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Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction

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Abstract: It's important to note that Alzheimer's disease can also affect individuals over the age of 60, and in fact, the risk of developing Alzheimer's increases with age. Additionally, while deep learning approaches have shown promising results in detecting Alzheimer's disease, they are not the only techniques available for diagnosis and treatment. That being said, using Region-based Convolutional Neural Network (RCNN) for efficient feature extraction and classification can be a valuable tool in detecting Alzheimer's disease. This new approach to identifying Alzheimer's disease could lead to a more accurate and personalized diagnosis. It can also help in early treatment and intervention. However, it's still important to continue developing new methods and techniques for this disorder. Considering this our work proposes an innovative Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction approach in this paper. The exhaustive experimental result carried out, which proves the efficacy of our Alzheimer prediction system.

I. INTRODUCTION

Alzheimer Disease (AD) and dementia [1] are both types of neurodegenerative disorders that have a widespread impact on millions of people globally. Diagnosing AD and dementia is often challenging due to the overlap of their symptoms with those of other diseases. When Alzheimer's disease is in its initial phases, patients may experience forgetfulness or aging symptoms. As the disease progresses, cognitive abilities decline, including decision-making and daily task performance. Although no treatment is currently available, following a set of guidelines may help to slow its progression. Accurately diagnosing the disease is vital to improving the quality of life for patients. With the ongoing rise in Alzheimer's cases, there is an ethical imperative for innovation in the fight against this disease, which represents two-thirds of the fifty plus million dementia patients globally. Alzheimer's has now surpassed cancer as the most feared disease in the US, with a new case being recorded every three seconds worldwide. Alzheimer's disease detection is a challenging, complicated and time-absorbing task that necessitates both brain imaging reports (MRI'S) [2] and human knowledge. The traditional approach to detecting Alzheimer's is costly and often error-prone. Therefore, using a faster Region-based CNN may offer a more reliable, faster, and cost-effective alternative for detecting Alzheimer's.

Brain MRI data provides a plethora of information about the structure of the brain and can be used to detect AD and dementia accurately. A Faster R-CNN (Region-based Convolutional Neural Network) algorithm [3] is a popular deep learning technique used for object detection tasks. It is two-tiered network that firstly identifies regions of interest(ROI) and after that classifies them as a specific object. This method has been successfully used in various fields, including medical image analysis. The use of deep learning algorithms such as Faster R-CNN for detecting AD and dementia has shown promising results in several studies. These algorithms can accurately detect subtle changes in the structure of the brain that are indicative of these diseases. With further research and development, this approach has the potential to become a valuable device for detection and diagnosis of Alzheimer's disease and dementia.

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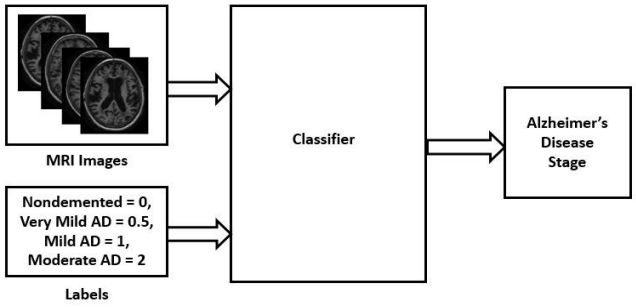

Fig.1: System Flow of Diagram

The data flow of proposed Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction system was shown in Figure.1. Where the MRI images will be given as training input, as it is supervised learning approach we should send relevant class labels also. The classification system uses our proposed Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction to predict the severity of the disease. The example training samples for our proposed Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction system shown in Figure.2.

