



REAL-TIME AUTOMATED RADIATION THERAPY DEVICE FOR LUNG TUMORS

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ABSTRACT

Our project represents a transformative approach to lung tumor treatment, pioneering the convergence of state-of-the-art technologies. Leveraging the capabilities of AI, we employ Jetson Nano to precisely analyze MRI videos, swiftly and accurately detecting the presence and location of lung tumors. Once identified, the coordinates of these tumors are seamlessly transferred to a microcontroller using TCP protocol as wireless communication technology, which organizes the complicated movements of a robotic arm. This robotic arm is connected to a laser that serves as the channel for delivering radiation therapy. To ensure seamless control and supervision, a user-friendly Graphical User Interface (GUI) is integrated into the system. To replicate patient scenarios, we incorporate a lung manikin. Our project not only aims to improve treatment outcomes but also has the potential to set new standards in the field of oncology and healthcare.

INTRODUCTION

Radiotherapy treatments for cancer tumors are getting more popular as technological advancements make it more accurate, reliable, and safe. However, these advancements have also increased the complexity of the devices that deliver it, and companies around the world are actively trying to develop a device that would revolutionize the industry. Our project introduces an innovative way to treat lung tumors, utilizing advanced technology and leveraging the capabilities of AI. Our goal is to increase the chances of successful radiotherapy treatment, thus leading to quicker recovery time and less operation complications. We invite you to explore our innovative approach and its potential to reshape the future of lung tumor treatment.

PROBLEM STATEMENT

Current radiation therapy struggles to adapt to moving tumors, current operations are not precise and often have to be done again, wasting time for both the patients and the hospitals.

CONSTRAINTS

Data loss: some data may be lost during transmission from the detection device to the treatment device, such loss is hard to discover or deal with.

Overflow: detection device (sender) may send more data than treatment device (receiver) can fit in its queue, causing loss of data due to overflow.

Tumor size: Tumors come in different sizes, while the treatment system only has one laser available. Thus, the device is only able to perfectly hit one size of tumors, while other tumor sizes would be hit less effectively.

Tumor shape: similar to the previous constraint, tumors come in different shapes, which hurts the effectiveness of the treatment due to the laser's fixed shape.

SPECIFICATIONS

- AI Model Accuracy: 90-95%
- AI Model Precision: 85-95%
- AI Model Recall: 85-95%
- AI Model Inference Time: 300ms
- AI Model Intersection over Union (IoU): 85-95%
- Affected Surface Area: 1cm²
- Maximum distance Range of Robotic Arm >= 35cm
- Robotic Arm Angle of Rotation: 180 degrees
- Transmission Data rate: 2Mbps
- Transmission Bit Error Rate: 0.1%
- Operation Time: 15 minutes or less

PROTOTYPE DESIGN

The system contains two components:
1- Detection Device



Figure 1: Detection Device

This device consists of jetson nano, Ai Agent, touch screen, detection software and GUI.

The jetson nano is used as a processing power, Ai agent for lung tumor detection, GUI to control and monitor the system, touch screen to simplify the use of the system and detection software to implement our detection algorithm and integrate the Ai agent, GUI and communication software.

