

CLASSIFICATION OF DIFFERENT STAGES OF DENTAL CARIES USING DEEP LEARNING TECHNIQUE

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Technology degree in Biomedical Engineering.

By

JASMINE J (37240030)

KAAVIYA V (37240039)



**DEPARTMENT OF BIOMEDICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

MARCH -2021



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Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in

DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Jasmine J (37240030)**, **Kaaviya V (37240039)** who carried out the project entitled “**Classification of Different Stages of Dental Caries using Deep Learning Technique**” under my supervision from **October 2020** to **March 2021**

Dr. T. SUDHAKAR, M.Sc., Ph.D.,

Internal Guide

Dr. T. SUDHAKAR, M.Sc., Ph.D.,

Head of the Department

Submitted for Viva voce Examination held on **10.4.2021**

Internal Examiner

External Examiner

DECLARATION

We, **Jasmine J (37240030)** and **Kaaviya V (37240039)** hereby declare that the Project Report entitled “**Classification of Different Stages of Dental Caries using Deep Learning Technique**” done by us under the guidance of **Dr. T. Sudhakar** M.Sc.,Ph.D., Department of Biomedical Engineering is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Biomedical Engineering.

DATE: 10.4.2021

1.

Handwritten signature of Jasmine J in blue ink on a light blue grid background.

PLACE: Chennai

2.

Handwritten signature of V. Kaaviya in blue ink on a light blue grid background.

SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to the **Board of Management of SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. T. Sudhakar** M.Sc., Ph.D., and **Dr. J. Premkumar** M.Sc., Ph.D., **Head of the Department, Dept. of Biomedical Engineering** for providing me necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. T. Sudhakar** M.Sc., Ph.D., **Department of Bio Medical Engineering** for his valuable guidance, suggestions and constant encouragement paving the way for the successful completion of our project work.

We wish to express our thanks to all **Teaching and Non-teaching** staff members of the **Department of Biomedical Engineering** who were helpful in many ways for the completion of the project.

ABSTRACT

Dental caries could be a widely prevalent disease world-wide. No matter age, it's shown to own a negative impact on the health related quality of life. Data suggests that there has been a decline within the prevalence of tooth decay worldwide but has been at markedly different rates in high and middle/low income countries. While there has been a greater decline within the high income countries which could majorly be attributed to the utilization of fluorides and established preventive programs while in some low and middle income countries, there decline has been less or inverse thanks to the increasing consumption of sugars and refined foods. Thus, during this project we use Dental X-ray images to detect the presence of dental caries in a patient effectively. We apply Resnet50 a deep learning algorithm for feature extraction and machine learning algorithms for classification to detect the presence of dental cavities in a patient without the requirement of several consultations from different doctors. An application is also developed in such a way that an input image of the dental x-ray images will be given and an output is obtained detecting the presence of cavities. This results in earlier detection of the presence of the occurrence of dental cavities and allows us to require prior actions immediately to avoid further consequences in an efficient and cheap manner avoiding human error rate. Thus this project is employed to detect the presence of dental cavities in a patient very effectively.

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LIST OF ABBREVIATIONS

CNN	Convolutional Neural Network
SVM	Support Vector Machine
ILSVRC	ImageNet Large Scale Visual Recognition Challenge
ReLU	Rectified Linear Unit
SARSA	State-Action-Reward-State-Action
DDPG	Deep Deterministic Policy Gradient

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Dental caries could be a widely prevalent disease world-wide. In line with world Oral Health data Bank, prevalence varies from forty ninth to eighty three percentage across whole totally different countries. In spite older, it's shown to possess a negative impact on the health connected quality of life. Data suggests that there has been a decline at intervals the prevalence of decay worldwide but has been at markedly whole totally different rates in high and middle / low gain countries. Whereas there has been a much bigger decline at intervals the high gain countries which may majorly be attributed to the employment of fluorides and established preventive programs whereas in some low and middle gain countries, there decline has been less or inverse because of the increasing consumption of sugars and refined foods. Delivery of effective patient care, health services management, public health and health politics unit addicted to credible data. The Health Organization (WHO) has advocated epidemiological surveys to be undertaken every 5 years to appear at the self-propelled patterns of oral diseases and to make a world oral health data bank. The knowledge presently procurable at intervals the planet oral health information bank has been sourced from countries having a strong illness surveillance/reporting system or on the construct of systematically conducted national oral health surveys. Though wide rife, the distribution and severity of decay varies across countries and among varied regions at intervals a rustic. For world observation functions, the planet Health Organization recommends the employment of certain index age groups to summarize the burden of decay and different oral diseases. The age groups 5 years, 12 years, 15 years, 35-44 years and 65-74 years unit chosen to represent dentition, instantly once permanent teeth eruption (except third molars), exposure of teeth to the oral atmosphere for an honest quantity of some time, adulthood and geriatric population severally. Asian country with its wide ethnic, geographic and cultural diversity is taken into consideration as a rustic of the many nations. Quite expectedly illness patterns unit wide varied at intervals varied states / regions of

the country. However, with the absence of a sturdy illness coverage system, there's no amount of your time observation of oral diseases at intervals within the country.

1.2 OUTLINE OF THE PROJECT

Improving human health has been the subject of the various analysis investigations. So throughout this project we've an inclination to use Dental X-ray images to sight the presence of decay in a patient effectively. We apply Resnet50 a deep learning algorithm for feature extraction and machine learning algorithms for classification to detect the presence of dental cavities in a patient without the requirement of several consultations from different doctors. An application is also developed in such a way that an input image of the dental x-ray images will be given and an output is obtained detecting the presence of cavities. This results in earlier detection of the presence of the occurrence of dental cavities and allows us to require prior actions immediately to avoid further consequences in an efficient and cheap manner avoiding human error rate. Thus this project is employed to detect the presence of dental cavities in a patient effectively.

1.3 CLASSES OF DENTAL CARIOUS LESIONS

- **CLASS I** - Cavity in pits or fissures on the occlusal surfaces of molars and premolars, facial and lingual surfaces of molars, lingual surfaces of jaw incisors .
- **CLASS II** - Cavity on proximal surfaces of premolars and molars.
- **CLASS III** - Cavity on proximal surfaces of incisors and canines that do not involve the incisal angle.
- **CLASS IV** - Cavity on proximal surfaces of incisors or canines that involve the incisal angle.

CHAPTER 2

LITERATURE SURVEY

Andras Horvath *et al.*, (2019) reportable higher detection of medically salient choices. Within this work, a pair of CNN architectures a subpixel network then the alleged U-net – square measure thought of for the resolution sweetening of 2d cone-beam CT image slices of ex vivo teeth. To do so, a training set of 5680 cross-sectional slices of 13 teeth and a check set of 1824 slices of 4 structurally fully completely different teeth were used. A pair of existing reconstruction-based super-resolution ways that practice ℓ_2 -norm and total variation regularization were used for comparison. The results were evaluated with fully completely different metrics (peak signal/noise ratio, structure similarity index, and different objective measures estimating human perception) and later image- segmentation-based analysis. Within the analysis, micro-CT photos were used as ground truth. The results counsel the prevalence of the planned CNN-based approaches over reconstruction-based ways that within the case of dental CT photos, allowing higher detection of medically salient choices a bit like the scale, shape, or curvature of the inspiration canal.

Abdolvahab Ehsani Rad *et al.*, (2018) throughout this study a replacement segmentation methodology supported level set (LS) is planned in a pair of phases; IC generation practice morphological knowledge of image and intelligent level set segmentation utilizing motion filtering and back propagation neural network. The segmentation results square measure economical and proper as compared to different studies. The new approach to isolate each segmental tooth image is planned by victimisation integral projection technique and have map designed for each tooth to extract the native knowledge then to search out decay house. The achieved overall performance of the planned segmentation methodology was evaluated at 100 twenty periapical dental radiographs (X-ray), with photos at ninetieth and so the detection accuracy of ninety eight.

Nima Karimianet *et al.*, (2018) implemented deep convolutional neural networks and optical coherence picturing (OCT) imaging modality for classification of oral

tissues to search out early dental caries. OCT photos of oral tissues with varied densities were input to a CNN classifier to figure out variations in tissue densities. The planned technique was valid on ex-vivo solar calendar month photos of human oral tissues documented to effectiveness of this technique.

Olaf Ronneberger *et al.*, (2015) conferred a pure machine learning approach using a U-shaped deep convolutional neural network (u-net) for the fully automatic segmentation of dental x-ray photos into the classes decay, enamel, dentin, pulp, crown, restoration and passage treatment. The planning of the u-net consists of a obtaining path to capture context and a bilateral increasing path that allows precise localization. It shows that such a network are typically trained end-to-end from solely many photos. The network reaches a dice similarity of over seventieth for the frequent classes enamel, dentin and pulp. The common dice similarity for all classes is 56.4%.

Angelino *et al.*, (2017) developed a approach with NIR (850 nm) semiconductor diode imaging system by complex NIR offer nevertheless as intraoral camera thus on choose the low sensitivity regions of the teeth. To urge the decay at intervals the ten willing human subjects, the image of the teeth was provided by NIR and this NIR was in command of providing the supplementary evaluations and so the de-mineralized areas were disclosed in conjunction with the deep and superficial cracks by means of the camera-wand system. This technique had high clinical utility, simple to use, easy, and it had been low in value, whereas compared to the radiographs. The foremost disadvantage of this technique is that it isn't correct.

Joonhyang Choi *et al.*, (2018) reportable automatic detection system with aim of investigating the decay tooth in associate early stage. Throughout this technique four modules were used, like horizontal alignment of pictured teeth, chance map generation, crown extraction, and refinement. Further, to strengthen the performance of the planned model, the pictured teeth were aligned throughout a awfully horizontal manner. The chance map of the decay was generated from the fully convolutional network. The decay within the crown region were obtained from the improvement schemes additionally as from the edge-based level set

methodology. Moreover, therefore on boost the performance of detection, the non-maximum suppression methodology was indulged.

