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A Model to Detect Parkinson's disease Using MRI Data

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Abstract **-** The major goal is to create opportunities for deep learning algorithms to be used in order to understand better and diagnose Parkinson's disease. The loss of dopamine-producing neurons causes Parkinson's disease, a degenerative disorder. When the condition first manifests, patients have tremors, bradykinesia , poor posture, and balance among other mobility impairments that progressively get worse over time. Additionally, as the global ageing population grows exponentially, more people are developing Parkinson's disease, which places a significant financial strain on governments. Parkinson's disease patients' structural alterations in the brain brought on by dopamine deprivation can be seen using magnetic resonance imaging (MRI). In this study, MR images of people with Parkinson's disease and healthy controls were attempted to be classified using a deep learning neural network. To enhance Parkinson's disease diagnosis, the convolutional neural network is used. MR images are practised and checked in order to obtain the accuracy metrics.

This project's major goal is to develop a method for precisely diagnosing and staging diseases using magnetic resonance imaging (MRI). Deep learning is excellent at diagnosing illnesses and interpreting photos. A rising corpus of research indicates that the detection and prognosis of Parkinson's disease may require the use of deep learning techniques. When it comes to forecasting diseases, deep learning models are incredibly powerful. The best early detection accuracy deep learning algorithms are hence the subject of increased research. In this experiment, the illness stage will be determined by brain imaging. Also, we would want to suggest an effective deep learning approach for early disease prediction utilizing MRI data. The data set came from Kaggle. In this article, We'd like to propose a deep learning method for diagnosing Parkinson's illness that makes use of the CNN algorithm.

Index Terms – *Parkinson.s Disease, Magnetic Resonance Imaging (MRI),* Convolutional Neural Network(CNN)

I. INTRODUCTION

One of the most common neurodegenerative diseases, Parkinson's disease (PD) has an incidence rate of 1-2 occurrences per 1,000 persons and a prevalence rate of 1% in those over 60. (Tysnes and Storstein, 2017). Between 1990 and 2016, the projected number of people affected by PD worldwide rose from 2.5 million to 6.1 million due to age-standardized prevalence rates and an increase in the number of elderly people. 2018 (Dorsey et al.). Parkinson's disease (PD), described by Jankovic (2008), is a degenerative neurological condition that has an impact on several elements of movement, including conception, starting, and implementation (Contreras-Vidal and Stelmach, 1995).

Clinical indicators, such as the description of range-of-motion symptoms, and medical observations are frequently used to make the diagnosis of Parkinson's disease (PD). On the other hand, conventional diagnostic methods can indeed be opinionated as they focus just on perception of movements that can be difficult to characterize due to being occasionally invisible to the human eye. Early Parkinson's disease (PD) non-motor symptoms can also be minor and caused by a variety of other diseases. Thus, because these symptoms are frequently disregarded, it might be challenging to identify PD at an early stage.

Machine learning techniques have been used to categorize patients with PD as well as normal individuals or patients exhibiting clinical symptoms similar to those of PD (including neurological conditions or even other Parkinson's psychiatric disorders) in order to address these issues and improve PD diagnosis and evaluation processes. We did an analysis of the literature based on journal articles in the IEEE Xplore and PubMed databases up until February 14, 2020, in order to provide a detailed overview of the modalities and machine learning algorithms used in the diagnosis and differential diagnosis of PD. In all, 209 research publications were included in this study. Relevant data were sought, and the aims, data-sources and kinds, machine learning algorithms, and associated results were all analysed.

Our research highlights the huge potential for incorporating state-of-the-art genetic markers as well as deep learning into medical decision, leading to a more systematic and thorough evaluation of Parkinson's.

Historically, motor symptoms have been used to diagnose PD. Even though clinical investigations have shown the primary signs and symptoms of Parkinson's disease (PD), the majority of the measures used to assess the illness's severity have not undergone in-depth research and evaluation (Jankovic, 2008). Even though non - motor symptoms (e.g., developmental impairments like focus and organization shows, insomnia, and tactile abnormalities like olfaction disruptions) are common among individuals before they develop symptoms of Parkinson's disease (PD), they are not specific enough, are challenging to evaluate, and/or differ from each individual (Zesiewicz et al., 2006).

