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Department Of Information Technology

WELCOME

Automatic Fruit Detection, Counting and Sorting using Computer Vision and Machine Learning Algorithms

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TITLE

AUTOMATIC FRUIT DETECTION, COUNTING AND SORTING USING COMPUTER VISION AND MACHINE LEARNING ALGORITHMS

INTRODUCTION

- Reduce input cost, minimize work time, increase yield, and improving fruit quality to boost profit margin.
- Contractors are used to count the fruit manually . A lot of time is wasted to count fruits and it degrade the quality of fruits.
- Solution to automated fruit yield estimation is to use machine learning ,deep neural network and computer vision techniques.
- Save money spent on manual counting

NEED OF PROJECT

- Help the farmers in horticulture industry
- Robotic Harvesting of on tree fruits
- Reduce labor cost and labor work
- Avoid damaging of fruit

LITERATURE SURVEY

No.	Title	Publication and Year	Author	Description	Limitations
1.	Deep Fruits: A Fruit Detection System Using Deep Neural Networks	Sensors, Aug. 2016.	Inkyu Sa, Zongyuan Ge, Feras Dayoub, Ben Upcroft, Tristan Perez, and Chris McCool	Fruit detected using deep convolutional neural networks	Fruit counting should be done
2.	Deep Count: Fruit Counting Based on Deep Simulated Learning	Sensors, April-2017.	Maryam Rahnemoonfar and Clay Sheppard	Counting of fruits is done	sliced,dried fruit is also counted.

LITERATURE SURVEY

No.	Title	Publication And Year	Author	Description	Limitations
3.	A Machine Vision-based Maturity Prediction System For Sorting Of Harvested Mangoes	IEEE Transactions On Instrumentation And Measurement, July 2014	Chandra Sekhar Nandi, Bipan Tudu, Chiranjib Koley	Prediction Of Maturity Level Performed from Video Signal	Misclassification occur due to scratches or black spot
4	A Novel Red Apple Detection Algorithm Based on AdaBoost Learning	IEIE Transactions on Smart Processing and Computing, Aug. 2015.	Donggi Kim, Hongchul Choi, Jaehoon Choi, Seong Joon Yoo and Dongil Han	AdaBoost learning algorithm for recognition of fruit.	Operation only done on Citrus fruit.

PROBLEM STATEMENT

"Application of machine learning, deep neural network, computer vision and image-processing techniques for fruit classification ,detection and counting of fruits present on tree in an image.

RESEARCH COMPONENT

Build an accurate , fast and reliable automatic fruit classification, detection and counting model.

SCOPE

- The scope of this project is limited to 12 different categories of fruit
- Ex. Orange, lemon, pineapple, banana, strawberry, pomegranate, granny-smith apple, blueberry, cherry, peach, raspberry and walnut are the fruits used to train dataset.

