

Prostate Cancer Detection Using Deep Learning

Sachin Paithane^{1,*}, Sanika Padwalkar², Vivek Nikam³, Prashant Pawar⁴, Priti Warungse⁵

Abstract

Prostate Cancer is a cancer occurs in prostate gland which is located in male reproductive system. According to the WHO (World Health Organization) the estimated cancer cases in the year 2020 is about 1.4 Million. Prostate cancer is one of the reason for death in men. In this paper we have presented Secondary verification tool for doctors or for normal users to check patient have a cancer or not. And also other things are disused in this paper like implementation of the Deep learning CNN (Convolutional Neural Network) for detection of prostate cancer using input as ultrasound image. We have discussed why we have selected Deep learning CNN algorithm for detecting prostate cancer in our previous paper which is also in titled as prostate cancer detection using deep learning. We are also discussing which libraries are required for implementing this project and other tools and hardware requirement for this project.

Keywords: Prostate cancer, prostate cancer detection, deep learning, CNN, deep learning model, medical use

INTRODUCTION

In the previous research paper we have discussed how we selected the CNN algorithm for our project and why it is selected for this project. Now we are going to discuss how the CNN algorithm is implemented and how it is used for our project. And what libraries are used and tools are used and which programming language is used for developing this project. For developing this deep learning project we have used Bharati Hospital Pune prostate gland Ultrasound Image dataset which contains total 400 images those are divided into three group as Normal, Benign Prostatic Hyperplasia and Adenocarcinoma.

The programming language used for developing backed of the project is Python and for developing front end we have used HTML and for designing the HTML tags we have used CSS and CSS framework Bootstrap, And other python libraries for developing CNN algorithm like Tensorflow, keras. And for image preprocessing we have used OpenCV, Imutils, Pillow. And for mathematical calculation and

array processing we have used pandas and numpy. And matplotlib is used for plotting the graphs. The hardware requirement for this project is processor is 15 or higher and RAM 4GB and Memory is required but not so large.

Author for Correspondence

Sachin Paithane
E-mail: spaithane9172@gmail.com

¹⁻⁴Student, Computer Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India

⁵Professor, Computer Engineering, NBN Sinhgad School of Engineering, Pune, Maharashtra, India

Received Date: December 12, 2023

Accepted Date: December 15, 2023

Published Date: December 25, 2023

Citation: Sachin Paithane, Sanika Padwalkar, Vivek Nikam, Prashant Pawar, Priti Warungse. Prostate Cancer Detection Using Deep Learning. International Journal of Biomedical Innovations and Engineering. 2023; 1(2): 21–26p.

The purpose of this system is to detect prostate cancer using ultrasound image of prostate gland. Input to this system is ultrasound image. After giving ultrasound image to system preprocessing is done on input ultrasound image. After preprocessing ultrasound image is given to CNN algorithm in the CNN algorithm different layers of CNN works on that ultrasound image of prostate

gland and extract features from that image and those features are used to predict the stage of prostate cancer.

LITERATURE REVIEW

A Transient Enhanced Ultrasound (TeUS) proposed [2], involving the investigation of varieties of signals like backscattered signals which are from the tissue over an arrangement of ultrasound outlines. propose to utilize profound Recurrent Neural Networks (RNN) which expressly demonstrate the transient data in TeUS. The exploring a few models of RNN, they showed as the Long Short-Term Memory (LSTM) systems accomplish the most elevated exactness in isolating malignant growth from kind tissue present in prostate. If the relative Gleason score [3] has been allocated to the diagnosed prostate cancer, the accurate therapy followed by the needs to be specified promptly.

The assist pathologists and the radiologists with respect to timely diagnosis, they suggest in this particular paper a system aimed at inferring the score of Gleason and the therapy for prostate cancer using systematic methods Unsupervised Deep Embedding for Clustering Analysis explains about clustering [4]. Clustering is central to many data-driven application domains and has been studied extensively in terms of distance functions and grouping algorithms. Relatively little work has focused learning representations for clustering. However misclassification of any images doesn't gives the approximate result [5].

METHODOLOGY

We have used CNN algorithm for implementing prostate cancer detection system and we have used python programming language. And some other python libraries which helps in implementing CNN algorithm and preprocessing ultrasound image of prostate gland [6].