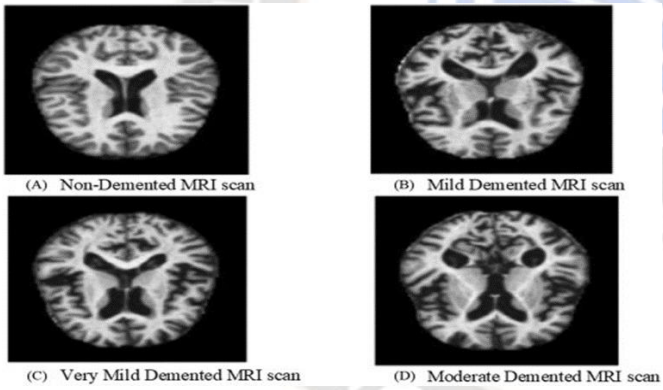

Fig 2: MRI Scans of Different Stages of Alzheimer's Diseases

II. LITERATURE REVIEW

Since the early 2000s, researchers have been using various machine learning approaches to predict the onset of Alzheimer's disease using MRI images alone. We analyzed various techniques used by researchers by searching the Couscous and Lined (Medical Literature Analysis and Retrieval System Online) databases. These techniques include clustering classification, regression, K-Means clustering, Convolutional Neural Network, and Artificial Neural Networks (ANN).

In reference article [4] developed a novel method to assist doctors in detecting Alzheimer's disease using functional connectivity scans. He used graph theory to analyze the scans and tested the accuracy of the results using three alternative techniques. He employed Random Forest, Artificial Neural Network like CNN and Support Vector Machine (SVM) trained on Superior Parietal Lobule (SPL) characteristics. The three models had an accuracy of 89%, 96.7%, and 89.8%, respectively, and the precision of the three algorithms was 87.5%, 99%, and 93.5%, respectively.

In reference article [5] used MRI to distinguish Alzheimer's disease from mild cognitive decline and healthy control groups. He employed different algorithms, including SVM, Regularized Extreme Learning Machine (RELM) and Independent Vector Machine (IVM) for this classification procedure. Furthermore, he proposed a racially biased strategy based on kernels to deal with diverse complex data patterns. Based on his classification technique, he found that RELM had superior metrics.

In reference article [6] compared the performance of imputation versus non-imputation approaches using the "Random Forest" algorithm. They found that the imputation approach had an accuracy of 87% while the non-imputation method had a correctness of 83%. They also categorized the participants as either "non-demented" or "demented."

III. Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction System:

This section will focus on putting the system into practise using the conceptual design from as a foundation. The implementation will always be practical to fulfil the demands revealed hear, with the purpose of being helpful to address the research question introduced at the start of the report.

In this proposed system we can go through the implementation of steps in the base algorithm so that the researchers can easily find out the way for their required data and go beyond this implementation. And also, we can see the process of pre-processing of the dataset and the technique used to implement further. The Architecture of Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction System proposed is given figure.3. The details of each step given in following sections.

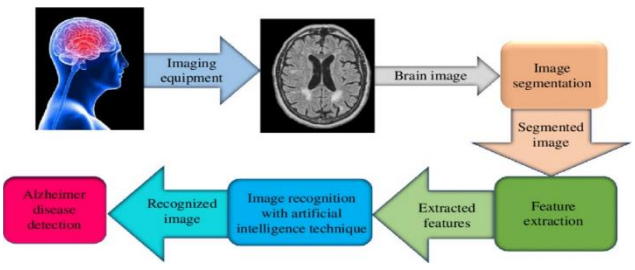

Fig 3: Architecture Region-based Convolutional Neural Network Driven Alzheimer's Severity Prediction Model.

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3.1 Data collection and pre-processing

We can find the numerous no. of data sets but doing with real data which are scanned by the doctors of old age people will give us more accurate and good scope for the researchers to find the best solution to cure this AD. So that for AD disease we collected the dataset from Kaggle which has the MRI scan images which has about 6000 plus MRI scan images.

In this 6000 plus MRI images we are further implementing through the AD disease stage like mild demented, very mild demented, moderate demented and non-demented. This classification given a more scope to find which stage the AD disease effected the person so that he/ she can cured further taking medicines given by the experts.

