Original Article

Bone Density Analysis and Osteoporosis Prediction Using Novel Convolutional Neural Network over Support Vector Machine Algorithm

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Abstract

Aim: The aim of this study is to detect bone cancer by using the proposed Novel Convolutional Neural Network over Support Vector Machine Algorithm.
Materials and Methods: Sample groups that are considered in this project is CT Scan dataset that can be classified into two, one for Convolutional Neural Network and other for Support Vector Machine, Dataset are tested using 233.9s 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: Support Vector Machine algorithm has better efficiency (87%) when compared to Convolutional neural Network algorithm efficiency (78%). Statistical significance difference (two-sided) is 0.01 ($p<0.01$).
Conclusion: Support Vector Machine algorithm performed significantly better than the Convolutional Neural Network algorithm.

Keywords: Bone density analysis, Osteoporosis Prediction, Novel Convolutional Neural Network, Support Vector Machine, Machine Learning, Image Processing.

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INTRODUCTION

The aim of this research is to predict Osteoporosis and bone density analysis using CT Scan data using Novel Convolutional Neural Network Algorithm and to compare proposed algorithms with Support Vector Machine Algorithm. In this case the experiment aims to improve the rate of efficiency in predicting bone cancer in early stages. (Taneja et al. 2021) Osteoporosis is the uncontrolled division of aberrant cells that spreads throughout the body. (Gonçalves, Souza, and Fernandes 2022) Bone cancer is a complex disease that can be caused by a variety of genetic and physiological causes. It causes unregulated cell proliferation, resulting in demonic bone tumors that spread to other parts of the body. In the human body, various kinds of bone cancer have been discovered. Sarcomas are a type of bone cancer. (Hossain and Rahaman 2018) Bone cancer is classed as benign or malignant in the majority of cases. Bone tumors begin in bone tissue, and when cancer cells spread throughout the body via the bloodstream and lymph vessels, it is referred to as malignant bone cancer. (Durgarao and Sudhavani 2020) The American Cancer Society released an estimate of bone cancer affected patients in 2014, indicating that roughly 3020 new cases were diagnosed. The most common cause of bone cancer in humans is a tumor. To diagnose a bone tumor, medical research has developed a variety of imaging models such as CT, MRI, and X-Ray. There should be a computer-assisted diagnostic (CAD) system that automatically separates bone tumors from X-Ray pictures using reliable parameters. Many researchers have proposed various approaches for image processing by distinguishing bone tumors from human X-Ray images in the literature. (Cheng, Chen, and Freimanis, n.d.) No approach is flawless, and the algorithm's performance needs to be enhanced in order to do more research and deliver better human-centric diagnosis. (Kasinathan and Jayakumar 2022) This paper's ultimate purpose is to extract the CT Scan bone images in the dataset of bone cancer in order to predict bone cancer and bone density analysis. Some of the major applications of the research are to find the occurrence of cancer in bone at an early stage, alert and take precautionary measures, better diagnosis and reduce the risk factor.

There are around 79 IEEE papers and 161 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)(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 (Hasan et al. 2021). The drawbacks of bone cancer may include Hair, blood-forming cells, and cells lining the digestive tract are among the typical cells that are frequently damaged. Nausea and vomiting, hair loss, infection, and exhaustion are all possible side effects.Bone cancer may be detected and classified accurately at an early stage, which can save many lives around the world. The system that has been devised is as follows may be used to identify and classify bone cancers Images from an MR scanner. Adaptive neuron clustering and fuzzy C-mean clustering. (Sekar and Raja Sekar 2017) For the detection and classification of bone cancer, a fuzzy inference method was used. The main aim of our project is to detect osteoporosis by using Convolutional Neural Network over Support Vector Machine 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 Convolutional Neural Network and group 2 is taken as Support Vector Machine. The Novel Convolutional Neural Network algorithm and Support Vector Machine 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, the input image processing depends on the mean pixel density value and image id. which are processed into the detection model using opencv library and efficiency of both Novel Convolutional Neural Network and Support Vector Machine algorithms are 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 and Bone density analysis with CNN model and SVM model. 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 Density Analysis and Osteoporosis Prediction with CNN and SVM

Step 1: Image Preprocessing

We're mostly concerned with image preprocessing. The fundamental purpose of image enhancement is to improve the overall appearance of the data in the image. Fig.3 represents the block diagram for the preprocessing steps.As a result, the outcomes are more suitable for further image processing. In these we can read, resize, denoise and then smoothing edges of the image. Fig.4.represents the normal and preprocessed image.

