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An Intelligent Humanoid Pepper Robot For Serving To Human Using Voice Recognition and Generation Model

A Research Project report submitted in partial fulfilment of the requirements for the award of the degree of

Master in Artificial Intelligence

Department of Computer Science and information technology

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DECLARATION

I hereby declare that this research project report is based on my original work except for citations, quotations and support from the research supervisor which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at University of Tabuk or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this research project report entitled "**An Intelligent Humanoid Pepper Robot For Serving To Human Using Voice Recognition and Generation Model**" was prepared by **Ms. SARA BADER ALOTAIBI** have met the required standard for submission in partial fulfilment of the requirements for the award of Master in Artificial Intelligence at Department of Computer Science, Faculty of Computers and Information Technologyh, University of Tabuk KSA.

Approved by,

Signature :

Supervisor : Dr Manimurugan S

Date :

ABSTRACT

Throughout time, robots were believed to have been created for the purpose of serving man. Yet with the development of technology, the robot service is no longer restricted to industrial domains, but nowadays robots can be widely seen around us performing multiple sets of tasks. The human robot interaction is a field attracting a great deal of interest because of the special relationship between humans and robots. In this study, we aimed to use the humanoid robot Pepper to answer the questions of Hujjaj in Makk in a time-efficient manner and with great accuracy, while presenting the robot in a humane form. The Robot is programmed to roam freely until it encounters a user, then it introduces itself and its purpose. The users can ask Pepper questions and receive the answers via our proposed Voice recognition and generation model.

Keywords: Humanoid Robot, Pepper, Interactive, Question answer, Voice Recognition

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Chapter1: Introduction

Robots have always been an interesting topic even before they were developed, examined, and manufactured. In the early 1900s robots have appeared in many entertainment domains such as the famous play by Karel Čapek talking about the unfair use of robots and their revolution against the human race. Prior to that, in another work, a biological create part human part mechanical was also introduced as Frankenstein in 1818. With the development of technology in the previous decades, the idea of robots became more real, and with time more robot projects were being discussed to be implemented (Amudhu & Thamil, 2020). After that, the exponential growth of Artificial Intelligence (AI) lead to the introduction of this AI concept into the robotics field.

The word robot has a Czech origin, which is the word “robota” signifying forced labor. The exact translation reflects on the reason behind the creation of robots. After all, robots are created for the purpose of supporting humans, helping them with difficult tasks, enhancing the human activity, and in some cases replacing humans (Amudhu & Thamil, 2020). Consequently, multiple types of robots have been developed including drones, military robots, agricultural robots, etc… These robots belong to the mobile robots’ category, when they can have motion due to their flexible joints, and they could be important assets in underwater research and space exploration (Crnokić, Grubišić, & Volarić, 2017). Yet, humans are always looking for ways to improve these technologies.

Focusing on the human need for social interactions and conversations, the research was then geared towards creating social robots rather than industrial robots (Smakman, Konijn, Vogt, & Pankowska, 2021), and Socially Assisting Robots SARs were introduced. Social robots are built differently and have built-in features and qualities that allow them to maximize the human experience especially by providing more trust. One of the most obvious features of social robots is their shape, since most of them are built in a human-like form. In addition, social robots are taught the social norms (Bartneck & Forlizzi, 2004) and have at least partial automation which makes them even closer to humans. Such social robots exhibit human-robot interaction HRI modules and thus can be utilized in various arenas such as surgical fields and assistive technologies like rehabilitations (Hancock, Billings, & Schaefer, 2011) and improvement of motor functions in injured individuals. Based on HRI, several robots are employed alongside humans in industrial environments such as car production or assembly factories. Similarly, these robots can perform some medical tasks such as preparing blood samples. In agriculture, robots are assisting humans in the cultivation process, detection of weeds, and smart watering systems.

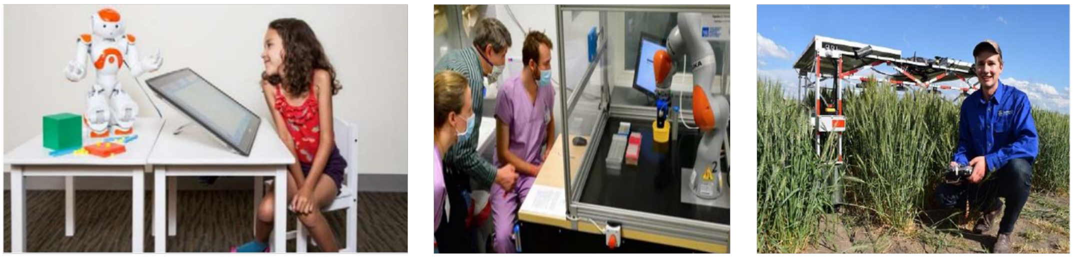


Figure 1 Potential Uses of Social Robots (Sharkawy, 2021)

However, one of the most interesting research topics involving humanoid robots and HRI is the education field and all of its related branches (Sharkawy, 2021), even though robots have already been involved in education in the 1970 in some form. Several robots based on many different technologies were used in a wide range of educational proposals to serve education-specific purposes. For instance, the android robot SAYA was used in elementary school to motivate students to learn more about science (Hashimoto, Kato, & Kobayashi, 2011). This robot was equipped with facial expressions alongside hand and head movements, and it was able to observe the students' interaction according to which the robot's operator would react. Numerous similar activities were performed with students in schools using the SARs robots and the results showed that having these robots enhanced the capabilities of the students and increased their excitement to learn (Pandey & Gelin, 2017).

Humanoid robots are special robots that possess human like details not only in the physical appearance, but humanoid robots can show human-like interactions and perform human social skills. With respect to humanoid interactions with humans, several details are considered, as explained in the figure below. The figure (Blar, Jafar, & Idris, 2015) illustrates that the technologies that allow the humanoid to properly interact with humans including both software and hardware systems. To ensure maximum interaction, the humanoid robots must be equipped with manipulators and audio systems that allow the execution of a certain action whether it was an effective action or an emotion. Similarly, software systems such as sensors for speech recognition and human emotion analysis sensors, in addition to cameras and internal processors are also essential in HRI.

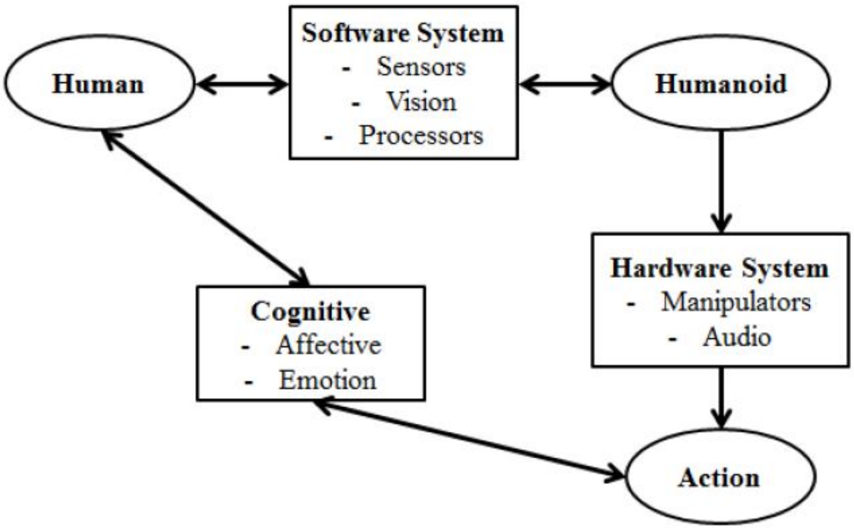
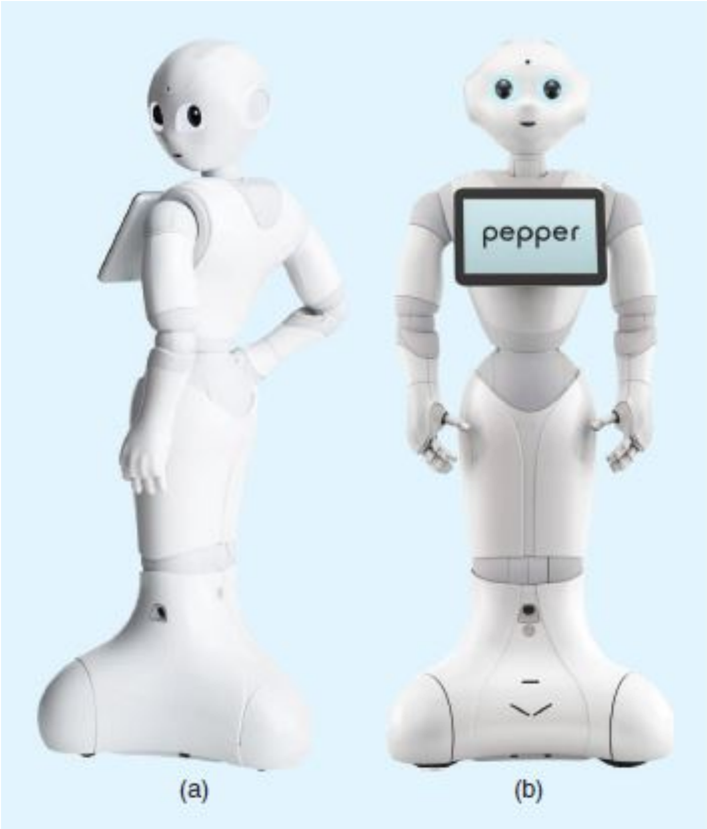


