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Fabrication and Development of Mobile Robot

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***Abstract*—Mobile robots are the challenging mechatronics build with advanced features which includes mainly the movements and interactions with humans. Mobile robots are yet at a young stage of development which is to be the future, these robots are expected to help humans with their work and be a companion. This paper presents the development of a Mobile robot equipped with a structure composed of aluminium strips and 3D printed mounts for coverings, servo motors for arm and shoulder movements, and DC encoder motors for base movements and rotation. The robot utilizes a camera mounted on its forehead for human detection and approaches individuals to greet them with a "namaste" gesture. The primary objective is to create a sequence control program and an Interactive GUI to enable the robot to detect humans and execute predefined actions based on the detected inputs. The GUI, developed using Python and the PyQt5 library, facilitates user interaction and provides additional information about the robot's functionality. Leveraging face detection algorithms and speech synthesis, the robot can engage in verbal communication with users. The code is implemented in Python, executed on a Raspberry Pi, which serves as the control unit for the robot's operations.**

***Index Terms*— Mobile Robot, PyQt5, GUI, Raspberry Pi.**

I. INTRODUCTION

In the late 20th century, robotics emerged as a rapidly advancing field, with Mobile robots standing out for their ability to mimic human form and behaviour. Equipped with sophisticated sensors, actuators, and AI algorithms, they navigate and interact with their environment much like humans. Recent years have seen significant improvements in their physical design and cognitive abilities, making them more agile, flexible, and capable of complex movements. Their potential applications are diverse: in healthcare, they assist in patient care; in hazardous environments, they navigate and manipulate objects; in manufacturing, they revolutionize production processes; in education, they offer personalized learning experiences; and in entertainment, they captivate audiences with lifelike interactions.

However, challenges persist, including achieving seamless human-like movement and ensuring robustness and reliability. Ethical considerations surrounding their use, such as privacy issues and job displacement, necessitate careful regulation. Nevertheless, as researchers and engineers continue to push boundaries, mobile robots are poised to play an increasingly integral role in society, contributing to advancements in healthcare, manufacturing, education, entertainment, and beyond, provided their development proceeds responsibly, addressing both technical challenges and ethical concerns.

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II. PREVIOUS WORKS

The paper "Mass produced sociable humanoid robot" by Amit Kumar Pandey and Rondolphe Gelin, likely explores the advancements in humanoid robotics, particularly in creating robots capable of social interaction for mass production. It likely discusses the technical aspects, applications, and societal impacts of these robots, aiming to advance human-robot interaction experiences and explore their potential in various fields 'Ref. [1]'.
The paper "A review on humanoid robotics in health care" likely delves into the applications and implications of humanoid robots in healthcare settings. It probably examines how these robots are currently used in patient care, rehabilitation, and medical procedures, while also addressing challenges and ethical considerations. Overall, it aims to offer insights into the evolving role of humanoid robotics in improving healthcare delivery and outcomes 'Ref. [2]' .
The paper "Humanoid robots go to school" likely delves into the integration of humanoid robots into educational environments, examining their role in teaching and learning. It probably discusses the ways in which these robots impact student engagement, teacher practices, and the overall learning experience. Additionally, it may explore the challenges and ethical considerations associated with their use in schools, aiming to provide insights into their potential benefits and implications for education 'Ref. [3]'.

III. EXPERIMENTAL PROCEDURE

A. Design of robot

The mobile robot was meticulously designed using Solid Edge, a powerful CAD software. The design process involved creating detailed 3D models of the robot's components, including its aluminium frame, 3D-printed mounts, and servo motor attachments. Solid Edge's intuitive interface and advanced modelling capabilities facilitated precise geometry creation and assembly, ensuring optimal fit and functionality of each part. By leveraging Solid Edge's comprehensive tools for visualization and simulation, we were able to refine the design iteratively, resulting in a robust and aesthetically pleasing mobile robot ready for fabrication and implementation in real-world scenarios.

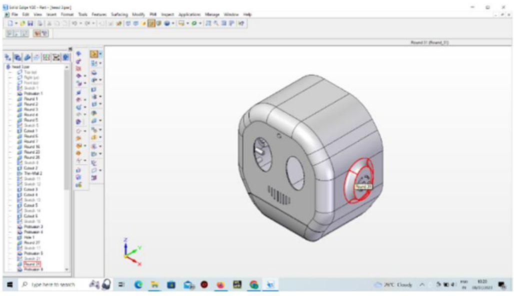

Figure 1 : CAD design of robot head

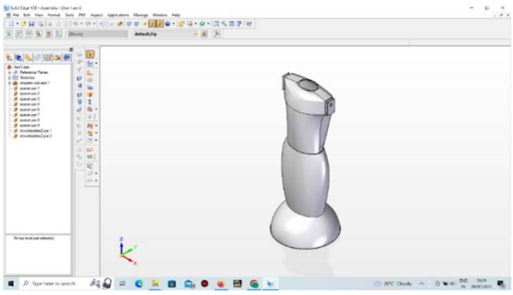

Figure 2 : CAD Design of Robot Body

B. Fabrication Process

The mobile robot fabrication began by selecting materials for durability. Aluminium, known for its lightweight and sturdy properties, formed the structural frame. TIG welding meticulously joined aluminium strips, forming the skeleton. Body components were then 3D printed, allowing for precise customization and integration with the frame. High-torque servo motors (150kgcm) were housed in the 3D printed mounts for arm and shoulder movements. DC motors (50kgcm torque) facilitated base movement and rotation. Upon assembly, the robot stood 5 feet tall and 2 feet wide, balancing human-like proportions and practicality. The result: a robust and versatile mobile robot ready for diverse tasks.

