SAVITRIBAI PHULE PUNE UNIVERSITY

A PROJECT REPORT ON

CLASSIFICATION OF ABSTRACT IMAGES USING MACHINE LEARNING

SUBMITTED TOWARDS THE
FULFILLMENT OF THE REQUIREMENTS OF

BACHELOR OF ENGINEERING (Computer Engineering)

BY

Animesh Karnewar	Exam No:B120054328
Yash Gupta	Exam No:B120054496
Chinmay Sawant	Exam No:B120054421
Ameeth Kanawaday	Exam No:B120054325

Under The Guidance of

Prof. D.T. Mane

DEPARTMENT OF COMPUTER ENGINEERING
Pune Institute of Computer Technology
Dhankawadi, Pune-411043

Pune Institute of Computer Technology
DEPARTMENT OF COMPUTER ENGINEERING

CERTIFICATE

This is to certify that the Project Entitled

CLASSIFICATION OF ABSTRACT IMAGES USING MACHINE LEARNING

Submitted by

Animesh Karnewar	Exam No:B120054328
Yash Gupta	Exam No:B120054496
Chinmay Sawant	Exam No:B120054421
Ameeth Kanawaday	Exam No:B120054325

is a bonafide work carried out by Students under the supervision of Prof. D.T. Mane and it is submitted towards the fulfillment of the requirement of Bachelor of Engineering (Computer Engineering).

Prof. D.T. Mane
Internal Guide
Dept. of Computer Engg.

Dr. R. B. Ingle
H.O.D
Dept. of Computer Engg.

Dr. P. T. Kulkarni
Principal
Pune Institute of Computer Technology

Signature of Internal Examiner

Signature of External Examiner

PROJECT APPROVAL SHEET

Project Title

CLASSIFICATION OF ABSTRACT IMAGES USING MACHINE LEARNING

Is successfully completed by

Animesh Karnewar	Exam No:B120054328
Yash Gupta	Exam No:B120054496
Chinmay Sawant	Exam No:B120054421
Ameeth Kanawaday	Exam No:B120054325

at

DEPARTMENT OF COMPUTER ENGINEERING

PUNE INSTITUTE OF COMPUTER TECHNOLOGY

SAVITRIBAI PHULE PUNE UNIVERSITY,PUNE

ACADEMIC YEAR 2016-2017

Prof. D.T. Mane	Dr. R. B. Ingle
Internal Guide	H.O.D
Dept. of Computer Engg.	Dept. of Computer Engg.

Abstract

A picture is worth a thousand words. It refers to the notion that a complex idea can be conveyed with just a single image or that an image of a subject conveys its gist or spirit more efficiently than a description does. An artist using his/her imagination and using surrounding as a canvas creates a painting which consists of many different elements, viz color tones, shapes,intensity, patterns, and rhythms. Abstract painting uses a visual language of form, color, and line to create a composition that may exist with a degree of independence from visual references in the world. Abstract art isn't about making perfect copies of real life. Sometimes, it isn't even about giving the impression of real life without all the little details. In fact, depending on the artists, abstract art became about the process itself. This makes the task of classification of the paintings into genres altogether more difficult. In our project, we describe a systematic method for a machine learning based approach to classifying digital images of abstract art into their most apt artistic styles. This task is mainly achieved by feature extraction and analysis of the prominent features of a class. To increase the classification efficiency, we have used a Convolutional Neural Network on the dataset for complex feature learning. Furthermore, the task of analysis of color emotions of the artistic image helps to gain further insights of the said classes. In the project, we conduct feature extraction along several dimensions like the number of edges, geometric shapes, blob count and color count to construct a Deep Neural Network classifier to identify the style of the painting. To increase the effectiveness of classification we ensemble the two models i.e. Convolutional Neural Network and Deep Neural Network. The hybrid model thus formed outperforms the separate singular models and hence add to the efficiency of classification. The predicted classes and color emotions are used as hashtags which add to the social use of the system. This system can be used in indexing of digital libraries and stores for proper organization and storage of digital abstract art. Thus, by using modern machine learning algorithms and applications of deep learning we strive to learn the elements and features and quantize them to predict the artistic style and genre of the painting.

Acknowledgments

It gives us great pleasure in presenting the project report on ***'CLASSIFICATION OF ABSTRACT IMAGES USING MACHINE LEARNING'****.*

We would like to take this opportunity to thank our internal guide ***Prof. D.T. Mane*** *for giving us all the help and guidance we needed. we are really grateful to him for his kind support. His valuable suggestions were very helpful.*

We are also grateful to ***Prof.R.B.Ingle*** *Head of Computer Engineering Department, PICT, Pune for his indispensable support and suggestions.*

In the end our special thanks to ***Dr. Parag Kulkarni*** *for providing various resources such as laboratory with all needed software platforms, continuous Internet connection, for Our Project.*

Animesh Karnewar
Yash Gupta
Chinmay Sawant
Ameeth Kanawaday
(B.E. Computer Engg.)

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CHAPTER 1
SYNOPSIS

Project Title

CLASSIFICATION OF ABSTRACT IMAGES USING MACHINE LEARNING

Project Option

Industry Sponsored Project

Internal Guide

Prof. D.T. Mane

Sponsorship and External Guide

iKnowlation Research Labs pvt ltd.
Guide: Dr. Parag Kulkarni

Technical Keywords (As per ACM Keywords)

1. Computer Methodologies
    (a) C.2 ARTIFICIAL INTELLIGENCE
        i. C.2.1 Learning
            A. Connectionism and neural nets
            B. Induction
            C. Knowledge acquisition
            D. Language acquisition
            E. Parameter learning
        ii. C.2.2 Distributed Artificial Intelligence
            A. Multi agent systems
        iii. C.2.3 Vision And Scene Understanding
            A. Intensity, color, photometry, and thresholding
            B. Shape
            C. Texture
            D. Representations, data structures, and transforms

Problem Statement

Construct a system using Machine Learning to classify an artist's painting into the genre and interpret the emotions of the painting.

Abstract

- A picture is worth a thousand words. It refers to the notion that a complex idea can be conveyed with just a single still image or that an image of a subject conveys its meaning or essence more effectively than a description does. An artist by the use of his/her imagination and using surroundings as a canvas creates a painting which consists of many different elements, viz color tones, color strokes, intensity, patterns and rhythms. Abstract painting uses a visual language of form, color and line to create a composition that may exist with a degree of independence from visual references in the world. Using modern machine learning algorithms and applications of deep learning we strive to learn these elements and quantize them to predict various implications of the image. The emotions in the image are to be mapped in mathematical models. This will allow us to predict what the artist wants to convey through his/her image. All these would then be mapped into hash tags so as to improve the social applications of the project.

Goals and Objectives

- Classify the images using machine learning to be able to predict the class of the image.
- Detect dominant colors and map the color emotions of the image
- Detect geometrical patterns
- Combining the results of two models
- Creating an ensemble network
- Present relevant Hash tags

Relevant mathematics associated with the Project

System Description:

Let, S be the solution perspective of the given problem statement.
S={ s,e,X,Y,F,DD,NDD,Su,Fu }

where,
s=start state ;
such that, y={ ϕ }
e=end state;
such that, y={Relevant Hash-tags }

X=set of Input ;
such that,
X={x1} where, x1=Input Image

Y=set of Output ;
such that,
Y={y1,y2,y3.y4,y5,y6,y7}
where,
y1=Class Hashtag1
y2=Class Hashtag2
y3=Class Hashtag3
y4=Colour Emotion Hashtag4
y5=Colour Emotion Hashtag5
y6=Colour Emotion Hashtag6
y7=Colour Emotion Hashtag7

F=set of Functions ;
such that,
F={$f_{cnnpredictor}, f_{dnnpredictor}, f_{coloremotionanalyser}, f_{ensembler}$}
where,
$f_{cnnpredictor}$=function that gets CNN class probabilities

$f_{dnnpredictor}$=function that gets DNN class probabilities

$f_{colouremotionanalyser}$=function that gets colour emotion analysis
$f_{colouremotionanalyser}$:$x_1 \rightarrow \{y_4, y_5, y_6, y_7\}$

$f_{ensembler}$=function that combines probabilities of CNN and DNN to get finalresults.
$f_{ensembler}$:$x_1 \rightarrow \{y_1, y_2, y_3\}$

DD=Deterministic Data
={ two dimensional 3 channel rgb image }

NDD=Non Deterministic Data
={ ImageSize, resolution }

Names of Conferences / Journals where papers can be published

- IEEE Transactions
- Springer
- ACM
- Conferences In IIT

Review of Conference/Journal Papers supporting Project idea

YEAR	TITLE	AUTHOR	JOURNAL	SUMMARY
2016	Identifying emotions aroused from the paintings	Xin Lu, Neela Sawant, Michelle G. Newman	Springer Open	Adaptive learning algorithm that leverages labeled photographs and unlabeled paintings to infer the visual appeal of paintings
2016	Style classification and visualization of art paintings genre using self organizing maps	Sang-Geol, Eui-Young Cha	Springer Open	Need to develop objective features to classify art paintings based on scientific methods. For the global features of paintings, color is important
2015	Colour-emotion association study on abstract art painting	Cik Fazilah Hibadullah,Alan Wee-Chung Liew,Jun Jo	IEEE	This paper focuses on the study of relationships between colours and emotionson abstract art images. In this work, the colour featurevectors were extracted from images using the fuzzy colour histogram method

2010	Impressionism, expressionism, surrealism: automated recognition of painters and schools of art.	Shamir L, Macura T, Orlov N, Eckley DM, Goldberg IG	ACM	We describe a method for automated recognition of painters and school arts based on their signatures styles and studied computer based analysis.
2010	Using machine learning for identification of art paintings	Alexander Blessing, kai Wen	Stanford Press	Classifying the paintings based on artists using multi-class SVM with state of the art features
2009	Classifying paintings by artistic genre: An analysis of features and classifier	Jana Zujovic, Lisa Gandy, Scott Friedman, Brian Pardo, Thrasyvoulos N. Pappas	IEEE	Using simple features, it is possible to grasp concepts used for describing a painting. Feature extraction involves gray-level processing and color processing

Table 1.1: Literature Survey

Plan of Project Execution

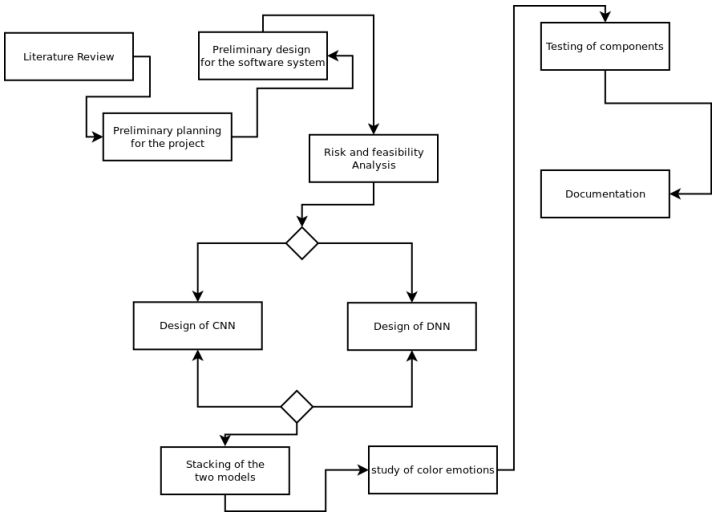


Figure 1.1: Project Execution Plan

step: 1 Analysis of the problems with previous works through literature survey.

step: 2 Prepare preliminary design for the software system.

step: 3 Analysis of risk and feasibility.

step: 4.1 Design of CNN

step: 4.2 Design of DNN

step: 5 Stacking the models together for error reduction.

step: 6 Study of color emotion and analysis of the results

step: 7 Testing the components.

step: 8 Completion of documentation and reports.

