

# Using AI and Blockchain in the Healthcare Systems

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**Abstract** - Medical records scanning services enable healthcare professionals to access and manage patient information much more easily than with paper charts. As technology improves there is a growing need to digitize and back up patient records electronically. Our system proposes a complete system where the patient can submit the images of their medical records, these images are then scanned by lab OCR Engine, analyzed, summarized, and stored on the cloud with proper security and standards. Our system not only analyzes textual data but also provides analysis of Brain CT Scans and Chest X Rays using a Convolutional Neural Network. It provides best practices, reduces cost, increases security, and most importantly; makes the lives of patients easier. The system also aims to provide Blockchain-based storage and retrieval of the stored data.

**Key Words:** Optical Content Recognition (OCR), Blockchain, Convolutional Neural Network (CNN)

## 1. INTRODUCTION

The fact is Digitization of medical records is incredibly low in Indian hospitals[2] and extremely high within the international scenarios as per government reports. Having documents scanned and saved electronically, can lower production time, increase communication and collaboration within the team, and increase accessibility, unencumbered office space, and most significantly economize[6]. There are several benefits to the healthcare industry that are offered through medical records scanning. Physical documents from past trials might be an honest resource for healthcare companies to check their current clinical trial operations so as to enhance their best practices[4]. As an example, a hospital looking to collect

data on the overall health of their patient population might want to digitize documents from clinical trials conducted there within the past. Patient reports, likely from outside clinics or physicians, may additionally contain helpful information about likely side effects of a drug and the way individual patients may respond[5]. It's particularly important to include all relevant patient information when new side effects are discovered or if a patient has had allergies thereto within the past.

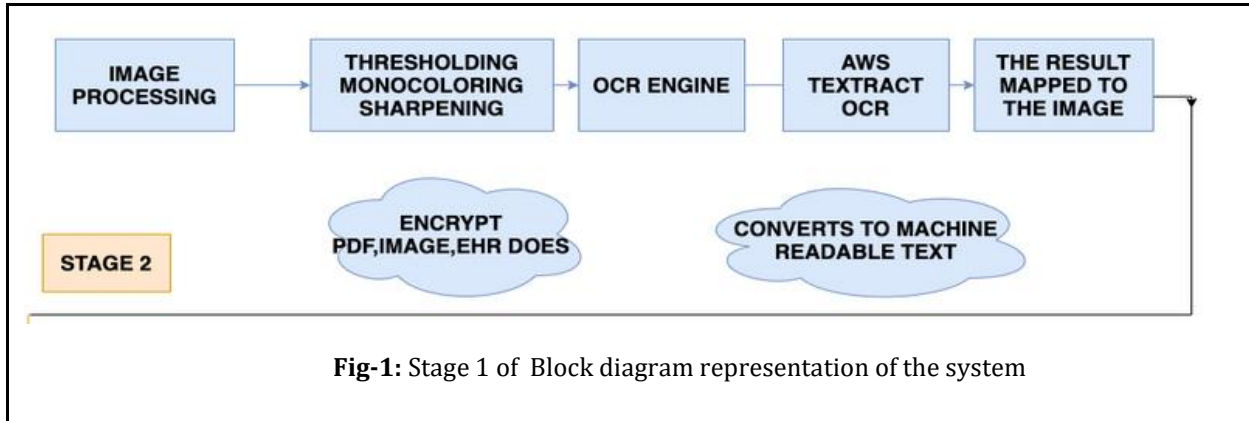
Healthcare companies can get pleasure from this information [5] by having access to each past reaction to a given drug and using that awareness to boost patient care.

## 2. LITERATURE REVIEW

To generate textual reports automatically from the medical images [1], medical image captioning, and text generation [2] for more accurate diagnosis and generation of medical records. Why and how to design a proper electronic health record (EHR) storage system which is consistent, available at all times, and well-integrated with old patient records [3]. The solution should be most accurate and should be tested with various algorithms as they must be free from false positive or negative reports [4]. The documents uploaded should be retrieved as fast as possible. FTP should be avoided and data should be stored locally [5]. All the possible forms of information must be extracted from the medical documents as all are important [6]. The files of patients stored must be tamper-proof and immutable also they must be readily available when required. This is made possible using IPFS (InterPlanetary File System) distributed system which helps access documents readily [7] [8].