C. Control of the Robot

The mobile robot's control system centred on the Raspberry Pi 4B+ as the central processor, managing all sequences and interactions. A mounted camera captured live frames for real-time face detection using Raspberry Pi's object detection algorithms, accurately identifying humans nearby. Upon detection, the robot aligned itself towards the human subject, executing a "namaste" greeting with servo motors in its arms. Ultrasonic sensors provided continuous environmental scanning, ensuring safe navigation by detecting obstacles. Additionally, a 7-inch chest screen showcased a Python-based GUI for user interaction and information access, enhancing engagement and demonstrating the robot's adaptability. This integrated system empowered the mobile robot to

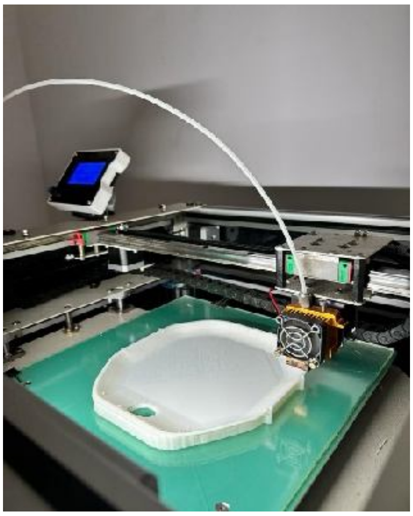

Figure 3 : Aluminium Welding Figure 4 : 3D printing of robot parts

perceive its surroundings, engage with humans, navigate safely, and offer a seamless interface for diverse applications.

D. GUI Development

The GUI for the mobile robot utilized Python and PyQt5 Designer for frontend design, with pyttsx3 enabling speech capabilities. It featured multiple windows, starting with an introductory window offering an overview of the associated institution. Subsequent windows provided detailed information on departments, faculty, research, and facilities. Navigation was facilitated by strategically placed buttons, allowing seamless transition between sections. Visually appealing elements and intuitive design principles enhanced user engagement. Speech capabilities, integrated via pyttsx3, enabled verbal communication with users, enhancing accessibility. Overall, the GUI prioritized user-friendly interaction, combining intuitive design, comprehensive content, and speech capabilities to enhance the robot's usability and appeal.

IV. Results and Discussions

A. Mobility Test

The mobile robot's mobility was crucial for its autonomy, achieved through DC motors at the base, allowing it to navigate predefined paths with precision. These motors provided ample torque for effective manoeuvring across surfaces. Additionally, servo motors in the neck enabled horizontal and vertical head movements, facilitating environment scanning and human face detection. High-torque servo motors in the arms and shoulders allowed for fluid, expressive gestures like the "namaste" greeting. Coordination of mobility, neck, and arm movements was seamlessly managed by the Raspberry Pi 4B+ processor, integrating sensor data for real-time decision-making. This combination endowed the robot with autonomy and versatility, showcasing its potential in various applications.

Figure 5 : Robot Structure

B. Sequence and GUI Test

Our mobile robot project utilized the efficient Haar cascade classifier for real-time face detection. While it has limitations, it remains practical for such scenarios. For GUI development, we chose PyQt5, enabling easy desktop application creation. Its features ensured responsiveness and supported advanced functionalities like database connectivity. Though mastering PyQt5 required effort, it empowered us to create a sophisticated interface. In summary, combining Haar cascade-based face detection and PyQt5-based GUI development enabled the creation of a versatile mobile robot with enhanced user experience, showcasing innovative solutions in robotics and human-computer interaction.

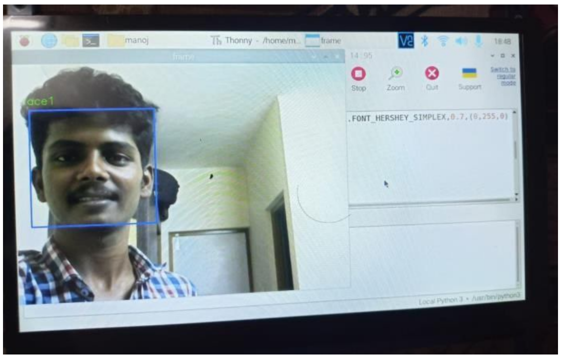

Figure 6 : Real Time Face Detection

Figure 7 : GUI windows

V. Conclusion

In conclusion, our mobile robot project signifies a significant milestone in robotics and human-computer interaction. Through the utilization of advanced technologies such as Haar cascade-based face detection and the PyQt5 framework for GUI development, we've developed a versatile robotic platform capable of autonomous navigation, facial recognition, and interactive communication.

Our meticulous fabrication process, involving aluminium structures, 3D-printed components, and high-torque servo motors, has yielded a mobile robot with fluid mobility and expressive gestures, enhancing its interactions in diverse environments.

Integration of Haar cascade-based face detection algorithms enhances the robot's responsiveness and adaptability in social interactions, while the intuitive GUI developed using PyQt5 provides users with seamless interaction.

While showcasing the efficacy of established technologies, our project underscores the ongoing advancements and challenges in robotics. As technology evolves, continued research and innovation will be essential to enhance mobile robots' accuracy, robustness, and versatility in various applications.

Ultimately, our mobile robot project demonstrates the potential of robotics to augment human capabilities and enhance user experiences, paving the way for future advancements in human-robot collaboration across diverse industries.

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