CHAPTER 2
TECHNICAL KEYWORDS

Area of Project

Computational And Artifical Intelligence

Technical Keywords

1. Computer Methodologies
    (a) C.2 ARTIFICIAL INTELLIGENCE
        i. C.2.1 Learning
            A. Connectionism and neural nets
            B. Induction
            C. Knowledge acquisition
            D. Language acquisition
            E. Parameter learning
        ii. C.2.2 Distributed Artificial Intelligence
            A. Multi agent systems
        iii. C.2.3 Vision And Scene Understanding
            A. Intensity, color, photometry, and thresholding
            B. Shape
            C. Texture
            D. Representations, data structures, and transforms

CHAPTER 3
INTRODUCTION

Project Idea

- To be able to detect complex emotions and various characteristics of the image using machine learning to classify it into various classes.

Motivation of the Project

- On looking at the general description for any abstract art we noticed some keywords that objectively describe the art. We thus feel that if we make a system to get these objective characteristics we could give a brief idea about the description of an image.
- To prove that a hybrid model works better for classification tasks.

Literature Survey

- R. Kumi, C. M. Conway, M. Limayem and S. Goyal, "Research Article Learning in Colour: How Colour and Affect Influence Learning Outcomes ", *IEEE Transactions on Professional Communication*, vol. 56, pp. 2-15, 2013.
- S. Zeki, "Inner vision: An exploration of art and the brain", *Oxford University Press*, 1999.
- M.Livingstone, "Visionandart: The Biology of Seeing",*International conference on advanced biology*, New York: Harry N. Abrams, 2002.
- C.F. Hibadullah, A.W.C. LiewandJ.Jo,"Colour emotion association study on abstract art painting," *Machine Learning and Cybernetics (ICMLC), International Conference on Machine Learning and Cybernetics*, Guangzhou,pp. 488-493, 2015.

CHAPTER 4

PROBLEM DEFINITION AND SCOPE

Problem Statement

Construct a system using Machine Learning to classify an artist's painting into the genre and interpret the emotions of the painting.

Goals and objectives

Goal and Objectives:

- Classify the images using machine learning to be able to predict the class of the image.
- Detect dominant colors and map the color emotions of the image
- Detect geometrical patterns
- Combining the results of two models
- Creating an ensemble network
- Present relevant Hashtags

Statement of scope

- The images used for training the CNN will be resized to 100*100 format. The images will be colored and all the B/W images will be removed. For color emotion analysis and texture the image as a whole will be considered.
- The manual extraction of features and identifying the intricate aspects of an image can help in classifying any type of image.
- Describing emotions associated with an image on the basis of a psychological mapping of colours to emotions.

Major Constraints

- Input image must be abstract
- Input must be a two dimensional 3 channel rgb image
- Input image must be readable(not corrupted).

Methodologies of Problem solving and efficiency issues

- Neural Networks inherently use matrix operations for solving the problem. We plan to parallelize these operations using GPUs.
- Using Theano/TensorFLow configured to use the GPGPUs we increase the computation speeds.
- Using a neural network as ensembler for two models

Outcome

- Ability to predict the various implications of a given abstract image.(i.e. relevant keywords)

Applications

- Indexing of paintings in art museums
- Generating relevant hashtags for social media applications
- Psychological analysis

Hardware Resources Required

Sr. No.	Parameter	Minimum Requirement
1	CPU Speed	4 GHz
2	RAM	4GB
3	StorageSpace	1GB
4	Nvidia GPU	TitanX

Table 4.1: Hardware Requirements

The resources described above are the minimum requirements needed to deploy the system on server.

Software Resources Required

Platform :

1. Operating System: Linux Ubuntu 14.10 or higher
2. IDE: Jupyter Notebook
3. Programming Language: Python
4. Frameworks: TensorFlow, Keras
5. Modules: PIL,OpenCV,Scikit,Scipy, Sckit-learn, SkiImage,Numpy etc

Since, OpenCV has myriads of image processing functions we decided to use it for feature extraction. Keras provides user friendly way to spawn neural networks. Tensorflow packs in reliability and scalability. Hence we used it as a backend for keras.

CHAPTER 5
PROJECT PLAN

Project Estimates

Reconciled Estimates

Cost Estimate

Our project requires us to work mainly on GPUS , the cost of which is borne by our college under the Nvidia GPU education center scheme.Apart from this all our other softwares are open source and hence require no cost.

Time Estimates

By the end of 2016 we plan to set up an end to end system with bare minimum functionality.

Project Resources

- iknowlation research labs
- Nvidia GPU Education center, PICT, Pune
- Web Crawler(dataset acquisition)
- Internal Guide (Prof D.T. Mane)
- Open Source Software (Ubuntu, TensorFlow,Jupyter)

Risk Management

This section discusses Project risks and the approach to managing them.

Risk Identification

1. Risk 1: Dataset having corrupted images.

2. Risk 2: Invalid training set labels

3. Risk 3: Grayscale images

4. Risk 4: GPU not working properly

5. Risk 5: Irrelevant hashtags being produced.

Risk Analysis

The risks for the Project can be analyzed within the constraints of time and quality

ID	Risk Description	Probability	Impact		
			Schedule	Quality	Overall
1	Corrupted Images	Medium	Low	High	Medium
2	Invalid Labels	Low	Low	High	Medium
3	GrayScale Images	Low	Low	Low	Low
4	GPU error	Medium	High	High	High
5	Irrelevant hashtags	Medium	Low	High	Medium

Table 5.1: Risk Table

Probability	Value	Description
High	Probability of occurrence is	$> 75\%$
Medium	Probability of occurrence is	$26 - 75\%$
Low	Probability of occurrence is	$< 25\%$

Table 5.2: Risk Probability definitions

Overview of Risk Mitigation, Monitoring, Management

Following are the details for each risk.

Impact	Value	Description
Very high	$> 10\%$	Schedule impact or Unacceptable quality
High	$5 - 10\%$	Schedule impact or Some parts of the project have low quality
Medium	$< 5\%$	Schedule impact or Barely noticeable degradation in quality Low Impact on schedule or Quality can be incorporated

Table 5.3: Risk Impact definitions

Risk ID	1
Risk Description	Corrupted Images
Category	Development Environment.
Source	WebCrawler
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	Ignore Such Images
Risk Status	Occurred

Table 5.4: Risk Impact definitions

Risk ID	2
Risk Description	Invalid Labels
Category	Development Environment
Source	Web Crawler
Probability	Medium
Impact	Medium
Response	Mitigate
Strategy	Ignore
Risk Status	Identified

Table 5.5: Risk details

Risk ID	3
Risk Description	Irrelevant hashtags
Category	Output
Source	Web Crawler
Probability	Low
Impact	Medium
Response	Reject
Strategy	Ignore
Risk Status	Identified

Table 5.6: Risk details

Risk ID	4
Risk Description	GPU Error
Category	Development Environment
Source	NvidiaPc's
Probability	Low
Impact	High
Response	Immediate repair
Strategy	requires immediate attention
Risk Status	Identified

Table 5.7: Risk details

Risk ID	5
Risk Description	GrayScale Images
Category	Input
Source	Web Crawler
Probability	Medium
Impact	Medium
Response	Reject
Strategy	Ignore
Risk Status	Identified

Table 5.8: Risk details

Project Schedule

Project task set

Major Tasks in the Project stages are:

- Task 1: Identify Source of dataset
- Task 2: Apply appropriate preprocessing
- Task 3: Train CNN
- Task 4: Identify features to be extracted and train DNN
- Task 5: Ensemble network to combine CNN and DNN
- Task 6: Generate final hashtags

