Elevating Customer Engagement: The Role of Humanoid Robots as Receptionists

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Abstract

The deployment of humanoid robots as receptionists has emerged as a transformative approach in reshaping customer interaction dynamics. This research explores the broader landscape of utilizing humanoid robots to augment receptionist roles, focusing on their impact on customer engagement in educational institutions. This study delves into the evolving trends of humanoid receptionists, examining their capacity to revolutionize traditional customer service paradigms. As we navigate this exploration, we consider the potential benefits and challenges associated with integrating humanoid robots into receptionist roles. By analyzing the broader implications, we aim to provide insights into how these technological advancements can enhance the overall customer experience.

Keywords: Humanoid Robots, Customer Engagement, Multithreading, Human - Robot Interaction, Empathetic Technology, Semantic Analysis

1 Introduction

The integration of humanoid robots into various facets of our daily lives has witnessed unprecedented advancements, sparking innovative approaches to traditional practices. One such paradigm shift unfolds in the realm of customer service, where humanoid robots assume the role of receptionists, transforming the landscape of customer interaction. This research endeavors to explore the broader applications and implications of employing humanoid robots as receptionists, with a specific focus on their utilization in educational institutions.

As technology continues to evolve, the potential of humanoid robots to redefine customer engagement becomes increasingly evident. Educational institutions, serving as hubs of interaction, provide a unique setting to examine the impact of these robots on user experience. [1] By examining the multifaceted aspects of their integration, including technological sophistication, emotional interaction, and the use of intelligent algorithms, this study seeks to unravel the nuanced dynamics between humanoid robots and customers.

The exploration encompasses not only the advantages but also the challenges associated with the introduction of robotic receptionists. Through an analysis of multithreading capabilities, remote monitoring systems, and language support, we aim to paint a comprehensive picture of the transformative potential of humanoid robots in elevating customer service experiences. When introducing a developed robot, it is important to create an environment for the effective use of that robot. [9] and [13]. This research sets the stage for a deeper understanding of the evolving intersection between technology and human interaction, ultimately contributing to the ongoing dialogue surrounding the integration of humanoid robots as receptionists.

2 Related Work

The landscape of humanoid robots in receptionist roles has witnessed dynamic evolution, reflecting a growing interest in leveraging advanced technologies to redefine customer engagement. Previous projects in the field have explored the application of robotics in customer service, with a notable emphasis on enhancing user experience.

Several studies have delved into the integration of AI-driven systems in humanoid robots for customer interactions. When a robot assists in an assembly task or serves as a handyman, the human operator in effect ‘programs’ the robot as the work unfolds. [12] and [15]Notable projects have focused on speech recognition, gesture-based communication, and emotion detection to create more personalized and empathetic interactions. While these projects showcase the potential of AI in human-robot engagement, they often fall short in addressing the holistic receptionist experience. Moreover, various humanoid robots have been already made such as Sophia and Ameca who claim to be using AI as well to interact with people. Meanwhile From a socioeconomic perspective, virtual assistants can help with unbiased information and advice on sensitive subjects. [11]

In the domain of robotic receptionists, the "Anushka" project emerges as a distinctive endeavor, combining the intricacies of emotional intelligence, multithreading capabilities, and a real-time monitoring system. Unlike existing projects, Anushka employs a dynamic heartbeat mechanism and parallel emotional tone analysis during conversations, providing a unique touch to the receptionist interaction. The integration of strategic eye gestures, selective information storage, and extensive language support further distinguishes Anushka as a comprehensive and user-centric solution.

Moreover, the project acknowledges the critical aspects of security and privacy in customer interactions through its unidirectional data flow in the remote monitoring system. This dimension sets Anushka apart from existing projects, ensuring not only technological sophistication but also a commitment to user privacy [10].

In summary, while prior works have contributed valuable insights into the integration of AI in humanoid robots for customer service, the "Anushka" project introduces a new dimension by redefining the holistic receptionist experience. The synergistic integration of emotional intelligence, multithreading capabilities, and a user-centric design positions Anushka as an innovative and comprehensive solution in the landscape of humanoid receptionists.

