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Thermal Anomaly detection and BreastCancer Risk Prediction: Using DITI and Deep Learning Approach

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ABSTRACT
Breast cancer is one of the most fatal diseases responsible for the death of women all over the world. About one in eight of women is subject to breast cancer over the course of her lifetime. There is no effective method to prevent or know the reasons for the growth of these cancerous cells, however the number of deaths can be reduced by early detection. Early detection of breast cancer will facilitate the treatment process.
For this purpose we are using DITI and a deep learning approach. Digital Infrared Thermal Imaging (or DITI) is a non-invasive clinical imaging procedure used to detect and monitor many diseases and physical injuries. The images generated by the infrared scanning device allow us to visualize and quantify changes in skin surface temperature. The approach we are using will consist of two outputs. In the first output we are detecting thermal anomalies in the Region of Interest(ROI). For obtaining this output, we will preprocess the thermal images to obtain ROI and will apply a detection algorithm to find the thermal anomaly. The second output will consist of a prediction of the risk of breast cancer. For this we would be considering the thermal pre-processed images. These images would be used for extracting characteristic features using image processing. These collected features are used as input for the Back Propagation Neural Network(BPNN) to predict the risk of Breast Cancer.
Keywords **-** Digital Infrared Thermal Imaging, Back Propagation Neural Network, Region of Interest, Breast Cancer, Thermal Anomaly

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I. INTRODUCTION

The purpose of this project is to find thermal anomalies in the thermal scans generated using DITI[1] and finding a novel set of useful features which will be used for predicting the probability of positive breast masses using back propagation neural networks. The solution deals in the medical diagnostic field to give alert in early stages & detect future occurrence of life threatening disease and eventually reduce the mortality rate. The operational model is very simple, we need to follow some protocol before taking a scan by the doctor. The principle of operation of this modality is unique when compared with current available modalities in the medical field.

The important operational difference between our solution and present modalities is that we monitor physiological aspects and interpretations are based on this fact. The present scenario for detection of Breast Cancer is based on appreciable anatomical changes, which causes quite delay in detection resulting in an increase in mortality rates and serious medical complications. As our solution monitors precancerous physiological changes in early stages which helps physicians to decide the line of medication well in advance to save the life of the patient. Added advantages of this solution are Radiation Free, No Touch – No Pain, Non-Invasive, suites for a wide category of patient, can be used repeatedly, and are portable. Medical infrared diagnostic center uses the technique of DITI for diagnosing different types of medical conditions like broken bones, thyroid related problems, early cancer detection, diabetes, etc. The organization is led by Prof. Rupesh Joshi who is also the mentor for this project.

A. Problem Statement

To automate the process of early detection of cancer using DITI by finding Breast anomalies using image processing andprobability of positive breast cancer masses using BPNN.

B. Scope

This project will consist of creating an automated process for finding anomalies and risks in thermal scans of patients for early detection of severe medical conditions, which aims to streamline the already existing process. The project includes finding thermal anomalies and predicting probability values of positive thermograms containing breast masses. The proposed project will help in early detection of cancer before it causes severe damage to the patient. It is also a gateway to automate future processes for detecting thermal anomalies and ultimately removing human intervention. For future scope, the project can be deployed commercially for all the infrared diagnostic centers across the country which can help to diagnose different medical conditions in early phases.

C. Objectives

- Early prediction of Breast cancer risk to minimize thedeath rate using DITI and BPNN.
- To automate the process of examining the thermographic images to find anomalies using image processing.

II. LITERATURE SURVEY

In [2], Ola O. Soliman used the concept of symmetry for finding the probability of positive breast mass characteristics using a BPNN with input layer consisting of 32 neurons and a hidden layer consisting of 8 neurons followed by output layer consisting 1 neuron. This technique was tested on 63 IR single breast images(29 Healthy and 34 malignant) and had an accuracy of 96.51%.

In [3], Nader Abd El-Rahman Mohamed used the concept of image processing to find 32 features which are fed to BPNN with an input layer consisting of 32 neurons and a hidden layer consisting of 15 neurons. The output layer consists of a 1 neuron. The technique was tested on 206 thermography images of the breast(187 normal and 19 abnormal patterns) and had an accuracy of 96.12%.