Task network

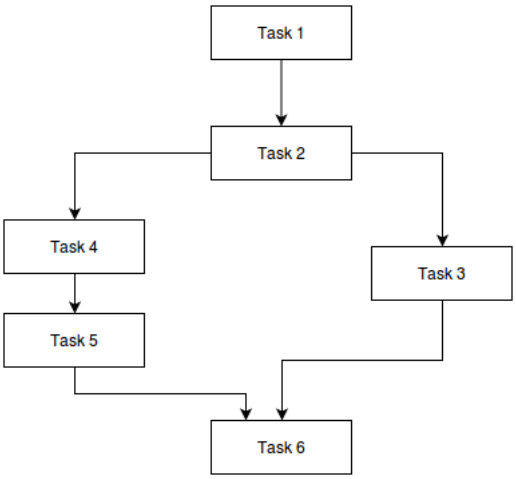


Figure 5.1: Task network

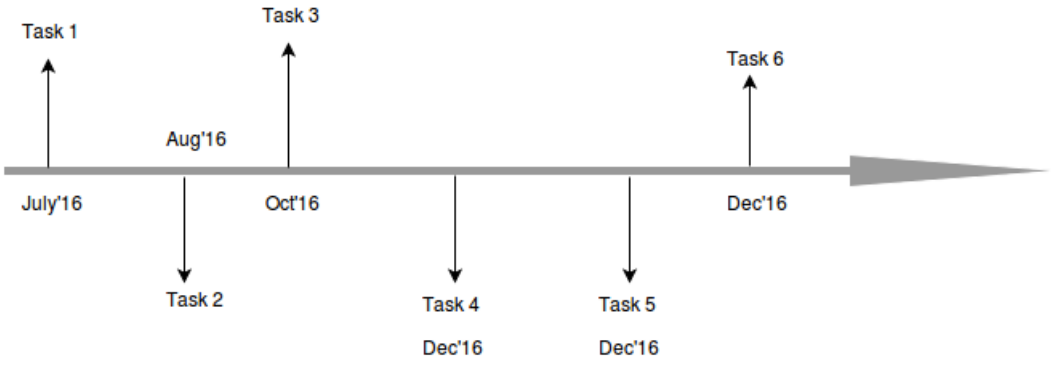


Figure 5.2: timeline chart

Timeline Chart

Team Organization

Team structure

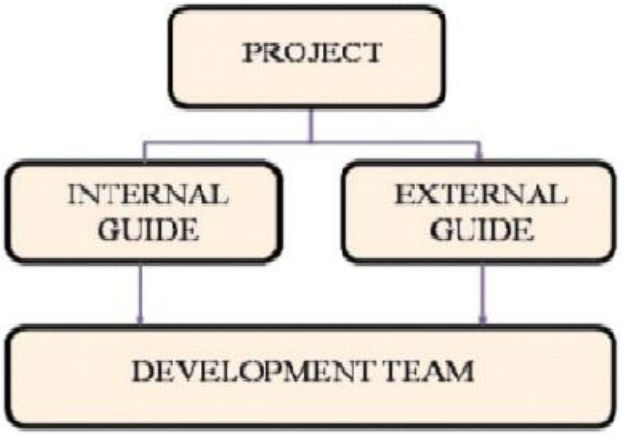


Figure 5.3: Project team structure

Management reporting and communication

- Email with our sponsor
- Regular in-person meetings with the guides
- Periodic reviews
- Github for maintaining code
- Verbal Communication amongst development team

CHAPTER 6

SOFTWARE REQUIREMENT SPECIFICATION

Introduction

Purpose and Scope of Document

To be able to detect complex features in an abstract image and classify it based on numerous features. Using machine learning to classify abstract images

Problem Statement

- Abstract Art in its whole Is difficult to understand by laymen. The subtleties and the hidden meaning is perceived only by some. We will try to learn these hidden meanings and cues of the colour tones and other features and predict the various implications of the image.

Scope

- Classify the images using machine learning to be able to predict the genre of the image.
- Detect dominant colours and map the colour emotions of the image.
- Detect patterns and brush strokes to aid in classification task

Overview of responsibilities of Developer

- To design a system which will extract features from an image and classify the image.
- To develop a machine learning model for the same.

Usage Scenario

User profiles

- The target users for our systems will be large museum image database managers who would want a definite way to store such abstract art. We are also targeting the users who would want to view all images with some particular feature

Use-cases

All use-cases for the software are presented. Description of all main Use cases using use case template is to be provided.

Sr No.	Use Case	Description	Actors	Assumptions
1	Use Case 1	End User wanting to see all images with a particular hashtag	End user	Existing database of images indexed by hashtags
2	Use Case 2	Database manager wanting hashtags to store images	database administrator	fully working system with relevant hashtag generation
3	Use Case 3	Sorting paintings in museum with corresponding classes	database administrator	fully working system with class prediction

Table 6.1: Use Cases

Use Case View

Use Case Diagram. Example is given below

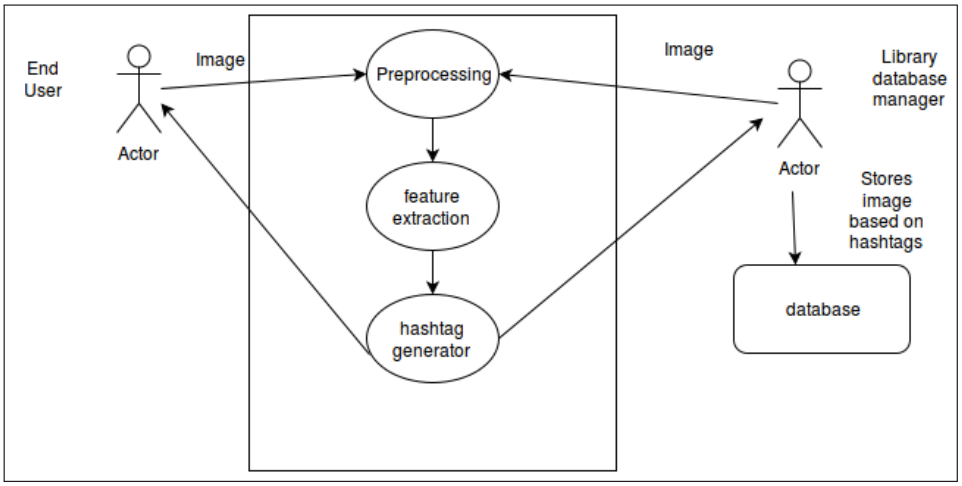


Figure 6.1: Use case diagram

Data Model and Description

Data Description

Data set consists of images of abstract art and the files are preprocessed and stored as pickle files in the filesystem.

Data objects and Relationships

Each image will have a set of attributes (labels) stored in a different pickle file or a csv file.
Sample fields

- filename - the image filename (training files are in train.zip)
- title - the title of the painting, if available (string)
- style - the style of the painting (string)

Functional Model and Description

A description of each major software function, along with data flow (structured analysis) or class hierarchy (Analysis Class diagram with class description for object oriented system) is presented.

Data Flow Diagram

Level 0 Data Flow Diagram

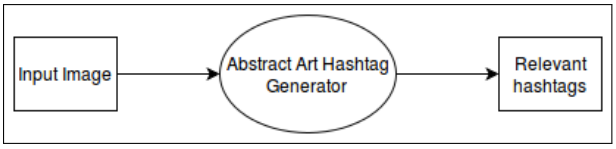


Figure 6.2: level 1 data flow diagram

Level 1 Data Flow Diagram

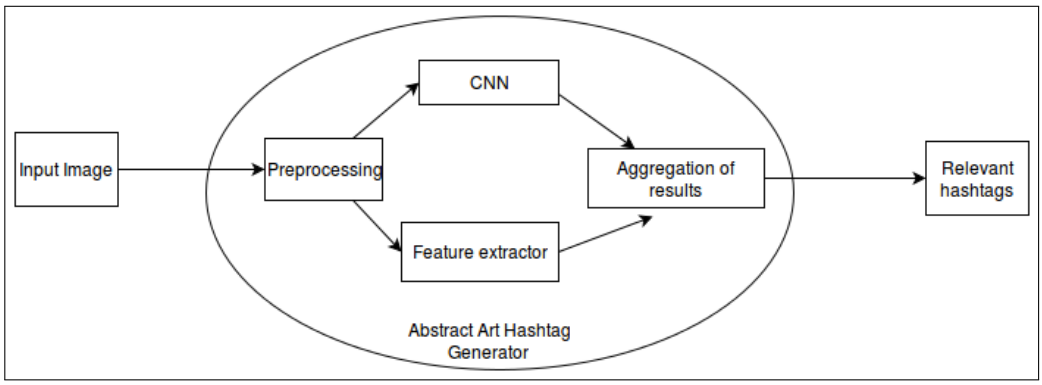


Figure 6.3: Level 2 data flow diagram

Description of functions

The functions will include: Input() function to take the image as input. The train() function will be used to train the model and test() will be used to test the model. Finally display() function will display the results.

Activity Diagram:

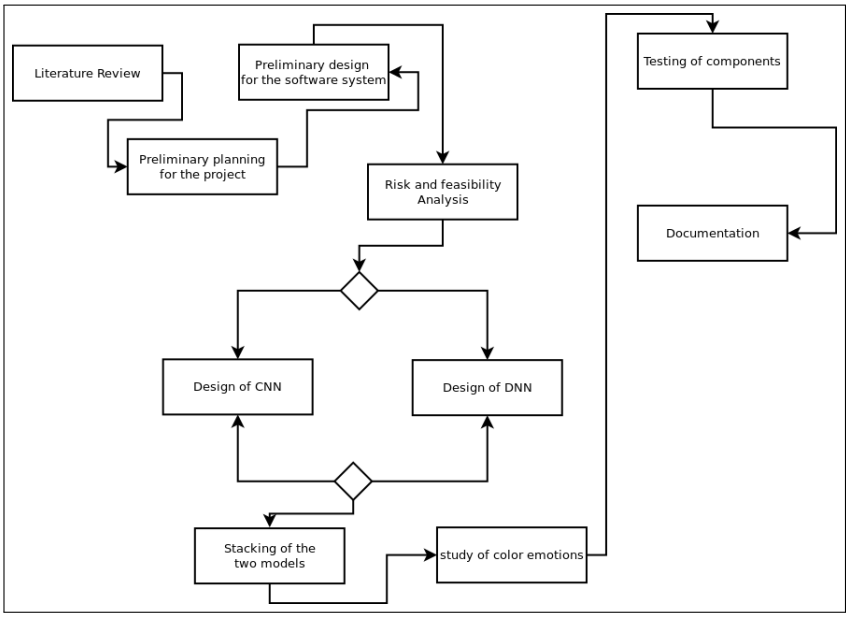


Figure 6.4: Activity diagram

Non Functional Requirements:

- Interface Requirements - Ability to upload a image or drag and drop an image in a white box

- Performance Requirements - Fast output of the classes of the image to be displayed

- Software quality attributes such as availability [related to Reliability], modifiability [includes portability, reusability, scalability], performance, security, testability and usability[includes self adaptability and user adaptability]

State Diagram:

State Transition Diagram

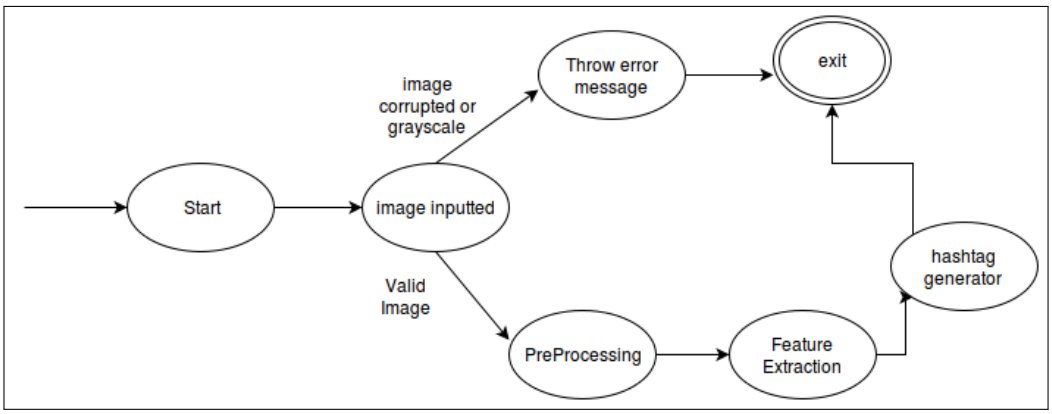


Figure 6.5: State transition diagram

The above diagram shows the state transition diagram of our system. The states are represented in ovals and state of system gets changed when certain events occur. The transitions from one state to the other are represented by arrows. The figure shows important states and events that occur while training and further while classifying.

