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Diabetic Retinopathy Image Grading Using Deep Learning Based Pipeline

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Annotation: Diabetic retinopathy is considered one of the most dangerous diseases that affect the eye and may lead to complete blindness if early diagnosis is not performed and the required treatments are not performed.

It can be recognized by retinal lesions, which are microvascular aneurysms, hemorrhages, and secretions.

Previous image processing methods for diabetic retinopathy have been able to manually diagnose the degree of the lesion, but are timeconsuming and inaccurate.

In our study of this topic, a research framework was proposed using advanced retinal image processing, deep learning, and enhanced decision tree algorithm for high-resolution images.

We pre-process retinal image data sets to highlight signs of disease by comparing the patient’s current condition and comparing it to prior images that show the degrees and type of disease using a neural network to extract features of the retinal images, and based on that, the patient’s condition is initially diagnosed.

1.1 Introduction

Diabetes mellitus is a chronic, progressive disease caused by inherited or acquired deficiency in the production of insulin by the pancreas. If blood sugar is not kept in a specific range, some long-term complications of the eyes, feet, and kidneys can start developing quickly. According to the WHO (World Health

Organization), at the end of 2014, 422 million people in the world had diabetes

(a prevalence of 8.5% among the adult population. Many of the deaths caused by diabetes 43%) occur under the age of 70 1. However, with a balanced diet, proper physical activity, immediate medication, and regular screening for complications, diabetes can be treated, and its consequences avoided. Diabetic retinopathy is a diabetes complication that affects the eyes, triggered by high blood sugar levels. It occurs as a result of long-term accumulated harm to the small blood vessels in the retina and is the leading cause of loss of vision. A sample diabetic retinopathy image as shown in Figure 1.1.

Figure 1.1: A sample diabetic retinopathy image

This classification can range from mild non-proliferative retinopathy to severe proliferative retinopathy or even normal retinas.

The accuracy of the pipeline is evaluated by comparing the algorithm's grading results with the ground truth labels provided by human experts. This evaluation helps validate the model's performance and assess its clinical usability. Overall, using a deep learning-based pipeline for diabetic retinopathy image grading can improve the efficiency and accuracy of diagnosis, enabling early detection and intervention for diabetic patients, consequently reducing the risk of vision loss.[1]

1.2 The importance of the retina

The retina is a vital structure in the eye that plays a crucial role in vision. It is a thin layer of tissue located at the back of the eye, composed of specialized cells called photoreceptors. These photoreceptors are responsible for converting light into electrical signals that can be transmitted to the brain, allowing us to perceive and interpret visual information.

The importance of the retina can be seen in several ways:

- **Visual perception:** The retina is essential for our ability to see and perceive the visual world. It captures light and converts it into neural signals that are transmitted to the brain through the optic nerve. Without a healthy retina, vision can be significantly impaired or lost altogether.
- **Visual acuity:** The retina contains a high concentration of cones, which are responsible for color vision and sharp visual acuity. These cones are particularly concentrated in a central area of the retina called the macula. A healthy retina ensures clear and detailed vision, allowing us to read, recognize faces, and perform other visually demanding tasks.
- **Maintenance of eye health:** The retina is a reflection of overall ocular health. Changes or abnormalities in the retina can indicate various eye conditions, such as macular degeneration,

diabetic retinopathy, or retinal detachment. Early detection and treatment of these conditions are crucial in preserving vision and preventing further damage.

- **Diagnostic tool:** The retina can serve as a diagnostic tool for assessing systemic health conditions. Certain diseases, such as hypertension, diabetes, or cardiovascular disease, can manifest changes in the retina. By examining the retina, healthcare professionals can detect early signs of these systemic conditions and initiate appropriate management. [2]

1.3 Retina problems

The retina can be susceptible to various problems and conditions that can affect vision and overall eye health. Some common problems of the retina include:

- **Diabetic retinopathy:** It is a complication of diabetes that affects the eyes. It is caused by damage to the blood vessels in the light-sensitive tissue at the back of the eye (retina).

In the early stages of diabetic retinopathy, the walls of the blood vessels in the retina become weak. Small bulges appear protruding from the walls of the blood vessels, and sometimes fluid leaks into the retina. The tissue in the retina may swell, resulting in white spots on the retina. As diabetic retinopathy progresses, new blood vessels may grow and threaten the vision as shown in figure 1.2.

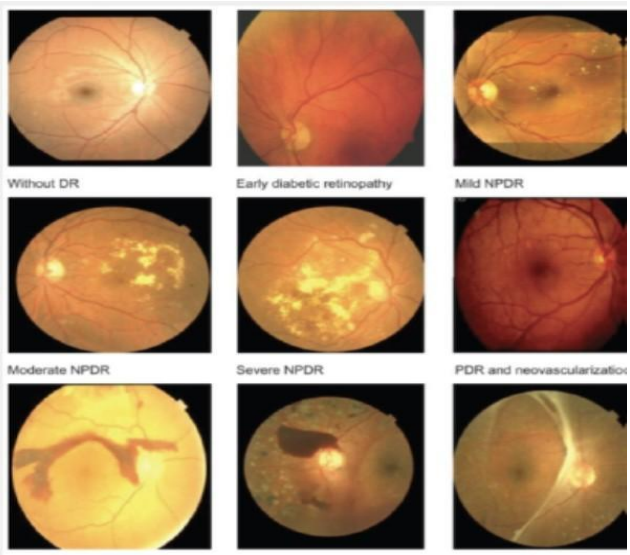

Figure 1.2: types of diabetic retinopathy

- **Retinal detachment:** This occurs when the retina peels away from the underlying layers, leading to a separation. Retinal detachment is a medical emergency and requires immediate attention as it can cause permanent vision loss if not treated promptly.

- **Macular degeneration:** This condition primarily affects the macula, the central part of the retina responsible for detailed vision. Macular degeneration can lead to a loss of central vision, making it difficult to read, drive, or recognize faces.

- **Retinal tears and holes:** These occur when the retina develops breaks or openings, typically due to aging, trauma, or other eye conditions. Retinal tears and holes can cause symptoms like floaters, flashes of light, or blurred vision.

Immediate medical attention is necessary to prevent retinal detachment.

- **Retinal vascular occlusions:** These occur when the blood vessels supplying the retina become blocked or narrowed. Retinal vascular occlusions can lead to vision loss or distorted vision depending on the severity and location of the blockage.

- **Retinitis pigmentosa:** This is a rare genetic disorder that causes the breakdown and loss of cells in the retina. It often leads to difficulty seeing at night or in low light, as well as a gradual loss of peripheral vision. [3]

1.4 Techniques for detecting retinal diseases

Angiography in the vascular area: In general, angiography in the vascular area, and vascular surgery in the area of prostate enlargement.

Fluorescein angiography: allows doctors to clearly visualize the aneurysm in the front part of the eye. A fluorescent pigment muscle, which is visible in blue light, runs through one of the veins of the person's blood vessels. The pigment moves within the person's aneurysm, until it reaches Dilated blood vessels of the retina. After a final period of pigment aspiration, a rapid series of optical images of the retina, choroid, optic disc, iris, or a combination of these. The pigment fluoresces within the blood vessels, highlighting the open blood vessels, Angiography is useful. Fluorescein is particularly effective in diagnosing corneal neovascularization, vasculitis in the blood vessels of the eye, and rheumatoid arthritis. This type of angiography also includes people with laser treatment parts of the retina.

