Syrian Arab Republic

Distinction and Creativity Agency

National Center for the Distinguished

Design and Implementation of a Robotics System for Medical Assistant in Hospitals

Haider Salamah (12th grade), Zein Mohammad (12th grade)

National Center for the Distinguished

Abstract:

An increasing number of hospitals are responding to modern demographic, epidemiological, and administrative challenges moving from a traditional organizational model to a patient-centered (PC) hospital model. Which in turn has greatly increased pressure on human resources, and drained a lot of their energies.

The idea of our project is based on automating hospitals in part by making robots perform some medical tasks that are dangerous or tiring for humans. We implemented an assistant mobile robot navigating based on ArUco markers distributed in the work area to perform couple of tasks, first one is transporting supplies throughout the offices and rooms of the hospital using a 3 DOF arm mounted on it, especially in rooms with patients who have infectious diseases, the second task is handling out a facemask for pedestrians who are not wearing one, for this task we used Kinect camera, the camera detects the masks by using trained CNN mobile net v2 model. This model was trained using about 3050 photos and tested using about 800 photos. After training we got 98.58% accuracy in the cross validation test. To control the electrician components, we used Arduino communicating with Raspberry pi via ROS (Robot Operating System). Finally, we did a business model canvas to study the economic benefits for our project.

Keywords: ROS, Arduino, Raspberry pi, CNN model, ArUco.

Introduction:

The use of robots in healthcare is a growing trend that seems to be gaining momentum in recent years. From the first robotic surgical assistant more than a decade ago, to new research today, the use of robotics in healthcare is advancing rapidly. Medical robotics have undergone a variety of creative improvements over the years from researchers in an effort to give direct patient care, raise the standard of care, and help with various therapies.(Sujatha Alla, 2021)

The assistant robot's design must be adaptable to navigate around the environment without human guidance. It also needs to be capable of making decisions and carrying out tasks precisely. Due to all of these requirements, artificial intelligence models should use, and that assist the robot in interacting with people and other objects.

Mechanism design:

For the design of the main robot, we used Matrix and Tetrix Parts. The Robot is a four wheeled mobile robot with Omni wheels which allows for lateral movement in all directions. The robot has a 3DOF arm mounted on it for task execution.

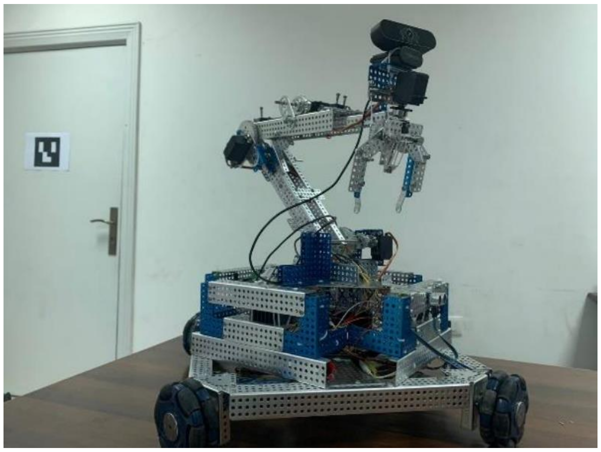

Figure 1: the designed robot.

Electrical connections between boards are other parts:

The connections are simulated using proteus simulator as shown below:

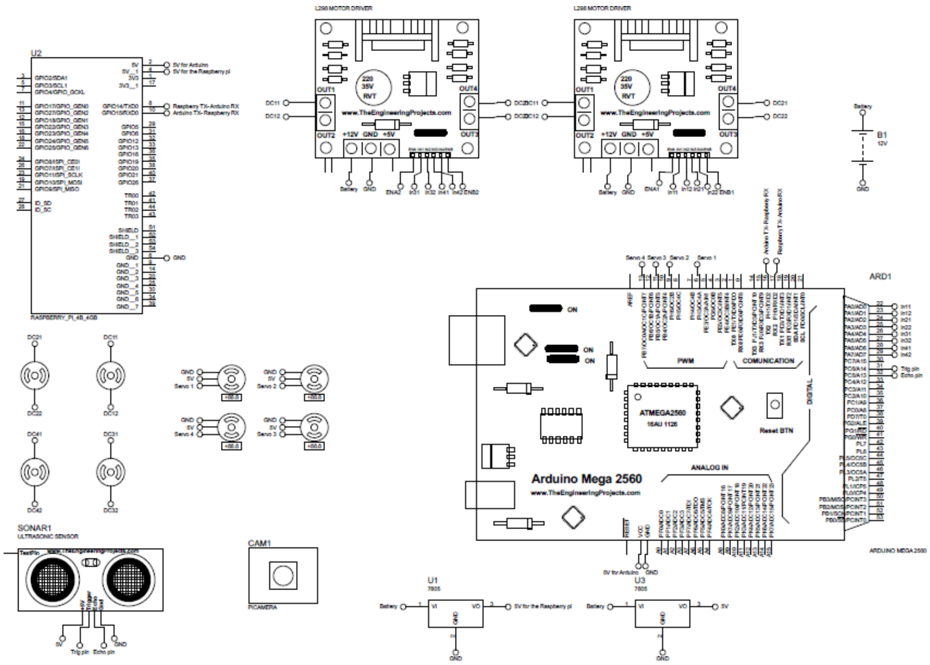

Figure 2: connections in the robot

IDEs and systems:

1. **ROS:**Robotic Operating System is a group of libraries and tools those assist in creating robotics projects, ROS was built using modern algorithms and tools(Robotics, Open, 2021), so ROS is one of the best ways to build your robotic project, and the most important thing is that ROS is not an operating system (OS). ROS classifies as an open-source environment, so it is compatible with the Linux and Ubuntu OS Debian etc.…. because the ROS became easier to develop with the open-source OS, and it is not compatible with mac OS and windows because they are not open-source OS.

2. **Arduino IDE:** IDE used to program the Arduino boards.

3. **Proteus:** Program for simulation any electronic circuit and also any project could be simulated using proteus, in addition proteus is used to design PCB.

4. **Google Colab:**Online programming platform, Google Colab is used to train the CNN model because of the features (fast GPUs, big RAM and Disk memory).

Algorithms:

1. ArUco markers navigation algorithm:

ArUco markers are similar symbols to barcodes, they are mainly used in the navigation algorithms, the ArUco markers can be dealt easily by using the openCV python library (Detection of ArUco Markers, 2022) that contains pre-built functions to detect and deal with ArUco markers. So we used a Camera to detect ArUco markers that are planted on walls in the way of the robots. The Robot will navigate based on the distance of the ArUco marker from it (depth can be calculated from one camera by calculating the area of the detected marker. The further the robot is the smaller the area will be; the area increases linearly as the robot gets closer to it).

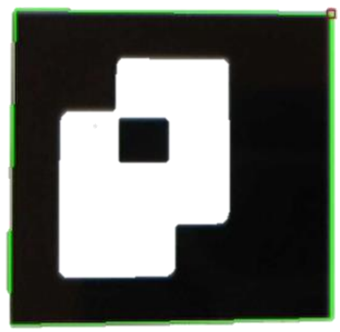

Figure 3: sample of a detected ArUco.

2. Face mask detection algorithm:

For this task we found lots of algorithms, but we decided to use CNN mobile net model version 2, because we want to run the trained model on Raspberry pi efficiently in fast way, the standard CNN model uses 2D convolutions, while mobile net version 2 uses a new kind of convolutional layer, known as Depthwise Separable convolution. The main difference between the two convolutions is that in the regular 2D convolution performed over multiple input channels, the filter is as deep as the input and lets us freely mix channels to generate each element in the output. In contrast, depthwise convolutions keep each channel separate. (Fadi Al-Turjman, 2023)

```
baseModel = MobileNetV2(weights="imagenet", include_top=False,
  input_tensor=Input(shape=(224, 224, 3)))
headModel = baseModel.output
headModel = AveragePooling2D(pool_size=(7, 7))(headModel)
headModel = Flatten(name="flatten")(headModel)
headModel = Dense(128, activation="relu")(headModel)
headModel = Dropout(0.5)(headModel)
headModel = Dense(2, activation="softmax")(headModel)

model = Model(inputs=baseModel.input, outputs=headModel)

for layer in baseModel.layers:
  layer.trainable = False

opt = tensorflow.keras.optimizers.legacy.Adam(lr=INIT_LR, decay=INIT_LR/EPOCHS)
model.compile(loss="binary_crossentropy", optimizer=opt,
  metrics=["accuracy"])
```