Design Constraints

- The training speed will depend upon the size of the images.
- Feature extraction will be proportional to the complexity of the said image.
- The dominant color will be a result of the combination of background and foreground of the image.
- The computation speed is a direct function of number of cores on the GPU and the processor speed
  Memory: 8GB
  Physical Memory: Up to 20GB

Software Interface Description

The software will have a web based interface which will allow user to upload images. The page will be developed in HTML , CSS and other dependent languages.

CHAPTER 7

DETAILED DESIGN DOCUMENT USING APPENDIX A AND B

Introduction

Describing the basic architecture diagram.

Architectural Design

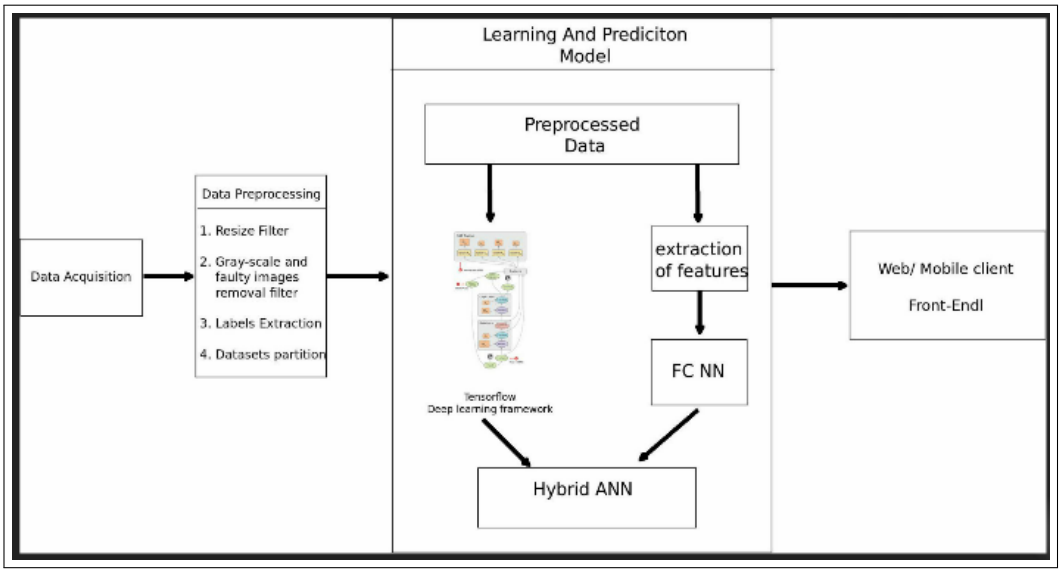


Figure 7.1: Architecture diagram

The above diagram shows the basic workflow of the system. The images are converted to 100x100px resolution and gray scale images are filtered out. After the preprocessing two parallel models were run.

The CNN module helps finding the intricate features in an image. The features are extracted from the image to be trained by the DNN. The combination of two networks is done by implementing hybrid neural network which ensembles the result.

Data design

Internal software data structure

The data files internally are stored in variables and then the data is stored as pickle files for further use.

Global data structure

The global data used will be the unprocessed images which will be used throughout the model.

Temporary data structure

The python numpy array will hold the temporary data.

Database description

The training data is available to us in the form of a csv file from which we extract the necessary labels.

Component Design

- Data Acquisition: This component involves acquiring the training and testing datasets from web crawler. We collected abstract images of ten classes and approximately 300 images per class. The dataset consisted of 2700 images.

- Data Preprocessing: Involves actions such as removal of corrupted images, removal of gray-scale images, re-sizing of images. The input images given for training and testing of CNN were re-sized to 100x100px resolution. As the color emotions analysis played vital role in describing abstract art, we removed the gray-scale images. The corrupted images as well as images having alpha channel were eliminated.

- CNN: Involves the use of the Tensor Flow Library to create a CNN that learns on the training data for prediction of genres. CNN helps in identifying intricate features in the image. CNN that we implemented consisted of convolution layer, max pooling layer and fully connected

layers.

- Feature Extraction and FC Neural Network: Involves extracting other objective features from an image such as colour patterns and geometrical shapes and feeding them to a normal deep neural networks. By manually observing the dataset and literature survey we came up with some distinct features. Features that are extracted are as follows.
  - Edge frequency
  - Color count
  - Square count
  - Triangle count
  - Half circles
  - Circle count
  - Edge count
  - Blob count
- Hybrid ANN: Involves aggregation of the results from component 3 and 4 to accurately generate hashtags.

- FrontEnd: This is the GUI that we will be creating to serve as the final front end for our project.

CHAPTER 8
PROJECT IMPLEMENTATION

Introduction

Classification of abstract art using its distinctive features itself is a difficult task. Our system proposes a hybrid model consisting of Convolutional Neural Network and Deep Neural Network. This model helps identifying the intricate features as well as distinctive features with relative images. It's a proof of concept which can be applied on any type of applications and can be widely used in analyzing psychological emotions of a person.

Tools and Technologies Used

Tools

- Jupyter Framework - A python environment for python and python conda development
- Django Framework - A python framework for UI development
- Selenium - Testing tool
- Libraries including Tensorflow, Keras, OpenCV, etc

Technologies

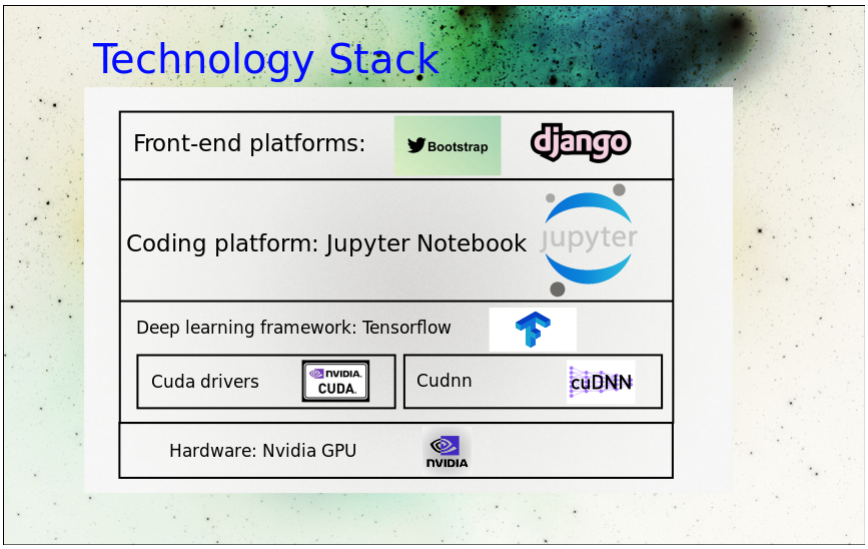


Figure 8.1: Technology stack diagram

Methodologies/Algorithm Details

Stochastic Gradient Descent

```
initialize network weights (often small random values)
  do
    forEach training example named ex
       prediction = neural-net-output(network, ex)  // forward pass
       actual = teacher-output(ex)
       compute error (prediction - actual) at the output units
       compute {\displaystyle \Delta w_{h}} \Delta w_h for all
       weights from hidden layer to output layer   // backward pass
       compute {\displaystyle \Delta w_{i}} \Delta w_i for
       all weights from input layer to hidden layer
       // backward pass continued
       update network weights // input layer not
       modified by error estimate
  until all examples classified correctly or another
  stopping criterion satisfied
  return the network
```

Stochastic gradient descent is optimization technique for minimizing the objective function that is written in a differential form. It tries to identify the minima or maxima by iterating over train cases. It is a popular technique for training many models in machine learning for reducing the error rate and increasing accuracy. This method helps in converging the results till the local minima.

Back propagation Algorithm

Back propagation algorithm is common method for training neural networks and used with gradient descent optimization technique. Back propagation algorithm is used for calculating the gradient of the loss function by using the error values. For the next iteration it updates the weights in the network to minimize the loss function.

