

Detecting Osteoporosis using Novel Multitask Cascaded Convolutional Neural Network over Traditional CNN Algorithm

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Abstract

Aim: The aim of this study is to detect bone cancer by using the proposed Novel Multitask Cascaded Convolutional Neural Network over Traditional CNN Algorithm. **Materials and Methods:** Sample groups that are considered in this project is CT Scan dataset that can be classified into two, one for Novel Multitask Cascaded CNN and other for Traditional CNN, Dataset are tested for G-power to determine the sample size and for train set analysis. Nearly 215 CT Scan images have been used in each group for testing of cancer. **Results:** Novel Multitask Cascaded Convolutional Neural Network algorithm has better efficiency (86%) when compared to Traditional CNN algorithm efficiency (75%). Statistical significance difference (two-sided) is 0.01 ($p < 0.05$). **Conclusion:** Novel Multitask Cascaded Convolutional Neural Network algorithm performed significantly better than the Traditional CNN algorithm.

Keywords: Bone Cancer Detection, Novel Multitask Cascaded Convolutional Neural Network, Traditional CNN, Machine Learning, Osteoporosis, CT Scan.

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INTRODUCTION

The aim of this research is to detect Osteoporosis using CTScan data using Novel Multitask Cascaded Convolutional Neural Network Algorithm and to compare proposed algorithm with Traditional CNN Algorithm. In this case the experiment aims to improve the rate of efficiency in detecting bone cancer in early stages. (Kim et al. 2013) Cancer is the uncontrolled division of aberrant cells that spreads throughout the body. One of the types of cancer is bone cancer. Bone cancer is a disease that affects the bones. An intelligent assistive algorithm for bone tumor detection from human X-Ray images based on binary Blob analysis (Bharodiya and Gonsai 2020). The sickness is malevolent and malignant, and it is produced by cell division in the bone that is unregulated. Sami Bourouis, Ines Chennoufi, Kamel Hamrouni, "Multimodal Bone Cancer Detection Using Fuzzy Classification and Variational Model", Springer. The majority of bone cancer is a life-threatening and often occurring malignancy cancer. (Yoo et al. 2013) The earlier bone cancer is detected, This paper's ultimate purpose is to investigate the photos of bone cancer in order to determine the tumor's location.

There are around 56 IEEE papers and 121 google scholar papers have been published over the past 5 years. The most cited article is "Multimodal Bone Cancer Detection Using Fuzzy Classification and Variational Model" (Bourouis, Chennoufi, and Hamrouni 2013). Malignancy starts when the body's cells turn rogue. Cells in practically any part of the body have the potential to develop into tumors and spread to other parts of the body. The cells of the bones are where essential bone malignancy begins. ("Detection of Skin Cancer Using Deep CNN" 2020) Bone cells that have turned out to be destructive are the tumor cells. This segment's data is all about the importance of bone growth. The great majority of people with tumor cells in their bones do not have necessary bone development. ("Efficient Way to Detect Bone Cancer Using Image Segmentation" 2019). They have illness cells in their bones that have spread from a tumor elsewhere in the body. Auxiliary or metastatic bone disease is the term for this condition. In my opinion the above most cited article is best compared to the other articles.

Our institution is passionate about high quality evidence based research and has excelled in various fields (Parakh et al. 2020; Pham et al. 2021; Perumal, Antony, and Muthuramalingam 2021; Sathiyamoorthi et al. 2021; Devarajan et al. 2021; Dhanraj and Rajeshkumar 2021; Uganya, Radhika, and Vijayaraj 2021; Tesfaye Jule et al. 2021; Nandhini, Ezhilarasan, and Rajeshkumar 2020; Kamath et al. 2020). In the existing research they didn't identify efficient accuracy for calculating time. (Taneja et al. 2021) Screenings have a number of problems, including false positive and false negative results, which lead to unnecessary investigations. A skewed test result can potentially go unnoticed, causing a hidden cancer to go undetected (Bach-Mortensen 2002). The publication

used the GGD study to show how to discern the size and phases of the newly identified disease in bone cancer cells. The method is analogous to how the human brain layers the most representative and helpful pieces to create hierarchical learning representations. Classic approaches to some of the most challenging issues, such as cancer detection and object detection, are demonstrated through these methods. (Löffler et al. 2021) Convolutional neural networks are the machine learning framework used here. The main aim of our project is to detect osteoporosis by using Multitask Cascaded Convolutional Neural Network over Traditional CNN Algorithm.

