Design of a Robot for Healthcare Assistance in the Times of COVID-19

Aayushi Nainan

Abstract With the world reeling under the COVID-19 pandemic, maintaining distance from fellow humans is the new social interaction norm. During these unprecedented times, the medical fraternity and health workers are in dire need of additional help. Robots have been deployed for quite some time for facilitating industrial and healthcare needs. This paper tries to highlight the gap between affordable robots available for health institutions and the demand for them. The aim of this article is to design a prototype robot that can deliver food and medical trays to COVID-19 patients in hospitals to restrict human interaction and hence preventing the further spread of the disease. Autodesk Fusion 360, a computer-aided design tool, has been extensively used to design the robot.

Keywords Robot · Health care · COVID-19 · Fusion 360

1 Introduction

Robots have been making a profound impact in assisting and simplifying medical procedures and healthcare facilities around the globe. It has already established its prominence in niche applications like sensory prosthetics for amputees, exoskeletons in rehabilitation centers for delivering targeted physical and occupational therapy, microbots for delivering medication to a specific part within the body, and humanoids as assistants to doctors [1]. Technological advances in artificial intelligence (AI) sensor technology, 3D printing, and voice activated devices have further opened avenues for scientists and researchers to find applications of robots in enhancing and monitoring a patient’s health outcomes.

With the sudden emergence of the corona virus, the world has come to a standstill. Enforcing lockdown in order to force people into maintaining social distancing and to prevent the large-scale local, national, and international human interaction has inspired and motivated the author to contribute to the cause. This article proposes a
design for a low-cost, remotely controlled robot to assist in delivering food trays to patients in hospital wards while maintaining the healthcare guidelines.

The rest of the paper is organized into various sections. Literature review for applications of robots in healthcare institutions has been extensively explored in Sect. 2, while the tools employed for design of the robot along with the description of the proposed product are explained in Sect. 3. Section 4 deliberates the final design of the robot. The article is concluded with suggestions for future scope in Sect. 5.

2 Literature Review

Robotics in the last few decades has emerged as the most challenging field of research especially in industries and healthcare institutions. Extraordinary evolution in use of robots has been witnessed in assisting health patients, administrators, and healthcare facilities to enhance the well-being of the patients by simplifying intricate surgical procedures [2]. With significant research and developments of robots for health care, however when it comes to actual deployment in the field, few have seen the light of the day. Researchers in [3] have proposed a framework wherein the usability of robot from the service scape perspective can be verified. The authors analyzed the equipment, design, space, and ambience parameters of a nursing robot using a GUI design. In applications of wearable robots like myoelectric hand, authors in [4] evaluated the electromagnetic interference of biosensors in the control mechanism. A walking robot partner was well accepted by anxious individuals in a survey conducted in Japan [5]. They also suggested the use of a humanoid robot as an exercise partner in healthcare scenario. With robots finding applications as a human replacement in healthcare sector, it has eased the lives of elderly with mild cognitive impairment. Deploying the robot for assistance is constrained by the lack of intelligence that the robot can have. Research is gravitating toward development of smart robots which can mimic and understand human behavior and react appropriately. The role and extent of embedded AI powered with deep learning in humanoid was explored in [6] with the authors concluding that it immensely optimized the benefits of cognitive training for elderly individuals suffering from age-related cognitive decline. Results of a study on the perception and acceptance of a socially assistive robot platform “Stevie” in improving the working condition of healthcare workers were explored, conducted, and listed in [7]. Its potential to empower the elderly with independence while also providing them with social companionship was asserted by the authors. With amalgamation of advanced sensors, embedded computing and AI technology, authors in [8] have presented an intense and detailed study of robots and human–robot symbiosis in the areas of medication management, assistance to medical professionals, and its role in revamping the healthcare workflow.

Interdisciplinary research has led to collaboration of AI and knowledge of mechanical/electronics engineering to deploy interactive robot agents in healthcare scenarios. Interactive robot was employed during a therapy intervention and the results indicated that participants showed 3.5 times more trust in the therapy as compared to that
delivered by a human agent [9]. Study of intelligent and autonomous robot which can collaborate with humans in social environment has been explored in [10] due to rapid advancements in the areas of AI and Internet of things. To maintain the stability of the robot while walking in different terrains, the authors in [11] proposed an adaptive fuzzy controller method to correct errors on the joint actuators by analyzing foot motion parameters based on ground conditions. Bluetooth and wireless technology have also found its way in optimizing the intelligence of the robots in controlling the motion of arms and can be utilized in healthcare applications [12].