The Figure.4 shows the severity of **Alzheimer's** disease which further used as class labels in supervised leanings. Here are the four classified MRI scanned images for classifying the stage of AD disease:

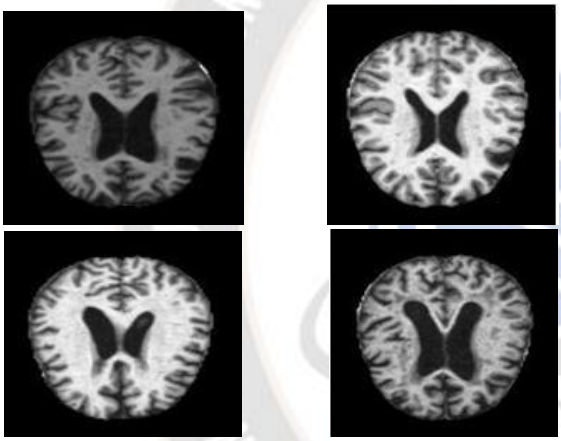

Fig 4. Classes labels of Alzheimer's disease severities given by MRI scan images

You may be confused that, how Alzheimer's disease finds on MRI scan dataset? Here is the answer that , normally the brain will be fine in early stages. In later stages the brain may got shrink and we can abnormally detect by seeing but we cannot sure about AD. Like decrease in the size of the different areas of the brain. And also, that this AD commonly or mainly attack on the temporal and parietal lobes of the brain. And also, you can consider some of the white and grey matter can effect changes due Alzheimer's disease attack in human beings. Most of the data sets are need to be pre-processed whether to check the data is being correct or not to evaluate and visualize the model with many machine learning algorithms. Anyway, the visualization can be explained in detail in further section. In this model or to evaluate the model thus we used pre-processed data and got checked with suitable python code that the data is correctly reshaped and all those things. We do pre-processing of the data to make sure that the data is correct and remove any noise like unwanted features to build a perfect RCNN model.

As the conceptual design flows here is the actual base algorithm implantation is that RCNN algorithm (Convolutional Neural Network). We are using RCNN algorithm because it has a special feature that it will not require any manual involvement to diagnose the AD inside the person. But other algorithms will require manual interaction so that they will observe the MRI scanned image to diagnose and other implications.

In the way of RCNN algorithm implementation, we have chosen Google collab because it doesn't require to install any packages manually and problems will not be occur. The following steps have been implemented and for Django for web interface we have run the model in the Jupiter Notebook and saved the model with .h5 extension for further uses with less time for execution. Figure.5 shows Sudo_code to balance and shuffle the dataset

```
df0 = df[df['NACC_ALZ'] == 0]
df1 = df[df['NACC_ALZ'] == 1]

df0 = df0.sample(8500)
df1 = df1.sample(8500)

df = pd.concat([df0, df1])

#Shuffle
df = df.sample(frac=1).reset_index(drop=True)
```

Fig.5: Sudo_code to balance and shuffle the dataset

3.2 Architecture Of Faster RCNN (Region – Based Convolutional Neural Network) Algorithm

The Fast R-CNN image detection technique is a two-phase object detection method that firstly identifies areas of interest before putting these areas through a Convolutional Neural Network (CNN) . It's also an improvement on the Region-Based CNN, which adopts a simple object recognition process but integrates a CNN after features extracted. This extended fast **RCNN arproch for Alzheimer's severity prediction was shown in Figure.6.**

The RCNN model may be used to assess fresh brain scans and find any indications of Alzheimer's disease once it has been trained. This can be an effective tool for both early illness identification and diagnosis as well as for tracking the course of the disease over time.

Layers present in Region - Based Convolution Neural Networks are :

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- Input layer
- Convolutional Networks
- Region Proposal Network
- Pooling Layer
- Fully Connected layer
- Output layer

