# WRAP, A Multimodal Interface for Geriatric Adults

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**ABSTRACT**
WRAP is an interactive waiting room kiosk developed and tested with geriatric adults that aims to both educate and entertain them during long waiting times that may occur while visiting a clinic. This multi-modal system demonstrates how a system can adapt to a user, without directly asking about their potential disabilities. In addition, we will discuss the various iterations that our system went through before the development of our prototype, and how user feedback/testing played an integral role in the development of our system. Through user testing we received positive feedback about the current prototype of WRAP. Users are looking forward to the future deployment of the system.

**Author Keywords**
Multi-modal Interfaces, Synthesized voice, Geriatric education.

**ACM Classification Keywords**

Human factors, Speech recognition and synthesis, Medical information systems.

## INTRODUCTION

In today's society, as medical technology becomes more advanced, and the average expected age increases, a large population group is growing fast, geriatric adults. As this group rapidly increases, geriatric clinics and doctors' become more and more busy within their daily schedule, creating even less time for doctor patient interaction. To combat this issue, healthcare education needs to be provided through a different medium, such as a waiting room kiosk. WRAP, the Waiting Room Associate Program, hopes to expand on previous work done in this field, and shed some new insight onto creating and attracting geriatric adults into using such systems.

Early in the development of WRAP, we observed the waiting room of a geriatric clinic in Boston Medical Center. This specific clinic has about 1,100 patients who have an average age of 76, with 16% of them over age 85. Although the range in the educational background of these patients ranges greatly, their computer knowledge was in general on the lower end of the spectrum. Additionally, in this specific clinic, a kiosk aimed at providing healthcare education to geriatric adults had been installed. This kiosk was developed by the Relational Agents Group at Northeastern University as part of a four year study of geriatric adults and healthcare education and a continuation of the virtual agent described in their early papers [1].Over the course of our hour long observation; we noticed a few key issues that the currently deployed system had.

The issues that Tanya, the kiosk in place at BMC currently had ranged from minor ones such as bugs related to user input, all the way to users getting frustrated with the system and leaving in before their interactions was completed. While interviewing some of the patients in the waiting room, few of them had noticed the system or used it before. This was especially surprising since the kiosk had been deployed in the waiting room for many months prior to our observational study. In addition, many of the users stated they did not understand the purpose of such a system, and felt as if the computer was not for them to use. Also, many of the users complained about the problems they had using the system due to their disabilities, which ranged from hearing loss to the inability to stand for long periods of time.

To address some of these issues, we began development of WRAP, and designed it with two main features in mind. The first of these two features was that the user needed to feel as if the system was accommodating to their needs, instead of the user having to accommodate to it. At the same time, we did not want to discourage users with disabilities from using our system, and wanted the system to adapt to the user's needs transparently. The way we attempted to accomplish this goal is by asking users a series of questions early on in their interaction with the system. Their responses to these questions would then be used to govern what features the system should present in order to create a more enjoyable interaction between the user and the system.

Additionally, we wanted to make sure that we try to attract as many users as possible to the system, and hopefully educating a larger population, those who explicitly are interested in learning more about health care. To accomplish this, we integrated the ability for users to check their waiting time. The waiting time was based on the volume of patients that are currently scheduled with the doctor that day, and gave the user an estimate on how long they had before seeing their doctor. After we have presented the user with their waiting time, we then give them the freedom to choose their topic of interaction. These choices range from healthcare information to entertainment.

Finally, by following some of the basic heuristics for dealing with geriatric adults found in Hawthorn paper [2], we aimed to develop and field test our design at an old age home near Boston Medical Center. The goal of this user testing sessions was to see how effective our design principles were, and how to improve on them.

## RELATED WORK

As mentioned earlier, WRAP was heavily influenced by the kiosk installed by the Relational Agents Group at Northeastern University. The goal of their study was to educate and motivate older adults to increase the amount of walking they did on a regular basis. This not only showed that such interfaces can be effective at motivating older adults, but similar systems can be effective with the geriatric population regardless of the participants health literacy level.

In addition to Bickmore et al. paper, many of the design principles and interface design ideas were heavily influenced by Hawthorn's paper on the possible implications of aging for interface design. In this paper, Hawthorn mentions many basic rules to follow when developing interfaces for older adults on topics ranging from font size to button layout. By following and building upon these theories, we developed additional features in our system to make sure we accommodate for their specific needs. This includes features such as the ability to hear any page as spoken text and making sure that the most important text found in each page is not located within their peripheral vision.