Figure 2 Software and Hardware involved in HRI (Blar, Jafar, & Idris, 2015)

Two of the most commonly used humanoid robots are NAO and Pepper robots. Pepper is able to display body language, move around, perceive, and interact with its surroundings. With the help of advanced technologies, Pepper can analyze the voice tone and facial expressions of people to recognize their respective emotions which allows the interaction to appear more real (Pandey & Gelin, 2018). In the physical features, Pepper is a 1.2 meters tall body on wheels, having seventeen joints to allow smooth movement and gesture generation. It can manage for 12 hours without the need for recharging indicating a good battery life, even though the charging option is available. In addition, the robot does not possess sharp edges which makes it safe to be around people of all ages and in all sorts of environments. The figure shows the physical features of Pepper (Pandey & Gelin, 2018). Additionally, Pepper has a gender-neutral voice, even though the robot itself might sometimes be addressed as he or she by users. In terms of interactivity, the developers of Pepper took into account that at certain times the communication can be non-useful or unreliable. To avoid the latter challenge, Pepper can interact with its users through a touch screen, speech, light emitting diodes LED, and tactile head and hands.

Figure 3 Front and Back view of Humanoid Robot Pepper (Pandey & Gelin, 2018)

Even though Pepper is often used in classrooms and libraries, this does not limit its abilities in other fields of education where users just need answers to their questions about any topic. This means that humanoid robots can be involved in museums answering the questions of visitors about art pieces present in the museum, or in industrial factories answering workers' questions about the specifics of certain machines or certain mechanical items. Similarly,



pepper humanoid robot can be utilized to answer Islamic related questions in Islamic environments.

1. Need for the research

Our motivation for this work is that people visiting Makkah, Iraq for Hajj season often have many questions about Hajj or Omra rituals, the history of Islam and the building of Kaaba as well as other related questions. The Muslim Hujjaj there would like to get accurate correct answers in a timely efficient manner, which is overwhelming to human guides, especially when considering the large crowd. For this reason, our objective is to create a program where Pepper humanoid robot can approach Muslims, introduce itself and its purpose then answer the question of Hujjaj correctly.

2. Aims and Objectives

In this study, our general objective is to create a system implemented on Pepper the humanoid robot to answer the possible questions of Hujjah visiting Makkah. However, our specific aims are to make sure that the robot is capable of understanding the questions, answering the question by answer retrieval mechanisms, and doing so in a quick time. Furthermore, we aim to make the robot as interactive as possible to ensure that Hujjaj have a level of trust in him, and they feel that he is truly capable of helping them. One of the most important issues for us is to make sure that the robot's answers are 100% accurate.

3. Significance of the Research

This research will replace human guides since it is capable of answering more questions of multiple people in a short period of time. Pepper robot does not get tired or confused as a human does, so it guarantees a full-time capability of answering questions of Hujjaj. With time and more work, Pepper is also capable of answering a wider range of questions that a human might not have knowledge about.

4. Conclusion of Chapter1

This chapter sheds the light on the topic of using robots in general in the presence of humans, and more specifically, the use of humanoid robots around humans and their versatility in multiple fields. This chapter also focused on the description of humanoid robot Pepper and its special characteristics.

2. Similar Studies

2.1. Introduction of Chapter 2

There's a huge pool of studies when it comes to implementing humanoid robots in a human environment. In this section, we selected a group of similar studies that involve humanoid robots such as Pepper and NAO to be discussed.

2.2. Discussion of Similar Studies

The study by Rozanska et al. (Rozanska & Podpora, 2019) discussed the concept of IoT-based humanoid robot and its implementation in interaction with humans. The authors dealt with WeegreeOne robot and aimed to advance it to the point that it could be used later on in hospitals or assisted living facilities. The robot is capable of performing nonverbal communications with humans based on several qualities such as speech-text transformation, in addition to its ability to interpret human body language and behavior. WeegreeOne can recognize emotions based on a hardware consisting of sound sensors and video camera as input from the human participation. Furthermore, the robot includes a touch screen that can be used to further communicate with the robot. These recorded information are communicated with the embedded system, consisting of Raspberry Pi, which allows the translation of speech input into text file storage and also permits the storage and retrieval of files from Cloud. This input processing system needs to take place in order to generate a proper response. The robot reacts to human interaction through several approaches, starting with communication via the touch screen where the robot can display images, to actually generating voice reactions by transforming text to speech, and finally by performing various gestures supported by the flexible limbs of the robot due to presence of motors. Moreover, to enhance the emotional experience of human participants, the robot is capable of analyzing their emotional state via ALMood module which can also assess the degree of involvement of the human participant based on facial expressions and body movement. However, this robot model has room for more advancements especially since its emotion sensor capabilities are limited to only a few emotions.

Kiilavuori (Kiilavuori, Sariola, Peltola, & Hietanen, 2021) and her colleagues analyzed the psychophysiological responses of 42 participants with respect to their interaction with a robot vs. a human with direct or averted eye contact in both cases. In their study, the aim was to assess the familiarity of the human-robot interaction through measuring several aspects such as heart rate deceleration, zygomatic and corrugator muscle activity, as well as arousal SGR based on both the self-assessment and subjective assessment. The participants were faced with a human at a time, then a humanoid android (or vice versa). The main difference in experimentation would be the gaze of the model (human or robot) which is once forward with direct eye contact, once with averted gaze to the right, and once with averted gaze to the left. The robot in this case was the humanoid NAO from SoftBank robotics. The participants were asked to fill out a questionnaire to evaluate their feelings after both interactions including the likeability of the NAO robot, its animacy, and intelligence. In addition, the researchers collected physiological data from the participants through electrodes in their hands, and face expressions were also monitored alongside heart rate monitoring. The study concluded that skin conductance results are significant between eye contact vs. no eye contact in both models, where the difference between human eye contact vs. robot eye contact was also significant. Direct eye contact also increased the zygomatic muscle activity and lowered the corrugator muscle activity in both models. The main take away from the study is that a humanoid robot with direct eye contact is capable of inducing psychophysiological responses that are similar to those induced by a human.

