

Historic Voiceworks



FINAL WORK - NICOLE HORWARD - JUNE 2019

Historic Voicebot

Final Work

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Abstract

The Historic Voicebot is an interactive installation that allows museum visitors to talk to a historical figure through both chat and voice call. Through this project, I aimed to create a new experience that will boost interest, engagement and involvement by providing interactive content tailored to each individual museum visitor.

The concept of the Historic Voicebot is based on extensive research about interactive installations and chat- and voicebots. First, I looked at how new technologies, like AI and Machine Learning, are currently being used in the context of museums. Additionally, I've explored which qualities and attributes a voicebot needs in order for it to accurately represent a historical figure. I've researched which type of interactive installation would be best suited for this concept and which hard- and software would be required to develop it. Lastly, I also looked at how visitors experience communicating with a voicebot in a museum setting.

The concept was brought to life in an ever evolving agile manner. The development phase was done in small parts with an emphasis on continuous improvement.

The result is a prototype that consist of both a touchscreen with animations and a vintage phone, which can be used to talk to a historic person, in this case Ada Lovelace. Lovelace was the first computer programmer, and through the Historic Voicebot you can ask her all sorts of questions about her life, her work and the museum.

Overall, I'm proud of what I was able to achieve and I believe that the Historic Voicebot is a great example of how new technologies can be implemented to create fun and unique experiences for museum visitors.

Preface

INTERACTIVE MUSEUM VISITS

A museum visit can be a wonderful way to explore the world and learn about topics like art, history and science. However, a museum visit can also become monotonous and boring very quickly, which is a big problem for both the museums and their visitors.

To fully enjoy a museum, visitors need to relate to the story that's being told, they need to be immersed in the experience. (Weller, 2015)

One way of doing this, is by making exhibitions interactive. Everything around us has become more interactive and connected over the years. People, especially younger generations, also expect this from museums, although this isn't always the case.

Another way of making a museum relatable, is by tailoring the content to the visitor. Currently, all visitors are presented the same information in exactly the same way, despite their differences in interests, knowledge and age. To truly engage visitors, it's necessary to connect with them and alter the information that's offered to fit to their needs.

For example, it's very frustrating if you have a specific question about a historic person or an exhibition, but the answer is nowhere to be found within the museum itself.

No matter how interesting the pieces on display are, visitors that can't relate



to the exhibition won't be engaged or involved. When visitors don't grasp the story the museum is trying to tell, they are less likely to recommend the museum, leave a positive review or come back again.

Historic Voicebot

AN INTERACTIVE CHAT- AND VOICEBOT INSTALLATION FOR MUSEUMS

The Historic Voicebot is chat- and voicebot installation that engages visitors using interactivity, storytelling and tailored content. Visitors can talk to a historical figure, through either chat or voice call, to ask any questions they might have.

The interactive installation consists of a touchscreen and a vintage telephone. The display will feature an animated version of the historical figure, with subtitles underneath allowing all visitors to follow the conversation.

Visitors can ask questions through either the telephone or via the touchscreen. To call, they simply need to pick up the telephone and start talking.

For those that prefer chatting, there are buttons on the screen with the most popular questions, so these can quickly be asked.

Use case

Initially, I set out to work with an existing local museum, but as my search for a collaboration partner yielded no results, I'll be working with a fictional, yet realistic use case for the prototype of the Historic Voicebot.

The Museum

The museum for this use case is a STEM oriented museum. I've chosen this topic because I'm personally in-

terested in science, technology, engineering and mathematics. On top of this, it's also in line with my study of Multimedia and Communication Technology.

Museums that fall into this category include the Deutsches Technikmuseum in Berlin, the Deutsches Museum in Munich, the Heinz Nixdorf Museumsforum in Paderborn and the NEMO Science Museum in Amsterdam.

The Historic Person

The historical figure for the prototype of the Historic Voicebot is Ada Lovelace. I've chosen Lovelace because she fits perfectly within a STEM oriented museum. Her work was, especially during her lifetime, unrecognised because it was ahead of its time. Lovelace was the first computer programmer, and yet many people haven't heard of her, which is why a voicebot of Ada Lovelace would be a great addition to any STEM museum.

The exhibition

For this use case, the Historic Voicebot of Ada Lovelace will be placed in an exhibition about the evolution of computers and technology. Lovelace's voicebot will quite possibly stand out amongst the other items on display, not only because it's an interactive installation, but she also doesn't seem

to come from an era of computer technology, the early 19th century.

The purpose

The purpose of the Ada Lovelace voicebot is to engage museum visitors in a new and interactive way. The Historic Voicebot will provide content tailored to the individual visitor, and let them explore the parts of the exhibition that they're interested in.

The idea is that visitors can ask Lovelace all kinds of questions and have a casual conversation with her. This way, visitors will be immersed in both her story and the exhibit itself in a unique way. A summary of possible visitor interactions can be found in the appendix.

Research

HOW CAN NEW TECHNOLOGIES, LIKE AI AND MACHINE LEARNING, IMPROVE THE INTERACTIVITY AND VISITOR EXPERIENCE IN MUSEUMS?

The main focus of my final work is exploring how new technologies, like AI and Machine Learning, can improve the interactivity and visitor experience in museums.

Therefore it's no surprise my main research question is: How can new technologies, like AI and Machine Learning, improve the interactivity and visitor experience in museums?

In order to thoroughly research this, I will first answer the following sub-questions:

1. How are AI and Machine Learning currently being implemented in museums?
2. How can a historical figure be accurately represented by a voicebot?
3. Which type of interactive installation is best suited for a voicebot in a museum?
4. Which hard- and software is required to develop this?
5. How do visitors experience communicating with a voicebot in a museum?



How are AI and Machine Learning currently being implemented in museums?

NEW TECHNOLOGIES APPLIED IN MUSEUMS

New technologies like artificial intelligence (AI) and machine learning are being implemented in several different ways by museums. Typically, these efforts can be divided into two categories with each its own use case.

The first way new technologies are being used, is by implementing machine learning to analyse museum data. Museums have typically collected vast amounts of data over the years. Manually analysing samples and records would take trained professionals many years to complete, making it a tedious, time-intensive and very expensive task. By using machine learning algorithms, large amounts of data can be analysed quickly and patterns can easily be detected. (Smith, 2017)

A great example of this is the National Museum of Natural History in Washington D.C. Their botanical collection, consisting of items like pressed flowers and grasses, contains no less than five million specimens. By installing a camera and conveyor belt construction, they are able to digitize 750,000 specimens each year. Neural networks are then able to categorise and distinguish the samples with an accuracy of over 90%. After this process is done, the curators will use all this data to look for new patterns on a global scale, something that was unimaginable just a couple of years ago. (Smith, 2017) (Ciecko, 2018)

The second way new technologies are being implemented by museums, is by using artificial intelligence to aid visitors. This is usually done by developing chatbots, most of which are Facebook chatbots. (Ashri, 2017) (Berger, 2017)

However, chatbots in museums are nothing new. In 2004, Max the conversational agent was created, becoming one of the more famous bots to guide visitors in museums. Since then, it's become easier and cheaper to create chatbots, which is why they've been making a comeback. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004)

The Historic Voicebot falls into this last category of artificial intelligence that aids museum visitors. In the chapter "Competition Analysis", I've taken a closer look at some of the chatbots being used in museums and the research that's been done about them.

To summarise, new technologies like AI and Machine Learning are currently being implemented by museums to either analyse the vast amounts of data they have, or to aid the visitors.

How can a historical figure be accurately represented by a voicebot?

SHAPING THE CHARACTER OF CHAT- AND VOICEBOTS

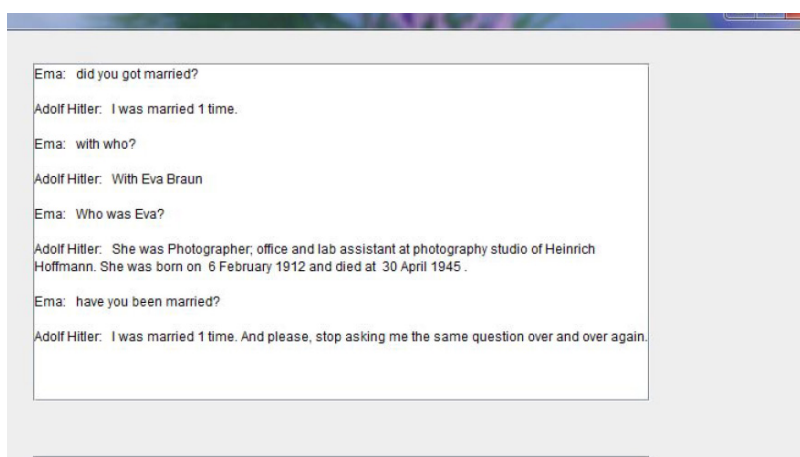
In order for the voicebot to work successfully, it needs to accurately represent a historic person.

