

Real-Time Classification of Local Orange Fruit Quality Using YOLO (You Only Look Once) and SVM (Support Vector Machine) Methods

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ABSTRACT

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Oranges are a fruit that we often encounter and are even consumed by people because of their various benefits. Oranges have commercial value in Indonesia and have a fairly wide reach. In order to increase competitiveness, oranges must also meet market standards, both domestic and foreign, so that they can be accepted by consumers. Of course, in this case, orange selection is very important. Increasing sales and market competition by sellers, important indicators in selecting citrus fruit are in terms of size and color. In general, the selection of citrus fruit is done manually and based on human thinking, which causes several weaknesses that must be corrected, including requiring a long time, human visual limitations, and being influenced by human psychology itself. This is what causes inconsistencies in selection. Oranges do not comply with existing market requirements. So a research was carried out regarding the quality classification of local citrus fruit using the YOLO (You Only Look Once) and SVM (Support Vector Machine) methods in real time. In the comparison made between the two methods used, YOLO was found to be the best method for classifying citrus fruit.

INTRODUCTION

Research on real-time classification of local orange fruit quality using YOLO and SVM methods stems from the increasing need for automation and efficiency in the agricultural sector. Traditional methods of manual fruit quality assessment are often subjective, time-consuming, and prone to inconsistencies (Taofik et al., 2018). This can lead to economic losses due to improper grading, waste of resources, and reduced consumer satisfaction.

Several factors contribute to the need for automated systems:

- **Labor costs:** The agricultural industry often faces challenges related to labor availability and costs. Automating fruit quality classification can reduce the reliance on manual labor, making the process more cost-effective.
- **Quality control:** Maintaining consistent fruit quality is crucial for market competitiveness. Automated systems can provide objective and consistent quality assessments, ensuring that only high-quality fruits reach consumers.
- **Real-time processing:** The ability to assess fruit quality in real-time is essential for optimizing post-harvest handling, storage, and distribution processes (Zhu & Spachos, 2021). Real-time classification enables timely decision-making, reducing the risk of spoilage and waste (Raj et al., 2021).
- **Technological advancements:** Recent advancements in computer vision, machine learning, and hardware have made it possible to develop sophisticated automated systems for fruit quality classification (Chen et al., 2022). Algorithms like YOLO and SVM have demonstrated promising results in object detection and classification tasks, making them well-suited for this application (Zhu & Spachos, 2021).
- **Surface Defect Detection:** Surface defects (e.g., canker, sunburn) are important criteria for grading fruit (Li et al., 2025).

Therefore, the research on real-time classification of local orange fruit quality using YOLO and SVM methods aims to address these challenges by developing an efficient, accurate, and cost-effective solution for automated fruit quality assessment. Such a system can help improve the overall efficiency and profitability of the orange fruit industry while ensuring that consumers receive high-quality products.



LITERATURE REVIEW

The classification of fruit quality is crucial in the agricultural industry, impacting pricing, consumer satisfaction, and waste reduction (Bhargava & Bansal, 2021); (Raj et al., 2021). Traditional manual methods of quality assessment are subjective and inconsistent (Taofik et al., 2018). Therefore, the development of automated systems for real-time fruit quality classification has become a significant area of research. This review focuses on the application of YOLO and SVM methods for real-time classification of local orange fruit quality.

YOLO for Fruit Detection and Quality Assessment

YOLO is a real-time object detection system that has gained popularity in various applications, including agriculture. Several studies have used YOLO for detecting and classifying fruits. For example, YOLOv8 has been utilized for sweet orange leaf disease detection (Preanto et al., 2024). In the context of fruit quality, YOLO can be used to detect surface defects (Li et al., 2025) and classify different grades of fruit (Zhu & Spachos, 2021).

SVM for Fruit Quality Classification

Support Vector Machine is a machine learning algorithm that is effective for classification tasks. SVM has been applied to fruit grading systems (Zhu & Spachos, 2021) and fruit type classification (Nosseir & Ahmed, 2019). It can be used to classify fruits based on features such as color, texture, and size (Bhargava & Bansal, 2021).

Combined YOLO and SVM Approaches

Some studies have combined YOLO and SVM for a more robust fruit classification system (Zhu & Spachos, 2021). YOLO can be used to detect the fruit in real-time, and then SVM can be used to classify the quality of the detected fruit based on its features.