Step 2: Image Segmentation

This stage is critical in image processing methods. As the name says, segmentation divides the image into many segments. By separating the image into pieces based on the attributes of the pixels, the tumor area can be found. The preprocessed image is converted into a binary image to extract the tumor part.

Step 3: Feature Extraction

The technique of decreasing the number of resources required to explain a large amount of data is known as feature extraction. The high number of variables involved in advanced data analysis is one of the most significant challenges. Feature extraction is a broad term that relates to methods for producing combinations of variables to get around these problems while still accurately describing the data.

Step 4: Training and Testing Classifier The training procedure is completed after the feature extraction step. The CTscan Dataset is used as input to the classifier in order to create indices during the training phase. It is possible to add various and more datasets into the test classifier in order to test the classifier's accuracy. The method of testing is done to determine whether or not the bone has malignancy.

Step 5: Osteoporosis Prediction

After all the steps we need to predict osteoporosis and bone density analysis with Enhanced Residual Network algorithms and Traditional CNN to detect the images and identify the cancer based on the mean pixel density. Fig.5. describes the dataset of the CTscan images.

Convolutional Neural Network

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning system that can take an input image, assign relevance (learnable weights and biases) to various aspects/objects in the image, and distinguish between them. The main distinction between a typical Artificial Neural Network (ANN) and a CNN is that a CNN only has one completely linked layer, whereas in an ANN, each neuron is connected to all other neurons.

