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Panchadeva: Sculpture Image Classification using CNN-SVM

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ABSTRACT

Rich culture and heritage have been a very promising factor when it has come to the land of India. India is a land which is enriched with a vast amount of architectural sculpture, rare sculptures, temples and many more. When it comes to the classification as well as recognition of these Rare Indian Sculptures, it is often a very challenging task. In the realm of image recognition, classification, and identification, entity recognition of Indian sculptures might be seen as one of the most complex and challenging challenges. This project primarily consists of a database which is manually constructed. The database consists for a total of five entities belonging to the various Indian Gods. In this project, we have considered Lord Ganesha, Lord Hanuman, Lord Krishna, Lord Shiva and lastly Lord Vishnu thus adding up to a total of five entity classes. Every image has a distinctive feature which separates and differentiates it from the rest of the images or pictures. The orientation, angles, sizes as well as the colours of all these images play a very crucial and important role in the training and processing of the machine learning model which is to be implemented. Here, the model is trained on a total of 500 images with each of 100 images belonging to one entity class. Support Vector Machine and Convolutional Neural Network, respectively, can be used to assess the efficacy and accuracy of the proposed model. Using a combination of the Deep Learning, Convolutional Neural Network (CNN) along with Sequential model with categorical cross-entropy and SoftMax functions assisted by SVM(Support Vector Machine) -the model that this project trained has enabled us to achieve an accuracy of 94%.

Keywords: *CNN, SVM*

INTRODUCTION

Hindu, Buddhist, Jain, and other religions all have their own gods and goddesses that are worshipped in temples throughout India. These temples are frequently decorated with elaborate carvings and sculptures that represent different deities and mythological scenes. Temples in India vary in size and architecture, but they all serve as a place of devotion and worship for devotees.

The temples in India are known for its sculptures as well as the carvings which is found in the walls, pillars and ceilings of the temple. With so much of rich, complex and minute information pertaining to each of the entity class, it has made the identification, classification and recognition of each of these aspects more challenging and difficult to process. This problem has been primarily addressed through our project as well as research paper

-PanchaDeva classification. The concept of image classification plays a very important role in order to answer the question – "which entity or class does the model belong to?" or "what is the class number to which the selected or predicted entity falls in or corresponds."

FIG 1: Sample images of Lord Ganesha

Image recognition is the process of modifying what a machine (computer) sees to enable classification of the observed objects for the goal of making additional decisions by analyzing the digital data captured. Image recognition, as used, for example, in recognizing people in images, is really a special case of the pattern recognition domain, which has uses in many different scientific domains. Many fields, such as mapping and geology, as well as physics, bio-identification, security, industry, and robots, can benefit from its use. It is a method for using different processes to an image in order to enhance it or extract some useful information from it. It is a form of signal processing where a picture serves as the input, and the output can either be another image or features or properties associated with that image. The system then has the ability to do the required activity without requiring human interaction. As a result, the moderation procedure will be quicker, less expensive, and more effective.

FIG 2: Sample images of Lord Krishna

Over the past years the findings of many ancient idols of gods have started to be found at regular intervals of times. Finding, recognizing, classifying of these sculptures is becoming a very difficult task as the day passes. These sculptures contain such small, important details which is not visible to the human eye. Several machine learning technologies have been developed to assist archaeologists. These models help to categorize, identify patterns and also find the similarities between them and provide a valuable output. Through this research paper, we aim to provide a strong, efficient, and accurate leaning model which would be able efficiently classify the entities into its respective categories and also help in providing accurate percentage of prediction of the model used. The primarily objective is to create a multiclass sculpture classification and identification system which would have the ability to classify any sculpture entity in an image format and in return provide the user with an accurate output.

