

PAPER • OPEN ACCESS

## Breast Cancer Detection Using Deep learning and IoT Technologies.

To cite this article: Siddhant Salvi and Ameya Kadam 2021 *J. Phys.: Conf. Ser.* **1831** 012030

View the [article online](#) for updates and enhancements.

You may also like

- [Use of risk projection models to estimate mortality and incidence from radiation-induced breast cancer in screening programs](#)  
M Ramos, S Ferrer, J I Villaescusa et al.
- [Breast Imaging \(A Breast Disease Book Edition\)](#)  
Richard Gordon
- [Machine Learning Classification Techniques for Breast Cancer Diagnosis](#)  
David A. Omondiagbe, Shanmugam Veeramani and Amandeep S. Sidhu



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

243rd ECS Meeting with SOFC-XVIII

**More than 50 symposia are available!**

Present your research and accelerate science

Boston, MA • May 28 – June 2, 2023

[Learn more and submit!](#)

# Breast Cancer Detection Using Deep learning and IoT Technologies.

Siddhant Salvi<sup>1</sup> and Ameya Kadam<sup>2</sup>

<sup>1</sup>Bachelor of Engineering in Electronics and Telecommunication, D.J. Sanghvi College of engineering, Mumbai, India.

<sup>2</sup>Asst. Prof. Department of Electronics and Telecommunication, D.J. Sanghvi College of engineering, Mumbai, India

siddhantsalvi99@gmail.com, kadam.ameya@gmail.com

**Abstract:** In today's world fostering health is of utmost importance. The prevalence of health issues has posted a serious burden on the doctors across the globe and because of this treating every patient efficiently becomes difficult. To ease the burden on the doctors there have been significant revolutionizing ideas that has changed the healthcare industry. With the advancements in computer technology, accurate and faster results can be generated and accordingly the patients can be treated. Detection of cancer in early stages is still an issue in the healthcare. According to the World Health Organization, the diagnosis and eradication of cancer cells can be done, if they are detected in their early stages. Hence, to mitigate the issues pertaining to cancer, early detection of cancer cells is must. Of all the different types of cancer the patients being affected with breast cancer is at the top. Many women are vulnerable to breast cancer and hence the detection of those cancer cells becomes important to eradicate them from the patient's body. According to the WHO, around a million women died in 2011 because of breast cancer and this issue is burgeoning. Breast cancer is the second most common cancer in women and men worldwide. In 2012, it represented about 12 percent of all new cancer cases and 25 percent of all cancers in women. Breast cancer enhances when cells in the breast begin to grow out of control. These cells usually form a tumour that can often be seen on an x-ray or felt as a lump. The tumour is malignant (cancer) if the cells can grow into (invade) encompassing tissues or spread (metastasize) to far off territories of the body. The survival from breast cancer is also less. This paper tries to put forward a solution that could help the patient determine whether she is vulnerable to breast cancer at an early stage itself so that with proper treatment, the breast cancer cells can be eradicated.

**Keywords**—Deep learning, Convolutional Neural Network, Machine learning, Imageprocessing, Medical Imaging, Thermal Imaging, IoT, IR camera sensor, Breast cancer detection.



## 1. Introduction

The advent of machine learning has bolstered many industries. Many industries are being benefitted because of machine learning. Machine learning has helped provide solutions which initially was thought to be arcane and unintelligible. Machine learning also finds its application in the field of healthcare. Various problems, which the doctors were not able to solve, are being solved with this technology. Machine learning has found its application in the health industry. The success of machine learning algorithms at computer vision tasks in recent years comes at an opportune time when medical records are increasingly digitalized. It can be used to for classification, detection, prediction of diseases in the patient. Machine learning along with deep learning has helped the health industry to a great extent. Healthcare providers generate and capture a lot of different data which can be in the form of text or image which contain important and valuable signals and information. Using these earlier derived data, machine learning integrates, analyses, and accordingly makes prediction. The application in the health industry include one dimensional bio-signal analysis, prediction of the medical events such as seizures, cardiac arrest, development of tumour etc., drug discovery, computer aided health diagnosis and analysis. Image processing using the concept of deep learning is used to detect the possible health problems in the patient. On the similar basis, using deep learning, breast cancer cells can be detected in the individual. This paper is also on the similar basis. It tries to provide solution to the age-old problem of breast cancer. Using deep learning complex patterns in the image dataset can be fathomed. On the basis of the images in the dataset, the model can be trained to determine the presence of breast cancer cells and further classifying into benign or malicious, so the doctor can accordingly treat the patient and the death of the patient because of breast cancer can be eradicated. Convolutional neural network of the machine learning technique has become one of the efficient methods to detect, diagnose the health of the patient. Convolutional neural network performs image processing on the available data that has been previously generated and based on the veritable images, the algorithm is performed in order to check for similarity and thus to make predictions based on the images obtained.