III. SYSTEM ARCHITECTURE

The architecture of the proposed system is shown in Fig 4.1. From the architecture diagram we can clearly see how the different components of the system as well as the stakeholders interact with each other.

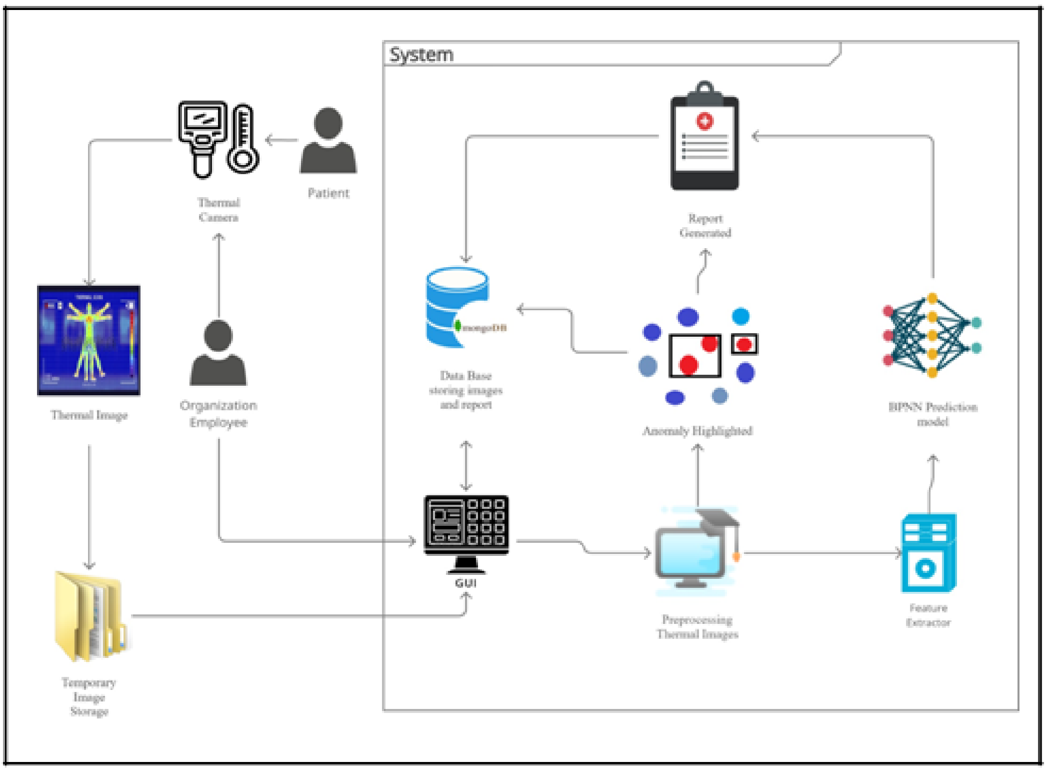

Figure 1 System Architecture Diagram

As per the architecture, the employee will interact with the system through GUI. With the help of this GUI, he/she can retrieve as well as store patient information, thermography and medical reports. The patient will interact with the thermal camera to generate thermal images which will be further diagnosed. The GUI will take thermal images from the temporary Image storage as an input and will send these images to the image preprocessing module. This module will remove the back-ground, extract the region of interest(ROI).This ROI is given as input to thermal anomaly module as well as to feature extraction module.The thermal anomaly module will highlight the temperature anomaly in the ROI. The feature extractor module will take the ROI as an input and extract the 32 Characteristic features from it. These features are used as an input for the BPNN which will generate a probability value of the positive breast mass being present in the breast. This value is used to define the risk of breast cancer which will be added to the report.The temperature anomaly obtained through thermal an anomaly module and probability value generated by BPNN are included in the patient report which is stored in the database.

IV. METHODOLOGY

In this section, we briefly discuss the main steps of theproposed approach to detect breast cancer.

1. Patient preparation and image data acquisition

The scan is performed in a controlled environment and the patients are told to follow some standard guidelines before the scan can take place. The reason for these strict measures is, there are several factors which can affect the temperature of the human body, even wearing a certain cloth can affect the temperature of the body, thus resulting in the faulty scan which will affect the output of the program.

