Symptom and Image based Disease Detection and Doctor Recommendation using Machine Learning

by

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Step 1: Prototype Selection

Abstract

The cost of treatment, especially in corporate hospitals, is making the life of the citizens difficult. People dread falling sick for fear of falling into a debt trap. Most of the private hospitals vary their prices by imposing hidden fees on different people. In many situations, the cost of medicines, devices, tests, and interventions is so high and unessential that it is a sheer wastage of resources. It is evident that the market is in dire need of healthcare options. But the inflated prices in the common health services prove that there are not a lot of healthcare options for most of the people in India. There is a clear demand for healthcare services that alleviate the fear of huge debt and offer financial security. An app that uses machine learning to diagnose the symptoms and provide basic details about the disease before consulting a doctor will provide a suitable solution. For minor problems, it suggests a basic remedy and for a major problem, it recommends a doctor near you for consulting. Our system then recommends the right hospital near you and a list of doctors in your locality based on two criterion (i.e., cost of treatment and reviews of the doctor) which the patient can choose from accordingly. This eliminates the consultation fees for minor problems. An additional feature in the app will be skin and eye disease detection through image classification. As this type of disease is not minor, we will recommend a doctor based on the detected disease for all the classifications.

1. Problem Statement

About 55 million Indians were pushed into poverty in a single year due to patient-care costs, as per a study by the Public Health Foundation of India. The cost of treatment, especially in corporate hospitals, is making the life of the citizens difficult. People dread falling sick for fear of falling into a debt trap. Most of the private hospitals vary their prices by imposing hidden fees on different people. In many situations, the cost of medicines, devices, tests, and interventions is so high and unessential that it is a sheer wastage of resources. Finding the right doctor for your diagnosis can be a very painstaking process using up a lot of your time and financial resources.

2. Market/Customer/Business Need Assessment

It is evident that the market is in dire need of healthcare options. But the inflated prices in the common health services prove that there are not a lot of healthcare options for most of the people in India. There is a clear demand for healthcare services that alleviate the fear of huge debt and offer financial security. The consumers need clear and consistent information about the costs associated with medical treatments.

3. Target Specifications and Characterization

The proposed solution will cater to different types of customers in the following ways:

- Individuals and Families – By providing healthcare services, quality healthcare options at reasonable prices. and avoiding them from falling into financial hardship due to medical expenses.
- Healthcare Providers – For those who are interested in adopting more transparent pricing models and improving patient satisfaction and looking to expand their patient base by offering cost-effective services.
- Heath Insurance Companies – For those who are seeking to partner up or integrate our solution to offer more affordable health insurance packages to their customers.
- Government Health Agencies – As they are responsible for healthcare policy and regulation and are interested in promoting affordable and accessible healthcare. They can look for data and insights for informed healthcare policy decisions.
- Corporations – For companies interested in employee wellness programs and healthcare cost management by providing cost-effective healthcare benefits to their employees.
- Medical Tourism Providers – Organizations involved in medical tourism that want to offer affordable and transparent healthcare options to international patients.

4. External Search

Here is the comparison of different treatment costs in New Delhi.

Treatment	Minimum Price	Maximum Price
Kidney disease	1,500/-	5,000/-
Cardio-vascular disease	1,70,000/-	4,50,000/-

Bladder Stones	21,800/-	2,10,000/-
Angioplasty	70,000/-	4,50,000/-

[Source: Digit]

These are just some of the figures and unfortunately the hospital does charge extra hidden fees on these costs. The problem is that most of the people do not earn this kind of money.

An article published by the World Health Organization in December 2021 clearly states how more than half a billion people pushed or pushed further into extreme poverty due to health care costs around the world due to the COVID-19 Pandemic. [Source: WHO]

An article by The Tribune states how medical debt is a major cause of poverty in India. [Source: The Tribune]

The article published by DownToEarth states how India's persistently high out-of-pocket health expenditure continues to push people into poverty. [Source: DownToEarth]

Recently, an article published by Scroll.in also presented the same information. [Source: Scroll.in]

5. Applicable Patents

- Disease prediction system using open source data [Source]
- Disease diagnoses-bases disease prediction [Source]
- Disease prediction system based on big data [Source]

6. Applicable Regulations

- The permission to collect patient's data.
- Unauthorized use of patient's data and medical information should be avoided.

7. Applicable Constraints

- Continuous collection and management of data.
- Continuous expansion, training, and improvement of ML algorithm.
- Domain Knowledge from medical experts.
- Access to a large network of Healthcare Professionals and Health Insurance Providers.

8. Concept Generation

The people around the country need something that helps them make their life easier. This solution will cater to a large number of people as it would eliminate the mostly unnecessary consultation costs, provide them with viable options according to their problems and help them to move forward without the fear of a financial disaster.

9. Concept Development

The patient's disease will be classified based on their symptoms and a solution will be provided. They will have the option to choose a doctor according to their financial capabilities only if there is a serious health concern. If not, they can save the basic consultation fees by performing a basic remedy.