According to the research paper “Evaluating Quality of Chatbots and Intelligent Conversational Agents”, there are a number of attributes that determine the quality of a chatbot. This list of properties was created by summarizing all relevant previous works about chatbots, making this an extensive list. The full list of quality attributes for a chatbot can be found in the appendix. (Radziwill, Benton, 2017)

Two of the features mentioned on this list, are detrimental to creating a voicebot that depicts a historical figure.

First and foremost, the voicebot needs to be knowledgeable. It needs to be able to answer specific questions about the historic person and maintain a conversation about a relevant topic. (Radziwill, Benton, 2017)

In 2013, two researchers attempted to do just this. By purely using data gathered about a certain historic figure from websites and other plain text sources, they designed a chatbot that could accurately answer questions and hold a themed discussion. They accomplished this by using fact extraction software to turn the written text into facts, which were in turn added to the chatbot.



Whilst this chatbot was very knowledgeable, it only presented facts in a very monotone and matter-of-fact way. It had all the functionalities, but no charm or personality. (Haller, Rebedea, 2013)

Coincidentally, the second crucial property of the voicebot is that it must have its own personality and be able to have convincing, natural interactions with users. (Radziwill, Benton, 2017)

Generally speaking, there are two ways a bot can be given a personality. Either it can be created automatically by mimicking an existing person, or a personality can be created manually, using a framework to guide the process.

In 2017, it was attempted to generate four chatbots with a personality using neural networks. They were made to represent characters from popular TV

shows: Barney from How I Met Your Mother, Sheldon from The Big Bang

Theory, Michael from The Office, and Joey from Friends.

To do this, scripts from these four shows were used to train a machine learning model. The data from the TV shows, which was about 50.000 pairs of dialog and response per show, turned out not to be enough to create fully functional chatbots. This meant that the chatbots couldn't take the context or the previous parts of the conversation into account when responding.

However, they were able to create four bots that respond to the last user input, each in their very own way, very clearly in the style of the TV character they mirror. (Nguyen, Morales, Chin, 2017)

Another way of giving a chatbot a personality is by manually creating



one. Smestad designed and tested a framework to create chatbot personalities based on four components: the brand the chatbot represents, the needs of the users, the role of the chatbot and an appropriate personality model.

Whilst manually crafting a personality for a chatbot requires a lot of work and writing skills, the efforts do seem to pay off. According to Smestads research, a chatbot that has a per-

sonality significantly improves both the user experience and the overall perception of the brand, compared to a chatbot that provides the same functionalities but has no personality. (Smestad, 2018)

To conclude, in order for a historical figure to be accurately represented by a voicebot, the bot needs to have enough data about the person to answer specific questions and maintain a conversation, whilst also convey-

ing the personality of the person it represents.

Michael (The Office) Rude, abrupt Thinks he's the best boss 	Barney (HIMYM) Very bro-y Likes to hit on women Drinks a lot 	Sheldon (BBT) Socially awkward Thinks other people are stupid 	Joey (Friends) Not very smart but kind A player 
<p>> hi 4_michael have a seat . > who are you? 4_michael i 'm just a friend . > what's your name? 4_michael michael scott. > do you have a girlfriend? 4_michael i have a lot . > tell me a joke 4_michael no , i 'm not gonna tell you . > you are boring. 4_michael you are . > where do you work? 4_michael right here . > tell me michael. why do you work here? 4_michael i thought i had to do something better . > bye bye michael 4_michael bye .</p>	<p>> who are you? 2_barney i am the master of the most barney . > hi barney! 2_barney hi , have a drink . > oh thanks. what drinks do you have? 2_barney whatever what do you do ? > i'm a student. 2_barney a . . . buddy . > yeah? 2_barney sleep with her mom ? > lol no 2_barney because she 's not happy . > ha ha okay. how's work? 2_barney okay . > just okay? 2_barney oh , okay . > what do you think of that girl over there? 2_barney do not even try to try to that girl . > noooooooooo 2_barney legendary !</p>	<p>> hi 1_sheldon hello . > who are you? 1_sheldon i 'm sheldon . > what's up? 1_sheldon i see how i could do . > what can you do? 1_sheldon i have to tell you a secret . > tell me. 1_sheldon no . > what do you like to do for fun? 1_sheldon i want to leave . > to go home? 1_sheldon no . > how are you doing? 1_sheldon i just wanted to sleep . > sleep! 1_sheldon penny , i am getting too much for you .</p>	<p>> hey what's up 4_joey hey ! > how are you? 4_joey oh , oh , i 'm fine ! > what's your name 4_joey joey , joey . > who are you? 4_joey oh , joey 's joey ! joey ? > joey joey joey 4_joey what ? > tell me a joke. 4_joey a woman . > a woman is not a joke! 4_joey oh , i am very sorry .</p>

Which type of interactive installation is best suited for a voicebot in a museum?

DESIGNING INTERACTIVE INSTALLATIONS FOR MUSEUMS

Interactive installations can be found in many museums, but not all are equally successful. According to the research paper “Learning from Interactive Museum Installations About Interaction Design for Public Settings”, there are a number of things to take into account. (Hornecker, Stifter, 2006)

First of all, most people visit museums in groups, and sharing the experience with others plays a big role in the overall visit. Therefore it’s crucial that the interactive installations in museums support group activities, both in terms of the activity itself and the physical space.

Activities that stimulate interaction, communication and learning from each other, are great for groups. Another way of encouraging teamwork is by providing different roles that group members can take on during the activity.

For the physical aspect of the installation, it’s important that there’s enough space to accommodate all the members the group, and provide them with a good view of the exhibit. Touchscreens are a good way to do this, because it’s both interactive and it’s easy to see what others are doing from a distance. (Hornecker, Stifter, 2006)

A second thing to take into account, is that all the exhibits in a museum are competing for the attention of the visitors. The first ten seconds of the interaction need to give people a reason to stay, otherwise they will move on to the next thing that catches their eye. So, it’s crucial that the the first interactions are fun, simple and straightforward, to give users a quick win experience. After this critical first impression, the activity can slowly become more and more complex. (Hornecker, Stifter, 2006)

The third thing to note is that, according to the observations made by Hornecker & Stifter, the only exhibits in the museum that reached all types of visitors, were the hands-on, interactive exhibits. These interactive installations were able to attract visitors of all ages and interests, even from a large distance. The same can’t be said for all the other things on display. Elderly people often avoided anything that looked like a computer, walking around these installations in a circle. (Hornecker, Stifter, 2006)

Mixed-media installations, that combined more traditional haptic input devices with modern technologies, proved to be the most successful. This combination carried elderly visitors over the threshold of using a computer, whilst also encouraging children and teenagers to interact with objects other than a screen. This meant that one installation was able to create interest

and curiosity about an unfamiliar topic for all types of visitors, which is what a museum is ultimately all about. (Hornecker, Stifter, 2006)

The points mentioned above are crucial for any installation in a museum. So what would the ideal interactive installation for a voicebot in a museum look like?

First of all, the interactive installation should be inclusive. As mentioned in the Target Audience Analysis, which can be found in the appendix, a very diverse group of people regularly visits museums. The voicebot should naturally be accessible to as many visitors as possible. Therefore, people should be able to ask questions and receive the answer in a number of different ways. (VRIND, 2017)

In this case, questions can either be asked by speaking into a microphone, by clicking on a frequently asked question, or by manually typing a question. The answers will be spoken through a speaker and appear as text (subtitles) on a screen.

On top of this, the voicebot should ideally be a mixed-media installation, as this has proven to be a successful way of engaging a broad audience. For the Historic Voicebot, the traditional haptic input device will be a vintage telephone, which visitors can pick up to ask questions and hear the answer. The modern technological aspect of the installation will be a touchscreen, via which visitors can write their own questions, and read the answers given by the voicebot.

Thirdly, the first interactions with the voicebot need to be fun and simple, to quickly engage visitors. With the Historic Voicebot, people only have to pick up the phone or click on one of the frequently asked questions to start a conversation with the historical figure. This should give them a quick win experience. To catch the eye of passers-by, an animated version of the person will be present on the touchscreen. It will move around and invite people over for a quick chat.