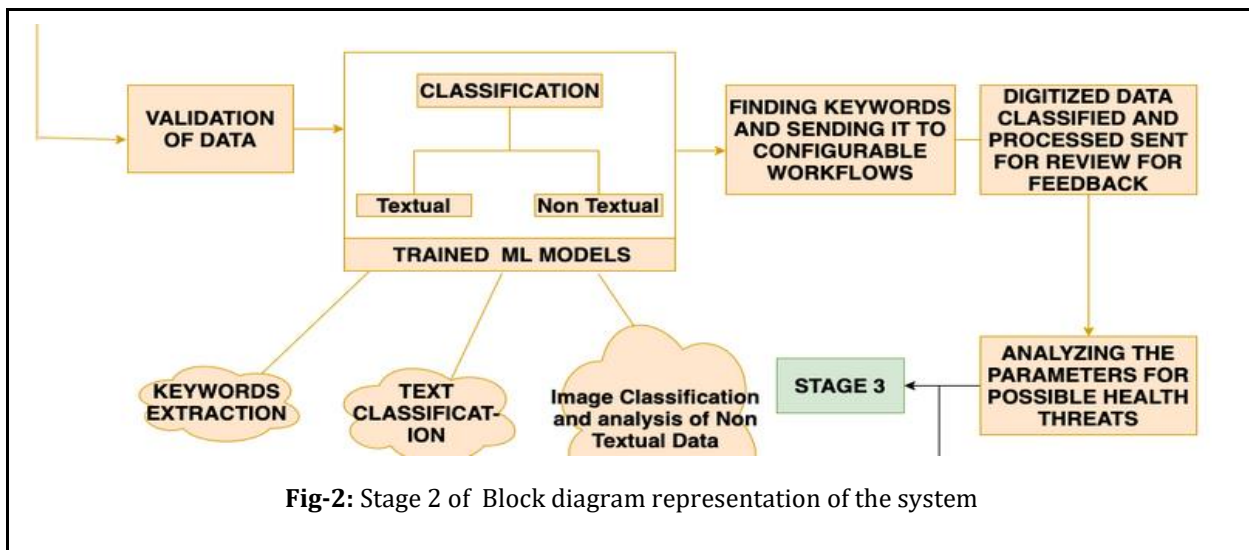
### 3. SYSTEM DESIGN

#### 3.1 Stage 1



- In the first step after the image gets uploaded by the user the images uploaded by the user gets stored in the AWS EC2 storage after enhancing the image using Image processing.
- The processed images are then sent to the AWS Textract engine which processes the image and provides us with the textual data. These data can be obtained in various forms like key-value pairs, tabular data, and sets of dictionaries. This data extracted is then stored and linked with the images.