Materials And Methods

The research work was performed in the Image Processing Laboratory, Department of Computer Science and Engineering, Saveetha School of Engineering, SIMATS. The proposed work contains two groups. Group 1 is taken as Novel Multitask Cascaded Convolutional Neural Network and group 2 is taken as Traditional CNN. The MTCNN (Novel Multitask Cascaded Convolutional Neural Network) algorithm and Traditional CNN algorithm were evaluated a different number of times with a sample size of 10 with confidence interval of 95%, and with pretest power of 81% and maximum accepted error is fixed as 0.05.

After dataset collection, the null values and unimportant content in the datasets were removed by preprocessing and data cleaning steps. After cleaning and preprocessing the data, an ideal input for the detection model is produced, which are processed into the detection model using opencv library and efficiency of both Novel Multitask Cascaded Convolutional Neural Network and Traditional CNN algorithm is calculated.

Testing setup for this proposed system used a Kaggle notebook and pycharm. Kaggle notebook is a software which is used for creating the Osteoporosis Detection with MTCNN model and Traditional CNN. Hardware configuration for this proposed system is Intel core i5 8th gen processor and requires 4GB random access memory and 256GB Solid state drive used. The configuration of the system is windows 10 operating system and kaggle notebook software and python programming language 3.8.3.

Testing Procedure for Bone Cancer Detection with MTCNN and Traditional CNN

Step 1: Preprocessing

Every recorded image is affected by noise in most cases, the result is low quality, so it is very important to extract accurate and important information from the image pre-processing. Preprocessing is done by removing noise from the image. Main steps in preprocessing are:

1. Image Filtering
2. Sharp Image
3. Replicate Image

Step 2: Feature Extraction

Feature extraction can accurately predict the amount of resources required from a big quantity of data.

Step 3: Training

After the feature extraction step, the training process is done. Training step involves CTScan Dataset as input to the classifier to generate indices.

Step 4: Testing Classifier

In the Test classifier import different and more datasets to test the accuracy of the classifier. Testing process is used to detect if the bone has cancer or not. In this step the classifier shows the result of cancer if it shows 1 means cancer and 0 means no cancer.

Step 5: Detecting Osteoporosis using machine learning algorithms

Using the Bone Cancer Detection with MTCNN algorithms and Traditional CNN to predict the images contains cancer or no cancer. In Fig.3. represents the cancer analysis graph of CT Scan Dataset in that 987 images contain cancer and 1569 images do not contain cancer.

Multitask Cascaded Convolutional Neural Network

Multitasking Cascade Convolutional Neural Networks (MTCNN) is a human cancer recognition architecture that uses a three-level (P-Net, R-Net, and O-Net) cascade structure. This intends to reduce the computational time of the entire MTCNN process.

Inputs: CT scan data set

Selected features and Accuracy.

Get CTScan()

CTS_slices=pd.read_csv("cnn1.csv")

read_Img=CTS_slices

Img<-exp(Img)

for Img i to n

img_ids = Img.str.split('.').str[0]

assert df_centers.img_id.equals(img_ids)

Output:

```
df_train = pd.DataFrame(mat_images, columns=['pxl' + str(i) for i in
                                             range(img_ids)])
df_train = pd.concat([df_train, df_train_hflip, df_train_vflip],
                     ignore_index=True)
X = df_train.drop(columns=['img_id', 'cx', 'cy']).values.reshape((-1,
IMG_HEIGHT, IMG_WIDTH, IMG_CHANNELS))
Y = df_train[['cx', 'cy']].values
X_train,X_test,y_train,y_test<-split features set and labels into train subset and test
subset
history = model.fit(X_train,y_test<-split features set and labels into train subset and
test subset

V<-MTCNN(X_train,y_train)
score<-evaluate(i,y_test,v)
return score
```

Traditional Convolutional Neural Network

A convolutional neural network, also known as CNN or ConvNet, is a class of neural networks that specializes in processing data in grid-like topologies such as images. Each neuron functions in its own receptive field and is connected to other neurons to cover the entire field of view. Convolutional neural networks (CNN / ConvNet) are the most commonly used class of deep neural networks for the analysis of visual images.