The application of machine learning techniques in the healthcare sector is growing quickly. As the name implies, artificial intelligence enables software to learn from data and create meaningful depictions in a semi-automatic manner. Machine learning models have been used to evaluate a wide range of information modes for the diagnosis of Parkinson's disease (PD), which include handwriting structures, motion (Yang et al., 2009; Wahid et al., 2015; Pham and Yan, 2018), and Sakar et al. (2013).

Previous research only had access to data from sensing devices, kinematics, and motor functions when it came to diagnosing and evaluating Parkinson's disease (PD). In addition, a couple of these analyses only considered works from 2015 and 2016(Pereira et al.).

Due to this, applying machine learning to the analysis of clinical and non-clinical data from the a diverse modalities has frequently produced high diagnosis accuracy in human subjects. To enable more precise and well-informed decision-making, this may drive the application of innovative biomarkers and machine learning algorithms in the clinical context.

II. RELATED WORK

[1] Using a machine learning model and vocal voice dataset and NNge classifier got an accuracy of 83.9%. NNge classifier is a model that takes speech signals as input and recognise the output based on the frequency of voice.

[2] Anila M. and Dr. G. Pradeepini gave a presentation entitled "Diagnosis of Parkinson's disease using ANN". The main objective of this study is to diagnose Parkinson's illness in individuals through speech analysis. ANN, Random Forest, KNN, SVM, and XG Boost are just a few of the machine learning techniques used to find the best model for this task. Moreover, error rates are calculated, and performance indicators for every system are contrasted. The main drawback of this approach is that it is limited to ANNs with two layers that are hidden. Also, the two hidden layers of this specific neural network are sufficient and efficient for tiny datasets. They just utilised one method for feature selection, which lowers the number of features.

[3] Arvind Kumar Tiwari has turned in a research paper titled "Machine Learning-based Approaches for Prediction of Parkinson's Disease". The most significant feature out of all the features for predicting Parkinson's disease was chosen in this study using feature selection algorithms with minimal redundancy and maximum relevance. In comparison to other machine learning-based techniques like bagging, boosting, random forest, rotation forest, random subspace, support vector machine, multi-layer perceptron and decision tree BA, the random forest with 20 features chosen by minimal level duplication and optimal significance function collection techniques had an accuracy level of 90.3%, a precision of 90.2%, a Mathews 12 correlation coefficient of 0.73, and ROC values of 0.96.

[4]A deep learning model for predicting Alzheimer's disease [9] was developed using long short-term memory (LSTM) and recurrent neural networks (RNN). 90% of the SCRP dataset was used for training, and risk scores of their study for predicting AD using drug information in the dataset of 2324 patients SCRP AD achieved a high out-of-

sample score of 0.98-0.99 Area Under the Precision-Recall Curve (AUPRC). When the model was trained with less than 1,500 samples from the SCRP dataset, the AUPRC dropped to 0.89.

he study's title is "Parkinson's Disease Diagnosis Using Deep Learning," according to Mohamed Alissa [14].Using Deep Learning, Recursive Neural Networks (RNN), and Convolutional Neural Networks (CNN), this study principally aims to automate the process of diagnosing PD by differentiating between healthy individuals and PD patients. As different imaging and motion datasets may capture distinct aspects of this illness, this study will also analyse whether PD test is more successful in the discrimination process (especially cube and spiral pentagon datasets).

[6] In this study, the speech signals dataset, ANN, and CNN were combined. The experimental results demonstrate that the suggested models perform more accurately than the current state-of-the-art. The Voice Impairment Classifier does have a classification accuracy of 89.15 percent, however, the VGFR Spectrogram Detector has a classification accuracy of 88.1%.

[7] Afzal Hussain Shahid and Maheshwari Prasad Singh have described a deep learning method for forecasting the onset of Parkinson's disease [19]. This study used the constrained input feature space of Parkinson's remote monitoring dataset to construct a Deep Neural Network (DNN) algorithm for estimating the course of the illness (PD). For predicting overall and motor UPDRS as PD advanced, a PCA-based DNN model was also proposed. Actual PD dataset from UCI was utilised to validate the DNN model. The suggested model is a DNN, therefore adding more data points to the datasets could improve its performance.