Shashikant Patil *et al.*, (2019) developed AI techniques to guage correct detection of decay practice feature extraction and classification of the dental photos in conjunction with consolidation reconciling insect rule (DA) rule and Neural Network (NN) classifier. This work emphasizes the accomplishable effectiveness of science and NN algorithms for the detection and identification of decay. A awfully distinctive and improved model shows significantly worthy performance in characteristic decay practice image method techniques.

Laura A Zanell Calzada *et al.*, (2018) reportable the presence and absence / restorations of decay. The methodology is performed constructing a dense artificial neural network (ANN), as a computer-aided identification tool, making an attempt to hunt out a generalized model that permits for classifying subjects. As validation, the classification model was evaluated through a mathematics analysis supported a cross validation, shrewd the accuracy, loss perform, receiving operating characteristic (ROC) curve and house to a lower place the curve (AUC) parameters. The results obtained were statistically vital, obtaining associate accuracy 69% and AUC values of 0.69 and 0.75. supported these results, it's accomplishable to conclude that the classification model developed through the deep ANN is ready to classify subjects with absence of decay from subjects with presence or restorations with high accuracy, to stay with their demographic and dietary factors.

Casalegno *et al.*, (2019) rumored a deep learning model for the machine-controlled detection and localization of dental lesions in TI pictures. This technique depends on a convolutional neural network (CNN) trained on a linguistics segmentation task. With solely 185 coaching samples, the model achieved AN overall mean intersection-over-union (IOU) score of 72.7% on a 5-class segmentation task and specifically an IOU score of 49.5% and 49.0% for proximal and occlusal unhealthy lesions, severally and additionally created a simplified task, throughout that regions of interest were evaluated for the binary presence or absence of unhealthy lesions and achieved a region underneath the receiver

operational graph of 83.6% and 85.6% for occlusal and proximal lesions, severally. The work demonstrates that a deep learning approach for the analysis of dental pictures holds promise for increasing the speed and accuracy of tooth decay detection, supporting the diagnoses of dental practitioners, and up patient outcomes.

Prajapati *et al.*, (2017) rumored correct classification of dental diseases victimization labelled dataset consisting of 251 Radio Visiography (RVG) x-ray pictures of 3 totally different categories is utilized for classification. CNN performs well in natural image classification issues wherever massive dataset is on the market. Throughout this paper they experimented on the performance of CNN for diagnosing of little labelled dental dataset. In addition, transfer learning is utilized to reinforce the accuracy. Experimental results are conferred for three totally different architectures of CNN. Overall accuracy achieved is implausibly encouraging.

Geetha *et al.*, (2020) developed AN algorithmic rule for diagnostic system with neural network for diagnosing of tooth decay in digital radiographs the diagnostic system includes of Laplacian filtering, window primarily based adjustive threshold, morphological operations, applied mathematics feature extraction and back-propagation neural network. The system provides AN accuracy of 97.1%. There's a need for up the system for classification of tooth decay depth. a lot of improved algorithms and high amount and top of the range datasets could provide still higher cavity detection in clinical apply.

Moutselos *et al.*, (2019) developed a Deep Learning model (Mask R-CNN) to find and classify decay on occlusal surfaces across the total 7-class ICDAS (International tooth decay Detection and Assessment System) scale. Usually this can be often accomplished with none image pre-processing technique and by utilizing super pixels segmentation for the experts' annotations and additionally the analysis of the classifier. Throughout this technique transfer learning and information augmentation are used throughout the coaching of the model. The paper discusses technical details, provides initial results and denotes points for any improvement by fine-tuning the classifier along side an extended dataset.

CHAPTER 3

AIM AND SCOPE

3.1 AIM OF THE PROJECT

The aim of this project is to determine the presence of dental cavities in a patient effectively and to classify the different dental classes diseases by developing an application in such a way that an input image of the dental x-ray images will be given and an output is obtained detecting the presence of cavities.

3.2 SCOPE OF THE PROJECT

- An application employing java script framework react JS are going to be developed as an hospital application where an input dental X-ray images are uploaded to perform diagnosis for dental caries.
- To reduce the time required to detect the presence of dental cavities
- To reduce human error rate.

3.3 EXISTING METHOD

- They aimed to propose a deep learning method to effectively improve the accuracy of reading salient features of dental CT images.
- The system aimed at better detection of medically salient features such as the size, shape, or curvature of the root canal.

3.4 DISADVANTAGES OF EXISTING SYSTEM

- The system does not provide an effective technological solution to detect dental caries in a patient.
- The system only focuses on improving the detection of salient dental features.

3.5 PROPOSED SYSTEM

- In this project we apply a deep learning algorithm to detect dental cavity.
- We will be applying resnet a deep learning algorithm to predict the highest accuracy.
- Detect its presence without the need of a number of consultations from different doctors.
- This leads to earlier prediction of the presence of the dental cavity and allows us to take prior actions immediately to avoid further consequences in an effective and cheap manner avoiding human error rate.
- Optimization and loss minimization techniques will be applied to increase the accuracy of model.
- An application is also developed in such a way that an input image of the dental x-ray images will be given and an output is obtained detecting the presence of cavities.
- Thus this project is used to detect the occurrence of dental cavity in a patient effectively.

CHAPTER 4

METHODOLOGY

4.1 TECHNOLOGIES USED

4.1.1 Deep learning

Deep learning is to boot a transportable coding system package that mimics the network of neurons in associate exceedingly terribly brain. It's a cluster of machine learning and is termed deep learning as a results of it makes use of deep neural networks.

Deep learning algorithms are created with connected layers.

- The first layer is termed the Input Layer
- The last layer is termed the Output Layer
- All layers in between are noted as Hidden Layers. The word deep suggests that the network be an area of neurons in extra than a strive of layers.

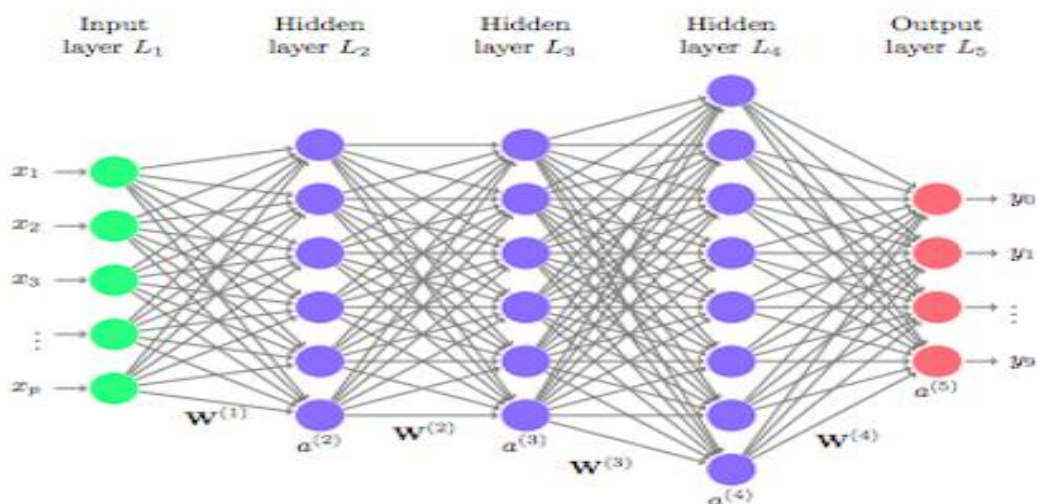


Fig: 4.1 Deep Learning Layers

Each Hidden layer consists of neurons. The neurons are connected to every totally utterly totally different. The cell will process then propagate the signal it receives the layer on high of it. The strength of the signal given the cell among future layer depends on the load, bias and activation perform.

4.1.1.1 Deep Learning Process

A deep neural network provides progressive accuracy in many tasks, from object detection to speech recognition. They are going to seek out automatically, whereas not predefined data expressly coded by the programmers.

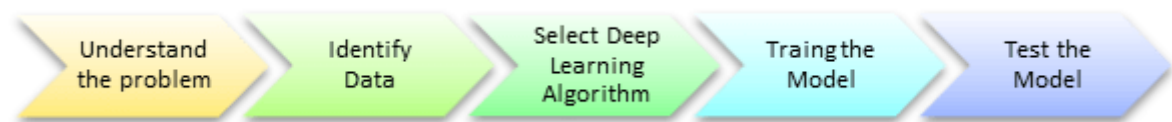


Fig : 4.2 Deep Learning Process

Each layer represents a deeper level of information, i.e., the hierarchy of information. A neural network with four layers will learn heaps of advanced feature than there with a strive of layers.

The learning happens in an passing strive of phases:

- The first section consists of applying a nonlinear transformation of the input and build a arithmetic model as output.
- The second section aims at rising the model with a mathematical technique noted as spinoff.

The neural network repeats these a strive of phases several to thousands of your time until it's reached a tolerable level of accuracy. The repeat of this two-phase is termed degree iteration.

4.1.1.2 Convolutional Neural Networks (CNN)

CNN a multi-layered neural network with a singular vogue designed to extract extra and additional advanced selections of the data at each layer to determine the output. CNN's are compatible for activity tasks.