The project is started off with a database which is manually formed and consisting of various and vast images of five gods which are to be identified and classified respectively. The five key entities which are taken into consideration are – Lord Ganesha, Lord Hanuman, Lord Krishna, Lord Shiva and Lord Vishnu respectively. The images constituting the database are of a single format of JPG. Also, the database in divided into three phases namely-training, validating, and testing. The images in

the database are of various sizes, colours, angles, and orientations. The learning model which has been trained has helped reach an accuracy percent of 94%.

FIG 3: Sample images of Lord Hanuman

FIG 4: Sample images of Lord Shiva

The structure of the paper consists of the following sections namely – Literature Survey, Methodology, Implementation, and results-discussions respectively.

The main goal and most important objective of this work would be to actively help in classification, identification, and recognition of the sculptures and provide important insights found through the model used.

FIG 5: Sample images of Lord Vishnu

LITERATURE SURVEY

Multi-Class Entity classification and.sculpture detection is an unique topic od study and not much research or work has been done on it . Multiclass sculpture classification in a whole has not been fully recognized and is yet to be studied in dept. Also, not of much research as well as implementation in this field has been found. Here, in this section we have laid out few of the key and important findings related to this field which has been used and executed by various authors and researchers.

The methodology starts with capturing the images from the dataset and then normalising them. Image normalisation is a process, often used in the preparation of data sets for artificial intelligence (AI), in which multiple images are put into a common statistical distribution in terms

of size and pixel values; however, a single image can also be normalised within itself. The feature vector extraction is then performed, which is essentially done by an abstraction of an image used to characterise and numerically quantify the contents of an image, and then uses a TensorFlow neural network to classify the images[1]. As a result, the classification has an accuracy of nearly 79 percent.

The image pre-processing is done from the data set, and then the model is trained with the normal convolutional neural network (CNN) with 60 epochs. After training the model, it achieves an accuracy score of 0.175.[2]

This is an implementation of the Viola-Jones Detection Framework. This implementation of the Viola-Jones Framework requires Python version 3.5.2 and uses the OpenCV module[3]. This framework mainly focuses on the steps of creating classifier cascades. Cascade classifiers are trained using several positive images and arbitrary negative images. The model has high accuracy and a low false-positive rate.

The image pre-processing is done from the data set. Then the feature vector extraction is performed[4], which is essentially done by an abstraction of an image used to characterise and numerically quantify the contents of an image, and thus the image is being classified with an accuracy of 98.3%.

The image classification is done with the CIFAR-10[5]. It is a well-understood dataset and widely used for benchmarking computer vision algorithms in the field of machine learning. The Accuracy is of 75%.

TABLE 1: Comparison of recent research papers

Reference Paper No	Methodology/ Model used	Merits And Findings
[1]	Image Capturing and Normalization Feature Vector Extraction TensorFlow Neural Network Classification Visual	High precision rate (79%)
[2]	Image Pre-processing Using the method of normal CNN	After training this model for 60 epochs the model accuracy is 0.175
[3]	OpenCV implementation of Viola-Jones Face Detector, Cascade classifiers trained on images	High accuracy and low false positive rate
[4]	image pre-processing, image feature extraction and classifier	Accuracy of 98.3%
[5]	image classification on CIFAR-10	Accuracy of 70%

PanchaDeva Methodology

This section of the research paper primarily focuses on the specifications of the methodology used in the project. The methodology has been shown in the form of a flow chart diagram as well as a fully detailed architectural or block diagram respectively. The flow chart helps one to understand the basic outline of the list of steps taking place during the process of image classification and recognition while the architectural block diagram gives us the in-dept analysis and information about the step wise stages involved in the image classification, identification and recognition. The flow chart and the block diagram has been represented in fig.6 and fig.7 respectively.