[8] Siva Sankara Donthi Reddy and Udaya Kumar Ramanadham presented the article "Prediction of Parkinson's Disease at Early Stage Using Big Data Analytics" [21]. This study primarily discusses several Big Data analytics methods that can be applied to timely disease diagnosis. Verifying the predictive algorithms' accuracy is the key objective. Their forthcoming studies seek to suggest an efficient mechanism to diagnose this type of neurological disorder based on some symptoms in the early stage with greater accuracy by utilising various Big Data analytics techniques, such as Hadoop, Hive, R programming, MapReduce, PIG, Zookeeper, HBase, Cassandra, Mahout, etc.

[9] This article emphasises that while existing medications can improve symptoms, none can repair brain damage or stop the illness from developing, suggesting that Parkinson's cure may one day be developed. Parkinson's UK researchers are now working to develop new treatments that can build on previous advancements and explore these cutting-edge areas of research.

[10] Dragana Miljkovic, et al. proposed a paper entitled "Machine Learning and Data Mining Methods for Managing Parkinson's Disease" [7]. In it, the author concluded that the predictor part was able to predict 15 different Parkinson's symptoms separately based on medical tests performed by the patients. Machine learning and data-mining techniques are applied to each symptom, yielding an accuracy between 57.1% and 77.4%, with tremor detection having the highest accuracy.

III. EXISTING METHODOLOGY

A little more than 1% of people over 60 have Parkinson's disease. Thus, early detection of Parkinson's disease is crucial for effective therapy. Parkinson's disease diagnosis necessitates meticulous medical examinations. Magnetic resonance imaging's provision of neuroanatomic biomarkers aid in the early diagnosis of this problem in Parkinson's Disease patients or in determining the disease's stage.

The current technique made use of a machine learning algorithms to extract characteristics from a person's medical record history that were then useful for determining whether or not that person had Parkinson’s disease. Although our model accurately predicted output for parkinsonian’s with usual symptoms, it was unable to determine if an individual with atypical symptoms will develop the condition. A person with atypical parkinsonism is one whose medical history does not match any of the signs of PD.

There is still a need for more accurate and effective techniques to support PD diagnosis, although there are many different types of research and studies being undertaken to anticipate PD. When studying speech signals, the NNge classification algorithm is known to provide reliable results. However, they have been used to diagnose PD without elaborating on the methods used to obtain the results.

In order to analyse the findings, an experiment was carried out using the NNge classification method. The accuracy was increased to 82.23% using the NNge parameters. The accuracy of the normal settings and the optimised settings was nearly identical.

Disadvantages of the existing system:

The following are some drawbacks of the existing system

1.This model accuracy is less than 85%.

2.When the disease is finally identified, it has already impacted 60% of the patient's body.

3.This technique requires more human involvement. Thus requires more time.

IV. PROPOSED METHODOLOGY

MODEL 1 ARCHITECTURE:

The native deep neural networks are used to create a deep learning custom algorithm in the proposed system. A typical neural network is made up of layers of various sizes, kinds, and flattening and pooling techniques. Some of the various layer types that make up our algorithms include convolution layers, pooling layers, normalising layers, dropout layers, and finally dense layers. In MRI, Parkinson disease is detected utilising a novel CNN-based technique. We will investigate and analyse Parkinson's disease in great detail. Using the analysis, we will create a deep learning model that can determine whether a subject has the condition. To extract characteristics, some brain regions with a dopamine shortage are utilised. These features boost the model's value and increase its precision.

In this project we are using two different models for predicting the parkinson’s disease using MRI data. The models that are used are customized an CNN model and VGG_19 model. The VGG19 model consists of 16 convolutional layers divided 4 at one time, followed by dense and flatten layers.

Initially, our algorithm grabs the data and remodels it into the dimensions of 228x228 pixels. The data set we have taken has grayscale images. Convolutional Neural Network (CNN) model is an sequential model. (CNN/ConvNet) is a subsection of deep neural networks that are utilized in deep learning to evaluate visual images ConvNet does not use matrix multiplications, which is often how neural networks are thought of. It uses an approach called convolution.

