston based company named Humanyze. It promises to optimize how people works in office environment. To achieve such goal, it works by constructing physical, real - life, social networks based from social interaction of its wearers. As the name and its goal suggest, social activity defined with multiple correspondents interchange informations both subtle and explicitly. Thus, Sociometric Badge cannot work on its own. The deal usually comes with a set of Sociometric Badges and its supporting environment (an application to extract data, as well as web client).

Although, Sociometric Badge primarily intended to be used in office environment, there are requests come from social scientists as well. Traditionally, social scientists use interview, observation, and survey to get social data. In the recent day, there are technologies to leverage interview and survey. For example, with Skype people can conduct interview over the Internet and there are web based applications like Google Form or Survey Monkey to help people to make online survey. However, there are no latent technologies that can be used to help social observation just yet. Sociometric Badge can be the answer for such problem, as it can help social scientists to do social observation and give additional parameters to interview and survey.

The highlight of this project is about a misfit principle between social scientists and the Sociometric Badge itself. The Sociometric Badge started from a sequence of similar researches and products. The original inspiration was from 1992's Active Badge by Olivetti Research. Between Active Badge to the Sociometric Badge, there are others similar projects. These projects led into the development of the Sociometric Badge in 2008. However, after 2008, there are little to no information of the Sociometric Badge. Until, it then re - appeared as a commercial product. As the nature of common commercial products, the Sociometric Badge became a close - ended product. There are neither hardware and software development kit for the newest version of the Sociometric Badge. This is a bummer for the social scientists if modifications are necessary. Additionally, as the time this paper is written, the only way to buy the Sociometric Badge is with an email form in the bottom of the company's website. There is

no obvious "Buy Now" button as it is usually in e - commerce based website. I tried to contact them to ask for informations regarding the Sociometric Badge, however there are no reply. These problems are what make the Sociometric Badge is not accessible to use for research purposes.

Aside from the Sociometric Badge itself, recently, there is Rhythm Open Badge. Rhythm Open Badge is an open source project with MIT License and has its repository hosted within GitHub. Known from its homepage, this project offers cheap solution to help people with interaction studies. At some senses, most of it, Rhythm Open Badge is similar to the Sociometric Badge. Rhythm Open Badge project started on 21st January 2016. At the time this paper is written it is still under development. Hence, the documentation is not yet complete. From this point, one could make Rhythm Open Badge with downloading schematics, fabricating the board, attaching the electronic components, then uploading the codes.

I define myself as someone who do programming more than making electronics. In my personal view doing and learning programming is more "portable" and has little to no risk compared to learning and making electronics. It is hard to make a choice on which electronics development kit to develop with, when there are many to choose, yet the differences are just pin layout and the programming. Additionally, in these recent days, electronics development kits depreciate faster than before due to new solutions come every months. Hence, I want to set this project to make an alternative device to the Sociometric Badge that is in higher level than the Rhythm Open Badge, with low - risk, easy to make and modify approaches and with more codes and less about electronics.

Overall, this paper is about detailed progress on my attempt to create aforementioned device which is the alternative to the Sociometric Badge. This paper starts a chapter about previous projects and products as implementations. The idea of this chapter is to define what are the features for current iteration (the result from this project) and the features for future iterations. After knowing what could be the possibilities, user groups will be determined. From this chapter, it is known that the primary user group will be the social scientists. However, there will be discussions on whom else could benefit from any informations come from this project. Next is about Limitations and Requirements. Limitations are defined as project and technical limitations. The purpose of Limitations and Requirements is to define Design Principles and Design Goals. Principle in general is used as a track, so the project will not go outside its context. The difference between Project Requirements and Design Goals is that Requirements are points that I need to do as the only doer of this project. Whereas Design Goals are objective that the deliverables from this project need to achieve. After all of these, there will be tests. The tests will be usability testing and implementation test. This paper then ended with Conclusion. In Conclusion, there will be Advices for future similar projects and Possible Implementations.

Chapter 2

Project Scope and State of the Art

2.1 Introduction

To establish a concise project, one needs to look for inspirations. This project aims to create "test the water" approach for real - life social data gathering. There are many ideas of social data gathering those can be looked into, thus the parameters can go up infinitely. However, to keep everything under control, limitations are necessary and benchmark point need to be set. Since every thought had gone in and out from the Humanyze's Sociometric Badge even before any formalities happened, I set the badge as the main reference point for this project.