Tutan Nama et al. (Nama, Deb, Debnath, & Kumari, 2020) published a paper titled "Designing a humanoid robot integrated Exer-Learning-Interaction (ELI)" which discussed the designing of a humanoid NAO robot for the purpose of creating a better learning environment for children who need specific help. The main goal was to develop a robot-interaction system which allows the children to communicate with a robot through hand gestures as a means of enhancing their cognitive abilities. The NAO robot interaction system is based on percept action sequence PAS- module and leap motion module. The children would show a certain hand gesture to the robot through the leap motion tracking zone. It is then the robot's job to recognize this gesture based on the different degrees of freedom and then collect the gestures by passing them through piNAOqi SDK on python script. The different hand gestures should mean different things, and the robot should react to them based on their meaning. The output gestures done by the robot could be shoulder rolls, head pitch, head yaw, etc. the NAO robot is also capable of detecting whether the gesture is performed by the left hand or the right hand. By implementing this project, children would be able to learn the meaning of basic gestures used for nonverbal communication. By comparing the leap gestures to the robot gestures, it appeared that the robot can correctly manipulate the movements but in a slight delay of 5 ms.

Al Barakeh et al. (Al barakeh, Alkork, Karar, Said, & Beyrouthy, 2019) aimed to evaluate the perception of a humanoid robot in several areas and through several implementations to get an idea about how humans would react to presence of a service robot. The paper discussed the qualities and characteristics of humanoid robot Pepper as well as its capabilities depending on its flexible structure. The authors implemented Pepper as a university receptionist at American University of the Middle East where the robot would engage with the surrounding environment according to two predefined modes: free-movement and engagement mode. Whenever the robot is not occupied with human interaction, it will be roaming freely in the area whilst performing appropriate gestures. On the other hand, upon recognizing human presence or human speech, the robot will switch to engagement mode and welcome the human in a conversation about the university. The robot will be able to interact with different humans according to their needs, being students, staff, or outside visitors. The study continued to perform a short survey in the state of Kuwait and concluded that the participants would prefer service robots at airports more than hospitals, malls, or banks. Lastly, upon implementing Pepper in a maker fairs, it became evident that certain companies are interested in the publicity that Pepper can provide for them given his interesting perception by the public.

To further understand the perception of robots and their acceptance among the common population, Nyholm et al. conducted a detailed interview to view the population's perspective on the use of humanoid robots in healthcare (Nyholm, Santamäki-Fischer, & Fagerström, 2021). In healthcare domains, humanoid robots are capable of assisting in cognitive training, physical tasks, and monitoring of vital signs. In order to understand their reaction to humanoid robots, five female and seven male participants were included in the study, whose ages ranged between 24 and 77. The participants were shown a video of Pepper, the humanoid robot, helping in areas of healthcare, and the video also shows the learning capabilities of Pepper and its design to interact with people. Afterwards, a qualitative analysis of data took place to answer four questions: are humanoid robots reliable? Are humanoid robots safe? Are humanoid robots likeable? Are humanoid robots caring? The answers of the participants were ambivalent, where contradiction in opinions arose in all the four questions. Some participants considered the robots reliable since they perform their tasks precisely and according to their programming, whereas others though that the robots are unreliable, and if their intervention is necessary, it must be under the supervision of human professionals. With respect to safety, the overall reaction was that it is preferable for robots to do simpler tasks such as registering data or applying treatments for rather simple illnesses, since some of the participants were afraid of software malfunction. As for likeability, the shape of the robot was triggering by either being too human-like for one group, or not human enough for the other. In addition, some participants found the robot voices unpleasant. Finally, the participants considered the robots as generally uncaring because they have no emotions, but they also gave insight on helpful ideas to make robots look more caring, such as having warmer hands, and being employed to entertain lonely patients.

Youngwoo Yoon and his colleagues developed a gesture generation neural network model operating in humanoid robots (Yoon, et al., 2018). Before development of the model, the researchers collected data from TED talks and called it the "TED Gesture Dataset" which is large, has different content and multiple speakers with many hand gestures, and transcript of the speech. In total, the videos and their scripts were 1295, and the human poses were extracted using OpenPose frame by frame. After that, automated selection and annotation of these clips took place. From the dataset, the shots collected were 14,221 (approximately 11 shots from each video) and made up for 52 hours' runtime. Each of the words from the transcript was encoded as one-hot vector, and the embedding model GloVe was used. In addition, the human poses were normalized and converted into 10 dimensional vectors with the help of PCA technology. The proposed neural network consisted of encoder (of speech context), decoder (for gesture generation), and soft attention mechanism in addition to two layered GRU and Adam optimization. As a result, the model was able to show different gestures even when the sentences are similar, and it can differentiate gestures with respect to "me", "you", and "big". However, a prototype was also implemented on the NAO humanoid robot and the robot was able to perform the same gestures as in the 2 dimensional model with a minimal processing time. Furthermore, this developed model can be implemented in other robot platforms.

In the educational domain, Tanaka et al. tried to develop a learning application relying on interaction with pepper and a teacher presenting on its screen (Tanaka, Isshiki, & Takahashi, 2015). In order to do that, the developers based their work on care receiving robots design and total physical response methodology to ensure the interactive experience while learning. The aim was to make it look as though pepper is also learning with the student from the presence of the teacher. The application was focused towards Japanese children of 5 years old to teach them English from the comfort of their home. The lesson is given by a teacher through a pre-recorded video displayed on the chest of pepper while he looks down at the screen to learn with the children. The developers created three different learning programs: Color, Let's Try, and Body. In the first program, pepper communicates with the children asking them to choose items around them based on the color that the teacher just explained. The children would find items and show them to pepper who asks the teacher what's the name of this color, and him with the children repeat after the teacher. In the let's try program, an item is shown that the children along with pepper must imitate using their bodies while learning its English word, such as "plane". Finally, in the Body program, the children learn about their body parts in english while pepper touches his body parts as well. To be even more interactive, Pepper is programmed to high-five the children when they learn new things, and to take pictures of the children while studying to encourage them. This application was beneficial but after testing, a few challenges arose, and a few mishaps that need further work.

Podpora et al. aimed to expand the interaction system of a robot with humans by implementing external smart sensors (Podpora, Gardecki, & Beniak, 2020). The main objective was to be able to gain as much information as possible about humans in-sight before an actual engagement between them and the robot takes place, or in other terms, to perform interlocutor identification and gaining of parameters. The idea then was to integrate smart sensor elements and bring them together through the internet of thing technology, to preview a prototype of the system in a small office desk. In the main system, pepper has control over the door access, but also the mainframe is connected to a group of smart sensors for the purpose of detection and identification of interlocutor. These sensors include a camera, a microphone, a database, and a Bluetooth sensor, which takes advantage of database to collect the last name of employees and previous conversations, as well as any topic they would be interested in. furthermore, the system supports several services such as speech-to-text, translation, and NLP in addition to voice and live chat app services. The robot can gain information about who is approaching through multiple smart subsystems such as the video input stream subsystem VISS, thermo-vision subsystem, and RFID and Bluetooth subsystems. The use of this human identification smart sensor HISS allows the detailed identification of the individual based on his age, gender, and its interlocutor class (employee, guest, client). Upon putting the system to trial, the users got the impression that they were actually talking to the robot, where in fact, the system behind the robot was doing the actual work.

Neggers et al. (Neggers, Cuijpers, Ruijten, & IJsselsteijn, 2021) in their paper tried to understand and visualize the surrounding area by which human find themselves comfortable in the presence of a moving robot. It is commonly agreed upon that robots must respect human social rules and take them into account while interacting with them, but also these rules must be considered in physical presence and movements around humans. Humans must feel safe and comfortable in their personal space when they are passed by a robot, which is why the authors aimed to find out what particular distances or movement patterns affect the comfort of humans. For this purpose, the authors performed two sets of experiments one of them using the humanoid robot Pepper, and the other one using an autonomous guided vehicle AGV. In the first experiment, Pepper was used to walk around twenty participants (12 females and 8 males) starting from different positions making the general movement clockwise or counterclockwise, moving at three variable distances, and having 4 different passing sides. These in total make up 24 trials of movements. Each participant went through these 24 trails and answered questions about their level of comfort during them. Similarly, these 24 trails were performed by the AGV on new participants (twenty-one this time) where 15 females and 6 males were involved. The authors found a correlation between the age and the degree of comfort such that the older participants felt more comfortable than the younger ones. In addition, rANOVA was used to determine the significance of correlations between the comfort level and the three parameters. In both Pepper and AGV, there was a significant correlation in the cases of distance and passing from the side, also the participants with both robots felt more comfortable when it was passing in front of them than when it was passing behind. Inverted Gaussian was also used to quantify the comfort/discomfort and to plot a comfortable personal space model for pepper and AGV aside.