Indocyanine green angiography: Allows surgeons to see blood vessels in the retinal blood vessels and walk. As in fluorescein angiography, the fluorescein dye in the uterus is inserted into the nose. This type of angiography provides doctors with more blood vessels in Blood vessels in the blood vessels in the bladder blood vessels Fluorescein angiography is used. Indocyanine micellar dye angiography is used green degeneration and detection of hematomas in the new eye.

Optical coherence tomography (OCT): provides high-resolution images of the anatomical vitreous screen in part of the eye, such as the macula, retina, sacrum, and optic nerve. In retinal eyes. It resembles a tomographic plate for optical imaging with an attractive layout, but it uses light instead of sound. Ocular CT scanning is used to view the eye's retina, including spatial degeneration, disorders that can cause new blood vessels to form in the eye, and glaucoma.

Computed tomography (CT) and magnetic resonance imaging (MRI): Both CT and MRI can be used to obtain detailed information about the anatomical structures inside the eye and the glass wall that surrounds it (the orbit). These experiments are used to experiment with the eye, especially if the doctor suspected the presence of a foreign body in the eye, or noticed tumors in the orbit or visual symptoms, and visual symptoms.

Electroretinogram (ERG): This test measures the electrical responses of the retina to light stimulation. It helps in evaluating retinal function and can identify conditions such as inherited retinal diseases or abnormal retinal activity. [4]

1.5 Problem Statement

Diabetic Retinopathy is a clinical diagnosis that affects eyes, represented by the presence of several retinal lesions like microaneurysms (MA), hemorrhages (HE), hard exudates (EX), and soft exudates (SE).

Therefore, success in the diabetic retinopathy grading task mainly depends on how well lesions can be extracted. Lesions extraction considers some very small details, like microa-neurysms , and some larger features, such as exudates, and sometimes even their position relative to each other on images of the eye.

For ordinary people, those lesions may be very small and hard to detect because of image noise; thus achieving good results in the grading task would be very difficult. The primary problem this research tries to address is how to extract features of diabetic retinopathy from retina images, especially lesions of DR. This problem can be further decomposed into the following three sub-problems. An image of the affected retina and the healthy retina as shown in Figure 1.3. [5]

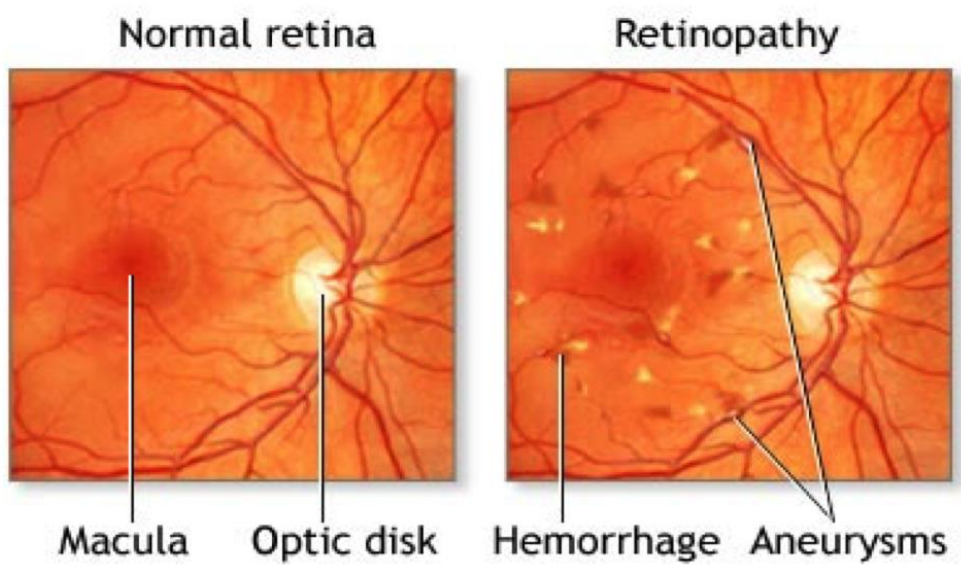

Figure 1.3: affected retina and the healthy retina

1.6 Deep Learning

Deep learning, which has been the new research frontier, has gained popularity in many tasks. The main advantage of many deep learning algorithms is that networks composed of many layers, can transform input data (e.g., image) to outputs (e.g., binary value, True or False) while capturing increasingly higher-level features. Unlike traditional machine learning methods, in which the creator of the model has to choose and encode features ahead of time, deep learning enables the model to automatically learn features that matter. That is very important because feature engineering typically is the most time-consuming part of machine learning practice.[6][7]

2.1 Deep learning

Deep learning is a subfield of machine learning that focuses on neural networks and algorithms inspired by the structure and function of the brain called artificial neural networks. These neural networks are capable of learning from data that is unstructured or unlabeled, which allows them to perform tasks such as image and speech recognition, natural language processing, and more.

Deep learning is particularly effective for tasks where the input data is highdimensional, such as images, audio, and text. It has seen great success in areas such as computer vision, speech recognition, and natural language processing. Deep learning models have achieved state-of-the-art performance on a wide range of tasks, surpassing human-level performance in some cases. Shown in figure 2.1 [8]

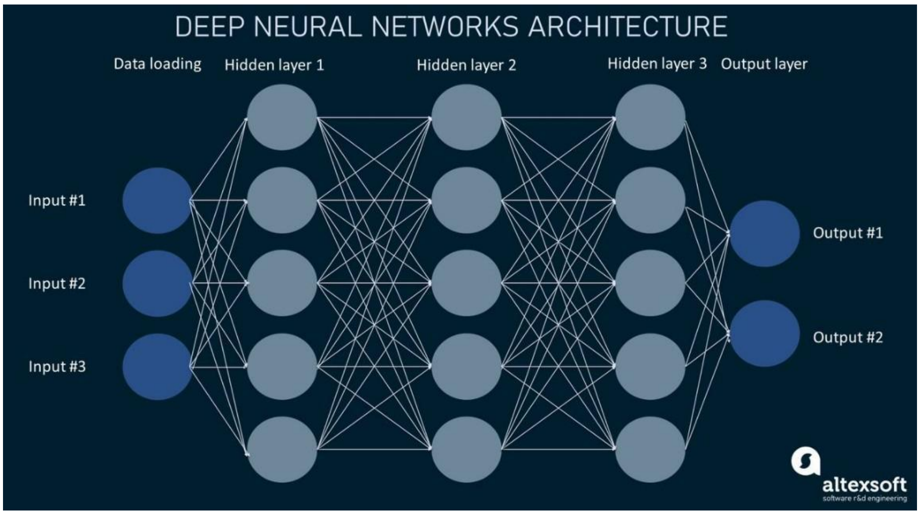

Figure 2.1 deep neural networks

2.2 Medical Image Analysis

Medical image analysis is a specialized and dynamic field that aims to use technology to evaluate medical images for the purpose of diagnosing diseases and guiding treatment. It relies on the detection and accurate analysis of images taken from various medical techniques such as X-rays, MRI, and CT scans.