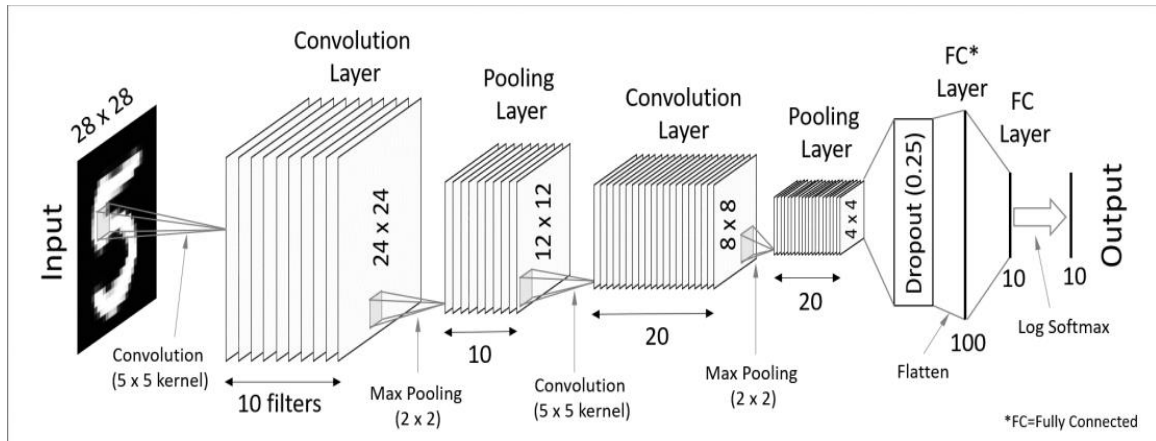


Fig: 4.3 CNN

CNN is usually used once there's degree unstructured data set (e.g., images) and then the practitioners ought to extract information from it.

For instance, if the task is to predict a picture caption:

- The CNN receives a picture of as associate example a cat, this image, in pc term, is else a bunch of the image half. Generally, one layer for the greyscale image and three layers for a color image.
- Throughout the feature learning (i.e., hidden layers), the network will check that distinctive selections.
- Once the network whole learned the thanks to acknowledge an image, it's planning to provides an opportunity for every image it's responsive to. The label with the only real probability will become the prediction of the network.

A Convolutional Neural Network (CNN, or ConvNet) are a special quite multi-layer neural networks, designed to acknowledge visual patterns directly from part

footage with bottom Pre-processing. The ImageNet project is else associate outsized visual database designed to be used in visual seeing code package analysis. The ImageNet project runs degree annual code package contest, the ImageNet massive Scale Visual Recognition Challenge (ILSVRC), where code package programs contend to properly classify and observe objects and scenes.

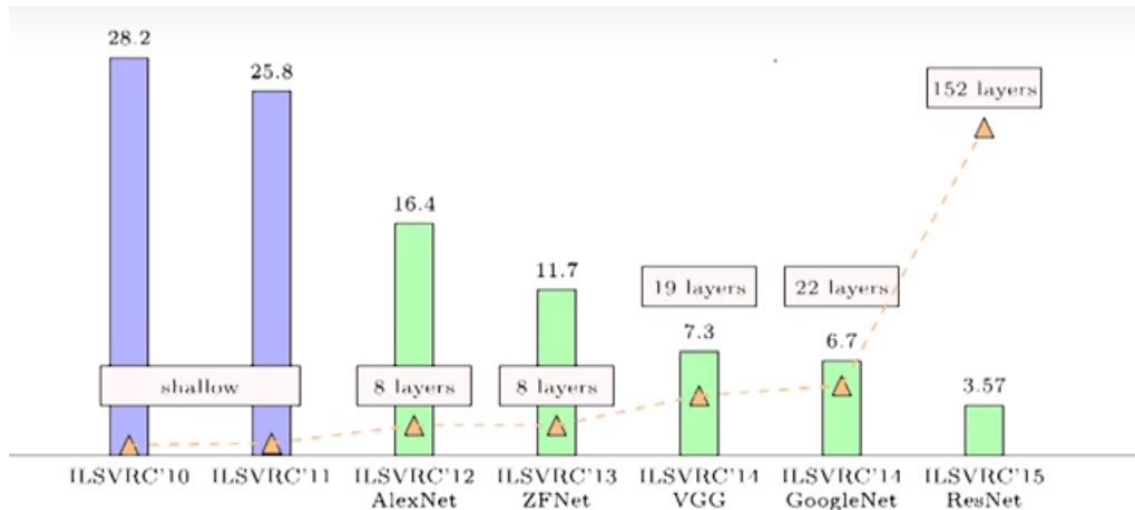


Fig: 4.4 Types of CNN

4.1.2 Machine Learning

Machine Learning is that the earth of study that has computers the potential to hunt out whereas not being expressly programmed. ML is one in every of the foremost exciting technologies that one would have ever encounter. As a result of it's clear from the name, it offers the laptop computer that produces it heaps of a tiny low amount like humans: the property to be told. Machine learning is actively getting used presently, perhaps in extra places than one would expect.

A set of machine learning is closely associated with technique statistics, that focuses on making predictions follow computers; but not all machine learning is arithmetic learning. The study of mathematical improvement delivers ways in which within which, theory and application domains to the sphere of machine learning. Technique is to boot a connected field of study, specializing in alpha data

analysis through unattended learning. In its application across business problems, machine learning is else named as prognostic analytics.

Machine learning involves computers discovering but they are going to perform tasks whereas not being expressly programmed to undertake and do to thus. It involves computers learning from data provided therefore as that they perform positive tasks. For easy tasks assigned to computers, it's potential to program algorithms telling the machine to execute all steps required to resolve the matter at hand; on the computer's part, no learning is required. For heaps of advanced tasks, it's strong for somebody's to manually find yourself the desired algorithms. In follow, it's planning to end up to be heaps of wise to assist the machine develop its own formula, instead of having human programmers specify every needed step.

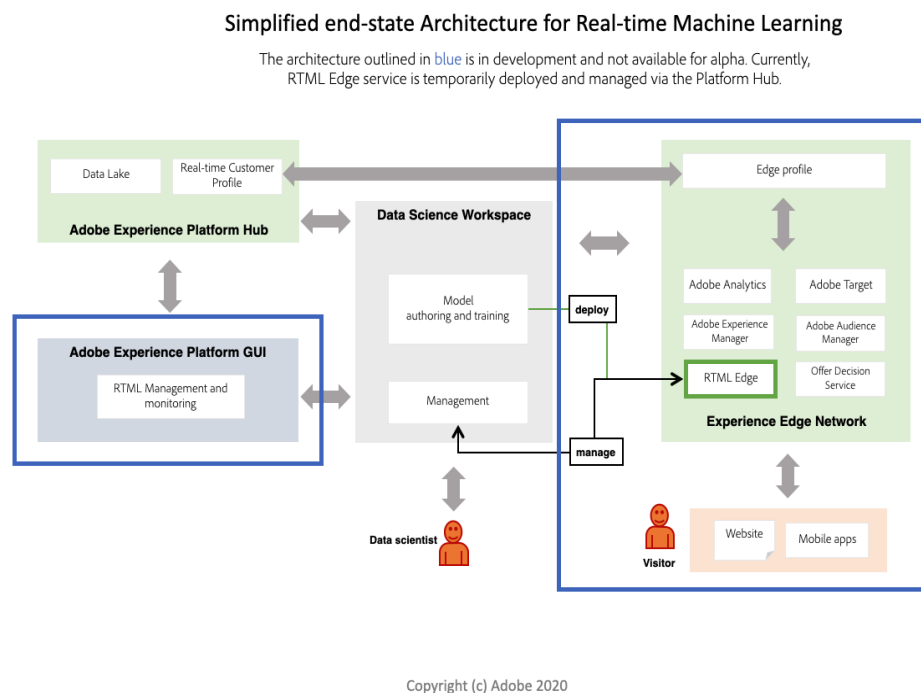


Fig : 4.5 Machine Learning Architecture

4.1.3 Front End Development

ReactJS primarily is degree code document JavaScript library that's used for building user interfaces specifically for single page applications. It's used for handling scan layer for web and mobile apps. React to boot permits to form reusable UI parts.

React permits developers to form massive web applications which may modification data, whereas not reloading the page. React is to be fast, scalable, and simple. It works alone on user interfaces in application. This corresponds to seem at among the MVC model. It's going to be used with a combination of assorted JavaScript libraries or frameworks, like Angular JS in MVC.

JSX stands for JavaScript XML. It's degree XML/HTML like syntax used by React. It extends the ECMA Script thus XML/HTML like text can co-exist at the aspect of Java script react code. This syntax is employed by the pre-processors to rework language like text found in Java script files into ancient Java script objects. With JSX we've AN inclination to are able to go a step additional by everyplace another time embedding the language code at intervals the Java script. This makes language codes easy to grasp and boosts Java script's performance whereas making our application durable.