Semantically, Sociometric Badge is a wearable badge - like device to detect and process incoming social signal. The problem is that nowadays the term of "social signal" mislead into anything that refer to activities in Internet social networking (Facebook, Twitter, YouTube), whereas Sociometric Badge is meant for real - life social activities. The flow is to get real - life social data from the continuous world and process it with computer to make sense of the data received. This means the obvious needs of sensors, specifically sensors to take real-life social data. Furthermore, as suggested by Carthal Gurrin in XXX, social data needs to be taken ambiently to preserve its naturality. Thus, for this project to make an alternative to Sociometric Badge, the form is matter and it should not be intrusive to be worn and to be seen. And by defining Sociometric Badge as a wearable technology, any related devices need to work as independently as possible or to have at least a form of wireless communication. Internally there are three qualities those need to be looked into when looking for related inspirational devices to Sociometric Badge: the sensor, the physical form, and either the independence of the device or the form of wireless communication.

As from my side, personally, I will look into inspirations those I can learn from. To deduct by myself what are the proper things to do for this project,

although are not necessary, the availability of documentations are good to have. Sadly, it is hard to get internal information for commercial devices. However, despite how hard it is to get internal informations for commercial devices, each of them is happened to be a shipshape and an appropriate product to learn from. On the other side of the spectrum, there are many do it yourself (DIY) electronics badge projects those are usually focused on their easiness to be made and modified. These DIY projects fit with this project low - risk, small commitment principles. Both spectrum could exists within a specific research that had previously been done. So, based on the availability of informations I give three classifications based on the device's project type: commercial, do it yourself, and research. And for the kind of informations, I will look for any documentations those are made by each first parties of every respective inspirational devices, these usually related to source codes and schematics.

2.2 Project Scope

In my point of view, Sociometric Badge lives in the sub-set of life logging. Specifically, Sociometric Badge is a interactivity measuring device with more intention for corporate uses. This notion suggests that every general life logging implementations can be used as an alternative to the Sociometric Badge.

But what are the catches? What makes general life logging appliances are different than things similar to Sociometric Badge? General life logging devices are meant for end - consumers. Hence, the resultant data need to be easily comprehended by human being regardless of the intelligence. Additionally, these kind of devices should be able to be used wherever, whenever its users want to. These reasons imply the use general capture module like audio recorder or video camera, as the outputs are rich in context and can be easily understandable. However, audio and video present large and unnecessary informations for specific device like Sociometric Badge. The use of more specific sensors can be seen in these specific devices and less in general life logging devices. Additionally, unlike general life logging device, Sociometric Badge can only be active in specific environment to limit its context. It will not work on itself as it needs to have others Sociometric Badges present for data to be compared.

Overall, the differences between general life logging and devices like Sociometric Badge lies on the limitation and data interface. Life logging application need to be understood by many spectrum of people. On the other hand, devices similar to the Sociometric Badge limit themselves to a certain group of people. The data can be interfaced and shrunk down based on that specific group of people. Also, Sociometric Badge and its predecessors can only be used under specific conditions. For example, Sociometric Badge can only be used within an office building with other similar devices active. Although, general life logging device can be used for the same situation as well, the conveniences and practicalities to enforce those specific conditions are not there.

The table XXX presents both general and specific life logging implementations. The specific life logging implementations are ones those are related to

human interaction. Aside from life logging appliances, due to lack of development between 2014 - 2016, there will be some DIY wearable devices as well. For this matter, I personally cherry picked ones those have features that could benefit Sociometric Badge.