Last but not least, the space around the voicebot should be big enough to entertain a medium sized group. Whilst not everyone is able to talk to the voicebot at the same time, people will be able to follow the conversation via the touchscreen display.

Which hard- and software is required to develop this?

THE ARCHITECTURE OF THE HISTORIC VOICEBOT

Creating an interactive installation with a voicebot requires a number of different components.

The technical architecture of the Historic Voicebot was created based on the functional analysis, which can be found in the appendix.

The Historic Voicebot consists of three main parts: the interactive installation, the frontend and the backend.

Interactive Installation

Raspberry Pi - Google AIY Voicekit

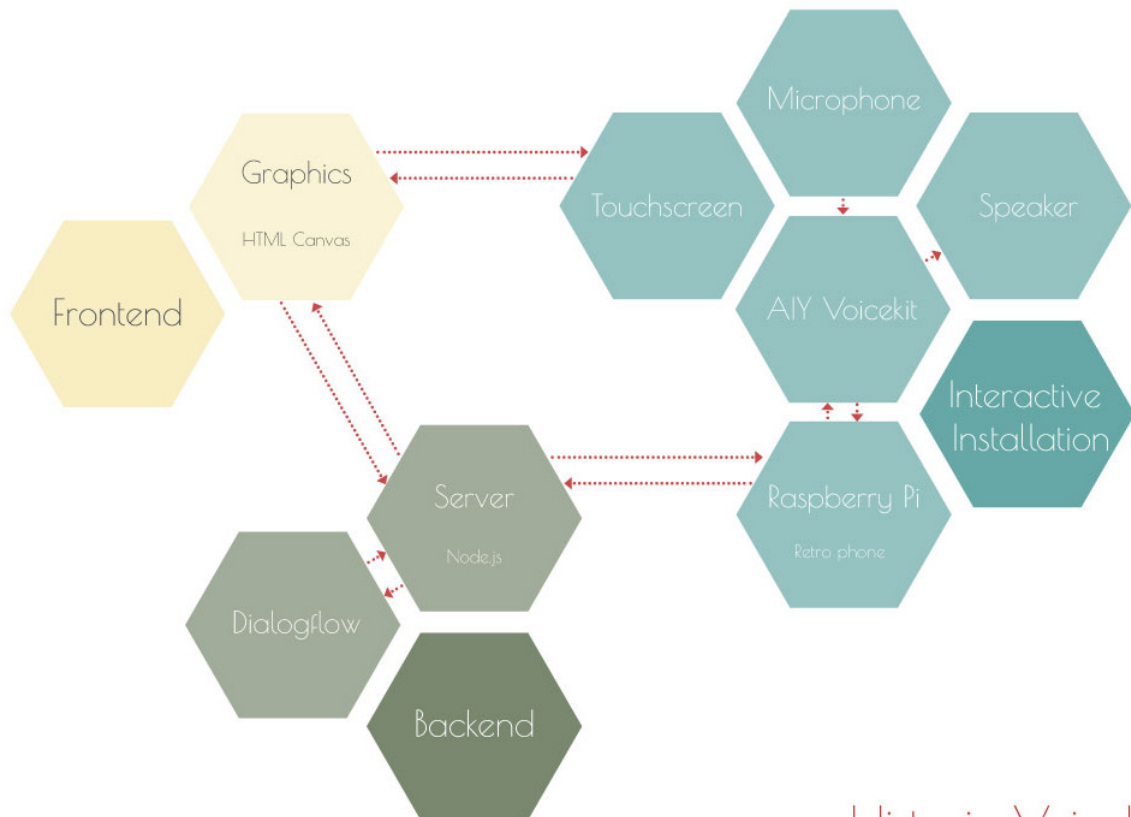
A crucial aspect of the interactive installation is that it can capture speech, so visitors can ask questions. It also needs to be able to reply, by using a speaker.

A very practical and easy setup to achieve this is the Google AIY Voicekit. This is a DIY kit to play around with

voice-controlled AI, containing a Raspberry Pi, a microphone and a speaker.

I've chosen the AIY Voicekit, because it's easy to use and it can be integrated into almost any type of physical installation. On top is this, it's also a very affordable solution.

The Raspberry Pi will capture speech with the microphone, turn this into text and send it to the server in the backend. The answer returned by the server will be turned into speech and



Historic Voicebot Architecture

announced via the speaker attached to the Raspberry Pi.

The microphone and the speaker of the AIY Voicekit will be integrated into a vintage telephone, creating an interesting physical object that will catch the eye of museum visitors.

Touchscreen

The second aspect of the interactive installation is a touchscreen. Museum visitors can use this screen to select a frequently asked question and start a conversation with the historical figure. This screen also shows the output of the Voicebot as text (subtitles), as well as an animated figure that represents the historic person.

Backend

Server

The main part of the Historic Voicebot, the brains of the operation, will be provided by the Node.js server. The server orchestrates everything, and is connected to Dialogflow, the frontend graphics and the physical phone.

Dialogflow

Dialogflow is Google's conversational agent software, which perfectly integrates with the AIY Voicekit, which is one of the reasons why I've chosen

it. It also offers a lot of practical features, including making small talk and webhooks.

Dialogflow will get the text input from both the touchscreen and the microphone from the server, and return an answer. The answer is based on 20 question and answer pairs that have been added to the knowledge base, as described in the chapter Development later on.

The answer will be sent to both the Raspberry Pi for voice output, and to the HTML canvas frontend for graphical output.

Frontend

Graphics

The frontend consists of a HTML Canvas page that shows the output of the Voicebot, via an animated version of the historic person with subtitles.

Visitors can also use this screen to select a frequently asked question to start a conversation with the historical figure.



How do visitors experience communicating with a voicebot in a museum?

HUMAN-ROBOT INTERACTIONS

Human-robot interactions have been the subject of many movies and many more scientific studies. But how would people experience communicating with a chat- or voicebot in a museum?

When Max the conversational agent was created and placed inside the Heinz Nixdorf MuseumsForum in Germany back in 2004, researchers attempted to answer exactly this question.

Max was a human-like 3D character that appeared on a screen and had conversations with museum visitors. Visitors could communicate with him via a keyboard. This way speech recognition problems in a noisy museum were avoided, and it made sure that Max could only talk to one visitor at a time.

Max also displayed nonverbal behaviour, including waving, smiling and other facial expressions. This behaviour was linked to his “emotional system”. For instance, after repeated insults, Max would be in a very bad mood and leave the screen to de-escalate rude visitor behaviour. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004)

Throughout a two-month period Max’s interactions with people in this real-world setting were recorded and analysed. The results of this were pretty fascinating, it turns out that people were very likely to use human-like conversation strategies, like greet-



ing Max, making smalltalk and asking questions like “How are you?”. In about a third of all conversations visitors took the time to say goodbye to Max before leaving, even though they could just walk away to end the conversation. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004)

Another interesting thing to note is that people started testing the intelligence of the bot by asking questions, answering in a foreign language or giving obviously wrong answers, for instance saying their name is “Michael Jackson” or their age is “125”.

Also a lot of flaming was recorded, around 11% of all user input was abusive, insulting, pornographic or politically incorrect in nature. As a result, Max would get annoyed and leave the screen an average of 3 times a day. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004)

Overall though, people treated Max like a person and tried to interact with him in a nice and human-like way, which is a good indication that visitors would be open to speaking with a historical person via voicebot in a museum setting.

Implementation

THE PROCESS OF CREATING THE HISTORIC VOICEBOT

Tools

To guide the process of creating the Historic Voicebot, I used a number of different tools. To organise my to do's and share them with my promotor, I used the planning tool Trello.

On top of this, I used Toggle to keep track of my time.

Managing the code and creating reliable backups was done by using GitHub.

Last but not least I documented the whole process, including a number of YouTube videos, on my Final Work blog.