Fig : 4.6 React JS Architecture

4.2 SYSTEM ARCHITECTURE

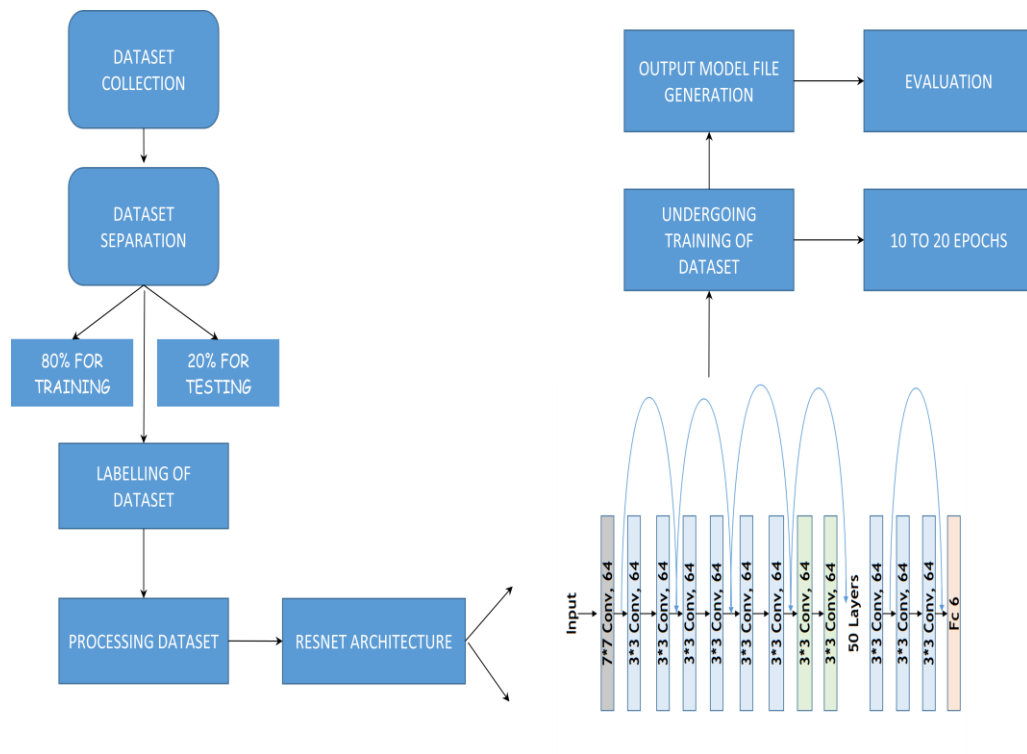


Fig: 4.7 System Architecture

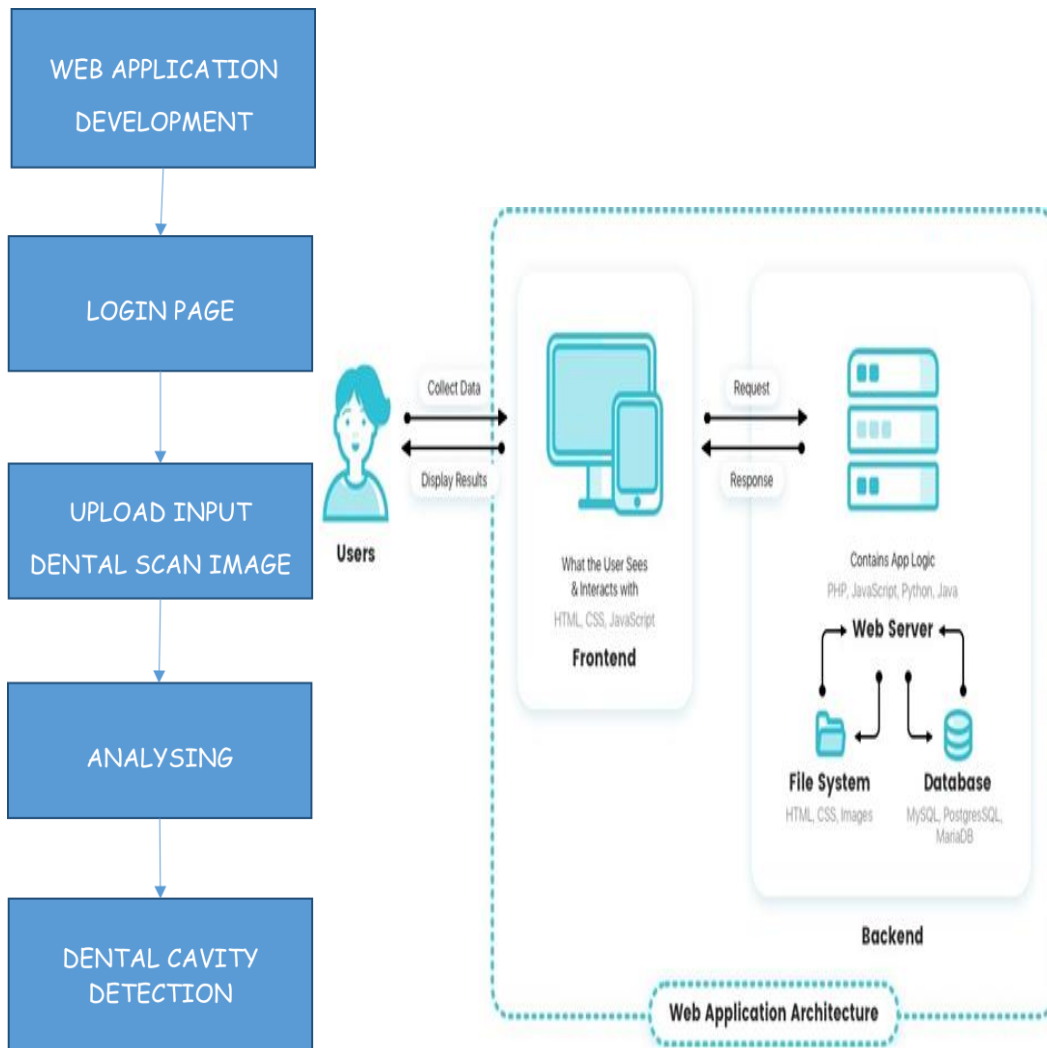


Fig : 4.8 Web Application Architecture

4.3 MODULE DESCRIPTION

- Dataset Collection Module
- Separation of dataset
- Data augmentation module
- Feature extraction using resnet architecture
- Classification using machine learning algorithms
- Web application development

4.3.1 Dataset Collection Module

- Dataset assortment module is that the method of grouping X-ray pictures of teeth that may be processed by the system for activity of deep learning process.
- There are 3 steps of grouping information,
 - Manually finding and downloading the X-ray pictures which might take an extended time merely because of the quantity of human work concerned.
 - Since information has become such a valuable trade goods within the deep learning era, abundant of the info will be found from third party resources.
 - Starting with a network pre-trained on an outsized dataset, and so fine tune on our own.

4.3.2 Separation Of Dataset

- To train any deep learning model no matter what variety of dataset is getting used the dataset needs to be split into coaching dataset and testing dataset.
- The dataset is split within the magnitude relation 80:20 i.e. eightieth of the info are going to be used for coaching the model whereas twenty will be used for testing the model that's engineered out of it.
- When cacophonous a dataset there square measure 2 competitive concerns:
 - If you have got less coaching information, your parameter estimates have larger variance.
 - And if you have got less testing information, your performance datum can have larger variance.

4.3.3 Data Augmentation Module

- Data augmentation could be a technique to unnaturally produce new coaching information from existing coaching information. Usually this can be often done by applying domain-specific techniques to examples from the

coaching information that create new and completely different coaching examples.

- Image information augmentation is that the most well-known variety of information augmentation and involves making remodeled versions of pictures at intervals the coaching dataset that belong to identical category because the original image.
- The performance of deep learning neural networks typically improves with the standard of knowledge offered.

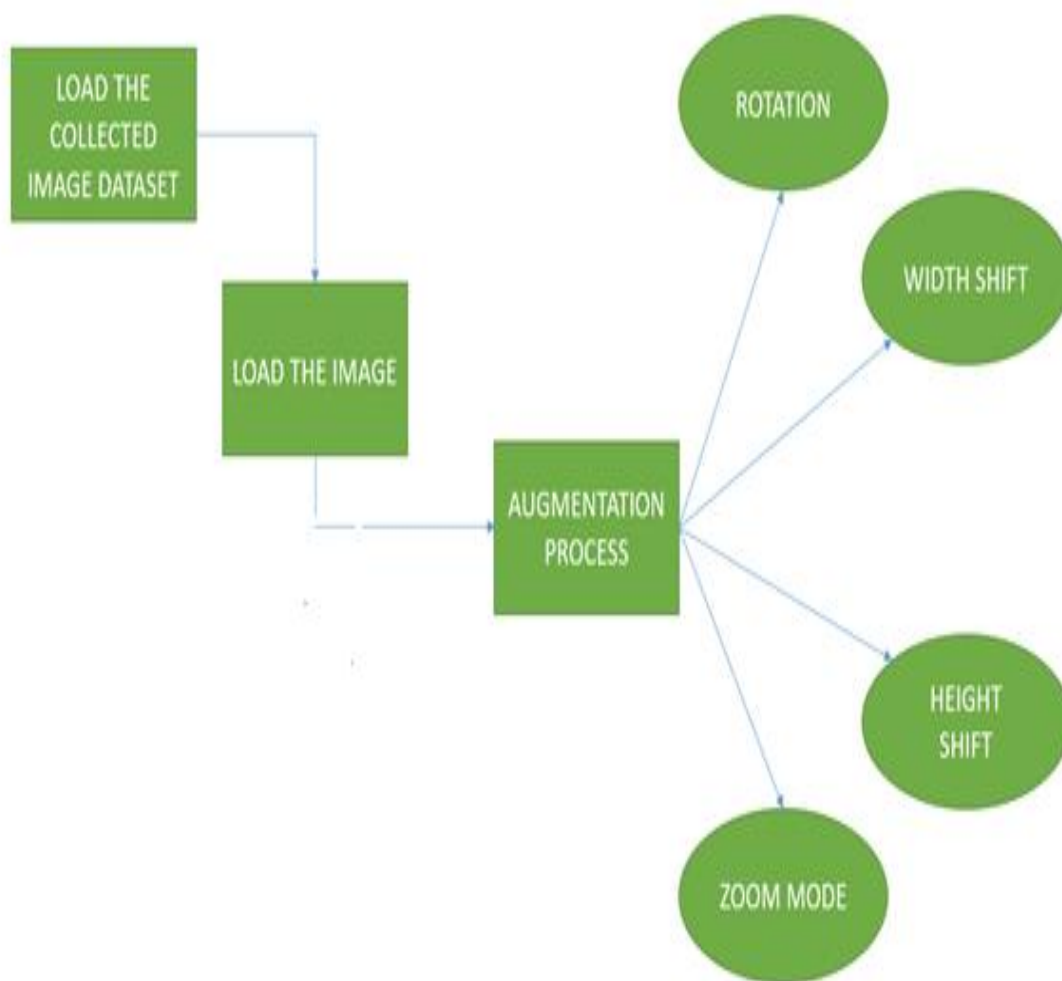


Fig : 4.9 Data Augmentation

4.3.4 Feature Extraction Using Resnet50

In this project the resnet50 design is utilized to effectively determine and discover the presence of decay.