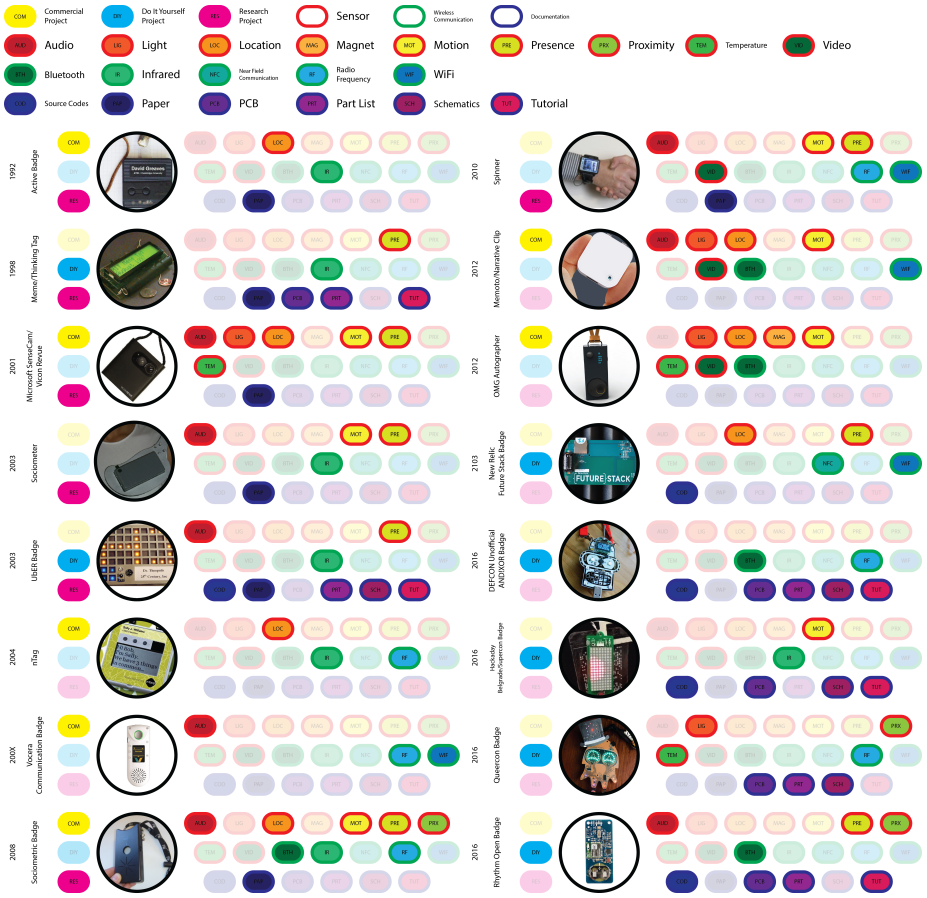

Figure 2.1: XXX

2.3 State of the Art

2.3.1 Active Badge

Active Badge is a smart office badge for location tagging appeared in 1992. The research for this badge started on 1989. The University of Twente Computer Science department is listed as one of the recipient for the first batch of the Active Badge. Aside from Active Badges those appeared in research institution, this badge was used and originally purposed for office environment. It has simple

infrared location tagging for its wearer to access rooms within the office building. Active Badge declined in use when mobile phone and world wide web became more accessible to people.

2.3.2 Meme/Thinking Tag

The project was first started as Meme Tag and then named into Thinking Tag. Back then, the idea of "meme" still came from the original Richard Dawkin's meme XXX which is an idea, behavior, or style that spreads from person to person within a culture. And Meme Tag stands still on that definition. At its first usage, user needs to go to a computer booth to set their personal message (hence, meme). When there are other Meme Tag wearers, users can both point the infrared transceiver to each others for exchanging memes. It was used at event where there are a lot of people (usually conference). In the recent days, I see that Twitter took this same principle and add "Internet" into it.

2.3.3 Microsoft SenseCam/Vicon Revue

Microsoft SenseCam was a project at Microsoft Research but then carried out by a promising imaging company named Vicon. It changed name from Microsoft SenseCam into Vicon Revue and it became commercial product with price tag around 800 USD. There were ten years from Microsoft to Vicon. During those ten years a lot of researches happened ranging from health care (aiding people with Alzheimer) into Microsoft SenseCam as personal use. The initial use was actually to present Microsoft SenseCam as a wearable "human blackbox" as it records any possible interactions from its wearer point of view. Although it has no wireless communication, as the price and intention suggest, Microsoft SenseCam/Vicon Revue is packed with a lot of sensors and can be operated independently.

Initiated in 2001, Microsoft SenseCam has its first prototype done with PIC micro controller. In my opinion, PIC was equivalent to what Arduino serves nowadays, an easy to interface development kit for electronics development. This suggest that device as extensive and as features packed like Microsoft SenseCam could be started with a humble electronics development kit.

2.3.4 Sociometer

From the name and features, I suggest that Sociometric Badge was a follow up project from Sociometer. Sociometric Badge has everything more than what Sociometer has. However, the intention is different as Sociometer is meant to be used for longer period of time. This makes significant decision on the form. Sociometric Badge is an entirety of normal office badge packed with sensory features. Sociometer, in the other hand, is designed to be as ergonomics as possible with its shoulder pad look. The decision was XXX because of the needs to be worn all - day the device need to be as comfortable as possible. The cue is that the wearers will not feel like they are wearing Sociometer. As

previously mentioned on how device with intention like Sociometer needs to be ambient, Sociometer's shoulder pad design suggest a new perspective on pervasive computing. As the computer unit is not hidden to the surrounding but is hidden for the main user.

2.3.5 UbER Badge

UbER Badge came from the same person who then decide to make Spinner XXX as, perhaps, a follow up project to UbER Badge. The idea of UbER Badge roots in DIY principles as there are a lot of documentations available for commonalities to make UbER Badge for themselves. UbER Badge aims to aid researcher on studying human interaction. UbER Badge itself is very flexible to develop. There are many ways to adjust UbER Badge based on needs. Wholly, the later Rhythm Open Badge also seems very similar to UbEr Badge.

2.3.6 nTag

nTag is perhaps the commercial solution that is similar to Meme/Thinking Tag. The main feature is to share messages and preferences to other wearers, thus makes networking and starting conversation in conference easier. Additionally, there are a lot of features for the event organizer, for example to manage logistic and on - badge questionnaire.