A report on medical image analysis typically relies on several important elements, including:

1. **Image anatomy:** A detailed description of the internal structure of the medical image, identifying different organs and structures and any visible abnormalities (if present).
2. **Tissue assessment:** Evaluation of the types of tissues present in the image and identifying any deformities or changes in those tissues.
3. **Abnormalities and markers:** Commenting on any anomalies or abnormal changes in the image that may be related to specific diseases.
4. **Diagnostic recommendations:** Conclusions about the potential diagnosis based on the presented image, including recommendations for further tests if necessary.[9]

2.2.1 X-RAY

X-rays are a form of electromagnetic radiation that can pass through the body to create images of the internal structures, such as bones and organs. X-ray technology is commonly used in medical imaging to diagnose and monitor a variety of conditions, including fractures, infections, tumors, and other abnormalities During an X-ray procedure, a small amount of radiation is directed through the body onto a detector, which captures the image of the internal structures. Dense structures like bones appear white

(radiopaque) on the X-ray image, while softer tissues appear in various shades of gray.

X-rays play a crucial role in medical imaging as they provide detailed images that help healthcare providers diagnose and treat various medical conditions. X-rays are quick, painless, and non-invasive, making them a valuable tool in modern healthcare. it's important to note that while X-rays are generally safe and effective, healthcare providers take precautions to minimize radiation exposure, especially for pregnant women and children. Discussions of the benefits and risks of X-ray procedures should always take place between patients and their healthcare providers.

Overall, X-rays are an essential tool in medical diagnostics, providing valuable information that aids in the accurate diagnosis and treatment of a wide range of medical conditions as Shown in the figure 2.2. [9]

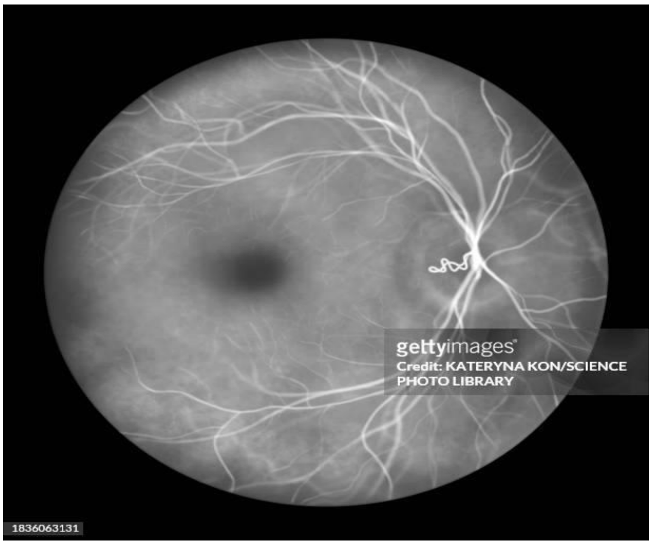

Figure2.2: Xray vision

2.2.2 CT (Computed Tomography)

Computed tomography is commonly referred to as a CT scan. A CT scan is a diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce images of the inside of the body. It shows detailed images of any part of the body, including the bones, muscles, fat, organs and blood vessels.

CT scans are more detailed than standard X-rays. In standard X-rays, a beam of energy is aimed at the body part being studied. A plate behind the body part captures the variations of the energy beam after it passes through skin, bone, muscle and other tissue. While much information can be obtained from a regular X-ray, a lot of detail about internal organs and other structures is not available.

In CT, the X-ray beam moves in a circle around the body. This allows many different views of the same organ or structure and provides much greater detail. The X-ray information is sent to a computer that interprets the X-ray data and displays it in twodimensional form on a monitor. Newer technology and computer software makes three-dimensional images possible.

CT scans may be performed to help diagnose tumors, investigate internal bleeding, or check for other internal injuries or damage. CT can also be used for a tissue or fluid biopsy as Shown in Figure 2.3. [10]

Figure 2.3: human eye and brain CT vision

2.2.3 MRI (Magnetic Resonance)

An MRI (magnetic resonance imaging) scan is a test that creates clear images of the structures inside your body using a large magnet, radio waves and a computer. Healthcare providers use MRIs to evaluate, diagnose and monitor several different medical conditions.

There are two main types of MRI machines: closed bore and open. While closed bore MRI machines take the highest quality images, open MRI machines may provide more comfort during the imaging due to the lack of an enclosed space as shown in the figure 2.4. [11]

Figure 2.4: human eyes and brain MRI scan

2.2.4 Ultrasound

Ultrasound, or sonography, is a medical imaging technique that uses highfrequency sound waves to produce images of the internal organs of the body. Ultrasound is used in a variety of medical applications such as prenatal imaging to monitor pregnancy, imaging of internal organs like the heart, liver, and kidneys, detecting tumors and cancers, as well as in vascular imaging. Ultrasound works by emitting high-frequency sound waves that are safe for the body and creates detailed images of internal organs by measuring how the sound waves reflect off different tissues. The technology is known for its safety and high accuracy, making ultrasound a common and important tool in medical diagnosis as it can accurately and quickly detect many conditions and diseases without the need for invasive procedures. In general, ultrasound technology is considered a modern and effective tool in diagnostic medicine and is widely used to detect many medical conditions and diseases quickly and accurately. Shown in the figure 2.5 [12]

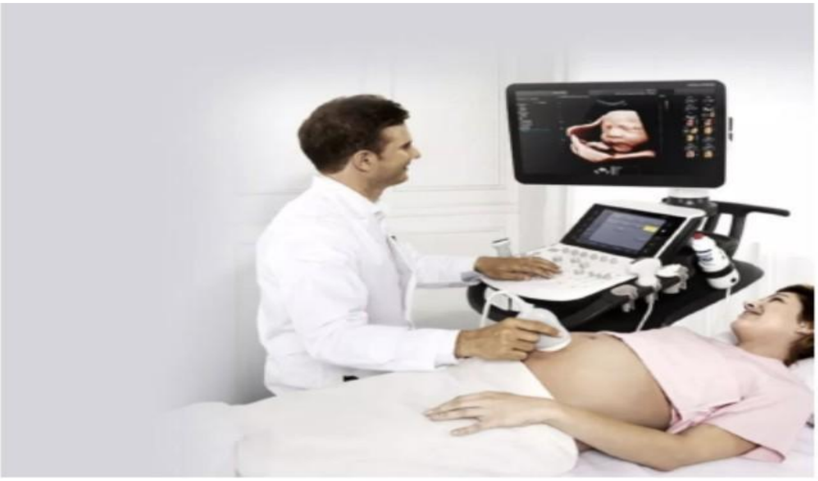

Figure 2.5 ultrasound

2.3 Diabetic Retinopathy Grading

Diabetic retinopathy is a diabetes complication that affects the eyes and can lead to blindness if left untreated. The grading of diabetic retinopathy is typically done using the International Clinical Diabetic Retinopathy Disease Severity Scale, which categorizes the disease into several stages:

1. **No apparent retinopathy (NDR):** In this stage, there are no visible signs of retinopathy.
2. **Mild nonproliferative retinopathy (NPDR):** Microaneurysms (small balloonlike swellings in the tiny blood vessels of the retina) start to appear.
3. **Moderat nonproliferative retinopathy (NPDR):** In addition to microaneurysms, some blood vessels that nourish the retina become blocked.
4. **Severe nonproliferative retinopathy (NPDR):** More blood vessels are blocked, depriving several areas of the retina of their blood supply.
5. **Proliferative diabetic retinopathy (PDR):** New blood vessels start to grow in the retina and into the vitreous humor, the gel-like substance that fills the eye. These new blood vessels are fragile and prone to bleeding, causing vision problems.
6. **Advanced diabetic eye disease (high-risk PDR):** This stage involves significant growth of abnormal blood vessels, which can lead to severe vision loss and other complications.[13]