ARCHITECTURE OF PROJECT

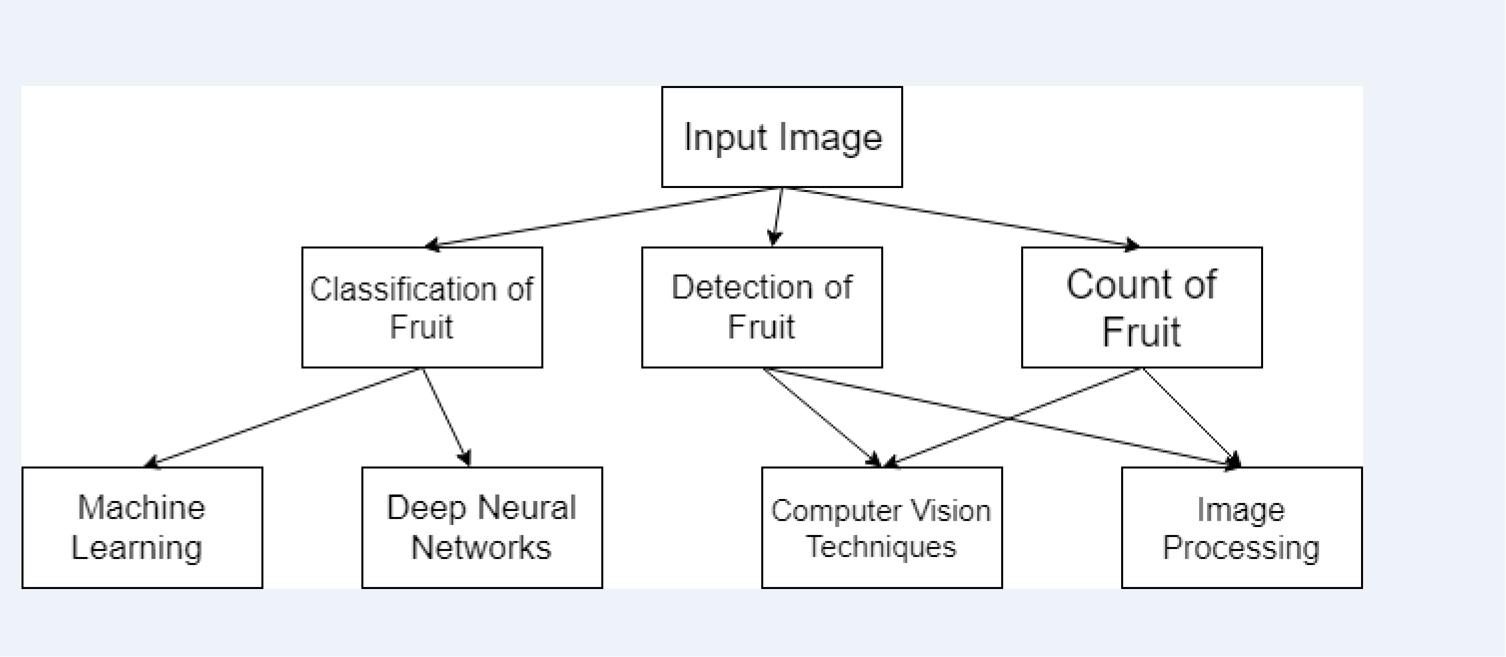


Fig: Architecture flow of project

ARCHITECTURE: MACHINE LEARNING

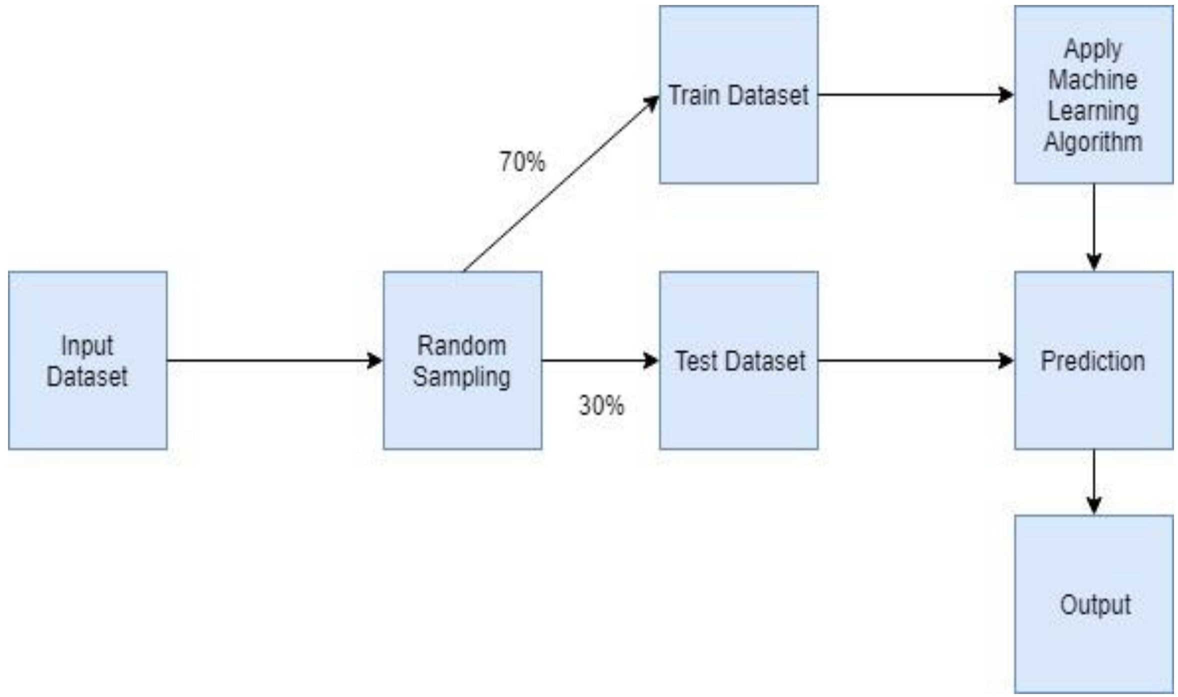


Fig :Architecture for Machine Learning Algorithms

DATASET DETAILS

Fruit	Number of Training Images	Number of Test Images
Oranges	345	134
Lemon	246	100
Pineapple	377	113
Banana	320	170
Strawberry	305	100
Pomegranate	146	100
Granny Smith Apple	392	100
Blueberry	500	500
Cherry	500	500
Peach	500	500
Raspberry	500	500
Walnut	500	500
Total Images	4631	3317

Table 3.1: Details of Dataset

ARCHITECTURE FOR DNN MODEL

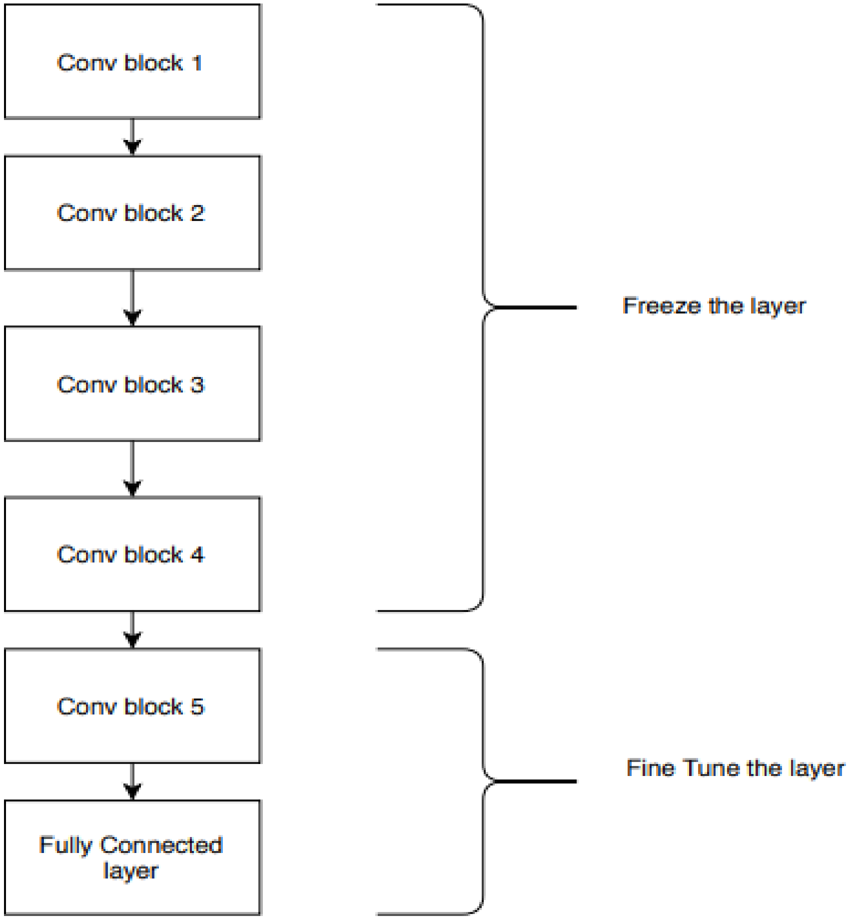


Fig: Fine - tuning of Vgg-16 network

ARCHITECTURE FOR IMAGE PROCESSING

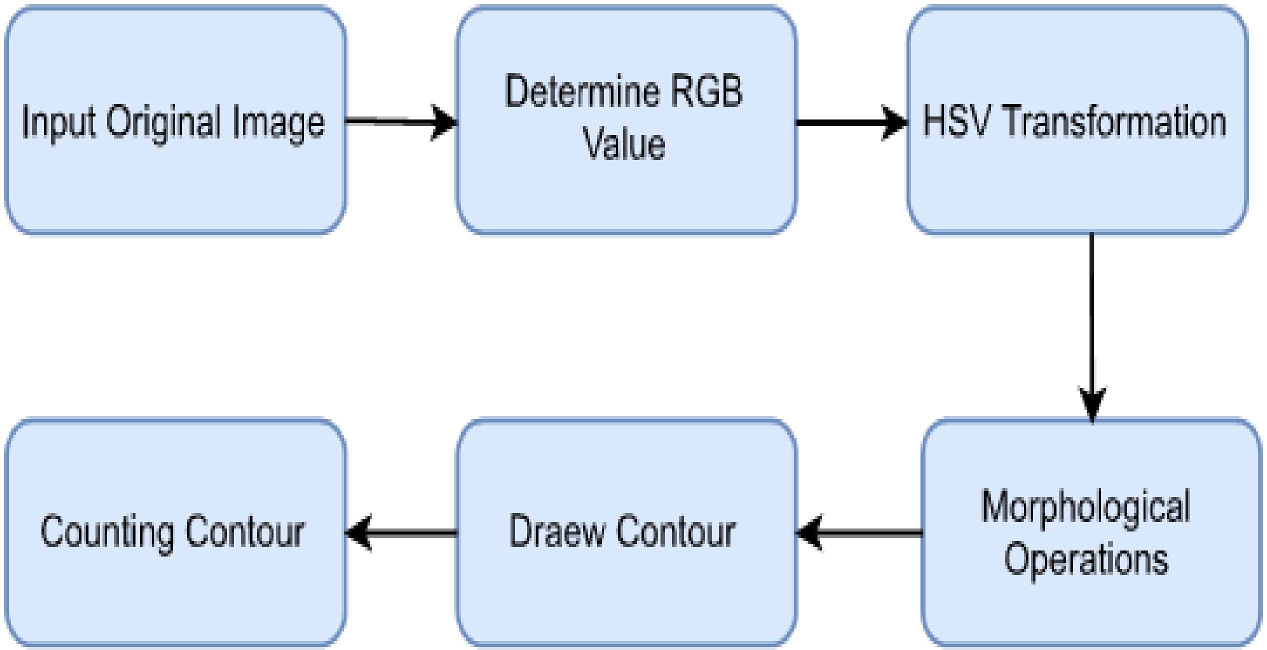


Fig 1: Flowchart for Detection and Counting of on tree Fruits.