Inputs: CT scan data set

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
```

Support Vector Machine

SVM stands for Support Vector Machine and is a supervised machine learning method capable of classification, regression, and even outlier detection. Drawing a straight line between two classes is how the linear SVM classifier works.SVM's purpose is to partition datasets into classes so that a maximum marginal hyperplane can be found (MMH). Data Points that are closest to the hyperplane are referred to as support vectors.

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<-SVM(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 Convolutional Neural Network and Support Vector Machine 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 the Support Vector Machine appears to have better accuracy than the Novel Convolutional Neural Network algorithm.Table 1 represents the attributes of CTscan Dataset. In Fig.1. represents theArchitecture for Osteoporosis Prediction and Bone density Analysis estimation for each CT Scan image using SVM algorithm, from dataset processing to output of each image.Table 2 represents the sample accuracy of SVM and CNN algorithms. Table 3 shows the statistical calculation such as mean, standard deviation and standard error mean for CNN and SVM algorithms. It is inferred that the deviation for T-test is far lesser than the comparison algorithm. Moreover, the accuracy value of SVM is around 87.3. while the loss is around 18.40, which seems to be superior to the CNN classifier. In Table 4, it was observed that the Levens test for equality of variance and its significance for SVM is 1.778 and 0.928, respectively and standard error difference and confidence interval are lower than CNN classifiers. Mean accuracy and mean loss graph is depicted in Fig. 2. SVM seems to appear better for the given CT Scan dataset of Bone Cancer Prediction.

DISCUSSION