It's essential for individuals with diabetes to have regular eye exams to detect and manage any signs of diabetic retinopathy early on. Treatment options for diabetic retinopathy include laser therapy, injections, and in some cases, surgery. If you have diabetes, it's crucial to work closely with your healthcare provider to monitor and manage your condition to help prevent complications like diabetic retinopathy. [14]

2.4 Tree-based Algorithms

Tree-based algorithms are machine learning algorithms that use decision trees as their primary model for making predictions or classifications. These algorithms recursively partition the feature space into smaller subsets based on the values of input features, leading to a hierarchical tree structure. Each node in the tree represents a decision based on a feature, and each leaf node represents a class label (in classification) or a prediction value (in regression). Examples of tree-based algorithms include Decision Trees, Random Forest, Gradient Boosting Machines (GBM), and XGBoost Shown in the figure 2.6 .[15]

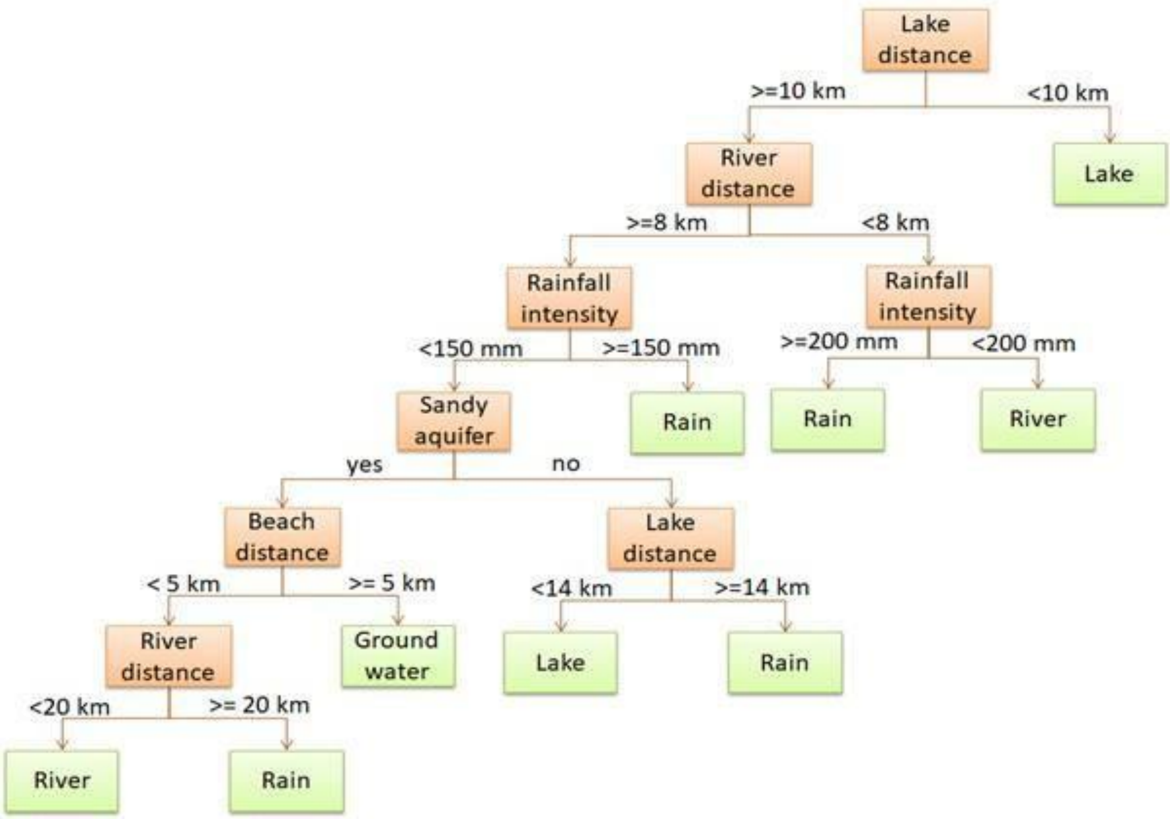

Figure 2.6: Tree-Based Machine learning

Tree-based algorithms work by recursively partitioning the feature space into smaller subsets based on the values of input features. Here's a general explanation of how they work:

1. Building the Tree:

- The algorithm starts with the entire dataset at the root node of the tree.
- It selects a feature and splits the dataset into subsets based on the values of that feature.
- This process is repeated recursively for each subset, selecting features and splitting until a stopping criterion is met, such as reaching a maximum tree depth or minimum number of samples in a node.

2. Decision Making:

- Once the tree is constructed, it can be used to make predictions or classifications.
- To make a prediction for a new data point, it traverses the tree from the root node down to a leaf node based on the values of the features.
- At each node, a decision is made based on the feature value, directing the traversal down the appropriate branch.

3. Leaf Nodes:

- When the traversal reaches a leaf node, the prediction or classification associated with that node is returned as the final output.

4. Ensemble Methods (Optional):

- Some tree-based algorithms, such as Random Forest and Gradient Boosting Machines, use multiple decision trees to improve predictive performance.
- In Random Forest, multiple decision trees are trained on random subsets of the data and combined to make predictions through voting or averaging.
- In Gradient Boosting Machines, decision trees are built sequentially, with each tree focusing on the errors made by the previous trees.[16]

Tree-based algorithms offer several advantages:

1. **Interpretability:** Decision trees are easy to understand and interpret, making them particularly useful for explaining the reasoning behind predictions or classifications.
2. **Handling Non-linear Relationships:** Tree-based algorithms can capture nonlinear relationships between features and target variables without the need for complex transformations.
3. **Feature Importance:** These algorithms can provide insights into feature importance, helping to identify the most relevant features for prediction or classification.
4. **Robustness to Outliers:** Decision trees are robust to outliers and noisy data, as they make decisions based on majority voting within each partition.
5. **Handling Mixed Data Types:** Tree-based algorithms can handle both numerical and categorical features without the need for feature scaling or encoding.
6. **Scalability:** They can handle large datasets efficiently, especially with ensemble methods like Random Forest and Gradient Boosting Machines.
7. **Less Preprocessing Required:** Compared to some other algorithms, tree-based methods require less preprocessing of the data, such as feature scaling or normalization.
8. **Ensemble Methods:** Ensemble methods like Random Forest and Gradient Boosting Machines further improve predictive performance by combining multiple decision trees.

Overall, tree-based algorithms are versatile and powerful tools for various machine learning tasks, offering simplicity, interpretability, and robustness. [16]

2.5 Decision Tree

A decision tree is one of the most powerful tools of supervised learning.

algorithms used for both classification and regression tasks. It builds a flowchart-like tree structure where each internal node denotes a test on an attribute, each branch represents an outcome of the test, and each leaf node (terminal node) holds a class label. It is constructed by recursively splitting the training data into subsets based on the values of the attributes until a stopping criterion is met, such as the maximum depth of the tree or the minimum number of samples required to split a node. During training, the Decision Tree algorithm selects the best attribute to split the data based on a metric such as entropy or Gini impurity, which measures the level of impurity or randomness in the subsets. The goal is to find the attribute that maximizes the information gain or the reduction in impurity after the split.

What is a Decision Tree?

