A Robotic Platform for Assistance in the Medical Triage Process

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Triage is the process of partially assessing and ordering patients as to the priority of need for medical care. However, in disaster scenarios and atypical events, overcrowding of the care system can occur. In this context, a collaborative robot, able to share the work environment with health agents, could be in charge of the repetitive triage tasks, leaving the medical team with the care. Thus, this paper aims to develop a virtual prototype for medical triage assistance, nicknamed BayIEEEmax. The 3D model was created in SOLIDWORKS 2018, the electronic circuit was designed in KiCad, and the simulation was performed through ROS.

Keywords: Triage. Collaborative Robots. Medicine Robots.

Introduction

Derived from the French word “trier”, which means “to sort or select”, triage is the medical practice of sorting patients, following their need for medical attention [1]. The term was first used around 1792 by the Surgeon in Chief of Napoleon’s imperial guard, Baron Dominique Jean Larrey, to describe the necessary act of sorting the large numbers of wounded soldiers based on the criticality of their injuries [2,3].

Triage is usually employed when medical facilities are overloaded because of the great demand for people in need of medical attention but not enough resources to care for all of them properly. Overloading usually happens due to wars, natural disasters, terrorist attacks, or pandemics, like the one caused by the SARS-CoV-2 virus, also known as “COVID-19” [3,4].

Despite being essential for assessing and validating emergency procedures for many hospitals, modern triage still faces problems that can significantly decrease its ability to correctly prioritize patients most in need of clinical care [5]. Notwithstanding the need for patients to be appropriately triaged in the first few minutes after entering the hospital, many hospitals worldwide suffer from long waiting periods between procedures, both resulting and occurring as a consequence of ineffective triage systems [5,6].

Such problems derive from organizational issues with hospital management and the lack of proper training of triage nurses for the correct diagnostic and subsequent prioritization of patients [5]. Collaborative robots are a specific kind of robot designed to work side-by-side with human workers in a shared space. In general, the repetitive tasks are left to the robot, while the mental ones are executed by humans [7]. Furthermore, they have shown great promise in performing complex tasks in constantly changing environments [8]. Therefore, to improve the triage process, the insertion of robots and AI in this first step after entering some emergency departments can save time and optimize this process, especially in cases with large crowds of patients waiting for the service.

Furthermore, these insertions can automatically set all the data acquired from each patient directly in the system of the hospital or clinic, doing some easy, safe, and simple tasks in an automatic way to improve the overall scenario [9,10]. This paper’s main objective is to conceptualize a virtual prototype of a robotic assistant for medical triage,

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nicknamed "BayIEEEmax", as a possible solution to the problems faced by current triage systems. The following section presents the project's methodology, subdivided into 3D modeling, electronic design, and simulation; the third one presents the results achieved, and finally, the last section, is shown the conclusion, as well as the next steps planned for the project.

Materials and Methods

This study is characterized as qualitative and exploratory, backed primarily by the research of bibliographical material about the theme. Besides, the development of the virtual prototype itself was subdivided into three sections: the 3D model, the electronics, and the simulation, with a description of the tools for developing each section.

3D Model

To better visualize the design, we used the SOLIDWORKS 2018 software to build a 3D (three-dimensional) model that could be reviewed and modified before building the actual robot and also could adjust any necessary parameters, parts, and/or fit. In addition, building a CAD also aims to achieve not only the feasibility of building the design to fit each part, but to create a robot that is aesthetically pleasing to people.

Electronic Design

KiCad is a computational program for the computer-aided electronic design that aims to enable the conception of layouts and their conversion to printed circuit boards (PCB). Because it is Open Source, it allows the usage of 3D models and footprints created by companies or users of this software. Using KiCad allows the user to develop a circuit plan, build a board that will be made for the desired function with the selected components, and avoid expenses with the misplacement or lack of space between components. In addition, possible circuit connection faults are identified during circuit construction, and the software itself alerts the user to connection errors found.

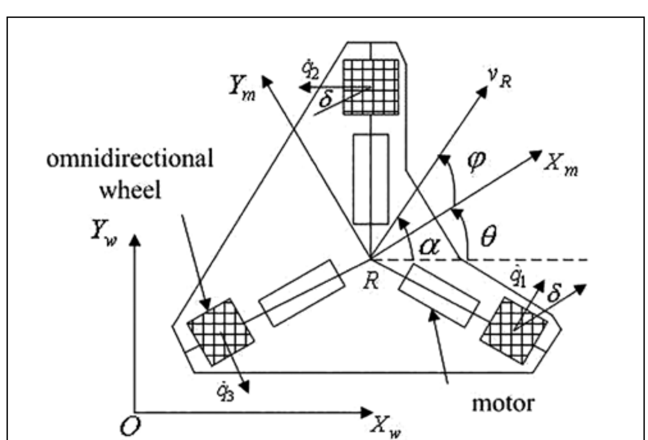
Simulation

Robot Operating System (ROS) is an open-source framework with several valuable tools for robot development. For example, it can simplify for the user the process of communicating the different components of a robot, such as the motors, sensors, batteries, and software, through a modularized system based on topics and nodes. ROS was adopted as the simulation and implementation tool of the robot logic because, besides having several packages already developed, it also natively supports the C++ and Python programming languages. Another point is that the programming can be loaded directly into embedded systems, such as the Raspberry Pi 4, the controller used as the robot's control unit, without requiring modifications in the code itself.