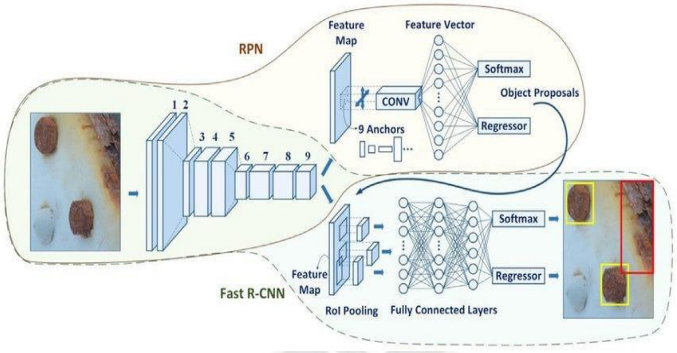

Fig 6: Flow of Faster RCNN Algorithm for Alzheimer's severity prediction

The convolutional layers process the input picture initially in order to extract visual information. After that, the Region Proposal Network suggests areas of interest (ROIs) in the input picture that might include brain regions impacted by Alzheimer's disease. In the Roi Pooling layer, features are taken out of the ROIs and reduced to a predetermined size for processing. After processing these attributes, the fully linked layers categorise the ROIs as either healthy or afflicted by Alzheimer's disease. The final classification result, showing whether the input image is likely to represent a healthy brain or one impacted by Alzheimer's disease, is then provided by the output layer.

IV. EVALUATION

The accuracy of an autonomous learning model is the most often used indicator to assess its performance. In addition to being used to assess the system's overall performance, this metric will serve as a guide for choosing between various model hyperparameters. This allows for the selection of the parameter combination that offers the highest degree of accuracy. The data set for evaluation is obtained form open source database [7].

RCNN Algorithm :

Layers present in Region - Based Convolution Neural Networks are :

- Input layer
- Convolutional Networks
- Region Proposal Network
- Pooling Layer
- Fully Connected layer
- Output layer

The data is divided into two parts training data and testing data. 70% data is training data and 30% data is testing data. The data is trained first by using the algorithm then the remaining data is tested. There are 6 layers for the used algorithm which can be seen by using the code. The layer and its type, output shape (with respect to dimensions), number of parameters is given as the output.

```
model. Add(Flatten(input_shape=(224,224,3)))
```

Verifying whether the aforementioned layers are trainable is crucial to ensure smooth execution of the code. It is imperative to confirm this to avoid any potential issues. The term "epoch" refers to a time period and is used in this context to indicate the number of times the model has iterated over the training dataset. The number of epochs utilized is significant as it influences the model's internal updating process, which ultimately impacts its efficiency.

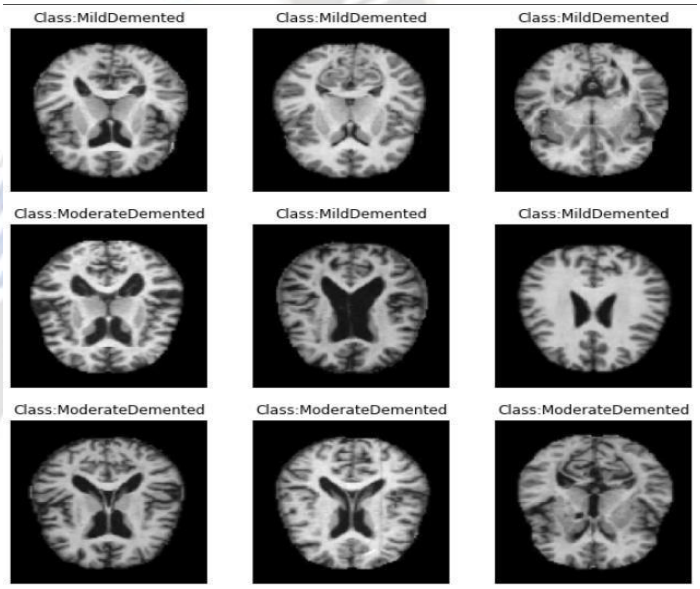

Fig 5: Displays a grid of 9 images with labels

GUI Widget

To launch the Alzheimer's detection project using RCNN, we must first open the Anaconda PowerShell prompt and navigate to the project folder using the "cd" command. Once we're in the correct directory, we can enter the command "python manage.py runserver" in the command shell to initiate the server and start the project. Upon successful execution, a URL will appear on the screen, which we need to note down http://127.0.0.1:8000/. We can then launch a web browser and enter the URL from the command prompt, which will direct us to the respective GUI of the Alzheimer's detection using RCNN project. The above said was implementations with GUI version is shown in Figure.7 and Web based implementation shown in Figure.8.