In order to get the accurate results, certain guidelines need to be followed by the lab attendant, some of them are described below:

All investigations ought to be acted in a room where surrounding temperature is rigorously controlled, liberated from drafts, and without openness to critical outside or inward infrared sources. Ventilation frameworks ought to be intended to stay away from wind stream onto the patient and imager, and characteristic convection kept at or underneath 0.2 m/s. Dividers and roof ought to be of a matte completion non-intelligent to infrared radiation. Mirrors, glass outlined pictures, glass cupboards, or any intelligent surface ought not be set in the imager field of view. Covered deck is liked.

The warm imaging room ought to in a perfect world be kept between 20-21 degrees Centigrade (68-70 degrees Fahrenheit). The temperature of the room ought to be to such an extent that the patient's physiology isn't changed to the purpose of shivering or sweating. Room temperature shifts during the direction of an assessment should be progressive so that consistent state physiology is kept up and all pieces of the body can change consistently. The temperature of the room ought not shift more than one degree Celsius over the span of an examination. The mugginess of the room should likewise be controlled to such an extent that there is no dampness developed on the skin, sweat, or fume levels that can collaborate with brilliant infrared energy. Relative Humidity underneath 70% is by and large satisfactory.[4]

2. Region Of Interest Extraction

In this step we need to extract the region of interest from the thermal images. This process is done manually using proper selection of pixels from the breast area. When the pixels are selected by the user, the convex hull algorithm[5] is applied on those pixels. Using this algorithm, we will get a mask which is then used to extract the ROI.

