

**Major Project On**

**Multilabel Classification Using Deep Neural Network**

**Gaurav Kumar**

Department of Computer Science & Engineering

Sikkim Manipal Institute of technology

[gaurav\_201800295@smit.smu.edu.in](mailto:gaurav_201800295@smit.smu.edu.in)

**Aditi Karmakar**

Department of Computer Science & Engineering

Sikkim Manipal Institute of technology

[aditi\_201800107@smit.smu.edu.in](mailto:aditi_201800107@smit.smu.edu.in)

Guided by:

**Mrs. Chitrapriya Ningthoujam**

Assistant Professor

Department of Computer Science & Engineering

Sikkim Manipal Institute of technology

[chitrapriya.n@smit.smu.edu.in](mailto:chitrapriya.n@smit.smu.edu.in)

**TABLE OF CONTENT**

|  |  |  |
| --- | --- | --- |
| **SL NO** | **TITLE** | **PAGE NO.** |
| **1** | **Abstract** | **2** |
| **2** | **Introduction** | **2** |
| **3** | **Literature Survey** | **3-4** |
| **4** | **Problem Definition** | **4** |
| **5** | **Solution Strategy** | **5-6** |
| **6** | **Design** | **7** |
| **7** | **Progress Update** | **8-11** |
| **8** | **Results** | **12-13** |
| **9** | **Work to be done** | **13** |
| **10** | **Gantt Chart** | **14** |
| **11** | **References** | **15** |

**Abstract**

Feature extraction is a well-known method for lowering computing complexity and improving multi-label picture classification accuracy.When it comes to automating the process of creating meta data or offering suggestions to consumers based on features in their photographs, image labeling comes in useful.

Multi-label image annotation is mainly concerned with assigning semantic concepts or labels

for a given image. Due to large increase of digital images all over the world, efficient ways to analyze, annotate and manipulate image data has become highly important. The task of multi-label classification of image can be conducted by using machine learning algorithms.

After creating a dataset consisting of 10 distinct classes comprising photographs of various genres, the goal of this project is to extract features from images using CNN and label them using KNN methods.

**Introduction**

**Image Classification**

Image classification involves the extraction of features from the image to observe some patterns in the dataset. Using an ANN for the purpose of image classification would end up being very costly in terms of computation since the trainable parameters become extremely large.

**Convolutional Neural Network(CNN)**

The convolutional neural network (CNN) is a class of **deep learning neural networks**. CNNs represent a huge breakthrough in image recognition. They’re most commonly used to analyze visual imagery and are frequently working behind the scenes in image classification. We will be solving a multi classification “: butterflies, chess, cups, food, landscape, plates, pokémon, pollen grains, spoons, sports” using Convolutional Neural Network(CNN)

**Multi-Label Classification with Deep Learning**

Multi-label classification is a predictive modelling task that involves predicting zero or more mutually non-exclusive class labels.

Neural network models can be configured for multi-label classification tasks.

We will be using Keras Framework. Keras is an open source neural network library written in Python. It is capable of running on top of TensorFlow, Microsoft Cognitive Toolkit.

KNN is a non-parametric and lazy learning algorithm. Non-parametric means there is no assumption for underlying data distribution.

**LITERATURE SURVEY**

|  |  |  |  |
| --- | --- | --- | --- |
| **SL NO** | **PAPER AND YEAR OF PUBLICATION** | **FINDINGS** | **RELEVANCE TO PROJECT** |
| 1. | CNN-RNN: A Unified Framework for Multi–Label image Classification (2016) | The CNN part extracts semantic representations from images; the RNN part models image/label relationship and label dependency | The proposed framework combines the advantages of the joint image/label embedding and label co-occurrence models by employing CNN and RNN to model the label co-occurrence dependency in a joint image/label embedding space. |
| 2. | Automatic X-ray COVID -19 Lung Image Classification System based on Multi-level Thresholding and Support Vector Machine(2020) | Classifies the corona affected X-ray images from others through usage of the deep features. The technique is useful for the clinical practitioners for early detection of COVID-19 infected patients | The model presents high accuracy where the average sensitivity, specificity and accuracy of the lung classification were 95.76%,99.7% and 97.48% respectively. |
| 3. | Visual Attention in Multi-Label Image Classification (2019) | Results show that the new saliencysub-network improves multilabel image classification performance. | Analysisofthe correlation between visual attention and multi-label image classiﬁcation. |
| 4. | Accurate Multilevel Classification for Wildlife images(2021) | Presents an exhaustive study of different methods to perform multilevel classification from color images applied to the problem of classifying wild animals and plant species. | Experiments show that increasing the resolution of the images impact on the ﬁnal accuracy, as the ﬁner details are very important to determine the exact species of each being are preserved. |
| 5. | Multi-Label Classification Methods for Image Annotation(2016) | Represents the comparison between different multilabel methods is conducted on image categorization by using scene, flag, corel5k and Nus-wide5k datasets. Experimental results determine that multi-labelk- Nearest is the best performance algorithm. | The graphical performance illustration of accuracy result shows that the classification accuracy of all methods is less than 70% for all datasets including scene, flag, corel5k, NUS-WIDE-5K. |