Muneeb Imtiaz Ahmad (Ahmad, Bernotat, Lohan, & Eyssel, 2019) and his colleagues published a paper titled "Trust and Cognitive Load During Human-Robot Interaction" which is an exploratory study where the authors try to understand trust relationships between humans and robots. There were several objectives in this study, including to discover the relationship between human cognitive load and trust of robots while knowing their error rate, and to understand the effect of thropomorphism in the degree of trust. The authors programmed a game "matching the pairs" that can be played by humans with the help of robots that are either human like (pepper) or non-human like (husky). To measure the cognitive load and trust levels, the pupillometry was performed using Tobii glasses pro 2 to track eyes, and a form of godspeed questionnaire was also conducted for the trust evaluation. This game was developed with 5 given points to each participant, and these points either increase by one or decrease by one depending on whether they can guess the pair and match it correctly. Before the game starts, the robot in each cases introduces itself with its specific capabilities and error rate (which can be 3% or 50%). The robot and the human sit facing each other with the game tiles between them, and even though the robot is equipped with augmented reality function allowing him to learn the positions of the tiles, the human has an option of asking for help or not asking for help. Furthermore, the participants filled out the questionnaire before and after the game to be able to compare results after interaction. The results showed that whenever the cognitive load of the participants increased, their trust in the robot decreased (inversely proportional relationship). In addition, the results showed that humans were more trusting in pepper than they were in husky.

Moritz Merkle (Merkle, 2019) designed a study to compare the responces of customers to service failure of human vs. service failure of a robot. The researcher had two research questions to be answered by experimentation, do customers find robots less satisfying in service than humans? And how does a failing service affect the satisfaction with overall service between humans and robots. The participants were given experimental situations at random where they are served by a robot successfully, served by a human successfully, served by a robot with failure, and served by a human with failure. A detailed script was given to the robot and the human so that no differences are significant. The total satisfaction of customers was measured based on a scale from 1 to 5. In general, the customers were more satisfied with the robot service than human service even though the difference in satisfaction was not significant. However, upon the failed service, the satisfaction with both human and robot decreased. After the failed service, the customers were still more satisfied with pepper the robot than with the human service supplier.

Thunberg et al. (Thunberg & Ziemke, 2021) aimed to create a more customer-based design for humanoid robots according to what the users desire to have in terms of communication skills and qualities. The idea stems from the fact that humans would find better services from robots if they can perform the tasks that the users expect them to. For this purpose, the authors chose the humanoid robot Pepper as a model and the participatory method of design also known as PICTIVE. A total of five participants were involved in this study, where each one of them sat alone with the session leader to design his most suited sociable robot. The process includes three major phases which are the label phase, sketch phase, and interview phase. In these different steps, the participant would share how he or she expect the robot to interact with its surrounding, and produce three design ideas for the robot. One of the ideas that the participants came up with is a menu that shows what tasks Pepper is capable of executing which could be shared on his chest screen for example. And finally in the interview phase, the participants were asked what they expect of Pepper in different scenarios. The most common labels that the participants used was the voice synthesis as a primary communication way, followed by display symbols label. In addition, the study concluded that the users had several design ideas that they didn't know how to communicate in the PICTIVE design process.

Guggemos (Guggemos, Seufert, & Sonderegger) and his colleagues discussed in their paper the acceptance of Pepper robot in the academic field, more specifically as an assistant in higher education classes. The authors aimed to analyze the adaptive-ness, trustworthiness, and social appearance and presence of pepper within the classroom students. For the purpose of assessing the acceptance of pepper, the unified theory of acceptance and use of technology UTUAT was used in their study. Within the lecture at the st. Gallen university, the students were shown a sample of task that Pepper is capable of performing to familiarize them with what pepper can do in the academic context especially learning. Lexi was the pepper model used in the study, and the lecturer explains that it can answer the students' questions since the lecturer himself cannot possibly answer 1500 students. During the lecture, Lexi was listening to the lecturer like the other students, and it assisted in answering the questions through a chatbot for approximately 45 minutes. Lexi performs several tasks including greetings, reading, motion abilities to demonstrate emotions as well as alerting. After the lecture, all of the 1552 students were asked to fill an online questionnaire, but only 462 were completed. Furthermore, 55.41% of the students perceived Lexi as female, 6.93% as male, and 37.6% didn't give Lexi any gender. In the data analysis, PLS-SEM was used. The study concluded with several findings that include the academic writing course of choice can represent several large scale educational courses. Upon analysis, it was found that the students can't find themselves relying on Lexi or any social robot to assist with their learning process. This might be due to lack of interactions that are generally present between the lecturer and students. For example, Lexi only answered the questions but didn't give feedback to the students or motivate them to think more of the answer or to associate their previous knowledge on the topic. In addition, the students found that the voice feature is more important than the visual appearance of the robot to impact adaptive-ness and trustworthiness.

Nguyen (Nguyen, 2020) discussed the effect that humanoid robots have on the public libraries in several areas in Australia. Nguyen aimed to explore the impact of these robots on the general and specific atmosphere of libraries based on the experience and point of view of librarians working there as well as the clients. The study is a thematic approach analysis based on interviews conducted with librarians and on observations by the research team focusing on the interactions between humans in the library and the humanoid robot. The interviews were 10, conducted about libraries in different areas in Australia and took place in person, over the phone, or through skype, for a total of approximately 40 to 50 minutes each. The interview questions consisted of open ended questions and further questions to allow the interviewee to elaborate on his opinions. In addition, observations took place in 5 other libraries across Australia where robot-interaction sessions were held, or just informal sessions took place. The qualitative analysis gave four themes as a result. These are: humanoid robots are teachers, challengers, assisting, and community builders. In more detail, the study concluded that the robots were used as an attraction factor in libraries, and often NAO robot was taken on trips to school, where it interacted not only with children but adults as well. Humanoid robots were also viewed as good entertainers. In some libraries, robots were used as teachers to encourage students to learn coding for example, and other tasks that the robot is capable of teaching, which was a creative method to use the robot and motivate the curiosity of people in the library. In addition, robots helped in increasing the confidence of children and teaching them English. None the less, robots cannot fully replace the librarians especially due to their lack of emotion, but they are viewed as excellent assistants. It is also noteworthy that librarians faced difficulties with the robots in the beginning due to them being a new field and a newly added technology.

Qidwai et al. (Qidwai, Bin Abul Kashem, & Conor, 2019) investigated the benefits of using humanoid robots in assisting the teachers in teaching children with Autism Spectral Disorder ASD some academic and social skills. For this purpose, some children selected by psychologist and upon agreement with their parents were chosen to participate, where NAO designed some activities to examine their attention, behavior, and speech. The designed programs were also discussed afterwards with the teachers to make sure that they are suitable for these children. The first social program was the story telling session where the teacher uses NAO for live-streaming and NAO interacts with the children encouraging them. Gaming activities were also used where the children played with NAO games such as Simon says. Another activity is performing a set of morning exercises where the children need to mimic the movement of the robot. A song activity was also included and it looked like it was the most enjoyable activity among these kids. To notice the influence of having NAO robot assistant, variables such as response time, response type, memory, and number of trails were analyzed. As expected, the outcomes of these activities in the first sessions were not good, however as the weeks went by (program is held once a week for several weeks), the children were able to make significant improvements. Among the findings of the study, in addition to the fact that children have improved response and interaction with NAO in the different social activities, is that game like Simon says can greatly improve the coordination skills of ASD children. The results obtained were also compared to results from similar activities but without NAO, and it was observed that ASD children when trained with NAO humanoid robot give much better results.