2.3.7 Vocera Communication Badge

Vocera Communication Badge is a commercially available wearable communication device for critical environment. Its demands, most of the time, come from hospitals for their need of communication devices for emergency situation. Vocera itself offers rugged Android phone with the same intention as an alternative to the badge. The use of RF and WiFi as its wireless communications suggest that those are reliable wireless communications as communication needs to be always available. Vocera Communication Badge costs around 20.000 USD for 75 users, with inclusive supporting system. Thus, this is not a personally owned device.

2.3.8 Sociometric Badge

The research of Sociometric Badge was published on 2008 XXX. It is still the latest research project that has intention to make a wearable set of social sensors. After the aforementioned research, around 2011, there are little to no publication on what was the development status of Sociometric Badge. Until finally, it reappeared back commercially under company named Humanyze.

I infer Sociometric Badge as a corporate life logging implementation or as a FitBit for personal development XXX. Sociometric Badge promises to enhance people collaboration especially in corporate setup. It works in pre - determined environment along with other Sociometric Badges. It able to detect if there are

abnormalities during conversation/interaction. Additionally, Sociometric Badge comes with a client interface for its wearer to see every data have ever recorded from the Sociometric Badge. From there the users could infer by themselves at which part of interaction they are lacking or if they overdo it. Fortunately the process does not happen automatically, users need to submit and move the data from their Sociometric Badge to main computer to see what Sociometric Badge records.

2.3.9 Spinner

Spinner is a lifelogging implementation with third person point of view. It is intended to help people to make an automated video log with little to no manual editing. The result of Spinner is a video that display the life of the wearer from third person perspective, adjusted as such it is similar to a pre - determined pattern. The pattern can be chosen from pre - made patterns, made from scratch, or combination of both. Most of available pre - made patterns are based on popular movies like Star Wars. The resultant video expected to have the same flow with the provided pattern. I think the pattern is a set of predetermined sensory values that, if the condition meet, makes the statically placed camera node to start recording videos. After some times, it starts to compose videos for specific user based on user's available video clips and the provided pattern.

It has two things: the wearable sensors device with wristwatch like form and statically placed sensors node. The wearable sensors node uses RF to communicate to the static node to inform if it needs to capture data from the users. At bare minimum there are a sensor attached into the wristwatch and a video camera in the static node. In this case, it has motion detection to reference back with the previously provided pattern.

Spinner ecosystem is a good example of social data gathering from third person point of view. This suggest less technical requirements on the moving, wearable sensory unit and more requirements into the statically placed sensory nodes. As previously mentioned, social data gathering needs XXX to be ambient and form is matter, there might be technical requirements for putting larger or more sensors that make the wearable device become more intrusive and obvious to see. The solution is to leverage the environment itself as a host for sensors.

2.3.10 Memoto/Narrative Clip

Memoto/Narrative Clip is the closest dedicated life logging implementation to consumer. It priced around 299 USD for the latest version and 150 for the first version. The price is three times cheaper than other consumer life logging device (Vicon Revue and OMG Autographer). It appeared in a featured KickStarter campaign for a product named Memoto in 2012, before it changed name into Narrative Clip. Narrative Clip is a dedicated life logging device. It has a camera, accelerometer, and a precisely small form. It has no buttons and interactions happen from gesture input received by the accelerometer. The whole system

(device with its supporting software) provides easy tagging system to manage photos and videos from the device itself.

Narrative Clip suggest the use of camera as a multi - modal sensor for self - social data gathering. The presents of camera means that there is no need to have another sensor since everything can be inferred from photos or videos. The lack of qualitative sensor values, however, suggests that the usage of Narrative Clip for real life social data gathering requires context given manually by human.

2.3.11 OMG Autographer

OMG Autographer is another consumer level life logging implementation derived from the discontinued Vicon Revue. It appeared in the same year with Memoto's KickStarter campaign, although sadly both the company and the product itself are discontinued. What set OMG Autographer from Memoto/Narrative Clip are price and features. OMG Autographer priced around 800 USD, and with very specific purpose it serves makes this device to be less accessible for general consumers. However, it has more features packed than Memoto/Narrative Clip. It has a built - in GPS and magneto meter to detect the orientation and where the camera is facing. OMG Autographer will manually take pictures based on input from sensors. To some sense this is what Spinner achieved without Spinner's limitation on pre - defined environment. For these qualities, I define OMG Autographer as a smarter version of Narrative Clip.