Inputs: CT scan dataset

Output:

Selected features and Accuracy.

Get CTScan()

CTS_slices=pd.read_csv("cnn1.csv")

read_Img=CTS_slices

Img<-exp(Img)

for Img i to n

```
img_ids = Img.str.split('.').str[0]
```

```
assert df_centers.img_id.equals(img_ids)
```

```
df_train = pd.DataFrame(mat_images, columns=['pxl' + str(i) for i in
                                             range(img_ids)])
```

```
df_train = pd.concat([df_train, df_train_hflip, df_train_vflip],
                     ignore_index=True)
```

```
X = df_train.drop(columns=['img_id', 'cx', 'cy']).values.reshape((-1,
IMG_HEIGHT, IMG_WIDTH, IMG_CHANNELS))
```

```
Y = df_train[['cx', 'cy']].values
```

```
X_train,X_test,y_train,y_test<-split features set and labels into train subset and test
subset
```

```
history = model.fit(X_train,y_test<-split features set and labels into train subset and
test subset
```

```
V<-CNN(X_train,y_train)
```

```
score<-evaluate(i,y_test,v)
```

```
return score
```

Dataset is collected from CT Scan Dataset. In the dataset 70% is used for training and 30% used for testing. The MTCNN and Traditional CNN algorithms were evaluated with respect to training, and tests were conducted with the required parameters to improve the accuracy percentage.

Statistical Analysis

Statistical software used in the study is IBM SPSS version 26. The independent sample T-test calculation for analyzing equal variance, standard error, and levene's test are evaluated. Attributes like image id, mean density value, pixel density, detection and class are dependent variables. Independent sample T-test has been carried out for evaluating the accuracy.

Results

In this proposed system it was observed that MTCNN appears to have better accuracy than the Traditional CNN algorithm. Table 1 represents the attributes of CTscan Dataset. In Fig. 1. represents the architecture for detecting osteoporosis for each CT Scan image using Convolutional Neural Network algorithm. Table 2 shows the sample accuracy of MTCNN and Traditional CNN algorithms. MTCNN uses optimization procedures to deliver high accuracy. Table 3 shows the statistical calculation such as mean, standard deviation and standard error mean for MTCNN and Traditional CNN algorithms. It is inferred that the deviation for T-test is far lesser than the

comparison algorithm. Moreover, the accuracy value of MTCNN is around 86.8. while the loss is around 18.40, which seems to be superior to the Traditional CNN classifier. In Table 4, it was observed that the Levens test for equality of variance and its significance for MTCNN is 1.778 and 0.329, respectively and standard error difference and confidence interval are lower than Traditional CNN classifiers. Mean accuracy and mean loss graph is depicted in Fig. 2. MTCNN seems to appear better for the given CT Scan dataset of Bone Cancer Detection.

Discussion

The proposed system provides better bone cancer detection using a multitask cascaded convolutional neural network with a count vectorizer with over 86.8% accuracy compared to traditional convolutional neural network algorithms.

Cancer is a deadly disease that affects people of all ages. More than one in three people will experience cancer at some point in their life. By evaluating diagnostic medical techniques such as X-rays, CT scans, and positron emission tomography (PET) scans, the general purpose is to (Renard-Penna et al. 2015) identify the affected area in the bone tract, i.e., the abnormal growth and phase of the disease. Since the scanned images may not have a high resolution due to the large number of layers per pixel and noise, it is necessary to pre-process the images with a medium filter to remove the noise. Certain features of the preprocessed image are evaluated using a genetic approach and retrieved by CNN. The recovered images are classified and (Ellmann et al. 2020) recorded with a CNN classifier to determine the stage of the disease, which helps the doctor make treatment recommendations. The results of the proposed method show a higher incidence of early detection of bone cancer.

The machine learning approach has proven successful in the field of medical imaging diagnosis, disease prediction, and bone cancer diagnosis, as well as in the field of risk assessment. (Sinthura et al. 2019) In this paper we conclude that there are many scientific challenges that need to be addressed, such as, (Bourouis, Chennoufi, and Hamrouni 2013) Computerized health care systems for diagnosing early-stage bone cancer have been shown to be very effective, especially in countries like India, where the mortality rate is high and the doctor-patient ratio is very low. This scenario results in dependence on medical imaging in the diagnosis of cancer. (Jabarpour, Abedini, and Keshtkar 2020)

Conclusion

The MTCNN algorithm detects cancer with better accuracy of 86% compared to Traditional CNN algorithm with 75%.