It is possible to successfully capture the spatial and temporal dependencies in an image using these layers. Filters are used to do this. These layers use a weight-sharing technique and have a substantially smaller number of parameters than typical feed-forward layers, which reduces the amount of computing required. Filters (or kernels) that are stretched over the entire depth of the input volume make up each layer's learnable parameters, although they have a limited receptive field. Each kernel is convolved over the height and width of the input volume when an input is subjected to forward pass, resulting in a 2-D activation map of that filter.

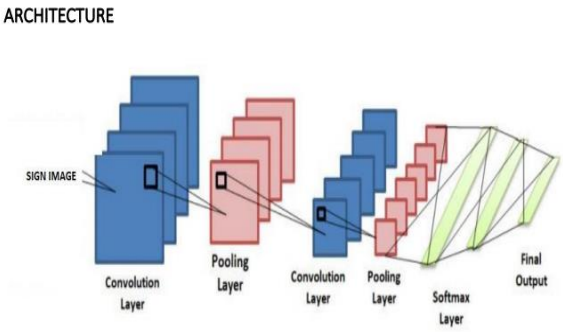


FIG: CNN Model Consisting convolution and pooling layers

Fig 1 . Architecture of the model

Three fundamental activities make up the feature extraction process:

• Convolutionally filter an image to look for a certain feature

• Find that feature inside the filtered image (using the ReLU activation)

• Decrease the picture size to feature its credits (greatest pooling) Highlights are improved by utilizing MaxPool layers.

We have used ReLU as the activation function in hidden layers and Soft max activation function in the output layer of our model.

MODEL 2 ARCHITECTURE:

- The matrix (224, 224) was shaped since this network was given an RGB picture of fixed size (224 * 224) as input. - The sole preprocessing that was carried out was to take the mean RGB value generated for the entire training set and subtract it from each pixel. - They used kernels with a size of (3 * 3) and a step size of 1 pixel to cover the entire image. To keep the image's spatial resolution, spatial padding was applied. - Max-pooling was carried out with a 2 * 2 pixel window and page 2. - Next, a rectified linear unit (ReLu), which was shown to be significantly superior than tanh or sigmoid functions, was employed to add nonlinearity to the model in order to improve classification accuracy and computing efficiency. Three completely linked layers were built, the first two of which had a size of 4096, the third of which is a SoftMax function and has 1000 channels for 1000-fold ILSVRC classification. The VGG19 model's layers are given below:

ConvNet Configuration					
A	A-LRN	B	C	D	E
11 weight layers	11 weight layers	13 weight layers	16 weight layers	16 weight layers	19 weight layers
input (224 × 224 RGB image)					
conv3-64	conv3-64 **LRN**	conv3-64 **conv3-64**	conv3-64 conv3-64	conv3-64 conv3-64	conv3-64 conv3-64
maxpool					
conv3-128	conv3-128	conv3-128 **conv3-128**	conv3-128 conv3-128	conv3-128 conv3-128	conv3-128 conv3-128
maxpool					
conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256	conv3-256 conv3-256 **conv1-256**	conv3-256 conv3-256 **conv3-256**	conv3-256 conv3-256 conv3-256 **conv3-256**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512	conv3-512 conv3-512 **conv1-512**	conv3-512 conv3-512 **conv3-512**	conv3-512 conv3-512 conv3-512 **conv3-512**
maxpool					
FC-4096					
FC-4096					
FC-1000					
soft-max					

VGG-19 Architecture

The dataset which we used is available on Kaggle. We have merged the train and test directories found in the dataset, and split them using “sklearn.modelselection.train_test_split” to achieve good results in the training process.