ALGORITHMS :MACHINE LEARNING

Algorithm: Decision Tree

1: Compute the entropy for dataset 'S'

$$H(S) = \sum_{c\,\in C} -P(C)log_2 P(C)$$

2: For every attribute:

2.1: Calculate entropy for all categorical values

2.2: Calculate information gain for the current attribute

$$IG\ (A,S) = H(S) - \sum_{t\,\in T} -P(t)log_2 P(t)$$

3: Choose the highest gain attribute as root node.

4: Repeat step 2 and 3 until get whole desired tree.

Algorithm: K-Nearest Neighbors

1. Initialize the value of K
2. for i = 1 to m,

2.1: Calculate Euclidean distance between the points

$\rho\ (x, x') = \|\ x - x' \| =$

2.2 Arrange all Euclidean distance to x in increasing order.

i.e. for all i < m, $\rho(x, x_{\pi i(x)}) \le \rho\ (x, x_{\pi i +1(x)})$

2.3 Get top k rows from the sorted array

2.4 Get the most frequent class of these rows

2.5 Return the majority label among $\{y_{\pi i(x)} : i \le k]$

ALGORITHMS :MACHINE LEARNING

Algorithm: Gaussian Naive Bayes

Input: 1. 'x' represents features in the dataset
2. 'Ck' represents labels in the dataset

Output: Choose the label which has highest probability score

Algorithm: Gaussian Naive Bayes
1: Calculate the probability that the vector belongs to each class P(Ck | x_1, x_2…. x_n)
where P (Ck | x) = $\frac{(\mathrm{P}(\mathrm{x} \mid \mathrm{Ck}) * \mathrm{P}(\mathrm{Ck})}{P(x)}$
2: Choose the class which has highest probability score

ALGORITHMS : FINE TUNING OF VGG-16 MODEL

Algorithm: Fine-tuning of Vgg-16 model
Step 1: Define the fully connected layer
Step 2: Load the ImageNet pre-trained weight
Step 3: Truncate the last layer i.e. softmax layer of the vgg-16 network and and replace it with new softmax layer of 12 categories.
Step 4: Freeze the weights of first few layers of the pre-trained network.
Step 5: Fine-tune the model by minimizing the cross entropy loss function using stochastic gradient descent (sgd) algorithm and set smaller learning rate to train the network.
Step 6: Load our own dataset, split it into training and testing sets, and start fine-tuning the model by setting value of batch size and number of epoch.
Step 7: Save model with '.h5' extension
Step 8: Stop.

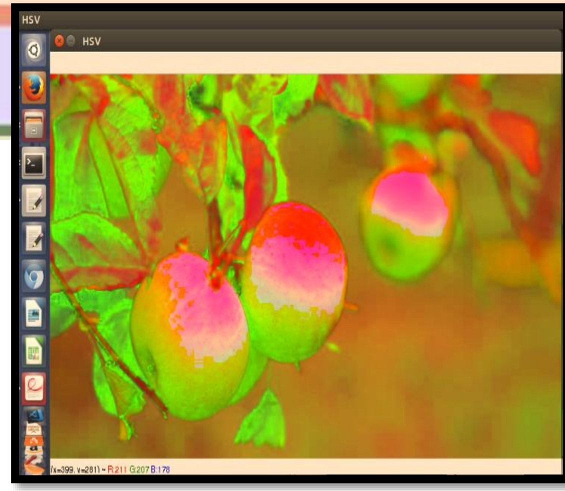
ALGORITHM: DETECTION AND COUNTING OF FRUIT

Algorithm for detection and counting of fruit
Input: Set of N images.
Output: Polygon fitting and number of counts for detected fruit

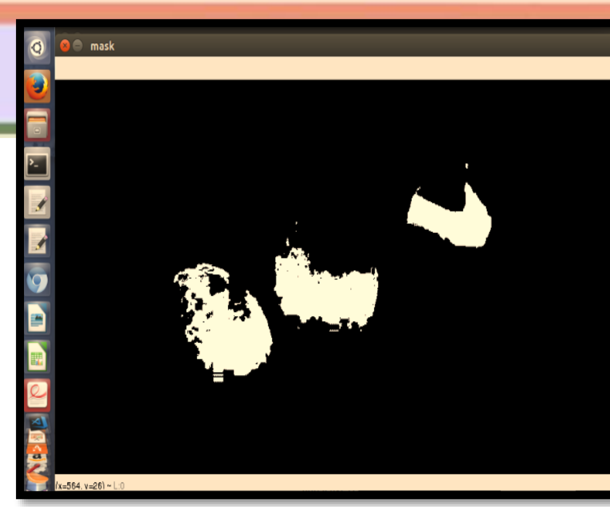
```
1:for x=0 : x=N
2:          take image
3:          resize picture=W x H
4:          convert into HSV
5:          Set Threshold
6:          if HSV image > threshold then
7:              detect object
8:       else
9:           Remove object less than threshold
10:       Loop:
11:           Obtain (X,Y) coordinate center
12:            Contour the object
13:            count the object
14:       else
15:            reject
16:       end loop
17:end procedure
```
.

Observations

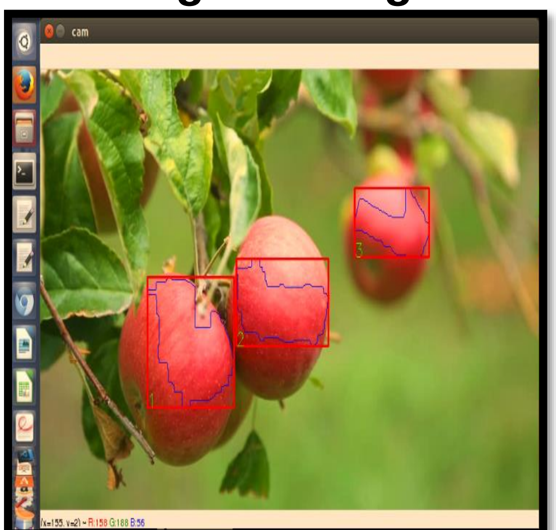
A.Original image



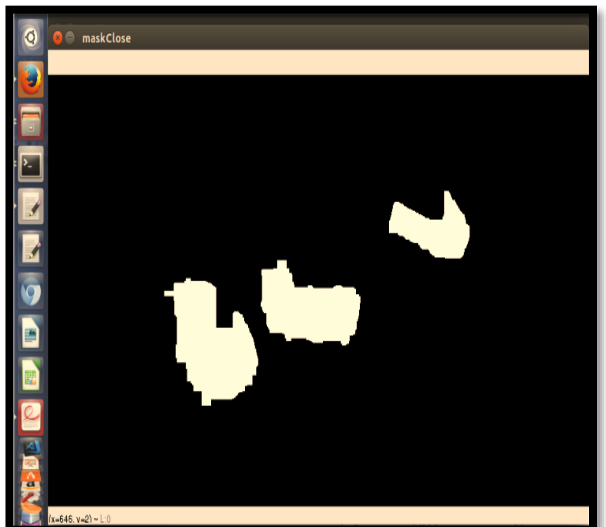
B. HSV image



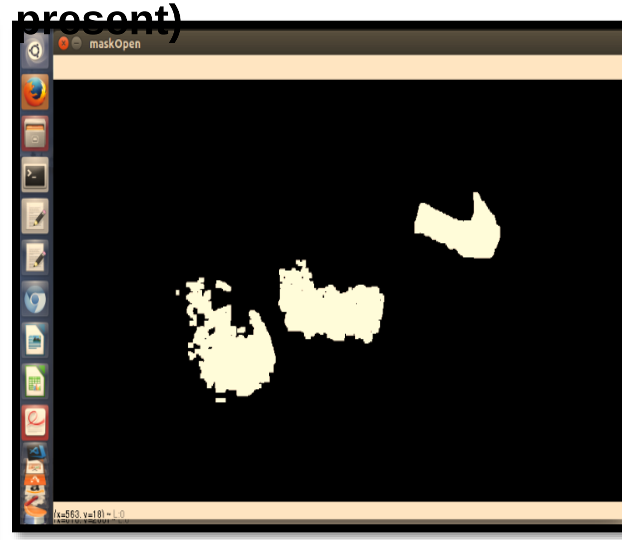
C. Mask image(noise present)



