Capstone project

Definition

Project Overview:

Building an image classifier that could distinguish between different classes of fruits given their image datasets.

Problem Statement:

The main aim of this project is to build a classifier that can distinguish different classes of fruits.

Given a new input image of a fruit, the classifier should be able to predict the class.

Here, convolutional neural network will be used since convnets are good for image classification due to its good performance.

Metrics:

The evaluation metrics used to quantify the performance of both the benchmark model and the solution model presented are:

- Accuracy:
    a) Accuracy is the ratio of number of correct predictions to the total number of predictions.
    b) Accuracy = Number of correct predictions/Total number of predictions.
    c) Since the dataset is balanced, we have used accuracy as an evaluation metric.
- Loss function
    a) Loss function is a measure of how good a prediction model does in terms of being able to predict the expected outcome.
    b) The main aim of neural network is to reduce this loss function.

Analysis

Data Exploration:

- Dataset is obtained from Kaggle(Fruits-360).
- There are 65429 images in total.
- Training set size: 489005 images.
- Test set size:16421 images.
- There are 95 different classes(fruits).
- The size of each image is 100x100 pixels.

  This dataset is a balanced dataset as the number of instances of data points in each class is around 490

Examples of images extracted from the dataset:

- Apple Braeburn:

- Banana:

- Grape Blue:

- Orange:

Algorithms and Techniques:

- Here, I am building an image classifier using convolutional neural network that can distinguish different classes of fruits given their image dataset.
- CNNs are used here due its high performance in case of image classification.
- Our classifier will consist of convolutional layer, max pooling layer, flatten layer, dense layer and activation functions.
- The image classifier is trained using training dataset consisting of 489005 images.
- This image classifier is tested using test dataset consisting of 16421 images.
- The goal here is to reduce loss and increase accuracy.
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Benchmark:

Model	**Optimizer**	**Epochs**	Training accuracy	Training loss	Testing accuracy	Testing loss
One of Kaggle kernels	Adam	25	0.9941	0.0161	0.9589	0.154164

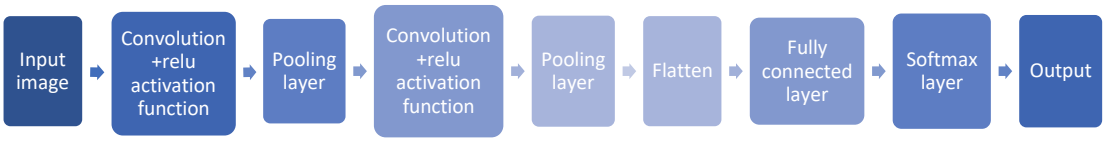
Methodology

Data pre-processing:

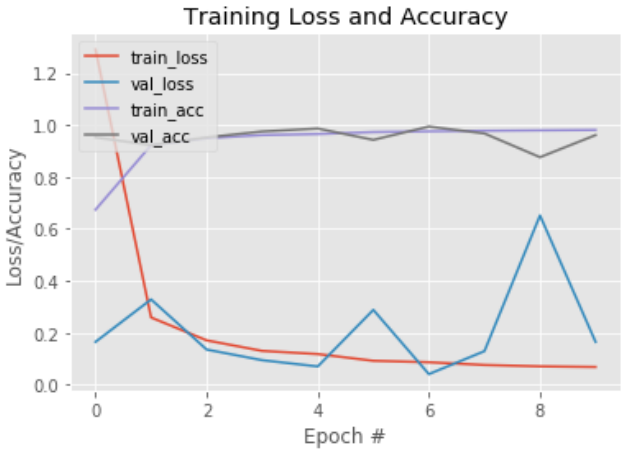
- The input image is 100 x 100 px.
- The image is first compressed to 65 x 65 px.
- The image is then converted into array.
- The labels are assigned to these images.
- We further pre-process the input image by scaling the data points from [0, 255] to the range [0, 1].
- Then the entire dataset into training and testing set.
- 75% of the dataset constitutes training set. The rest 25% of the dataset constitutes testing set.

Implementation:

- Data pre-processing
- Model architecture was designed. This model was trained using RMSPROP optimizer and 10 epochs
- Below model architecture was initially designed.



- Loss/Accuracy vs Epochs graph was plotted to visualize how accuracy changes with epochs.



