Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4317: Senior Design II
Fall 2023

Team Majestic
RFID Smart Stethoscope

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Revision History

Revision	Date	Author(s)	Description
0.1	6.26.2023	MA	document creation
0.2	6.28.2023	MA, EML, CN, KT	first draft completed
0.3	8.11.2023	MA,CN	Version 2 completed
1.0	12.6.2023	MA,	Final version completed

Contents

1 Problem Statement 6

2 Methodology 6

3 Value Proposition 6

4 Development Milestones 6

5 Background 7

6 Related Work 7

7 System Overview 7

8 Roles & Responsibilities 8

9 Cost Proposal 8
- 9.1 Preliminary Budget 9
- 9.2 Current & Pending Support 9

10 Facilities & Equipment 9

11 Assumptions 9

12 Constraints 10

13 Risks 10

14 Documentation & Reporting 11
- 14.1 Major Documentation Deliverables 11
  - 14.1.1 Project Charter 11
  - 14.1.2 System Requirements Specification 11
  - 14.1.3 Architectural Design Specification 11
  - 14.1.4 Detailed Design Specification 11
- 14.2 Recurring Sprint Items 11
  - 14.2.1 Product Backlog 11
  - 14.2.2 Sprint Planning 11
  - 14.2.3 Sprint Goal 11
  - 14.2.4 Sprint Backlog 11
  - 14.2.5 Task Breakdown 11
  - 14.2.6 Sprint Burn Down Charts 12
  - 14.2.7 Sprint Retrospective 12
  - 14.2.8 Individual Status Reports 12
  - 14.2.9 Engineering Notebooks 12
- 14.3 Closeout Materials 12
  - 14.3.1 System Prototype 12
  - 14.3.2 Project Poster 12
  - 14.3.3 Web Page 13

14.3.4 Demo Video 13
14.3.5 Source Code 13
14.3.6 Source Code Documentation 13
14.3.7 Hardware Schematics 13
14.3.8 CAD files 13
14.3.9 Installation Scripts 13
14.3.10 User Manual 13

List of Figures

1 High level system overview 8
2 Example sprint burn down chart 12

List of Tables

1 Budget Estimation 9
2 Overview of highest exposure project risks 10

1 Problem Statement

At the UTA simulation center they train nurses to understand how to detect and treat many types of ailments through use of actors called standardized patients. These standardized patients are traditionally healthy individuals acting as if they are suffering from some medical issue, so when a nurse would use their stethoscope on them it would sound completely normal and healthy. We will develop a system to allow for learners to use a stethoscope and listen to a variety of different auscultation sounds on a healthy patient that would not be able to produce those sounds.

2 Methodology

For this project we will be developing a shirt that can be worn by a variety of standardized patients that contains many chips with data on them that when scanned can play the audio of different auscultation sounds depending on the part of the body they correlate to. In addition we will need to develop a way for the smart hospital to reprogram them easily to allow for them to change the sounds produced to accompany their need.

3 Value Proposition

This project will bring an improvement to the educational systems provided by the university's smart hospital. It will allow for the smart hospital to train nurses in ways they could not previously. Allowing for the nursing students attending the university to get hands on training listening to and understanding auscultation sounds. This will in turn make the university's nursing program even more accredited and attract new students to attend the university.

4 Development Milestones

RFID Smart Stethoscope milestones:

- Project Charter first draft - June 2023
- System Requirements Specification - July 2023
- Architectural Design Specification - July 2023
- Demonstration of Reading an RFID tag - August 2023
- Detailed Design Specification - September 2023
- Demonstration of Loading an RFID tag into a database - September 2023
- Demonstration of Playing an audio file from an embedded computer - September 2023
- Demonstration of Connecting the software database to the embedded computer - October 2023
- Demonstration of Scanning RFID to hear a sound - October 2023
- Demonstration of Reprogramming the sound that the RFID chip plays - November 2023
- Final Project Demonstration - December 2023