The design of ResNet50 has four stages as shown at intervals the diagram below. The network will take the input image having height, breadth as multiples of thirty two and 3 as channel breadth. For the sake of rationalization, we have a tendency to square measure planning to think about the input size as $224 \times 224 \times 3$. Each ResNet design performs the initial convolution and max-pooling victimization 7×7 and 3×3 kernel sizes severally. Afterward, Stage one of the network starts and it's three Residual blocks containing three layers every. The dimensions of kernels performs the convolution operation altogether three layers of the block of stage one square measure sixty four, sixty four and 128 severally. The curvilineal arrows check with the identity affiliation. The broken connected arrow represents that the convolution operation at intervals the Residual Block is performed with stride two, hence, the scale of input square measure reduced to half in terms of height and breadth however the channel breadth square measure doubled. As we have a tendency to progress from one stage to a unique, the channel breadth is doubled and additionally the dimensions of the input is reduced to half.

Finally, the network incorporates a median Pooling layer followed by a very connected layer having a thousand neurons (ImageNet category output).

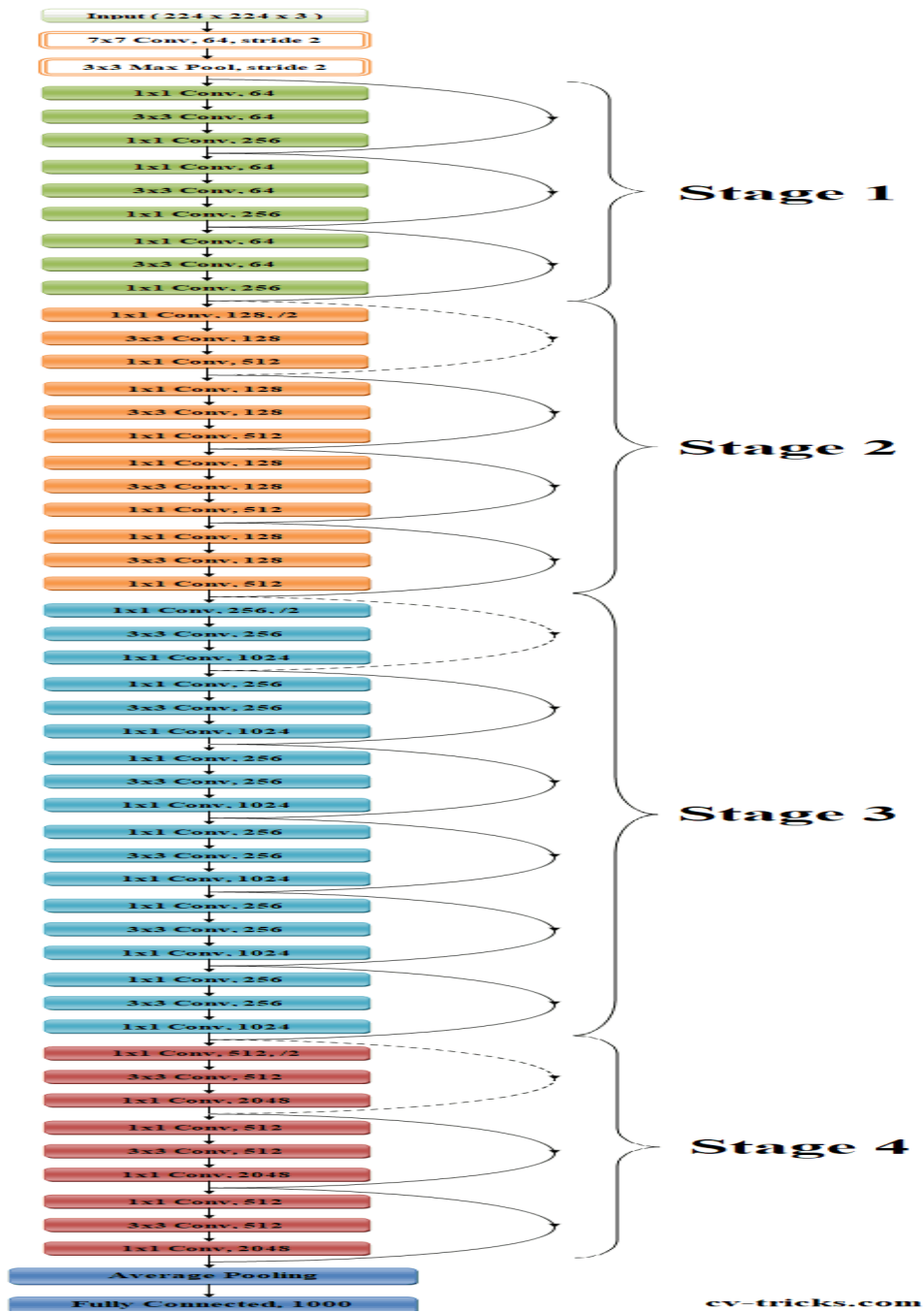


Fig : 4.10 Resnet 50 Architecture

4.3.5 Classification using machine learning algorithms

In this project 2 completely different machine learning algorithms logistic regression and SVM algorithms are used for giving a comparison of their accuracies.

- Logistic Regression**– This method is employed for analyzing the dataset and produces a binary outcome. One or a lot of autonomous variables could have consisted of the dataset. The result's determined by these variables that square measure divided in nature. That suggests solely 2 results square measure attainable. It's a particular class of regression and it's used at intervals the sole because of predict the binary and categorical output. Logistic Regression technique is employed to manage the impact of various autonomous variables that square measure given at the identical time. This technique additionally predicts anybody of the 2 freelance classes of variables. Supply regression styles the best-fitting perform with the assistance of the foremost probability technique thus on maximise the chance of classifying the recognized information into the right division. Numerous appliances of supply regression square measure forecast market trends, to travel looking the success and failure rates in results, verity or false class in recruiting workers supported their performance in want of employment, image categorization, health care .

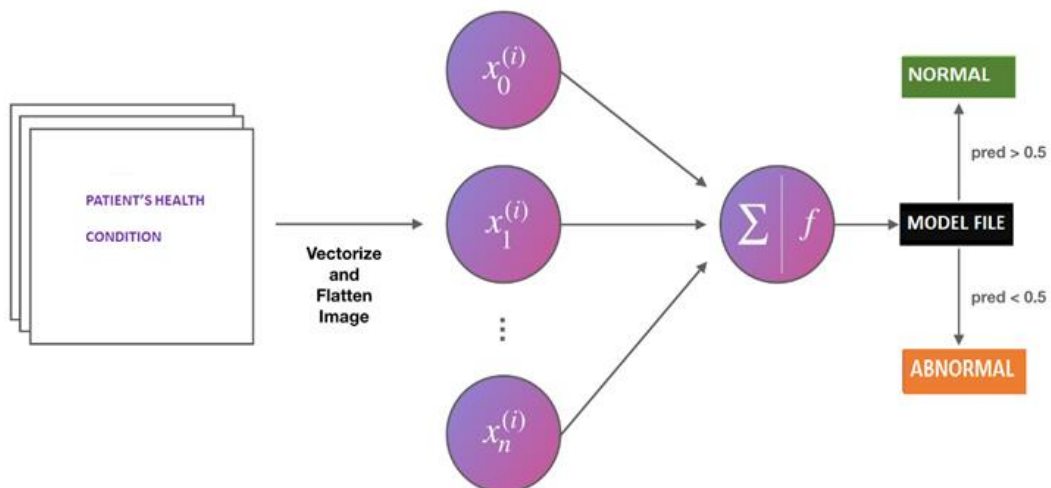


Fig: 4.11 Logistic regression architecture

- Support Vector Machine** - SVM is one in every of the foremost standard supervised Learning algorithms, that is employed for Classification also as Regression issues. However, primarily, it's used for Classification issues in Machine Learning. The goal of the SVM algorithmic program is to make the simplest line or call boundary that may segregate n-dimensional house into categories in order that we will simply place the new datum within the correct class within the future. This best call boundary is termed a hyperplane. SVM chooses the acute points/vectors that facilitate in making the hyperplane. These extreme cases square measure known as support vectors, and thus algorithmic program is termed as Support Vector Machine. Think about the below diagram during which there square measure 2 completely different classes that square measure classified employing a call boundary or hyperplane.

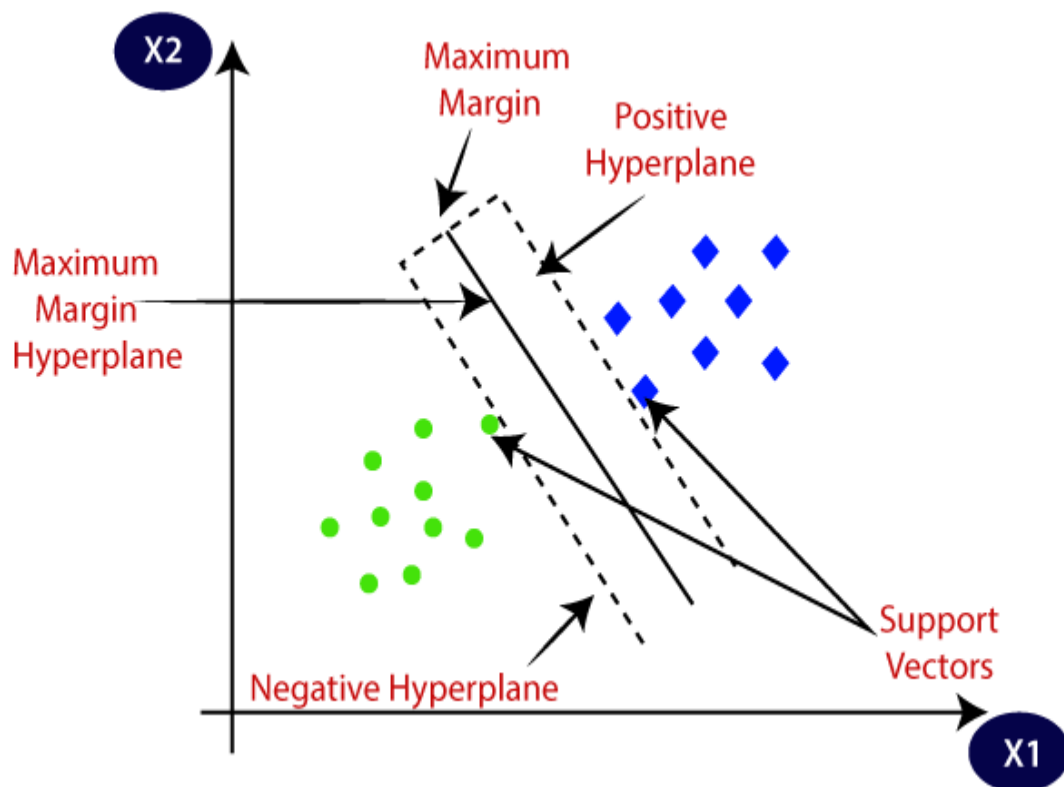


Fig : 4.12 Support Vector Machine architecture

4.3.6 Web Application Development

- In this project, react JS is utilized as a framework for net development. React JS could be a Java Script library employed in net development to create interactive components on websites (User Interfaces).
- Due to its several advanced options like Virtual DOM, Interactive interfaces, Easy-to-use, Alternatives to alternative libraries, SEO friendly, versatile Development, fast access to developers this can be been used for developing the net application.
- An application is developed in such the way that an input image of the dental X-ray image are going to be given and an output is obtained.
- An information are going to be managed victimization that the prediction method happens within the backend and also the result's been fetched through the net application.