- Final training and testing accuracies/losses were recorded.
- This model was tested with sample images. Below are some examples:

```
In [35]: Image(filename='samples/sample_pineapple.jpg',width=140,height=140)
```

Out[35]:

```
In [36]: predict_label("model_rmsprop","label_bin","samples/sample_pineapple.jpg")

loading model from disk........
classifying image....
Pineapple
```

```
In [37]: Image(filename='samples/sample_banana.jpg',width=140,height=140)
```

Out[37]:

```
In [39]: predict_label("model_rmsprop","label_bin","samples/sample_banana.jpg")

loading model from disk........
classifying image....
Banana Lady Finger
```

```
In [40]: Image(filename='samples/sample_strawberry.jpg',width=140,height=140)
Out[40]:
```

```
In [41]: predict_label("model_rmsprop","label_bin","samples/sample_strawberry.jpg")

         loading model from disk........
         classifying image....
         Strawberry

In [42]: Image(filename='samples/sample_apple.jpg',width=140,height=140)
Out[42]:
```

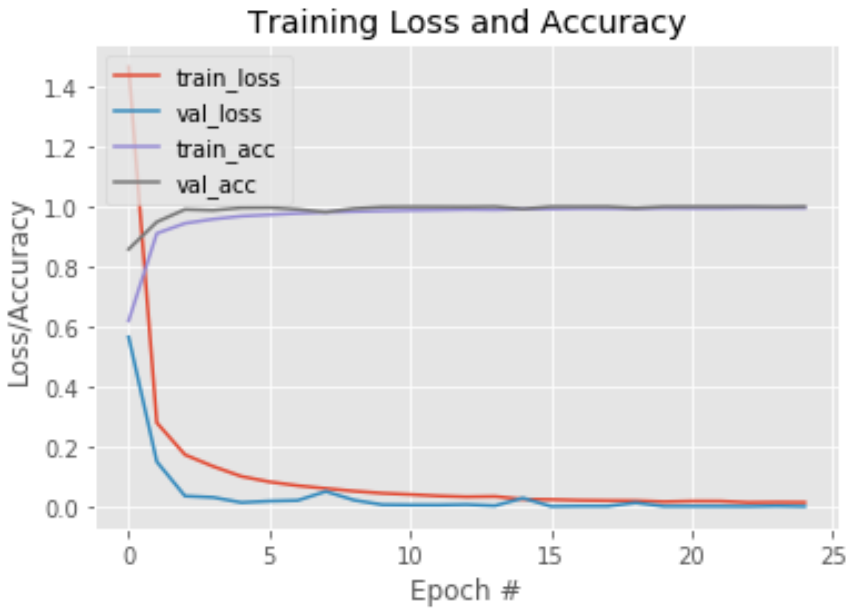
```
In [43]: predict_label("model_rmsprop","label_bin","samples/sample_apple.jpg")

         loading model from disk........
         classifying image....
         Tomato Cherry Red
```

- As seen from above examples, last image which is an apple is wrongly classified as Tomato Cherry Red.

Refinement:

- A new model was designed. This model was trained using ADAM optimizer and 25 epochs.
- Loss/Accuracy vs Epochs graph was plotted to visualize how accuracy changes with epochs.



- Final training and testing accuracies/losses were recorded.
- This model was tested using the same sample images. Below are some of the examples:

In [47]:
```
Image(filename='samples/sample_pineapple.jpg',width=140,height=140)
```

Out[47]:

In [49]:
```
predict_label("model_adam","label_adam","samples/sample_pineapple.jpg")
```

```
loading model from disk........
classifying image....
Pineapple
```

In [50]:
```
Image(filename='samples/sample_banana.jpg',width=140,height=140)
```

Out[50]:

In [51]:
```
predict_label("model_adam","label_adam","samples/sample_banana.jpg")
```

```
loading model from disk........
classifying image....
Banana Lady Finger
```

In [52]:
```
Image(filename='samples/sample_strawberry.jpg',width=140,height=140)
```

Out[52]:

In [53]:
```
predict_label("model_adam","label_adam","samples/sample_strawberry.jpg")
```

```
loading model from disk........
classifying image....
Strawberry
```

In [54]:
```
Image(filename='samples/sample_apple.jpg',width=140,height=140)
```

Out[54]:

In [55]:
```
predict_label("model_adam","label_adam","samples/sample_apple.jpg")
```

```
loading model from disk........
classifying image....
Apple Red Yellow 1
```

```
In [56]: Image(filename='samples/sample_orange.jpg',width=140,height=140)
Out[56]:
```

```
In [57]: predict_label("model_adam","label_adam","samples/sample_orange.jpg")
loading model from disk.....
classifying image....
Orange
```

- As seen from the above pictures, this model has correctly classified apple as Apple Red Yellow 1.
- From this model, we concluded that increasing epochs and using ADAM optimizer gives better results.
- Training and testing accuracies of this model is better than the previous model.