3 Literature Review

3.1 Robotic Receptionist ISSN [ONLINE]: 2395-1052 Pandurang Kalli, Manoj P B (2019)

The research paper on the "Robotic Receptionist" addresses the unexplored realm of human-robot social interaction. Originating from the broader Social Robots Project, the paper introduces "ROBO-R," a robotic receptionist designed for sustained interactivity at office reception desks. Focused on filling the perceived friendliness gap in computers, ROBO-R's stationary presence near the main entrance enables dynamic interactions with visitors. The paper details ROBO-R's functionalities, employing image processing, speech conversion, and natural language processing. The proposed system aims to redefine the receptionist experience, emphasizing user-friendliness and technological sophistication [5].

3.2 Humanoid Robot as Receptionist in Institutes e-ISSN: 2395-0056 Bhavana Ekunkar1, Jagruti Choudhari (2021)

The research paper, "Humanoid Robot as Receptionist in Institutes," explores the development of a humanoid robot with human-like capabilities, focusing on applications in public sectors. Using an Arduino microcontroller and embedded systems, the robot recognizes objects, makes decisions, and responds to user queries. The paper highlights the importance of socially supportive robotics for effective communication. Simulation results demonstrate the synchronized functioning of the robot's components, and hardware implementation involves a person-detecting robot with blinking eyes and salutation. The study concludes with the potential for humanoid robots in diverse applications and the integration of advanced technologies for universal responsiveness [2] .

3.3 Managing Uncertainty in Time Expressions for Virtual Assistants University of Michigan, Microsoft Research Xin Rong , Adam Fourney (2017)

The research paper, "Managing Uncertainty in Time Expressions for Virtual Assistants," addresses the challenge of handling imprecise temporal expressions (ITEs) in interactions with virtual assistants (VAs). Authors Xin Rong, Adam Fourney, Robin N. Brewer, Meredith Ringel Morris, and Paul N. Bennett investigate the diverse set of ITEs used by people in communication and planning, reflecting motivations such as conveying uncertainty or task priority. The study employs surveys, interviews, and analysis of a large corpus to understand user expectations and preferences. The paper concludes with design implications for future virtual assistants, emphasizing the importance of accommodating temporal nuances in user input [7] .

3.4 Virtual Assistants and Their Performance In Professional Environments IEEE

This paper explores the evaluation of virtual assistants in an industrial context, focusing on technical, economical, and organizational perspectives. Collaborating with IBM and an anonymous client company, the study assesses two IBM Watson Assistants developed for the IT Service Desk and Ethics Compliance department. Utilizing quantitative and qualitative methods, including user testing and surveys, the research evaluates technological performance, organizational benefits, and potential cost savings. The findings emphasize the importance of combining quantitative metrics with qualitative measures for a comprehensive assessment. Specific conclusions highlight the relative nature of technological performance, identified organizational benefits, and the potential of virtual assistants in narrower and broader use cases [6].

3.5 Robots and Robotics in Nursing PMCID: PMC9407759 Gil P. Soriano, Yuko Yasuhara (2022)

This article delves into the intersection of technological advancements, nursing theories, and robotics in healthcare. With the aging population on the rise, the integration of technologies, specifically robots with artificial intelligence (AI), becomes crucial in addressing healthcare demands, especially in the face of human resource understaffing. The paper explores the interdisciplinary field of robotics in nursing, emphasizing its role in supporting and collaborating with healthcare professionals. It also highlights concerns regarding the potential replacement of humans and the ethical considerations in deploying robots in nursing practice grounded in caring science. The article underscores the need for further research to understand the implications and applications of robotics in nursing [14].

SNo	Paper Title	Author name and year	Technology	Outcome
1	Robotic Receptionist ISSN [ONLINE]: 2395-1052	Pandurang Kalli, Manoj P B (2019)	Image processing, speech conversion, and natural language processing	Redefined the receptionist experience, emphasizing user-friendliness and technological sophistication
2	Humanoid Robot as Receptionist in Institutes e-ISSN: 2395-00562	Bhavana Ekunkar1, Jagruti Choudhari (2021)	Robotics with Arduino microcontrollers	Person-detecting robot with blinking eyes and salutation