4.4 SOFTWARE USED

- Microsoft visual studio
- Python

4.4.1 Microsoft Visual Studio

In this project we've associate inclination to make use of the Microsoft visual studio as a result of the IDE. Microsoft Visual Studio is associate integrated development surroundings (IDE) from Microsoft. It's accustomed develop portable computer laptop computer programs, additionally as websites, web apps, web services and mobile apps. Visual Studio uses Microsoft code development platforms like Windows API, Windows Forms, Windows Presentation Foundation, Windows Store and Microsoft Silver light. It'll prove every native code and managed code.

Visual Studio includes a code editor supporting IntelliSense (the code completion component) but as code refactoring. The integrated program works efficiently as a

source-level programme and a machine-level programme. Varied constitutional tools embrace a code profiler, designer for building interface applications, web designer, class designer, and data schema designer. It accepts plug-ins that enhance the utility at on the point of every level—including adding support for provide management systems (like Subversion and Git) and adding new toolsets like editors and visual designers for domain-specific languages or toolsets for various aspects of the code development lifecycle.

Visual Studio supports thirty six all absolutely all totally different linguistic communications and permits the code editor and programme to support (to variable degrees) nearly any language, provided a language-specific service exists. constitutional languages embrace C, C++, C++/CLI, Visual Basic .NET, C#, F#, JavaScript, Type Script, XML, XSLT, HTML, and CSS. Support for various languages like Python, Ruby, Node.js, and M among others is gettable via plug-ins. Java (and J#) were supported among the past.

4.4.2 Python

In this project we've associate inclination to make use of the python language as a results of the event language. In technical terms, Python is associate object-oriented, language with integrated dynamic linguistics primarily for web and app development. It's totally partaking among the sphere of speedy Application Development as a results of it offers dynamic writing and dynamic binding picks. Python is comparatively easy, so it's straightforward to hunt out since it needs a singular syntax that focuses on readability. Developers can scan and translate Python code long easier than varied languages. In turn, this reduces the value of program maintenance and development as a results of it permits teams to figure collaboratively whereas not very important language and talent barriers. To boot, Python supports the utilization of modules and packages, which suggests that programs unit of measure usually designed throughout a awfully ancient vogue and code is reused across a diffusion of comes. Once you have got developed a module or package you wish, it's about to be scaled to be used in varied comes, and it's easy to import or export these modules.

CHAPTER 5

RESULTS AND PERFORMANCE ANALYSIS

5.1 COLLECTION OF DATASET

Dataset collection involves the process of collecting different dental cavities dataset.

Various datasets were collected and one example among the collected dataset can be found below



Fig : 5.1 Dataset collected

5.2 SEPARATION OF DATASET

The datasets are separated into different categories to undergo preprocessing which can be seen in the below figure

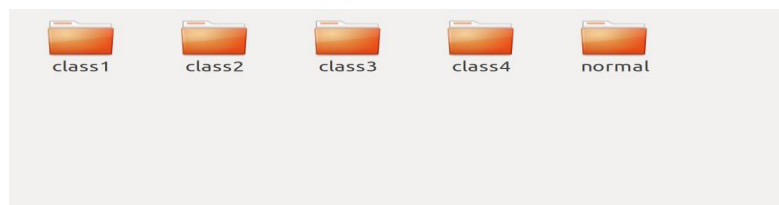


Fig : 5.2 Dataset Separation

5.3 BEFORE AND AFTER PREPROCESSING

The datasets are then preprocessed to form an equal aspect ratio so that it can be made ready for training with the model.



Fig : 5.3 Dental Image Before Preprocessing

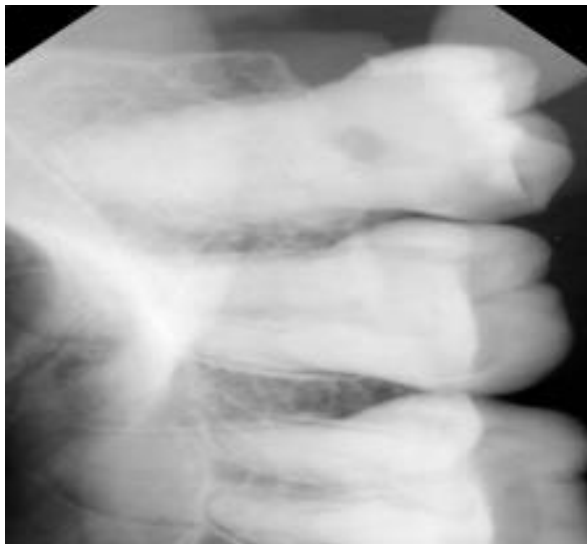


Fig : 5.4 Dental Image After Preprocessing

5.4 BEFORE AND AFTER DATA AUGUMENTATION

The next step is data augmentation which duplicates the collected data into many images so that the prediction percentage can be increased.



Fig: 5.5 Dental Image Before Data Augmentation

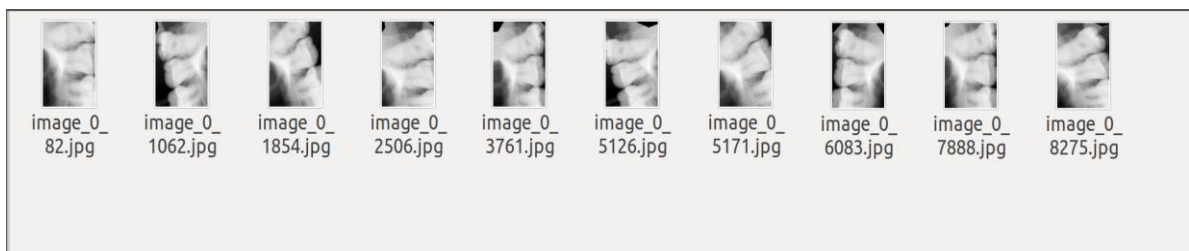


Fig : 5.6 Dental Image After Data Augmentation

5.5 FEATURE EXTRACTION

The datasets are trained using the resnet 50 architecture to achieve feature extraction and is been printed that can be seen in the following figure

```
[INFO] evaluating after fine-tuning...
```

	precision	recall	f1-score	support
class1	1.00	1.00	1.00	26
class2	0.90	1.00	0.95	19
class3	1.00	1.00	1.00	21
class4	0.88	1.00	0.93	21
normal	1.00	0.83	0.91	30
accuracy			0.96	117
macro avg	0.96	0.97	0.96	117
weighted avg	0.96	0.96	0.96	117

Fig: 5.7 Feature extraction using Resnet50 Architecture

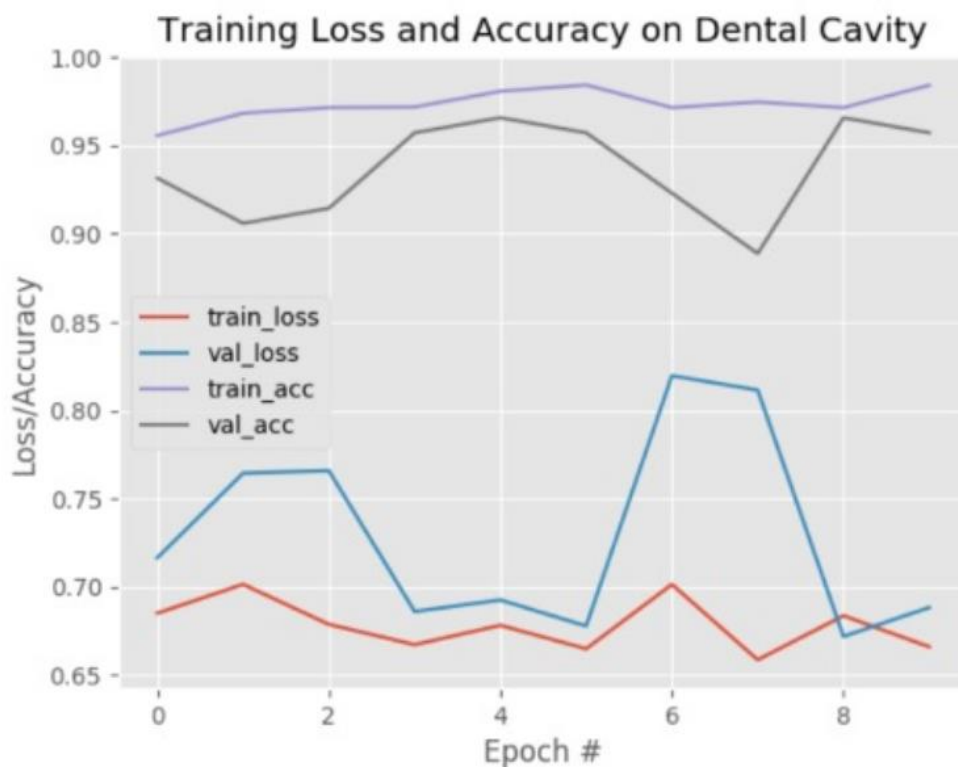


Fig : 5.8 Graph Obtained From Resnet 50 Architecture

5.6 TRAINING USING LOGISTICS REGRESSION

The next step is the training of the dataset with classification obtained using two different machine learning algorithms. The below image shows the training results obtained after using logistic regression for classification

```
[INFO] best hyperparameters: {'C': 0.1}
[INFO] evaluating...
      precision    recall  f1-score   support

class1      1.00      1.00      1.00        32
class2      1.00      1.00      1.00        32
class3      1.00      1.00      1.00        39
class4      1.00      1.00      1.00        30
normal      1.00      1.00      1.00        33

accuracy          1.00          166
macro avg      1.00      1.00      1.00        166
weighted avg   1.00      1.00      1.00        166
```