A decision tree is a flowchart-like tree structure where each internal node denotes the feature, branches denote the rules and the leaf nodes denote the result of the algorithm. It is a versatile supervised machinelearning algorithm, which is used for both classification and regression problems. It is one of the very powerful algorithms. And it is also used in

Random Forest to train on different subsets of training data, which makes random forest one of the most powerful algorithms in machine learning as Shown in figure 2.7.[17]

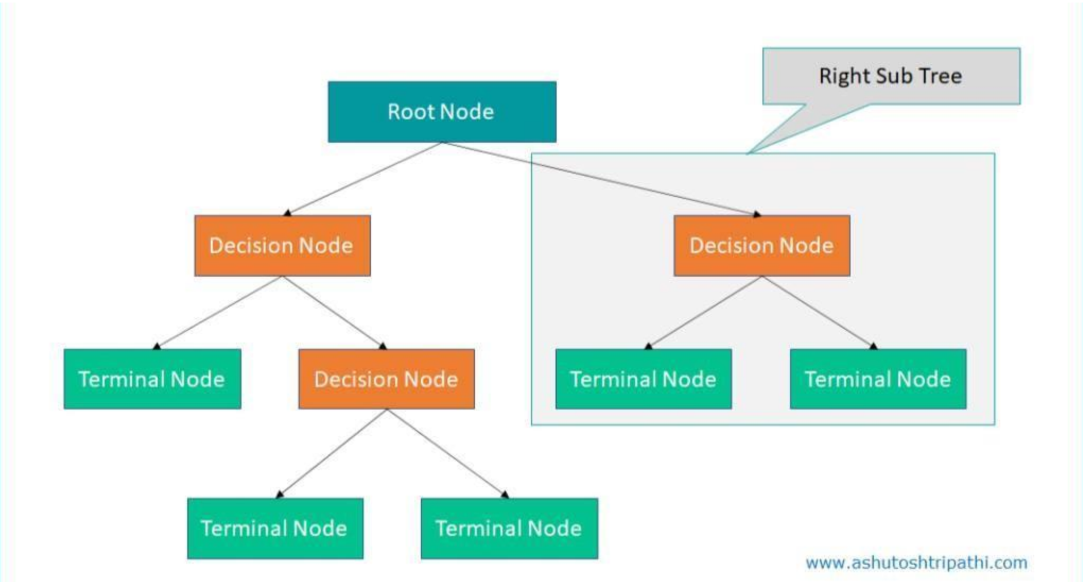

Figure 2.7 decision tree

Attribute Selection Measures:

Construction of Decision Tree: A tree can be “learned” by splitting the source set into subsets based on Attribute Selection Measures. Attribute selection measure (ASM) is a criterion used in decision tree algorithms to evaluate the usefulness of different attributes for splitting a dataset. The goal of ASM is to identify the attribute that will create the most homogeneous subsets of data after the split, thereby maximizing the information gain. This process is repeated on each derived subset in a recursive manner called recursive partitioning. The recursion is completed when the subset at a node all has the same value of the target variable, or when splitting no longer adds value to the predictions. The construction of a decision tree classifier does not require any domain knowledge or parameter setting and therefore is appropriate for exploratory knowledge discovery. Decision trees can handle high-dimensional data.

Entropy:

Entropy is the measure of the degree of randomness or uncertainty in the dataset. In the case of classifications, It measures the randomness based on the distribution of class labels in the dataset.

The entropy for a subset of the original dataset having K number of classes for the ith node can bedefined as:

H_i = -\sum_{k \epsilon K}^{n} p(i,k)\log_2p(i,k)

Where,

S is the dataset sample.

k is the particular class from K classes

p(k) is the proportion of the data points that belong to class k to the total number of data points in

dataset sample S. p(k) = \frac{1}{n}\sum{I(y=k)} Here p(i,k) should not be equal to zero.[17]

2.6 Data Preprocessing

Data preprocessing refers to the process of preparing and transforming raw data into a format that is suitable for analysis or machine learning tasks. This involves cleaning, formatting, and organizing the data to enhance its quality, usability, and effectiveness in subsequent analytical or modeling tasks.[18]

Six stages of data processing:

1. Data collection

Collecting data is the first step in data processing. Data is pulled from available sources, including data lakes and data warehouses. It is important that the data sources available are trustworthy and well-built so the data collected (and later used as information) is of the highest possible quality.

2. Data preparation

Once the data is collected, it then enters the data preparation stage. Data preparation, often referred to as “pre-processing” is the stage at which raw data is cleaned up and organized for the following stage of data processing. During preparation, raw data is diligently checked for any errors. The purpose of this step is to eliminate bad data (redundant, incomplete, or incorrect data) and begin to create high-quality data for the best business intelligence.

3. Data input

The clean data is then entered into its destination (perhaps a CRM like Salesforce or a data warehouse like Redshift), and translated into a language that it can understand. Data input is the first stage in which raw data begins to take the form of usable information.

4. Processing

During this stage, the data inputted to the computer in the previous stage is actually processed for interpretation. Processing is done using machine learning algorithms, though the process itself may vary slightly depending on the source of data being processed (data lakes, social networks, connected devices etc.) and its intended use (examining advertising patterns, medical diagnosis from connected devices, determining customer needs, etc.).

5. Data output/interpretation

The output/interpretation stage is the stage at which data is finally usable to nondata scientists. It is translated, readable, and often in the form of graphs, videos, images, plain text, etc. Members of the company or institution can now begin to self-serve the data for their own data analytics projects.

6. Data storage

The final stage of data processing is storage. After all of the data is processed, it is then stored for future use. While some information may be put to use immediately, much of it will serve a purpose later on. Plus, properly stored data is a necessity for compliance with data protection legislation like GDPR. When data is properly stored, it can be quickly and easily accessed by members of the organization when needed as Shown in the figure 2.8. [18]

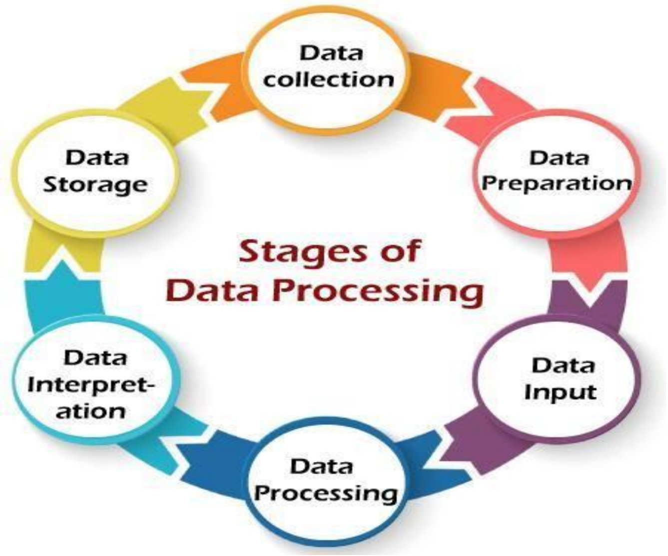

Figure 2.8 stages of data processing cycle

2.7 Data Augmentation

Data augmentation involves artificially increasing the size and diversity of a dataset by applying various transformations or modifications to the existing data samples. These transformations can include techniques such as rotation, translation, scaling, flipping, cropping, adding noise, or adjusting brightness and contrast as shown in the figure 2.9 [19]