Algorithm:

```
initialize network weights (often small random values)
  do
     forEach training example named ex
        prediction = neural-net-output(network,
        ex)  // forward pass

        actual = teacher-output(ex)
        compute error (prediction - actual) at
        the output units

        compute {Delta w_{h}} \Delta w_h for all
        weights from hidden layer to output
        layer  // backward pass

        compute {Delta w_{i}} \Delta w_i for all
        weights from input layer to hidden layer
        // backward pass continued

        update network weights // input layer
        not modified by error estimate
  until all examples classified correctly or
  another stopping criterion satisfied
  return the network
```

example:

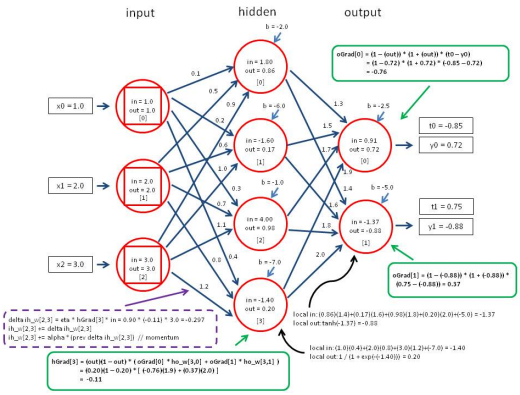


Figure 8.2: backpropagation diagram

Activation Functions

Rectified Linear Unit

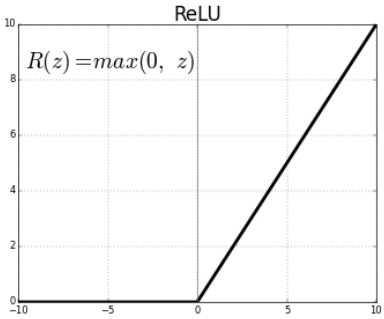


Figure 8.3: Rectified Linear Unit function graph

Sigmoid Function

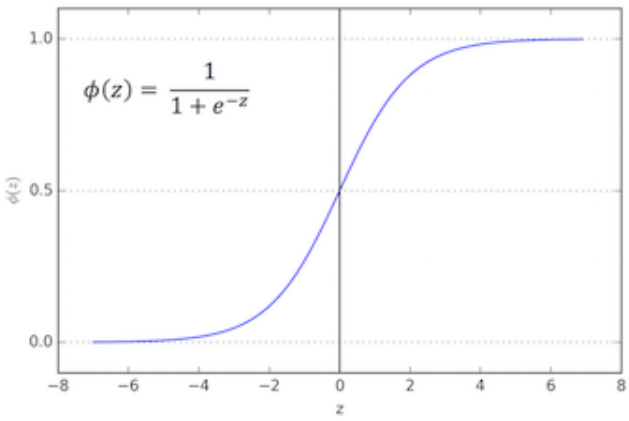


Figure 8.4: Sigmoid Function graph

Implementation details

- Data Acquisition: This component involves acquiring the training and testing datasets from web crawler. We collected abstract images of ten classes and approximately 300 images per class. The dataset consisted of 2700 images.

- Data Preprocessing: Involves actions such as removal of corrupted images, removal of gray-scale images, re-sizing of images. The input images given for training and testing of CNN were re-sized to 100x100px resolution. As the color emotions analysis played vital role in describing abstract art, we removed the gray-scale images. The corrupted images as well as images having alpha channel were eliminated.

- CNN: Involves the use of the Tensor Flow Library to create a CNN that learns on the training data for prediction of genres. CNN helps in identifying intricate features in the image. CNN that we implemented consisted of convolution layer, max pooling layer and fully connected layers.

- Feature Extraction and FC Neural Network: Involves extracting other objective features from an image such as colour patterns and geometrical shapes and feeding them to a normal deep neural networks. By manually observing the dataset and literature survey we came up with some distinct features. Features that are extracted are as follows.
  - Edge frequency
  - Color count
  - Square count
  - Triangle count
  - Half circles
  - Circle count
  - Edge count
  - Blob count

- Hybrid ANN: Involves aggregation of the results from component 3 and 4 to accurately generate hashtags.

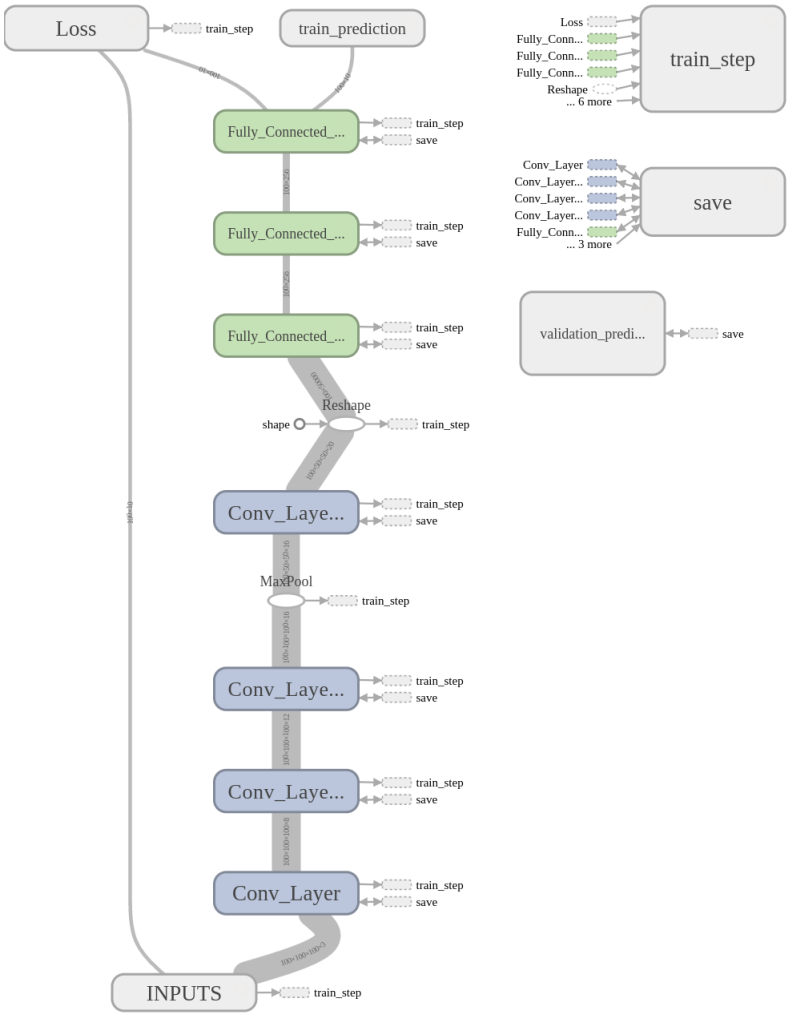


Figure 8.5: CNN architecture

- FrontEnd: This is the GUI that we will be creating to serve as the final front end for our project.

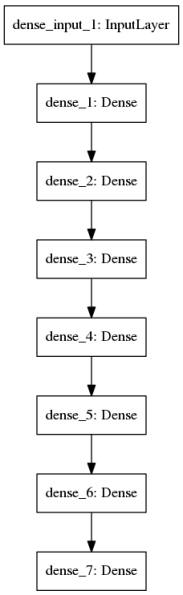
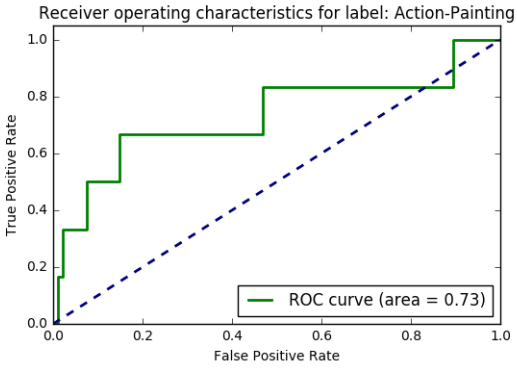
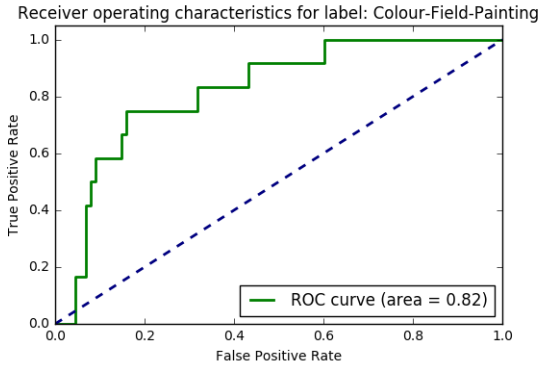


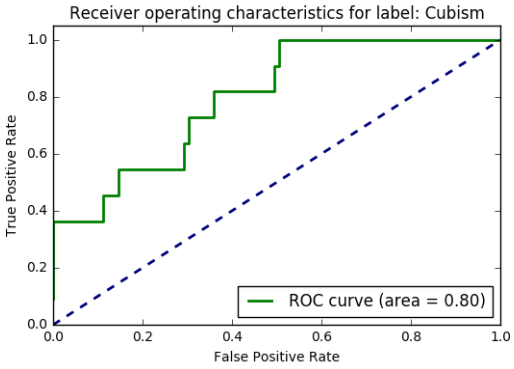
Figure 8.6: DNN architecture

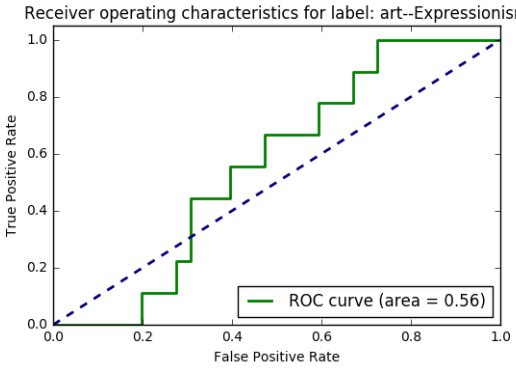
Verification and Validation for Acceptance

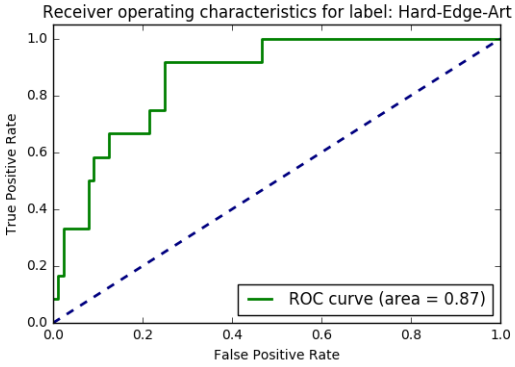
ROC for classes

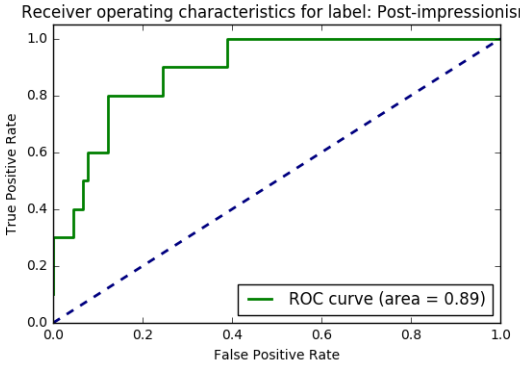


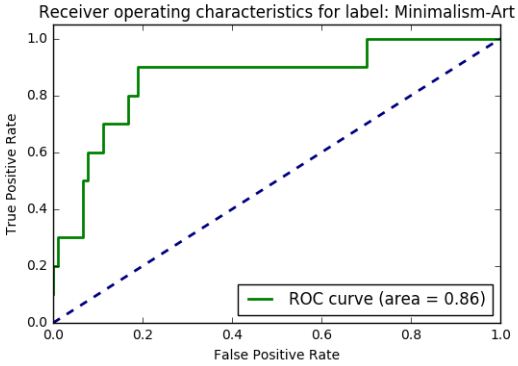


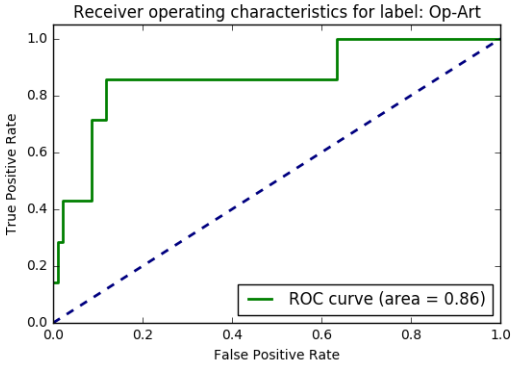

Receiver operating characteristics for label: Cubism
True Positive Rate
False Positive Rate
ROC curve (area = 0.80)