Another concept of thermal imaging is used to developing the picture of the cancer cells and tumour in the cancer cell. Thermal imaging is an upcoming technology which makes use of the infrared sensor to determine the heat of the region and with the help of the radiations given by the object it develops the image, which is known as thermography technology. Since all the objects having temperature above absolute zero gives out infrared rays, thermography can be used for the development of images, whether visible or invisible.

## 2. System Architecture

Initially, the machine learning model is trained, using the CNN algorithm. About 200000 images are used to train the model to achieve higher accuracy. The remaining images in the dataset are used for the purpose of validation. Once accurate results are achieved, the thermal imaging sensor is then integrated with the raspberry pi. Whenever the patient wants to know the status of the cancer cell, the patient can use the thermal imaging sensor to capture the image of the cancer cells. With the help of on-board computing on raspberry pi, the image obtained is given as the input to the trained model. The model performs CNN on the input image and then efficaciously determines whether the image given by the patient is benign and malignant. Furthermore, Wi-Fi technology has been incorporated to send the images captured, wirelessly over the cloud, so that the doctor can get an access to the image and thus can readily examine the condition of the patient and check for tumour growth. The infrastructure of the designed breast cancer predictor is displayed below.

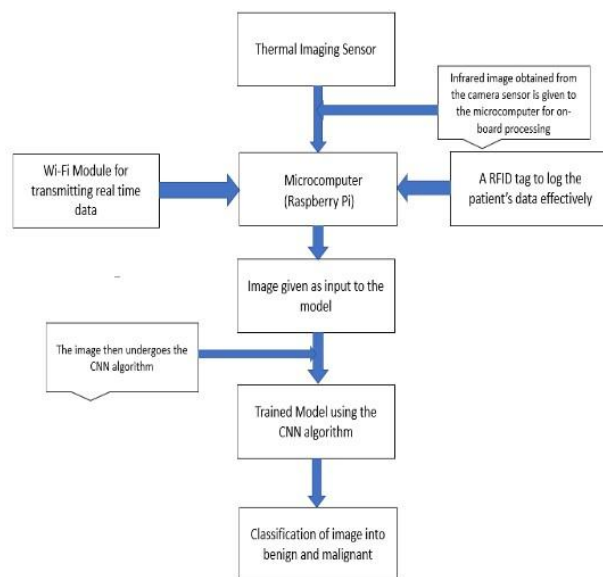


Figure 1: System Flowchart.

### 2.1. Hardware Implementation of the project

To make the system user friendly and to help the patient determine their breast cancer vulnerability, an implementation of IoT technique is done. An IR camera module is used for thermal imaging which is integrated with the microcomputer for capturing the thermal images of the cancer cells inside the body of the patient and check for the tumour size. A Wi-Fi module is also connected to the microcomputer so that the image taken can be sent to the doctor via cloud and accordingly doctor can examine the cancer cell for further treatment if the cancer cells detected are malignant.

- 1. Thermal Camera sensor:** A thermal camera which makes use of the thermographic method helps to capture the image using the infrared rays reflected by the object. It works like the camera that captures images using the visible light. Using the images captured by the thermal camera cancer cells can be detected.
- 2. Microcomputer (Raspberry PI):** A microcomputer is used to integrate the thermal camera and perform on board image processing to determine the presence of the cancer in the patient.
- 3. Wi-Fi module:** A Wi-Fi module is used for sending the real time images to the doctor for examining the cancer cells via cloud. Using this method, the doctor can treat the patient with ease by analysing the patient's case before hand.
- 4. RFID Reader:** A RFID reader is connected with the microcomputer to keep the patient's data secure and for easy and efficient logging of the data. This also helps keeping track of different users.