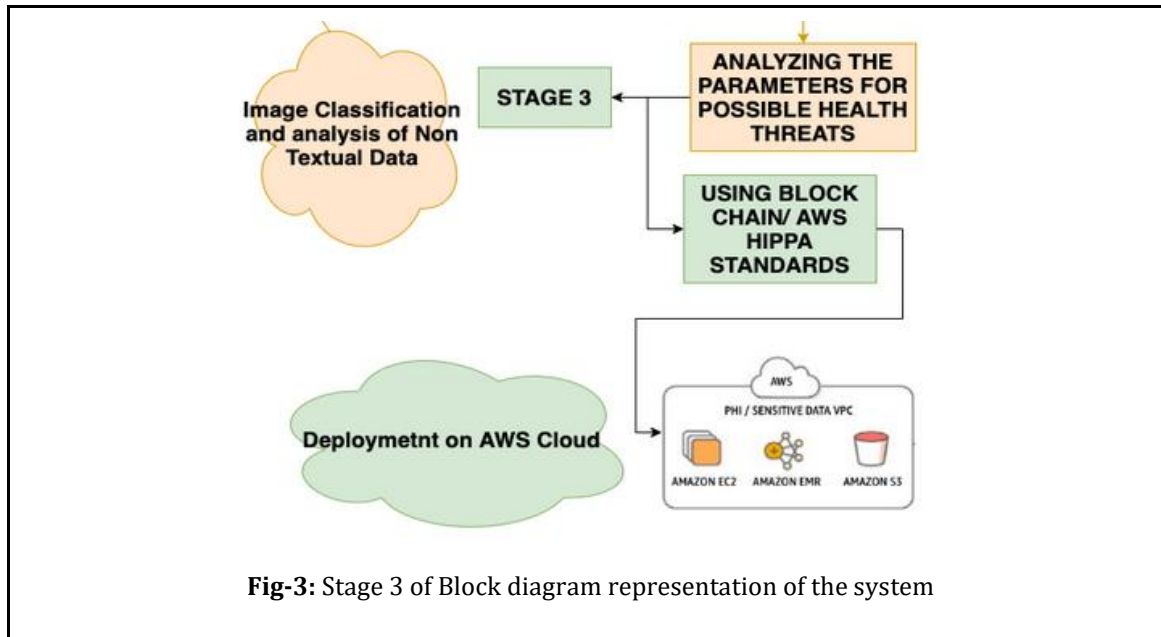
#### 3.2 Stage 2



- The validation of the images is done by scanning the appropriate dates, stamps, hospital names, patient names, etc, on the input images.
- The textual data is sent for Labelization, text classification, and keywords extraction
- The nontextual data (X-Ray Reports, CT-Scans) would be sent for image classifications and would be analyzed. This analysis would be a classification of diseases using CNN algorithms.

- Digitized data is then observed by an intermediary for validation and feedback.
- After validation, various parameters in the digitized data are considered which help in determining medical history, medical expenses, possible health threats, previous medical records, etc.
- All these data linked to their original input image are then stored in blockchain technology and would be deployed on AWS.

### 3.3 Stage 3



- Blockchain Uploading follows some simple steps where the browser helps select the file for uploading and then it is passed on to the IPFS which will generate an IPFS hash which will be passed to the Ethereum Smart Contract which will store the file to the Blockchain.

## 4. IMPLEMENTATION DETAILS

### 4.1 Textual Data

In this stage[Stage 1], storing, processing, and analyzing textual data such as Lab Reports are performed. The images uploaded by the user are enhanced using Image processing techniques.

These include image binarization, setting proper resolution, thresholding, and eroding and are encrypted and stored.

The processed images are then sent to AWS Textract and our custom trained open-source OCR (Tesseract). The best results obtained are stored. If the image contains tabular data, a CSV is exported out of that data. The extracted textual data is linked to the images and sent for processing. The validation of the images is done by scanning the appropriate dates, stamps, hospital names, patient names,

etc, on the input images.

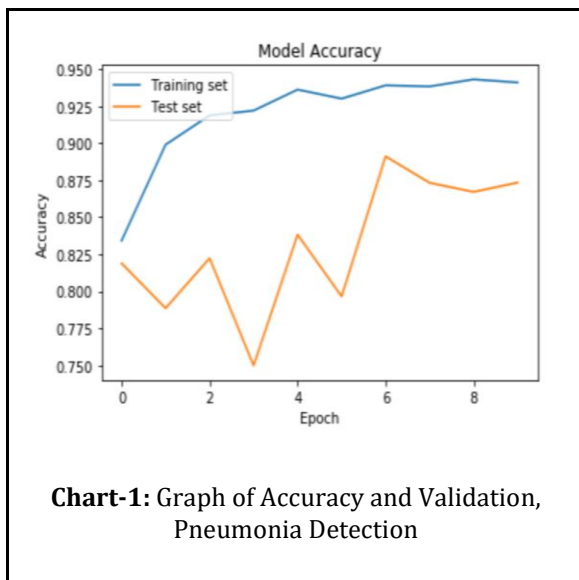
### 4.2 Non-Textual Data

#### 4.2.1 Pneumonia-X-Rays-of-Human-Lungs

This module has both back-end dependencies Keras and Flask and front-end dependencies and deployment. The module performs X-rays of human lungs classification using Convolutional Neural Networks with automated image pre-processing and internal procedures. Saved files of inspected models are saved on specific folders in an exceeding directory. For deploying we've used Flask rather than Django due to its simplicity and compatibility with Amazon Web Services (AWS) and Google Cloud Storage (GCS). App Engine in GCS could be a perfect tool for deploying a Keras model as an online application. We have

also uploaded our deployment environment and created a Python YAML file that the server understands.