F. Fruit Counting



E. Mask close



D. Mask open

COMPARATIVE ANALYSIS ML ALGORITHMS

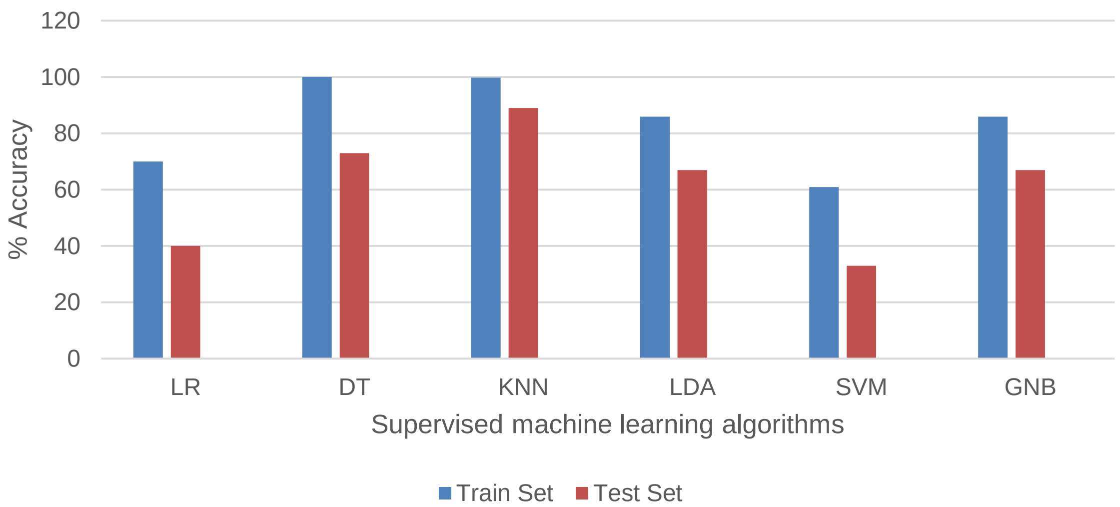


Fig : Comparative analysis of supervised machine-learning algorithms

ANALYSIS OF KNN

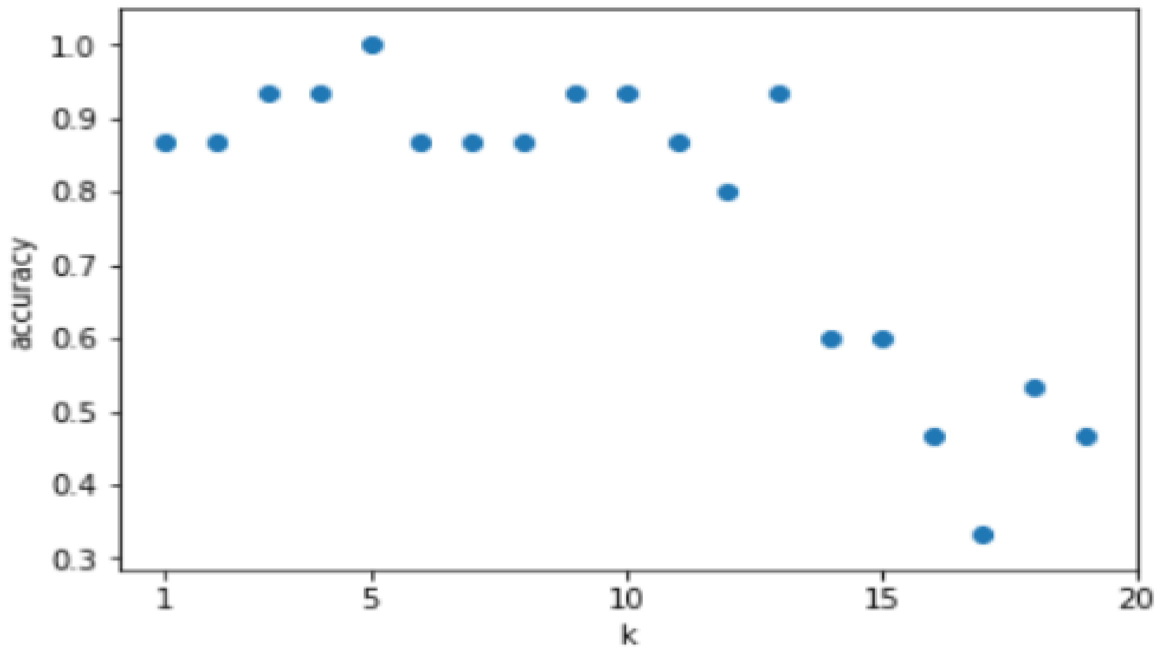


Fig: Accuracy obtained at various values of ‘K’