There is problem with Narrative Clip that OMG Autographer solved. Based on reviews from many consumer tech website, many Narrative Clip users comment on complains they received from people around them. The complain started when these surrounding people become aware of them being monitored by Narrative Clip. However, there is no such remarks on OMG Autographer. The hint could be on the obviousness of the camera. In Narrative Clip the camera design is very low profile and barely noticeable. On the the hand, OMG Autographer uses more obvious looking camera. From this notion I suggest people would not mind to be recorded if they are aware in the first place.

2.3.12 New Relic Future Stack Badge

New Relic is a company specialized in data analysis. The Future Stack Badge is their DIY proof of concept solution that was used in their first - ever conference. It formed as a normal conference badge with additional feature to exchange contact with tapping it into another Future Stack Badge. It was made with help of Electric Imp. Electric Imp is a small formed development kit to help hardware to be connected to the Internet.

Based from an article XXX the main developer has a good reason on why they were developing New Relic Future Stack Badge instead of using the widely available processing power from smart phone. The main reason is because homogeneity. Smart phones have varied features, for example Apple refused to have NFC until iPhone 6. Whereas at that point other flagship Android smart phones had already shipped with NFC. Hence, making a sensory kind of application for

smart phone become harder. Their answer was to develop a homogeneous hardware with easy to interface development kit to serve very specific need for their first - ever New Relic conference. Additionally, socially speaking most people would rather not to install an application for only specific amount of time.

2.3.13 DEFCON Unofficial AND!XOR Badge

DEFCON Unofficial AND!XOR Badge was a DIY badge made for 2016's DEFCON. DEFCON itself is a conference for people with interest in cyber security. Its general intention is just for fun, it has built - in puzzle to solve as well as chat application. However, there are features that would be good to be implemented in Sociometric Badge: the possibility of serial communication let this badge to be easily set with a common terminal application via USB and having LCD interface and buttons let its users to easily adjust settings without accessing computer. The former would make batch set up to be easier, whereas the later will be good to have in more research environment in case little adjustments are necessary.

It uses NRF development kit, that features low powered Bluetooth communication. Perhaps, DEFCON Unofficial AND!XOR Badge made with the same NRF development kit variant used to develop Rhythm Open Badge.

2.3.14 Hackaday Belgrade/Supercon Badge

Hackaday Belgrade/Supercon Badge came with more and less features than DEFCON Unofficial AND!XOR Badge. It is the featured badge for Hackaday conference. Although there is no tutorial to built one, there is a software development kit framework and guide to let its users develop application for this Hackaday Belgrade/Supercon Badge. Most of the time, applications on embedded wearable device are dead fixed unless there are hardware modifications or new codes upload to the micro controller. From implementations discussed in this chapter, only Hackaday Belgrade/Supercon Badge offers a way to develop applications for itself without hardware modifications and new codes upload.

2.3.15 Queercon Badge

Queercon Badge is the main conference badge for 2016 Queercon. It is visually attractive and socially aware. Queercon Badge as RGB LEDs that react based on the color set from nearby badge. So the color on the LED will depend on the color of surrounding badge. This happened with help of hopping RF communication through all possible Queercon Badge in range. If Hackaday Belgrade/Supercon Badge offers a way to develop an application, there are some in and out pins to let users to extend this badge with, perhaps, additional LEDs or sensors.

2.3.16 Rhythm Open Badge

Rhythm Open Badge is an open source implementation since Sociometric Badge went commercial. The project started in 21st January 2016 and still going. It is intended to help people to study human interaction. Although, open source and has its own GitHub hosted repository, due to still in development it lacks a lot information. There are three iterations done. The first one was done with Arduino compatible development kit, while the third one was done with NRF51 - DK BLE (Bluetooth Low Energy) based micro controller from Nordic Semiconductor. There is no information on what is the intermediate iteration. Rhythm Open Badge can be powered with a coin battery. This project and DEFCON Unofficial AND!XOR Badge give the importance of having low powered wireless communication like BLE for wearable Internet of Things project.

2.4 Conclusion

2.4.1 Multi-modal Sensor

I see that there are two classifications for sensor. There are traditional sensors like photo resistor that at most can only measure light intensity. There are multi - modal sensors that can carry multiple measurements. Examples of multi - modal sensors are things like audio recorder and video camera. There are a lot of features that can be extracted from audio or video. For example pitch and volume can be inferred from incoming audio, while from video light intensity and motion can be detected. To get the quantitative aspect from these sensor, additional layer of processing is necessary. Most of the time these are done at software level, for instance the usage of computer vision framework like OpenCV to do image processing.

Although the multi - modal sensors are very flexible, they have a lot of foot prints. Audio and video files take thousands bytes compared to data from traditional sensors that (usually an integer) only takes 8 bytes in 64 bits system. And not all available informations from those audios or videos will be used. As inferred from the development of Sociometric Badge XXX, the data produced from multi - modal sensor can be further dumbed down in size, thus only necessary informations are saved. However, this means there will be system that has fast enough enough processing power and plenty of volatile memories. These are not the qualities of wearable devices, since even flag ship smart phones will have difficulties to extract data from audio and videos.