Declarations

Conflict of Interests

No conflict of interest in this manuscript.

Author Contribution

Author JA was involved in data collection, data analysis, and manuscript writing. Author RSK was involved in conceptualization, guidance and critical review of manuscript.

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Tables and Figures

Table 1. Attributes of CT Scan Dataset

S.No	Images	Mean Intensity	Experimental	Prediction
1		248	Not Cancer	False


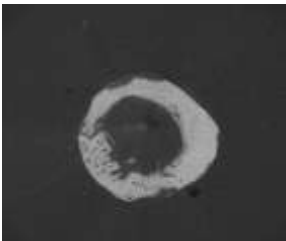

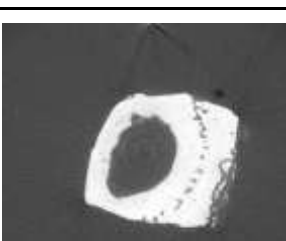
2		237	Cancer	True
3		244	Cancer	True
4		236	Cancer	True
5		242	Not Cancer	False

Table 2. Efficiency of Novel Multitask Cascaded Convolutional Neural Network and Traditional Convolutional Neural Network. The Multitask Cascaded Convolutional Neural Network algorithm is 12% more efficient than the Traditional Convolutional Neural Network algorithm.

Sample(N)	Novel Multitask Cascaded Convolutional Neural Network	Traditional Convolutional Neural Network
	Accuracy(%)	Accuracy(%)
1	86	75
2	85	74
3	84	72
4	82	70
5	81	69
6	79	67
7	78	65

8	76	64
9	74	62
10	73	61

Table 3. Comparison of the accuracy of Bone Cancer Detection of Multi Task Cascaded Convolutional Neural Networks and Traditional Convolutional Neural Networks. The MTCNN algorithm had the highest accuracy (86.8). Traditional Convolutional Neural Networks had the lowest accuracy (75.6).

T-Test:

Group Statistics

GROUP		N	Mean	STD Deviation	STD Error mean
ACCURACY	MTCNN	10	86.80	4.377	1.384
	T CNN	10	75.60	3.938	1.245

Table 4: Independent Sample T-Test is applied for the sample collections by fixing the level of significance as 0.05 with confidence interval as 95%. After applying the SPSS calculation, the Multitask Cascaded Convolutional Neural Network has accepted a statistically significant value ($p < 0.05$).

	Equal Variances	Levene's Test for Equality of Variance		Levene's Test for Equality of Variance						
		F	Sig.	t	df	Sig.(2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Accuracy	Assumed	.180	.676	6.338	18	.000	11.800	1.862	7.888	15.715
	Not Assumed			6.338	17.803	.000	11.800	1.862	7.888	15.715