COMPARATIVE ANALYSIS OF DNN MODEL

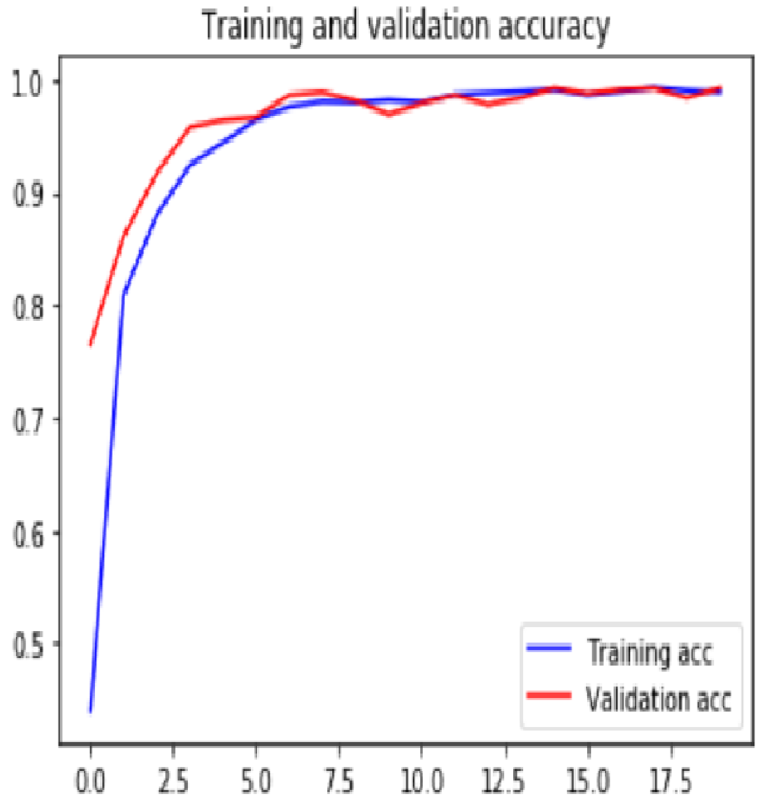


Fig: Training and Validation accuracy upto 20 epoch

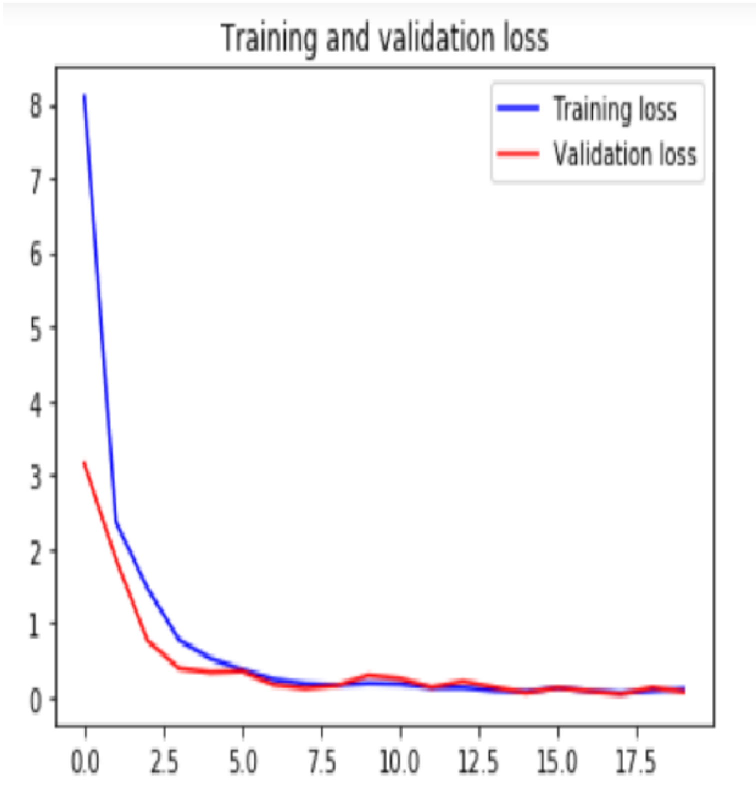
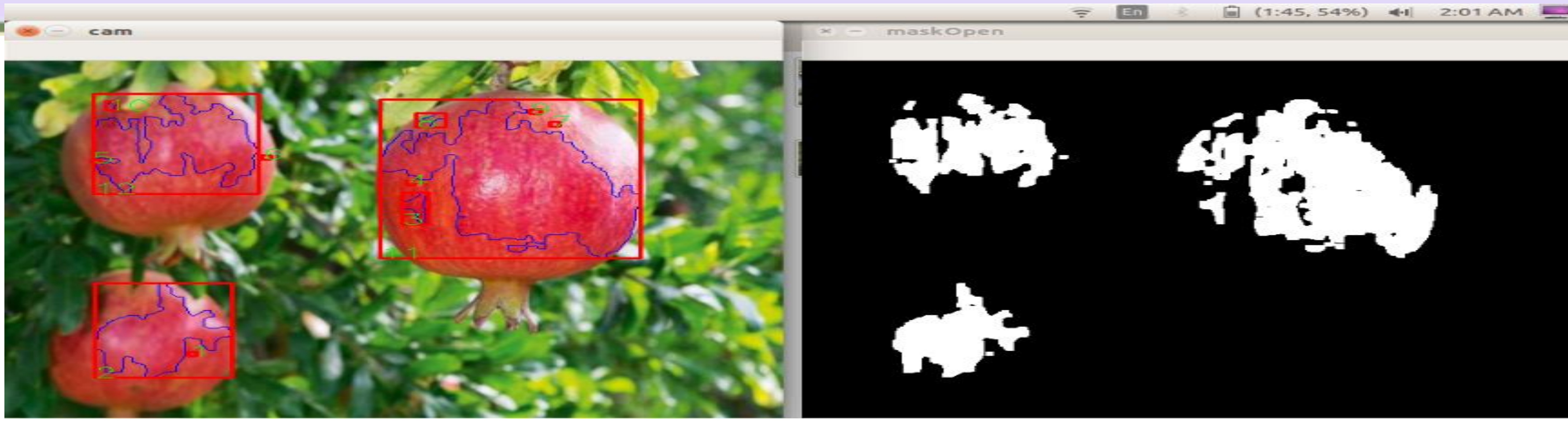
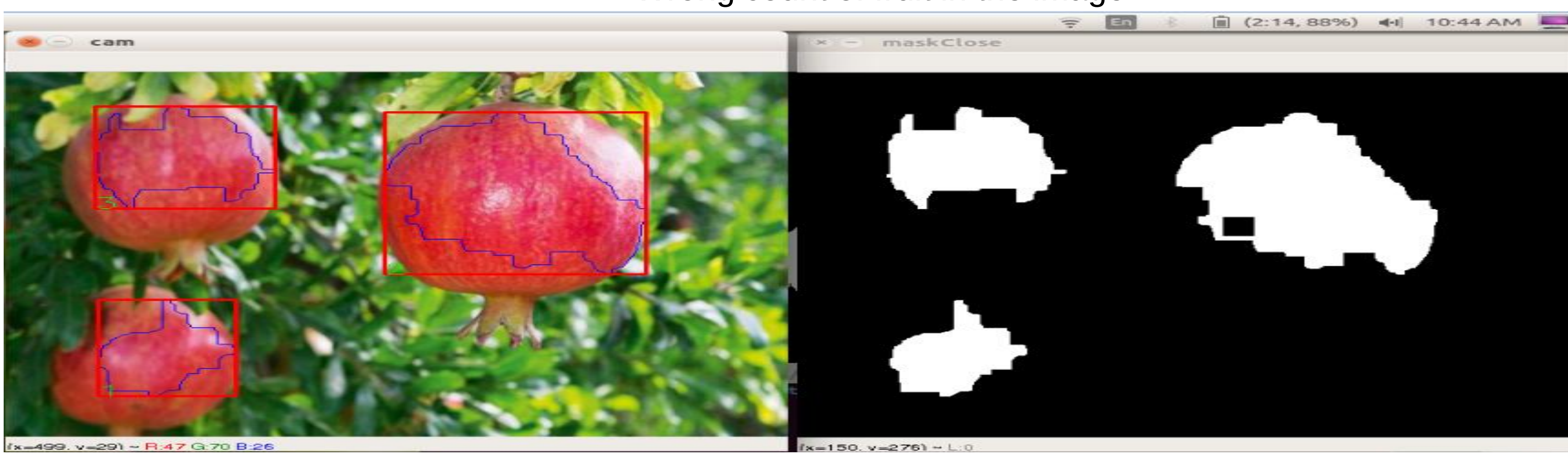