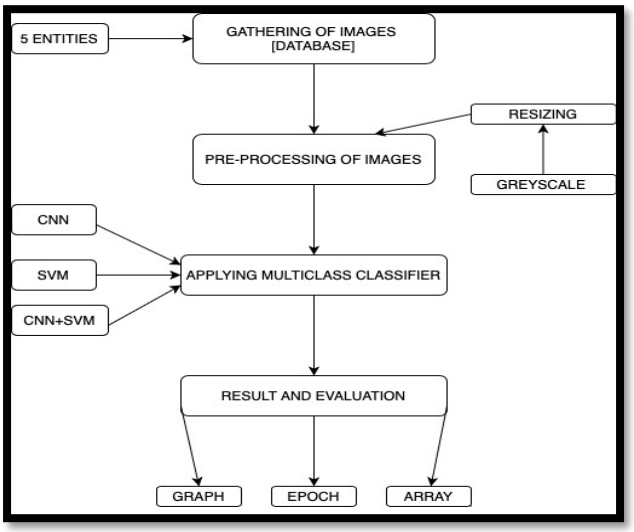

FIG 6: Panchadeva-Flow diagram

From the above flow chart, we can clearly understand the basic flow of the various stages involved in the process of multi-class image classification. It consists of four prime steps which a number of sub steps also involved. The prime stages are: Formation of the database, Pre-processing of the images, Implementation of the effective and efficient multi-class classification model, and lastly the result and evaluation section. The prime steps are also accompanied with a number of sub stages such as: Resizing and conversion to grey scale images, multiclass classifiers such as CNN, SVM, Decision Trees following by the representation of the results in the form of: Graphs, Epochs tables, and prediction arrays respectively.

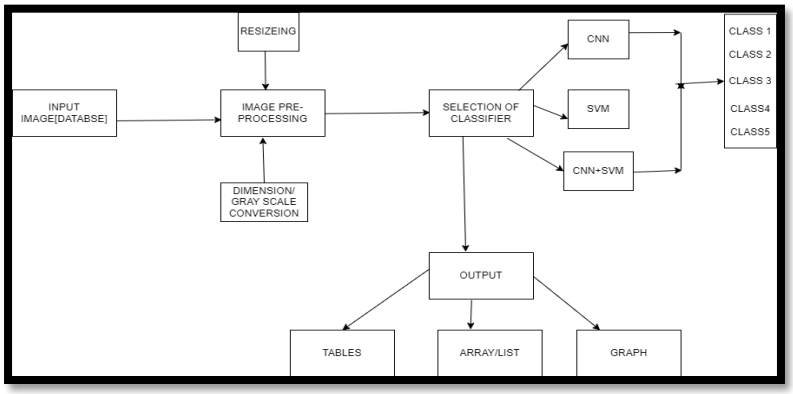

FIG 7: Panchadeva Architectural Block Diagram

The in -dept, detailed and elaborate explanation of the various stages, steps and sub steps involved in the process of multiclass image classification in explained in the above fig.7. The Re-sculpt architectural or block diagram plays an important role in clearly understanding the outline and the steps involved in the implementation of this project. Each of the stages have been explained in dept in the in subsequent sections respectively.

Acquisition of the images

This can be regarded as the first stage in any type of image processing models. It is very important to acquire or collect the right number of images

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in order to get an accurate result. In this project, the database has been manually formed.

The database consists of primarily 5 entities each of whose numerous images have been collected and saved. The images have been taken from various orientations, angles, different sizes, and of numerous colours respectively. The 5 five entities include: Lord Ganesha, Lord Vishnu, , Lord Hanuman, Lord Krishna, and lastly Lord Shiva.

After the formation of the database, the total number of collected images have been divided into three sections mainly for enabling the process of training, validating, and testing respectively. The main source of the images is goggle images. All the images in our database has been downloaded from google images.

Pre-Processing Of The Images

Image pre-processing can be termed as the second stage or step mainly involved in the process of multiclass image classification, recognition as well as identification. Pre-processing of the image plays a key role in defining the accuracy of the respective machine learning model used. It is very important to pre-process the images as the images that are collected come in various sizes, angles, orientations, formats and colors. By pre-processing them, we would be able to convert all the images into the required uniform format for precise and accurate results.