Step 2 – Prototype Development

The patient upon logging into the application, they can give their symptoms and their disease will be detected. Here is the functioning of the app:

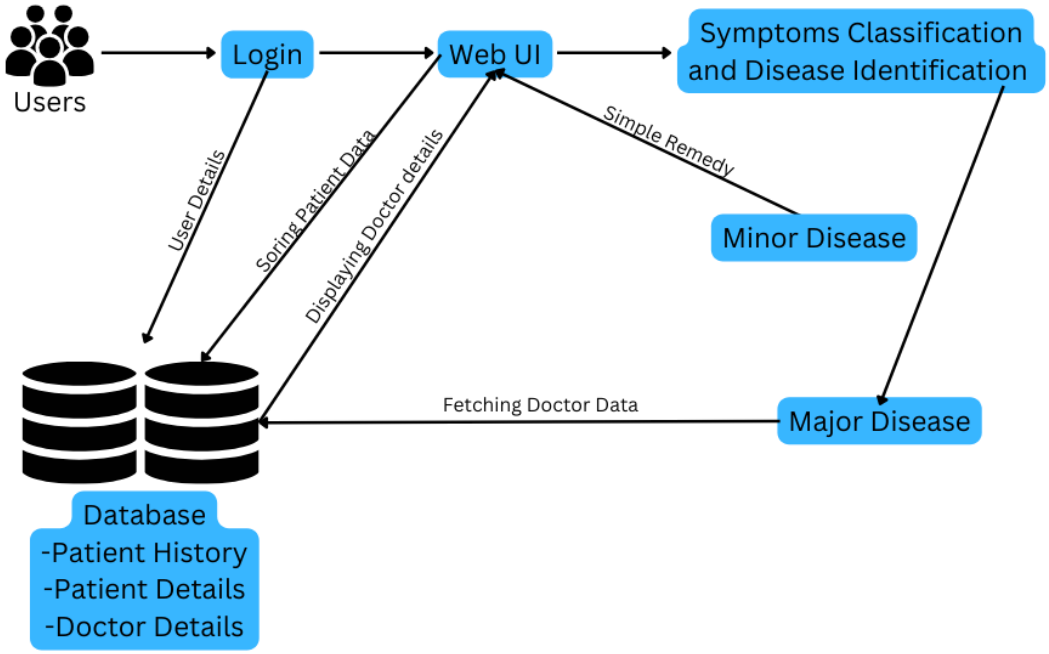


Fig. Basic Functioning of the app

Here is how the skin/eye disease detection feature works:

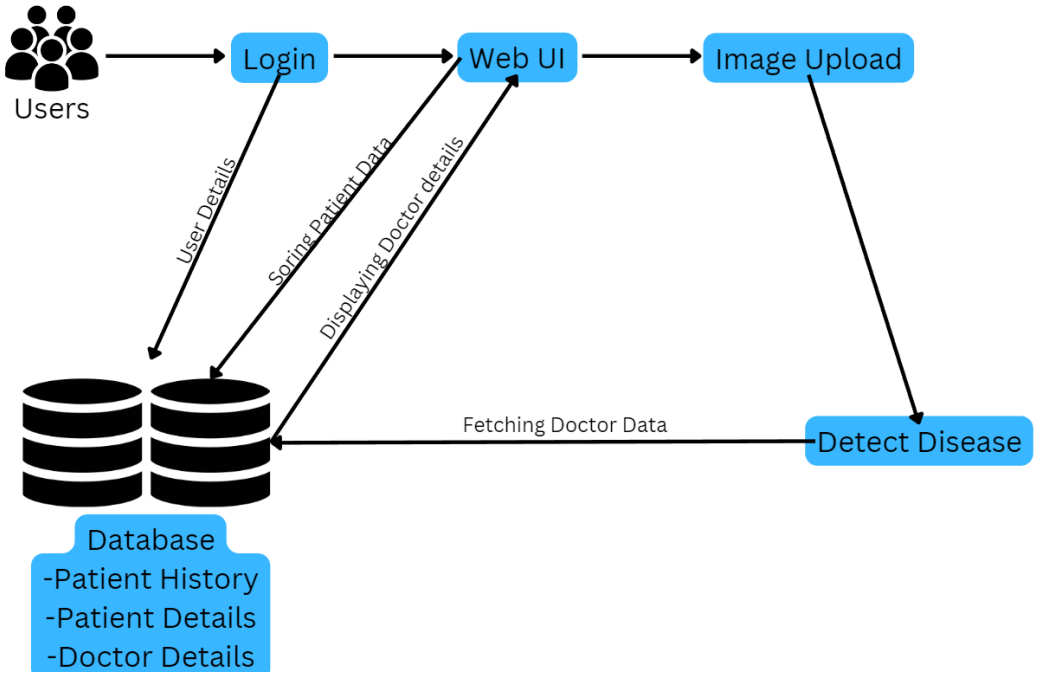


Fig. Skin/Eye disease detection feature

Product details

The product will consist of three parts that constitute our product.