**PROBLEM DEFINITION**

1. Multi-Label Classification is more acceptable than Multiclass classification and binary classification for images. When there are two or more classes and the data want to classify may belong to none of the classes or all of them at the same time.

2. The main challenge in multi-label classification is data imbalance. We can’t simply use sampling techniques as we can in multi-class classification. Data imbalance is a well-known problem in Machine Learning. Where some classes in the dataset are more frequent than others and the neural net to predict the frequent classes.

3. Binary classification is dichotomization applied to a practical situation. In many practical binary classification problems, the two groups are not symmetric, and rather than overall accuracy, the relative proportion of different types of errors is of interest.

4. Convolutional neural networks (CNNs) have shown a great success in single-label image classification, it is important to note that real world images generally contain multiple labels, which could correspond to different objects, scenes, actions and attributes in an image.

**SOLUTION STRATEGY**

**Load and pre-process the data**

First, load the prepared dataset (consists of 10 different classes) and then pre-process them as per our project’s requirement.To check how our model will perform on unseen data (test data), we create a validation set. We train our model on the training set and validate it using the validation set.

**Define the model’s architecture**

The next step is to define the architecture of the model. This includes deciding the number of hidden layers, number of neurons in each layer, activation function, and so on.

**Train the model**

Time to train our model on the training set! We pass the training images and their corresponding true labels to train the model. We also pass the validation images here which help us validate how well the model will perform on unseen data.

We can use the sigmoid activation function. This will predict the probability for each class independently. It will internally create n models (n here is the total number of classes), one for each class and predict the probability for each class.

Using sigmoid activation function will turn the multi-label problem to n – binary classification problems. So, for each image, we will get probabilities defining whether the image belongs to class 1 or not, and so on.

The main advantage of KNN over other algorithms is that KNN can be used for multiclass classification. Therefor if the data consists of more than two labels or in simple words if you are required to classify the data in more than two categories then KNN can be a suitable algorithm.

It works on all kinds of data on which the classification is to be performed.

**Algorithm for Multilabel classification using KNN: --**

Step 1: Load the training data.

Step 2: Prepare data by scaling, missing value treatment, and dimensionality reduction as required.

Step 3: Find the optimal value for K:

Step 4: Predict a class value for new data:

Step1:Calculatedistance(X, Xi) from i=1,2, 3,.,n.where X= new data point, Xi= training data, distance as per your chosen distance metric.

Step 2: Sort these distances in increasing order with corresponding train data.

Step 3: From this sorted list, select the top ‘K’ rows.

Step 4: Find the most frequent class from these chosen ‘K’ rows. This will be your predicted class.

**Algorithm for Multilabel classification using CNN:-**

Step1. Import the necessary modules as numpy, sklearn.metrics, confusion matrix, seaborn, sklearn.utils, shuffle, matplotlib.pyplot , cv2, tensorflow, tqdm .

Step2. We define location of dataset, define subplot, load image pixels, plot raw pixel data, load and summarize the mapping file for the landscape dataset, load file as CSV, summarize properties etc.

Step3. We create a mapping of tags to integers given the loaded mapping file, we create a mapping of filenames to tag lists and save into a compressed file for later use.

Step4. Calculate fbeta score for multi-label classification , define CNN model and finally plot diagnostic learning curves.