Information about cnn layers(convolution neural network layers)

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)           (None, 100, 100, 16)      1216

 max_pooling2d_3 (MaxPooling  (None, 50, 50, 16)       0
 2D)

 dropout_4 (Dropout)         (None, 50, 50, 16)        0

 conv2d_4 (Conv2D)           (None, 50, 50, 32)        12832

 max_pooling2d_4 (MaxPooling  (None, 25, 25, 32)       0
 2D)

 dropout_5 (Dropout)         (None, 25, 25, 32)        0

 conv2d_5 (Conv2D)           (None, 25, 25, 64)        51264

 max_pooling2d_5 (MaxPooling  (None, 12, 12, 64)       0
 2D)

 dropout_6 (Dropout)         (None, 12, 12, 64)        0

...
Total params: 4,785,442
Trainable params: 4,785,442
Non-trainable params: 0
```

```
from tensorflow.keras import optimizers
from keras.callbacks import ModelCheckpoint
adam = optimizers.Adam(learning_rate=.01, decay=1e-3)
filepath = 'model2.h5'
checkpoint = ModelCheckpoint(filepath=filepath,
                             monitor='val_loss',
                             verbose=1,
                             save_best_only=True,
                             mode='min')
callbacks = [checkpoint]
model.compile(loss='sparse_categorical_crossentropy',optimizer='adam',metrics=['accuracy'])
acn=model.fit(x_train,validation_data=x_test,epochs=10, steps_per_epoch=(len(x_test)//2) + 1, validation_steps=(len(x_test)//2) + 1
```

Fig 2 . Model Training

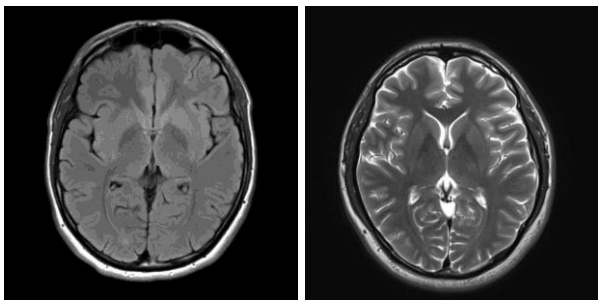
Here we have used Adam optimizer which has imported from TensorFlow K eras module and we have compiled the model with loss as sparse categorical Cross entropy.

V. RESULTS

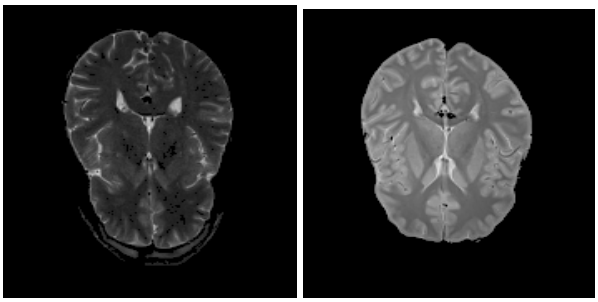
A. Dataset

We discovered MRI-related data on Kaggle that can be used to train various neural network models to detect Parkinson's disease in people. The MRI data consists of 1800 pictures of the brain that are 228 by 228 in size and divided into two categories:

- A) Non-Parkinson's disease image
- B) Parkinson’s disease image



(a) (a)



(a) (b)

Fig 3 . MRI Data Images

(a) Non-Parkinson's diseased image
(b) Parkinson's diseased image