- **Disease Detection**

The app takes symptoms of the patient and classifies the disease. The algorithm that is used is a Decision Tree Classifier.

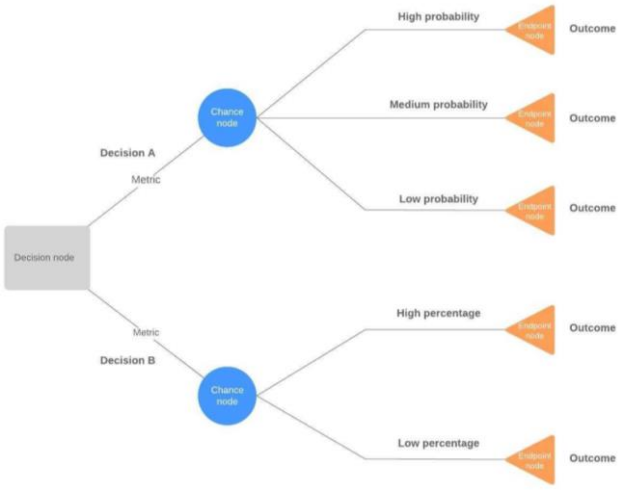


Fig. Decision Tree Classifier

As the product needs a lot of symptoms data we need to start with a small dataset and gradually scale it to a large dataset. This will provide for a good overview of

the product expansion. The dataset that can be use in development can be common disease dataset [Source: Kaggle]

- **Skin/Eye Disease Detection**

The skin and eye disease detection feature can be done using a Convolutional Neural Network

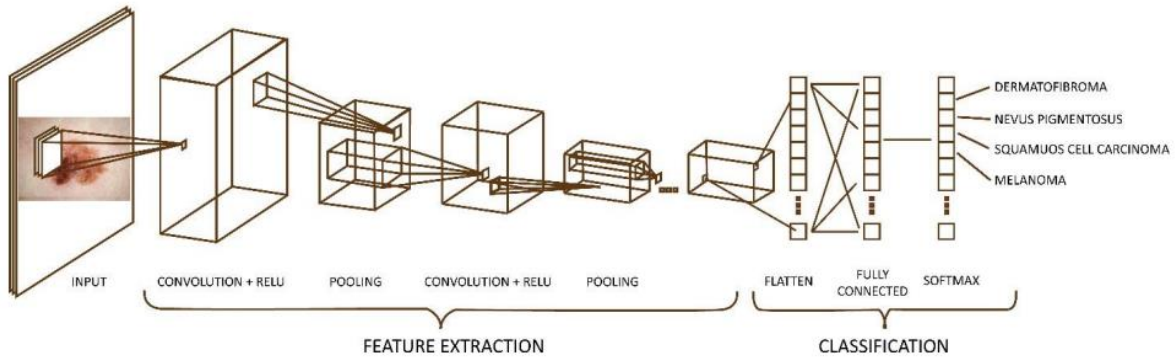


Fig. Architecture of CNN

The dataset that can be used is skin cancer ISIC [Source: Kaggle] and for eyes it is ocular disease dataset [Source : Kaggle].

- **Doctor Recommendation**

Based on the diseases detected the doctors in the locality are displayed that are experts in treating that disease. The doctor's details need to be collected by doing research and surveys. The dataset of doctors should include doctor's details, their specialty, cost of treatment, etc. This is a major process in the development of the product.

Implementation/Validation on Small Scale

Let us look at how these features work.

- **Common Disease Detection [GitHub]**

Complete Dataset consists of 2 CSV files. One of them is training and the other is for testing your model. Each CSV file has 133 columns. 132 of these columns are symptoms that a person experiences and the last column is the prognosis. These symptoms are mapped to 42 diseases. You can classify these set of symptoms and train your model on training data and test it on testing data.

```
df.dtypes
```

```
itching                 int64
skin_rash               int64
nodal_skin_eruptions    int64
continuous_sneezing     int64
shivering               int64
                        ...
inflammatory_nails      int64
blister                 int64
red_sore_around_nose    int64
yellow_crust_ooze       int64
prognosis              object
Length: 133, dtype: object
```

He is the possible prognosis that can be predicted.

```
df['prognosis'].unique()
```

```
array(['Fungal infection', 'Allergy', 'GERD', 'Chronic cholestasis',
       'Drug Reaction', 'Peptic ulcer diseae', 'AIDS', 'Diabetes ',
       'Gastroenteritis', 'Bronchial Asthma', 'Hypertension ', 'Migraine',
       'Cervical spondylosis', 'Paralysis (brain hemorrhage)', 'Jaundice',
       'Malaria', 'Chicken pox', 'Dengue', 'Typhoid', 'hepatitis A',
       'Hepatitis B', 'Hepatitis C', 'Hepatitis D', 'Hepatitis E',
       'Alcoholic hepatitis', 'Tuberculosis', 'Common Cold', 'Pneumonia',
       'Dimorphic hemmorhoids(piles)', 'Heart attack', 'Varicose veins',
       'Hypothyroidism', 'Hyperthyroidism', 'Hypoglycemia',
       'Osteoarthristis', 'Arthritis',
       '(vertigo) Paroymsal  Positional Vertigo', 'Acne',
       'Urinary tract infection', 'Psoriasis', 'Impetigo'], dtype=object)
```