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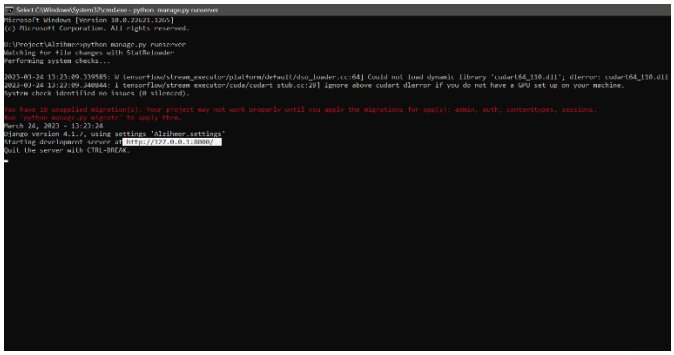

Fig 7: Copying of Development Server

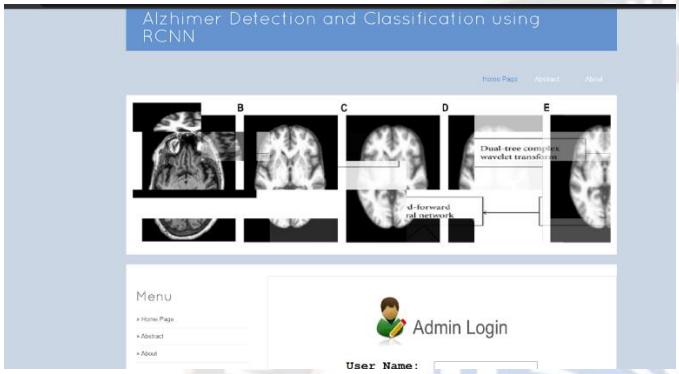

Fig 8: Web page

The admin has to log in with his credentials so that the patient's data will be secured from outsiders. Then click on classification there you have to upload the MRI scanned image for detection of Alzheimer stage of the patient. The following are the outputs of the project by uploading 4 stages of MRI scans. The uploading of input to Alzheimer severity prediction system is shown Figure.9 and corresponding outputs shown in Figure.10.

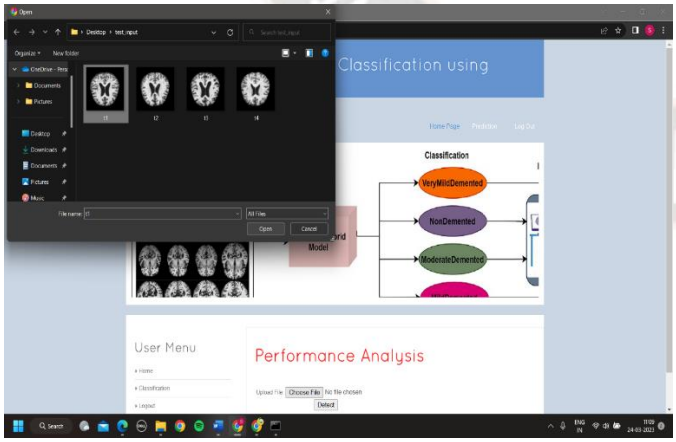

Fig 9: Uploading MRI scans

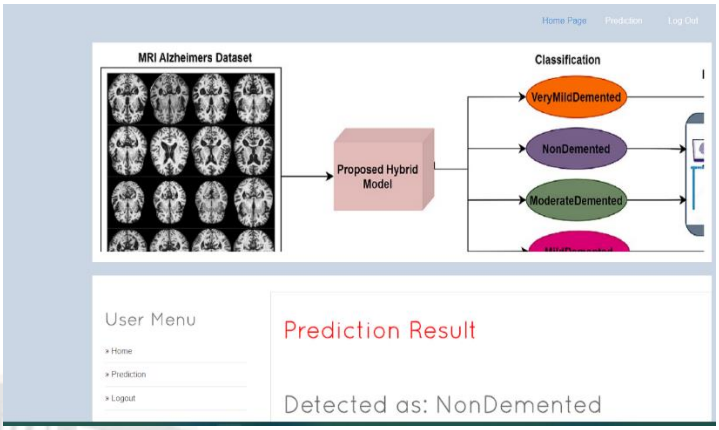

Fig 10: Output

Results :