The proposed system provides better Osteoporosis prediction using a Support Vector Machine with a count vectorizer with over 87% accuracy compared to Innovative convolutional neural network algorithms.
There are similar papers to analyze the bone density of porous bones using machine learning algorithms.In this research paper uses a screening and identifying method to identify cancer.Cancer is a lethal disease that strikes people of all ages. (Dayanand 2018) Cancer will strike more than one-third of the population at some point in their lives. The primary purpose of analyzing diagnostic medical techniques like X-rays, CT scans, and PET scans is to determine the damaged area in the bone tract, (Shang and Liu 2022) i.e., the disease's abnormal growth and phase. Because the scanned images may not have a high resolution due to the large number of layers per pixel and noise, they must be pre-processed with a medium filter to reduce the noise.CNN analyses and extracts various attributes of the preprocessed image using a genetic technique. (Jaquish et al. 2012) To determine the stage of the sickness and aid the doctor in making therapeutic recommendations, a CNN classifier is utilized to classify and record the recovered images. (Sharma et al. 2021) The proposed method's results demonstrate a better rate of early prediction 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, it can be conclude that there are many scientific challenges that need to be addressed, such as, 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 Novel Convolutional Neural Network algorithm detects Osteoporosis with better accuracy of 87% compared to Support Vector Machine algorithm with 78%.

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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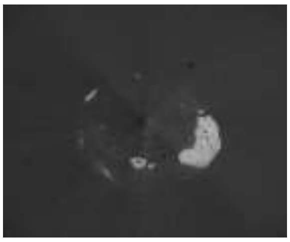
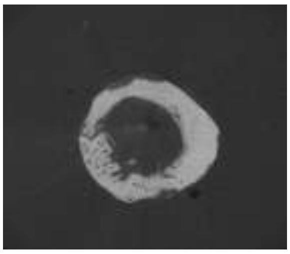
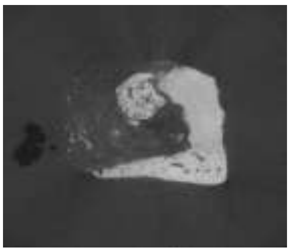
TABLES AND FIGURES

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