Finally, many of the heuristics and guidelines used to design WRAP are based on Dix [3], Nielsen [4], and Rosson and Carrol[5] texts on user interface design. Although these texts did not focus specifically on working with older adults, both of these textbooks contained information tailored towards the development of proper user interfaces. The goal of these interfaces was not only to accommodate the largest range of users, other principles as well such as minimizing the load placed on user's cognitive memory by not relying on complex multi-level modes and other such features. Additionally, the feedback we received during from the graduate students during the heuristic evaluation of our study was roughly based upon Nielsen's work on the Ten Usability Heuristics.

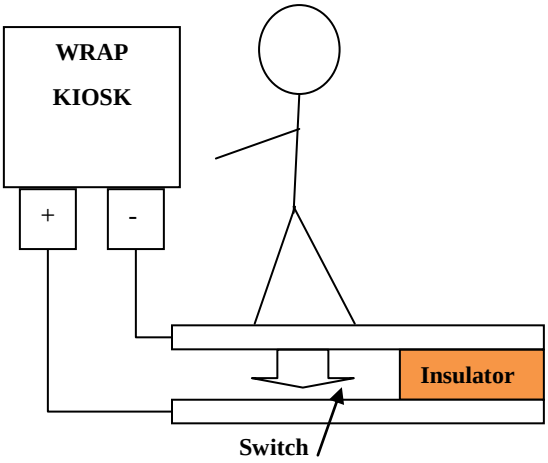


**Figure 1 User sensor of WRAP**

After the observational study at Boston Medical Center, we decide on a number of features that should be included in our prototypes of WRAP. Each feature was designed to help resolve the problems we observed during our study and are listed in the next section.

## DESIGN

### Automated Detection of Users

WRAP tries to prompt use of the system by engaging people it detects near it. Using the sensor as shown in Figure 1, WRAP detects when users are close enough to the kiosk, when the circuit is complete. Upon detecting the user, WRAP says "Welcome to BMC, please press the screen to continue.", so that users might notice the existence of the system and try to use it. Additionally, the sensor also detects when a user leaves the system and reverts back to its main screen when no users are detected.

### Help

After the initial screen the system hosts an instruction screen. This screen gives the user the purpose of the system. It also mentions the provision of the Speaker button at the top right corner of the screen. This screen mentions the various topic and sub-topics under each of them. This is presented to help the user find the information they require. The system assumes that he user has no prior knowledge about computers, thus gives an example of a button and explanation of how to use it.

### Estimate the waiting time

Another essential feature of WRAP is its ability to give patient their approximate waiting time. This helps user plan out how they want to spend their waiting time. Because we give them this choice, we provide users with the option to end their interaction with the system early. We provide this option because we do not want users to feel forced into

using the system, and want them to feel as if it's there option to continue to use the system or not.

**Multimodal output**

Multimodal output is a significant feature of WRAP. Since users may have different preferences and interests, we try to adapt the system to fit their needs. Additionally, by getting their preferences, we try to detect potential problems the user may have such as hearing loss or poor vision. To do this, we ask the user early in their interactions with the system which activity they enjoy the most, watching TV, reading the newspaper, or listening to the radio. Based on this input, we set WRAP to one of three modes. The TV mode assumes the user prefers visual and auditory input, and replaces the content of each page with video clips describing the contents of the page. The next mode, newspaper, assumes that the user enjoys reading, so the contents of each page are displayed as text only. Finally, we have radio mode, which assumes the user prefers to hear the content of each page. In this mode we automatically read the content of each page to the user. By doing this we hope to encourage users to use the system without feeling as if their disabilities, if any hindered their use of the system.

**Provide Health Information and Entertainment**

WRAP not only provides the medical information that can be found on the flyers that hanging on the wall of BMC, but also provides entertainment to users during their waiting time. We understand that patients have to endure very long waiting times, which can range to beyond 45minutes from what we observed. In these cases, we wish to provide as much enjoyment to the users as possible, and try to keep their interest in the machine for as long as we can. To try and provide as many topics as possible to the user, we have included healthcare information highly relevant to older adults, dealing with topics such as fall prevention and vaccines. Additionally, we allow users to check their information about Zodiac and Numerology as a way to relax.