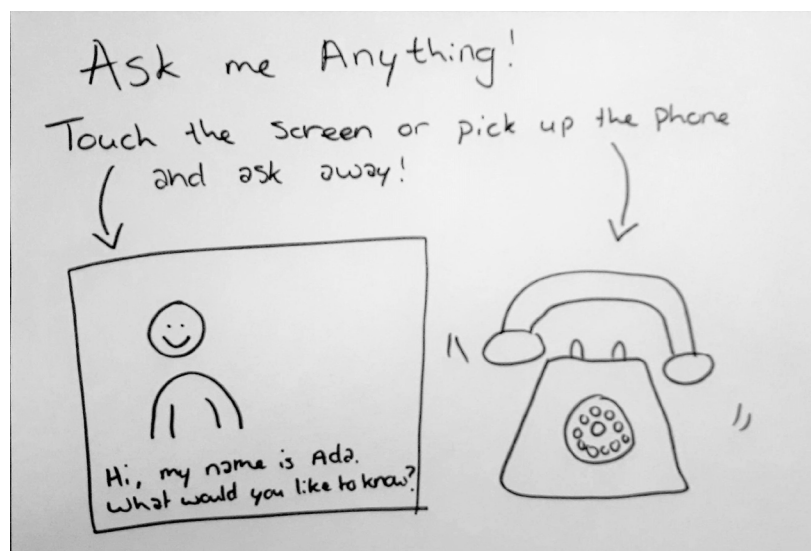
Concept

Based on the research, I came up with the first concept of the Historic Voicebot. As you can see in this sketch, the basic idea was combining a touchscreen with an old telephone that would allow museum visitors to ask questions and talk to a historic person.

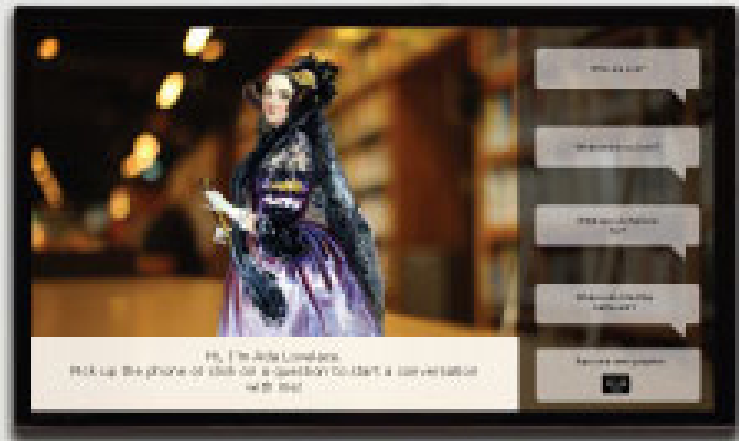
The touchscreen contains an animated version of the historical figure with subtitles of the spoken text. The screen also has buttons to quickly ask a question and the option to use an on-screen keyboard to type your own question.

Research

The whole process of the Historic Voicebot started with answering the five research questions based on literature studies, as described in the previous chapters.



Ada Lovelace





Concept

Of the Historic Voicebot

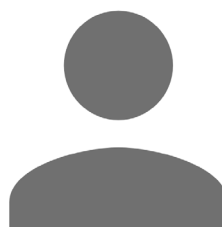
Initially, I envisioned this as a big interactive installation within the museum. In this mock-up, you can clearly see it is intended to be centrepiece, a real show-stopper.

Throughout the process, the idea slowly evolved into a smaller version of this installation, mainly because the success of the concept leans heavily on personal interactions and therefore works best for smaller groups. For a museum, the impact of the Historic Voicebot would be the greatest if there are multiple versions of either the same or different historical figures within the building. Lastly, the prototype of the smaller version would be more realistic to achieve with a limited budget and within the timeframe of my Final Work.

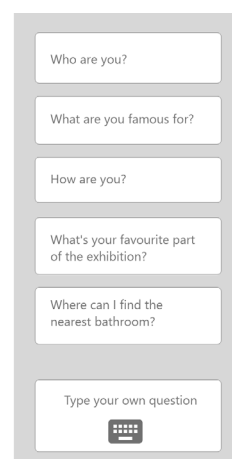
Design

THE EVOLUTION OF THE HISTORIC VOICEBOT DESIGN

With the changing of the concept and through user testing, the design of the touchscreen also evolved over time. A number of experiments and designs can be seen here. The most notable change in the design was going back to basics by using an original painting of Ada Lovelace for the animations and leaving the background and portrait orientation of the painting intact. This really set the right atmosphere for the Historic Voicebot going forward. With this, the placement of the subtitles and the FAQ buttons was also reworked.



I was born more than 200 years ago, on the 10th of December 1815.





Ada Lovelace



Historic Voicebot





Architecture

THE TECHNICAL ARCHITECTURE OF THE HISTORIC VOICEBOT

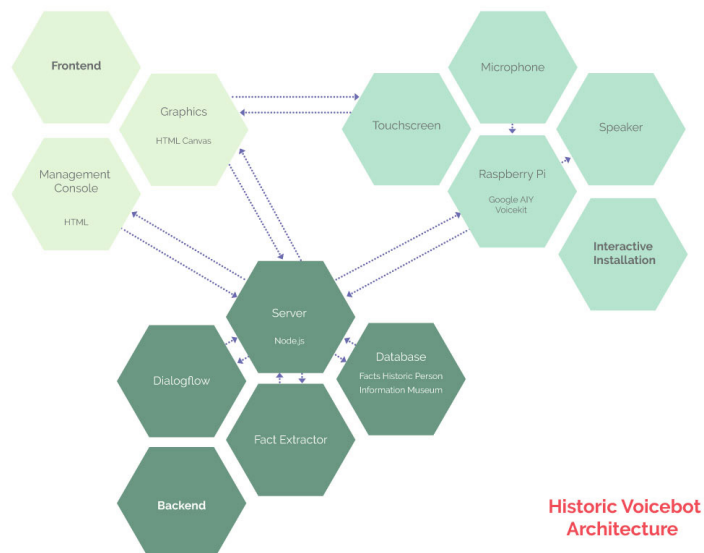
Based on the answer to the fourth research question, “Which type of hard- and software is required to develop this?”, I started the development phase of the Historic Voicebot.

I created the first prototype following the initial architecture outlined here. After demonstrating this first version at my evaluation in January and discussing it with a number of people, I realised that this architecture wouldn’t be scalable. To allow for the Historic Voicebot to be rolled out on a larger scale, I sat together with some IT experts and came up with a new and improved architecture using multiple servers to support bidirectional communication and webhooks.

Whilst this would certainly be more scalable than the original solution, I ran into one main problem during the development. In order for the main server to send updates to each device, it needs to know and keep track of the IP addresses of each of the connected devices. This can certainly be done by writing IP address management logic, but this is far outside of the scope of this prototype.

After experimenting with Dialogflow as described in the next chapter, it turned out that the fact extractor and the database to store these facts were no longer necessary, hence these elements were also removed from the solution.

Overall, I simplified the architecture during the development phase. A detailed description of the solution is outlined in the chapter “Which type of hard- and software is required to develop this?”.



Chatbot

CREATING THE CHATBOT

Chatbot

To create the conversational agent in Dialogflow, I tried and tested a number of different approaches to get the most accurate and reliable answers possible. I also set out to automate as much of the dialog creation as possible.

First of all, I attempted to create the chatbot by only uploading documents to Dialogflow. I downloaded Ada Lovelace's Wikipedia page and added it as a knowledge base. Dialogflow really struggled with extracting the correct answers as they often made no sense, as you can see in the provided screenshot.

The next approach replacing the Wikipedia page with two articles written about Ada Lovelace. The results of adding these more descriptive texts were slightly better. The answers contained more relevant information, however it was often hidden in a large paragraph of text.