3	Managing Uncertainty in Time Expressions for Virtual Assistants	Xin Rong , Adam Fourney (2017)	IoT	Conveying uncertainty or task priority
4	Virtual Assistants and Their Performance In Professional Environments IEEE	E Persson (2020)	Computer and Information Sciences	Reduced time-to-resolution, Reduced handling time
5	Robots and Robotics in Nursing PMCID: PMC9407759	Gil P. Soriano, Yuko Yasuhara (2022)	Natural Language Processing	More proficient addressal of healthcare demands
6	Managing Uncertainty in Time Expressions for Virtual Assistants	Rong, X.; Fourney, A. (2017)	AI	Enhanced virtual assistant performance
7	Virtual Assistants and Their Performance In Professional Environments	Persson, E.; Torssell, J. (2020), Stockholm, Sweden	AI	Optimized virtual assistant usage
8	Robots and Robotics in Nursing	Soriano, G. P.; Yasuhara, Y.(2022)	Natural Language Processing	More competent speech synthesis
9	A method for constraint-based six degree-of-freedom haptic interaction with streaming point clouds (ICRA)	Ryden, F.; Chizeck, H. J. (2013)	Robotics	Improved haptic interaction
10	W3-privacy: understanding what, when, and where inference channels in multi-camera surveillance video	Saini, M.; Atrey, P. K.; Kankanhalli M. (2014)	Multimedia Tools and Applications and Privacy	Enhanced privacy protection
11	May I talk about other shops here?: modeling territory and invasion in front of shops	Satake, S.; Iba, H.; Kanda, T.; Imai, M.; Saiki, Y. M. (2014)	Robotics	Improved robot behavior modeling

12	Respectful Cameras: Detecting Visual Markers in Real-Time to Address Privacy Concerns [10]	Schiff, J.; Meingast, M.; Mulligan, D. K.; Sastry, S.; Goldberg, K. Y.(2007)	Privacy and Computer Vision	Enhanced privacy-aware camera systems
13	Anthropomorphism as a pervasive design concept for a robotic assistant [4]	Iossi, I.; Theis, C.; Grote, C.; Faubel, C.; Schöner, G. (2003)	Robotics	Improved human-robot interaction
14	Robotics Navigation Using MPEG CDVS [3]	Pedro P. B. de Gusmão, Stefano Rosa (2015)	Computer Vision and Autonomous Navigation	Loop Detection in Robotic Navigation Using MPEG CDVS
15	Privacy in Human-Robot Interaction: Survey and Future Work [8]	Matthew Rueben and William D. Smart (2016)	Privacy-Sensitive Robotics	Improved human-robot interaction

4 Methodology

The 'Anushka Robot' project integrates a diverse array of cutting-edge technologies to create a sophisticated humanoid robot capable of intelligent and engaging interactions. Our methodology revolves around the seamless synergy of Robotics, Artificial Intelligence (AI), Machine Learning (ML), Web Development, and IoT.

4.1 Design and Hardware Implementation:

The project begins with the meticulous design and implementation of the robot's hardware components. Anushka's physical structure, including limbs, joints, and sensory devices, is carefully crafted to ensure optimal functionality.

4.2 Programming and Brain Module Development:

Python serves as the backbone for developing the AI and ML algorithms that power Anushka's Brain Module. This module processes inputs from various sensors, allowing the robot to make intelligent decisions and generate contextually relevant responses.

4.3 Module Intercommunication:

The different modules, including Rolls, Vision, Neck, Hearing, Brain, Speech, Jaw, Hands, Palms, Eye, Monitoring, and Heartbeat, are intricately interconnected. This intercommunication enables seamless coordination, ensuring that Anushka operates cohesively in response to user interactions.