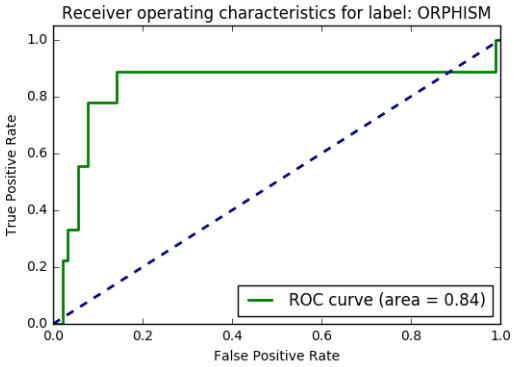

Receiver operating characteristics for label: art--Expressionism
True Positive Rate
False Positive Rate
ROC curve (area = 0.56)

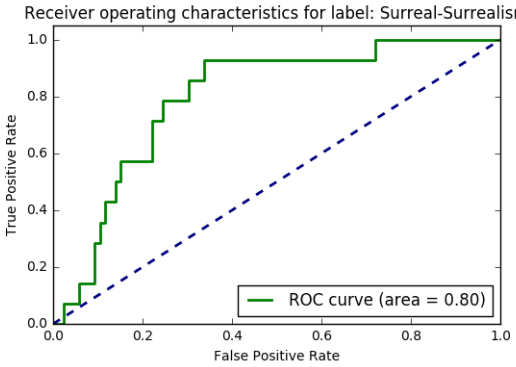

Receiver operating characteristics for label: Hard-Edge-Art
True Positive Rate
False Positive Rate
ROC curve (area = 0.87)


Receiver operating characteristics for label: Post-impressionism
True Positive Rate
False Positive Rate
ROC curve (area = 0.89)


Receiver operating characteristics for label: Minimalism-Art
True Positive Rate
False Positive Rate
ROC curve (area = 0.86)


Receiver operating characteristics for label: Op-Art
True Positive Rate
False Positive Rate
ROC curve (area = 0.86)


Receiver operating characteristics for label: ORPHISM
True Positive Rate
False Positive Rate
ROC curve (area = 0.84)


Receiver operating characteristics for label: Surreal-Surrealism
True Positive Rate
False Positive Rate
ROC curve (area = 0.80)

ROC(Receiver Operating Characteristic) curve is a fundamental tool for diagnostic the tests. It is a graph of true positive against the false positive for different possible cut-points.

ROC curve analysis for classes:

Classes	ROC accuracy
Action Paintings	0.73
Colour Field Painting	0.82
Cubism	0.80
Expressionism	0.56
Hard Edge Painting	0.87
Impressionism	0.89
Minimalism	0.86
OP Art	0.86
Orphism	0.84
Surrealism	0.80

Table 8.1: ROC validation results

CHAPTER 9
SOFTWARE TESTING

Type of Testing Used

Unit testing and Integration testing

Test Cases and Test Results

Input Field : Select File	Testing if browsing and uploading works
Other than image file uploaded	Warning modal pops up
Image file with alpha channel	Arithmetically handled
Large sized image uploaded	Image re-sized

Table 9.1: Testing cases table

Test Cases and Test Results

Unit testing on statement coverage:

1. **Test Case:** If taking input of any image results in corrupting of image, the result will be NULL.
   Solution: So, the image will be discarded temporarily from the database.

2. **Test Case:** If the image belongs to any other class inspite of defined classes, the results should be relative to its respective class.
   Solution: Such image will be considered under negative category.

Integration testing:

1. **Test Case:** Combining the CNN module and DNN module.
   textbfSolution: The results for the respective modules will be displayed for the image.

2. **Test Case:** Integration of color emotions with other modules.
   Solution: Respective results of each module will be shown.

Validation testing and test results:

Sr. No.	Use Case	Description	Actors
1.	Upload image	It browses the image from the system	User
2.	Validation of Image	It checks for alpha channel	User
3.	Gray-scale filtering	Gray-scale image removal	User
4.	Pre-processing Image	Validation of image for the system	Pre-processing module
5.	Displaying the results	Displaying hashtags for the image	CNN module

Table 9.2: Testing cases table

CHAPTER 10
RESULTS

Screen shots

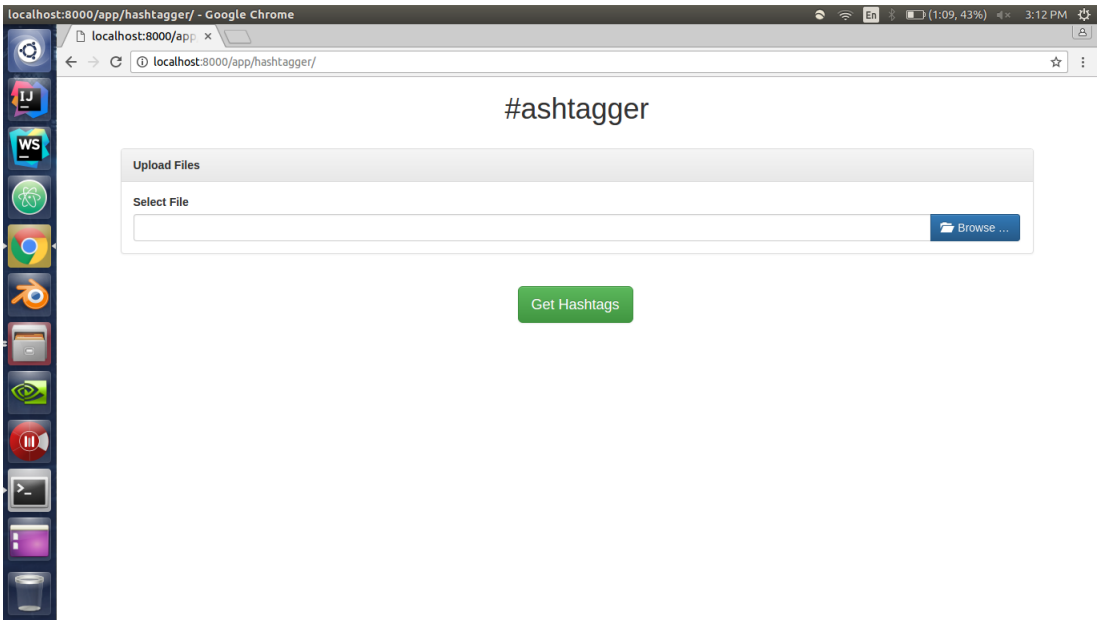


Figure 10.1: Home Page

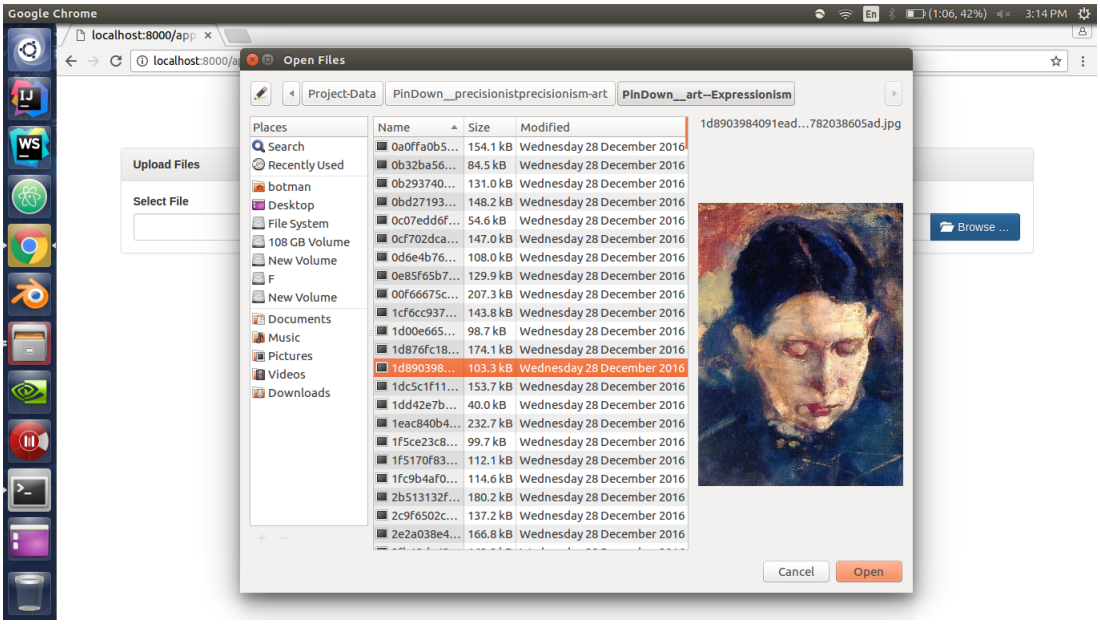


Figure 10.2: Browse Page

The top 3 relevant classes for the image with color emotion analysis hashtags are generated.