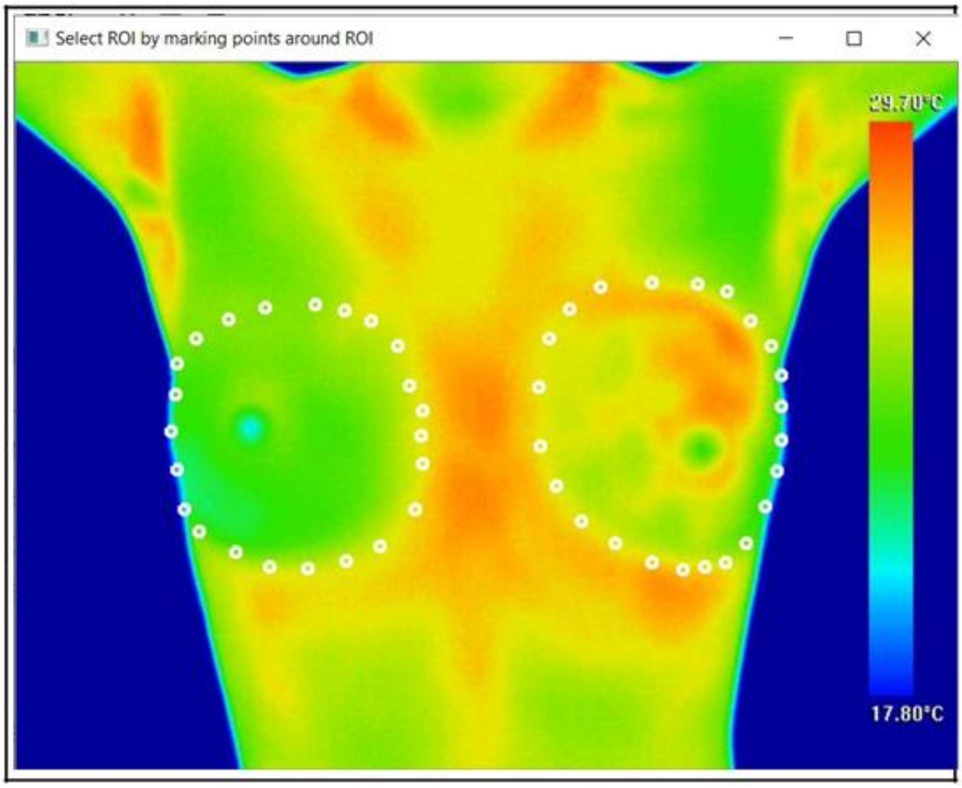

Figure 2: Pixels selected by user

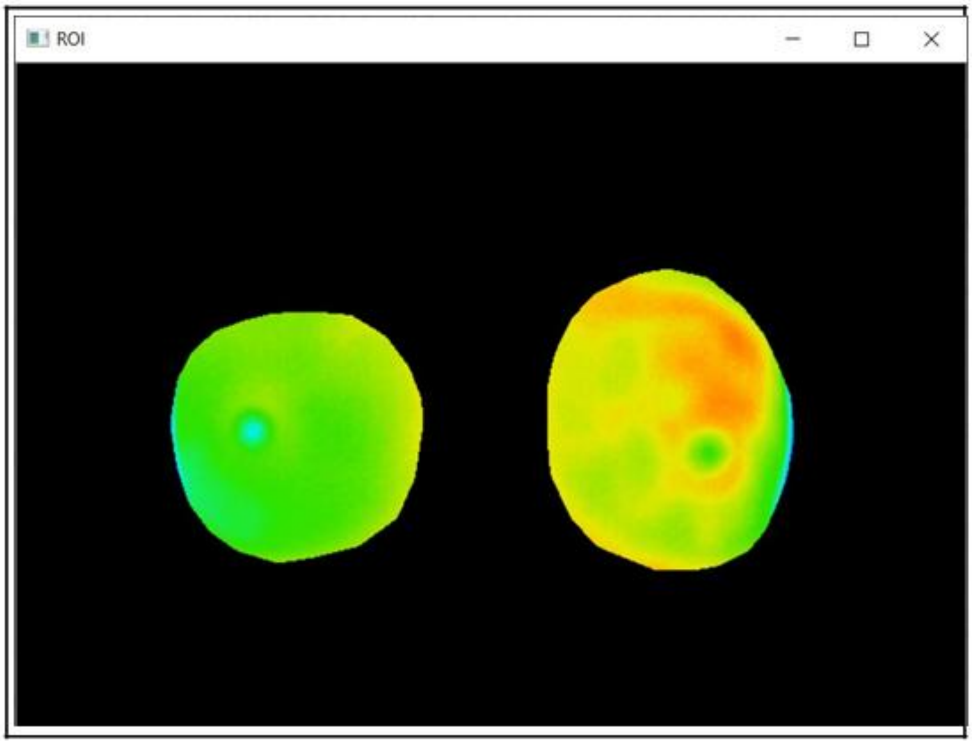

Figure 3: Extracted ROI

3. Anomaly Detection

In this project we are trying to detect and highlight thermal anomalies in the thermal images. The anomalies are thermal hot and cold spots which are called hyper and hypo thermal regions. For detecting these regions they are taking the ROI as input. Before processing the image the user needs to select the pixel from the image that he/she thinks is a normal pixel. Once the pixel is selected, the process of detection starts.

First we need to enhance the details of the image. After the details are enhanced, we need to apply the K-means algorithm[6] to remove any outliers from the image and make it homogeneous. Here the value of K used in K means clustering is 8. After applying the K-means algorithm, convert the image into grayscale[7]. Using the normal pixel selected earlier, create a matrix of size 3x3 with the normal pixel at its center. Calculate the average of all pixel values present in the matrix. Now traverse the entire image and compare the pixel values with the average value calculated earlier. If the difference between these two values is greater than a predefined threshold, consider that pixel as an anomaly and store it in a list. Once all the pixels are compared and stored in the list, traverse the list. The list will contain only the anomaly pixels, therefore we need to highlight them. To differentiate whether the anomaly is hyper or hypo, we need to consider its RGB value. If the red channel is greater than the blue channel, it means that the given pixel represents temperature from the colder side. And if the opposite is true the pixel represents temperature from the hotter side. With the help of this we can differentiate anomaly as hypo-thermal or hyper-thermal anomaly and highlight it by assigning it some other color. Figure 4 displays the hyperthermal thermal anomalies detected in the ROI. These anomalies are highlighted using brown color.