Armed with the information assembled from the various articles researched and with the motivation derived from the current scenario, the next section details the design considerations of the proposed robot.

3 Robot Design Considerations

Various design considerations were deliberated upon before actually getting down to developing the various components required for designing the proposed robot. Since the application of the robot is for a hospital ward environment, the size of the actual robot needed to be worked out. Two-dimensional sketches of the components were then created before proceeding with creating a three-dimensional model. Modifications to the design and deliberating on the appearance of the final product were the last step in the design consideration. Figure 1 enumerates the steps in designing the robot.

The following ideas were adhered to before proceeding further.

- The final design should be like that of a food rack.
- The robot can be operated using a remote controller.
- The patients’ respective food tray will automatically slide out based on the linear movement mechanism as given in Fig. 2.
- The patient can collect the food tray without touching anything else.
- The robot will continue to do the same until all food trays have been delivered to the patients.
- Once the trays have been collected in the same way as well, the trays as well as the delivering robot can be sanitized and disinfected before the next round of meals are circulated.

3.1 Fusion 360

The software used to develop the proposed design is Fusion 360. Autodesk Fusion 360, a CAD, CAM, and CAE software, is a cloud-based designing tool that gives one the opportunity to design, model, and simulate your projects digitally, turning their ideas into reality [13]. Replacing the lengthy process of manual designing with a quick, efficient, and automated process, Fusion 360 aids in drastically reducing
|   | DIMENSIONS | 1. Size and dimensions of the component with respect to the whole product were finalized |
|---|------------|------------------------------------------------------------------------------------------|
| 2 | SKETCHES   | 2. Two-dimensional sketches of the component were created                                  |
| 3 | MODEL      | 3. Three-dimensional models of the 2D sketches were created                                |
| 4 | MODIFICATION | Advanced features such as fillet were applied to enhance and improve the component          |
| 5 | APPEARANCE | Material, color, and texture was applied to the component based on its functionality         |

**Fig. 1** Steps in implementing design consideration for robot building

![Linear movement mechanism](image)

**Fig. 2** Linear movement mechanism
manufacturing costs by limiting the need to develop multiple prototypes before finalizing on a design. Additionally, by providing one with three-dimensional views of their designs and enabling them to edit it multiple times until perfection, Fusion 360 produces accurate designs with little room for error. Manually sketching designs and developing different prototypes with each edit results in an overall increase in costs incurred; however, Fusion 360 allows one to make multiple edits to the same design and reduces the need to make prototypes, hence reducing the total expenditure. Additionally, its simulation feature allows one to enhance the product working by indentifying its key structural aspects. Additionally, by providing one with three-dimensional views of their designs and enabling them to edit it multiple times until perfection, Fusion 360 produces accurate designs with little room for error. Figure 2 shows the design of a linear motion mechanism that can be implemented in making the physical prototype of the robot.

There are multiple CAD softwares such as Autodesk Inventor, Onshape, TinkerCAD, and Creo. For this article, SolidWorks and Fusion 360 were chosen for comparison. After an extensive comparison between Fusion 360 and SolidWorks, Fusion 360 was the selected software for this article mainly because it provides a large range of geometric tools that can be easily accessed [14, 15]. Furthermore, Fusion 360 offers a variety of robust tools that increase the efficiency of creating 3D models. However, its “multi-component part system” requires one to build all components in the same file in order to assemble it together, which can often be a negative aspect, especially when developing more complex designs [16].

The following Sect. 4 gives a detailed insight into the final design, appearance, and model of each component used to put together the proposed robot. It also contains a brief overview of the features used in Fusion 360 in order to complete each design.

4 Design of the Robot

This section provides a complete visual guide of the different components that were assembled together, creating the final robot. Additionally, the varied features used to create each component has been discussed in Table 1.

The remaining part of this section contains the images of each component separately.

Figure 3 shows the design of the food rack, and Fig. 4 shows the food tray with the food items while Fig. 5 shows the 3D model of the wheel.