The model implemented uses Raspberry Pi as the General-purpose board for sensor integration and storing sensor data. It is also used for cloud computing to send the data over the internet to the doctor. A database is created for all the images taken by the user using Google Firebase. The database thus generated is then given as the input to the trained model for detection of the breast cancer. This technique would help patients living in remote regions.

### 3. Data Set

The training of the system for determination of the cancer cells in the breast region of the patient requires dataset upon which convolutional neural network algorithm is performed. The dataset consists of images of the previously encountered cancer cells in the region of the breast of the patients

suffering from breast cancer. The image dataset is divided into three categories, one is the training category which is used to train the model. Further, the next category is the validation category which is used to validate the model developed and the last category is the testing dataset which is used to test the model that is developed. The Model is split into 80% training data, 10% validation data and 10% testing data.

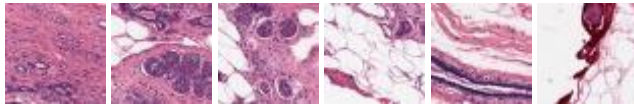


Figure 2: Negative images from the dataset of cancer cell images.

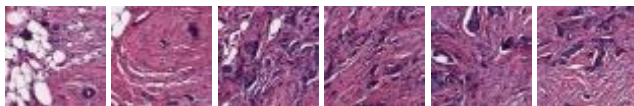


Figure 3: Positive images from the dataset of cancer cell images.

The entire image dataset is segregated into positive images and negative images for all the three categories. There are around 155370 negative images and around 62379 positive images in the training dataset. To further improve the model, 22689 negative images and 7753 positive images are tested.

## 4. Machine Learning Algorithm

### 4.1. Convolutional Neural Networks

Convolutional neural network, which is a deep learning algorithm, is a multilayer, feed forward neural network that uses perceptron's for supervised learning and to analyse data. It is usually used for image classification of the visual data. CNN is majorly used for medical imaging for classification and prediction of the medical data. The architecture of CNN is different from that of other neural networks. CNN represents the image in the form of tensors or matrix of dimensions more than two. Tensors are formed by nesting arrays within arrays.

CNN consists of various layers such as the convolutional layer, normalization layer, pooling layer, and fully connected layer. Convolutional neural network takes an image as an input and assigns weight to the image, applies biases so that it can differentiate the image from others and then applies filters with minimum pre-processing. The first layer of the CNN captures the low features of the image, the next layer extracts the high-quality features creating a network. The convolutional neural network consists of input layer, output layer along with some hidden layers between the input and output. The hidden layers are series of convolutional layers that convolve with the dot product of their matrix. The hidden layers are pooling layers, fully connected layers and normalization layers. They are called as hidden layers because the inputs and outputs are masked.

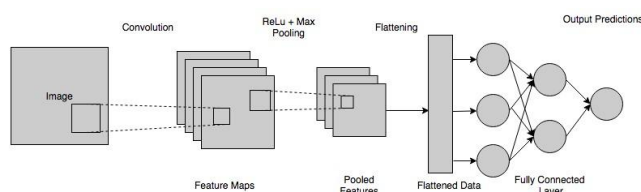


Figure 4: Architecture of Convolutional neural network.

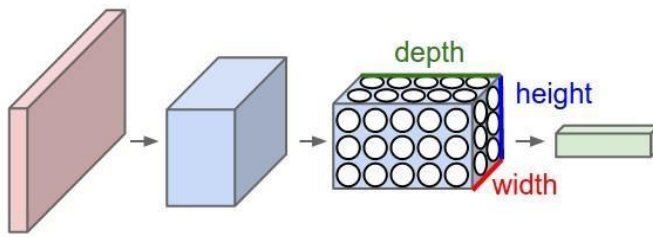


Figure 5: Image segmentation in CNN.