After some data preprocessing, we fit the data in a Decision Tree classifier with Gini Index for the information gain.

```
model = DecisionTreeClassifier(criterion='gini')
```

```
from sklearn.model_selection import train_test_split
```

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.7,random_state=3)
```

```
x_train.shape, x_test.shape
```

```
((1476, 132), (3444, 132))
```

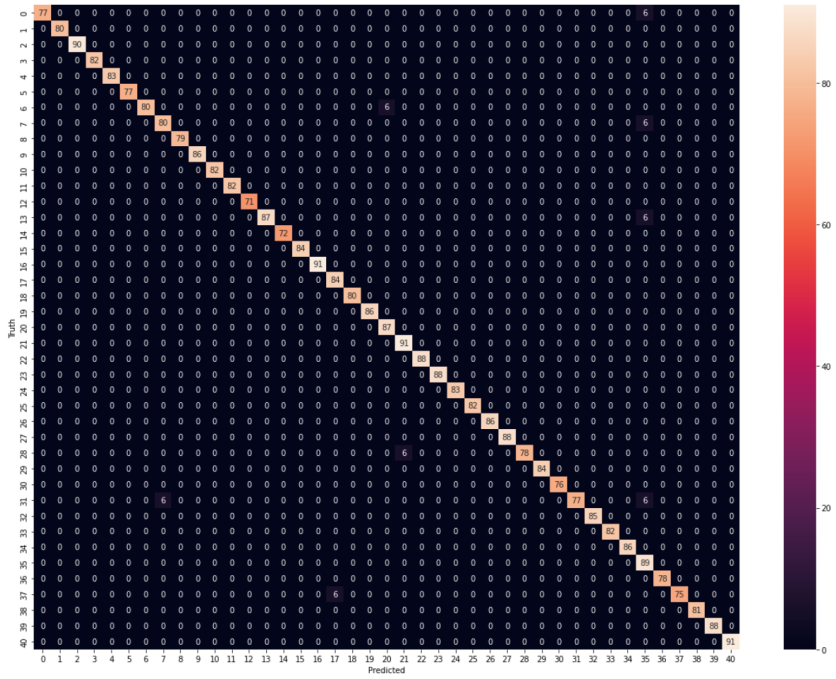
```
y_train.shape, y_test.shape
```

```
((1476,), (3444,))
```

```
model.fit(x_train,y_train)
```

```
DecisionTreeClassifier()
```

Here is the heatmap between predicted values and real values.



With the given data, the model performs quite well and is highly accurate.

```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      0.93      0.96        83
           1       1.00      1.00      1.00        80
           2       1.00      1.00      1.00        90
           3       1.00      1.00      1.00        82
           4       1.00      1.00      1.00        83
           5       1.00      1.00      1.00        77
           6       1.00      0.93      0.96        86
           7       0.93      0.93      0.93        86
           8       1.00      1.00      1.00        79
           9       1.00      1.00      1.00        86
          10       1.00      1.00      1.00        82
          11       1.00      1.00      1.00        82
          12       1.00      1.00      1.00        71
          13       1.00      0.94      0.97        93
          14       1.00      1.00      1.00        72
          15       1.00      1.00      1.00        84
          16       1.00      1.00      1.00        91
          17       0.93      1.00      0.97        84
          18       1.00      1.00      1.00        80
          19       1.00      1.00      1.00        86
          20       0.94      1.00      0.97        87
          21       0.94      1.00      0.97        91
          22       1.00      1.00      1.00        88
          23       1.00      1.00      1.00        88
          24       1.00      1.00      1.00        83
          25       1.00      1.00      1.00        82
          26       1.00      1.00      1.00        86
          27       1.00      1.00      1.00        88
          28       1.00      0.93      0.96        84
          29       1.00      1.00      1.00        84
          30       1.00      1.00      1.00        76
          31       1.00      0.87      0.93        89
          32       1.00      1.00      1.00        85
          33       1.00      1.00      1.00        82
          34       1.00      1.00      1.00        86
          35       0.79      1.00      0.88        89
          36       1.00      1.00      1.00        78
          37       1.00      0.93      0.96        81
          38       1.00      1.00      1.00        81
          39       1.00      1.00      1.00        88
          40       1.00      1.00      1.00        91

    accuracy                           0.99      3444
   macro avg       0.99      0.99      0.99      3444
weighted avg       0.99      0.99      0.99      3444
```

```
model.score(x_test,y_test)
```

```
0.9860627177700348
```

Here are the diseases it detects based on prognosis.