After designing each component separately, the final robot was assembled together using various joint features like rigid and revolute as seen above in Fig. 6.
Table 1  Features of Fusion 360 used to design various components of the robot

| Component                  | Sketch | Extrude | Revolve | Mirror | Joints | Other                        |
|----------------------------|--------|---------|---------|--------|--------|------------------------------|
| Food rack                  | Yes    | Yes     | No      | Yes    | Yes    | –                            |
| Food tray + food items     | Yes    | Yes     | Yes     | No     | Yes    | Fillet, appearance           |
| Wheel                      | Yes    | Yes     | Yes     | Yes    | Yes    | Line, trim, fillet, appearance |
| Linear motion mechanism    | Yes    | Yes     | No      | Yes    | Yes    | –                            |

Fig. 3  Design of the food rack

Fig. 4  Design of a sample food tray with sample food items
5 Conclusion and Future Scope

People from all parts of the world, all walks of life and all age groups are united in their fight against these unprecedented times caused by the corona virus. In an attempt to help, support and assist healthcare workers in hospitals, who are risking their lives to save the infected patients, the author has designed a probable model that can be implemented to protect the frontline workers. According to recent findings, hundreds of healthcare workers have been infected with the contagious coronavirus. With the implementation of the proposed design in this article, the risk of them contracting the disease can be lowered because they will be in less contact with the infected patients.
Although the proposed design has been developed on Fusion 360, the physical prototype is yet to be built. Keeping that in mind, the robot can be implemented on a larger scale, with more food racks to provide more patients, hence increasing in its working efficiency. Currently, the robot can be operated using a remote-controlled device; however, with more advanced research and after its testing, the working of the robot can be automated using the Python programming language.

Additionally, the material used in the design proposed above is aluminum, the same can be implemented using hard acrylic material. While this may make the robot more cost efficient, its ability to remain sturdy and take the weight of multiple food trays is yet to be tested.

References

1. Azeta, J., Bolu, C., Abioye, A., & Oyawale, F. (2018). A review on humanoid robotics in healthcare. MATEC Web of Conferences, 153.
2. Alotaibi, M., & Yamin, M. (2019) Role of robots in healthcare management. In 6th International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 1311–1314). New Delhi, India.
3. Han, J., Kang, H., Kwon, G. H. (2017). Understanding the service scape of nurse assistive robot: the perspective of healthcare service experience. In 14th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI) (pp. 644–649). Jeju.
4. Liao, W., Nagai, K., & Wang, J. (2020). An evaluation method of electromagnetic interference on bio-sensor used for wearable robot control. IEEE Transactions on Electromagnetic Compatibility, 62(1), 36–42.
5. Yamada, S., Nomura, T., & Kanda, T. (2019). Healthcare support by a Humanoid Robot. In 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 1–2). Daegu, Korea (South).
6. Vogon, A. A., Alnajjar, F., Gochoo, M., & Khalid, S. (2020). Robots, AI, and cognitive training in an era of mass age-related cognitive decline: a systematic review. IEEE Access, 8, 18284–18304.
7. McGinn, C., Bourke, E., Murtagh, A., Donovan, C., & Cullinan, M. F. (2019). Meeting stevie: perceptions of a socially assistive robot by residents and staff in a long-term care facility. In 2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 602–603). Daegu, Korea (South).
8. Pang, V., Yang, G., Khedri, R., & Zhang, Y. (2018). Introduction to the special section: convergence of automation technology, biomedical engineering, and health informatics toward the healthcare 4.0. IEEE Reviews in Biomedical Engineering, 11, 249–259.
9. Xu, J., Bryant, D. G., & Howard, A. (2018). Would you trust a robot therapist? Validating the equivalency of trust in human-robot healthcare scenarios. In The 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) (pp. 442–447). Nanjing. https://doi.org/10.1109/roman.2018.8525782.
10. Breazeal, C. (2017). Social robots: from research to commercialization. In 2017 12th ACM/IEEE International Conference on Human-Robot Interaction HRI (pp. 1–1), Vienna.
11. Chen, M., & Chen, K. (2019). Applying a stable dynamic walking mode of humanoid robot based on adaptive fuzzy control. In IEEE Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS) (pp. 177–180), Okinawa, Japan. https://doi.org/10.1109/ecbios.2019.8807808.
12. Varshney, V., Kumar, A., Saxena, T., Jha, P., & Tiwari, M. N. (2019). Design and development of intellectual robotic arm. In 6th International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 984–987). New Delhi, India.
13. https://academy.autodesk.com/getting-started-fusion-360.
14. https://all3dp.com/2/fusion-360-vs-solidworks-cad-software-compared-side-by-side/.
15. https://total3dprinting.org/solidworks-vs-fusion-360/.
16. https://www.sculpteo.com/blog/2018/10/24/battle-of-software-fusion-360-vs-solidworks/.