Also, we provide information about what Zodiac and Numerological information is. Both these systems require the user to input their date of birth. The date of birth entered by the user is validated by the system. It returns an error in case the user provides an invalid input. Zodiac Information: Based on the user input, the user is classified as one of the 12 Zodiac Signs. A brief description about this sign is presented to the user. Numerological Information: the input date received by the user is used to calculate the life path number associate with the date. These can range from 1 through 9. Typical characteristics associated with this life path number are presented to the user.

**Present Information related to the reason of visit**

WRAP is design to provide the most relevant information for users based upon their reason for visit. Instead of listing out all of the options for the user to choose from, we try to address any potential issues we detect the user may have through a series of questions. If the user selects that they are here to see a doctor, when they try and get healthcare information, we ask them what their reason for visit was. Based on this response, we will provide the most relevant information associated with the reason they are seeing the doctor. If they were just there for a checkup, system will show them the normal list of options. Also, we make sure not to limit users based on this, and give the users option to select from a list of topics if they desired to.

**Read aloud**

For those who have poor eye sight, WRAP has an indispensable feature that can be used to aid the user with their interactions with the system. At every page, there is a big button at the top corner of the screen with a speaker icon. If the user wants to hear the contents of the page, they just need to touch this button, and the system reads through the text on the current screen. This feature was found to be very valuable during our user testing.

**Back at any point**

We know that slips are almost impossible to design in any system. To combat this problem, we provide a way for users to undo any miss-operations. In the system there is always a Back button which will bring the user back to the previous page, so that user can redo what he or she just missed. Additionally, this allows users with computer knowledge to feel more comfortable with the system since the back button interface resembles ones found within web browsers. This similarity improves the usability of the system for power users who want to switch between different topics quickly.

**Other System Design Features**

The system has the below listed features especially for the targeted primary users:

- System uses very simple and plain English without any technical words.
- The Screens are not cluttered with too much of text.
- System has consistent look throughout. Three buttons at the top of the screen, the text in the center of the screen and user input buttons below the text.
- The text is always centered to the screen.
- System uses large fonts too aid visibility of the text.
- System uses huge buttons throughout.

### Design Improvements

After designing these core features, we conducted Paper Prototyping and Heuristic Evaluation to examine our design implementations. After each evaluation we had made some change to improve WRAP's usability.

### Paper Prototyping

Three participants (2 female and 1 male) between the ages of 60 and 90 with none or little computer experience were recruited from an old age home to participate in testing the paper prototype. White Sheets of size 5"x8" were used to depict the various stages in which the system would be. To carry out the test, one of the team members played the role of computer who changed the screens as the user performed some action. One of us played the role of the facilitator who gave briefing about the system and also explained about the tasks users were supposed to perform. Additionally one of us acted as moderator taking notes about the tasks and encouraging the users to talk their minds about the interaction. Participants were given a brief description about the system and its purpose: WRAP is designed to be placed in hospital clinics. The purpose of this system is to aid people visiting the clinic by either educating or entertaining them while they are waiting.

Participants were given four tasks:

(1) You come into clinic after a minor fall to see Doctor A at 11 am. Your favorite hobby is reading newspaper. You have to check your waiting time and learn about fall prevention.

(2) You are accompanying a friend to clinic. Additionally your hobby is listening to radio. You want to get Zodiac information to utilize your waiting time.

(3) You are accompanying a family member to a clinic. Additionally your hobby is reading newspaper. You want to know more about vaccines

(4) From the current point of the system get Numerology information.

### Results of Paper Prototyping

Users found the system simple and easy to understand. One major observation noted was: the users were not able to understand that Fall Prevention and Vaccines would be under Health Care Tips. We assumed that it is very obvious to find that information under health care tips. To fix this issue we revisited our introduction page which gave a brief description about the system and what the system could do. We included a line mentioning that Fall Prevention and Vaccines will fall under Health care tips. The other feedback we received was that the screen which required the user to enter their Date of Birth accepted the day field before the month. This was then fixed to accept the month before the date.

| Severity | Issues Raised # | Duplicates # | Issues Solved # | Issues Unsolved # |
|---|---|---|---|---|
| Catastrophic | 26 | 6 | 18 | 2 |
| Major | 3 | 0 | 3 | 0 |
| Minor | 48 | 8 | 37 | 3 |
| Cosmetic | 8 | 1 | 7 | 0 |

**Table 1. Heuristic Evaluation Results**

### Heuristic Evaluation

Before the Heuristic Evaluation, the system was developed to at least support the tasks listed under paper prototyping. Maximum of the Graphical User Interface (GUI) was implemented. WRAP was evaluated by 6 graduate students.