**DESIGN**

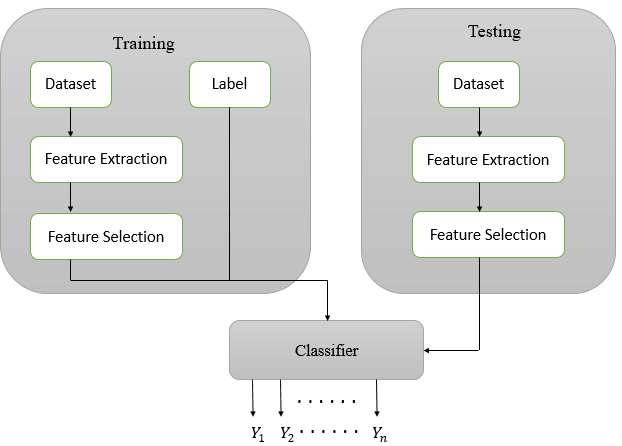


Fig.:- Block diagram of Multi-label Classifier

The input to the classifier is the image dataset for which labels must be assigned. Initially pre-processing is performed to extract a list of features. Though the non-informative features are removed.Before classification the most important words has to be identified which acts as features. Once the dataset has been obtained, it is imperative to perform some pre-processing in order to get the most significant images.After the images are pre-processed, the number of features in the document remains high and the high number of features is representative of the classification problem.

**Implementation details**

1. We used Keras Framework which is an open source neural network library written in python.

2. We used Python Programming Language and Jupyter notebook platform.

3. Images are classified into 10 different classes (butterflies, chess, cups, food, landscape, plates ,pokemon, pollen grains, spoons, sports ) and are extracted from kaggle website.

4. Libraries imported are:

1. NumPy-used for working with arrays

2. Os-provides functions for interacting with the operating system.

3. Sklearn.metrics module includes score functions, performance metrics and pairwise metrics and distance computations.

4. Confusion matrix is a table that is often used to describe the performance of a classification model on a set of test data for which the true values are known.

5. Seaborn is a Python data visualization library based on matplotlib .

6. Matplotlib is a cross-platform, data visualization and graphical plotting library for Python and its numerical extension NumPy.

7. CV2 is the module import name for opencv-python

8. TensorFlow is a free and open-source software library for machine learning and artificial intelligence.

9. tqdm is a library in Python which is used for creating Progress Meters or Progress Bars.

5. We define the model as the instance of Sequential() and then define the layers(Conv2D,MaxPooling2D,Flatten,Dense,Relu).

6. We used-sparse\_categorical\_crossentropy Loss function.

7. We used Adam optimization algorithm.

**PROGRESS UPDATE**

**For Multilabel Classification using CNN:**

Load and summarize the mapping file for the landscape dataset-

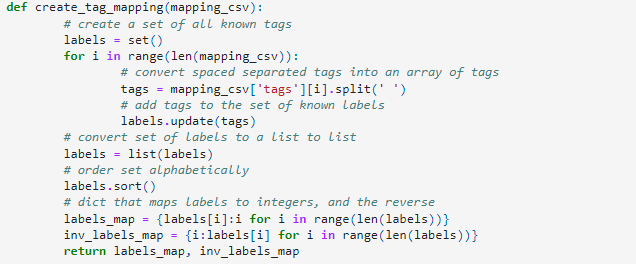
We load the CSV mapping file for the training dataset directly using the read\_csv() Pandas function. Running the example first summarizes the shape of the training dataset.



Create a mapping of tags to integers given the loaded mapping file-

We can tie all of this together into a convenience function called create\_tag\_mapping() that will take the loaded Data Frame containing the

train\_landscape.csv data and return a mapping and inverse mapping dictionaries.

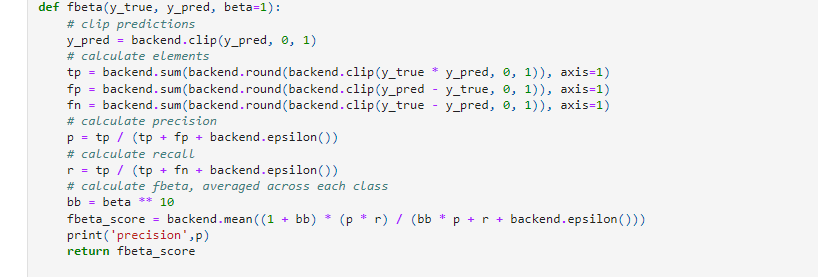


Load file as CSV.