Figure 4: The structure of the CNN mobile net model

For training we used dataset consists of almost four thousand label photo, we alsoimplemented augmentation in codeto create more data, then we split it into training set and validation set finally we run the code through 15 epochs to get high accuracy on validation and avoiding overfitting problem.

3. Item grabbing algorithm:

Simply when the ultrasonic sensor (that is in the front of the robot) detect a thing, the arm rise, after that if the camera does not detect a face then the thing will be an item to grab.

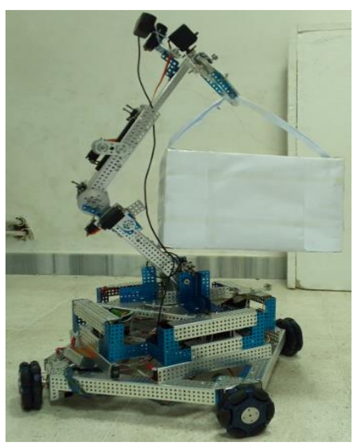

Figure 5: shows the robot grabbing a test item.

We can summarize the whole three algorithms using this flowchart as shown:

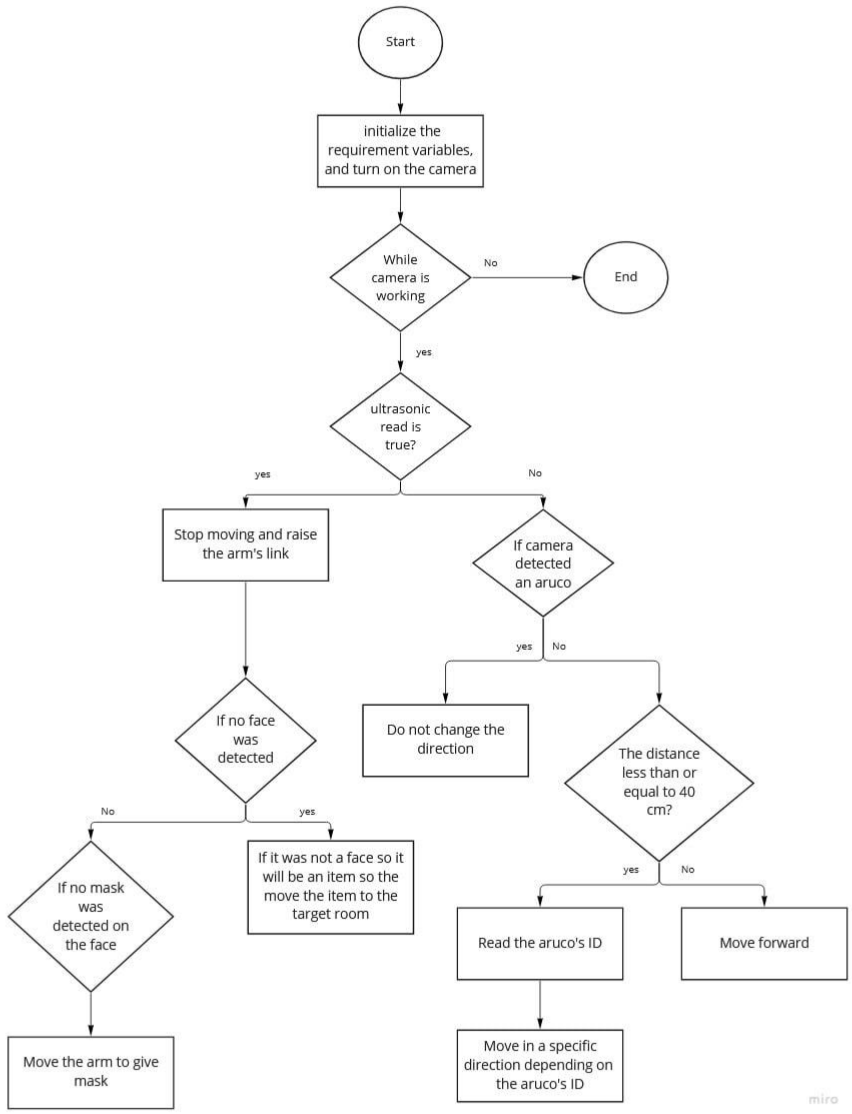