```
loss_v, accuracy_v = model.evaluate(validationGen, steps=(validationGen.n // 20) + 1, verbose=verbose)
loss, accuracy = model.evaluate(testGen, steps=(testGen.n // 20) + 1, verbose=verbose)
print("Validation: accuracy = %f  ;  loss_v = %f" % (accuracy_v, loss_v))
print("Test: accuracy = %f  ;  loss_v = %f" % (accuracy, loss))
plot_model_history(vggmod, out_path=output_dir)
```

Fig 4. Plotting accuracy and loss

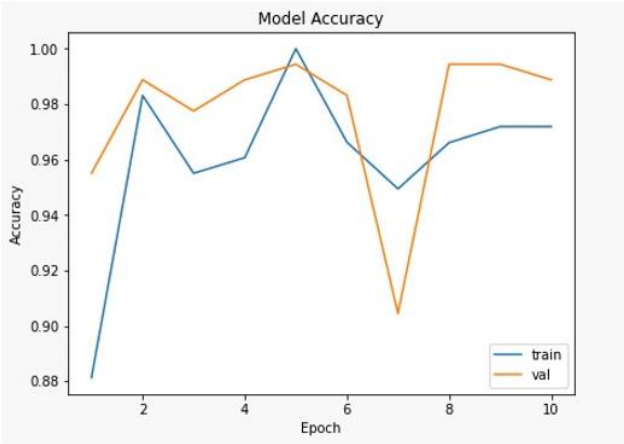


Fig 5. Training the model and finding the validation accuracy of the model

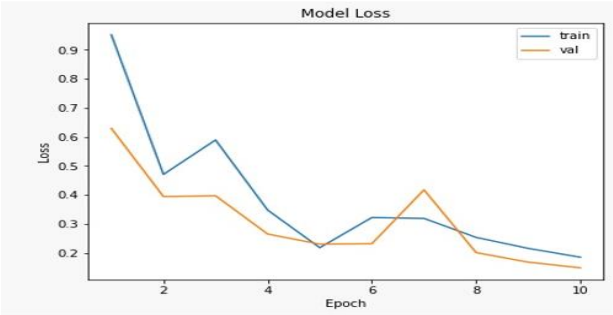
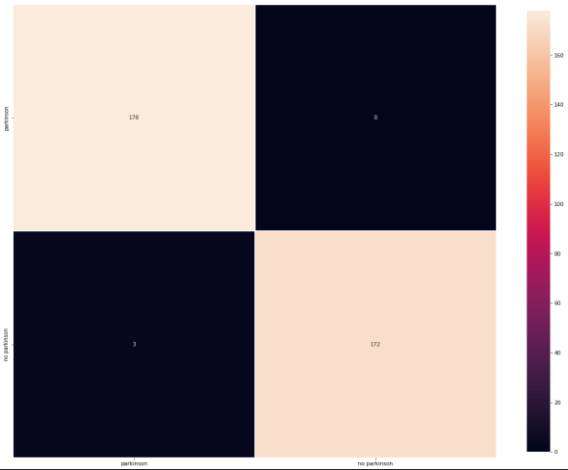


Fig 6. Training the model and finding the validation loss of the model

Through model training, we have verified the accuracy of this. For a patient, we have used our CNN model for predicting whether a person is having parkinson's disease or not.
Cofusion matrix:




```
from tensorflow.keras.preprocessing import image
from tensorflow.keras.models import load_model
model = load_model("model1.h5")
img = image.load_img(path+'\\n.jpg', target_size=(100,100))
x = image.img_to_array(img)/255
x = np.expand_dims(x, axis=0)
classes = model.predict(x)
print (classes)
# predicting images
#image = image.convert("RGB")
result = np.argmax(classes)
print(result)
if result==0:
    print('Parkinson')
else:
    print('No parkinson')
```

Fig 7. Predicting 0f Parkinson's disease

```
[[6.159083e-08 9.999999e-01]]
1
No parkinson
```

Fig 8. output

We have given an input as an image which is a non-parkinson's disease patient image and our model is predicted and output is given as no Parkinson.

B. Comparative results

To conduct a comparison study analysis, we created two unique models. Two CNN models were developed. A customized CNN model and VGG19 are the two models that make up Model 1. A customized CNN model is in Model 2. To increase accuracy, we have attempted to alter the models' hidden layers. In model 1, we used the transfer learning model VGG19 and a customized CNN model. We customized a CNN model for model 2. The same dataset was used to train and test both models. To improve the accuracy of both models, we tried to adjust the number of epochs.

Table II
COMPARATIVE STUDY RESULTS OF TWO CNN MODELS

	Accuracy	Number of epochs
Model 1(CNN)	98.04%	10
Model 2(VGG_19)	92.04%	10

VI. CONCLUSION

This initiative aims to rapidly implement a hospital model that will help in Parkinson's disease prediction using brain MRI. Early diagnosis allows the patient to receive the appropriate care to keep the disease under control

rather than waiting until it is too late to recognize the condition. We employed two separate models in this project: the VGG 19 and a specially created CNN (Convolutional Neural Networks).

The accuracy of the CNN model in these two models is 98.04%, whereas the accuracy of the VGG 19 model is 92.17%. So, when comparing these two models, the tailored CNN Model provides the best accuracy and outcomes for the diagnosis of Parkinson's disease using MRI data.

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