NAO humanoid robot is also effectively used in rehabilitation therapy as the study by Sanchez et al (Sanchez, Courtine, Gerard-Flavian, & Dauber-Natali, 2020) discussed. The focus of their study was the function of humanoid robots in assisting contact-free rehabilitation of people post-stroke accidents by designing an exercise for enhancing arm amplitude, memory, and precision of patients with the help of NAO robot. The chosen exercise was done according to NaoMarks that were printed on colored magnetic tiles on a 4 by 4 magnetic board. The robot as well as the patient were stationed in front of the board. Of course, NAO took part in introducing the exercise to the patients that the tiles will be shifted according to color in different timings, and that the patient has to memorize and recite their positions. These exercises can be modified according to each patient, his own challenges, and his own progress. The first goal was to improve arms amplitude such that the marks can be placed in varying distances away from the patient according to his injury, and according to his rehabilitation progress. Another goal was to improve the memory of patients and their precision. The role of NAO in precision analysis is important as it can give feedback about the number of wrong tries by the patients, the difference between the position of the correct tile and the wrongly chosen tile, and other factors. In addition, the humanoid robot can give little hints to the patients and encourage them. The benefits of this program is that it can be done at home and NAO sends the feedback, or it could be done at clinics but it allows better chances of the therapist to pay attention to all the patients with NAO's assistance.

Arent et al. (Arent, Kruk-Lasocka, & Niemiec, 2019) proposed an approach to use social robots for the diagnosis of children with autism. The authors here decided to use social interaction between children and the robot combined with a psychological method to assess autism in children. The observations during these experiments must be monitored and evaluated according to specialists who are trained psychologists as well as the statistical evaluation, upon analyzing recorded videos of the experiments. In this study, the teacher is involved alongside the child and the robot, and the researcher was also included to supervise the behavior of the robot. At first, the NAO robot was introduced to the children verbally and they danced together as a form of familiarization. The experiments involve a verbal dialogue in addition to two interactive games, which are “dance with me” to assess the motor-visual coordination skills and movement imitations among the children, and “touch me” which assesses the verbal instruction skills. After that, evaluations took place by raters based on video recordings of the experimental sessions. Overall, 5 boys and 1 girl were chosen to be evaluated on their interaction with NAO, and the results showed that these children perform significantly better in tasks that allow them to follow instructions, rather than imitation without verbal instructions. This is reflected by the fact that the children performed better in the touch me task rather than the dance with me task. These behavioral recordings can distinguish between autistic children and non-autistic children with the help of the social robot.

In their study, Pino et al. (Pino, Palestra, Trevino, & De Carolis, 2019) decided to create alternative methods to help the patients with mild cognitive impairment fight against cognitive decline. Thus, the effectiveness of social robots such as NAO for these purposes was evaluated. Three groups of outpatients from the center of dementia and cognitive disorder in Italy were selected, the first group consisting of 6 individuals, the second group of 8, and the third group of 7 people. These 21 individuals were trained once a week for 8 weeks where the session lasted for 1.5 hours. The age range of these patients was between 45 and 85 years old, and they must not be taking dementia medications. Several tasks were developed for NAO using Python and Choregraphe scripts among others, with slight modifications and enhancements between the three groups. The individuals were evaluated upon many criteria including verbal fluency, short and long term memory, and visual attention, whereas the NAO influence was also evaluated through PIADS and SUS. The selected tasks were the song-singer matching, stories and their related questions, associated and non-associated words and the words recall. In the first group, some technical challenges arose and some false negative or false positive results were being made, but they were fixed in the second group, and in the third group additional camera was added. A video analysis software was also used to capture the frequency and length of smiles and visual attention among the patients in each group. The result showed that the human interaction robot among these patients does not cause anxiety, yet values such as the verbal fluency significantly improved upon using NAO. On the other hand, depression, short term memory, and anxiety showed no significant difference. Furthermore, the patients showed significant increase in smile frequency and length, in addition to an increase in attention frequency and length during most of the tasks. The results obtained from this study encourage further research to evaluate the effect of robots in ecological settings for cognitive therapy.

Steinhaeusser (Steinhaeusser, et al., 2021) and his colleagues looked at social robots as great storytellers since they were used for this purpose widely, but they were interested in testing the influence of the robot's voice on its anthropomorphism. The research question posed by the authors was: is the gender specific voice a factor affecting the anthropomorphism of the robot? And three hypothesis arose which are: does having a gender specific voice instead of a neutral voice render the robot more acceptable? Is the perception of the robot affected by the gender of the user with respect to the gender-voice of the robot? And finally does the influence of the story itself changes with the change of the robot's voice? To answer these questions, the authors conducted online study with 137 individuals (70% females, 27.7% males and 2.2 diverse gender) where the social robot NAO performed a story telling using either a female voice, male voice, or neutral voice over a recorded video. The story choice was the Kwaku Ananse and the Pot of Wisdom, and NAO was taught to perform emotions and gestures through choregraphe. The male and female voices were used according to a new text to speech module other than NAO's, and the gender neutral voice was created using audacity. The NARS questionnaire and the TS were adopted to measure the attitudes towards the robot and the influence, as well as the transportation capabilities. In addition, the Godspeed questionnaire was used to determine the anthropomorphism of the robot. The results showed that the NAO robot was perceived as non life-like, so it was not perceived as anthropomorphic. The perception and the attitude towards the robot was not significantly affected by its voice's gender, nor does the gender of the user affect this perception. Furthermore, changing the voice of the robot based on gender did not affect the story transportation. Despite these results, the authors were able to conclude that males perceived the robot less negatively than the female participants.

Alarfaj et al. (Alarfaj, Alabdullatif, Albakri, & Abdul Karim, 2019) discussed a program in which the social robot NAO can help in improving the social skills of children with ASD in Saudi Arabia. Their main objective was to identify, develop, and assess the performance of a humanoid robot for the purpose of testing how the humanoid robot can affect the social skills of autistic children simply by interacting with them and performing a few tasks. To develop this therapeutic model, the objective was determined, followed by creation of multidisciplinary team made up of researchers, clinicians, and developers. After that, the next step was to develop 6 scenarios where the robot interacts with the children, accompanied with the development of an assessment method for the performance of the children, and then executing the design. The NAO robot was programed through Choregraphe, and the children where carefully chosen such that they are not vision or hearing impaired, not exhibiting self-harm, able to speak and understand Arabic commands, and are between 6 to 10 years old. The following interaction modules were created depending on the TEACCH guides: robot introduction, naming animals activity, finding hidden objects, imitating body movements, performing written command independently, and imitating another person's movements in a specific sequence. These tasks and interactions, according to the authors allows

NAO to be a great assisting therapist, where the progress of ASD children is assessed through their improvement in completing the tasks.

2.3. Comparison between Similar System

The table below represents a summary of the related studies, comparing their aims and approaches.