Pre-processing of the images collected in the database consists of two very important steps. These steps are namely: Resizing of the images and conversion of the images from RGB(Red Green Blue) to grey scale. It is very important to resize all the gathered and collected images so that during the time of processing of the respective machine learning model, all the images would be present in an unified manner. Conversion of the images into gray-scale is also equally important as it helps the learning model to efficiently work on the images and thus in return provide the best accuracy. In this project, the images have been collectively resized in the dimensions of 100x100 respectively and also scaled in gray scale subsequently. This process can be seen more in detail by closely seeing fig.8 and fig.9 inserted below.

```
try:
    gray=cv2.cvtColor(img,cv2.COLOR_BGR2GRAY)
    resized=cv2.resize(gray,(100,100))
    data.append(resized)
```

FIG 8: Gray scale conversion and Image Resizing

FIG 9: Gray scale conversion

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Selection of Classifier

This stage can be treated as the one of the most important part in any multiclass image classification. In this step, the most efficient and effective machine learning model is selected. It is always crucial to select the correct image classifier which can yield in accurate results. Various machine learning and classifying models are studied can the most effective as well efficient one is selected. There are numerous models which can be used in this phase. The selected model primarily works on three main phases: Training, Validating and Testing.

Various learning models such as CNN, KNN, ANN, SVM all can be used in order to accurately classify, identify and recognize the images present in the database respectively. Deep learning models can be used in here very effectively as they are very fast, accurate and efficient all at the same time. This project mainly deals in classification of five main entities and thus goes about using CNN+SVM as one of the effective, efficient model helping in determining a good accuracy. In this phase, multiple other models such as Naïve bayers, decision tress can also be used. Deep learning model like CNN is primarily used to help identify, sort, and recognize the images gathered in the dataset into its respective entity class. In this project, there are 5 entities which are required to be classified and thus selection of the right model is a challenging task. The CNN+SVM model used has helped in primarily labeling the respective classes in terms of numerals from 0 to 4 in a sequential manner with Lord Ganesha labeled as 0 to Lord Vishnu labeled as 4 respectively.

The classifier helps to generate a prediction array which accurately classifies the entities.

Output Analysis

This phase mainly deals with the accuracy and classification analysis. Here, the accuracy results obtained are closely analyzed and plotted. The output which the implemented learning model generates is in terms of three main parts: Epoch Tables, Graphs, and Prediction arrays. In this phase, the loss or error that is caught or seen is also captured and generated in terms of graphs and tables respectively. Error or Loss generated can be defined as the information or pixels or any image processing aspect that has been lost in the prior steps during the pre-processing of the respective images.

The output generated as represented in tables and graph gives the reader the best understanding of the effectiveness of the model used and also about how accurate is the model used. Prediction arrays also play an important role as the give us the prediction in terms of a set of values which accurately determine the respective 5 entity class.

Various libraries such as matplotlib and NumPy have been used. In this phase of classification, the output is constantly predicted in terms of epoch vales which include accuracy and loss percentages along with it respective graph and with an output image at end. All the results obtained are based on the comparison between the training, validating and testing images respectively.

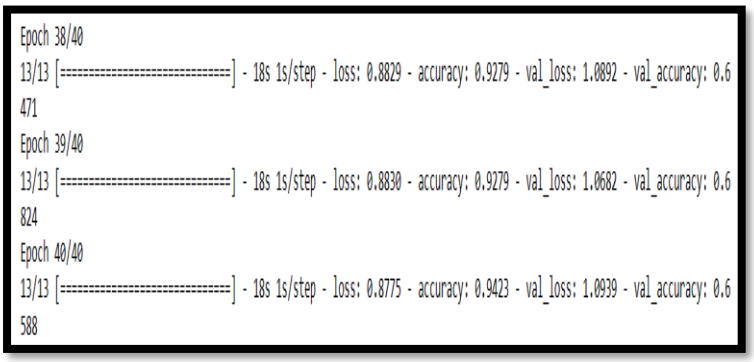

FIG 10: Output analysis

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Implementation

Implementation phase primarily lays emphasis on the important libraries, headers as well as models used in the building of this multiclass image classification model. It is very important in order to know about the implementation of the model as it tells us about the various classification models which have been used in implementing the respective model. Deep learning has been used to implement it using CNN combined with SVM as the main model in the classification, recognition and identification process.