Different layers of CNN are mentioned in details below:

1. **Input layer:** This is the primary layer of the CNN calculation where the input picture is changed over into the network of the shape  $[32 \times 32 \times 3]$ . This matrix holds the pixel estimation of the picture of width 32, height 32 and 3 shading channels RGB.
2. **Convolutional layer:** Convolutional layer is the significant layer in the convolutional neural organizations. This layer processes the yield of the neurons associated with the information. Every neuron is allotted a weight. The dot product of the loads of the neurons and the information is determined in this layer. There are different pieces of the convolutional layer. This layer takes the lattice type of the picture, applies channel on the acquired picture grid. The channel applied is a little in size when contrasted with the input picture network. The channel is applied to the whole picture framework through the stature, width of the picture. This channel gives the speck item between the info and the sections of the channel. The organization will learn channels that actuate when they see some sort of visual element, for example, an edge of some direction or a smear of some tone on the primary layer, or in the long run whole honeycomb or wheel-like examples on higher layers of the organization. Pictures are numerous dimensional amounts and consequently it is unviable to associate every neuron to all the neurons, along these lines it just interfaces with few sources of input. This spatial degree of network is called as open field of the neuron, which is the channel size.

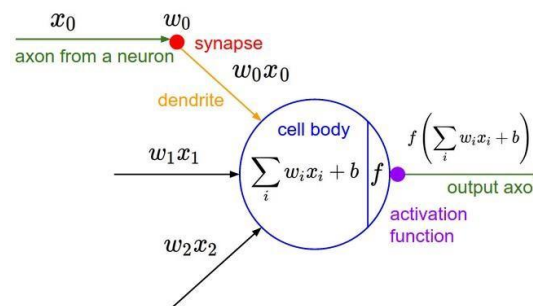


Figure 6: Mathematical representation of the neuron.

The connectivity of the neurons at the output side differs from that of the input. There are three parameters, which are considered for the connection to the output layer which is the last layer. The parameters considered are the depth, stride and zero padding. The depth corresponds to, how many filters need to be applied so that different neurons can look for different patterns in the input image such as the presence of oriented edge etc. The next parameter taken into consideration is the stride. This correspond to how we slide the filter on the input image. Last parameter is the zero padding. Zeroes are padded along the edges of the input. This enables us to ensure smaller output volumes.

The neuron fit is given by the formula,  $(W-F+2P)/S+1$ ..... (1) where W is the input volume size, F is the size of the receptive field size or the size of the filter, P is the zero padding across the border of the image and S is the stride that the filter will take on the input image.

3. **Pooling Layer:** It is available between two progressive convolutional layers to diminish the spatial size, to decrease the quantity of boundaries and calculation and consequently controlling overfitting. Pooling layer is a type of non-linear scaling back. It parcels the picture into sets of non-covering square shapes, and for every area, yields the most extreme.

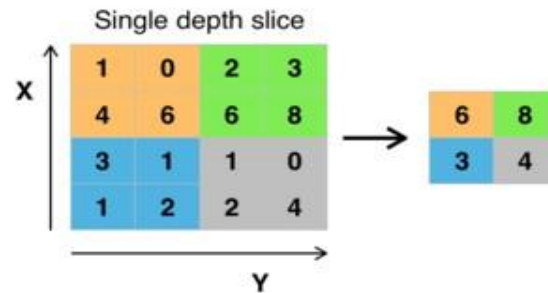


Figure 7: MAX Operation of the pooling layer to downsize the input image.

The Pooling Layer operates independently on every depth slice of the input and resizes it spatially, using the MAX operation. This layer accepts the volume of size  $W_1 \times H_1 \times D_1$ , and with the help of parameters like spatial extent  $F$  and stride  $S$ , it computes the size of the volume of the output as  $W_2 \times H_2 \times D_2$  where,  $W_2 = (W_1 - F) / S + 1$ ,  $H_2 = (H_1 - F) / S + 1$  and  $D_2 = D_1$

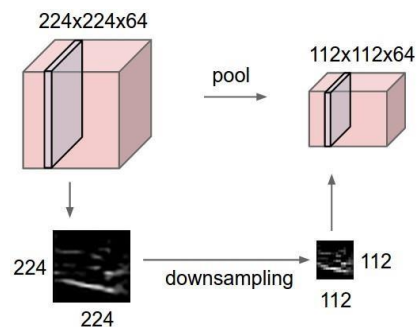


Figure 8: Pooling layer downsizing the input image.

4. **ReLU Layer:** ReLU is the abbreviation of rectified linear unit. It eliminates all the negative numbers from the picture and sets it to zero. It expands the nonlinear properties of the choice capacity and of the general organization without influencing the convolutional layers. The removal of the negative parameters takes place with the help of non-saturating function given by the formula,  $f(x) = \max(0, x)$ .