The dataset for 'Pneumonia X-rays of human lungs' was taken from Kaggle website which consisted of four thousand twenty images which consisted of one thousand seven hundred images not having Pneumonia and two thousand eight images having Pneumonia. We have constructed the CNN Architecture and trained the model with real data. The main purpose of this module was to make a CNN model that might classify if the patient has pneumonia or not. The objective of the Convolution model is to extract the high-level features such as edges, from the input image.



**Chart-1:** Graph of Accuracy and Validation, Pneumonia Detection

**Table-1:** Results of Pneumonia-X-Rays-of-Human-Lungs model

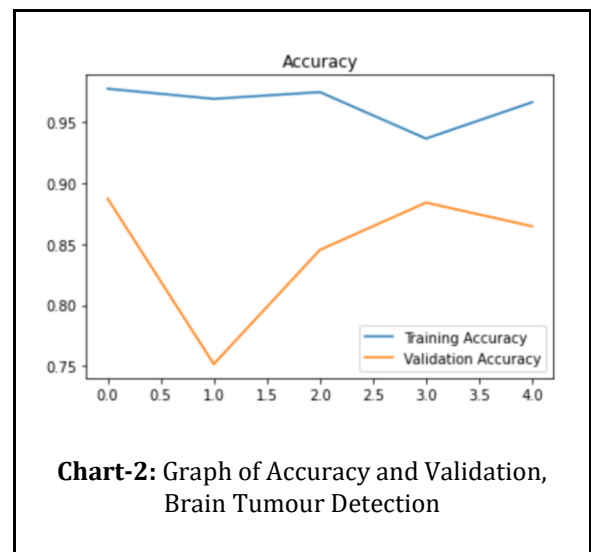
Set	Accuracy
Test Set	90.15%
Train Set	82.56%

The dataset for 'Brain Tumor Detection' was taken from Kaggle which consisted of ninety-eight images having Brain Tumour and one hundred fifty-eight images not having Brain Tumour. This dataset was then applied with image processing techniques to increase the number of datasets which included shearing, rotation and the size of the dataset was made three hundred ninety-eight (Tumour Present) and six hundred fifty-two (Tumour Not Present). The entire dataset is divided into two sets: The validation set and the test set. The validation set is the set used during the model training to adjust the hyperparameters and the test set is the small set that is used for final model performance evaluation. The main purpose of this module was to make a CNN model that might classify if the patient contains a tumor or not supported an MRI scan. We have got used the VGG-16 model architecture and weights to coach the model for this binary problem. We have used accuracy as a metric to justify the model performance.

The final results look as follows:

**Table-2:** Results of Brain Tumour detection model

Set	Accuracy
Train Set	91.78%
Test Set	85.23%



**Chart-2:** Graph of Accuracy and Validation, Brain Tumour Detection

#### 4.2.2 Brain Tumor Detection

#### 4.3 Blockchain

The clients are capable of uploading their files to the blockchain to be safe and secure. To safely store the files we need a distributed system and that is made possible by IPFS. It generates a hash for every document based on its Content and the file is accessible only by this hash. Also if someone makes a small change to this file then the hash of the file gets changed completely but a file once uploaded on IPFS cannot be changed as it is an immutable system. Also, it is a distributed network so files are much easier to access as it is a P2P network and they are tamper-free. The file upload on an IPFS network works in 3 steps:-

- Unique identification via content addressing
- Content linking via directed acyclic graphs (DAGs)
- Content discovery via distributed hash tables (DHTs)

IPFS uses Content addressing to identify content by what's in it rather than by where it's located. So according to the content, a hash is generated.