Libraries Used

It is very important to be aware of the various, different libraries which have been used in implementing this multiclass image classification model. Libraries play an important role as they help in identifying as well as increase the functionality and operation of the code, thus making the process more easy and fast to take place. In this project, multiple machine learning libraries have been used. These include: NumPy, Keras, TensorFlow, OpenCV. TensorFlow combined along with Keras is one of the very important libraries used in this model. Also, OpenCV has been used as it is regarded as one of the best image processing libraries which can be implemented for image classification, identification and recognition.

This work also includes the use of the NumPy library. NumPy is included as it helps in enabling a fast and efficient speed of processing during the various phases of the model training, validating as well as testing. Import OS also has been used here as it helps in navigating across various files in a swift and effective manner. In addition to this, Matplotlib library has been used for implementing the graph in order to plot the various values of accuracies and loss.

CNN-SVM MODEL

This work has been mainly implemented using CNN model which is assisted and combined with SVM. CNN can be considered as one of the very important used in the process of image classification, identification as well as recognition. The CNN model used in this work consists of an architecture containing various layers. These layers play a crucial role in the training of the CNN model. This model used consists of a sequential model along with three layers of conv2D for taking in the given inputs and generating a tensor of outputs along. Additionally, three layers of MAXPOOL2D along with the strides and pool sizes are used in order for the kernel to extract maximum area. Lastly, two different layers called the Dense and the Flatten layers have also been used for connecting the layers to the neural network and for extraction of the pooled map to a single column respectively. In deciding the model's output, both the dense layer and the flatten layer are important factors. Various activation function are also included which assist the layers in order to obtain an efficient CNN model. Additionally, the SVM model integrated uses the regularizers. Regularizers help in determining the extent of misclassification that takes place during the process of classification and helps in classifying as well as identifying the right entity into its respective category. The SVM model has been combined with the CNN model primarily in the compilation phase of the model using the regularizers as well the specific loss function of ‘squared_hinge’.

Loss And Activation Functions

During any image processing, there is always some amount of information that is lost in terms of pixels, colours and many more of such aspects. With the help of the Loss functions, these losses can be evaluated, analyzed as well as plotted based on the loss values obtained while running the model. Similarly, activation function also assists the flat and dense layers for more efficient training of the CNN model. This model used consists of ‘ ReLU’ as one of the main activation function. With a positive input, a linear function will output the input directly; otherwise, it will return zero. ‘ReLU’ along with other activation called ‘SoftMax’ is implemented in this multi-class image classification model. Softmax can be defined as a function primarily used in multiclass classification which converts a vector of real numbers into a probability distribution spanning over several classes. Using this function helps to

interpret the output of the neural network where the highest probability value resembles the predicted class within the multiclass. Using the softmax function enables the computation of a loss function, such as cross-entropy loss, which can be used to optimise the neural network's weights as it is being trained. Also, the SVM model integrated mainly uses the 'squared_hinge' loss function in order to combine the SVM into the CNN model in order to generate the required hyperplane for the classification of different entities respectively. SVM is primarily related with the hinge function and since here, the project deals with multiclass image classification, the 'squared hinge' loss function has been integrated.