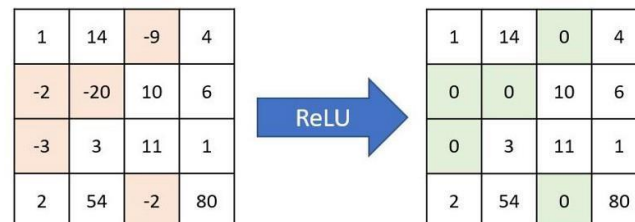


Figure 9: Removal of negative numbers to increase nonlinearity.

**Fully Connected Layer:** Finally, after several convolutional and max pooling layers, the high-level reasoning in the neural network is done via fully connected layers. Neurons in this layer have full connection to all the neurons in the previous layers.



## 5. Results and Implementation

With the help of the trained model, prediction of the breast cancer was done with accuracy of about 91%. The result of the patient with patient ID 8955 is displayed below.

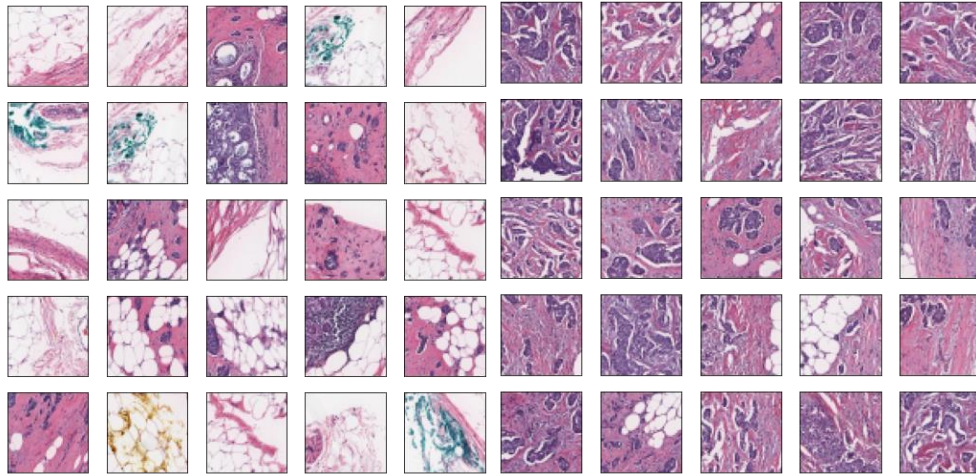


Figure 10(a): Negative Images of Patient ID 8955

Figure 10(b): Positive Images of Patient ID 8955

With these performance metrics like the model precision, model accuracy, model auc score and model recall, the performance of the algorithm is tested.