Table 1 Research Aim and Approach of the Related Studies

Research Title	Reference	Year	Aim	Research Approach
“Multimodal sentiment analysis applied to interaction between patients and a humanoid robot Pepper”	Rozanska &) (Podpora, 2019	2019	The aim was to advance the WeegreeOne robot to be useful in hospitals and assisted living facilities.	An external emotional sensor was used on humanoid pepper with Raspberry Pi to analyze body movements and facial expressions, as well as text and speech communication.
“Making eye contact with a robot: Psychophysiological responses to eye contact with a human and with a humanoid robot”	Kiilavuori,) Sariola, Peltola, & Hietanen, (2021	2021	The purpose was to check if direct eye contact with a robot has an impact on the physiological and psychological responses of humans.	NAO robot was used to interact with humans and the heart rate, check and brow muscle movements, autonomic arousal were measured.
“Designing a humanoid robot integrated Exer-Learning-Interaction(ELI)”	Nama, Deb,) Debnath, & (Kumari, 2020	2020	The aim was improve the gesture learning process for children with special needs.	NAO robot was used with a Leap Motion Controller to detect the accuracy of the child gestures and teach him how to do it properly.
“Pepper Humanoid Robot as a Service Robot: a Customer Approach”	Al barakeh,) Alkork, Karar, Said, & Beyrouthy, (2019	2019	The purpose was to develop a customer service robot at AUM reception.	Pepper Robot was designed to detect the presence of close people and engage with them through AI face detection, tracker, and text to speech.
“Users’ ambivalent sense of security with humanoid robots in healthcare”	(Nyholm, Santamäki-Fischer, & Fagerström, 2021)	2021	The aim was to investigate the level of trust between humans and robots in healthcare fields.	A video of Pepper was shown to participants where they performed interviews to assess their level of safety and security.

"Robots Learn Social Skills: End-to-End Learning of Co-Speech Gesture Generation for Humanoid Robots"	Yoon, et al.,) (2018	2018	The goal was to train a humanoid robot to perform human-like gestures.	NAO robot was fed with human gestures, and the robot imitates the gestures according to words through RNN encoder and decoder.
"Pepper Learns Together with Children: Development of an Educational Application"	Tanaka, Isshiki,) & Takahashi, (2015	2015	The purpose was to develop an educational system for children based on Pepper.	Pepper was used where three programs were designed. In addition, care receiving robot design and total physical response were employed.
"Human Interaction Smart Subsystem—Extending Speech-Based Human-Robot Interaction Systems with an Implementation of External Smart Sensors"	Podpora,) Gardecki, & (Beniak, 2020	2020	The purpose was to enhance the social aspects of humanoid robots.	Smart sensors were used on pepper robot such as the human identification smart subsystem, Bluetooth sensor, thermovision subsystem, and other services.
"Determining Shape and Size of Personal Space of a Human when Passed by a Robot"	(Neggers, Cuijpers, Ruijten, & IJsselsteijn, 2021)	2022	The aim was to identify the boundaries of personal space between humans and robots.	A humanoid and non-humanoid robot were used. After the movement of the robots close to humans, the feelings and opinions of humans were taken to visualize a safe personal space.
"Trust and Cognitive Load During Human-Robot Interaction"	(Ahmad, Bernotat, Lohan, & Eyssel, 2019)	2019	The goal was to understand the connection between human cognitive load and trust when dealing with humans.	Husky and Pepper robots were used to play a matching game with humans. Cognitive load and trust were measured eye tracking glasses, and participants also filled out a survey.

"Customer Responses to Service Robots Comparing Human-Robot Interaction with Human-Human Interaction"	(Merkle, 2019)	2019	This paper compared how participants perceive service failure of robots compared to humans.	Pepper robot was used to perform a service failure scenario. To find out the customer satisfaction, a survey was done.
"User-centred design of humanoid robots' communication"	(Thunberg & Ziemke, 2021)	2021	The purpose was to investigate how users might design the social interaction aspects of Pepper.	PICTIVE design model was used on Pepper robot. The designs were subjected to task-performing scenarios to assess the response of the users.
"Humanoid robots in higher education: Evaluating the acceptance of Pepper in the context of an academic writing course using the UTAUT"	(Guggemos, Seufert, & Sonderegger)	2020	The aim was to evaluate the acceptance of humanoid robot as an educational assistant.	NAO robot was used in a lecture to assist the professor by answering the questions of the students. The acceptance was reviewed through an online questionnaire.
"The Impact of Humanoid Robots on Australian Public Libraries"	(Nguyen, 2020)	2020	The study aimed to identify the impact of using humanoid robots in Australian libraries.	Several interviews took place with librarians from different regions in Australia that already deploy humanoid robots at their libraries.
"Humanoid Robot as a Teacher's Assistant: Helping Children with Autism to Learn Social and Academic Skills"	(Qidwai, Bin Abul Kashem, & Conor, 2019)	2019	The purpose was to determine the impact of using a humanoid robot in teaching children with autism.	NAO robot was used to interact with children according to instructions by an online teacher. The influence was evaluated according to number of trails for correct task performance and the respective time needed as well as behavioral retention.

“The use of a social assistive robot: NAO for post strokes rehabilitation therapy: a preliminary study”	(Sanchez, Courtine, Gerard-Flavian, & Dauber-Natali, 2020)	2020	The purpose was to use NAO robot to benefit patients in their rehabilitation after strokes.	NAO robot was used to allow patients to play a game to improve memory and enhance the arm motion amplitude.
“Social robot in diagnosis of autism among preschool children”	Arent, Kruk-) Lasocka, & (Niemiec, 2019	2019	The purpose was to use humanoid social robot to identify children suffering from autism.	NAO robot was used to interact with children and perform a dance with them and a touching game to assess the imitation skills in children. According to this, competent raters evaluate the performance of the children to determine whether they are autistic or not.
“The Humanoid Robot NAO as Trainer in a Memory Program for Elderly People with Mild Cognitive Impairment”	(Pino, Palestra, Trevino, & De Carolis, 2019)	2019	The aim was to employ a humanoid robot to help improve the cognitive abilities of elderly people.	NAO robot was used to read stories and ask related questions to participants. The attention, short and long memory were examined.
“Anthropomorphize me! - Effects of Robot Gender on Listeners’ Perception of the Social Robot NAO in a Storytelling Use Case”	Steinhaeusser,) (et al., 2021	2021	The purpose was to identify if gender specific voices of robots affected its perception and engagement levels.	NAO robot was used to tell a story in a male voice, a female voice, or gender neutral voice. “Transportation scale” and “negative attitude towards robots” were used to assess the involvement of participants in each case.

"Analysis of the Use of a NAO Robot to Improve Social Skills in Children with ASD in Saudi Arabia"	Alarfaj,) Alabdullatif, Albakri, & Abdul (Karim, 2019	2019	The aim was to study how humanoid robots can improve social skills of autistic children.	NAO robot was used in addition to TEACCH (Treatment and Education of Autistic and Communication related handicapped Children) to develop 6 scenarios to assess the children skills.

2.4. Conclusion of Chapter 2

This chapter was dedicated to discussing, in great detail, the studies that were focused on the design and implementation of humanoid robots that were either Pepper or Nao. This chapter discussed these studies among various fields, whether they were in the medical field, rehabilitation, or education.

3. Methodology

3.1. Introduction of Chapter 3

In order to achieve our goal of creating an interactive robot that answers the questions of Hujjaj, we need to focus on little details that can enhance the people's experience. The literature review discussed some papers that focus on humans' perception of robots in general and humanoid robots specifically. The importance of humanoid robots might be well understood among the human community, yet there remain some concerns around it. A fraction of humans perceives robots as non-emotional entities which makes them dissociated from the topics that trigger an emotional sense in humans. Similarly, some people find it hard to trust robots especially in critical fields such as medicine. However, it should be more acceptable for robots to be involved safely and with trust in educational fields since the robot would have all the necessary information built in, or easily accessible.

Our contributions are summed up as: 1) it is important that our developed program must render the human robot as humane as possible in order to maximize the positive interaction, and to make it more trustworthy. 2) our robot must accurately answer Islam-specific questions in an understandable language and time-efficient manner.

3.2. Implementation

FREE MOVEMENT MODE:

The first step involves the increased engagement between Pepper and humans which can be represented in Pepper's movement on the campus, Pepper's gestures, Pepper's eye contact, and Pepper's speech capabilities. Initially, the robot will be roaming in the campus with its senses activated. The robot is equipped with voice detection sensors, facial recognition sensors, and touch sensors, which means that when the robot is touched, the system will convert into engagement mode, meaning that a human might be in need to interact with the robot. Similarly, the robot would gain knowledge when a human is moving towards it, or if a human is speaking to it. Furthermore, the robot will be able to not bump into people or obstacles around it through instilled cameras. Additionally, Pepper can move to its charging station when it senses a low battery.