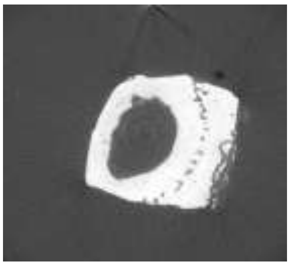
5		242	Not Cancer	False

Table 2. Efficiency of Convolutional Neural Network and Support Vector Machine. The Support Vector Machine algorithm is 9% more efficient than the Convolutional Neural Network algorithm.

Sample(N)	**Support Vector Machine Algorithm**	**Convolutional Neural Network Algorithm**
	Accuracy(%)	**Accuracy(%)**
1	87	78
2	86	77
3	84	75
4	82	73
5	81	72
6	79	69
7	78	68
8	76	65
9	74	63
10	72	61

Table 3. Comparison of the accuracy of Bone Density Analysis and Osteoporosis Prediction of Support Vector Machine and Convolutional Neural Networks. The SVM algorithm has the highest accuracy (87.3). Traditional Convolutional Neural Networks had the lowest accuracy (78.2).

T-Test:

Group Statistics

GROUP		**N**	**Mean**	**STD Deviation**	**STD Error mean**
ACCURACY	**SVM**	10	87.30	4.762	1.506
	CNN	10	78.20	4.709	1.489

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 Support Vector Machine 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	.008	.928	4.297	18	.000	9.100	2.118	4.650	13.550
	Not Assumed			4.297	17.998	.000	9.100	2.118	4.650	13.550

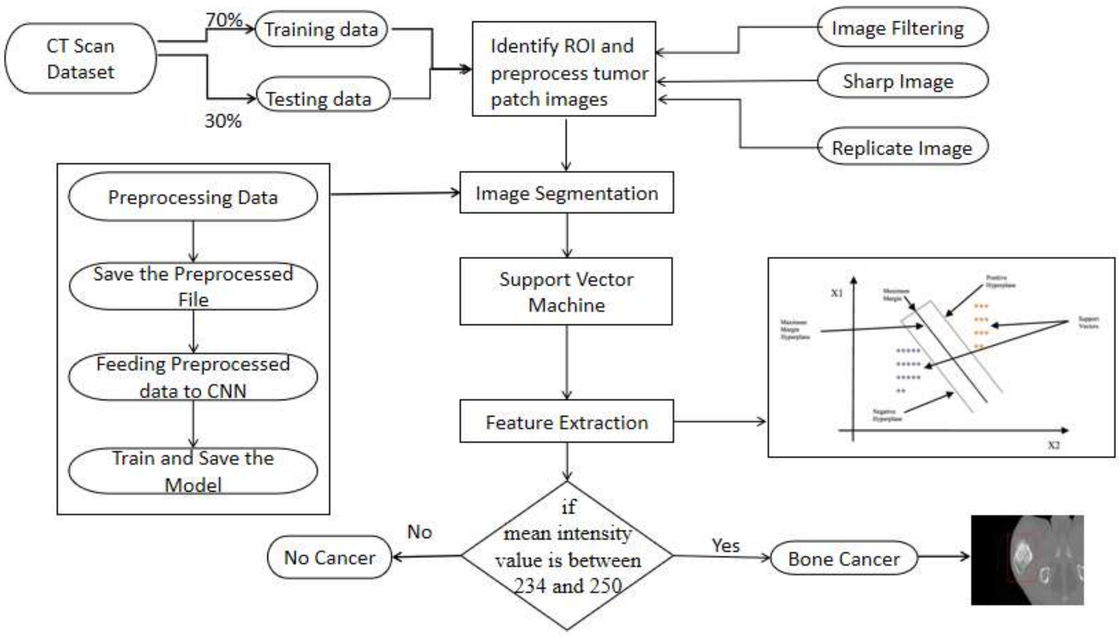


Fig. 1. Architecture for Osteoporosis Prediction and Bone density Analysis estimation for each CT Scan image using Support Vector Machine algorithm, from dataset processing to output of each image.

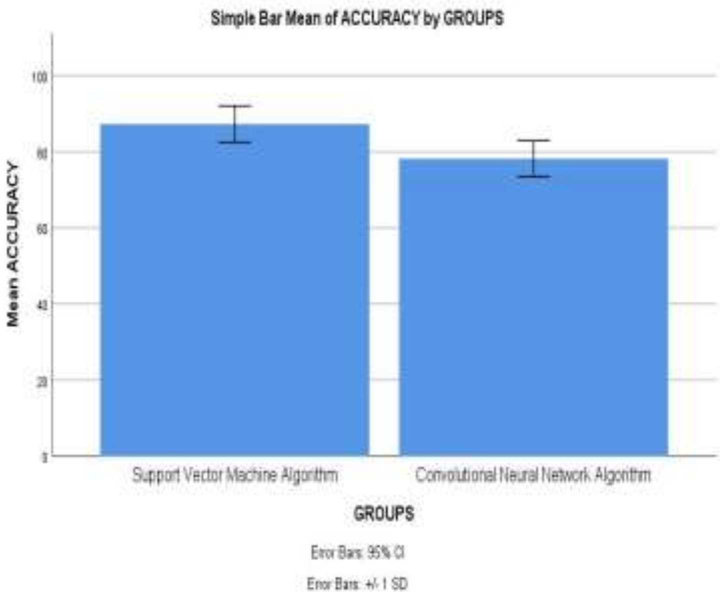


Fig. 2. Bar graph analysis of Support Vector Machine algorithm and Convolutional Neural Network algorithm. Graphical representation shows the mean efficiency of 87% and 78% for the proposed algorithm SVM and CNN respectively. X-axis : SVM vs CNN, Y-axis : Mean precision ± 1 SD.

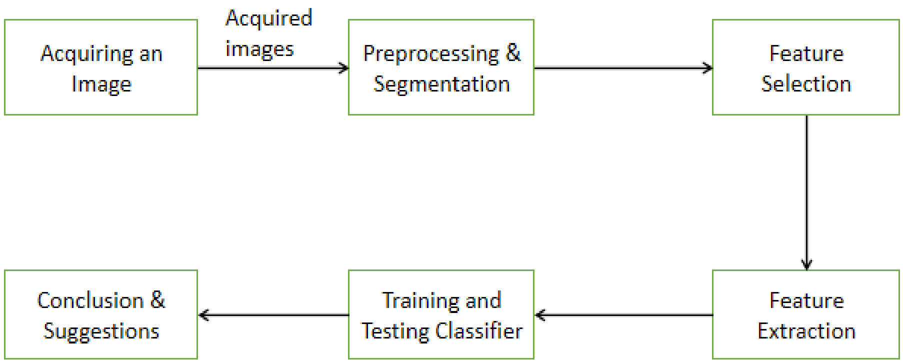


Fig. 3. Block Diagram

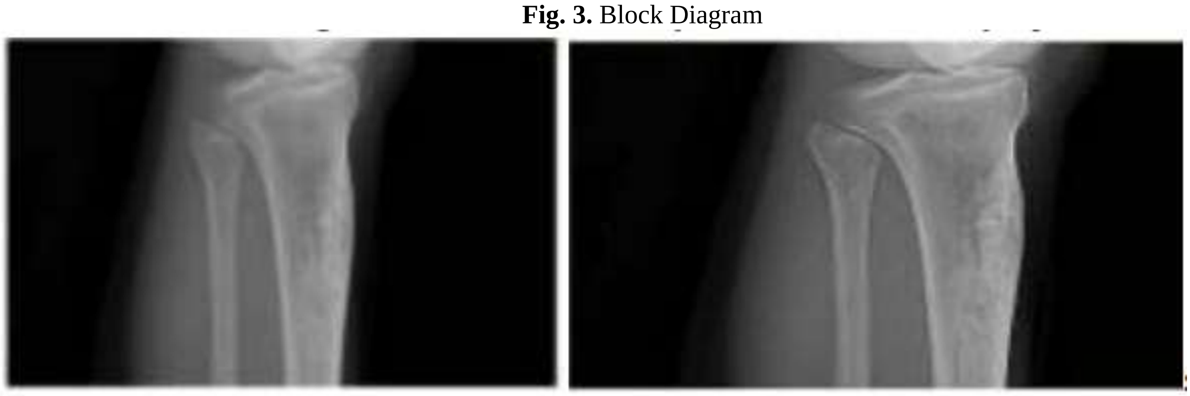


Fig. 4. a) Normal Image b) Preprocessed Image

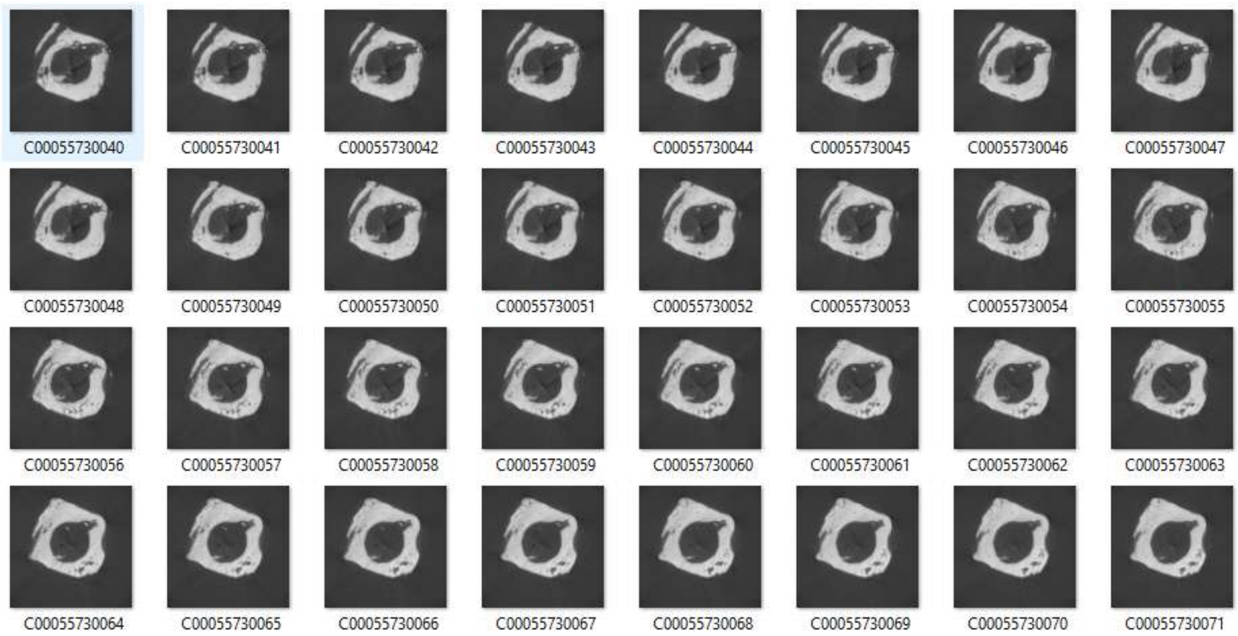


Fig. 5. Data stored in dataset of CTscan