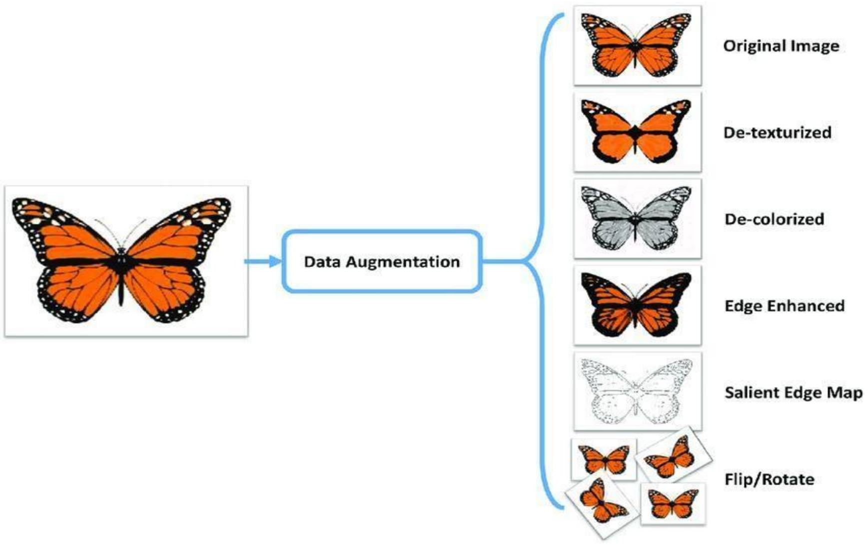

Figure 2.9 Image data augmentation

Here's how data augmentation typically works:

1. **Original Data:** Begin with a dataset containing a finite number of samples, representing the original training data.
2. **Transformation:** Apply a range of transformations to the original data samples. These transformations are often randomly selected and adjusted within certain limits to create variations while preserving the labels or classes of the data.

3. **Randomness:** Introduce randomness into the augmentation process by randomly selecting which transformations to apply to each data sample and by randomly adjusting the parameters of these transformations. This randomness helps diversify the augmented data and prevent overfitting.
4. **Augmented Data:** Generate augmented data samples by applying the selected transformations to the original data. Each augmented sample is treated as a new data point in the augmented dataset.
5. **Combination:** with Original Data: Combine the original data with the augmented data to create a larger and more diverse dataset for training machine learning models.
6. **Training:** Train machine learning models using the augmented dataset. By exposing the model to a broader range of variations and transformations in the data during training, data augmentation helps improve model generalization, robustness, and performance.

In summary, data augmentation is a valuable technique for enhancing the diversity and size of training datasets, thereby improving the performance and generalization ability of machine learning models.[20]

2.8 Benchmark

A benchmark is simply a test that is used to compare similar products. A computer benchmarking program works by running a series of well-defined tests on the PC to measure its performance.

In deep learning, benchmarking works similarly to other fields but is specifically focused on evaluating the performance of deep learning models on standardized datasets or tasks. Here’s how benchmarking operates in the context of deep learning:

1. **Selection of Benchmark Datasets:** Benchmarking typically begins with the selection of standard datasets that are commonly used in the deep learning community. These datasets often cover a variety of tasks such as image classification (e.g., ImageNet, CIFAR-10, MNIST), object detection (e.g., COCO), natural language processing (e.g., Penn Treebank, IMDb), and speech recognition (e.g., TIMIT). These datasets are widely recognized, publicly available, and representative of real-world scenarios.
2. **Definition of Evaluation Metrics:** Evaluation metrics are defined to assess the performance of deep learning models on the chosen datasets. For image classification tasks, common metrics include top-1 accuracy, top-5 accuracy, and mean average precision (mAP) for object detection tasks. For natural language processing tasks, metrics such as accuracy, precision, recall, F1 score, or perplexity may be used.
3. **Implementation of Deep Learning Models:** Researchers or practitioners implement or select a set of deep learning models to be evaluated. These models range from simple architectures like fully connected neural networks to more complex models such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), or transformer-based architectures.
4. **Training and Evaluation:** Each deep learning model is trained on the benchmark dataset using appropriate training procedures, such as stochastic gradient descent (SGD), Adam, or other optimization algorithms. The model’s performance is then evaluated using the predefined evaluation metrics on a separate validation set or using cross-validation.
5. **Comparison and Analysis:** The performance of the different deep learning models is compared based on the evaluation metrics. Researchers or practitioners analyze the results to understand the strengths, weaknesses, and trade-offs of each model architecture, hyperparameters, or training techniques.
6. **Establishment of Baseline:** The benchmarking results help establish a baseline or reference point for comparison, indicating the state-of-the-art performance on the chosen datasets and tasks.

7. **Reporting and Publication:** Researchers or practitioners document the benchmarking process, including the dataset used, models evaluated, evaluation metrics, and results obtained. They may publish their findings in academic papers, technical reports, or online repositories to contribute to the advancement of deep learning research as shown in the figure 2.10 . [20].

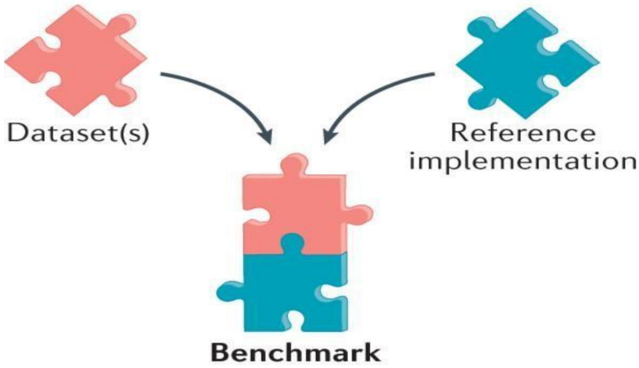

Figure 2.10 machine learning benchmark

2.9 Feature Extraction

Feature extraction is a process used in machine learning to reduce the number of resources needed for processing without losing important or relevant information. Feature extraction helps in the reduction of the dimensionality of data which is needed to process the data effectively. In other words, feature extraction involves creating new features that still capture the essential information from the original data but in a more efficient way.

When dealing with large datasets, especially in domains like image processing, natural language processing, or signal processing, it's common to have data with numerous features, many of which may be irrelevant or redundant. Feature extraction allows for the simplification of the data which helps algorithms to run faster and more effectively as shown in the figure 2.11. [21]

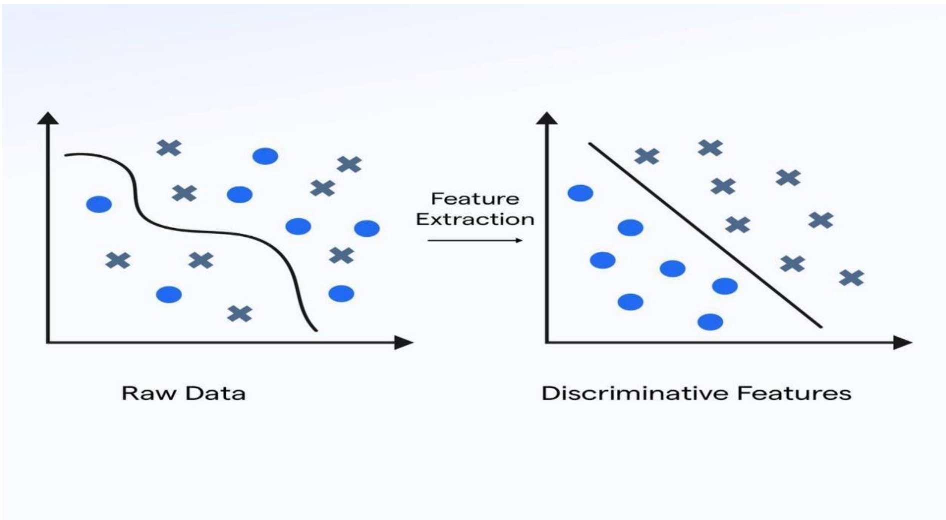

Figure 2.11 feature extraction techniques

2.10 Feature Blending

Features blending typically refers to a process in machine learning or data analysis where multiple sets of features, often derived from different sources or techniques, are combined or integrated into a single feature set for modeling or analysis.