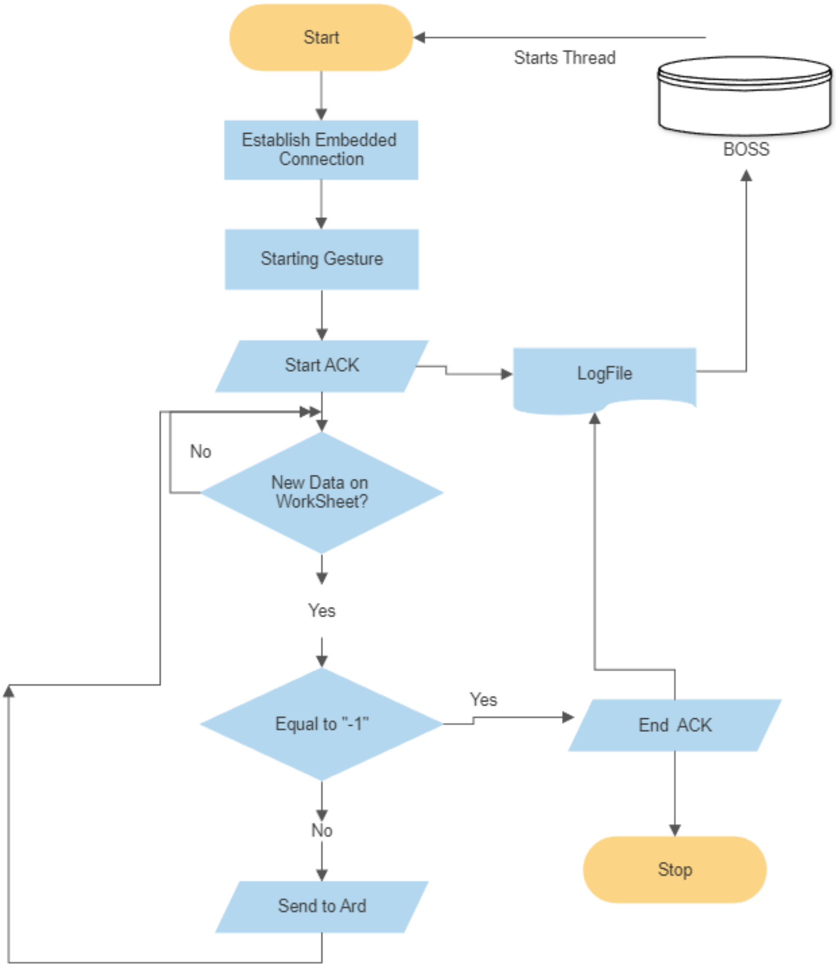

Fig. 1: Module Workflow Diagram. The process starts with the generation of request from the robot for a specific activity. This request is noted in the Worksheet file and completed by respective module running in parallel.

4.4 Integration of IoT for Sensory Input:

Anushka leverages IoT devices to enhance sensory input. Vision and audio data, crucial for recognizing people and processing spoken commands, are collected through advanced sensors and transmitted to the central processing system.

4.5 Web Development for User Interaction:

Web development technologies are employed to create an intuitive and user-friendly interface. This interface serves as the medium through which users can interact with

Anushka, input commands, and receive responses. It provides a streamlined experience for engaging with the robot.

4.6 Real-time Decision-making and Gesture Generation:

The integration of AI and ML allows Anushka to make realtime decisions based on the input it receives. The robot's gestures, including jaw movements, hand gestures, and eye expressions, are generated in sync with its speech, creating a lifelike and engaging interaction.

4.7 Centralized Control through BOSS:

The Bot Operations and Scheduling System (BOSS) acts as the central control program, orchestrating the execution of tasks, managing communication between modules, and ensuring a synchronized workflow. This centralized control enhances the efficiency and adaptability of Anushka. This comprehensive integration of robotics, AI, and web development technologies empowers Anushka to deliver a unique and intelligent conversational experience. The project aims to showcase the potential of humanoid robotics in creating a dynamic and interactive interface between machines and humans, fostering a new era of human-robot collaboration.

5 Overall System Architecture

5.1 BOSS: Bot Operations Scheduling System:

The proposed system modules need to interact with each other for data transfer and inter-program communication. Also, there needs to be a Master Module that keeps check over all the systems working correctly. It should keep check whether an error has occurred in any of the systems or separate modules and should be intelligent enough to resolve the errors itself or notify the user about it. Thus, A Master program with a proposed name of "BOSS: Bot Operations and Scheduling System" is designed to act as the master program for the modules such that an ecosystem of performance is built where each program is connected to one another and operates independent of the Operating System they are separately dependent on. The BOSS program also acts as a virtual machine for smooth functioning of all the modules together.