5 Background

At the university's smart hospital they bring in paid actors called standardized patients who act like they have particular ailments and diseases to help train the nursing students to identify and treat those ailments. The issue that the university is having with these patients is that they are actually healthy so their internal body sounds are those of a healthy individual, and so the university cannot train the nurses to listen for unhealthy sounds within the patients body. To help train their nursing students to use a stethoscope to listen for different auscultation sounds within the heart, lungs, and bowels of the healthy standardized patients this project will use a set of chips that the standardized patient can wear. When these chips are scanned it will play the audio corresponding to the part of the body that was just scanned. This allows for the nursing students to hear sounds that the standardized patients body would normally not be making.

To allow for a wide variety of different simulations that the smart hospital might want to run these chips must be able to be reprogrammed easily to allow for any ailment that the smart hospital wishes to train the students for that particular day.

6 Related Work

RFID has been used in our day to day lives whether it is using to get through security clearance or pay for a toll way. According to a small article on hackaday, it shows a project similar to the one being done where they used a stethoscope and modified it to read RFID chips. This was done by a TA from the University of Missouri by using headphones, a battery pack and some RFID chips [3]. Through this website it gives another source where a page that shows how this was done as well as the instructions of how to create your own. This person used a small hardware design that would read the chips off of the actor patient. From there the chips are attached one by one using normal tape on the corresponding location of where a doctor or nurse would listen to the organs. This project took a more simple approach in loading audio files manually as well as modifying the stethoscope with a small reader [2].

Another approach that was accomplished was the Cardionics Simscope simulator. This uses chips that are attached to the patient as patches and uses an application that uses audio playlist selected by the instructor to simulate as they look at each reader. Thee application also identifies which chips are being used to load the correct audio file that is preset to add for a specific area. The chips are also labeled to what area of the body it should be attached and what organ it will simulate. Each of the The stethoscope is battery powered and looks very efficient to use. This item is commercially available to any one that is interested in in using this product for educational purposes. It includes the software application as well as patches and the modified stethoscope [1].

The next approach done were students from the University of Tennessee. The project is called Medical Sound Simuvest that uses a shirt with RFID barcodes. The user will use a stethoscope modified with a small scanner in the end where they will hover over the barcode. As it scans it will go through the application and depending on the audio file that was placed for that area of the body them it will emit an audio sound. This approach is similar in the way of using a shirt to attach these barcodes. The solution we will be using are RFID chips instead of barcodes [4].

7 System Overview

This system will have a shirt that contains a large number of RFID or NFC chips within it. When these chips are scanned they will send a unique ID number to a small on board computer that tells the computer what part of the body that tag is from. The computer will use that ID number to look at a table of audio files that each correspond to a specific part of the patient's body. Then after finding the correct audio file to play based on the RFID or NFC chip's ID number it will play that sound to the headphones that the user of the stethoscope is wearing. The table inside of the on board computer will be populated by an external application and then written to the system. The application will allow the user to upload new audio files and then select which parts of the body play which audio sounds.

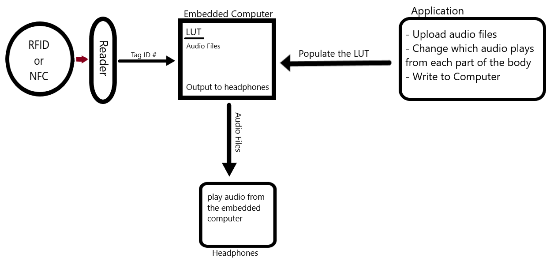

Figure 1: High level system overview

8 Roles & Responsibilities

The stakeholders of this project are all members of the team Michael Allen, Jamie Barajas, Efrain Morales Loya, Chau Nguyen, and Khoi Tran. Our sponsor from the smart hospital is Erica Hinojosa. The teams main point of contact is through Efrain Morales Loya who is handling the scheduling of sponsor and technical advisor meetings. Michael Allen, Cau Nguyen, and Khoi Tran are the computer engineering majors within the team and will be the part of the team responsible for the on board computer system, and making sure the hardware is what we need and working properly. While Jamie Barajas and Efrain Morales Loya are the computer science majors on the team and will be in charge of the software application determining what is needed and what is the best way to implement those changes. For all other parts of the project (The RFID shirt, the programming of chips, headphones, etc.) all members of the team will be responsible for making sure these goals get accomplished.