```
diseases
```

```
array(['(vertigo) Paroymsal  Positional Vertigo', 'AIDS', 'Acne',
       'Alcoholic hepatitis', 'Allergy', 'Arthritis', 'Bronchial Asthma',
       'Cervical spondylosis', 'Chicken pox', 'Chronic cholestasis',
       'Common Cold', 'Dengue', 'Diabetes ',
       'Dimorphic hemmorhoids(piles)', 'Drug Reaction',
       'Fungal infection', 'GERD', 'Gastroenteritis', 'Heart attack',
       'Hepatitis B', 'Hepatitis C', 'Hepatitis D', 'Hepatitis E',
       'Hypertension ', 'Hyperthyroidism', 'Hypoglycemia',
       'Hypothyroidism', 'Impetigo', 'Jaundice', 'Malaria', 'Migraine',
       'Osteoarthristis', 'Paralysis (brain hemorrhage)',
       'Peptic ulcer diseae', 'Pneumonia', 'Psoriasis', 'Tuberculosis',
       'Typhoid', 'Urinary tract infection', 'Varicose veins',
       'hepatitis A'], dtype=object)
```

Here is the prediction.

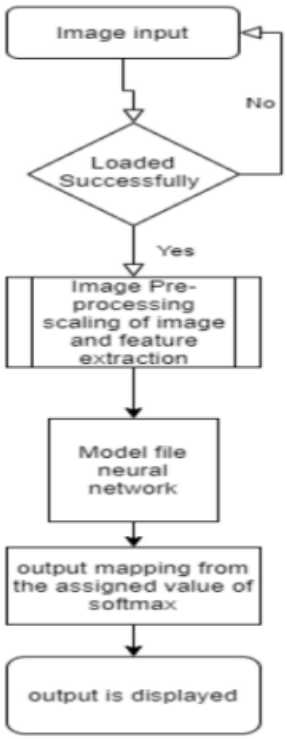
```
predict_disease(['shivering','skin_rash','itching'])
```

```
C:\Python310\lib\site-packages\sklearn\base.py:450: UserWarning: X does not have valid feature names, but DecisionTreeClassifie
r was fitted with feature names
  warnings.warn(
```

```
'Allergy'
```

With expansion of data and domain expertise there are a lot of improvements that can be made to the model.

- **Skin Disease Detection [GitHub]**



This set consists of 2357 images of malignant and benign oncological diseases, which were formed from The International Skin Imaging Collaboration (ISIC). All images were sorted according to the classification taken with ISIC, and all

subsets were divided into the same number of images, with the exception of melanomas and moles, whose images are slightly dominant.

The model can be designed to pre-process the image to a different texture and color-reverse which has a better option to increase its efficiency. The accuracy will definitely increase if both are treated as different models.

The data is imported and trained on a neural network.

```
prediction = Dense(len(folders), activation='softmax')(x)

# create a model object
model = Model(inputs=inception.input, outputs=prediction)
```

```
model.compile(
  loss='categorical_crossentropy',
  optimizer='adam',
  metrics=['accuracy']
)
```

The data is preprocessed and divided into a train and test set.

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator

train_datagen = ImageDataGenerator(rescale = 1./255,
                                   shear_range = 0.2,
                                   zoom_range = 0.2,
                                   horizontal_flip = True)

test_datagen = ImageDataGenerator(rescale = 1./255)
```

```
training_set = train_datagen.flow_from_directory('Datasets/train',
                                                 target_size = (224, 224),
                                                 batch_size = 32,
                                                 class_mode = 'categorical')
```

```
Found 7455 images belonging to 11 classes.
```

```
test_set = test_datagen.flow_from_directory('Datasets/test',
                                            target_size = (224, 224),
                                            batch_size = 32,
                                            class_mode = 'categorical')
```

```
Found 742 images belonging to 11 classes.
```

The data is trained for 20 epochs.

```
#model ggene.
r = model.fit_generator(
  training_set,
  validation_data=test_set,
  epochs=20,
  steps_per_epoch=len(training_set),
  validation_steps=len(test_set)
)
```