Then a Merkle DAG (Directed Acyclic Graph) is used to store content where each node has a unique identifier or a hash of the node's content.

Then to find the peers which are having the file one is searching for IPFS uses Distributed hash tables (DHT).

Even though making use of IPFS might make things simpler, making a Dapp and then hosting it is a task in itself. So here Fleek is a very useful tool for uploading the Dapps to the IPFS.

We are using Fleek's storage for AWS S3 as we are already using AWS S3 for storing our data. Fleek storage is the easiest and fastest way to upload or fetch files on IPFS. It securely stores files on IPFS and enables the AWS S3 as a storage solution. The Fleek storage for AWS S3 works in 8 steps:-

1. Getting an API Key from Fleek
2. Creating an AWS S3 client
3. Fetching the buckets from AWS S3
4. Listing all the files in the bucket using S3 client instance and a bucket name
5. Getting a public URL of the file uploaded to Fleek
6. Uploading all the files to the bucket
7. Getting the IPFS hash

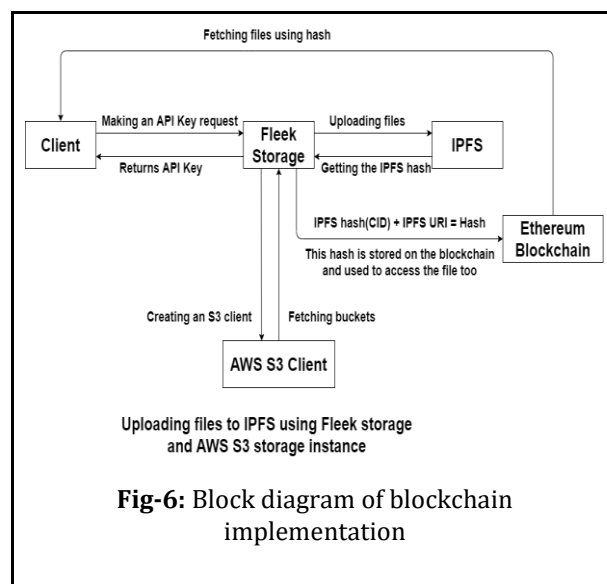
8. Fetching file from the hash from any IPFS Gateway.

After the IPFS hash which is called CID is generated it is combined with the IPFS URI to produce a hash that represents the file, is uploaded to the blockchain, in this case, Ethereum, and is also used to access it.

So this hash is stored in the blockchain instead of the entire file thereby reducing the cost of blockchain usage. As Fleek uses Ethereum as a blockchain, so these hashes are stored in Ethereum.

Also as IPFS hash is unique so the hash generated is also unique for every file stored on the blockchain.

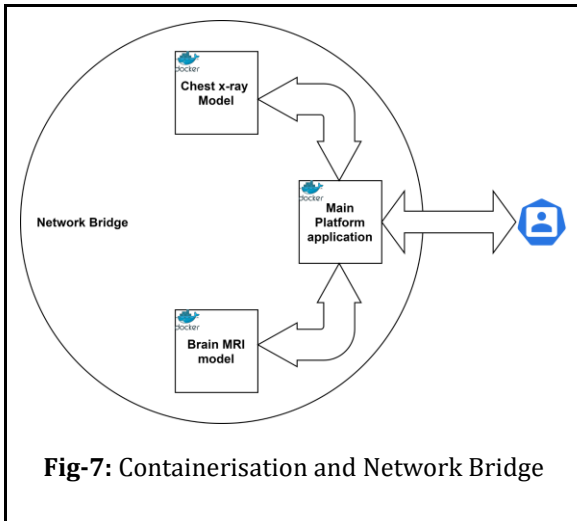
Hence if some part of the file is changed the entire file hash gets changed thereby keeping the original file protected and thereby maintaining the actual ownership of the file.