9 Cost Proposal

Our project, "RFID/Smart Stethoscope," is a significant innovation in the realm of nurse simulation training. The project's primary expenses fall into two categories: hardware development and software programming. In terms of hardware, we're focused on the production of a tag ID reader and the creation of a specialized T-shirt designed to hold RFID chips. Our software objectives involve programming the RFID chips and the tag ID reader to function together and creating an intuitive interface for the smart stethoscope simulation. We're grateful to have access to complimentary RFID resources from the RAID lab, which dramatically reduces our overall costs. Therefore, our main expenditures are the development of the tag ID reader and the T-shirt fabrication.

9.1 Preliminary Budget

Items	Cost
RFID chips	40
RFID Reader	55
Microcontroller	50
Headphone	40
Audio DAC	15
Battery	40
T-Shirt fabrication	35
Total Cost	275

Table 1: Budget Estimation

9.2 Current & Pending Support

RFID Smart Stethoscope funding sources:

- CSE Department (default funding): 800

10 Facilities & Equipment

For this project due to its hardware components the senior design labs will be used to design, test, and assemble our project. This will also give us a good location to meet and discuss the project in person. All team members will also meet and discuss the project digitally through the use of Microsoft Teams and Discord. Required equipment for this project will be access to 3D printers to help create parts for the smart stethoscope, and a sewing machine to create the shirt that will hold the RFID chips, as well as making the shirt adjustable so that standardized patients of different sizes will be able to wear it.

11 Assumptions

Assumptions are foundational in project management, serving as the underpinning beliefs or premises upon which planning and decision-making rest. They are treated as true for the sake of progressing with the project. However, it's vital to recognize that their validity may change as the project evolves. When assumptions prove incorrect, the project may face unforeseen challenges, requiring adjustments to the plan. For this RFID chip project, where the goal is to program chips with auscultation sounds for educational purposes, the team has identified several critical assumptions.

- It is assumed that the RFID chips chosen for this project possess the necessary storage capacity and data transfer rates to effectively manage the audio data of the auscultation sounds.
- The team assumes that the materials and fabrics in the shirts or wearable devices will not adversely affect the functionality of the RFID chips, thus maintaining sound quality.
- Another assumption is that the end-users, comprising students and educators, will have access to the requisite equipment, such as stethoscopes compatible with the RFID chips, and will possess the fundamental skills needed for their use.
- It is anticipated that the recordings of auscultation sounds will be of high quality, and that there will be no legal or copyright impediments to using them for educational purposes.

- The team assumes that the RFID chips selected will be consistently available in the market throughout the project, ensuring that there are no procurement delays.
- The budget allocated for this project is assumed to be adequate to encompass all costs, including those related to the RFID chips, audio data, development, testing, and integration.

The project team must routinely review and assess these assumptions. In preparation for any deviations that might emerge if an assumption becomes invalid, contingency plans are advised. Through comprehending and managing these assumptions, the project team can be well-equipped to address uncertainties and work towards the successful culmination of the project.