Preparation of the dataset which consists of different images of landscape which is labeled into 10 different classes namely: **person, houses, hills, trees, flowers, water, bridge, soil, sun, rocks**.

Calculate fbeta score for multi-label classification-

The scikit-learn library provides an implementation of F-beta via the fbeta\_score() function. We can call this function to evaluate a set of predictions and specify a beta value of 2 and the “average” argument set to “samples”.



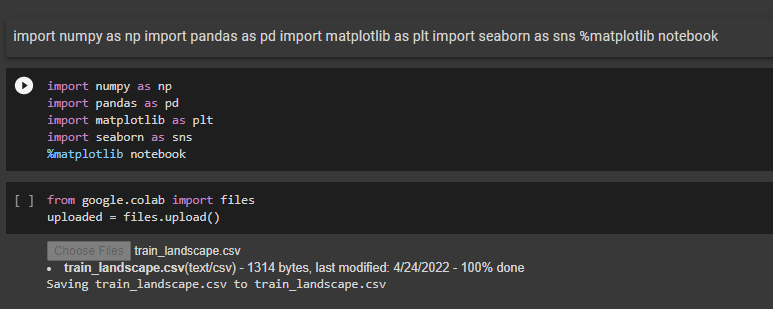
Define CNN model-

The define\_model() function below ties all of this together and parameterized the shape of the input and output, in case you want to experiment by changing these values or reuse the code on another dataset. The function will return a model ready to be fit on the landscape dataset.

****

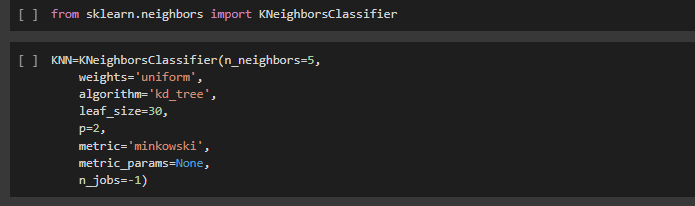
**For Multilabel Classification using KNN:**

Import libraries and load dataset-



Generating Model-

Let's build KNN classifier model. First, import the KNeighborsClassifier module and create KNN classifier object by passing argument number of neighbors in KNeighborsClassifier() function. Then, fit your model on the train set using fit() and perform prediction on the test set using predict().