Results

Model evaluation and validation:

- The final model is reasonable and aligning with solution expectations.
- The final model has been tested with new images to evaluate whether the model generalizes well to unseen data.
- Below is the justification which clearly shows Model trained using Adam optimizer and 25 epochs performs better.
- From the below table, we can conclude that changing number of epochs further from 25 to 50 has no effect.

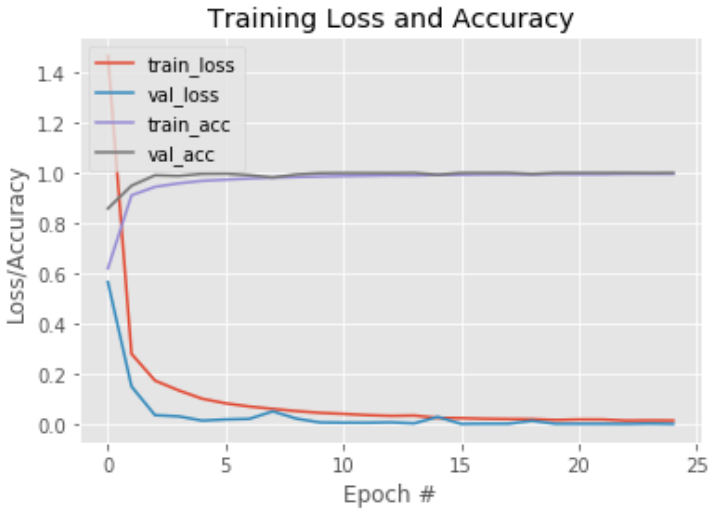
Justification:

Model	Optimizer	Epochs	Training accuracy	Training loss	Testing accuracy	Testing loss
Model	RMS PROP	10	0.9803	0.0710	0.9612	0.1648
Model(Final)	Adam	25	0.9950	0.0183	0.9999	4.4487e-04
Model	Adam	50	0.9978	0.0091	0.9999	4.4157e-04
One of Kaggle kernels	Adam	25	0.9941	0.0161	0.9589	0.154164

Conclusion

Free-Form Visualization:

- The final model had high training and testing accuracies.
- This can be verified using the plot below:



- Our final model was able to accurately predict the class of the fruit.
- Below are some of the examples:

```
In [47]: Image(filename='samples/sample_pineapple.jpg',width=140,height=140)
```

Out[47]:

```
In [49]: predict_label("model_adam","label_adam","samples/sample_pineapple.jpg")

loading model from disk.........
classifying image....
Pineapple

In [50]: Image(filename='samples/sample_banana.jpg',width=140,height=140)
```

Out[50]:

```
In [51]: predict_label("model_adam","label_adam","samples/sample_banana.jpg")

loading model from disk.........
classifying image....
Banana Lady Finger
```

```
In [52]: Image(filename='samples/sample_strawberry.jpg',width=140,height=140)
```

Out[52]:

```
In [53]: predict_label("model_adam","label_adam","samples/sample_strawberry.jpg")

loading model from disk........
classifying image....
Strawberry
```

```
In [54]: Image(filename='samples/sample_apple.jpg',width=140,height=140)
```

Out[54]:

```
In [55]: predict_label("model_adam","label_adam","samples/sample_apple.jpg")

loading model from disk........
classifying image....
Apple Red Yellow 1
```

Reflection:

The main aim of this project was to accurately classify an unseen image of a fruit.

The most important part of any machine learning project is to get clean and high quality data.

Kaggle is one of the platform which provides clean and high quality dataset.

The most interesting aspect of this project is how the learning rate can affect the accuracy.

If the learning rate is very small, training takes more time.

If the learning rate is very high, there are chances that we miss the local/global optima.

So, selecting the correct learning rate is a very important and difficult aspect in any project.

One more thing which we can see in this project is that increasing the number of epochs after some threshold does not affect the training and testing accuracies much.

Improvement:

There are several improvements that can be made in this project.

Pre-trained models can be used using the concept of transfer learning.

Better optimizers can be used to train the model.

Learning rate and decay can be better tuned to get good accuracies.

Models with many layers such Resnet can be used.

Resources

a) Kaggle dataset: https://www.kaggle.com/moltean/fruits
b) https://en.wikipedia.org
c) https://scikit-learn.org
d) https://developers.google.com/machine-learning
e) https://keras.io/
f) https://www.tensorflow.org/