12 CONSTRAINTS

For this project, which entails programming RFID chips with auscultation sounds and creating an application for educational purposes, the following constraints have been identified:

- **Budgetary Constraint:** The project has an allocated budget of $800. This budget encompasses all expenses including the procurement of RFID chips, acquisition of sound files, development, and testing. The project team must ensure that expenses do not exceed this budget.
- **Timeline Constraint:** The project is to be completed within a specific timeframe. The project team must adhere to a schedule that ensures that all phases, from programming the chips to integrating them into the wearables, are completed within the allotted time.
- **Legal and Compliance Constraint:** The use of auscultation sound recordings must comply with legal and copyright regulations. This may limit the types of sounds that can be used and will require proper licensing where necessary.
- **Resource Availability Constraint:** the procurement of RFID chips and materials for wearable devices is dependent on vendor availability and supply chains. This may affect the project's timeline and costs.
- **Compatibility Constraint:** The programmed RFID chips must be compatible with commonly used stethoscopes and other equipment. This imposes limitations on the types and specifications of RFID chips that can be used in this project.

13 RISKS

The risks are evaluated based on their probability of occurrence, size of loss (expressed in days of project schedule delay), and risk exposure (calculated by multiplying the size of loss by the probability of occurrence).

Risk description	Probability	Loss (days)	Exposure (days)
Availability of suitable RFID chips due to supply chain disruptions	0.3	12	3.6
Incompatibility issues between RFID chips and stethoscope equipment	0.2	8	1.6
Insufficient storage capacity of RFID chips for extensive audio data	0.25	15	3.75
Limited availability of experienced programmers for RFID chip programming	0.15	10	1.5
Delays in sound file acquisition for programming the RFID chips	0.1	6	0.6

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The initial version of the charter will be delivered on June 28, 2023. The project charter will be updated as requirements, dates or when other major details of the project are changed.

14.1.2 System Requirements Specification

The initial version of the System Requirements Specification with be delivered on July 12, 2023. The SRS document will be updated whenever requirements change.

14.1.3 Architectural Design Specification

The initial version of the Architectural Design Specification will be delivered on July 26, 2023. The ADS will be updated as major changes to the project's design are changed.

14.1.4 Detailed Design Specification

The initial version of the Detailed Design Specification will be delivered on September 25, 2023. The DDS will be updated consistently as changes are made to the systems of the project.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added to the product backlog if as a team we determine during our sprint planning meeting that the item needs to be added. The priority of the item will be determined by team consensus, and will be updated as we see necessary. The backlog will be tracked via a shared google drive file among team members.

14.2.2 Sprint Planning

Before each sprint we will have a team meeting either in-person or online depending on teammate availability to determine what needs to be accomplished that sprint. There will be 8 sprints total 4 sprints in Senior Design 1 and 4 sprints in Senior Design 2.

14.2.3 Sprint Goal

Sprint goals will be determined during the planning meeting and will look at the priority of the items in our backlog to help decide what must be accomplished that sprint. We will hold a meeting with our sponsor early each sprint to inform them of the progress from the previous sprint and the goals the next sprint to come.

14.2.4 Sprint Backlog

In the planning meeting we will determine as a group the items we would like to add to the sprint backlog that sprint. These items will be based off of items on the project backlog and working towards those goals as a whole. The sprint and project backlogs will be maintain on a Trello board.

14.2.5 Task Breakdown

During the sprint planning meeting tasks will be divided out based off of team members individual skills and how they best apply to the task at hand. As well as based off of personal preference towards which topics they have significant interest in. Any unclaimed tasks will be divided to make it so that each member of the team is putting in the same amount of effort. Each member is responsible for tracking their own time working on the task and reporting it to a shared excel file for that sprint.

14.2.6 Sprint Burn Down Charts

Sprint burn down charts will be developed via a shared excel document posted to google sheets, and each member will update the burn down chart as they put in effort towards the tasks.