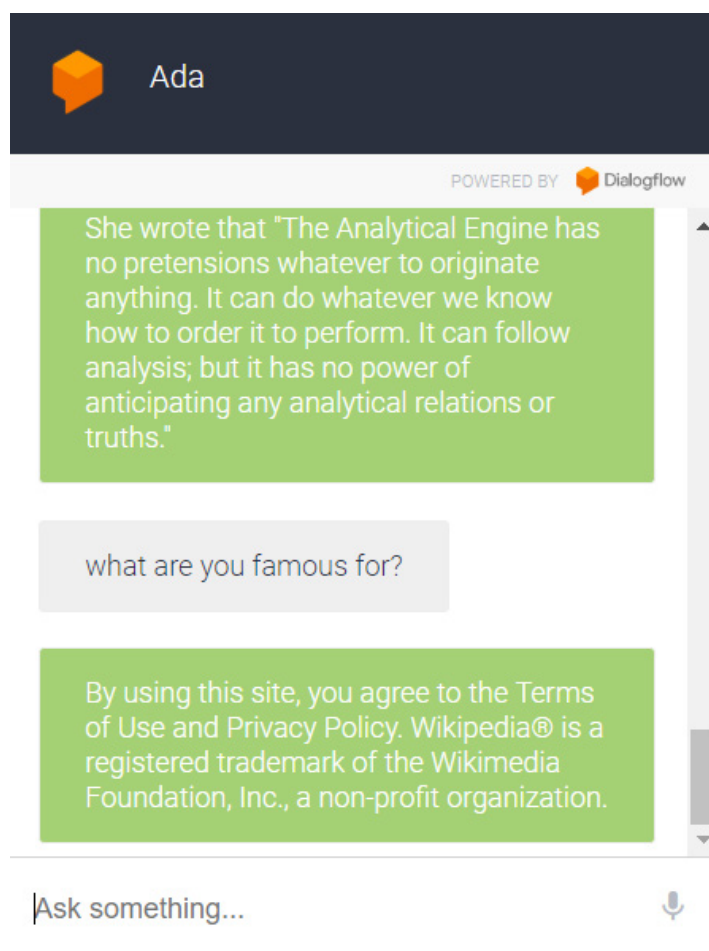
Another way of adding knowledge to a Dialogflow chatbot is by adding a CSV file with question and answer pairs. Based on the website of one of the museums I researched, I created 10 Q&A pairs and added these to Dialogflow. This approach turned out to work the best, as the chatbot could easily answer questions related to the ones in the Q&A document.

Additionally, I tried a hybrid version of the two where I added both the dense texts and the Q&A file to the knowledgebase. This had a very strange effect, as mentioned in Dialogflow's documentation (Google Cloud 2019):

"Confidence scores are not yet calibrated between FAQs and knowledge base articles. We suggest using only one of them at a time, as the best result may not always score the highest."

Dialogflow had troubles picking an answer, usually resulting in a fallback answer like "Sorry, could you say that again?". It also caused a large delay in giving a response, making it very very slow.

After discovering that Q&A pairs work the best when creating a chatbot with Dialogflow, I did some research on how this could be achieved automatically. A lot of people have been working on this problem, including Google



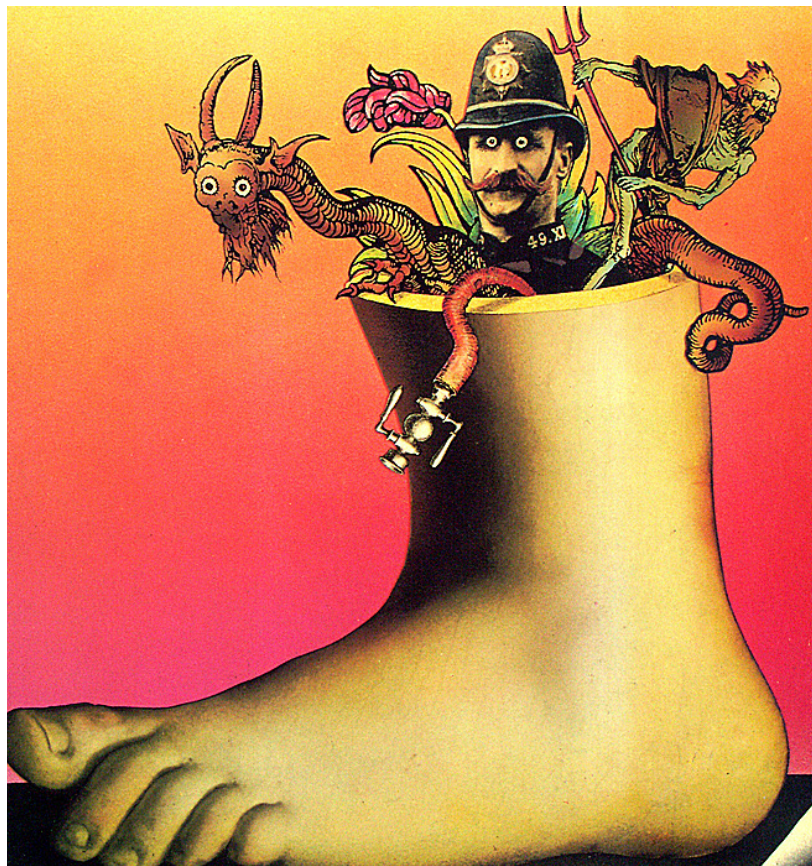
who has patented the idea of generating question and answer pairs from conversational texts (Google Patents, 2014). From what I've read, it's more or less achievable when you train a neural network and use a certain dataset, one that consists of a number of questions to which the answer is a segment of the corresponding text. Priya Dwivedi and her team were able to do this using the Stanford Question Answering Dataset, for example. (Dwivedi 2018)

Although it would be a great asset to automatically generate question and answer pairs about a historic person, setting up and testing a neural network is outside of the scope for the Historic Voicebot project. For the prototype, I've manually created 20 question & answer pairs and added these to Dialogflow. As you can see, Ada Lovelace's answers are now correct, timely and reliable.

Server

As mentioned in the architecture, the Node.js server is the brains of the operation, providing the connection between Dialogflow and the different devices.

For the first prototypes, the server was running locally on my laptop. For the current version, the server is deployed using Amazon Web Services.



Animations

For the animations of the historic person on the touchscreen, I was inspired by the work of Monty Python's Terry Gilliam. I opted to use cut-out animations because they can be created with just one image of the historic person. This is practical, as not all historical figures have been depicted in numerous pictures or paintings and it also requires no additional artwork to be created. This technique also ensures

the same look and feel, regardless of the historical figure.

The animations for the prototype were created by cutting various elements, like the arms, eyebrows and chin, out of a painting of Ada Lovelace using Adobe Photoshop. Each of these elements were individually placed on the HTML Canvas frontend. The TweenJS JavaScript library was used to move and animate these cut-outs based on the input from users and the responses from Dialogflow.

Interactive Installation

CREATING THE HISTORIC VOICEBOT

The interactive installation consists of two main parts, the touchscreen and the phone.

Touchscreen

I used a medium sized touchscreen placed inside a matching picture frame. As mentioned before, the screen was originally going to be placed landscape, but as the concept changed, so did the orientation. The final prototype has a touchscreen

standing up which shows the animations, subtitles and provides buttons for visitors to ask questions. In the earlier stages of the project, the concept also included the option to type your own question via an on-screen keyboard. However, this idea did not fit with the new layout and the limited size of the touchscreen, so in the end I opted to remove this feature.