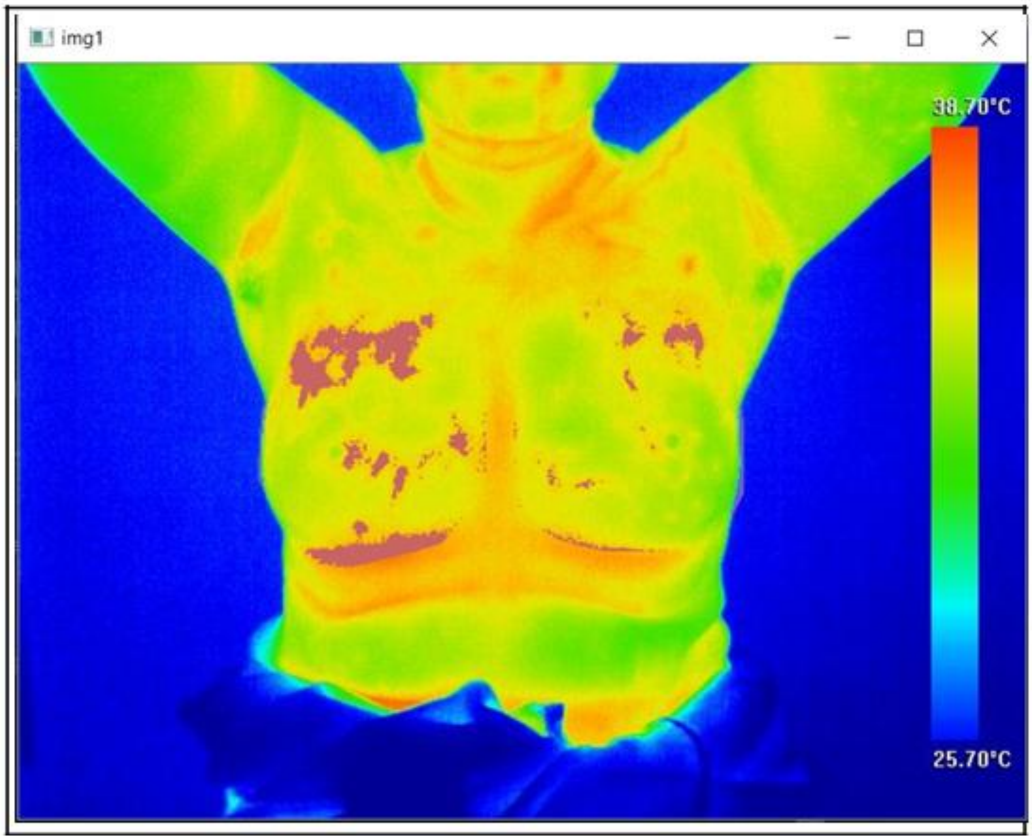

Figure 4: Anomaly Detection

4. Feature Extraction and Neural Network classifier

After the ROI is extracted, the extracted image is used for calculating the colour and texture moments. For the colour moments, the image is splitted into 3 channels i.e. red, green and blue. For each channel, the Mean, Standard deviation, Skewness and Kurtosis is calculated. This gives a total of 12 colour moments. For the texture moments, a Grey-Level Co-occurrence Matrix[8] is created. From this Grey-Level Co-occurrence matrix, "Contrast", "Energy", "Homogeneity", "Entropy" and "Correlation" are calculated across 4 directions. This gives a total of 20 texture moments, by combining these texture and colour moments, a valid feature vector of thirty two features is obtained. This feature vector is passed to the Neural Network classifier. The NN classifier implemented is a feed forward back propagation neural network[9] which consists of an input layer with 32 neurons, output layer with a single neuron and two hidden layers with 16 and 64 neurons each. The Error Functions used are Rectified Linear Unit(ReLU), hyperbolic tangent and Sigmoid.

V. RESULTS

The proposed method for anomaly detection can detect both hypo and hyper thermal regions in the ROI. The software application was tested on multiple images. Figure 5 shows the example of thermal anomaly highlighted. The brownish region displays hyperthermal region and the violet region displays hypothermal region.