Figure 6: Full flowchart of the robot tasks.

Software connecting between the boards:

We used ROS 1 noetic to connect the boards and so we defined three nodes: Raspberry Pi node, Arduino node, and camera node.

The camera node streams live video to the Raspberry pi node, which serves as the system's primary processor. The Raspberry then analyzes the video, detecting both the ArUco markers needed for navigation and the human faces to ensure that everyone is wearing mask. Finally, the Raspberry publishes a message containing the movement information to the Arduino node, which controls the arm and motors.

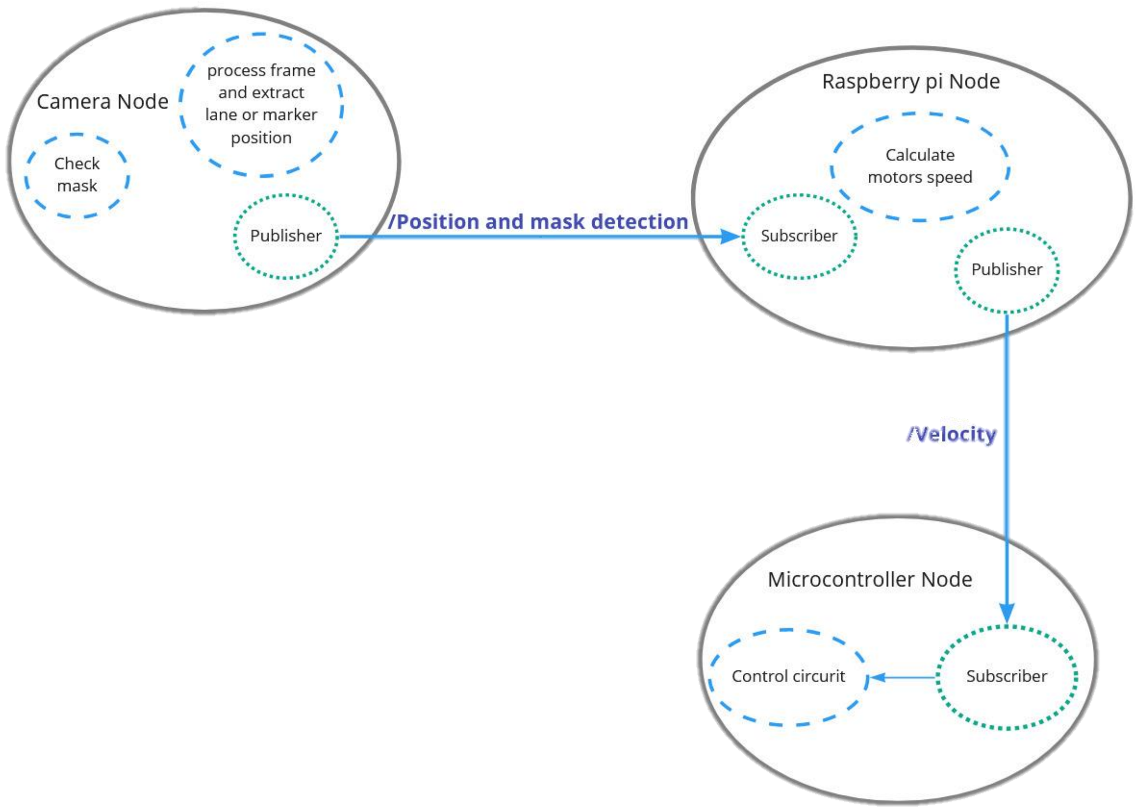

Figure 7: Flowchart shows the ROS nodes and topics

Business Model Canvas for our project:

<table>
<tr>
<td rowspan="2">KEY PARTNERS

Businesses that import class-one electronic and mechanical components.</td>
<td>KEY ACTIVITIES

Creation

Reporting

Promotion

Optimization</td>
<td rowspan="2">VALUE PROPOSITION

The Medical Industry

Medical staff</td>
<td>CUSTOMER RELATIONSHIP

Representative from the company that keeps in touch with customers and asks for feedback</td>
<td rowspan="2">CUSTOMER SEGMENTS

Hospital owners

Medical Insurance Companies

Companies in the medical field</td>
</tr>
<tr>
<td>KEY RESOURCES

Robotics engineers</td>
<td>CHANNELS

Word of mouth

YouTube

Facebook

Applying to contests and showrooms</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE

Staff Costs

Operating Expenses

Marketing Costs (Facebook and Instagram ADS).</td>
<td colspan="2">REVENUE STREAM(S)

One time purchase of a product

Charge Maintenance Fees</td>
</tr>
</table>

Results:

1. Our AI model provides its efficiency in detecting masks, navigation and arm tasks. In testing, the CNN model has around 98.58% accuracy, the following graph shows the accuracy and loss values (the losses were calculated using Binary Cross Entropy loss function) in the training and cross-validation test:

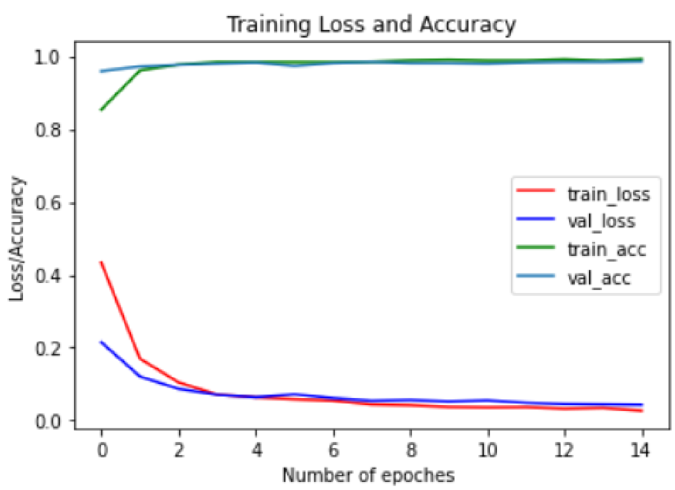

Figure 8: shows the values of train and validation accuracy/loss according to the number of epochs

2. The mechanism of the robots and the arm mounted on it was satisfying for the tasks mentioned and the navigate shows flexibility even if there are lot of human around.
3. The connection using ROS interrupts when the live video has large number of faces. So using pyserial to initiate the connection between Arduino and Raspberry Pi could be more efficient.

Conclusion and future visions:

In conclusion our project will solve lots of problems in healthcare, and it will make medical services easier and more economic to get for all the people around the world, also it will reduce the number of disease infections around the world and will make the job of healthcare workers much easier.

In the future we aim to:

1. Use other navigation teachings and algorithms like lane detection, GPS or SLAM technology.
2. Increase the number of robot tasks and add more robots to make a swarm of healthcare robots (maybe a robot for cleaning).
3. Use alternative energy source to charge the robots batteries like wind energy.
4. Increase the number of the train dataset that contains unique photos comparing to the dataset we used in trained our model.

References

1. *Detection of ArUco Markers*. (2022, Dec 29). Retrieved from OpenCV: https://docs.opencv.org/4.x/d5/dae/tutorial_aruco_detection.html
2. Fadi Al-Turjman, I. P. (2023). *Deep Learning for Healthcare Decision Making.* River Publishers.
3. Robotics, Open. (2021). *ROS - Robot Operating System*. Retrieved from ROS: https://www.ros.org/
4. Sujatha Alla, P. P. (2021). *Healthcare Robotics: Key Factors that Impact Robot Adoption in Healthcare.* virginia.