5.2 Hardware:

Anushka uses a HP ProDesk 600 G3 Mini, Intel® Core™ i3-6100T Processor 3M Cache, @3.20 GH, 16 GB DDR-4 RAM as a central processor. Various joints of the robot have 7kgcm, 15kgcm, and 30kgcm servo motors for effective torque. The entire system can be run on a 35C Li-Po battery. The robot has speakers Embelias @Home 2024 Team Description Paper 3 on its back, scapular region, and on the base of moving mechanism. An ANC microphone has been installed on its sternum region. The skull of the robot has been used by employing the Inmoov skull and the moving mechanism has been made by modifying the NexRobotcis Firebird-XII by removing its on-board computer, and controlling its motors using a cytron driver.

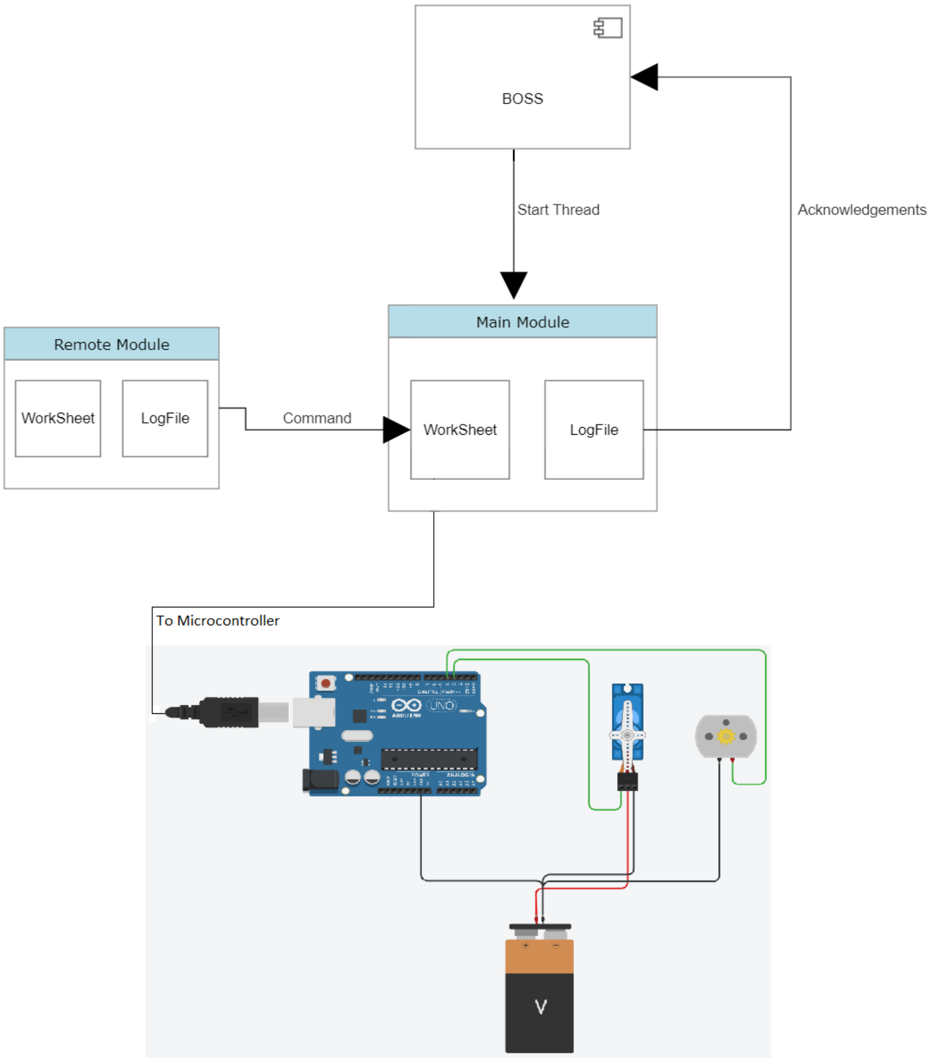

Fig. 2: Modules UML. The Micro-controller board receives a data string along with a ProcessID from the master process running on computer. This ID is used to perform respective actions from the microcontroller's side.

5.3 Communication and Task Flow:

Anushka follows a sequential process for judging the task and segregating a command from normal conversation. It can then take suitable actions to complete tasks ranging from Weather prediction, Home Automation to Following a Human using computer vision or automatically making its way, avoiding obstacles.