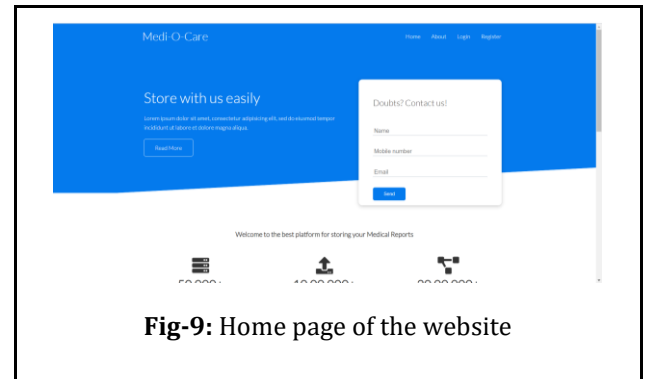
**Fig-6:** Block diagram of blockchain implementation

## 5. DEPLOYMENT

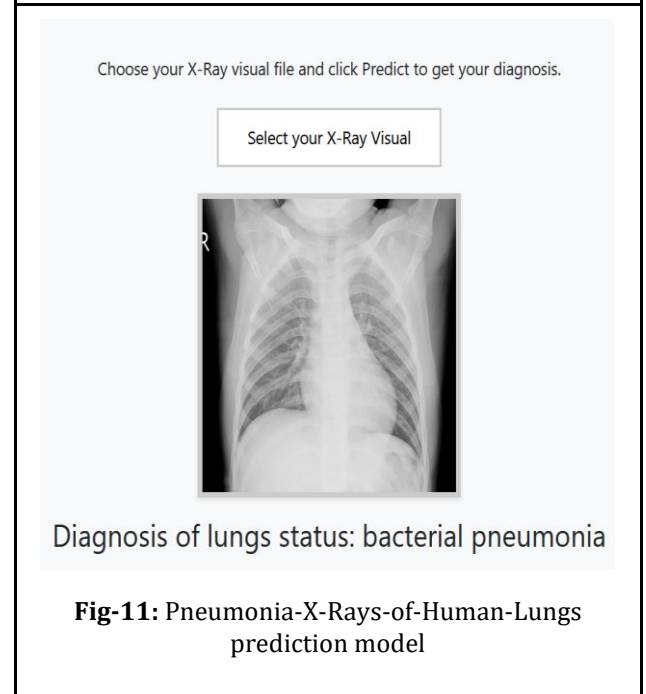
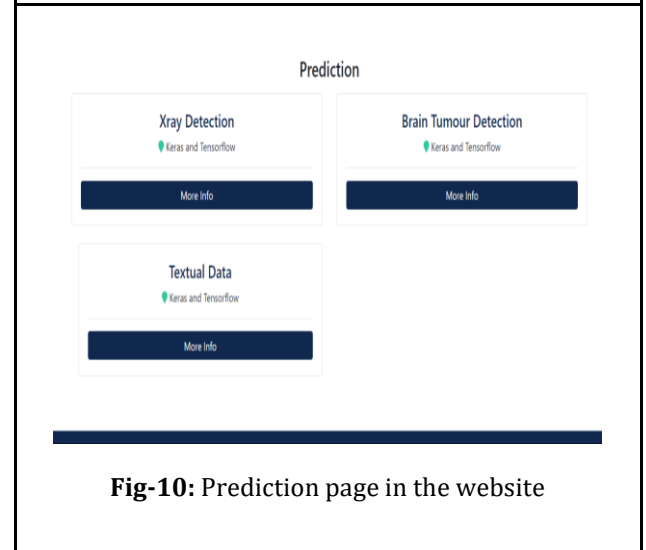
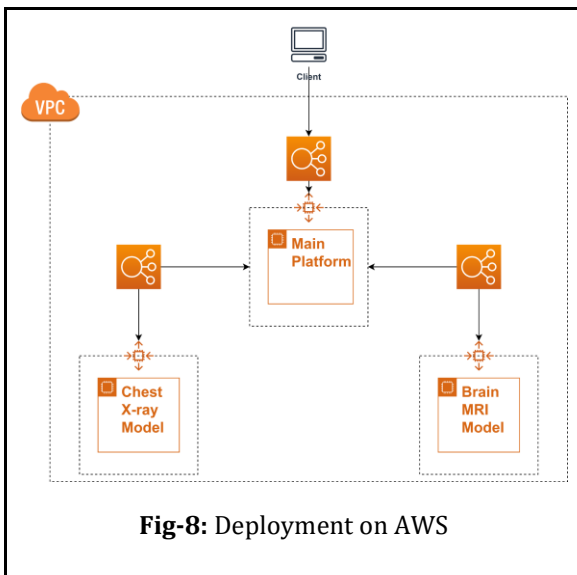
The complete medi-o-care system is divided into microservices for better performance, high availability, and fault tolerance of the system. The system is mainly divided into three microservices namely, the main platform, the chest x-ray model application, and the brain tumor MRI model. For the easy maintenance and deployment of the microservices, each microservice is containerized with the help of Docker. These Docker microservices are deployed inside a private network bridge.