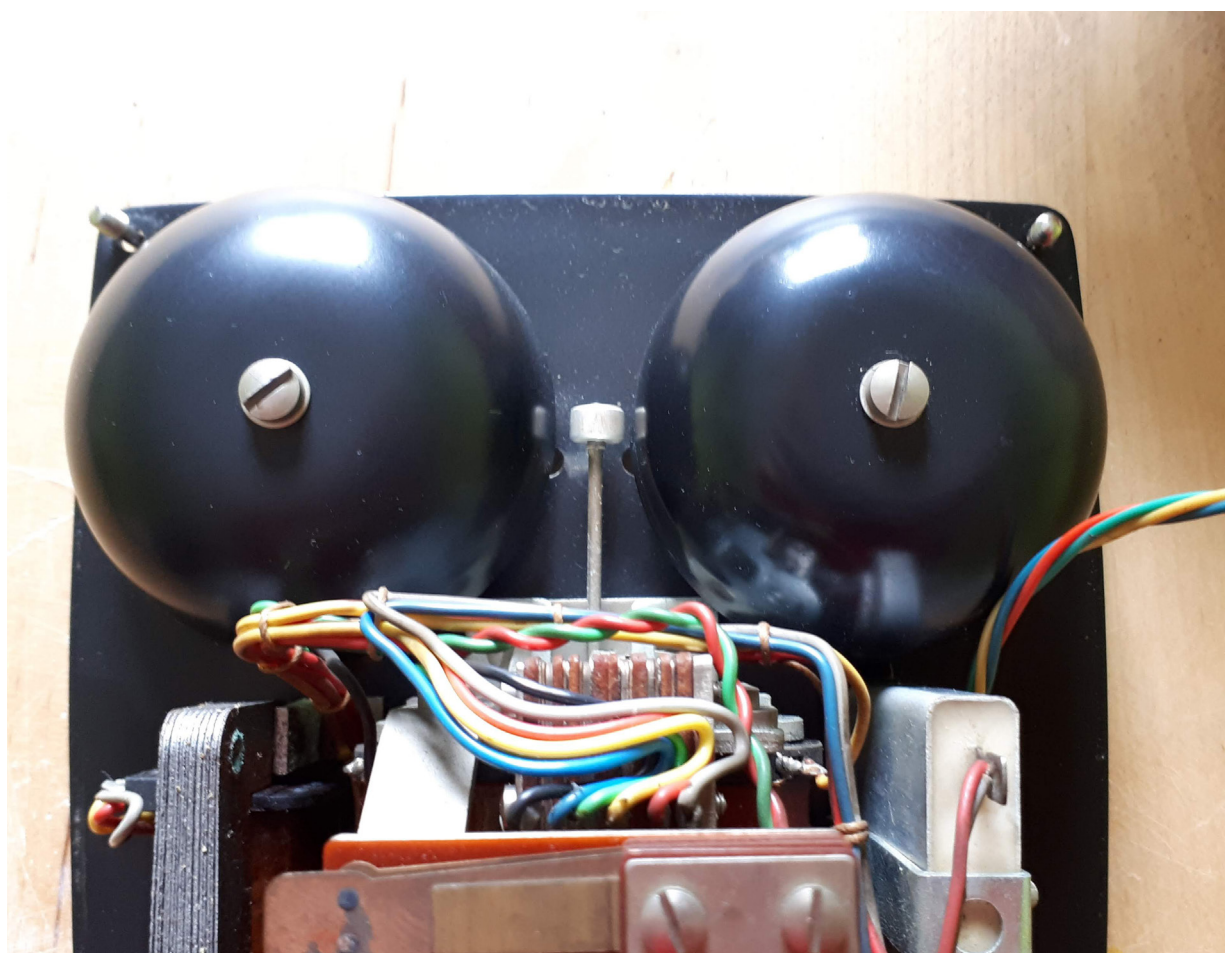
Phone

For the phone I tried to find one that was used during the Ada Lovelace era. Not only were phones invented long after she died, really old phones are hard to come by. Nevertheless, I was able to purchase an old Ericsson rotary phone produced in the 1960's.

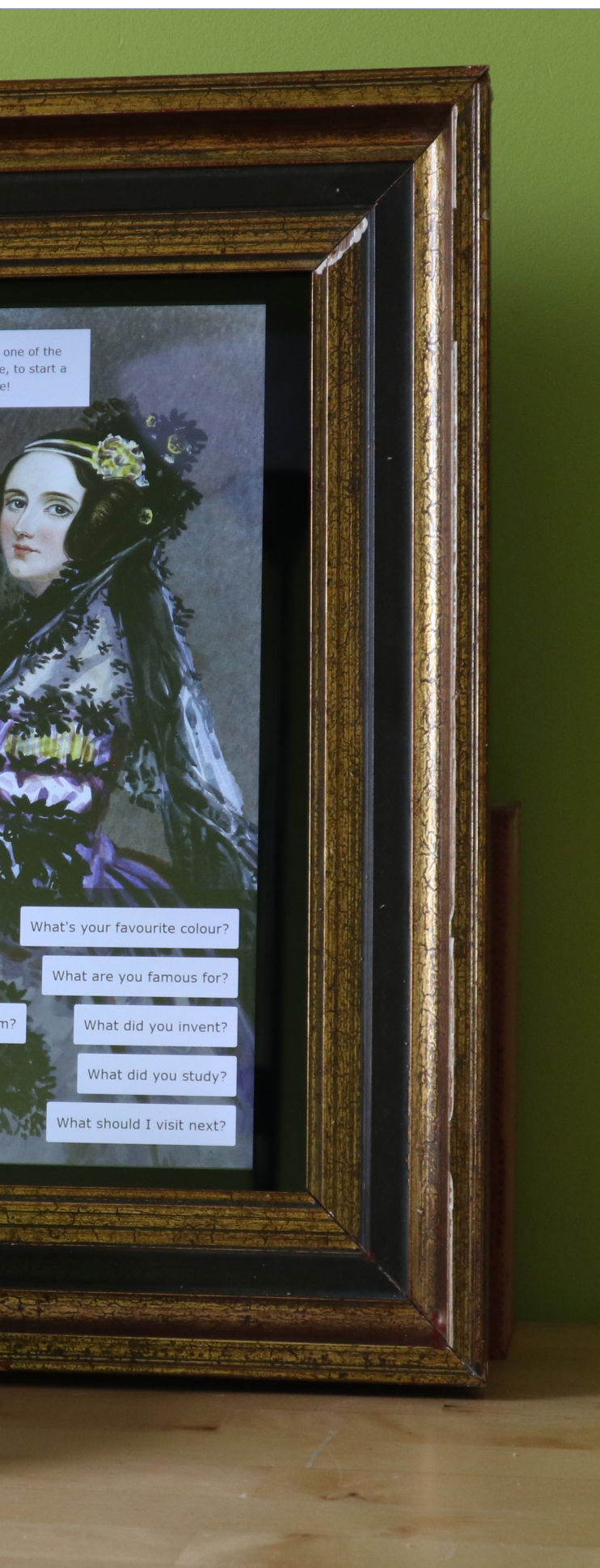
To create the working voicebot, I aimed to place the AIY kit inside the phone whilst reusing as many of the



original features as possible. I was able to reuse the speaker and the two bells inside the phone. The rotary disk was also kept intact, but is currently not functional. I updated the microphone that was inside the handle to a modern one, to be able to accurately capture the audio input. I replaced the old phone cord with a new one to be able to correctly wire the new microphone.







Result

The Historic Voicebot

The hard work and effort of the research, design and development phases have paid off and resulted in a working prototype of the Historic Voicebot. Throughout the whole process, the concept, idea and design have evolved and improved greatly. It was certainly not an easy task, but I'm proud of what I was able to achieve given the time and budget constraints.

Conclusion

HOW CAN NEW TECHNOLOGIES, LIKE AI AND MACHINE LEARNING, IMPROVE THE INTERACTIVITY AND VISITOR EXPERIENCE IN MUSEUMS?

New technologies, like AI and Machine Learning, are currently already implemented by museums to either analyse the vast amounts of data they have, or to aid the visitors. (Ashri, 2017, Berger, 2017, Ciecko, 2018, Smith, 2017)

However, these technological developments can also be used to create immersive experiences tailored to each individual visitor, which is what I set out to do with the Historic Voicebot.

First of all, I developed an interactive installation which was designed to be accessible to as many visitors as possible, by providing a number of different ways people can ask questions and receive the answer. (VRIND, 2017)

On top of this, the Historic Voicebot is a mixed-media installation consisting of both a traditional haptic input device, in this case the vintage phone, combined with a piece of modern technology, a touchscreen in order to appeal to a broad audience. (Hornecker, Stifter, 2006)

Furthermore the look and feel of the installation, including the ringing phone and moving animations, are enticing and catch the eye of museum visitors. The first interactions with the Historic Voicebot are fun and simple to quickly engage visitors and give them a reason to stay. (Hornecker, Stifter, 2006)

Lastly, I ensured that the Historic Voicebot is able to answer specific questions and maintain a conversation, whilst also conveying the personality of the person it represents to create an accurate and convincing experience. (Radziwill, Benton, 2017)

Overall, I believe that the Historic Voicebot is a great example of new technologies can be implemented to create fun and unique experiences for museum visitors, which will boost engagement and involvement with not only the historical figure but also the story and the message the museum is trying to convey.



Hi, my name is Ada. Click on one of the questions or pick up the phone, to start a conversation with me!

Who are you?

What's your favourite colour?

When were you born?

What are you famous for?

W

Appendix

Target Audience Analysis

WHO ARE MUSEUM VISITORS?

The target audience for the Historic Voicebot are people that visit museums. This is a very diverse and very broad audience, which makes the situation very interesting but also very challenging.

According to research published by the Vlaamse Regionale Indicatoren VRIND 2017, more than half of the Belgian population visited a museum, exposition or gallery in 2016. This number has been very stable for the past number of years and they predict it will stay that way in the years to come.

There are no significant differences between gender and the amount of museum visits. Age is also not a determining factor, the number of visits per age group is roughly the same. The only exception to this are people over the age of 75. In this age category only a quarter of people visited a museum in 2016.

What does seem to determine the amount of museum visits per year is the level of education. Of people who have completed university level education, 80% visited at least one museum, compared to only 20% of lower educated people.

Another interesting fact is that 40% of people visited a museum within Belgium and roughly 30% visited a museum abroad.