There are two solutions for managing data from multi - modal sensor: to store the data as it is or to strip the multi - modal sensor data during the run - time. The former requires big static memories, while the latter needs faster CPU and more RAM. From this table it is known that at least XX bytes are necessary to store data per day XXX. To put into perspective, a multi - modal only social device like Memoto/Narrative Clip offers 8 gigabytes on board memory, however it received the incoming data as it is without any further operation.

2.4.2 Context-given-agent

I suggest that there are two layers of results come from socially aware devices. The first layer is the raw sensor data from the device itself. However, just sole numbers are not enough for human comprehension, context needs to be given. This present the second layer of the results, of which context-given-agent will take role on determining context on each numbers. context-given-agent gives meaning to the numbers. For example, fitness tracking device measures the speed of its wearer. It shows information on how fast the wearer runs. However, for social data gathering the numbers does not mean anything. There are unlimited of possible contexts. For instances, whether the wearer was running as their daily routine or running to chase departing train from the station. Usually, common fitness tracking uses internal or smart phone GPS to determine where the user was running. If acceleration happened when the wearer was nearby train station, the latter context can be assumed.

Usually context-given-agent comes as a qualitative data (boolean, ID, or local position system). From the implementations listed in the table XXX position and presence are meant as a context given agent. However, quantity data like global positioning system can define context as well. Nowadays machine learning can be leveraged as a context-given-agent to detect patterns and then give meaning to the raw sensor data XXX. However, for smaller data set, context can be manually given by human as well. Finally, after both layers are identified, conclusion can be pulled.

Chapter 3

User Groups

There are two user groups or this project: social scientists and makers. Social science defined as a study on how people behave. Social scientists usually work on formal activities to adjust and to predict what are the people reactions given a set of situations. Maker defined as someone who make technology, representing do-it-yourself (DIY) sub-culture. Since both groups can exists independently, a person could be determined as both social scientist and maker.

This project wants to deliver an alternative to Sociometric Badge and The social scientist sit as the end-user of that deliverable. Makers, on the other hand, will act as mediators between the possible unknown realm of hardware/software development to the social scientists.

To make an alternative to Sociometric Badge, both groups need to communicate on the requirements and the limitations. In this project, social scientists need to determine the project requirements. While, makers need to determine what are the current technical limitations as well as their own limitations.

3.0.1 Social Scientists

This project deals with technology that could leverage the work of social scientists. As social science lives in different spectrum from common technological background, experiment with the use of technologies seems not quite nourished compared to other studies like design or business. This results as spaces for more specific technologies to fit in. In term of social data gathering, social scientists mainly use interview, observation, and questionnaire. For each of those, there are particular technologies that could be used to leverage the process. However, there are no tools that can be easily fit to leverage all together just yet.

The concept of computer exists in anything (pervasive/ubiquitous computing) and Internet exists in everything (Internet of Thing) can be used to power up interview, observation, and questionnaire. There are good ingredients can be taken from those implementations listed in previous chapter XXX. The obstacle will be to mix and match which components to use. Then, communicate the combinations to the makers.

3.0.2 Maker

As it is defined in The New York Times, maker is a technology based sub culture based on DIY culture. The sense of doityourself is for one to be able to make something without professional experience and professional tools. For this project, looking for specific people that exactly has the knowledge of embedded device and programming is not easy. However, there are a lot of hobbyists that could achieve to make the same thing for lower entry technical project.

Unlike social scientists, the term of "maker" will never have clear qualifications. In ideal case, maker needs to be able to derive a fitting technological solution given the design goals and limitations. Since the design goals for this project will be related to social sciences, especially psychology, suitable maker for this project would be someone who has ever done works on interfacing social interaction into discrete world.

The maker tasked to define limitations, design the technical approach to solve the problem, and to document process for further iterations. Makers need to understand what is the commonly used tools. And then use this tool to develop the solution. Since this project has high regard on the flexibility of the resultant device, documentations are necessary in case minor modifications are required.

Chapter 4

Project Requirements

I personally separate my deliverables into three categories: ideal requirement, minimal implementation, and realistic requirement. The ideal requirement refers to hypothetical scenario where limitations does not exists. This implies for a deliverable to be as ideal as possible disregarding limit on money, knowledge, and time available. The idea is to know all available possibilities. Hence later, the this ideal implementation can be further dumbed down into more down-to-earth solution. The minimal implementation refers to a minimal deliverable to test functionalities of the overall deliverable. The key is to make thing that is just barely testable. The goal is to set a stepping stone to develop the realistic implementation.