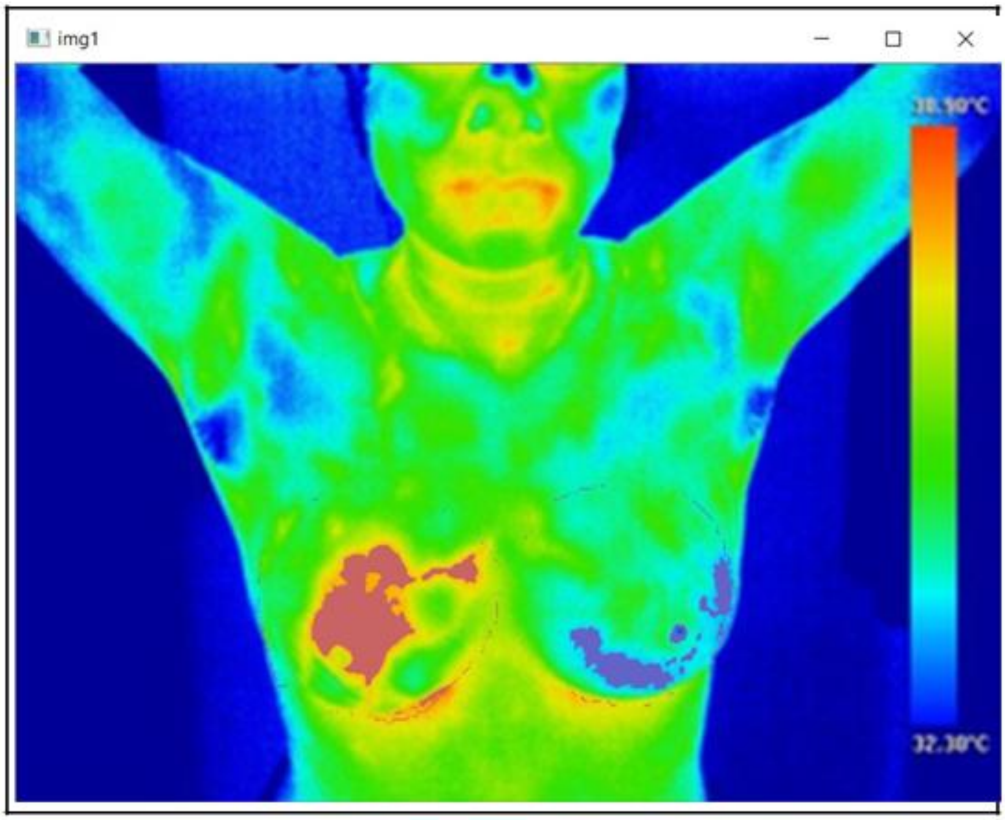

Figure 5: Hyperthermal and Hypothermal Anomaly Detection

The data-set used for this project contains a total of 107 front view[10] images containing both healthy and sick patients. Out of these 107 images, 85 images were used for training the neural network classifier and the rest of 22 images were used for testing. The results of confusion matrix for the trained model is as follows:

Expected Values			
		True	False
Predicted Values	True	7	1
	False	0	14

True Positives 7
True Negatives 14
False Positives 1
False Negatives 0
The accuracy achieved by the proposed model is

95.45%. From the above results, the Sensitivity is 100%, specificity is 93.33% and precision is 87.5%. The output of the project consists of a report containing the feedback from the radiologist followed by the neural network prediction. This is followed by anomaly detected images for all different views(Front, two lateral, two oblique). Figure 6 displays a part of the report showing the findings by the radiologist and the result of the neural network predicting if the patient has positive breast masses or not.

Name:	Firstname middlename lastname	Date:	2021-05-23
Referred By::	Dr. Firstname Middlename Lastname	Age:	21
C/P:	This text contains information about the special remarks	Patient ID::	2021-05-23,18:53:43.125389

DIGITAL THERMOGRAPHY STUDY : BILATERAL BREAST

Digital Thermography of Breast done with CX-640. All standard protocols were followed during scan.

FINDINGS

1] **Left Breast:** Finding 1
Finding 2
Finding 3

2] **Right Breast:** Finding 1
Finding 2
Finding 3

3] **NN Prediction:** Negative Breast
Mass Characteristics

Suggest: Finding 1
Finding 2
Finding 3

Thanks

Many thanks for reference. Imaging findings has its own limitations and needs to be correlated clinically.

Figure 6. Report

VII. FUTURE SCOPE

The anomaly detection in this project is performing well. However there is still some room for improvement.

The size of the data-set which was used for training neural network classifiers was inadequate to give expected accuracy.

So with a better and larger data-set the performance of neural network classifiers can be improved.

VIII. CONCLUSION

The proposed method displays an accuracy of 95.45%, hence, an approach for the early detection of breast cancer using thermal images which will detect thermal anomalies and extract a novel set of useful features to classify breast masses using back propagation neural networks is proposed. This allows us to conclude that we have obtained a series of promising results with some room for improvement, thus having a potential to obtain a breakthrough in the cancer study.

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