CNN (Convolutional Neural Network): CNN is a deep learning algorithm used for object classification and image recognition. In other words CNN is a network architecture for deep learning that learns directly from data. There are different layers in CNN algorithm like, Convolutional Layer, ReLU Layer, Polling Layer, fully connected layer, flattening layer, soft-max or output layer [7]:

In CNN we use filter matrix for filtering the features of image which is collected by convolutional layer filter matrix is also called as kernel matrix. The size of the kernel matrix is depends upon us. We have used 3X3 kernel matrix for this project. After applying the kernel matrix the original matrix size changes we can check what is the size when we use $n \times n$ kernel on original feature matrix by using following formula.

$$S=(h-f_h+1)X(w-f_w+1)$$

Here is,

S-Size of feature matrix after applying kernel matrix on original feature matrix.

h -height of the original feature matrix

w -width of the original feature matrix.

f_h -height of the kernel matrix.

f_w -width of the kernel matrix

We can use any number of time kernel matrix if we use kernel matrix n times then the formula is change as mentioned bellow.

$$S=(h-f_h*n+n)X(w-f_w*n+n)$$

In the above formula n represent the how many times the kernel matrix is used on to the feature matrix and the above formula is used only when we have to calculate size of feature matrix after applying more than one kernel matrix. If we want to calculate the size of feature matrix when we used

only one kernel matrix then we can use both the formulas but the first one is simple and easy to use. In this project we have used image of size 224x224 and the image is prostate gland ultrasound image which is in black and white format [8].

SYSTEM ARCHITECTURE

In Prostate cancer detection system architecture there is three main component which are responsible for finding the prostate cancer in a ultrasound image of prostate gland. The three main component of architecture of prostate cancer detection system are input, deep learning algorithm and output.

Input

In the input phase of the architecture input is given to the system the input is in the form of image of prostate gland. After giving input to the system some other operations are done on the image for improving the quality of the image. Operations like Preprocessing, Segmentation and Enhancement. This operations are also present in the architecture figure of the system just after the input block [9].

Preprocessing

In the preprocessing image is pre-processed it means some operations on image is performed like re-sizing image, clearing image, converting image to black and white image and some other operations are also performed using different python libraries which makes it easy. Python libraries used for preprocessing of image are OpenCV, Pillow, and Imutils. This all libraries are open source and they make the process of preprocessing image easy and less time consuming.

Segmentation

Segmentation is a process of dividing input image into small sub parts which can help algorithm to understand features quickly and accurately. In our system the preprocessed image is given to the segmentation block for segmentation.

Enhancement

This operation or block is used for improving the quality of the image by default the quality of image taken as a input is not enough good due to this we require this block or process for improving the quality of image. It makes feature extraction easy for CNN algorithm and it improve the accuracy of the result because of good quality of image [10].

CNN (Convolutional Neural Network)

CNN (Convolutional Neural Network) is a Deep Learning Algorithm used for object detection and image recognition. We have used this algorithm for checking which stage is shown in the ultrasound image of the patient. The CNN algorithm contain to main phases one is Feature Learning and another one is Classification.

Feature Learning

In the feature learning features are extracted and some operations on it are performed by CNN algorithm layers. The feature extraction part is done by the convolutional layer of the CNN algorithm. And then the feature rectifying is done by the ReLU layer and then the Pooling layer is applied on that feature matrix. This process is done any number of times it depends upon the how many time programmer written the code for layers. After applying all the layers comes under feature learning then the final feature matrix form feature learning is given to classification phase.

Classification

In the classification phase main work of classification is done by analyzing the features of the image or by analyzing the feature matrix of the image which is taken from feature learning phase. In the classification phase there are three main layers those are flatten layer, fully connected layer and softmax layer. In the flatten layer the multi-dimensional feature matrix of the image is converted into 1D

array of feature then it is given to the fully connected layer which is responsible for classification of the image in our case we have three classes such as, Normal, Benign Prostatic Hyperplasia and Adenocarcinoma. In the fully connected layer there are so many perceptron those are responsible for making decision and each perceptron is connected to its nearing perceptron. Fully connected layer gives three value to the soft max layer because of we have only three classes like as mentioned early after analyzing all the features. Then the soft max layer gives us one class whose probability is have. And using that class we have printed the final output as seen in Figure 1.

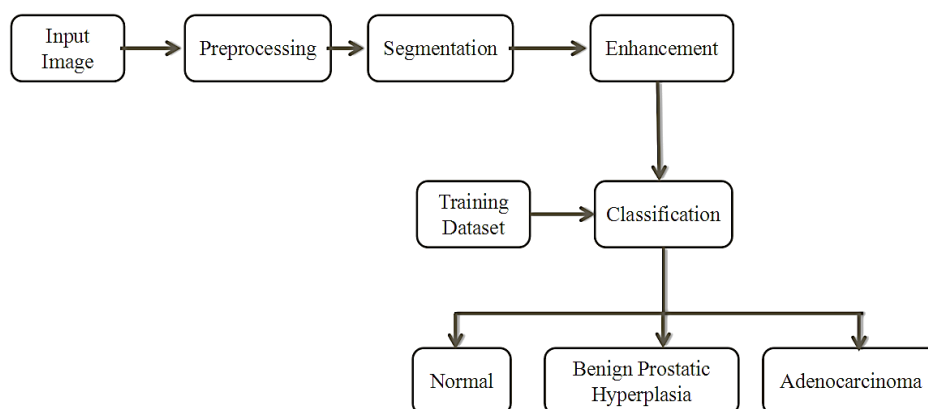


Figure 1. Architecture of Prostate Cancer Detection System.