2- Treatment Device

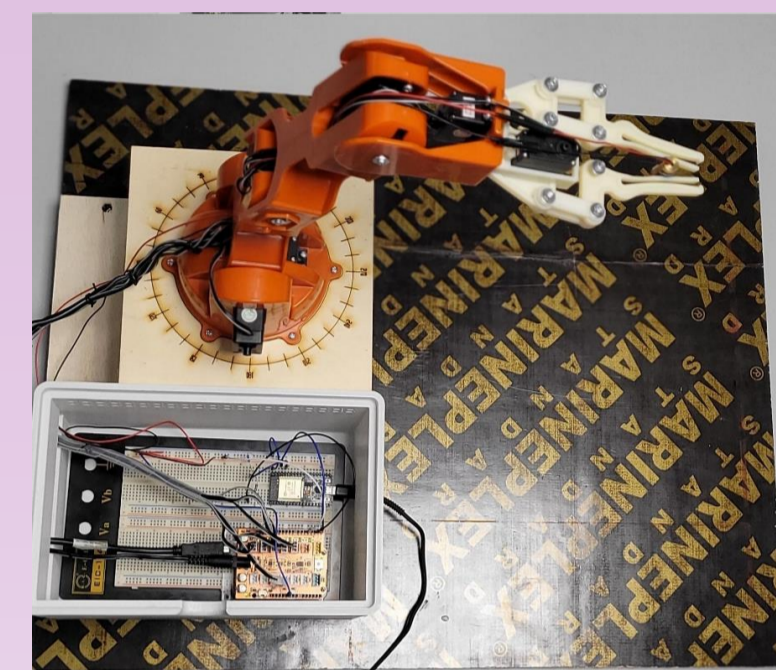


Figure 2: Treatment Device

The device consists of ESP32, Arduino, control software, Robotic Arm and Laser.

The ESP32 is used to receive the data from the detection system and forward it to Arduino, the Arduino is used to run the control software which is used to control the movement of the robotic arm and the activation of the laser.

Full system:

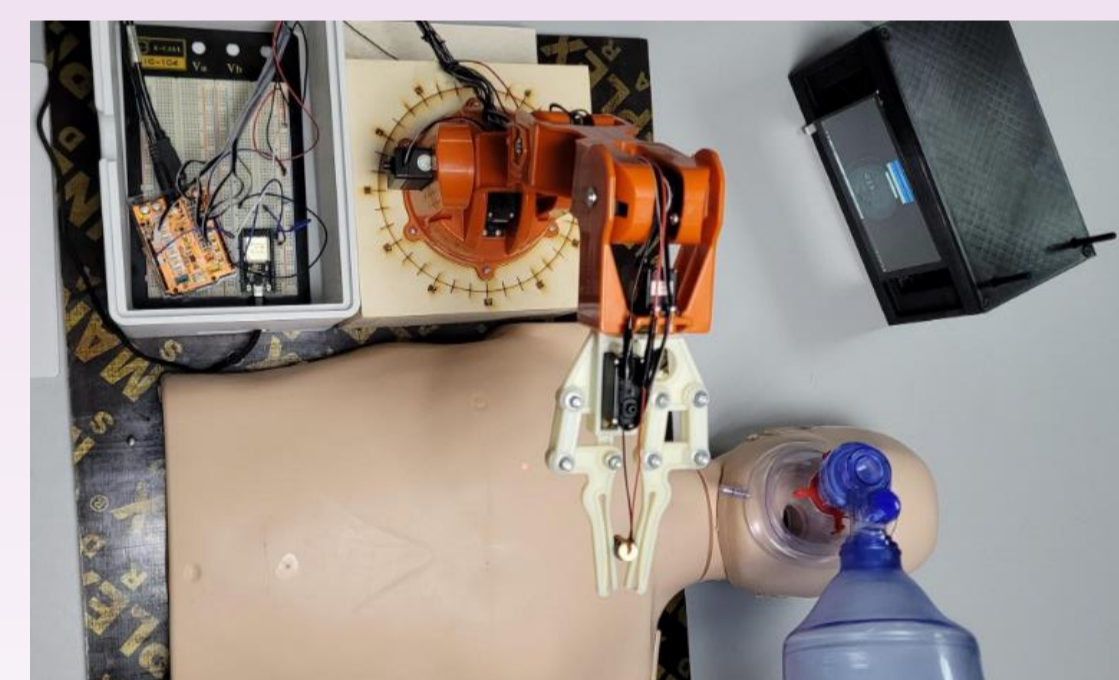


Figure 3: Full system

The system works as follows:

- The MRI data will be loaded to the jetson nano software.
- The Ai agent will detect any lung tumor and the processing will be in the jetson nano.
- The software of the jetson nano will define the location of the lung tumor.
- The coordinates of the detected tumor will be sent to the ESP32 through Wi-fi using TCP utilizing server-client approach.
- The ESP32 will send the data to Arduino using serial communication technology.
- The Arduino receives the coordinates from the ESP32 then convert them from 2D to coordinates for the robotic arm motors.