6 Perception Capabilities

6.1 Distance Approximation using single 2D camera:

The robot uses a novel approach for distance approximation using the lens maker's formula:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2}\right)$$

where:

- f is the focal length of the lens.
- n is the refractive index of the material of the lens.
- R_1 and R_2 are the radii of curvature of the two surfaces of the lens.
- d is the thickness of the lens.

By using an object whose actual width is already known (u) and the size of the image on the screen (v), the focal length of the camera (f) can be calculated using the lens formula. This formula can thus be used to determine the distance between the camera and the actual object by placing the values of (f) and (v), the size of the object on the computer screen. This feature is implemented in the Anushka Robot to follow the tagged person as well as maintain a formal distance from the person she follows.

6.2 Speech Recognition:

The robot uses open-source python libraries for online speech recognition such as speech recognition with recognize google and googletrans. Offline speech recognition systems such as snowboy and vosk were tried but rejected due to their limited usage and increased local system disk space for storing the data sets and language models. Further, local processing was avoided for faster operation as well as higher accuracy.

Anushka employs NLP algorithms like Sentiment Analysis, Stemming and RAKE to process and understand human language. These algorithms involved tasks like tokenization, part-of-speech tagging, named entity recognition, and sentiment analysis. By utilizing NLP, Anushka could interpret and extract meaning from spoken or written text, enabling it to understand user commands, generate appropriate responses, and engage in natural language conversations. A novel approach for 'question cacheing' allows the robot to store the questions and their answers locally based on their frequency of being asked in normal conversations.

6.3 Face Recognition:

Novel approach for identifying and prioritizing humans in real-time has been applied to the face recognition system to mimic human behavior. The face recognition system uses deep learning Convolutional Neural Network for first creating face embeddings and storing them in local database.

This database is routinely checked for repeating faces and their mapped names. Priority is given to people based on their number of times meeting the robot and time since last meeting. On a routine-base dumping, faces are "forgotten" if their priority is less, that is, the robot has met the person only once/twice and long time ago. Face recognition using computer vision typically involves several steps. Here's a high-level overview of the process:

6.3.1 Face Detection:

The first step is to detect and locate faces within an image or video frame. Various face detection algorithms, such as Haar cascades, Viola-Jones algorithm, or deep learning-based methods like convolutional neural networks (CNNs), are used to identify potential face regions.

6.3.2 Face Alignment:

Once the face is detected, it undergoes alignment to normalize its position and orientation. This step helps in reducing variations due to head pose, scale, and rotation, making subsequent analysis more robust. Landmark detection and geometric transformations are used for face alignment.

6.3.3 Feature Extraction:

The next step is to extract distinctive features from the aligned face. Features such as local binary patterns (LBPs) and scale-invariant feature transform (SIFT) are extracted using deep learning-based approach of FaceNet. These features capture unique characteristics of the face that can be used for identification or verification.

6.3.4 Face Representation:

The extracted features are used to create a compact representation of the face. This representation serves as a numerical summary of the face's features, allowing efficient comparison and matching. Here, the features are encoded into vectors.

6.3.5 Classification and Matching:

In this step, the face representation is compared with a database or a known set of faces. In the robot, we use a hybrid of support vector machines (SVM) and k-nearest neighbors (KNN) for classification of matching tasks. The goal is to identify the person associated with the face or verify if the face matches a particular identity.

6.3.6 Recognition and Verification:

Based on the classification or matching results, the system can recognize the person if a match is found or verify if the face belongs to a specific individual. The final decision is based on a threshold value of the statistical analysis of two determining factors: The last-seen time of that face, and the number of times that face has been seen by the robot.

6.4 Gesture Recognition:

The vision module of the robot is able to classify various gestures made by the users along with their detection confidence to suitably determine and remove false positives. On the confirmation of a gesture being made to the robot, it can respond back by mimicking the same gesture, using its hands module, or by responding to the gesture through speech.

The robot employes gesture recognition algorithms, which used techniques like template matching and technologies like TensorFlow and MediaPipe to identify and interpret hand gestures made by individuals. These were further trained on Teachable Machine to create datasets and classes to be fetched by Classifiers for real-time classification of gestures, allowing Anushka to respond to specific gestures with corresponding actions or gestures of its own

7 Parameters for Comparison

7.1 Integration of Robotic Capabilities:

The Anushka project stands out by seamlessly integrating various robotic modules, combining functionalities like speech recognition, natural language processing, and physical gestures. Unlike previous works focusing on specific robotic aspects, Anushka provides a unified, holistic robotic solution.