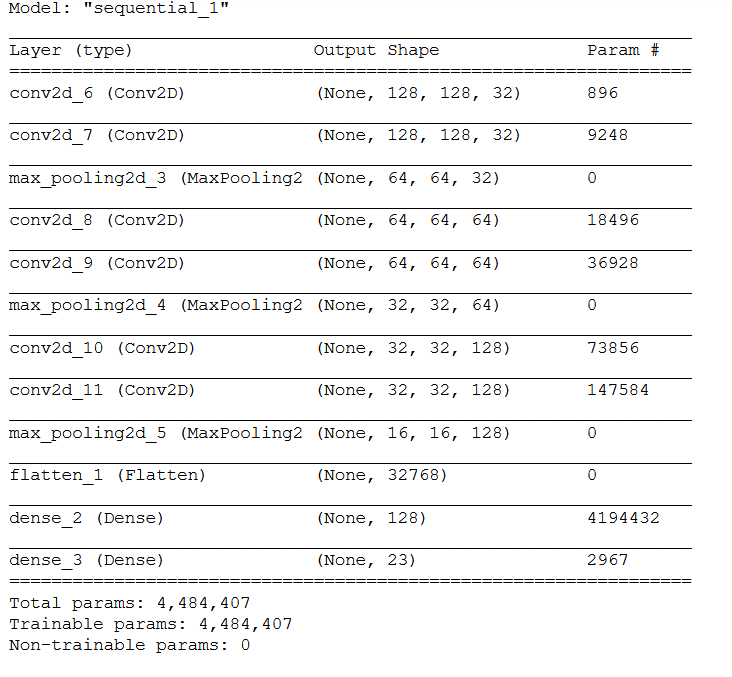


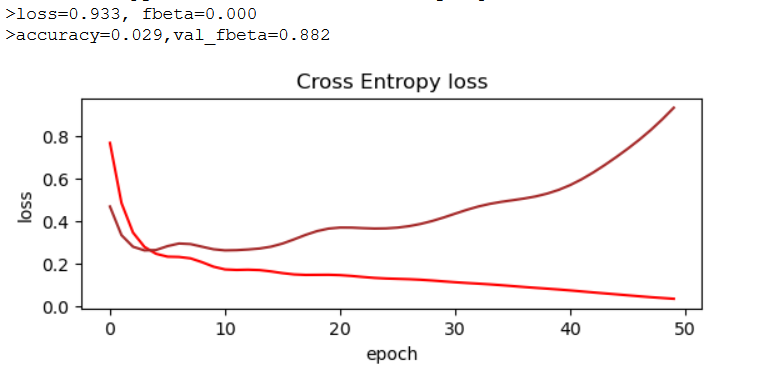
Preparation of **Survey Paper on different multi label classification**-

This survey paper emphasizes the idea of multi-label classification, analyses several assessment measures, and compares the available techniques. This work also connects multi-label issues to related but distinct problems that are frequently converted to multi-label problems in order to get access to a diverse set of multi-label methods. Multi-labelled classification has a wide range of applications, including text categorization, semantic picture labelling, and gene functioning classification, among others, and the scope and interest in these applications is growing. Depending on the characteristics of the classification problem, neural network models can be built to handle multi-label classification and perform well.

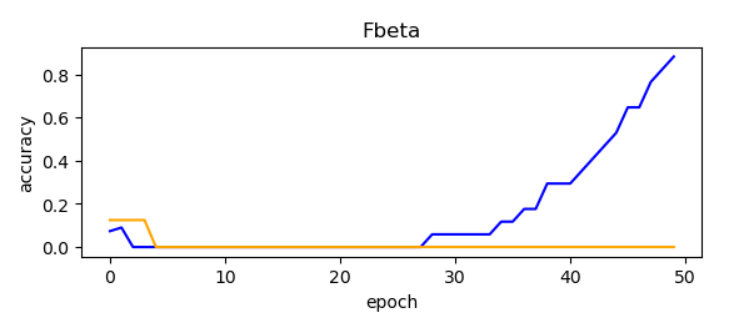
**RESULTS**

**CNN Model Layers:-**





**Fig. Loss vs epoch Graph**

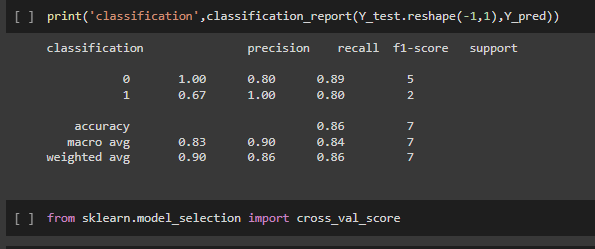
****

**Fig. Accuracy vs epoch Graph**

We got fbeta 88% in Multi Label Classification using CNN model. We will improve it as we expand our dataset size. While trying to train the model, we realized that our Validation Loss was increasing which depicts overfitting.

To overcome overfitting in image classification, you can either use earling stopping, data augmentation, regularization or use Dropouts.

**KNN Models-**

****

We got classification rate of 86% in Multi-Label Classification using KNN model. Here, we have increased the number of neighbors in the model and accuracy got increased.