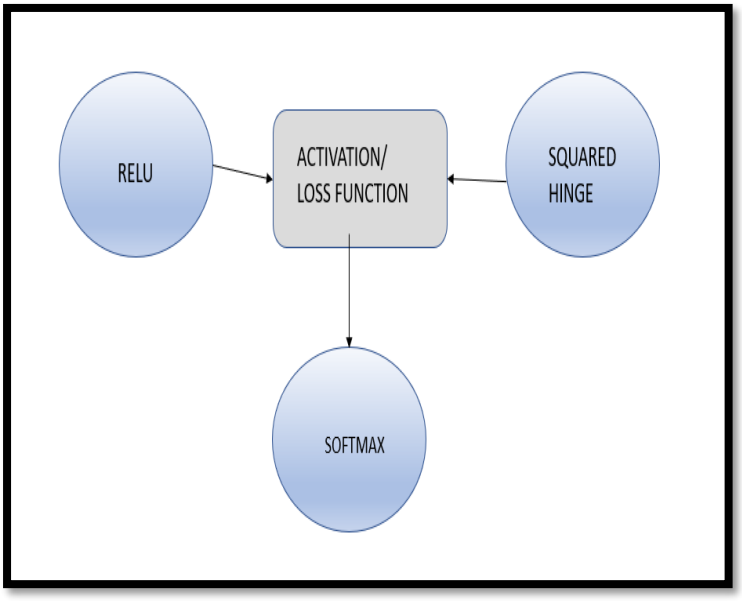

FIG 11: Types of activation functions used

RESULT AND DISCUSSION

In this phase of the research paper, the appropriate result obtained has been analyzed and discussed. The accuracy, loss, the variable accuracy as well as the variable loss percentages have been and has been plotted against each other in order to give a detailed functioning of the learning model used. The CNN-SVM model which has been implemented has been successful in order to categorize the images into its respective category.

Epoch Table

The total images stored in the database has been primarily split into two or three phases of: test, train and validation respectively. The test data consists of

80% of train and validation data while the remaining 20% is primarily been used for the purpose of testing. The accuracy of the model has been compared at different epoch cycles and has been tabulated as represented in table no 2. In addition to this, excessive values of the epoch have not been set to present any overfitting of the data and also to avoid any influence on the accuracy obtained.

The validation or the testing percent was set to 20%. Subsequently, the obtained accuracy as well as the loss values have been plotted using the matplotlib library.

TABLE 2: Epoch value table

Epoch Cycle No	Loss	Accuracy
1/40	0.96	0.81
5/40	0.95	0.84
10/40	0.94	0.86
15/40	0.93	0.87
20/40	0.91	0.89
25/40	0.92	0.88
30/40	0.89	0.91
35/40	0.88	0.93
40/40	0.87	0.94

Graph And Prediction

The corresponding graph of the accuracy as well as the loss function has been plotted with the help of matplotlib library. Below are the respective graphs as different values of the epoch cycles.

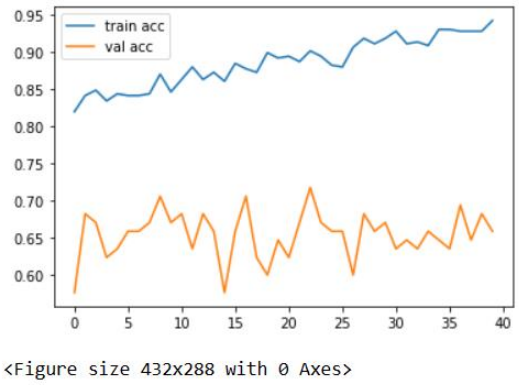

FIG 12: Graph indicating the accuracy trend

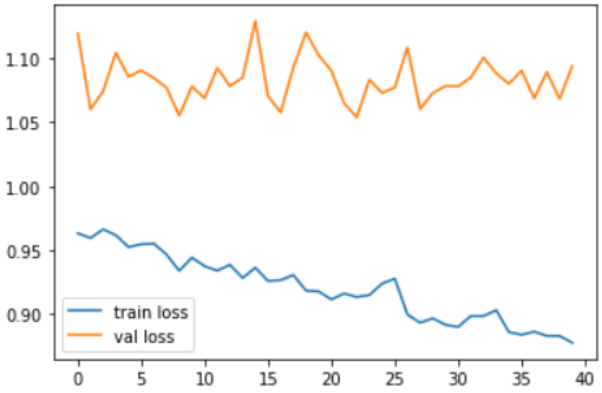

FIG 13: Graph indicating the Loss trend

This above graph contains the plotting of the respective accuracy values against the loss values with the epoch cycle being set to 40. From the graph, it can be indicated that the value of