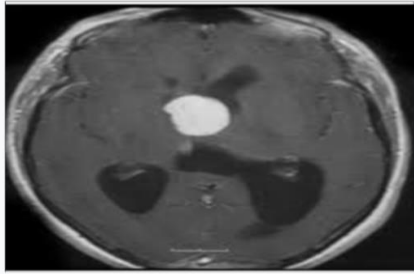


## 6. END-USER APPLICATION



This whole system is deployed on the Cloud(AWS) with the help of AWS ECS(Elastic Container Service). This helps the containers to Auto-Scale and Load Balance independently.





Result: **Brain Tumor detected**

Fig-12: Brain Tumor Detection model

TEST	HABIT/DIAGNOSIS	BIOLOGICAL REFERENCE RANGE	UNITY
<b>COMPLETE BLOOD COUNT (DATA WHOLE BLOOD)</b>			
HAEMOGLOBIN	15.0	13.5 - 18.0	g/dl
HCT (PCV)	45.7	42.7 - 52.0	%
R.B.C. COUNT	5.57	4.7 - 6.0	MM <sup>3</sup>
WBC	14.3	4.0 - 10.0	MM <sup>3</sup>
PLT	82.0	78 - 100	MM <sup>3</sup>
DIFF. WBC			
NEUTROPHILS	27.0	27 - 31	%
LYMPHOCYTES	32.0	32 - 36	%
MONOCYTES	14.0	11.5 - 14.0	%
PLATELET COUNT	249300	150000 - 400000	PL/MM <sup>3</sup>

Fig-13: Report of the patient after image processing

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Dr. Vinit R. Patel
SSRL
Diagnostics
Dr. Avinash Phadke
TEST REPORT
ACCESSION DATE
: 20/07/2020 08:52 AM
REPORTING DATE 20/07/2020 12:52 PM
ACCESSION NO
: 5053TG000373
PERN ID : INSIM2906675053
PATIENT NAME
MR. 3 N SINGH
AGE AGE /SEX SEX : 53 Years / Male
REFERRED BY
:
DR. AMEER PATIL
CENTRE : C$00006720
CLIENTPATIENT ID
DR. VINT' PATIL LAB - WALK IN-13
    
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Fig-14: OCR processed output

In order to use the application:

- The user needs to register on the website. Login credentials are provided to him along with the QR code of his encrypted folder.
- The user needs to log in to the system
- Upload his/her medical records.
- The document is then analyzed/uploaded to the AWS server and the analyzed results are shown on the screen.

### 7. CONCLUSIONS

The AWS Textract module was able to successfully extract, analyze and export the textual data with over 94% accuracy. The Brain tumor detection using convolutional neural network was able to classify the presence of Brain Tumour with d accuracy of over 95% over training data and over 87% over Test Data

The Chest X-Ray Pneumonia detection using convolutional neural networks was able to classify the presence of Brain Tumour with an accuracy of over 85% over training data and over 77% over Test Data.

The models were successfully deployed in a web app using flask and python and IPFS has made possible secure and tamper-proof storage of the files over the distributed system, thereby making the system more reliable for patients to keep their medical records over the network.

### 8. FUTURE SCOPE

- Connecting the app's reachability to the hospitals and doctors.
- Incorporating other machine learning modules pertaining to identifying diseases from reports.

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