DISCUSSION

The enhancement operation is crucial for improving image quality, serving as a pre-processing step before inputting images into the Convolutional Neural Network (CNN). Its primary role is to facilitate feature extraction, ultimately enhancing CNN algorithm accuracy.

CNN, a Deep Learning Algorithm, specializes in object detection and image recognition. It consists of two main phases: Feature Learning and Classification as seen in Figure 2.

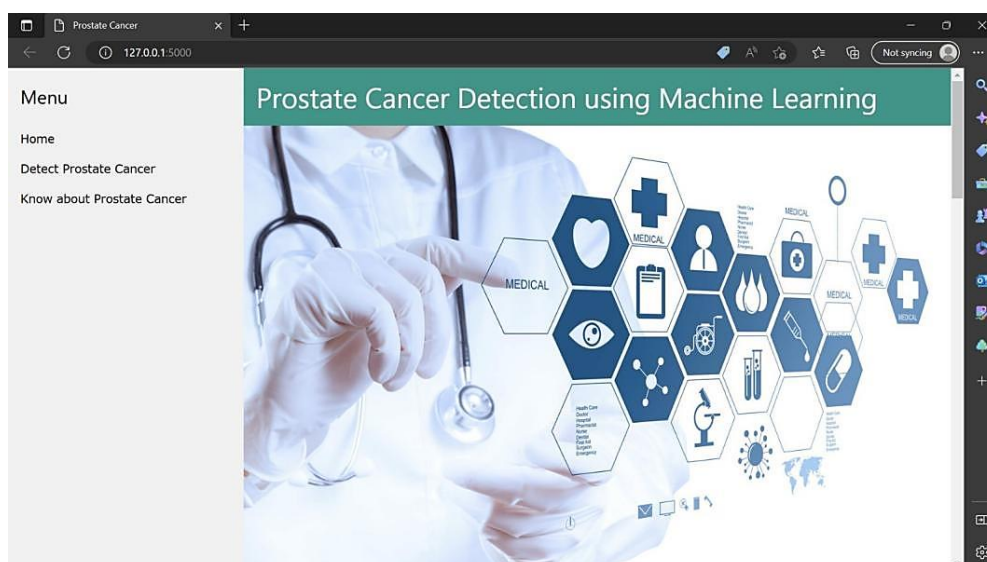


Figure 2. Prostrate cancer detectuion using machine learning on home page.

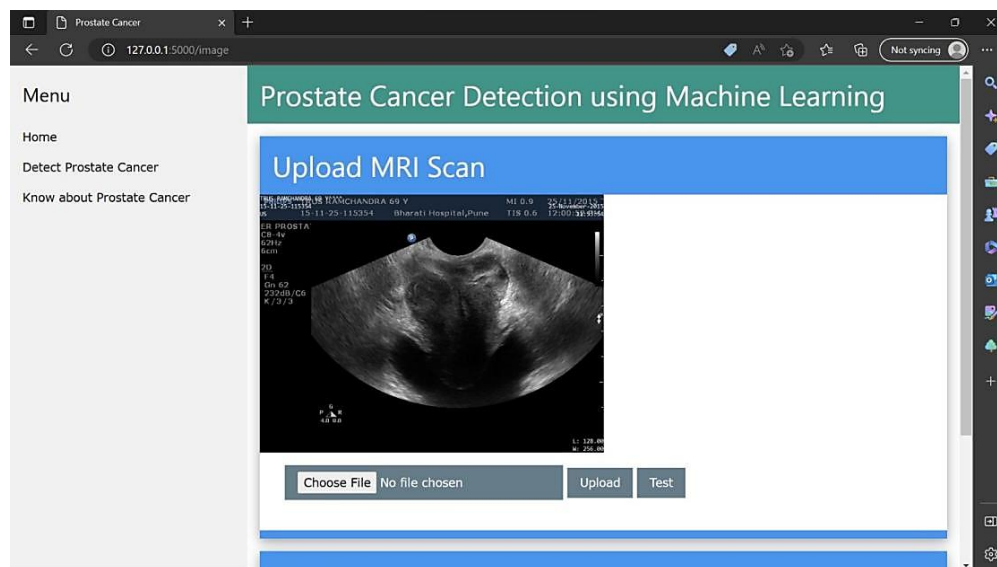


Figure 3. Prostrate cancer detectuion using machine learning on testing page.

Feature Learning involves the extraction and manipulation of features by CNN layers. The convolutional layer extracts features, followed by rectification through the ReLU layer and feature matrix pooling. This process iterates based on the programmed layers. The resulting feature matrix undergoes classification in the next phase as seen in Figure 3.