Fig: 5.9 Training using logistic regression

5.7 TRAINING USING SUPPORT VECTOR MACHINE

The below image shows the training results obtained after using Support Vector Machine (SVM) algorithm for classification.

```
      precision    recall  f1-score   support

class1      0.94      1.00      0.97        32
class2      0.31      1.00      0.48        32
class3      0.00      0.00      0.00        39
class4      1.00      1.00      1.00        30
normal      0.00      0.00      0.00        33

accuracy          0.57          166
macro avg      0.45      0.60      0.49        166
weighted avg   0.42      0.57      0.46        166

[INFO] saving model...
```

Fig: 5.10 Training using support vector machine (SVM)

5.8 WEB DEVELOPMENT

A web application using react JS is developed to effectively act as an interface to the user for effective analysis. The below image shows the login page to the web application.

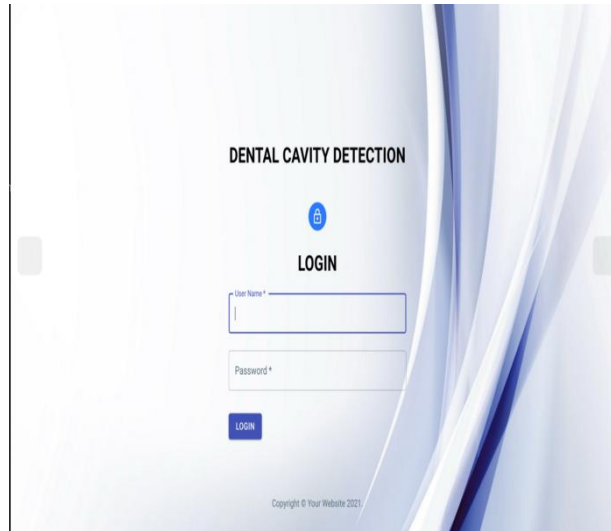


Fig: 5.11 Login page to the web application

The below image shows the user uploading a dental scanned image for effective dental cavity prediction

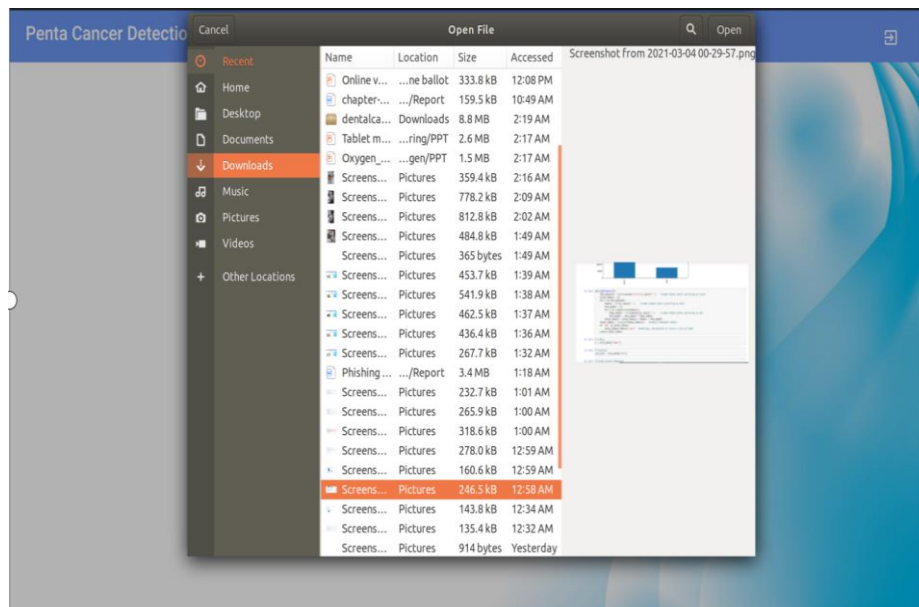


Fig: 5.12 Dental Scan Image Upload

5.9 RESULTS OBTAINED

On uploading an image the result shows the class to which the dental cavity is related to.