Results and Discussion

Omnidirectional wheels are a particular type of wheel that makes it possible to perform some moves (Figure 1) not allowed by differential movement with conventional wheels, such as rotating around its axis or moving diagonally without needing to change its orientation position. Thus, since the

Figure 1. Omnidirectional wheel diagram of movement.



space for maneuvering a robot inside a hospital may be scarce, we adopted this wheel, which was chosen to move in limited space.

The current version of the CAD model from the project (Figure 2) contains a base to occult the omnidirectional wheels with a torso, equipped with a socket at the front to Liquid Crystal Display (LCD) Touchscreen display, two arms, and two pots in the head for several uses. The squares in the front of the torso are purely esthetical to improving the visuals of the robot. The model shown has a total height of approximately 1.65 meters and wide of 0.86 meters. He will be made up of boards of MDF (Medium Density Fiberboard) in most of your entire body with PLA (Polylactic Acid) 3D printed to fill in little details like the squares in the front part. Initially, the construction process of the electronic project was done by creating charts of functionality and electronics distribution on the robot.

Figures 3 and 4 present the functionality and electronics distribution chart, where both were drawn in draw.io. Furthermore, Figure 3 shows the ARM microcontroller STM32F103C8 connected to an oximeter sensor, stepper motor, battery, AC/DC converter, driver, GPS module, IMU MPU, and analog current sensor; Raspberry Pi 4 is connected

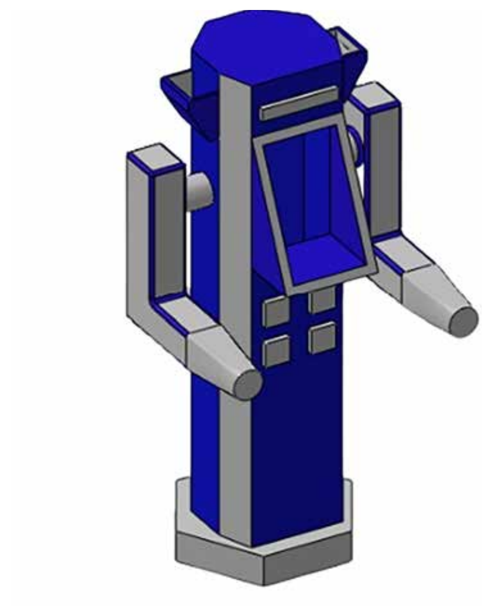


Figure 2. The current version of the 3D model.

to the module and thermal camera, two cameras compatible with raspberry, another camera for face recognition, a display, and a glucose and cholesterol sensor. And Figure 4 shows where the component will be located and its connection to the circuit.

Finally, Figure 5 presents the 3D circuit board design that was created in KiCad, where the schematic circuit and PCB layout can be drawn.