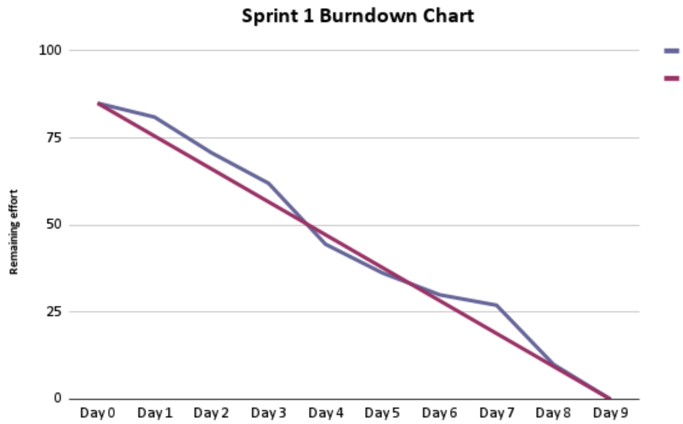

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

After each sprint we will hold a retrospective meeting where we will discuss what each member got accomplished, what they learned during the sprint, and any changes that may need to happen to keep the project running smoothly. In this meeting we will also determine what goals or tasks if any must be carried over to a future sprint.

14.2.8 Individual Status Reports

At the end of each week team members will give a status report to the other team members to help determine where they are and if any assistance must been given to them. These reports may also include a demo of what the team member as accomplished to help the other team members gain an understanding of what they have been working on.

14.2.9 Engineering Notebooks

Engineering Notebooks will be used to take notes, store brainstorming ideas, and hold any information we may research throughout the project. They will be used whenever we see fit with no mandatory minimum number of pages that must be filled.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will consist of the shirt that can hold the RFID/NFC chips, the chips themselves, The smart stethoscope that reads the chips and plays the audio, and the software to load the sounds onto the stethoscope. Testing may consist of simple demonstration or be testing within the smart hospital itself.

14.3.2 Project Poster

The poster will contain along with our names and team names the projects background, all of the key requirements, an example of our design, and the tools we used to develop this solution.

14.3.3 Web Page

The web page will be a blog post on the CSE Senior Design blog containing our team name, project timeline, list of team members, sponsor, background, and requirements. As well as all of our project files, and demo videos. A rough draft will be made in Senior Design 1, and a final post will be made during Senior Design 2.

14.3.4 Demo Video

The demo video will contain a step-by-step process of loading audio into the software. Then loading the audio files from the software onto the stethoscope, and finally it will show the user scanning different parts of the body via the RIFD/NFC shirt and the headphones playing different sounds based on the part of the body scanned.

14.3.5 Source Code

The type of version control for our system will mainly be used through GitHub,. through its use we will be able to have our source code on file and ready to use. The final product for our sponsor will be given the software on a USB flash drive or CD to download the software needed for the computers in the environment. This will have a ReadME file that will give instructions as well a all the terms needed for the software.

14.3.6 Source Code Documentation

Final documentation for the source code will be given in a PDF document. The code will include the functions of the areas in the program to identify what will go on within the program. This will also assist in troubleshooting or bugs that can occur with the use of the program. A program will be used to keep track on the classes and function written with their commented description.

14.3.7 Hardware Schematics

In this project we will be wiring the RFID/NFC reader to an embedded computer that can process the information received. Then we will wire the computer to a set of headphones that the user will use to listen to the output audio. Other wiring such as powering the computer and reader via batteries will also be included.

14.3.8 CAD files

A housing for the reader and on board computer will have to be modeled out in a CAD software like Inventor, and 3D printed to hold it all together. .STL or .OBJ files will be supplied within the closeout materials.

14.3.9 Installation Scripts

A USB drive with the files on it or a link to a GitHub will be supplied for the customer to install the software aspects on whatever computers they see fit to be able to write to the smart stethoscope.

14.3.10 User Manual

A demo video on how to use the smart stethoscope and the accompanying software will be supplied upon final delivery. Documentation for the software will also be included to explain the specific ways for the user to use it.

References

[1] Lance Baily. Cardionics provides simscope auscultation simulator for real-time standardized patient learning, Dec 2019.

[2] J Scott Christianson. Rfid stethoscope for medical sim, Sep 2017.

[3] Dan Maloney. Rfid stethoscope wheezes and murmurs for medical training, Feb 2017.

[4] Luke Stanley, Daniel Woods, Megan Hines, and Cris Cochran. Medical sound simu vest, 2022.