Classification analyzes image features using three key layers: flatten, fully connected, and soft-max. The flatten layer converts the multi-dimensional feature matrix into a 1D array, passed to the fully connected layer responsible for classifying the image. In this case, the CNN classifies images into three categories: Normal, Benign Prostatic Hyperplasia, and Adenocarcinoma.

This integrated process optimizes image quality and enhances the accuracy of CNN-based diagnoses

CONCLUSION

We have successfully developed the system for detecting the prostate cancer using ultrasound image of prostate gland. For training the model we have used Bharti hospital dataset of ultrasound image it contains total 400 images some of normal stage and some of Benign Prostatic Hyperplasia and some of Adenocarcinoma stage. We have developed this system using deep learning CNN (Convolutional Neural Network) algorithm. And for developing user interface (UI) we have used HTML and for designing user interface we have used CSS and Bootstrap which is CSS framework this all are used in flask framework of python which create web application for python projects. The user interface designed is simple and easy to understand. The final output after uploading image in web application is shown just below to the upload image in the application. The final output is the stage of the prostate cancer Normal, Benign Prostatic Hyperplasia, Adenocarsinoma.

REFERENCES

1. Y. Artan and I. S. Yetik, 2012, "Prostate cancer localization using multiparametric MRI based on semisupervised techniques with automated seed initialization," *IEEE Trans. Inf. Technol. Biomed.*, vol. 16, no. 6, pp. 1313–1323, doi: 10.1109/TITB.2012.2201731.
2. S. Azizi *et al.*, 2018, "Deep recurrent neural networks for prostate cancer detection: Analysis of temporal enhanced ultrasound," *IEEE Trans. Med. Imaging*, vol. 37, no. 12, pp. 2695–2703, doi: 10.1109/TMI.2018.2849959.
3. L. Brunese, F. Mercaldo, A. Reginelli, and A. Santone, 2019, "Prostate gleason score detection and cancer treatment through real-time formal verification," *IEEE Access*, vol. 7, pp. 186236–186246, doi: 10.1109/ACCESS.2019.2961754.

4. Y. Feng *et al.*, 2019, “A Deep Learning Approach for Targeted Contrast-Enhanced Ultrasound Based Prostate Cancer Detection,” *IEEE/ACM Trans. Comput. Biol. Bioinforma.*, vol. 16, no. 6, pp. 1794–1801, doi: 10.1109/TCBB.2018.2835444.
5. J. T. Kwak and S. M. Hewitt, 2017, “Lumen-based detection of prostate cancer via convolutional neural networks,” *Med. Imaging 2017 Digit. Pathol.*, vol. 10140, p. 1014008, doi: 10.1117/12.2253513.
6. W. Li *et al.*, 2019, “Path R-CNN for Prostate Cancer Diagnosis and Gleason Grading of Histological Images,” *IEEE Trans. Med. Imaging*, vol. 38, no. 4, pp. 945–954, doi: 10.1109/TMI.2018.2875868.
7. G. Litjens, O. Debats, J. Barentsz, N. Karssemeijer, and H. Huisman, 2014, “Computer-aided detection of prostate cancer in MRI,” *IEEE Trans. Med. Imaging*, vol. 33, no. 5, pp. 1083–1092, doi: 10.1109/TMI.2014.2303821.
8. M. Moradi, P. Abolmaesumi, D. R. Siemens, E. E. Sauerbrei, A. H. Boag, and P. Mousavi, 2009, “Augmenting detection of prostate cancer in transrectal ultrasound images using SVM and RF time series,” *IEEE Trans. Biomed. Eng.*, vol. 56, no. 9, pp. 2214–2224, doi: 10.1109/TBME.2008.2009766. ICCRDA 2020 IOP Conf. Series: Materials Science and Engineering 1022 (2021) 012073 IOP Publishing doi:10.1088/1757-899X/1022/1/012073 10
9. S. G. Schalk *et al.*, 2017, “Contrast-Enhanced Ultrasound Angiogenesis Imaging by Mutual Information Analysis for Prostate Cancer Localization,” *IEEE Trans. Biomed. Eng.*, vol. 64, no. 3, pp. 661–670, doi: 10.1109/TBME.2016.2571624. rial Network for Prostate Cancer Segmentation,” *IEEE Access*, vol. 7, pp. 131448–131458, doi: 10.1109/ACCESS.2019.2939389
10. Gorelick L, Veksler O, Gaed M, Gomez JA, Moussa M, Bauman G, Fenster A, Ward AD (2013) Prostate histopathology: learning tissue component histograms for cancer detection and classification. *IEEE Trans Med Imaging* 32(10):1804–1818. <https://doi.org/10.1109/TMI.2013.2265334>