Fig:Training and Validation Loss upto 20 epoch

COMPARISION BETWEEN MORPHOLOGICAL OPERATIONS



Wrong count of fruit in the image



Correct count of fruit in the image

RESULTS

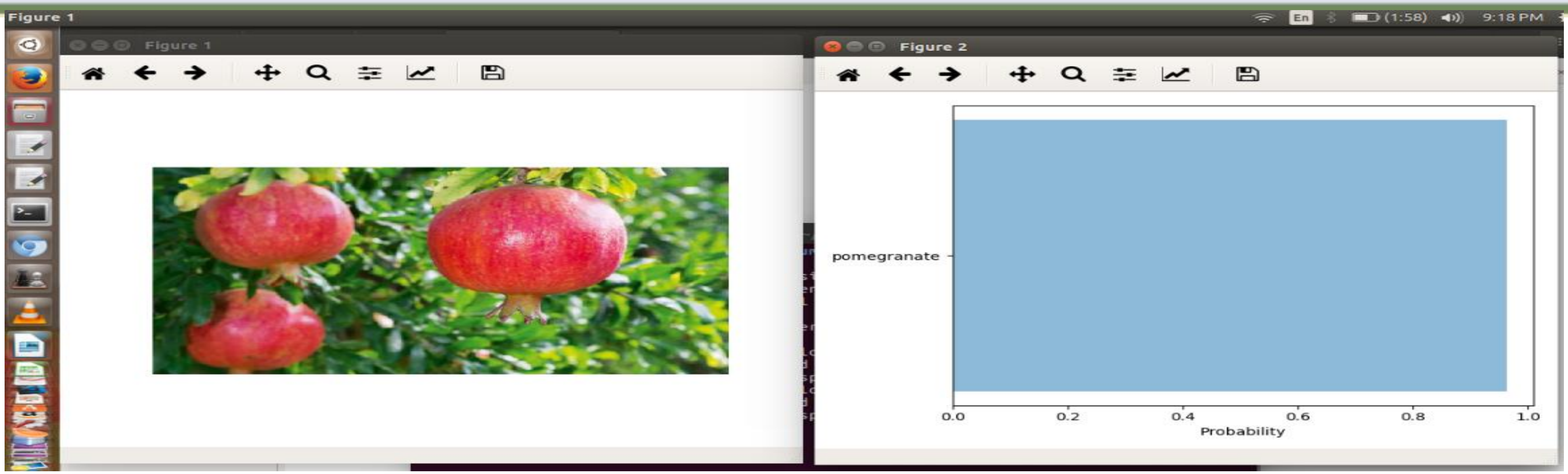


Figure 1
Figure 2
pomegranate
0.0
0.2
0.4
0.6
0.8
1.0
Probability
9:18 PM

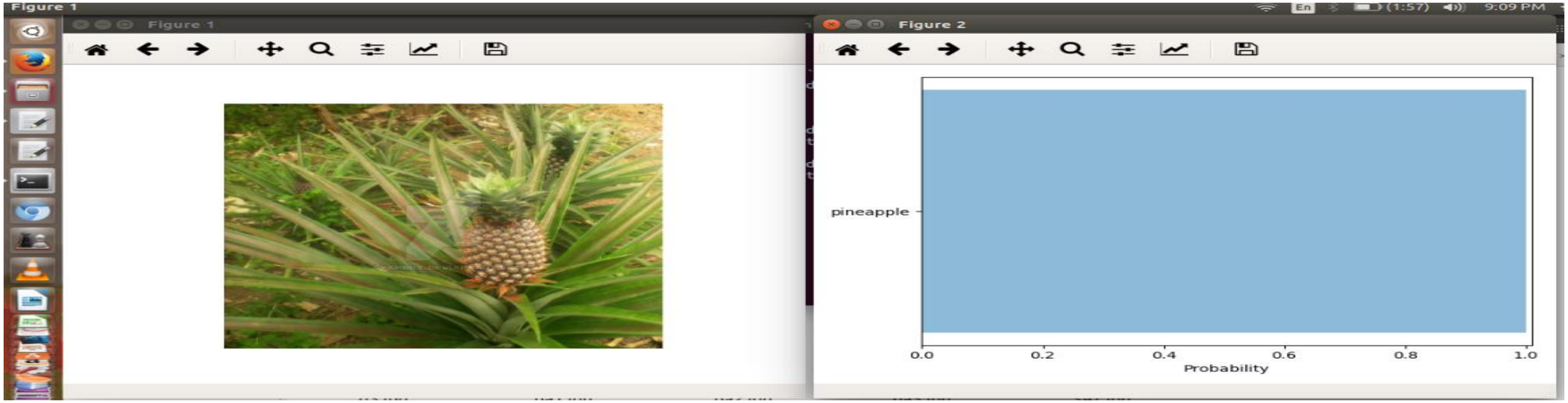


Figure 1
Figure 2
pineapple
0.0
0.2
0.4
0.6
0.8
1.0
Probability
9:09 PM

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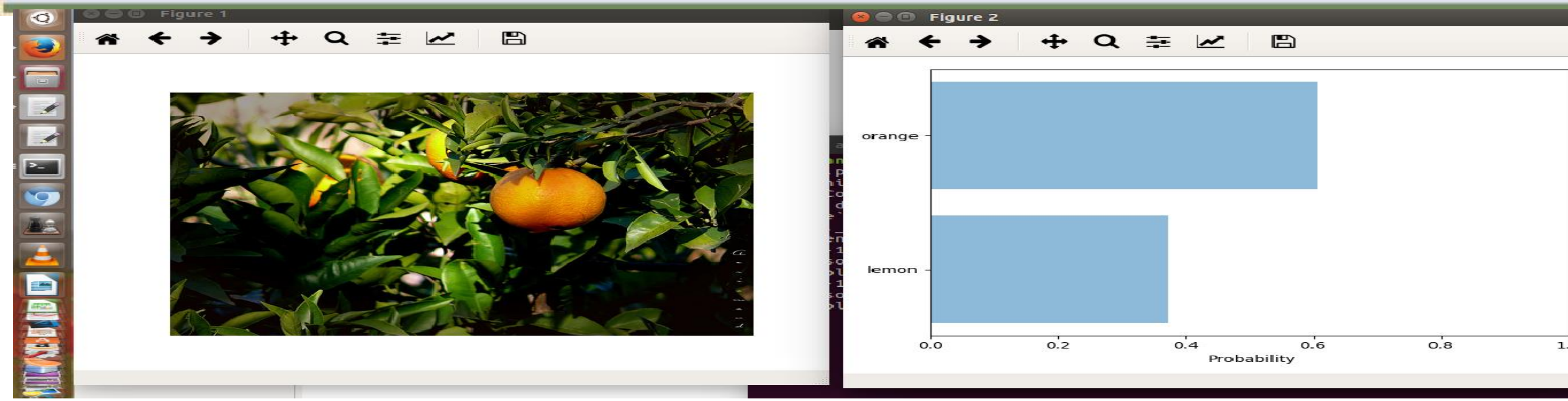
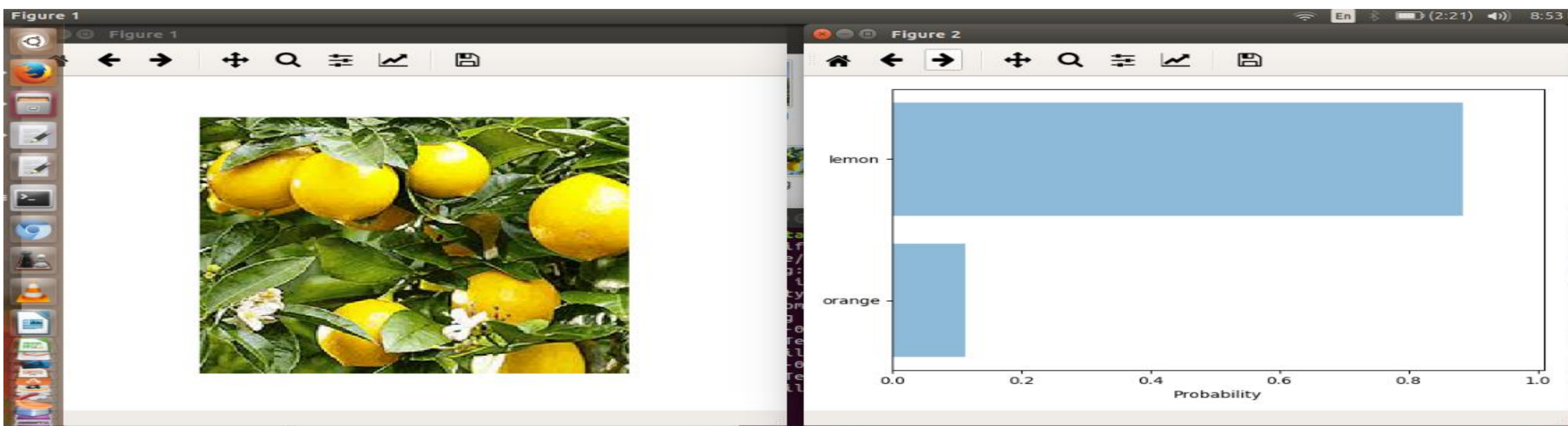
RESULTS