To summarise, the target audience for the Historic Voicebot consists of people who:

- Are any age
- Are any gender
- Have a variety of different education levels
- Live either locally or abroad
- Speak one or more different languages
- May or may not have mental or physical disabilities

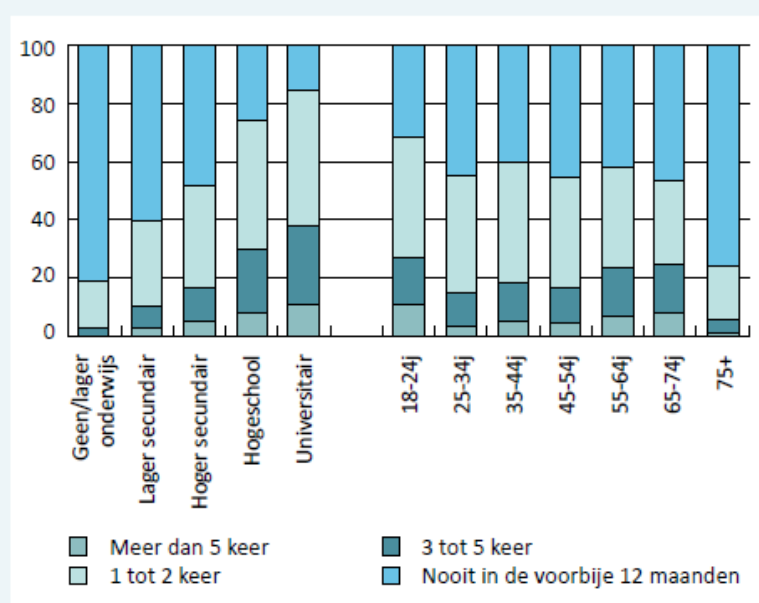
- Have a range of different interests
- Have other levels of knowledge about certain subjects

One of the main reasons for developing the Historic Voicebot is that the visitors of a museum are so different, and by keeping this in mind I hope to create an inclusive interactive installation that appeals to everyone.

(VRIND, 2017)

4.30 Museumbezoek naar opleiding en leeftijd.

Aandeel van de bevolking dat een museum, tentoonstelling of galerij bezoekt, naar opleiding en leeftijd, in 2016, in %.



Bron: SCV-survey 2016.

Market Analysis

THE MUSEUM MARKET IN AND AROUND BELGIUM

Historic Voicebot will target the museum market in and around Belgium.

SWOT Analysis

The SWOT analysis below takes a closer look at the market and the place of the Historic Voicebot in it.

Competition Analysis

Below, I discuss a number of chatbots used in and around museums, both in the past and in the present. Even though some of the research mentioned here was done in the early 2000's, it's still very relevant to what I'm trying to achieve today.

Max the Conversational Agent

Max the conversational agent was the first chatbot to talk to museum visitors through a screen in 2004.

There was a very interesting research paper written about Max called "A

Conversational Agent as Museum Guide- Design and Evaluation of a Real-World Application" by Stefan Kopp, Lars Gesellensetter, Nicole C. Krämer and Ipke Wachsmuth. Although the study was done more than 10 years ago, the results were very interesting and still relevant today.

First of all, it's intriguing to read how Max was designed and created. He was a human-like 3D character that appeared on a screen and had conversations with museum visitors. Visitors could communicate with him via a keyboard. This way speech recognition problems in a noisy museum were avoided, and it made sure that Max could only talk to one visitor at a time.

Max also displayed nonverbal behavior, including waving, smiling and other facial expressions. This behavior was linked to his "emotional system". For instance, after repeated insults, Max would be in a very bad mood and

leave the screen (to de-escalate rude visitor behavior).

Secondly, it's interesting to see how people interacted with Max. All his conversations were recorded and analysed, and the results are fascinating. People were very likely to use human-like conversation strategies, like greeting Max (57.6% of dialogs) and asking him small talk questions like "How are you?". Visitors also said goodbye to Max when leaving 29.8% of the time, even though they could just walk away to end the conversation.

Another interesting thing to note is that people started testing the intelligence of the bot by asking questions, answering in a foreign language or giving obviously wrong answers, for instance saying their name is "Michael Jackson" or their age is "125".

Also a lot of flaming was recorded, around 11% of all user input was abusive, insulting, pornographic or politically incorrect in nature. Max would get annoyed and leave the screen an average of 3 times a day.

Overall though, people treated Max like a person and tried to interact with him in a nice and human-like way, which is a good indication that visitors would be open to speaking with a historical person via voicebot. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004)

	Helpful	Harmful
Internal	<p><i>Strengths</i></p> <p>The product is new and innovative</p> <p>It's different and stands out from the rest</p> <p>Reusability of both the Voicebot and the interactive installation</p>	<p><i>Weaknesses</i></p> <p>Developed with limited resources</p> <p>The technologies used in the project are still very experimental</p>
External	<p><i>Opportunities</i></p> <p>There are many museums</p> <p>Not a lot of competition in creating interactive installations</p> <p>Museums are generally open to trying new things to entertain their visitors</p>	<p><i>Threats</i></p> <p>Budget cuts</p> <p>The advancements of the used technologies can be unpredictable</p>

The House Museums of Milan Chatbot

In the article titled “Chatbots in museums: Hype or opportunity?” I came across an interesting case study about a chatbot made for the House Museums of Milan. (BOIANO, BORDA, CUOMO,GAIA, ROSSI, 2018)

To attract a teenage audience and increase interactivity, a Facebook messenger bot was created. But unlike the other bots, it’s main goal was to be a tool for the visitors to help them solve a game set in the real, physical museum. The focus wasn’t on talking to the chatbot, but rather on exploring the galleries of The House Museums of Milan.

To me, it’s interesting to see how chatbots can be used to connect to the real world, instead of deviating from it.

The virtual companion was tested by 80 teenaged students from the area, and it seems very successful so far. 72% of the students thought the game was highly entertaining and 66% found it a useful learning tool, especially when used with others in a small group.

Make Your Museum Talk: Natural Language Interfaces For Cultural Institutions

Whilst reading about the House Museums of Milan Chatbot, I discovered

the creators tried something similar back in the early 2000’s. This time, it was attempted to make a virtual expert about Leonardo Da Vinci for the Science Museum of Milan.

The study “Make Your Museum Talk: Natural Language Interfaces For Cultural Institutions” was done in 2002 by Stefania Boia, Giuliano Gaia and Morgana Caldarini. (BOIANO, GAIA, CALDARINI, 2003)

The chatbot was made to answer questions about Leonardo Da Vinci and his life on the website of the Science Museum.

Instead of trying to recreate Leonardo himself, the chatbot resembled one of Leonardo’s machines. “We decided to avoid the obvious choice of making it look like Leonardo, because it would have been banal and very difficult to realize- how can you in fact program software to talk like a genius?”

Making it one of Leonardo’s machines also had other advantages, including being able to justify some of the bots errors and having the freedom to give the character more gestures and facial expressions.

Unfortunately, the Leonardo project was stopped before it could be thoroughly tested and launched.

However, the initial tests showed good results and positive user feedback. The creators had big plans for their bot, including SMS-features, making him talk, using voice input and creating interactions with other museum bots.



Designing a Chat-bot that Simulates an Historical Figure

This study, done in 2013 by Emanuela Haller and Traian Rebedea, tries to design a chatbot that simulates a historical figure, much like I'm attempting with the Historic Voicebot. They aimed to design a chatbot character with a matching personality, by only using data gathered about this historic person from websites and plain text sources.

To extract facts from a text, a set of different digital tools were used, including the Stanford CoreNLP libraries and WordNet. Not only did they use facts about their chosen historical figure, basic information about all the other people that were mentioned was also added to paint a complete picture.

It was interesting to read which resources were used and how they were able to turn a plain text into facts and those facts into a conversational chatbot. Although the technologies used might be outdated, the steps outlined in their research don't seem to have changed much, making this a valuable resource.

(HALLER, REBEDEA, 2013)

MoSCoW Analysis

MUST HAVE. SHOULD HAVE. COULD HAVE AND WON'T HAVE

Below I've analysed the requirements for the first version of the Historic Voicebot, divided into four categories: must have, should have, could have and won't have (this time).