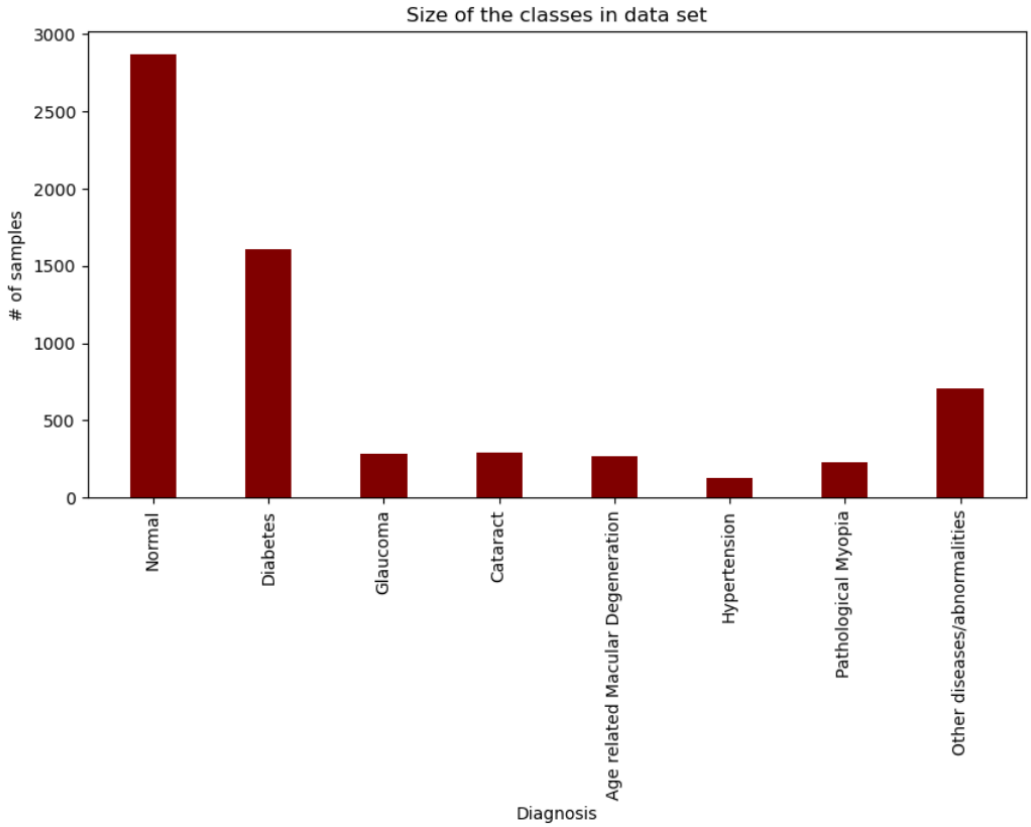
And by the end we have an accuracy of 0.8993

```
Epoch 20/20
233/233 [==============================] - 415s 2s/step - loss: 1.8030 - accuracy: 0.8993 - val_loss: 6.5997 - val_accuracy:
0.8032
```

- **Eye Disease Detection [GitHub]**

This dataset is meant to represent "real-life" set of patient information collected by Shanggong Medical Technology Co., Ltd. from different hospitals/medical centers in China. In these institutions, fundus images are captured by various cameras in the market, such as Canon, Zeiss and Kowa, resulting in varied image resolutions.

Annotations were labeled by trained human readers with quality control management. They classify patients into eight labels including Normal (N), Diabetes (D), Glaucoma (G), Cataract (C), Age related Macular Degeneration (A), Hypertension (H), Pathological Myopia (M), Other diseases/abnormalities (O).



Notice that the dataset is imbalanced, however there are more than 100 sample images for each class therefore there should be enough data per class to train a classification problem.

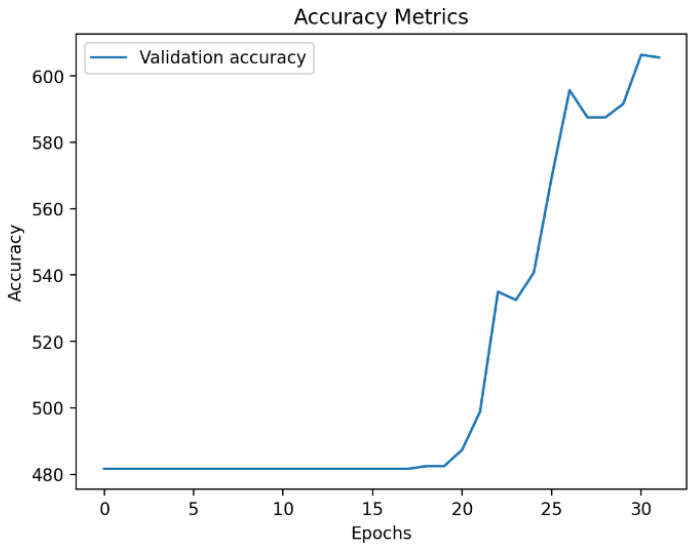
The data goes through extensive preprocessing and is fed to a neural network in batches.

```
# instantiate transfer learning model
resnet_model = models.resnet50(pretrained=True)

# set all parameters as trainable
for param in resnet_model.parameters():
    param.requires_grad = True

# get input of fc layer
n_inputs = resnet_model.fc.in_features

# redefine fc layer / top layer/ head for our classification problem
resnet_model.fc = nn.Sequential(nn.Linear(n_inputs, 2048),
                                nn.ReLU(),
                                nn.Dropout(p=0.4),
                                nn.Linear(2048, 2048),
                                nn.ReLU(),
                                nn.Dropout(p=0.4),
                                nn.Linear(2048, 8),
                                nn.LogSigmoid())

# set all parameters of the model as trainable
for name, child in resnet_model.named_children():
    for name2, params in child.named_parameters():
        params.requires_grad = True


# Disbribute the model to all GPU's
resnet_model = nn.DataParallel(resnet_model)

# set model to run on GPU or CPU absed on availibility
resnet_model.to(device)

# print the trasnfer learning NN model's architecture
resnet_model
```

The model is trained for 32 epochs and the accuracy comes out as 73.16% and validation accuracy is 59.13%.

```
Epoch 32 Batch 120
Accuracy: 73.16 %  Loss: 0.7215  Duration: 5.05 minutes
Validation Accuracy 59.13% Validation Loss: 1.2904
```

The accuracy tends to increase at the later epochs moving forward.