RESULTS

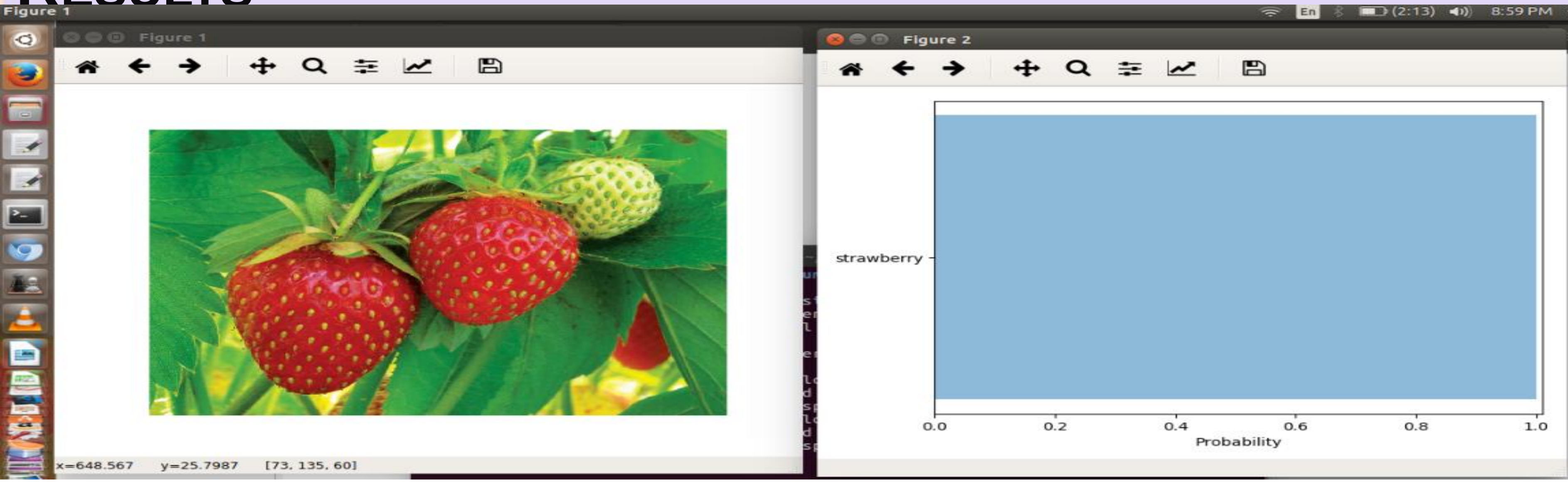


Figure 1
Figure 2
strawberry
0.0
0.2
0.4
0.6
0.8
1.0
Probability
x=648.567 y=25.7987 [73, 135, 60]
8:59 PM