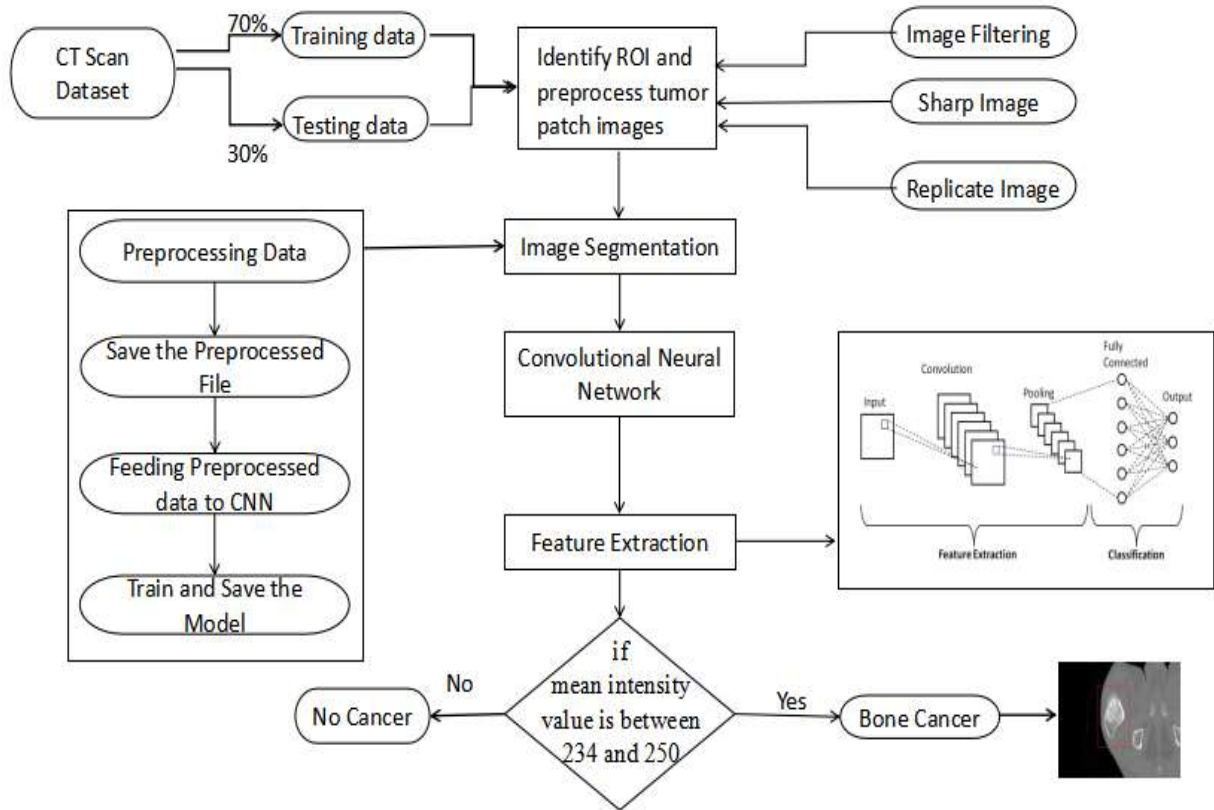


Fig. 1. Architecture for bone cancer detection estimation for each CT Scan image using Novel Multitask Cascaded Convolutional Neural Network algorithm, from dataset processing to output of each image.