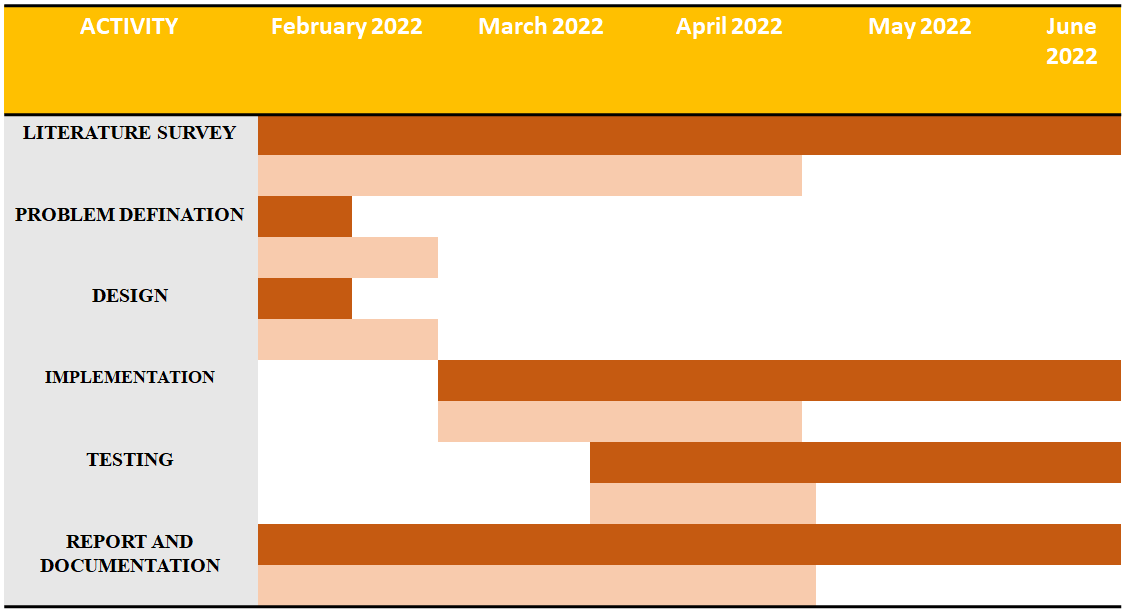
But, this is not necessary for each case that an increase in many neighbors increases the accuracy. The training phase of K-nearest neighbor classification is much faster compared to other classification algorithms. There is no need to train a model for generalization, That is why KNN is known as the simple and instance-based learning algorithm. KNN can be useful in case of nonlinear data. It can be used with the regression problem. Output value for the object is computed by the average of k closest neighbors value.

**WORK TO BE DONE**

**Preparation** and **publication** of the **research paper**.

**Expansion** of **Dataset.**

**Gantt Chart**

****

|  |  |
| --- | --- |
|  | **Proposed time frame for task completion** |
|  | **Actual time frame for task completion** |
|  |
|  |  |  |

**REFERENCES**

[1] Jiang Wang1 Yi Yang1 Junhua Mao2 Zhiheng Huang3∗ Chang Huang4∗ Wei Xu1 1Baidu Research 2University of California at Los Angles 3Facebook Speech 4 Horizon Robotics,” CNN-RNN:A Uniﬁed Framework for Multi-label Image Classiﬁcation”

[2] Lamia Nabil Mahdy,Kardy Ali Ezzat,Haytham H. Elmousalami, Hassan AboulElla,Aboul Ella Hassanien,Higher Technological Institute, Biomedical Engineering Department, Egypt, Faculty of Computers and AI, Cairo University, Cairo,Egypt, Faculty of Veterinary medicine, Cairo University, Egypt,Scientific Research Group in Egypt(SRGE),”Automatic X-ray COVID-19 Lung Image Classification System Based on Multi-Level Thresholding and Support Vector Machine” http://www.egyptscience.net.

[3] Yan Luo(University of Minnesota), Mina Jiang (University of Minnesota),Qi Zhao(University of Minnesota),”Visual Attention in Mutli-Label Image Classification”, Authorized licensed use limited to: Cornell University Library. Downloaded on August 20,2020 at 09:19:17 UTC from IEEE Xplore.

[4] Francisco Gomez-Donoso, Félix Escalona, Ferran Pérez-Esteve, Miguel Cazorla, "Accurate Multilevel Classification for Wildlife Images", *Computational Intelligence and Neuroscience*, vol. 2021, Article ID 6690590, 11 pages, 2021. <https://doi.org/10.1155/2021/6690590>

[5] Decubber S., Mortier T., Dembczyński K., Waegeman W. (2019) Deep F-Measure Maximization in Multi-label Classification: A Comparative Study. In: Berlingerio M., Bonchi F., Gärtner T., Hurley N., Ifrim G. (eds) Machine Learning and Knowledge Discovery in Databases. ECML PKDD 2018. Lecture Notes in Computer Science, vol 11051. Springer, Cham. https://doi.org/10.1007/978-3-030-10925-7\_18