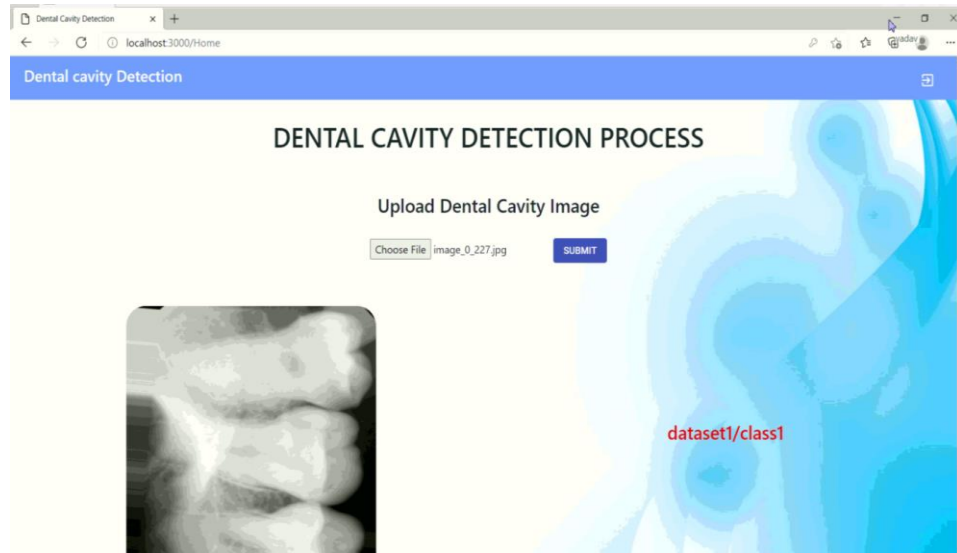


Fig: 5.13 Class 1 dental prediction

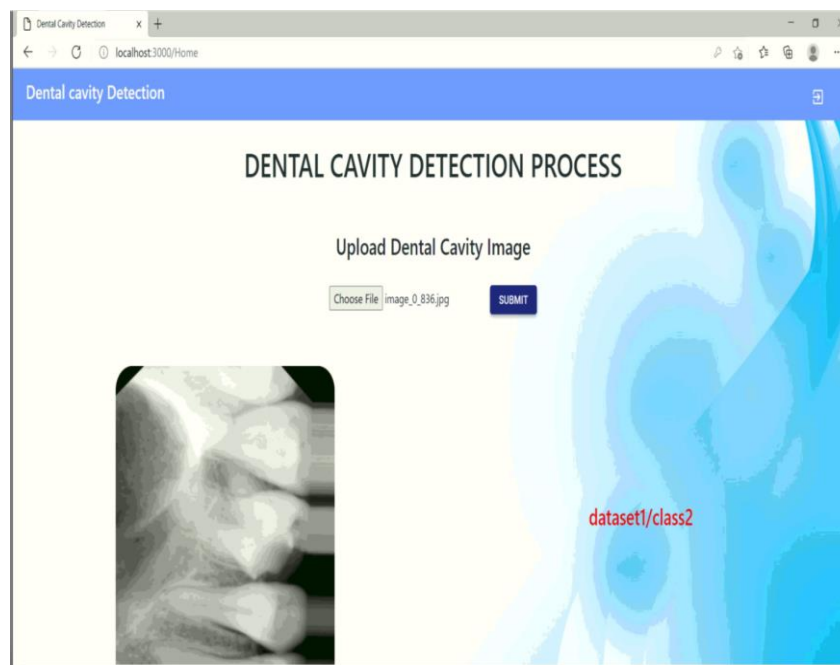


Fig: 5.14 Class 2 dental prediction

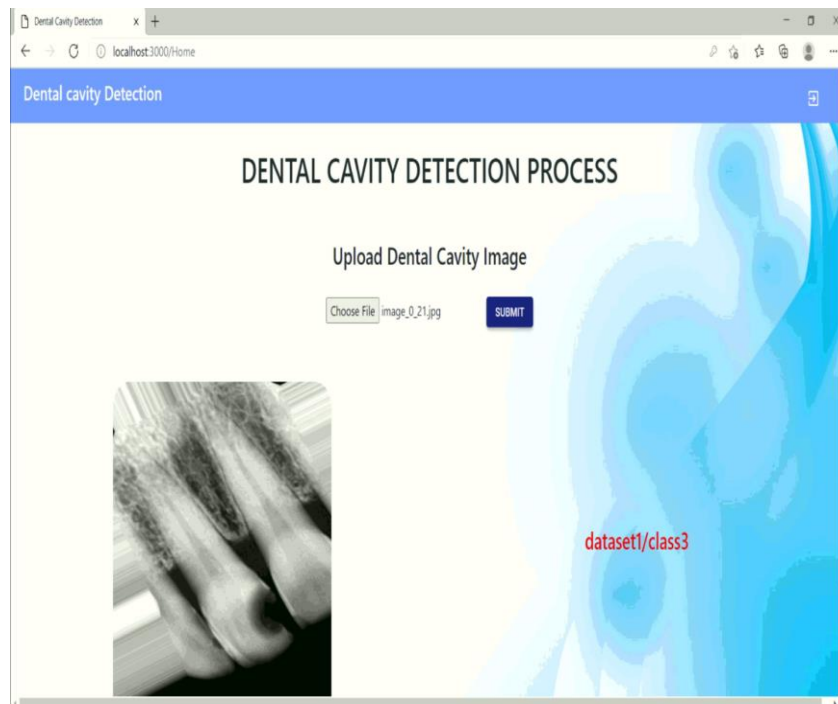


Fig: 5.15 Class 3 dental prediction

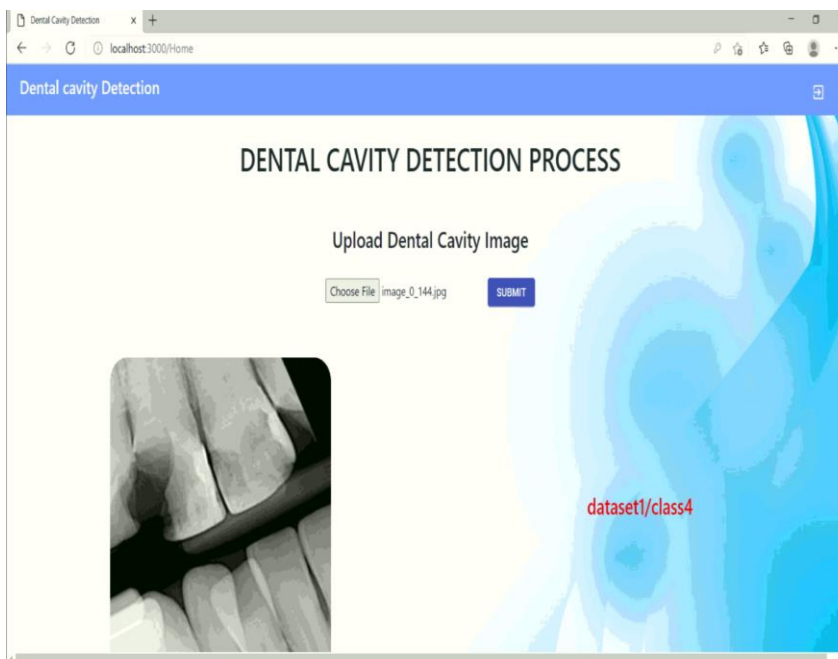


Fig: 5.16 Class 4 dental prediction

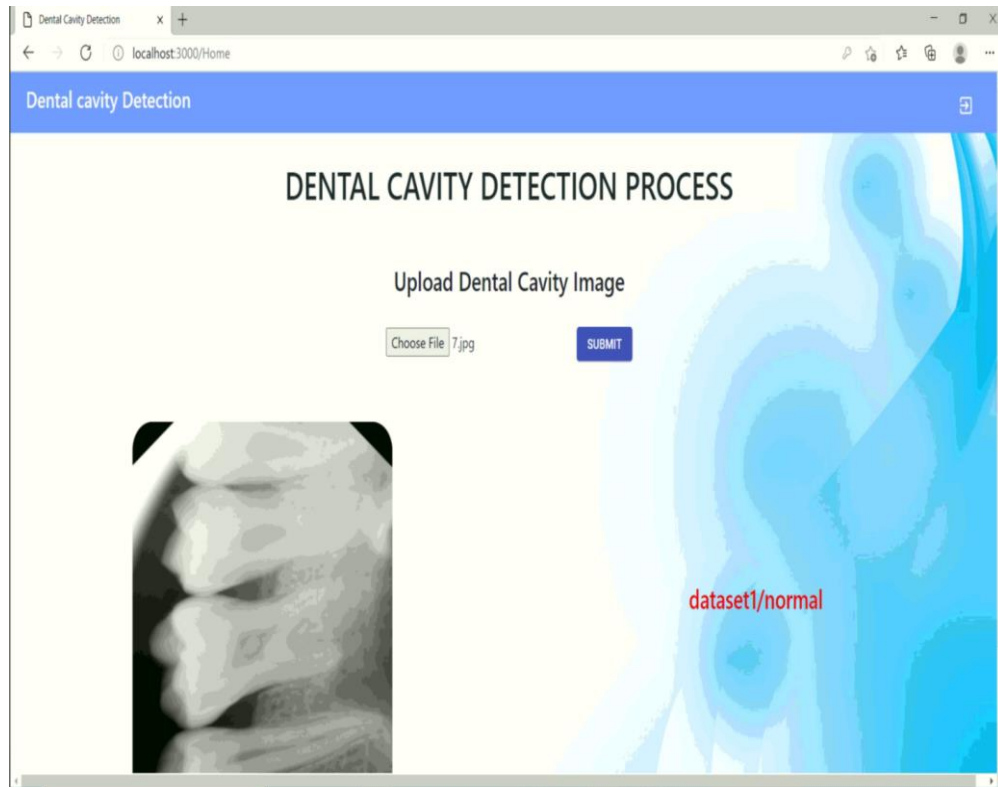


Fig: 5.17 Normal dental prediction

Thus, from the above results it is clear that we have efficiently made a project for successfully detection of for different dental cavities and a comparative analysis of the accuracies obtained after training with two different machine learning algorithms such as logistic regression and Support Vector Machine (SVM). Thus, we have successfully implemented the scope of the project.

CHAPTER – 6

SUMMARY AND CONCLUSION

6.1 SUMMARY

The detection of dental cavities is quite very important. This project is used to find the presence of dental caries and provide prior measures to avoid further consequences using a comparative analysis of the accuracies using two different machine learning algorithms such as logistic regression and support vector machine and also an application is developed in such a way that an input image of the dental X- ray images will be given and an output is obtained detecting the presence of dental cavities. This also helps in providing efficient treatment in a most cheap way and eventually reduce the time required for detecting and finding dental caries in the current state.

6.2 CONCLUSION

In this project , Resnet 50 a deep learning technique for feature extraction and a comparative analysis between two different machine learning algorithms such as logistic regression and support vector machine has been successfully done. The performance of classification method was validated based on accuracy, precision, recall, f1-score gave better results. Finally we compared and concluded that logistic regression outperforms SVM classifier with greater accuracy. An application is developed in such a way that an input image of the dental X- ray images will be given and an output is obtained detecting the presence of dental cavities. So this reduces the time required for manual classification and eliminates the human error rate by this project.

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APPENDIX

```
# python extract_features.py --dataset dataset --output features.hdf5
```

```
# import the necessary packages
```

```
from tensorflow.keras.applications import ResNet50
# from tensorflow.keras.applications import imagenet_utils
from tensorflow.keras.preprocessing.image import img_to_array
from tensorflow.keras.preprocessing.image import load_img
from sklearn.preprocessing import LabelEncoder
from pyimagesearch.io import HDF5DatasetWriter
from imutils import paths
import numpy as np
import progressbar
import argparse
import random
import os
import tensorflow as tf
```

```
# construct the argument parse and parse the arguments
```

```
ap = argparse.ArgumentParser()
ap.add_argument("-d", "--dataset", required=True,
                help="path to input dataset")
ap.add_argument("-o", "--output", required=True,
                help="path to output HDF5 file")
ap.add_argument("-b", "--batch-size", type=int, default=32,
                help="batch size of images to be passed through network")
ap.add_argument("-s", "--buffer-size", type=int, default=1000,
                help="size of feature extraction buffer")
args = vars(ap.parse_args())
```

```
# store the batch size in a convenience variable
```

```

bs = args["batch_size"]

# grab the list of images that we'll be describing then randomly
# shuffle them to allow for easy training and testing splits via
# array slicing during training time
print("[INFO] loading images...")
imagePaths = list(paths.list_images(args["dataset"]))
random.shuffle(imagePaths)

# extract the class labels from the image paths then encode the
# labels
labels = [p.split(os.path.sep)[-2] for p in imagePaths]
le = LabelEncoder()
labels = le.fit_transform(labels)

# load the VGG16 network
print("[INFO] loading network...")
model = ResNet50(weights="imagenet", include_top=False)

# initialize the HDF5 dataset writer, then store the class label
# names in the dataset
dataset = HDF5DatasetWriter((len(imagePaths), 7 * 7 * 2048),
                             args["output"], dataKey="features", bufSize=args["buffer_size"])
dataset.storeClassLabels(le.classes_)

# initialize the progress bar
widgets = ["Extracting Features: ", progressbar.Percentage(), " ",
           progressbar.Bar(), " ", progressbar.ETA()]
pbar = progressbar.ProgressBar(maxval=len(imagePaths),
                               widgets=widgets).start()

# loop over the images in batches
for i in np.arange(0, len(imagePaths), bs):

```

```

# extract the batch of images and labels, then initialize the
# list of actual images that will be passed through the network
# for feature extraction
batchPaths = imagePaths[i:i + bs]
batchLabels = labels[i:i + bs]
batchImages = []

# loop over the images and labels in the current batch
for (j, imagePath) in enumerate(batchPaths):
    # load the input image using the Keras helper utility
    # while ensuring the image is resized to 224x224 pixels
    image = load_img(imagePath, target_size=(224, 224))
    image = img_to_array(image)

    # preprocess the image by (1) expanding the dimensions and
    # (2) subtracting the mean RGB pixel intensity from the
    # ImageNet dataset
    image = np.expand_dims(image, axis=0)
    #image = imagenet_utils.preprocess_input(image)

    # add the image to the batch
    batchImages.append(image)

# pass the images through the network and use the outputs as
# our actual features
batchImages = np.vstack(batchImages)
features = model.predict(batchImages, batch_size=bs)

# reshape the features so that each image is represented by
# a flattened feature vector of the `MaxPooling2D` outputs
features = features.reshape((features.shape[0], 7 * 7 * 2048))

# add the features and labels to our HDF5 dataset

```

```
dataset.add(features, batchLabels)
pbar.update(i)

# close the dataset
dataset.close()
pbar.finish()
```