ENGAGEMENT MODE:

The engagement mode is activated when a human presence is detected. In this case, Pepper introduces itself as an assisting robot that can answer the questions of Hujjaj regarding Hajj and Omra. The human can interact with pepper through voice, and Pepper can reply with voice as well.

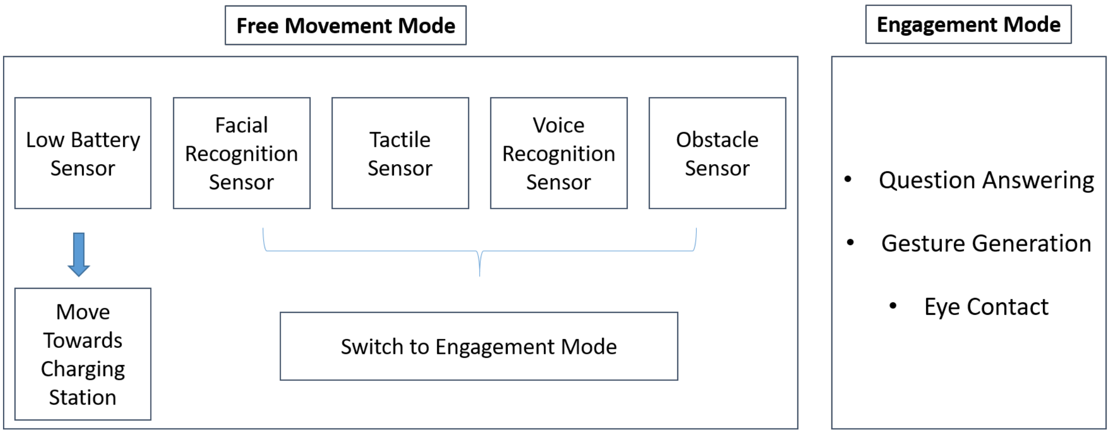


Figure 4 Visualization of the Two Modes of Pepper: Free Movement vs. Engagement Mode

Voice Question/Answer Model:

The proposed system is made up of four main modules which are the Speech recognition/ generation module, the question answering engine, the answer module, and update module.

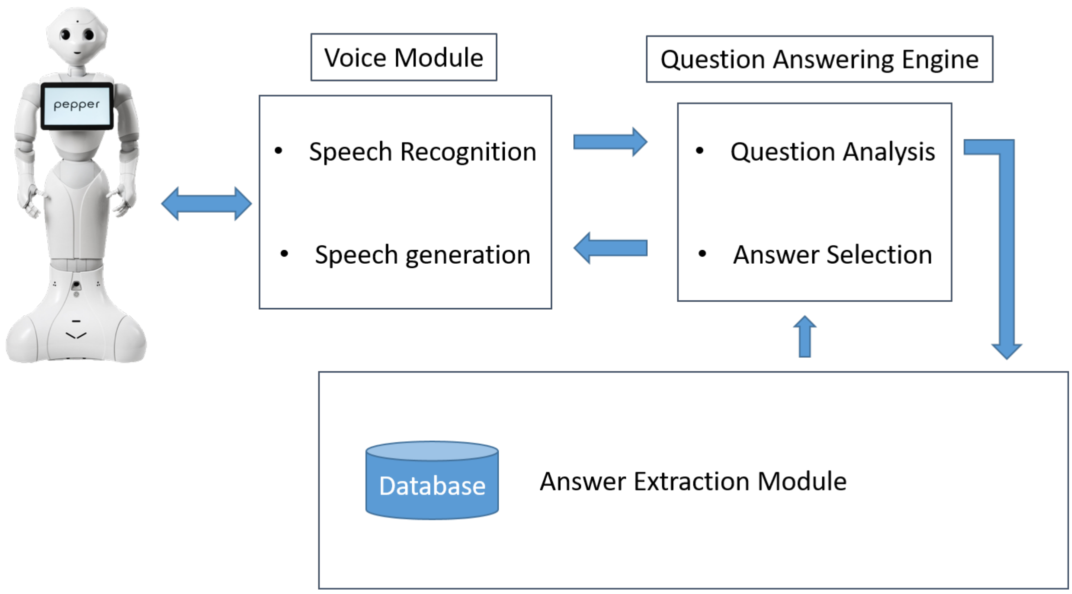


Figure 5 The Workflow Diagram for our Question Answering Feature

Initially, the robot receives a question through human speech recognition. Next, the robot relies on a question analysis technique in order to extract the keywords that are used in the question, and relate them with the answer database. In order to do so, the developers have developed an answer database containing information about Hajj and Omra, and Islam in general. After the analysis of the question, an answer is developed and chosen, which is communicated with the Q/A engine and then with the speech module in order to generate a speech representing the spoken answer. Additionally, if Pepper faces a new vocabulary that it doesn't understand, it will activate the touch screen asking the human to add this new word to the database for update.

It is also important within the engagement mode to maintain eye contact with the human, and perform body gestures to make the humanoid robot more engaging and trustworthy.

To develop the question answering model, a group of sentences must be collected relating to our topic. These sentences are in the form of question and answers.

Next, sentence patterns are defined. Sentences are defined in a formal query or sentence based on the samples above. The pattern in this case is similar to fill-in-the-blank. This means that the pattern has some variable slots that can be translated into class identifiers or interrogatives, etc…

After that, classes are assigned, and BNF grammar is built, which involves mapping the sentence pattern into standard BNF form. Then, the BNF grammar is translated to FSN grammar through BNF parser. Finally, the FSN classes are expanded into words.

When the robot receives a question, Part of Speech tagging, Answer Type tagging, and parsing occurs as processing steps.

3.3. Conclusion of Chapter3

This section describes the workflow of our study, alongside the tools and approaches that will be used to implement our interactive question answering system into Pepper in Makkah.

4. Results

4.1. Introduction of Chapter 4

In this study, our aim was to be able to integrate a socially acceptable and informative system into a humanoid social robot Pepper, in order to help muslims in Makkah during Hajj and Omra. To do so, we proposed that our robot roams in a free movement mode before finding a human. Once a human engages with Pepper, Pepper in turn will introduce himself and answer whichever questions the person has about Hajj procedures. The latter is possible through a voice Question/Answering model.

4.2. Behaviour of Pepper

In order to be able to control Pepper and allow him to generate the appropriate gestures, “Choregraphe” software was used. Choregraphe is an environment used by developers because it features some built-in function blocks that can be used by grouping them into libraries in order to generate an application for the robot. In addition, it is possible to modify the function blocks by using Python code after creating it. Fortunately, the applications that are developed in Choregraphe can be quite simple or quite complex depending on your needs from the robot. With the use of Python SDK, we can access the different modules and explore them before using them in our application.

In more details, we have explored and used Choregraphe version 2.5.5.5, where we created behaviours, animations, and dialogs. We also tested the applications on the Pepper robot, and we used python code to develop Choregraphe behaviors.

4.3. Speech Recognition

Nuance Solution is a compact speech solution for embedded systems, and it was used to run the built-in Speech Recognition system within Pepper. Nuance Solution can be accessed via through NAOqi, Speech-To-Text module. On Pepper’s head, there exist two loudspeakers on the left and the right side, in addition to four microphones that are incorporated in the head for the purpose of voice recognition. Furthermore, through Nuance, we can choose among the multiple languages, which one is preferable for our unique robot project.

4.4. Face Detection

Pepper can detect and identify the presence of faces through an artificial intelligence assisted technology known as facial detection. Facial recognition can function on images and videos where it is usually used for surveillance and real-time tracking of people in fields such as entertainment, law enforcement, and biometrics. In our study we used ALFaceDetection that allows the robot to detect the presence of an individual as well as to identify the eyes of an individual so that the robot can maintain eye contact with the person. This step is involved in the many approaches that we chose to enhance the social interaction between the robot and the humans.