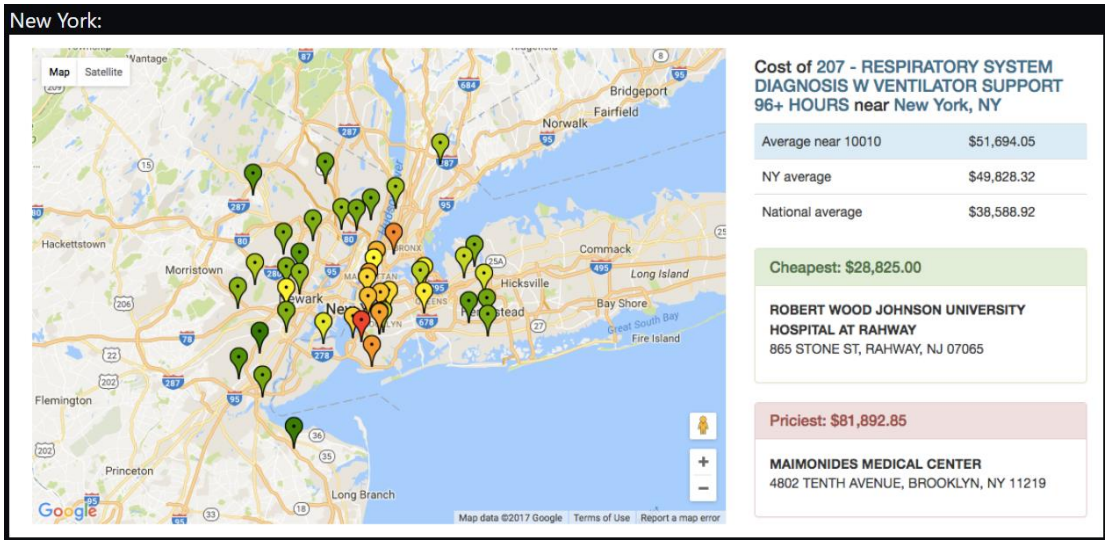
As the accuracy is not that great, more computational power and higher quality of data is required.

- **Doctor Recommendation [GitHub]**

As of now there is no proper way to recommend doctors as it varies from place to place. Although there is a GitHub repo that might help solve this problem.

Medi-Compare is a Web app that helps patients to compare the costs of medical procedures at hospitals in their region. By making hidden healthcare costs more transparent, we're empowering citizens to take a stand on their health and wallet.

This project was done for cities in the United States.



If this is implemented for India with proper data and integrated into our system, it will revolutionize the Healthcare industry forever.

This is a combination of services that can help the masses and eliminate the fear of medical debt in people forever.

Step 3 – Business Modeling

The proposed idea is to create an app that uses machine learning to diagnose the symptoms and provide basic details about the disease before consulting a doctor. For minor problems, it suggests a basic remedy and for a major problem, it recommends a doctor for consulting. Our system then recommends the right hospital near you and a list of doctors in your locality based on two criterion (i.e., cost of treatment and reviews of the doctor) which the patient can choose from accordingly. This eliminates the consultation fees for minor problems. Upon consultation the doctors will be charged a commission for providing them patients.

We will partner with Medical Insurance providers to provide health insurance in a simple and selective manner. The patients will have the liberty to choose what kind of health insurance they need. Furthermore, for corporates and organizations, we will charge a subscription fee for seamless utilization of the service on a larger scale.

An additional feature in the app will be skin and eye disease detection through image classification. This feature will be accessible with a basic subscription to

customers as a premium feature. As this type of disease is not minor, we will recommend a doctor based on the detected disease for all the classifications.