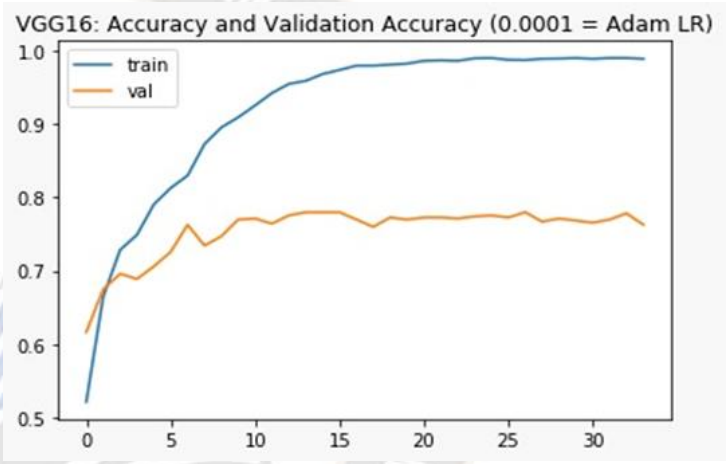

Fig 11: Accuracy graph

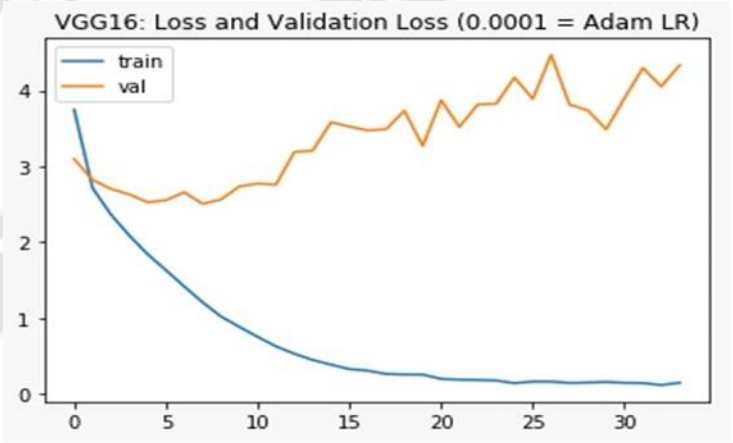

Fig 12 : Loss graph

Accuracy is the correctness of the data. Validation accuracy is also called as testing accuracy. Testing data which have accuracy is validation accuracy [8]. Loss is decrease in the performance of the testing data. Validation loss is the poor performance of the testing data. The Alzheimer prediction

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system accuracy graph shown in Figure.11 and Loss graph shown in Figure.12.

V. CONCLUSION

A deep learning model that can identify Alzheimer's disease cases based on brain MRI scans is currently being used. It can perform paired order analysis without the need for manual component extraction and has a 97.36% accuracy. This model is also ideal for testing with large datasets.

It can also be useful in areas where the test pack is inadequate. For instance, there hasn't been a lot of acknowledgements of the use of deep learning in the diagnosis of Alzheimer's disease in the clinical field. A review of the collected and clarified data on malignant growth in the esophagus shows that the proposed system is capable of handling the task.

FUTURE WORK

The field of AI-based techniques for Alzheimer's disease and other neurodegenerative disorders diagnosis is still in early stages, and there is much more potential for the further development and improvement. The possibility of implementing such systems onto web pages for more practical use is an exciting prospect, as it could make the diagnosis process faster, more accessible, and more cost-effective.

In the future, the current system could be evaluated on a larger dataset and potentially be configured as a web application for real-time screening and user interaction interface. This could allow clinicians to diagnose patients more efficiently and accurately. Furthermore, the auto feature algorithm can be modified to identify other neurodegenerative diseases automatically, expanding its potential applications.

One potential future extension of this project could be to incorporate a global positioning system (GPS) to suggest suitable hospitals for treatment. This could provide patients with valuable information and help them access the best possible care for their condition. However, such an extension would require careful consideration of ethical and legal implications and ensuring data privacy and confidentiality.

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