4.5. Final Results

4.5.1. Pepper-Human Interaction Results

Through voice, graphical interface, as well as non verbal communications, the humanoid social robot Pepper was able to efficiently sustain a positive interaction between itself and the human next to it. As a matter of fact, these software details that we implemented as described before contribute majorly to the functioning of the robot, especially because its technical parameters alone are not enough, including its computational power (Pepper Y20V16 is equipped with ATOM 1.9 GHz quad core, 1 GB RAM, 2 GB Flash, and 8GB Micro SDHC for its Linux-based operating system).

In our study, we integrated several software modules described below:

- ALAnimationPlayer module to generate gestures and to enhance the expressions of the robot.

- ALTablet module to collect information from the user through the touch panel. The tablet has also been used to display the text.

- ALTextToSpeech module to generate speech.

- Built-in ALSpeechToText module to convert human audio into text data.

- ALVideo module to visually process the surrounding environment.

- ALFaceDetection to detect the faces around Pepper.

After the completion of the programming, Pepper humanoid robot was able to successfully perform the following tasks: human recognition, speech recognition, answering the provided questions, display the answers via text on the tablet, and properly interact with the human using suitable gestures.

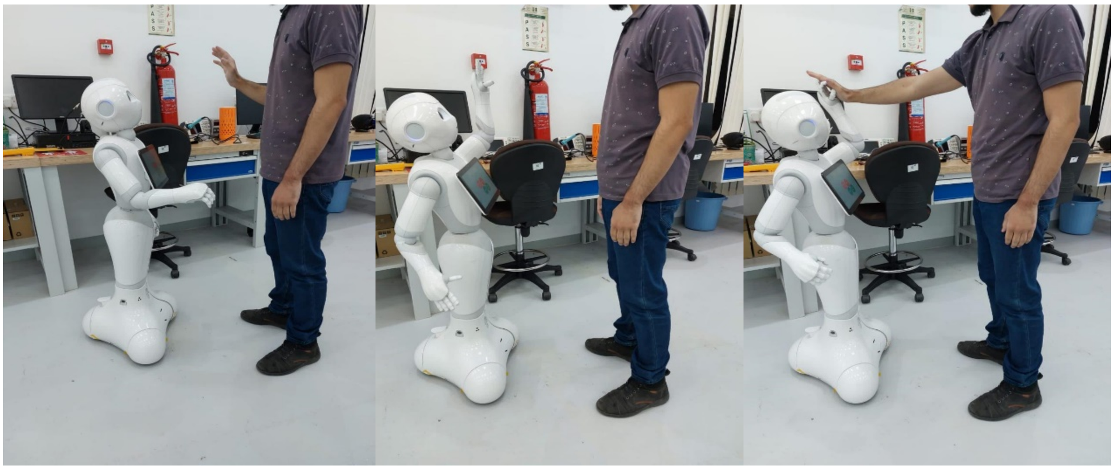


Figure 6 Pepper Robot interacting actively with a human through gestures

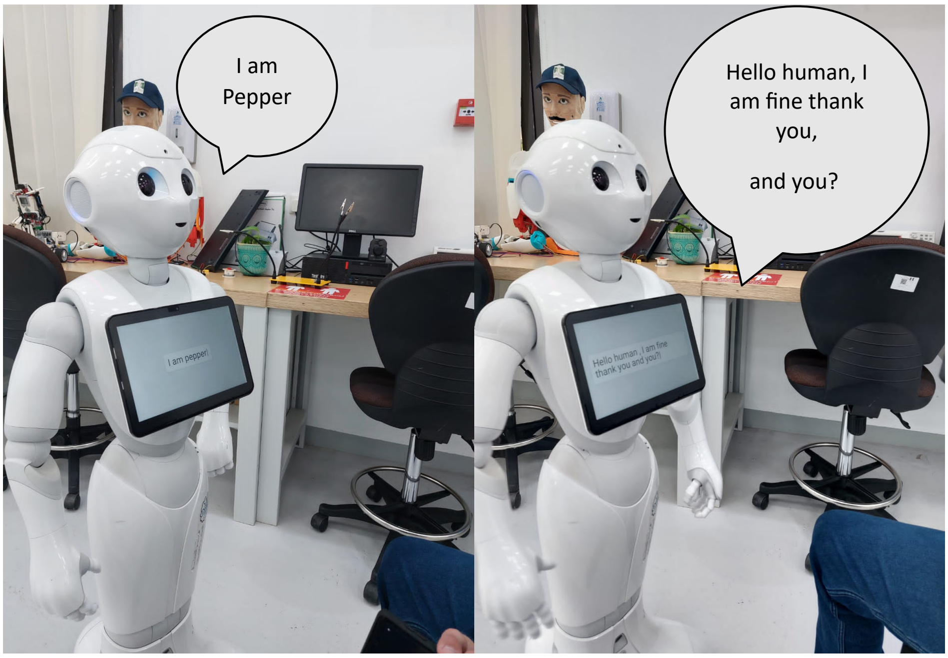


Figure 7 Pepper robot interacting verbally and through text with an individual

4.5.2. Question-Answering Results

In this section, we will provide a list of questions that Pepper was able to correctly answer every time.

- **Q**: Where is the beginning of the circumambulation of the house? **A**: The Black Stone: It is the beginning and end of the circumambulation.

- **Q**: Where does Hajj go? **A**: The Sa’y starts from Al-Safa and ends at Al-Marwah.

- **Q**: Where does the pilgrim begin the quest? **A**: from safa

- **Q**: How many runs does he try? **A**: Seven runs

- **Q**: When does standing in Arafah begin? **A**: The standing starts at Arafat from the dawn of the ninth day of Dhul-Hijjah.

- **Q**: When does the standing in Arafah end? **A**: Until the dawn of the next day;

- **Q**: Where does the pilgrim stand in Arafa? **A**: He knew it all

- **Q**: When does the pilgrim decompose his clothes? **A**: The dissolution of the ihram for Hajj for both men and women takes place after stoning Jamarat Al-Aqabah

- **Q**: How many days to throw? **A**: four days
- **Q**: How many pebbles does he throw each time? **A**: Seven stones

- **Q**: What is the size of the pebble that the pilgrim throws? **A**: The size of a chickpea

Figure 8 Pepper providing the correct answers to all of the asked questions

4.6. Conclusion of Chapter 4

This chapter discussed the results obtained by our implementation of the interactive system in Pepper humanoid robot. Pepper was able to successfully interact with humans and correctly answer their questions related to Hajj.

5. Conclusion

Day after day, Robots are being integrated into our daily lives and have the potential to serve in many fields and domains. For human robot interaction to occur, some concerns must be addressed such as the comfort level, the trust level, and the added value of the robot's presence.

In this study, our goal was to develop a system that employs a humanoid robot Pepper to communicate with Hujjaj in Makka and to be able to answer their Hajj or Omra questions. The Robot has features that allow it to engage with humans using gestures and body movements as well as maintaining eye contact. The robot in the arena will be moving freely until it encounters a human being either through facial recognition or voice recognition, upon which it will switch to engagement mode and begin answering the user's questions.

Upon software programming and development, Pepper robot's interaction with humans was tested in real-life. The robot was able to identify the voice of an individual and introduce itself to him, along with using the hello gesture. The robot then proceeded to answer the question that the individual had. The robot used audio to answer the questions as well as providing the answer in a text form on the tablet fixated on its chest.

5.5.1. Future Perspectives

In the current study, we implemented a system that incorporates multiple technologies into the humanoid robot Pepper, so that Pepper becomes capable of interacting with individuals and answering their questions. Currently, Pepper can answer a set of questions, yet Pepper will be trained in the future to answer even more questions. Furthermore, we will work on improving the social experience by allowing pepper to communicate with the speaker according to his language, thus Pepper might communicate in Arabic, Chinese, French, Spanish, etc…

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