accuracy reaches a peak point of 94% which verifies with the obtained accuracy of the same as well. Another trend which can be seen from the above graph is that with the increase in the value of the accuracy, the loss value subsequently decreases. This observed trend in the graph indicates that the learning model in this multiclass classification has been trained efficiently and successfully. Also, when observed the accuracy along with the variable accuracy is in the upward trend and is showing an increase while the loss as well as the variable loss is in the declining direction thus indicating a downfall. This proves that the model has been successful in classifying the entities into its respective categories matching its accuracy percentage. The labelling in the form of various colours in the above graph helps in differentiating the components involved in the plotting of the graph respectively.

```
result
```

```
array([[1.4226521e-04, 3.4005803e-03, 9.1466522e-05, 6.7242327e-06,
        9.9635893e-01]], dtype=float32)
```

FIG 14: Prediction Array for Vishnu

```
1/1 [==============================] - 2s 2s/step
Prediction :
vishnu

<matplotlib.image.AxesImage at 0x22400ecc7c0>
```

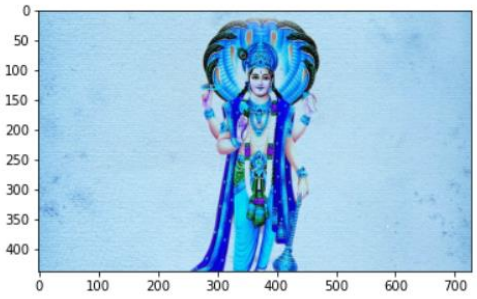

FIG 15: Model Prediction-Vishnu

```
1/1 [==============================] - 0s 281ms/step
Prediction :
krishna

<matplotlib.image.AxesImage at 0x25464eee760>
```

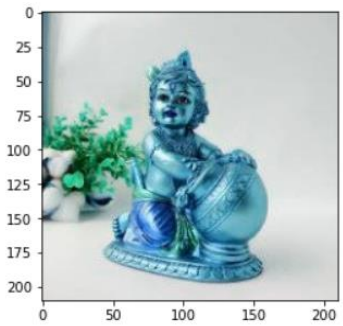

FIG 16: Model Prediction-Krishna

CONCLUSION

The CNN-SVM model used in this work has been successful in classifying, identifying as well as predicting the given image from the database into its respective category and to which entity it primarily belongs to. This CNN model has been trained with a sequential model in order to achieve the respective output of the images as well as the graphs. This model has also been supported with three very important loss and activation functions namely: 'ReLU (Rectified Linear Unit)', 'SoftMax' and 'Squared Hinge' respectively.

Also, after a successful training of the CNN-SVM model, a number of epoch cycles had been set in order to test the effectiveness of the trained model. The model was tested with different values of epochs respectively. After setting the epoch cycle as 30, the maximum accuracy of 94% was achieved. This accuracy percentage indicates that the leaning model has been trained as well as tested successfully. The model has rightly been able to classify the image as to which entity it belonged to.

In the near future, a variety of similar concept-based machine learning models along with various other techniques such as random forest, decision tress can be used in multiclass as well as multi-labelling projects which would help in identifying as well as correctly labelling the entities in its respective categories. This can help in classifying a greater number of entities and can successfully pave way into the mythological phase.

The CNN model can be enhanced with different activation functions as well as be advanced with more layers in order in build a model which would give more accuracy.

The concept on transfer learning can also be included along with the model in order to make a very accuracy learning model which can very efficiently classify, identify as well as categorize the given entity successfully.

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