Data features blending involves combining or integrating multiple sets of features from different sources or techniques into a single feature set for analysis or modeling.[21]

Here’s how it typically works:

1. Multiple Feature Sets: Start with multiple sets of features derived from different sources or techniques. These feature sets could be obtained through various means such as sensor data, domain knowledge, feature extraction algorithms, or pre-trained models.

2. Transformation (Optional): Optionally apply transformations or preprocessing steps to the individual feature sets to ensure compatibility and enhance their usefulness. This could include normalization, scaling, or encoding categorical variables.

3. Blending Process:

- Concatenation: One common approach is to concatenate or append the features from each set along a new dimension to create a combined feature matrix.
- Weighted Sum: Alternatively, you can combine the features using weighted sums, where each feature is multiplied by a certain weight and then summed together. The weights can be learned during training or manually specified based on domain knowledge.
- Feature Engineering: Create new features based on combinations or transformations of existing features, and then blend these new features with the original ones.

4. Model Training: Once the blended feature set is created, it can be used as input to train machine learning models or for further analysis. The models can learn from the combined information and make predictions based on the integrated feature representation.

5. Evaluation: Evaluate the performance of the models trained on the blended feature set using appropriate metrics and validation techniques. Adjustments to the blending process or feature selection may be made based on the evaluation results to improve performance further.

Overall, data features blending allows leveraging diverse sources of information or representations to improve the predictive performance of machine learning models and enhance the model’s ability to generalize to unseen data. It helps capture complementary information from different feature sets and enables more comprehensive analysis of the data. [22]

3.1 Introduction

The medical research uses artificial intelligence to streamline processes, automate repetitive tasks, and process vast amounts of data. You can use AI technology in medical research to streamline the drug discovery and development process from start to finish.[23]

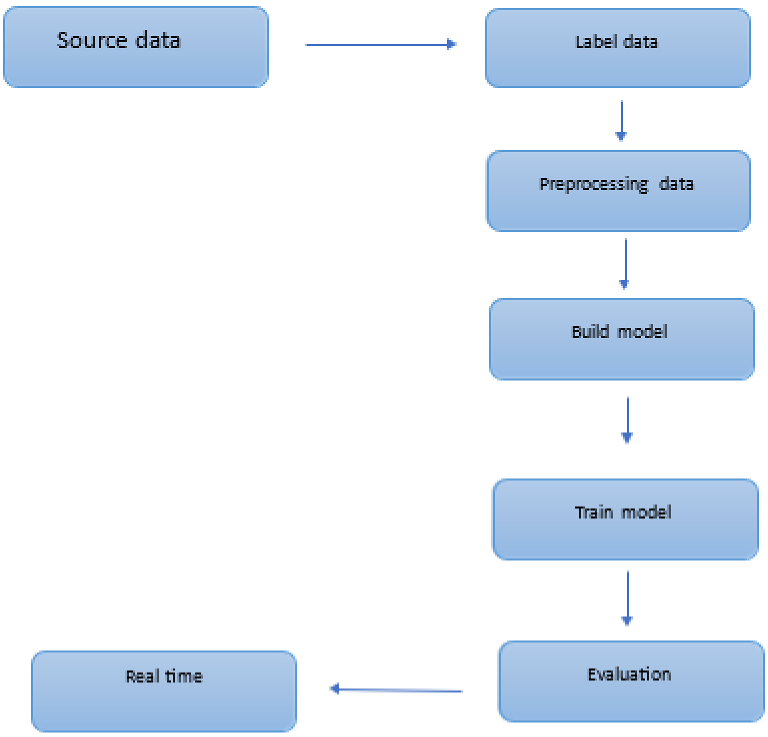

Figure 3.1 : flow chart

Block diagram shows the steps of work

3.2 steps of the work

1.First step : image sample as shown in figure 3.2 and figure 3.3

Figure 3.2: Normal retina

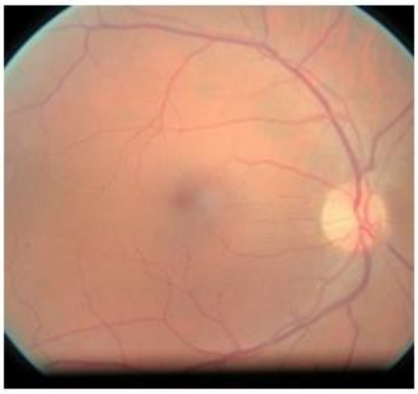

Figure 3.3: diabetic retina

2. second step: the main interface as shown in figure 3.4.

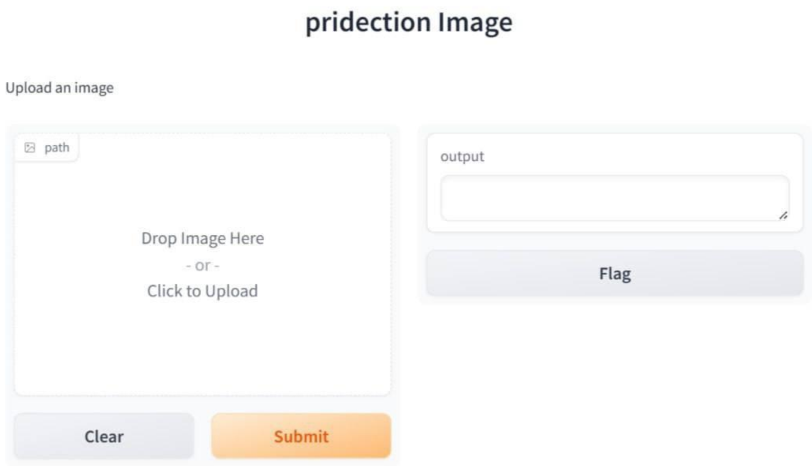

Figure 3.4: the main interface

The main interface of the program. The images are scanned and taken from the dataset available to us. There are four eye diseases in the dataset. The images are examined to see if they are normal or diseased.

3. third step: upload an image When we click here the dataset will appear as shown in figure 3.4.

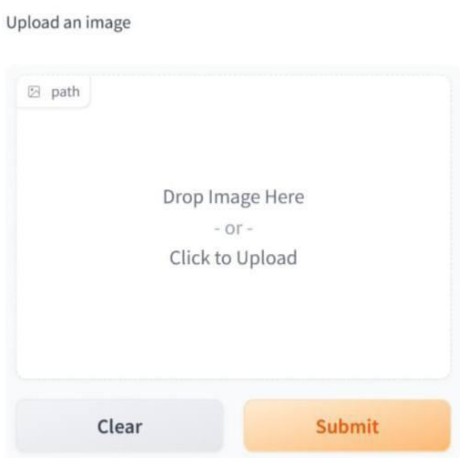

Figure 3.4: upload an image interface Select the image form the dataset.

Figure 3.5: dataset

The selected image as shown in the figure.