The goal of this project is to define and build realistic requirement. The upper ceiling point was set by previously defined ideal implementations. And, the entry point was set by defining minimal implementation. The process started by defining the ceiling point that can be further dumbed down, while practically making the from ground up. The result from the process is the realistic implementation.

4.0.1 Physical Computing

The ideal case scenario is to implement all known sensors have ever used for social data gathering. This notion and this project intention to make the alternative to Sociometric Badge with experiment and research in mind, suggest that the device needs to be easily extended and reduced as well. Hence, it can afford to be extended by various sensors those have not yet defined as useful for taking incoming social signal. In term of hardware flexibility, previously mentioned Queercon Badge offers two input and output socket in its uppermost section. These let its users extend the physical capability of Queercon Badge.

The minimal requirement is just to implement a multi-modal sensor to the alternative of Sociometric Badge this project is trying to make. The example of concise device that only use a multi-modal sensor is Memoto/Narrative Clip. It only have a camera to take both photos and videos. However, data comes

from photos or videos is very rich. Thus, there are a lot of things can be used to interpret for social scientists.

From both cases, the realistic approach is to keep using one multi-modal sensor and use specific context-given sensors. From the previous chapter XXX, the latent context-given-agent are either location, presence, machine learning, or manually given by human. Since I have no experience on machine learning, this makes only three options left. However, manually given context by human is not scalable. With increasing respondents, the amount of works will be increased exponentially. So, the options left in presence and location. Conveniently, both can be done with identification from infrared transceivers between devices. However, if I would choose which one is the more important, that will be presence detection. With ability to identify who is facing/around the user give more dimension for social experiment that related to real-life interactivity.

4.0.2 Software Development

Software requirement will be for complementary features that would be good to have for this project's deliverable. For this project there five possible software implementations: database server, mobile application client, physical client, web client, and web server.

For the ideal case scenario all of these are necessary. The most important things are database server and physical client/mobile application client. These define the minimal implementation.

The physical client refer to the software development that connects every hardwares mentioned on physical computer implementation XXX.

The database server need not to be a self-hosted database per see. It can also be an embedded one. In general, this refers more on the mechanism on where and how the data is stored. At minimal embedded database can formatted as .JSON, .XML, or just a bare .txt without specific format.

The realistic approach is to develop: physical client, web client, web server, and database server. The physical client is the main deliverable for this project. Web server acts as a mediator between web client as well as to interface database server. The importance of web client lies on the necessity to present data from database in higher level.

Issue on Developing Mobile Application

The mobile application refers to the development of mobile application as the alternative of Sociometric Badge itself. Although, the developer of Future Stack Badge XXX said that the problem lies in the heterogeneity of smart phone on-board sensors. However for testing purposes, at least basic functionality multi-modal data gathering like audio and video can still be interfaced easily.

The other counter point raised from Carthal Gurrin XXX, mentioned that form is matter and social data gathering should be not intrusive. Having form as a smart phone gives different meaning on the device, despite it meant to

behave like Sociometric Badge. For testing this should not be matter. However, if the research respondents are not tech aware (for example, kindergarten children, people with neurodegenerative diseases, ...) having proper form is important, since smart phone lost its context as a real-life social data gathering tool. This is why the use of smart phone as an alternative for Sociometric Badge is discouraged.

4.0.3 Form

Form is important. However, since I have no particular knowledge to make a good design. I took an approach to make a simple orthodox design with focus to fit all hardware components into smallest form possible.

The ideal form is similar to what already achieved by Memoto/Narrative Clip, a compact 3.6 cm x 3.6 cm x 0.9 cm formed device. However, this is not idea for development purposes.

The minimal form implementations is to create a form with some additional spaces for wires and in case of miscalculations. Then derived from the minimal implementation, the realistic form implementation needs to be a perfect fit for any hardware components used to make the physical client.

Chapter 5

Project Implementations

I used Arduino MEGA then Raspberry PI as a electronics development platform to make prototype for this project deliverable.

5.1 Arduino

Arduino is a the lowest entry point for electronics development platform. There are two kinds of Arduino those I think would be a fit for this project: Arduino UNO and Arduino MEGA. Arduino UNO/MEGA offers a user friendly development approach. As it is a mature open source project, Arduino UNO/MEGA comes with a lot of options to extended for both codes and for the physical hardware. Hence, Arduino UNO/MEGA is commonly used as development platform to kick-start electronics project.

Most of the time, for DIY electronics project, using Arduino UNO is more than enough. The reason to use the MEGA variant is in case the project need to have more input and output pins as well as large on-board memory to store more codes.

Based from my experience, trouble comes when the project started to get bigger. The use of third party library sometimes left unnecessary footprints. This causes the codes to take more spaces. On the other hand, Arduino especially the UNO variant has only 32 kilobytes to store codes, while the MEGA variant offers eight times more storage for codes than Arduino UNO. So, if Arduino project programmed with more than two libraries used, it might be good to start off using Arduino MEGA.