Briefing and tasks given were same as for Paper Prototyping. Evaluations were done using Nielsen's Ten Usability Heuristics [4].

### Results of Heuristic Evaluation

The results were as mentioned in the Table 1. We received a total of approximately 120 comments. Out of which 33 were good and 87 were issues that required some action. The issues were classified in the following categories:

*Catastrophic Issues*

Out these 87, 26 fell under catastrophic according to the evaluators. There were total 6 duplicates and only 3 required actual fixing. The issues were:

- Some of the language used in the system was improper; this was fixed by rephrasing the sentences.
- Some pages did not read the text. This was due to missing sound files and was resolved.
- Some of the questions asked by the system were ambiguous. These were rephrased along with corresponding buttons.

Some issues were left unresolved due to technical issues or time constraints. The issue raised was regarding the functionality to mute the system from reading the text as per users will. This functionality required use of some basic libraries. This is potential future work for the system.

*Major Issues:*

There were total 3 issues under this category. Only 1 of it required actual fix which was regarding the consistency of the font size throughout the system. This issue was resolved by maintaining consistent font size.

*Minor Issues:*

Out of 48 issues raised, 15 required fixes which were mostly concerned with re-phrasing the language used by the

system. 8 were duplicates. Three of them were unresolved. These included:

- Static information in the entertainment section. The TV mode handles this shortcoming and has been added as future enhancement of the system due to some issues mentioned further.
- Restricting the user input on dates. This has been marked as future enhancement of the system.
- Choice to mute the voice as mentioned above.

*Cosmetic Issues:*
Out of 8 issues raised, 2 were unresolved and 1 was a duplicate. Issues raised were mainly regarding the white space in the system and the button spacing. These were fixed by adjusting the text towards the center of the screen. Also the spacing between the buttons was increased and maintained constant throughout the system.

## IMPLEMENTATION

WRAP is developed in Java and uses Java Swing as the presentation API. The prototype is designed to run as a Java applet so any Computer with Java Standard Edition installed can easily run the system in their web browser.

WRAP is designed to operate like a slide show. In the system, there are a lot of pages. Every page decides the next page to be shown to the user. From the system's perspective, it sees all contents as a page, and is only responsible for updating to a new page when a request is made. Also saves information that has to be communicated to relevant pages. Based on this architecture, we develop and implement a framework that provides the following features: dynamic loading and unloading of pages, global variables that shared between the pages and load multimodal content based on users' preferences.

### Page Operations

Pages are the core concept of the system. All states of the system are represented as pages that will be shown. Every page has a unique name that can be referred by other pages. Before the system starts, all pages need to be registered with the framework, so that the framework knows where the pages are located when referenced. Every time a new page is requested, the framework creates a new instance of that page, and then loads it into the visible area (in WRAP, it's the main window). Pages can take advantage of the fact they are recreated each time. They are called by initializing themselves with some dynamic content, like displaying specific Zodiac information. The framework also maintains a stack of opened pages to support the go back feature. With the help of "Back", user can go back to previous viewed pages at any time.

### Global Variable

For sharing data between pages, the framework comes with a global variable feature. It has a shared space for pages to store data in, which allows them to communicate with each other. For example, when the user answers they are here to see a specific doctor, that information is stored as a global variable, and can then be retrieved at a later point to determine how long the user will have to wait for their appointment.

### Show Preferable Content

Another essential feature supported by the framework is its ability to show or play content based on user's preference. This feature is can be exhibited in multiple ways, such as playing the contents of the page to a user via voice if they requested the system to do so. Additionally, if the user clicks the speaker button at the top corner of the screen, the framework will try to play the corresponding sound file for the page.

Because of these powerful features and simple architecture, WRAP is a very scalable system. New page with new content can be added to the system with little effort. Also, sound file can be automatically played without altering a single line of code. This improves the maintainability of the system.

## EVALUATION

After implementing the Paper prototyping and heuristic evaluations the system had undergone significant changes. Also the missing functionality such as reading the text from some the screens was implemented. The missing content from the Fall Prevention and Vaccines screens was in place. A working prototype of the system was ready. This prototype was the then tested with the potential users of the system (Usability Testing). This resulted in revealing few usability issues. The detailed explanation is mentioned further.