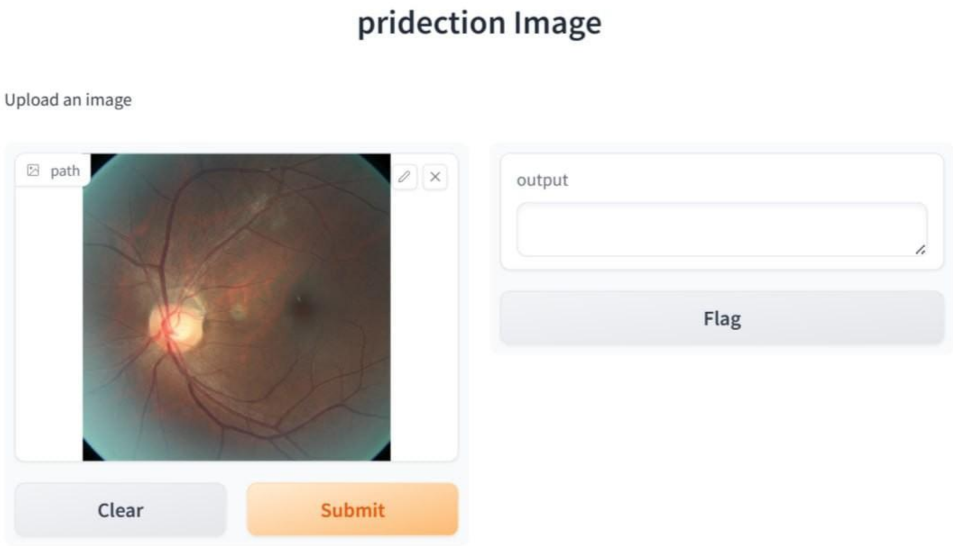

Figure 3.6: selected image

4. fourth step: the output result as shown in the figure 3.7.

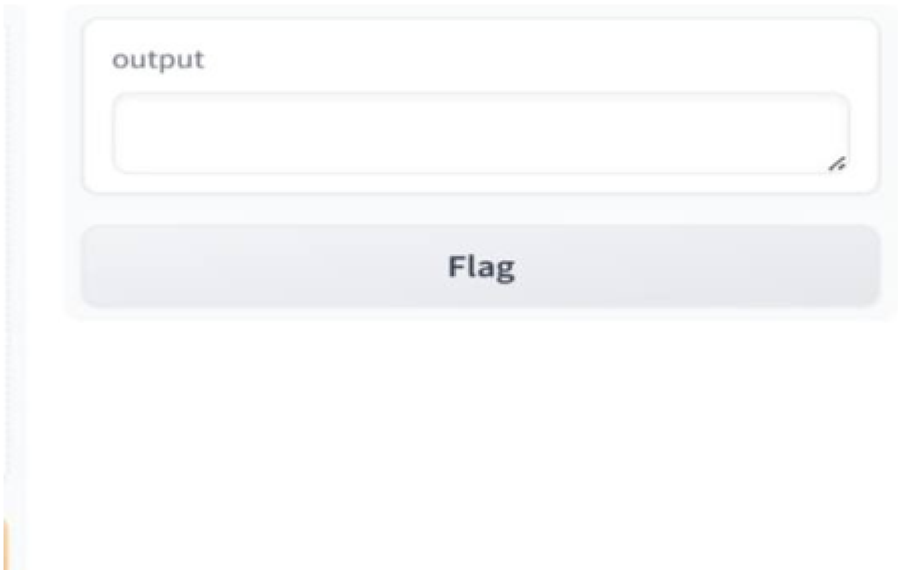

Figure 3.7: output interface

This is the result of the diabetic retina as shown in the figure 3.8.

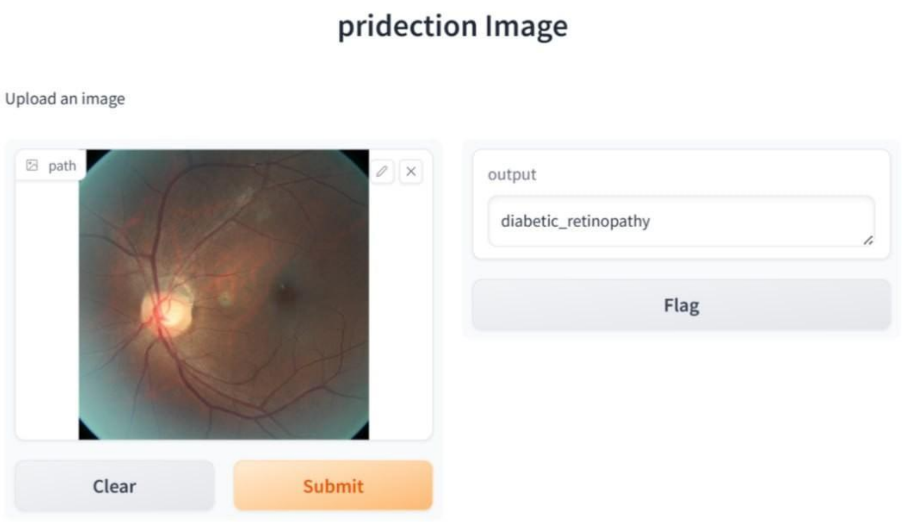

Figure 3.8: result of diabetic retina

This is the result of the normal retina as shown in the figure 3.9.

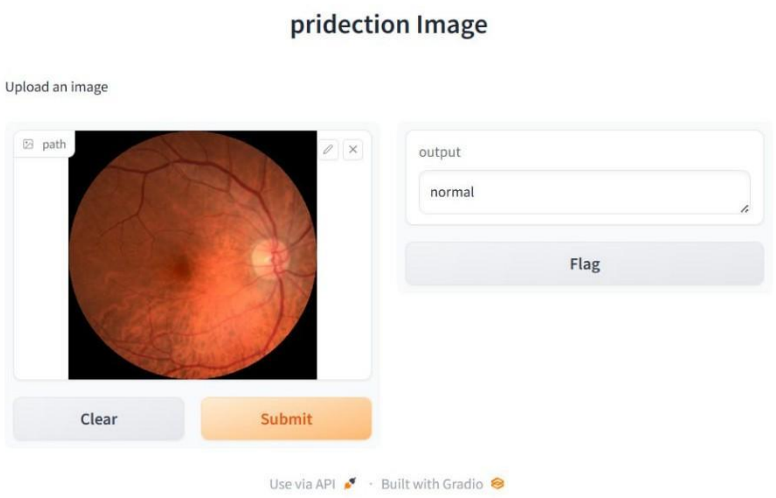

Figure 3.9: result of normal retina

4.1 Conclusion

Through this project, the problem of retinopathy was studied by diagnosing the degree of injury in diabetic patients by comparing the patient's current condition and comparing it throw pictures of cases in which the degree of injury was determined.

The tree algorithm was applied in the comparison and deep learning process We propose a novel deep learning based Tree based on a tree decision algorithm for grading diabetic retinopathy.

Previous work in diabetic retinopathy detection and grading work mainly relies on expert knowledge and hand-made features.

As main contributions of this study, we propose a novel composed of the following steps:

- Retina image preprocessing
- Deep learning-based feature extraction
- Comparing the current image with the images stored in the system, which determines the degree of injury

- Determine the level of Retinopathy

Data preprocessing methods, like standardization, morphological closing operation, and contrast enhancement, are very useful to highlight the lesions of the retina and enable making retina images efficient training. Compared to other retinopathy without preprocessing work.

4.2 Future work

We believe this method can be further improved, when:

1. More expert knowledge in DR can be applied.
2. More image preprocessing methods can be applied.
3. More labels on the retinal image can be used, like lesions segmentation labels.

In the future, we propose:

1. Increase the options for determining more precise degrees of retinal injuries.
2. Increase the dataset in more detail to determine the infection more accurately by using a higher number of datasets

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