7.2 User Interaction and Engagement:

Anushka introduces a sophisticated user interaction system with natural language processing, allowing users to communicate seamlessly. In contrast to some previous projects lacking in user engagement, Anushka prioritizes intuitive interactions, enhancing the overall user experience.

7.3 AI and Machine Learning in Robotic Behavior:

While other projects might utilize AI in isolated tasks, Anushka takes it a step further. The incorporation of AI and machine learning models in various modules enables realtime, context-aware responses and actions, setting it apart from projects limited to data analysis.

7.4 Community Engagement and Interaction:

Anushka not only focuses on technological advancements but also emphasizes community building. The inclusion of features like a farmer community platform promotes knowledge sharing, problem-solving, and peer support, establishing a comprehensive and supportive ecosystem.

7.5 Emotional Expression and Interaction:

Anushka goes beyond traditional robotic applications by incorporating emotional expression through gestures, facial expressions, and verbal responses. This emotional intelligence aspect is unique compared to projects that may lack a personalized and expressive interaction component.

7.6 Environmental Perception and Adaptability:

Anushka's integration of vision modules for people recognition, sign language interpretation, and autonomous navigation showcases an advanced level of environmental perception. This feature surpasses previous projects, enhancing the robot's adaptability to diverse scenarios.

7.7 Customization of Interactions:

Unlike fixed recommendation systems in some projects, Anushka offers personalized interactions. Users can engage in dynamic conversations and customize their interactions with the robot, ensuring a tailored experience aligned with their unique preferences and needs.

7.8 Localization of Robotic Capabilities:

Anushka addresses the challenge of efficiently combining various robotic capabilities, catering to different regions and user preferences. This localized approach enhances its relevance and adaptability, distinguishing it from projects with a more generalized scope.

7.9 Scalability and Future Adaptations:

Anushka is designed with scalability in mind, allowing for future expansions and adaptations to evolving technological landscapes. This scalability aspect ensures that the system can grow and accommodate new functionalities or improvements over time.

8 Conclusion

In conclusion, the Anushka Robot project stands as a groundbreaking initiative in the realm of robotics and automation, specifically designed to redefine human-robot interactions. By amalgamating cutting-edge technologies such as speech recognition, natural language processing, emotional expression, and autonomous navigation, Anushka brings a new dimension to the field.

Through extensive development and testing, we have showcased Anushka's proficiency in providing not just a robotic receptionist but a personalized, emotionally intelligent entity capable of dynamic conversations and expressive interactions. The project's fusion of robotic capabilities, AI, and community engagement underscores its commitment to pushing the boundaries of what robots can achieve.

In essence, the Anushka project transcends the conventional applications of robotics by introducing emotional intelligence, adaptability, and community-building aspects. As we move forward, the project holds immense potential for refinement and expansion, marking a crucial step towards reshaping the landscape of human-robot interactions and setting new standards in the field of robotics and automation.

9 Future Works

9.1 Augmented Interactivity for Nuanced Conversations:

Elevate Anushka's conversational capabilities through the seamless integration of advanced natural language processing. This enhancement aims to ensure not just accuracy but also a nuanced understanding of intricate queries, fostering a more sophisticated and engaging interaction with users.

9.2 Versatile Functionality Across Environments:

Propel Anushka beyond the confines of its current receptionist role. By expanding its capabilities, Anushka can seamlessly orchestrate guided tours, deliver articulate announcements, and undertake diverse tasks within a myriad of environments. This multifaceted functionality aims to enhance its utility across various domains.

9.3 Emotional Intelligence Integration for Empathetic Responses:

Imbue Anushka with a heightened level of emotional intelligence. This involves the incorporation of cutting-edge sentiment analysis and emotional recognition algorithms. By understanding and responding empathetically to human emotions, Anushka can establish a more meaningful and supportive connection with users.

9.4 Real-time IoT Interaction for Enhanced Connectivity:

Integrate Anushka with IoT devices in real-time, broadening its capability to interact dynamically with the surrounding environment. This includes connecting with smart home systems, controlling appliances, and accessing real-time information, amplifying Anushka's functionality and relevance in the ever-evolving technological landscape.

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