Must Have

The critical requirements in order for the voicebot to properly function:

- Interaction with visitors via a physical installation
- The ability for visitors to ask questions via speech
- The ability to answer basic questions about the historic person
- Support for one language, in this case English
- A display with a number of example questions
- A function to save all the visitor interactions for testing and development purposes
- Documentation about the realisation of the project

Should Have

The important but not necessary features:

- The ability for visitors to ask questions via chat

- The ability to answer questions about the museum itself
- The ability to answer questions about the location of items inside the museum
- The ability to make small talk with visitors
- A visual presence of the historic person either physical or on a screen
- On-screen subtitles, so visitors can also read the responses given by the voicebot
- Promotional materials about the project with information for both visitors and museums

Could Have

Desirable requirements to improve the user experience:

- A realistic and authentic voice
- A display with a dynamic list of most-asked questions
- Interaction with the rest of the museum, for instance showing the way to a certain location via ledstrips or indicating a specific object with lights
- The ability to make recommendations to visitors, for instance "if you like X, you might also be interested in Y". Y could be an

exhibition, a partnered museum, an event, an item available in the giftshop, etc.

- The ability to show the current mood of the historic person on the screen based on the conversation
- The ability to show images based on the conversation topic, for instance an image of an object that is being discussed
- An admin console to manage and adjust settings of the historic voicebot.

Won't Have (This Time)

Features that would be nice to implement at another time:

- Multi-platform support, for instance a museum website chatbot
- Age and mood detection of the visitors, with tailored answers
- Support for multiple languages

Functional Analysis

THE REQUIRED FUNCTIONALITIES

Based on the MoSCoW analysis above, the following functionalities are required for the software component of the Historical Voicebot.

For the MVP, the following functionalities are required:

- The ability for visitors to ask questions via speech
- The ability to answer basic questions about the historic person
- Support for one language, in this case English
- A function to save all the visitor interactions for testing and development purposes

These extra functionalities should be implemented in the prototype:

- The ability for visitors to ask questions via chat
- The ability to answer questions about the museum itself
- The ability to answer questions about the location of items inside the museum
- The ability to make small talk with visitors

- A visual presence of the historic person either physical or on a screen
- On-screen subtitles, so visitors can also read the responses given by the voicebot
- An admin console to manage and adjust settings of the historic voicebot.

The functionalities below could be added:

- A realistic and authentic voice
- A display with a dynamic list of most-asked questions
- Interaction with the rest of the museum, for instance showing the way to a certain location via ledstrips or indicating a specific object with lights
- The ability to make recommendations to visitors, for instance “if you like X, you might also be interested in Y”. Y could be an exhibition, a partnered museum, an event, an item available in the giftshop, etc.
- The ability to show the current mood of the historic person on the screen based on the conversation
- The ability to show images based on the conversation topic, for instance an image of an object that is being discussed

Visitor Interactions

WHAT COULD VISITORS ASK THE VOICEBOT?

In order to make the use case solid, I took a look at the questions visitors might ask a voicebot in a museum. The questions are based on what I would ask and on what visitors asked Max the Conversational Agent. (Kopp, Gesellensetter, Kramer, Wachsmuth, 2004).

Topics of conversation could include, but aren't limited to:

Life

What's your name?

How old are you?

What did you do?

When were you alive?

When were you born?

When did you die?

Where did you live?

Were you married?

What did you study?

Do you have kids?

How many languages do you speak?

Tell me about your life?

Work

What are you famous for?

How did you make this?

How long did it take you?

Tell me about your work.

The museum

Tell me about the museum

Where can I find (gift shop/bathroom/certain exhibit)...?

What's your favourite part of the museum?

What exhibit should I visit next?

When is the next guided tour?

Until what time is the museum open today?

The exhibit

Tell me more about this exhibit

What is your favourite part of the exhibit?

What items here did you make/discover/research?

Small talk

Hi!

How are you?

What's your favourite colour?

Do you also like ice cream?

Tell me a joke!

Bye! See you later!

Bot

Why are you here?

Who built you?

Evaluating Quality of Chatbots and Intelligent Conversational Agents

CHATBOT ATTRIBUTES

To discover how a historical figure can accurately be represented by a voicebot, I read the research paper titled “Evaluating Quality of Chatbots and Intelligent Conversational Agents” by Nicole Radziwill and Morgan Benton.

The paper outlines six categories and the corresponding quality attributes, shown here. (RADZIWILL, BENTON, 2017)

Category	Quality Attributes	References
Performance	<ul style="list-style-type: none"> ● Graceful degradation ● Robustness to manipulation ● Robustness to unexpected input ● Avoid inappropriate utterances and be able to perform damage control ● Effective function allocation, provides appropriate escalation channels to humans 	<ul style="list-style-type: none"> ● Cohen & Lane (2016) ● Thieltges (2016) ● Kluwer (2011) ● Morrissey and Kirakowski (2013) ● Staven (2017)
Functionality	<ul style="list-style-type: none"> ● Accurate speech synthesis ● Interprets commands accurately ● Use appropriate degrees of formality, linguistic register ● Linguistic accuracy of outputs ● Execute requested tasks ● Facilitate transactions and follows up with status reports ● General ease of use ● Engage in on-the-fly problem solving ● Contains breadth of knowledge, is flexible in interpreting it 	<ul style="list-style-type: none"> ● Kuligowska (2015) ● Eeuwen (2017) ● Morrissey & Kirakowski (2013) ● Wallace (2003) ● Ramos (2017) ● Eeuwen (2017) ● Solomon (2017) ● Cohen & Lane (2016)
Humanity	<ul style="list-style-type: none"> ● Passes the Turing test ● Does not have to pass the Turing Test ● Transparent to inspection, discloses its chatbot identity ● Include errors to increase realism ● Convincing, satisfying, & natural interaction ● Able to respond to specific questions ● Able to maintain themed discussion 	<ul style="list-style-type: none"> ● Weizenbaum (1966); Wallace (2003) ● Ramos (2017) ● Bostrom & Yudkowsky (2014) ● Coniam (2014) ● Morrissey & Kirakowski (2013)
Affect	<ul style="list-style-type: none"> ● Provide greetings, convey personality ● Give conversational cues ● Provide emotional information through tone, inflection, and expressivity ● Exude warmth and authenticity ● Make tasks more fun and interesting ● Entertain and/or enable participant to enjoy the interaction ● Read and respond to moods of human participant 	<ul style="list-style-type: none"> ● Morrissey & Kirakowski (2013) ● Pauletto et al. (2013) ● Solomon (2017) ● Eeuwen (2017) ● Ramos (2017) ● Meira & Canuto (2015)
Ethics & Behavior	<ul style="list-style-type: none"> ● Respect, inclusion, and preservation of dignity (linked to choice of training set) ● Ethics and cultural knowledge of users ● Protect and respect privacy ● Nondeception ● Sensitivity to safety and social concerns ● Trustworthiness (linked to perceived quality) ● Awareness of trends and social context 	<ul style="list-style-type: none"> ● Neff & Nagy (2016) ● Applin & Fischer (2015) ● Eeuwen (2017) ● Isaac & Bridewell (2014) ● Miner et al. (2016) ● Herzum et al. (2002) ● Vetter (2002)
Accessibility	<ul style="list-style-type: none"> ● Responds to social cues or lack thereof ● Can detect meaning or intent ● Meets neurodiverse needs such as extra response time and text interface 	<ul style="list-style-type: none"> ● Morrissey and Kirakowski (2013) ● Wilson et al. (2017) ● Radziwill & Benton (2017)

Pricing

AN ESTIMATION OF THE COSTS

Development Costs

An estimation of the costs to recreate the Historic Voicebot for a museum can be found below.

Operational Costs

A number of technologies have costs attached to them based on their usage. For this example, the costs were calculated based on one installation

being used eight hours a day, 6 days a week. The server is estimated to run 24 hours a day, 365 days a year. The speech-to-text functionality is estimated being active for four hours a day. For the text-to-speech functionality the estimate is 500,000 characters a day, the length of an average novel.

Development	
One developer, one month full time \$100 per hour	\$16,000
Hardware	
Google AIY Kit	\$150
Vintage Phone	\$50
Touchscreen	\$500
Total	\$16,700

Technology	Costs	Estimated yearly costs
Server, Amazon Web Services	Free for the first year \$0.05 per hour	\$450 / year
Google Dialogflow	Free up to 180 requests per minute \$0.002 / request	
Speech-to-text, Google Cloud	\$0.006 / 15 seconds	\$1,800 / year
Text-to-speech, Google Cloud	Monthly 0 to 4 million characters free \$4.00 / 1 million characters	\$500 / year
Total Operational Costs		\$2,750 / year

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