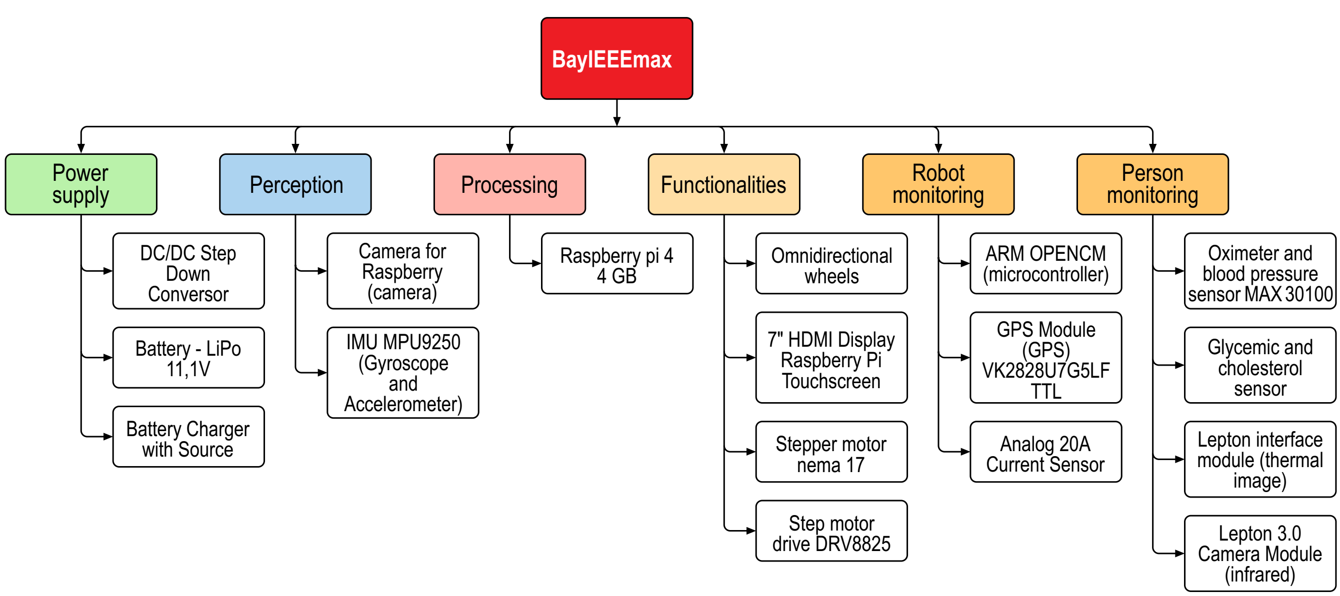


Figure 3. Diagram of BayIEEEmax functionalities.

Figure 4. electronics distribution on the robot.

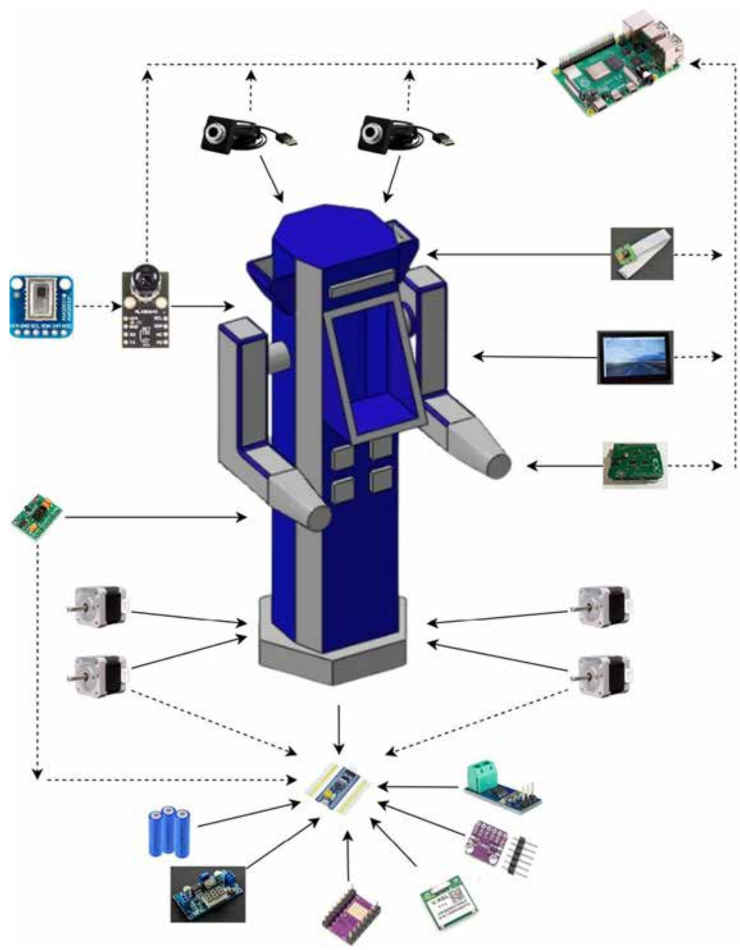
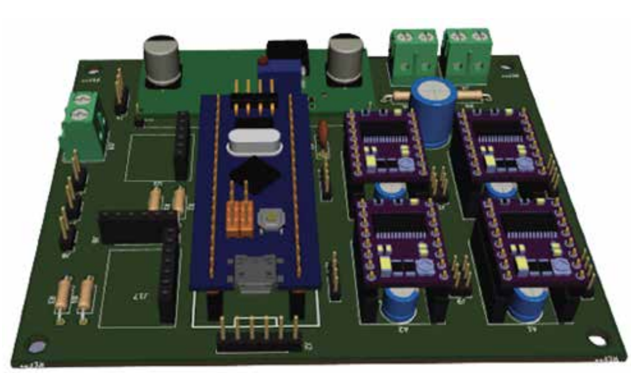


Figure 5. BayIEEEmax microcontroller board.



Conclusion

In this document, the current situation of the medical triage processes was presented, as well as how the occurrence of events such as wars, natural disasters, terrorist attacks, or disease outbreaks can lead hospitals to overcrowd in these critical moments. Furthermore, it was shown how the inclusion of collaborative robots in work environments could benefit the performance of activities. The progress for the 3D modeling, electronic design, and simulation of project BayIEEEmax were also shown. Considering how the robot would need to move within places with limited space, an omnidirectional wheel was deemed ideal for the robot's movement. A functionality distribution chart was also made, addressing the power supply, perception, processing, and monitoring process of both the robot and the patients in its care. In the following steps, the printed circuit board will be fabricated, the sensors and actuators will be connected, and the robot structure will be built. Some parts will be fabricated through 3D printing. Finally, the parts will be assembled and integrated to implement the logic developed in the simulation environment and the first tests with the physical prototype.

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