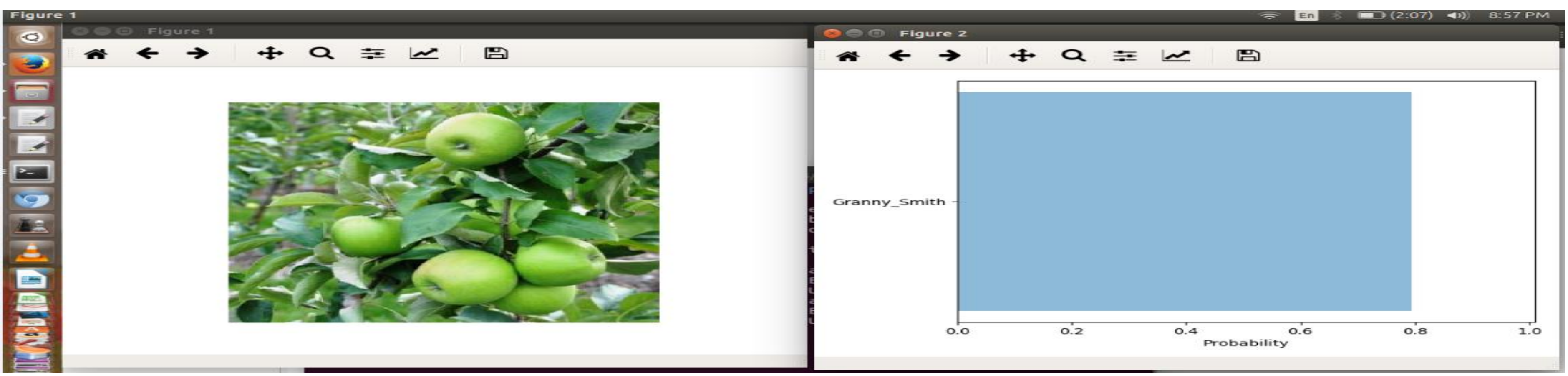


Figure 1
Figure 2
Granny_Smith
0.0
0.2
0.4
0.6
0.8
1.0
Probability
8:57 PM

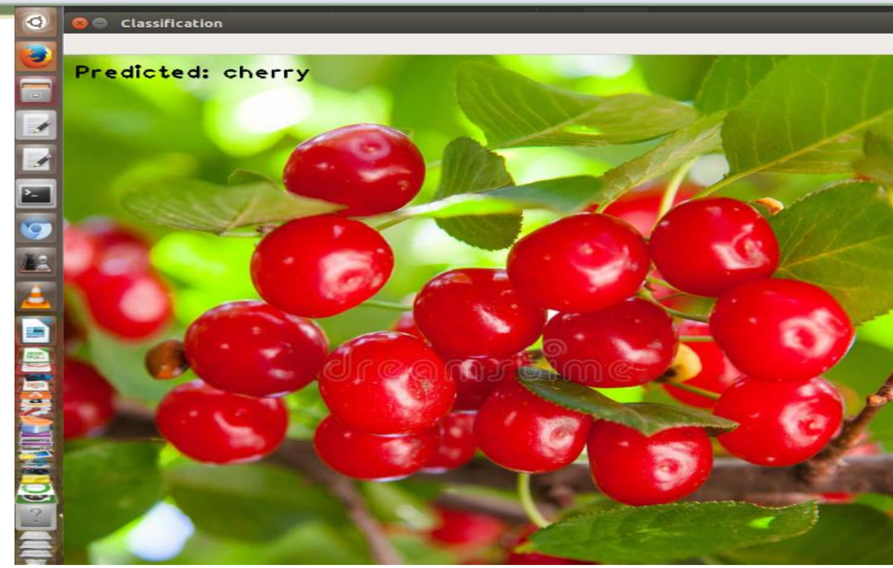
CONCLUSION


Classification
Predicted: walnut


Predicted: peach
(x=223, y=129) ~ R:47 G:27 B:28

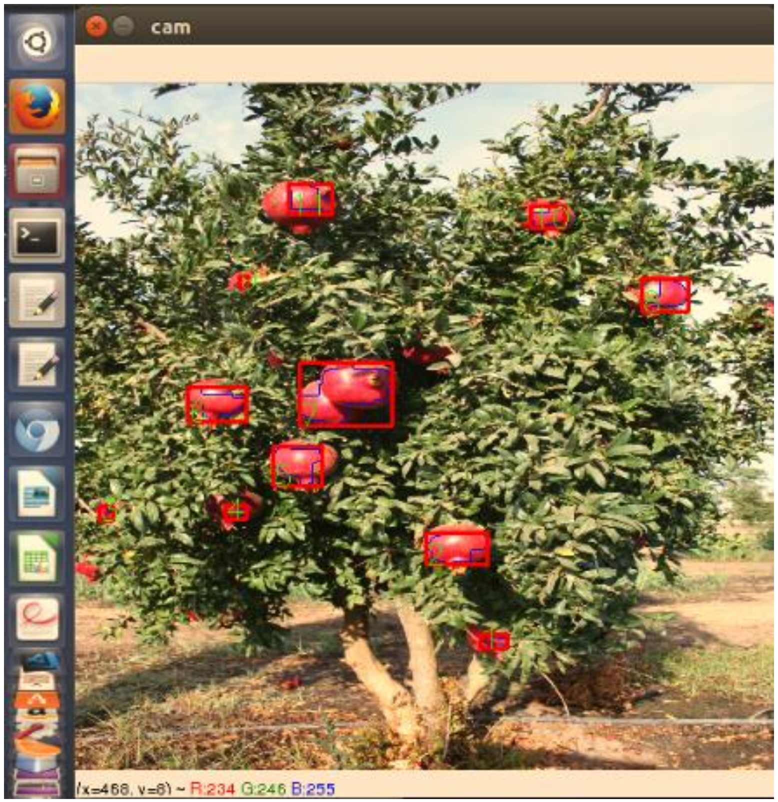
CONCLUSION


Classification
Predicted: blueberry
(x=400, y=172) ~ R:145 G:174 B:126

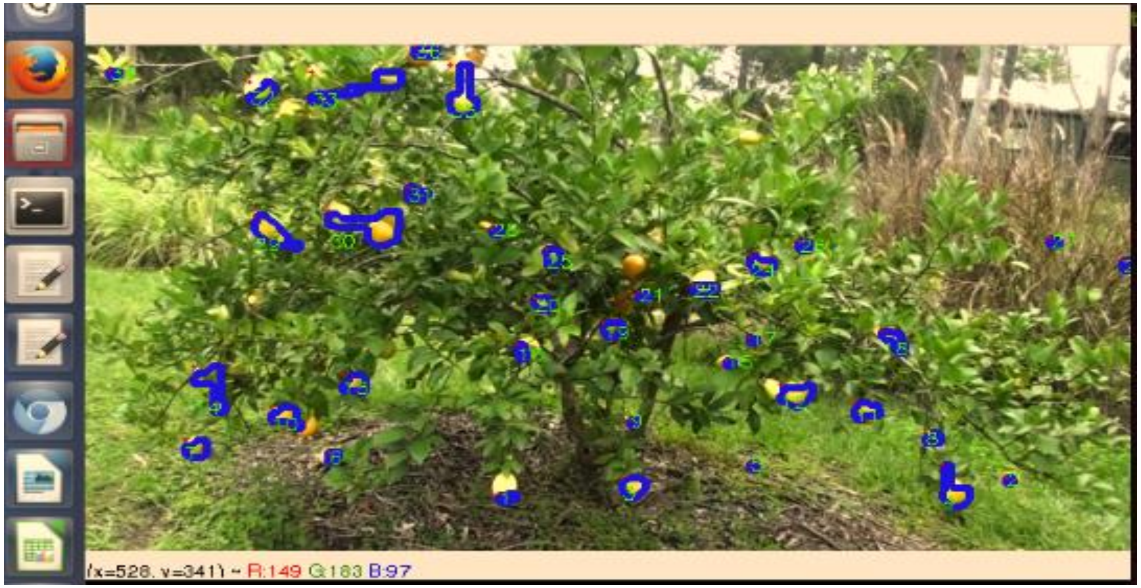

Classification
Predicted: cherry


Classification
Predicted: raspberry

CONCLUSION



CONCLUSION



CONCLUSION

- KNN is best algorithm amongst all supervised ML algorithms
- DNN accurately classify fruit as compare to ML algorithms
- 99.8% is the accuracy obtained at 20 epochs during training phase of model
- Image pre-poocessing, noise removal, morphological operation, contouring and counting has done sequentially to detect and count fruits.

PUBLICATIONS

PAPER PUBLISHED

1. Ankita G.Vaidya, Dr. A. M. Bagade, "Automatic Fruit Detection, Counting and Sorting using Computer Vision and Machine Learning Algorithms", *9th Post Graduate Conference of Information Technology* - iPGCON 2017.submit\Conferences\1ipgcon paper.pdf

2. Ankita G.Vaidya, Dr. A. M. Bagade, "Real Time Identification, Counting and Sorting of on tree Fruits", *International Conference on Communication, Computing, Storage & Energy*, Feb-2018submit\Conferences\2I2CTpaper.pdf

SUBMITTED

1. Ankita G.Vaidya, Dr. A.M. Bagade, "Robotic on tree fruit harvesting to increase the yield and fruit quality in fruit farming", Journal of The Institution of Engineers (India): Series B, July -2018submit\Conferences\3springerfinal.pdf

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3. A. Raihana and R. Sudha , "AFDGA: Defect Detection and Classification of Apple Fruit Images using the Modified Watershed Segmentation Method," IJSTE - International Journal of Science Technology & Engineering, vol. 3, no. 6,pp. 75-85, Dec. 2016.
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9. M. Bulanon, T. Kataoka, Y.Ota, and T.Hiroma, "A Segmentation Algorithm for the Automatic Recognition of Fuji Apples at Harvest," Biosystems Engineering, vol. 83, no. 4, pp. 405-412, Aug. 2002.
10. Kyosuke Yamamoto, Wei Guo, Yosuke Yoshioka, and Seishi Ninomiya, "On Plant Detection of Intact Tomato Fruits Using Image Analysis and Machine Learning Methods," Sensors, pp 12192-12206, July 2014.
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THANK YOU.