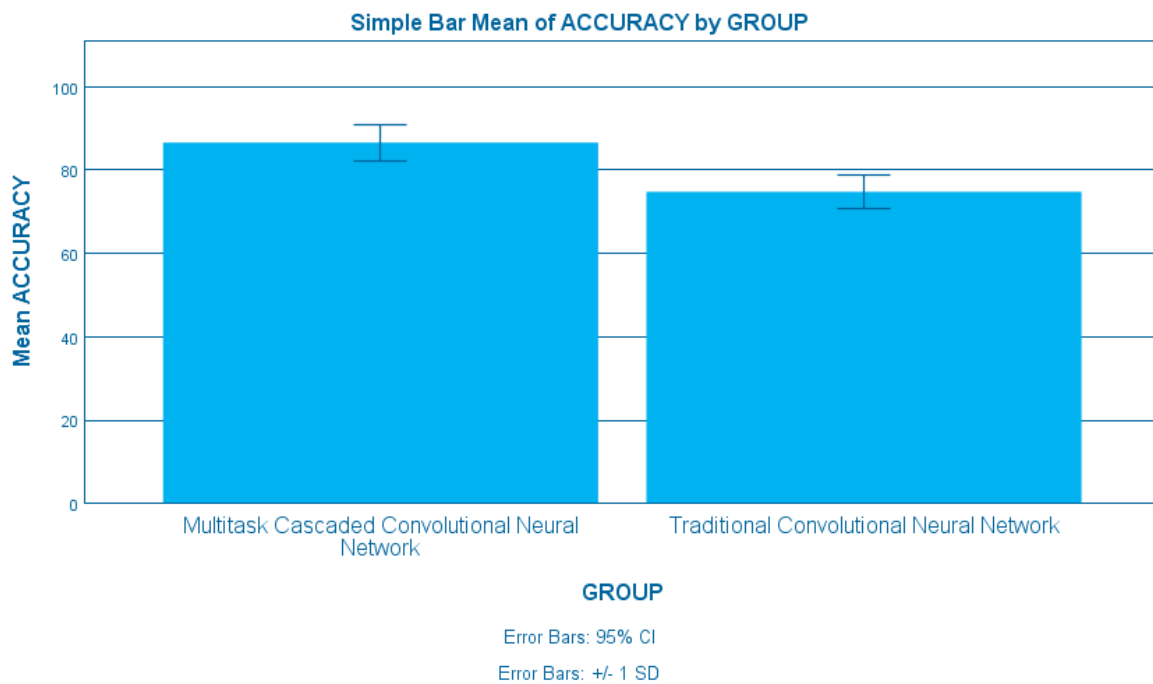


Fig. 2. Bar graph analysis of Multitask Cascaded Convolutional Neural Network algorithm and Traditional

Convolutional Neural Network algorithm. Graphical representation shows the mean efficiency of 87% and 75% for the proposed algorithm MTCNN and Traditional CNN respectively. X-axis : MTCNN vs Traditional CNN, Y-axis : Mean precision \pm 1 SD.

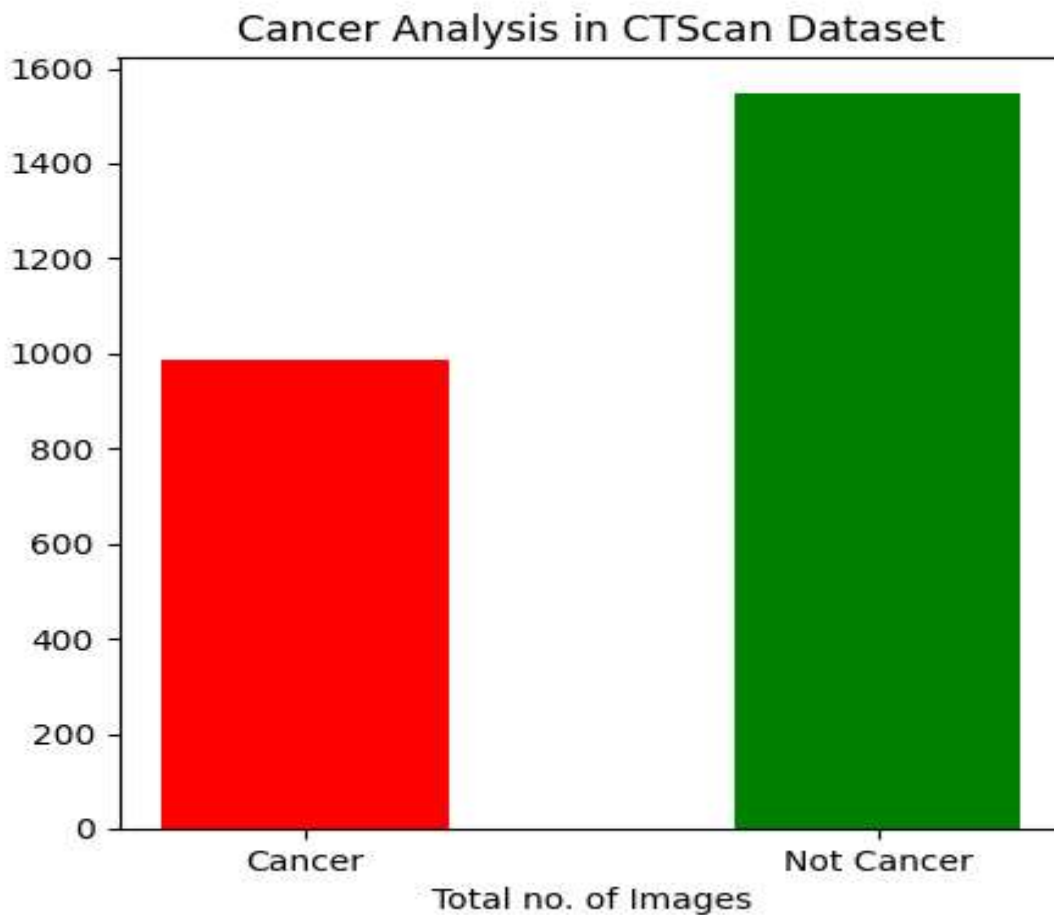


Fig. 3. The above graph represents the cancer analysis of CT Scan Dataset in that 987 images contain cancer and 1569 images do not contain cancer.