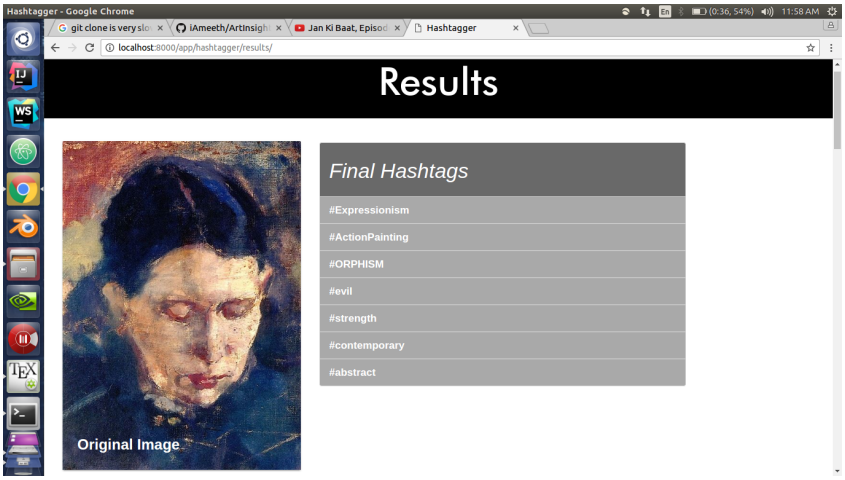


Figure 10.3: Browse Page

The detailed scores of the classes by CNN, DNN and Ensemble learning listed.

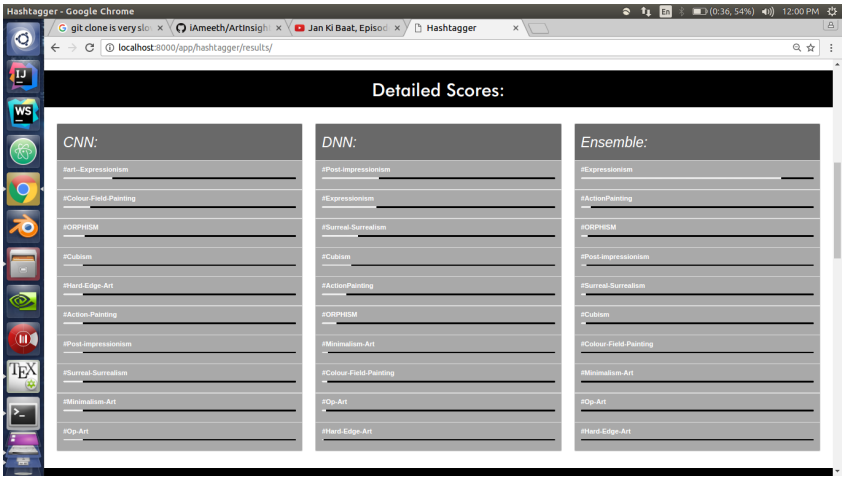


Figure 10.4: Result scores

CNN predicts the classes with respective probabilities. CNN analysis displays the top 3 classes having maximum probability scores.

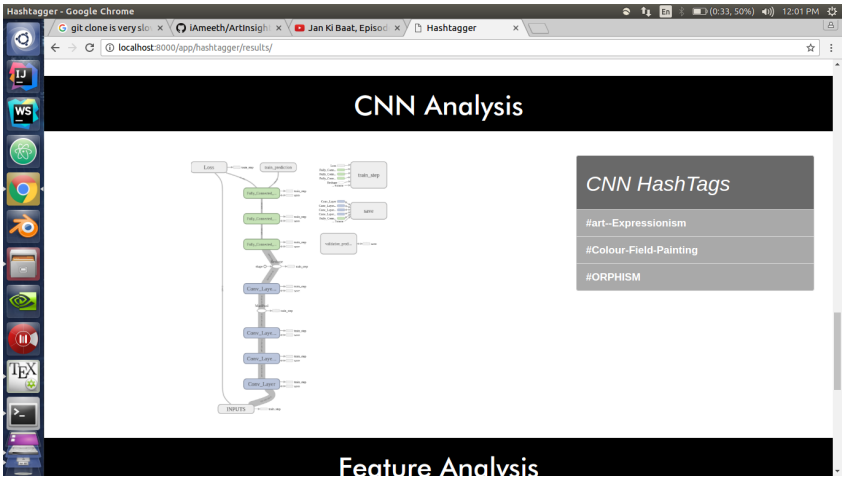


Figure 10.5: CNN Results

DNN predicts the classes with respective probabilities. DNN analysis displays the top 3 classes having maximum probability scores. The table shows the features took into consideration for DNN.

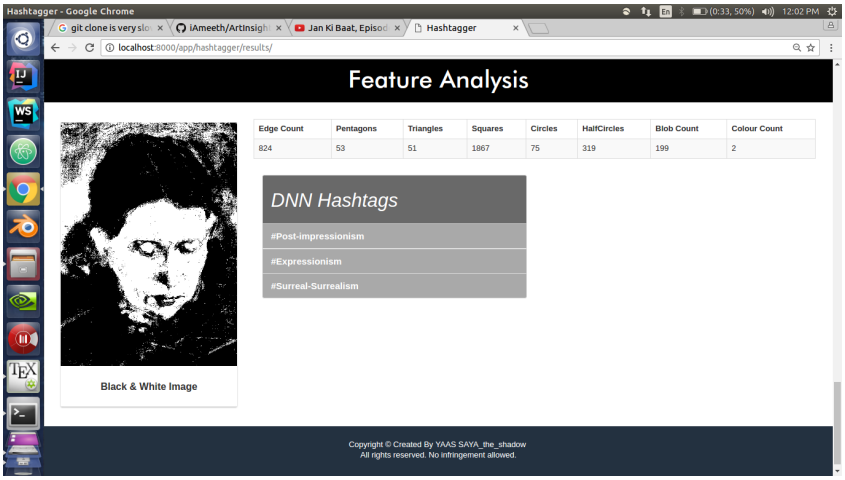


Figure 10.6: Feature and DNN results

Figure shows the palette of colors and dominant colors in a painting. The emotions attached with colors are matched in color emotion analysis.

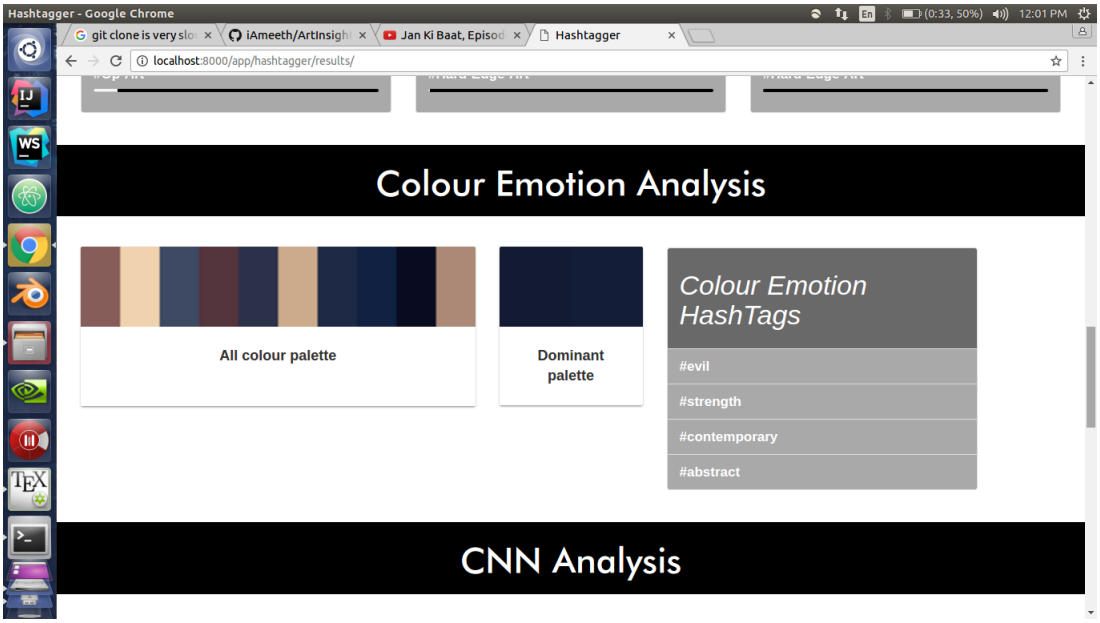


Figure 10.7: Color Emotion Analysis

Console Logs

Figure 10.8: Console Logs 1

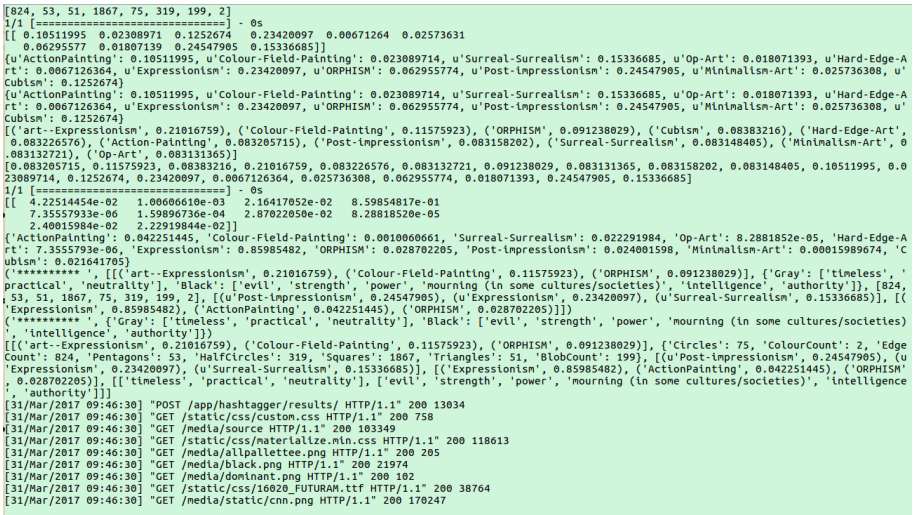


Figure 10.9: Console Logs 2

Accuracy, measures and details:

CNN results:

Classes	ROC area under the curve
Action Paintings	0.73
Colour Field Painting	0.82
Cubism	0.80
Expressionism	0.56
Hard Edge Painting	0.87
Impressionism	0.89
Minimalism	0.86
OP Art	0.86
Orphism	0.84
Surrealism	0.80

Table 10.1: ROC auc chart

DNN results:

No. of iterations	Accuracy obtained
20,000	58.23%

Table 10.2: DNN result chart

Combination results (Final accuracy):

No. of iterations	No. of images in training set	No. of images in test set	Accuracy obtained
20,000	2010	739	78.833%

Table 10.3: final ensemble result chart

CHAPTER 11

DEPLOYMENT AND MAINTENANCE

Installation and un-installation

The application is a web app. So, usage of the app is simply plug and play. No installation and uninstallation required

User help

The software design is quite intuitive and seldom requires the presence of a manual. Nevertheless, a help portal for the same has been instituted.