For this project, I tried to use Arduino MEGA to make the first iteration. Making an independent wearable sensor device is not possible with Arduino since the lack of static storage (can be extended with SD Card reader but that significantly increases codes size) and processing power. The problem was realized when I need to take data from multiple sensors, filter the data, and send it to database with specific tagging. The tagging will be the an identification string and a real-world time stamp. This result in in multiple operations need

to be done independently: time counter needs to be increased for every sample time passed in real-world (in this scenario it was a second), while keep waiting for data from sensor, as well as to sent data to database wireless.

For the timer I used the classic 555 timer chip to have the system take data regularly and to tag it with time stamp. There is other option that might a better fit for this situation, which is a real-world clock chip from Maxim Integrated. It has library for easy interface with Arduino as well.

The filter is very simple. In essence the system will not bother on very low value comes from the sensor. Since, raw sensor valued always from 0 to 1023, there is a necessity to convert the value into more human comprehensible value.

When I was developing with Arduino I used ESP8266 to sent data to simple web server and then to database over WiFi. However there was a problem of which these operations are not in sync to each other. The case was, when timer is ready, it asks sensor to capture incoming input, if there is a connectivity delay from the ESP8266 the options are either to buffer the data or to discard the data before the database input. The latter is not preferable. The former made the buffer grow larges. Additionally, because data input to the database need to be confirmed back to each clients, the process sometimes took longer than the sample time, hence the sensors misses its interval to capture data.

5.1.1 Conclusion

From my development time using Arduino. I concluded that for a project like this, where a lot of operations should happened independently to each other and not stacked together into a single thread, having access to multi-threaded programming can make the development process easier.

5.2 Raspberry PI

I decided to re-make the whole application back with Raspberry PI. The use of full featured Linux operating system make the development process easier. One can just develop a Linux application and then run it in Raspberry PI without little to no adjustment necessary. Raspberry PI uses Python as a programming language to interface with its input and output pins. A fresh install of Raspbian Linux includes Python library to interface with hardware easily.

My approach was to program everything as possible without the Raspberry PI itself. Started to program face detection using OpenCV and then audio pitch and volume detection using Aubio and Alsa. All libraries have a Python wrapper. However, the use of Alsa to interface audio input is so specific to Linux. Hence, I decided to change Alsa with higher level library so the pitch and volume detection can be in other operating system as well. The replacement of Alsa is PyAudio, which is a very extensive library to interface audio input and output.

After I done with programming for the multi-modal sensor, I went to establish database connection. There are a lot of choices for database. The obvious

one is to use SQL based database. SQL is the latent database that most people know. However, as suggested in XXX using SQL database for social data gathering limits the potential of adding additional information. Real-life social interactivity can be determined with less or more informations and not strictly to the amount that previously defined in the SQL scheme. This concept suggest me to use NOSQL database. Basically, NOSQL database is a recently popular variant of database that is not strict to a scheme. To some sense, NOSQL database is just a collection of documents formatted like JSON or Python's dict. There are two options I looked for this project's database: MongoDB and RethinkDB. I decided to use the latter because this project aims to have real-time information operation, of which what RethinkDB is promised. The nature of NOSQL database to be inputted arbitrarily benefit this project, since the data from sensor can be easily added or removed.

The web server done with Python's Flask. Flask is a minimal web library to establish web server a fast as possible. This project will not have a particular attention on developing web server itself. Since the web server is only used to let user to view what are inside the database (public API), a simple minimalistic library like Flask fits the needs. For web client I try to implement a visualization based on D3JS.

The latest programming I did before making the case was developing the context-given-agent. In this case I got myself two infrared LEDs and two infrared receiver. The circuitry is simple, each needs the infrared transceiver, a 10K Ohm resistor, and an NPN transistor. I used LIRC library to interface this self-made infrared transceiver.

The hurdles was when transferring the whole codes into Raspbian, the Raspberry PI official operating system. To get access to hardware, correct permissions need to be given. This is common security measure for any operating systems. In Raspbian, there are two default users: root and pi. root has the privilege of being super user. Being super users allow all possible modifications to the operating system, this includes hardware access. The default pi user, on the other hand, has limited access, unless specific permission is given by 'sudo'. 'sudo' refers to 'su' and 'do'. It gives normal privileged user to execute command on behalf of super user. The development was not pleasant due to I did not know what is the best practices. Then, I decided to set and run the codes with super user privilege, hence giving all hardware access. This is not the ideal situation, since imposing an application with super user privilege is the same with letting anyone goes in and out through your house. However, I found that this practice is suitable for development purpose.