### User Testing

Three participants (2 female and 1 male) between the ages of 60 and 90 with no or little computer experience were recruited to participate in the study. The testing was done on a 13" HP Tablet Touch Screen System with a screen resolution of 1280x 800**.** The participants belonged to the typical primary user group of this system.

They were given a brief description about the system and each was given 4 tasks as mentioned in the paper prototyping. Half an hour was allocated for these four tasks. One team member played the role of facilitator and explained the tasks to the user. Other team members took notes. The methodology used was Thinking Aloud. Users were given little prompting in order to complete the tasks within the allotted time limit of half an hour.

### Results of User Testing

The users were asked for feedback after they completed the tasks. The users look quite satisfied with the system. Some of the user quotes are:

*"It is nice and easy"*

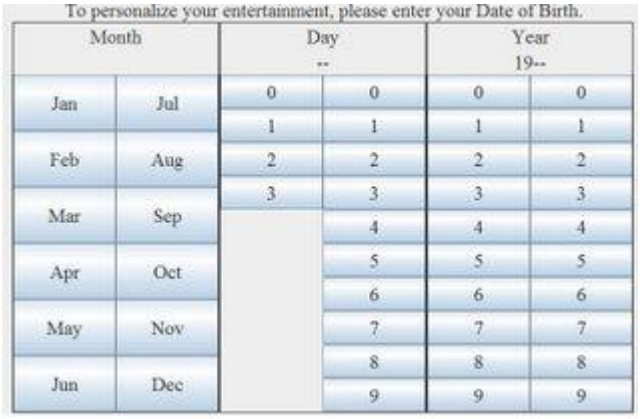


**Figure 2.Date of Birth Screen (Iteration 1)**

*"For elderly people it was very easy to understand"*

*"I hope this system is out soon"*

We faced an unexpected issue during the usability testing. Users found the Date of Birth screen confusing whereas there was no issue with it during paper prototyping. The users were confused with the two columns of button (see Figure 2) for the entry of the two fields of date (day and year). They seemed to be using the incorrect column of buttons for input. They pressed right side of rows to input the left part of the field (E.g. for 12, 1 forms the left part of the field). Two out of three, two users faced this issue. One of them pressed buttons associated with year field to enter the day field. Based on the user feedback we decided on the use a single set of buttons instead of two. We came up with a paper prototype of this interface to check the user's reaction on it. Users liked this interface (see Figure 3) over the earlier one. To reduce the confusion about the association of set of buttons with the field we added visual cues to the system. On pressing a button from any of the sets, the field associated with it would change its color. This acted as a feedback to the user input. Besides this, once the user has entered the date a confirmation is asked whether the input was the desired one. This prevented the system from a probable miss.

During the re-design phase of the system we came up with a third interface. This interface required the user to select the field (month, day or year) they wish to enter (see figure 4). We believe by doing so the user will not be confused about which field they entered. If time permitted we would have tested the two designs mentioned above and then include the interface with best results. At present the system uses the interface shown in Figure 3 as it was designed as per the user's feedback.

The other usability problem faced by the users was regarding the meaning of the terms Zodiac and Numerology. One of three users was not aware about the term Zodiac. Also none of the participants were about the Numerology. To aid user understanding an additional screen explaining these terminologies was included. The

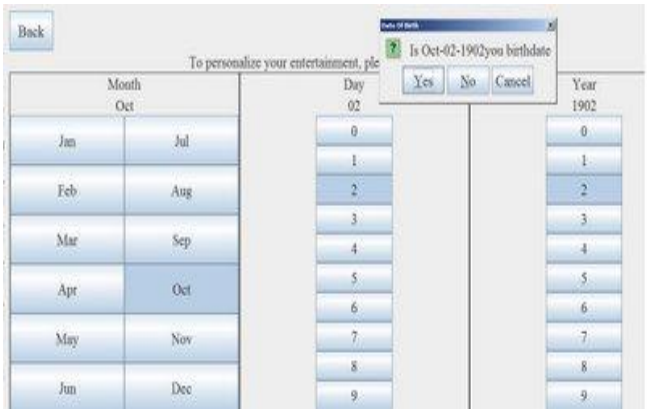


**Figure 3. Date of Birth (Iteration 2)**

Screen accepting the choice between these two options had a link to this page. Thus only the users that require this explanation would access this page for clarification.