Step 4 - Financial Modeling

Designing a financial equation for our business model involves considering various revenue streams, costs, and potential income sources. Let's break down our business model into key components and identify potential financial equations:

1. **Revenue from Consultation Fees:**
    - You mentioned that for minor problems, there would be no consultation fees, but for major issues, there might be. Let's denote the consultation fee as Fc.
    - The revenue from consultation fees (Rc) can be calculated as the product of the number of consultations (Nc) and the consultation fee (Fc): $Rc=Nc\times Fc$
2. **Commission from Doctors:**
    - You mentioned that doctors would be charged a commission for providing them with patients. Let Pd be the commission percentage, and Rd be the revenue from doctors: $Rd=Nc\times Fc\times Pd/100$
3. **Subscription Fees from Corporates and Organizations:**
    - For corporates and organizations, you mentioned a subscription fee (Fs). Let Ns be the number of subscriptions, and Rs be the revenue from subscriptions: $Rs=Ns\times Fs$
4. **Revenue from Health Insurance Partnerships:**
    - Partnering with medical insurance providers could bring in revenue. Let Pi be the percentage of the insurance premium you receive, and Ri be the revenue from insurance partnerships: $Ri=Ni\times Pi$
5. **Additional Feature - Premium Subscription for Skin and Eye Disease Detection:**
    - If you're offering a premium subscription for skin and eye disease detection, let Fp be the premium subscription fee, Np be the number of premium subscribers, and Rp be the revenue from premium subscriptions: $Rp=Np\times Fp$

6. **Total Revenue (*Rtotal*):**
    - The total revenue would be the sum of revenues from different sources: $Rtotal=Rc+Rd+Rs+Ri+Rp$
7. **Costs:**
    - Consider costs such as app development, maintenance, marketing, and any other operational costs.
8. **Profit (*P*):**
    - The profit can be calculated as the difference between total revenue and total costs: $P = Rtotal -$ Total Costs

It's important to note that these equations provide a simplified representation, and in practice, we need to consider various factors and dynamic aspects of our business. Additionally, market research and financial projections specific to your target audience and region would contribute to a more accurate model.

Developing the financial equation on limited scale:

Suppose in a month,

Fc = 500/-, Nc = 100/-

$Rc = Nc*Fc$ => 500*100 = 50,000/-

$Rd = Nc \times Fc \times Pd/100$ => 50000*10/100 (for 10% commission) = 5000/-

Premium Subscription,

$Rp = Np*Fp$ => 50*500 = 25,000/-

$Rtotal = Rd+Rp$ => 5000+25000 = 30,000/-

Let cost be 20,000/-

Profit = *Rtotal*-Total Cost => 30000-20000 = 10,000/-

Let,

Total profit = y

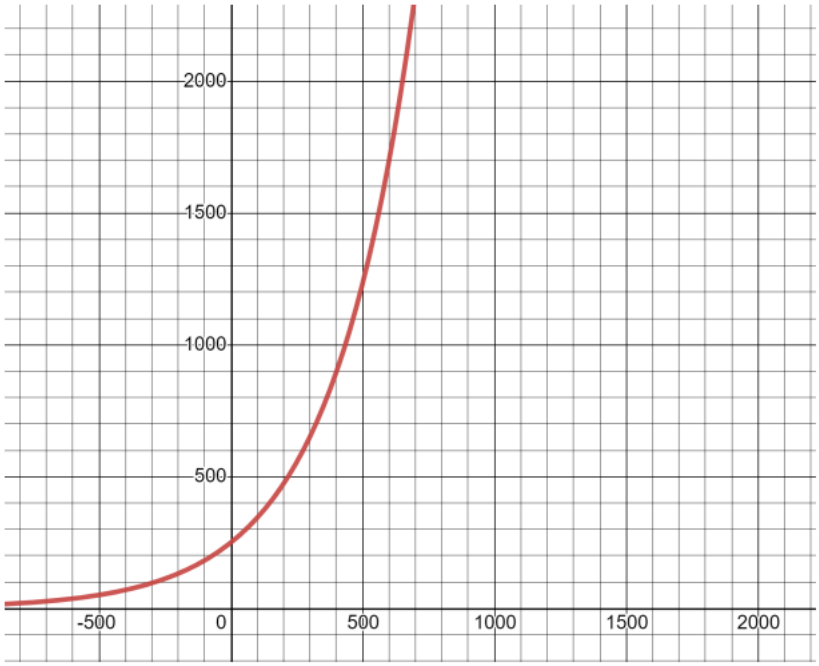
Price of product = m

Total sales as function of time = $x(t)$

Production and maintenance cost = c

Therefore, $y = mx(t) - c$

$\therefore y = 30000x(t) - 20000$



Conclusion

In conclusion, our product represents a significant step forward in addressing the pressing issue of healthcare accessibility and affordability in the modern age. The convergence of machine learning, medical data, and intelligent recommendation systems has empowered us to create a solution that holds the promise of revolutionizing the healthcare landscape. Through rigorous experimentation and careful algorithm selection, we can demonstrate the feasibility of accurately detecting diseases based on symptoms and medical images.

Our product is not without its challenges and limitations. The availability of diverse and high-quality medical data remains a hurdle, and the interpretability of machine learning models in healthcare continues to be an area of active research. However, these challenges serve as catalysts for future work and innovation, encouraging us to explore new avenues and improve upon our existing framework. Furthermore, our product contributes to the broader field of machine learning in healthcare. It aligns with the growing body of research focused on harnessing AI to tackle real-world medical challenges, ultimately improving the quality and accessibility of healthcare services.