Deployment Diagram:

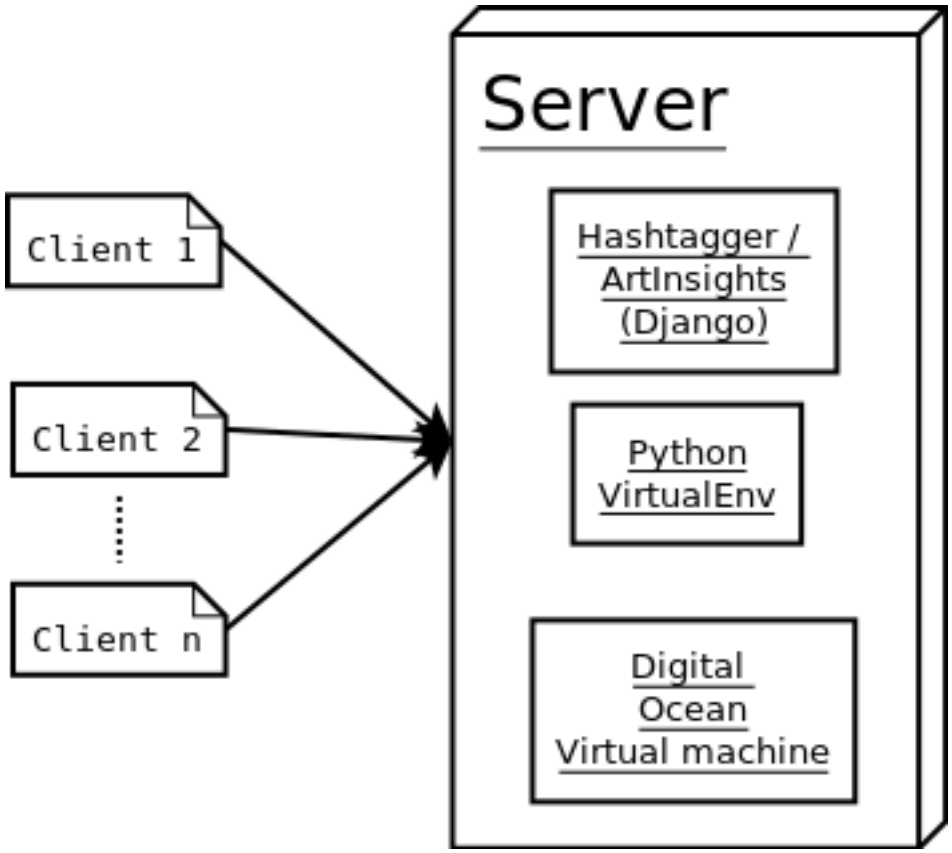


Figure 11.1: Deployment setup of the system

CHAPTER 12

CONCLUSION AND FUTURE SCOPE

Conclusion

Abstract Art in its whole is difficult to understand by laymen. The subtleties and the hidden meaning is perceived only by some. The basic aim of the project was to describe abstract art with the relevant keywords. We learned these hidden meanings and cues of the color tones and other features and predict the various implications of the image. We proposed a hybrid system which can be applied on any type of image processing and its description.
Thus with this project we are able to detect complex features and then generate relevant hashtags from those features.
This enables user to use this system and organise their images based on mood of the image or to emotions behind the setting.

Future Scope

The proof of concept can be helpful in determining the relevant keywords for any general image. The manual extraction of features helps in determining the distinct features particular class has and Convolutional Neural Network depicts the intricate features in an image. Combining both models in ensemble way can increase the accuracy on testing dataset.

ANNEXURE A
REFERENCES

Site References

- https://www.wikiart.org
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3170918
- http://www.gitxiv.com/posts/jG46ukGod8R7Rdtud/a-neural-algorithm\
-of-artistic-style
- https://en.wikipedia.org/wiki/Convolutional_neural_network
- https://en.wikipedia.org/wiki/Deep_neural_network

Literature References

- R. Kumi, C. M. Conway, M. Limayem and S. Goyal, "Research Article Learning in Colour: How Colour and Affect Influence Learning Outcomes ", *IEEE Transactions on Professional Communication*, vol. 56, pp. 2-15, 2013
- S. Zeki, "Inner vision: An exploration of art and the brain". *Oxford University Press*, 1999.
- M.Livingstone, "Visionandart: The Biology of Seeing. New York": *Harry N. Abrams*, 2002.
- C.F. Hibadullah, A.W.C. LiewandJ.Jo,"Colour emotion association study on abstract art painting," *Machine Learning and Cybernetics (ICMLC), 2015International Conference on Machine Learning and Cybernetics*, Guangzhou, 2015, pp. 488-493.
doi:10.1109/ICMLC.2015.7340605

ANNEXURE B

LABORATORY ASSIGNMENTS ON PROJECT ANALYSIS OF ALGORITHMIC DESIGN

ANNEXURE C

LABORATORY ASSIGNMENTS ON PROJECT QUALITY AND RELIABILITY TESTING OF PROJECT DESIGN

ANNEXURE D
PROJECT PLANNER

- For maintaining project source code we are using Github as our CMS (content management service).
- For Team messaging we are using Flock.
- Team interaction and design decisions over Whatsapp
- Documentation by Google Drive

ANNEXURE E

REVIEWERS COMMENTS OF PAPER SUBMITTED

1. Paper Title: Machine learning for classification of Abstract Images
2. Name of the Conference/Journal where paper submitted : (ICDLT) International Conference on Deep Learning Technologies 2017, Chengdu, China.
3. Paper accepted/rejected : accepted
4. Review comments by reviewer : The paper presents a machine learning based approach by stacking DNN and CNN to classify images.

   Minor changes are required as follows:

   - Change the color of reference number which is almost unseen.
   - Figure 3 to 5 have low resolution.
   - Table 1 fits to 1 page.
   - Lack of detailed description of the combinatory model (section III E).
   - Results shall demonstrated the comparison of combinatory model vs. DNN and CNN.

5. Corrective actions if any : only cosmetic corrections required. They were completed appropriately.

ANNEXURE F
PLAGIARISM REPORT

Plagarism Report:

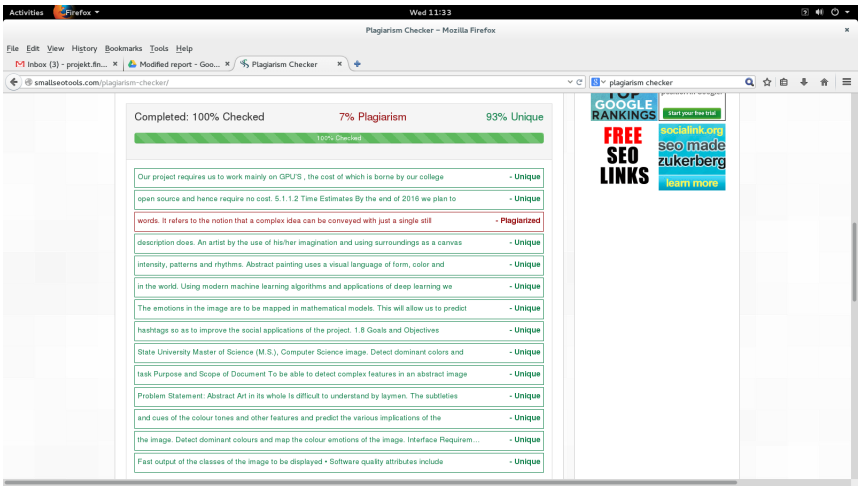


Figure F.1: Plagarism checker score of the project manuscript

ANNEXURE G

TERM-II PROJECT LABORATORY ASSIGNMENTS

ANNEXURE H

INFORMATION OF PROJECT GROUP MEMBERS

1. Name : Animesh Karnewar
2. Date of Birth : 3rd August, 1995
3. Gender : Male
4. Permanent Address : E-19, Rajas Garden, Model Colony, near Deep Bangla Chowk, Pune 411016.
5. E-Mail : animeshsk3@gmail.com
6. Mobile/Contact No. : +917744098513
7. Placement Details : placed at 'ThoughtWorks' through college campus recruitment drive.
8. Papers Published :
   - "Processing geospatial images using GPU" presented at Innternational Conference On Emerging Trends and Innovation In ICT (ICEI-2017), 978-1-5090-3404-8/17/31.00/2017 IEEE.
   - "Designing Python Code for Derivation of Flow Matrix" published in International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE), ISSN: 2277 128X, https://www.ijarcsse.com/docs/papers/Special-Issue/ITSD2015/32.pdf
   - "Cuda for Geospatial Image Processing" presented at National conference on Recent Trends in Computer Engineering (NCRTCE). PICT, Pune.

1. Name : Chinmay Sawant
2. Date of Birth : 13th July, 1995
3. Gender : Male
4. Permanent Address : A-6, Ratan Garden, Trimurthi Chowk, Katraj-411043.
5. E-Mail : chinmayssawant@live.com
6. Mobile/Contact No. : 9860071633
7. Placement Details : SoftTech Engineers Pvt Ltd.
8. Papers Published : No papers published

1. Name : Ameeth Kanawaday
2. Date of Birth : 8th November, 1995
3. Gender : Male
4. Permanent Address : B-4, Akshay Villa, Sinhagad Road, Pune-51.
5. E-Mail : ameeth.kanawaday@gmail.com
6. Mobile/Contact No. : 9028926244
7. Placement Details : None.
8. Papers Published : No papers published

1. Name : Yash Gupta
2. Date of Birth : 6th August,1995
3. Gender : Male
4. Permanent Address : i-2, Sacred Heart Town,Wanwadi,Pune-40
5. E-Mail : yash.gupta0695@gmail.com
6. Mobile/Contact No. : 9604603891
7. Placement Details : Placed at Eq Technologic
8. Papers Published : 1