7- The control software will move the robotic arm to the converted coordinates of the tumor then it will activate the laser.

GUI :

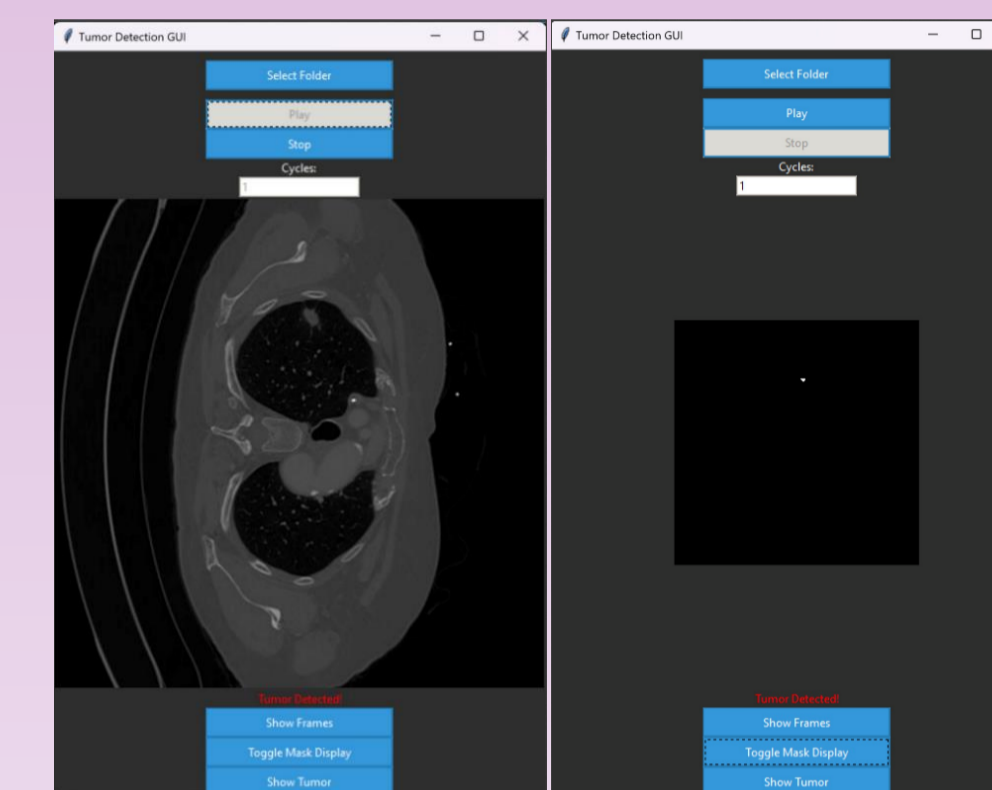


Figure 4: GUI

To use the program the user should first select a folder of MRI frames, after that the user should specify number of cycles then after loading the frames the user can start the system. Moreover, the program offers two display modes, the first one displays the MRI frames as a video while the second mode displays the predicted masks of the lung tumor. Also, the program offers a feature to show only a frame that contains the largest tumor before hitting it with the radiotherapy.

TESTING / VALIDATION

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15/15 [-----]
DeepLabV3+ Test Accuracy: 99.94%
DeepLabV3+ Test IoU: 93.77%
DeepLabV3+ Test Precision: 93.97%
DeepLabV3+ Test Recall: 92.83%
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Figure 5: Ai agent specifications

- This figure shows that our Ai agent meets its related specifications excluding the inference time, which has not been tested yet due unexpected problems with the Jetson Nano.
- Maximum range of robotic arm should exceed 35 cm
 $R = A \cos(a) + B \cos(b) + C \cos(c)$
 A (upper arm) = 12.5cm, B (forearm) = 12.5cm and C (hand) = 17.5cm
 $R = 12.5 \cos(0) + 12.5 \cos(0) + 17.5 \cos(0) = 42.5$ cm which is > 35 cm.
- Base motor can rotate 180 degrees.

CONCLUSION

In the end, we have presented our project prototype, as well as our constraints and specifications. We have then discussed the design in detail, and finally highlighted the specifications that have already been tested.