The last usability issue reported was accessibility to all the options the system could provide for its use. Especially during the fourth task which required the user to back from the vaccine information screen to get Numerology information. Though the system provided an option to return to the topic selection couple of users suggested this functionality to aid navigation.

### Usability Assessment Methods

After the usability testing, Questionnaire methodology was used to assess usability of the system. A short questionnaire with couple of open ended and couple of close ended questions was also given to the user after completing the four tasks. The results were as shown in Figure 5. These were used to measure the user satisfaction.

*Open Ended Questions*

Question1: Was the system easy to use?

Question2: Would you like to use this system in the future?

All the three users replied positively to these Questions.

*Closed Ended Questions*

Question3: Do you have any suggestions for the system?

Two out of three users suggested change the Date of Birth screen. This suggestion was implemented in the final working prototype. Besides this one of the users to include games and sports watch in the system for entertainment. Also under Health care tips, Medication information was requested. Pill's information with numbers rather than the color (which changed according to the manufacturer) was suggested. Other user requested updates on the Vaccines information in the system. Information regarding flu shots being given.

Question4: Did you find any parts of the system difficult to understand? (Mention them below)


**Figure 4. Date of Birth Screen (Suggested Re-design)**

Two out of three said that Date of Birth screen was little confusing. Besides that the whole system was very easy to understand.

## REFLECTION

After iterative development of WRAP, following were very important lessons learnt in an empirical way:

- Involving the users during early design phase of the system helps early detection of usability problems.
- Early detection of the issues reduces the number of usability problems during final Usability testing.
- Design changes made before the inception of the development phase of Software development reduces the overhead as compared to the design changes made after the development.
- Iterative process might involve extra efforts at the beginning of the iterations, like making the paper prototypes which do not form part of final system deployed. Eventually it ends rewarding with less number of usability problems raised.
- Designers can never think anywhere near like the users.
- Getting the users involved during the early stages helps in better understanding of users and their expectations.
- Never make any assumptions during the design features. What is obvious to designers may not be obvious to the users. User's perception is different from that of the designers.
- Usability problems discovered during different phases of software development is better than finding all of them at the very end.

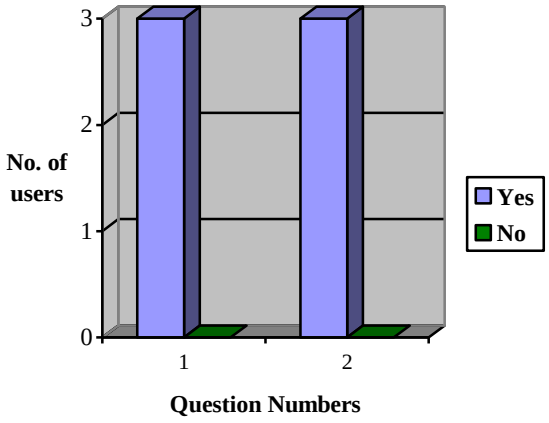


**Figure 5. Result of Questionnaire**

- System is never sufficiently tested. Different evaluation methods reveal different issues. Every individual has different cognitive capability which might lead to different usability issues.
- There is always a scope for improvement.

If we ever did this again, we would include one more step of user testing between the paper prototyping and usability testing. The users were not involved when the GUI was implemented. This would early detection of few usability problems like the one detected in the Date of Birth screen. If the heuristic evaluations were carried simultaneously with another round of the user testing with GUI with similar tasks used during paper prototyping, this would help fix few usability issues with minor changes in the system.

## FUTURE WORK

Due to some technical difficulties and time constraints the TV (video mode) of the system was not completed. This is potential future work for this system.

The waiting time calculation can be incorporated with additional interface for the Receptionist. Receptionist will have to update the people waiting in queue to meet a particular doctor. Combining this information along with the appointment time of the user, a simple algorithm can be used to calculate the approximate waiting time of the user.

Owing to the fact that the system is simple and IVR implementation of the system can be setup. This will help the users to check their waiting time while they are at home and decide waiting at their residence instead of the clinic. This will help reduce the major complaint of the long waiting time issues at the Geriatric clinics.

The system currently has limited options for entertainment. This can be extended to include some games or sports information as suggested by the users.

The functionality to stop the system from reading the text according to the user's will.

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