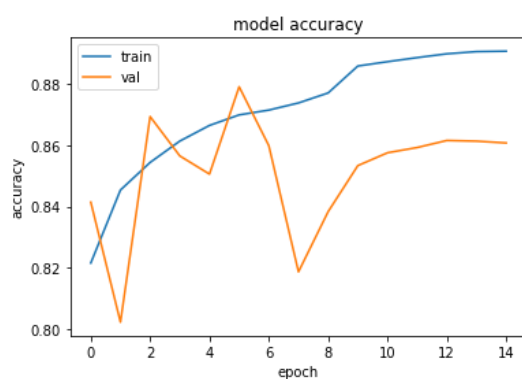


Figure 11(a): Model accuracy graph

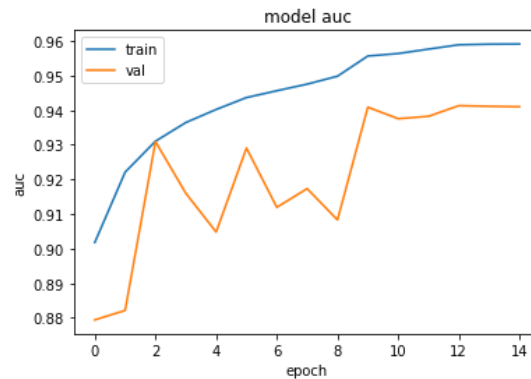


Figure 11(b): Model AUC score

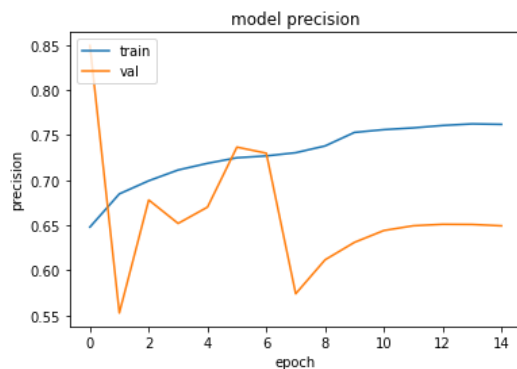


Figure 11(c): Precision of the Model developed

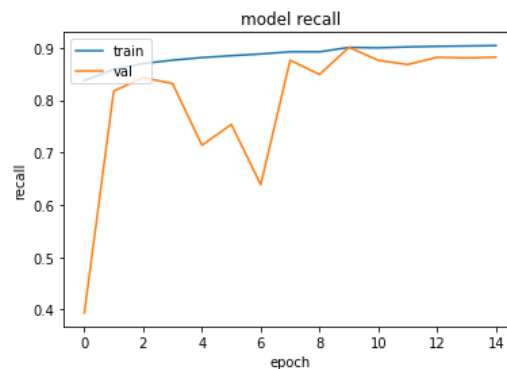


Figure 11(d): Recall score of the model



The CNN algorithm provides an accuracy of about 86% on the validation dataset. Having higher accuracy is important in healthcare as wrong predictions may cause issues. Thus, the model is further tested to improve to accuracy. The accuracy of the model is then further increased to 91%. The model was found to be about 76% precise. The performance metrics of the model was determined with different values of the epoch.

Table 1: Performance metrics of the model

Performance parameters	precision	Accuracy	AUC score	Recall Score
Scores	75.3%	87.84%	0.946	0.873

The dataset is further built upon the real time images provided by the thermal imaging sensor on which the machine learning model is applied to further improve the performance of the model and provide information related to breast cancer of the patient. An RFID tag helps logging the patient's information for further use.

## 6. Conclusion

For assistive paradigms, a need for real time health and behaviour detection with sensors input is prerequisite. With the advent of machine learning and deep learning concepts, real world health care problems can be solved with much ease as compared to the previously used methods in the healthcare. This paper provides a succinct information on how machine learning technique can be used to detect breast cancer in the patient effective and with ease. It also provides pith information on how IoT techniques can be amalgamated with machine learning to help patients residing in remote places where access to doctors is limited.

## 7. References

- [1] Deep Learning Applications in Medical Image Analysis by Justin Ker, Lipo Wang, Jai Rao, Tchoyoson Lim.
- [2] Ian Goodfellow and YoshuaBengio and Aaron Courville (2016). Deep Learning. MIT Press. p. 326.
- [3] "Convolutional Neural Networks (LeNet) – Deep Learning 0.1 documentation". Deep Learning 0.1. LISA Lab. Retrieved 31 August 2013.
- [4] <https://machinelearningmastery.com/convolutional-layers-for-deep-learning-neural-networks>
- [5] W. Ping, W. Jin-Gang, S. Xiao-Bo, and H. Wei, The research of telemedicine system based on embedded computer," in Proceedings of the 27th Annual International Conference of the Engineering in Medicine and Biology Society (IEEE-EMBS'05), pp. 114{117, IEEE, Shanghai, China, January 2006.
- [6] World Health Organization, Health Statistics and Health Information Systems, World Health Organization, 2012.
- [7] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6164870/>
- [8] [https://en.wikipedia.org/wiki/Thermographic\\_camera](https://en.wikipedia.org/wiki/Thermographic_camera)
- [9] "Thermal Imaging Application Overview". Bullard. Archived from the original on 16 September 2008. Retrieved 15 March 2013.
- [10] [https://www.researchgate.net/publication/322142760\\_Deep\\_Learning\\_Applications\\_in\\_Medical\\_Image\\_Analysis](https://www.researchgate.net/publication/322142760_Deep_Learning_Applications_in_Medical_Image_Analysis).
- [11] <https://www.who.int/cancer/detection/breastcancer>
- [12] [https://en.wikipedia.org/wiki/Convolutional\\_neural\\_network](https://en.wikipedia.org/wiki/Convolutional_neural_network)