Challenges and Future Directions

Despite the promising results, there are still challenges in using YOLO and SVM for real-time fruit quality classification. These include:

- **Computational cost:** Real-time processing requires efficient algorithms and hardware (Le & Ngo, 2025).
- **Dataset quality:** The performance of machine learning models depends on the quality and size of the training dataset (Le & Ngo, 2025).
- **Environmental factors:** Lighting conditions and other environmental factors can affect the accuracy of the classification (Bhargava & Bansal, 2021).

Future research directions include:

- Optimizing YOLO models for improved detection accuracy and efficiency (Le & Ngo, 2025).
- Exploring the use of other machine learning algorithms, such as convolutional neural networks (Raj et al., 2021).
- Developing mobile applications for real-time fruit quality classification (Zhu & Spachos, 2021).

METHOD

Making

Making Mini Conveyor Frameworks

In making a mini conveyor, several tools and materials are needed so that the mini conveyor can be made firmly, well and neatly according to the design that has been made previously. Among the tools and materials needed can be seen in table 1 below.

Table 1. Tools and Materials

No	Tools and materials	Amount
1	Wood	3 pieces
2	DC motor	2 pieces
3	Servo motors	3 pieces
4	Webcams	1 piece
5	Infrared Sensor	1 piece
6	Sandpaper	1 piece
7	Cardboard box	2 pieces
8	USB TTL	1 piece
9	Yellow motorbike gearbox	2 pieces
10	Plywood	1 piece
11	Led Strips	1 piece

The stages of making a mini conveyer are as follows:

1. On the conveyor belt, researchers used 3 pieces of wood, 2 yellow motor gearboxes and 1.2 m long sandpaper.



Figure 1. Conveyor equipment

2. To support the conveyor belt, the research used 2 pieces of wood as supports and 1 piece of wood as the base of the belt.
3. Then the author installed 2 yellow gearboxes as the belt drive motor.



Figure 2. Gearbox installation

4. After that, for the belt, the writer here used sandpaper, apart from its straight shape and also being suitable as a belt base, the sandpaper also has a strong enough friction force which makes it easier to move the oranges and to connect the sandpaper the researcher used hot glue on the ends of the sandpaper and then put them together.
5. After installing the belt, the author then paired the wood with another one to support the right belt.

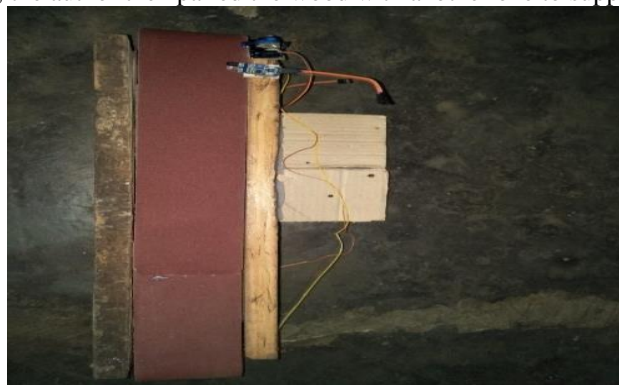


Figure 3. Belt installation

6. And for the wiring, the author here used 2 pieces of cardboard stacked together and then attached them to the belt support using hot glue.
7. After that, install the infrared sensor and also the servo which here functions as a stopper.



Figure 4. Installation of components

8. And also use a protoboard to connect sensors and servos to Arduino
9. To set up the gearbox the author used the L298N module
10. The author made a camera stand using plywood where the plywood was 30 cm long and 25 cm high



Figure 5. Making the camera mount and placing the components

11. On the left side the author made a hole which is useful for inserting the sensor
12. Then the author also attached the LED strip to the plywood to be installed. When all the components and cameras have been installed, the conveyor can be tested.



Figure 6. Conveyors

RESULT

The final stage after the design and manufacturing process is to see the results of creating the system and carry out analysis based on the resulting data obtained. Analysis of the results obtained based on the results of local citrus fruit quality classification and real-time testing will determine which method is best to use in the process of classifying local citrus fruit quality using the YOLO and SVM methods in real time.

Results of the YOLO (You Only Look Once) method in the software

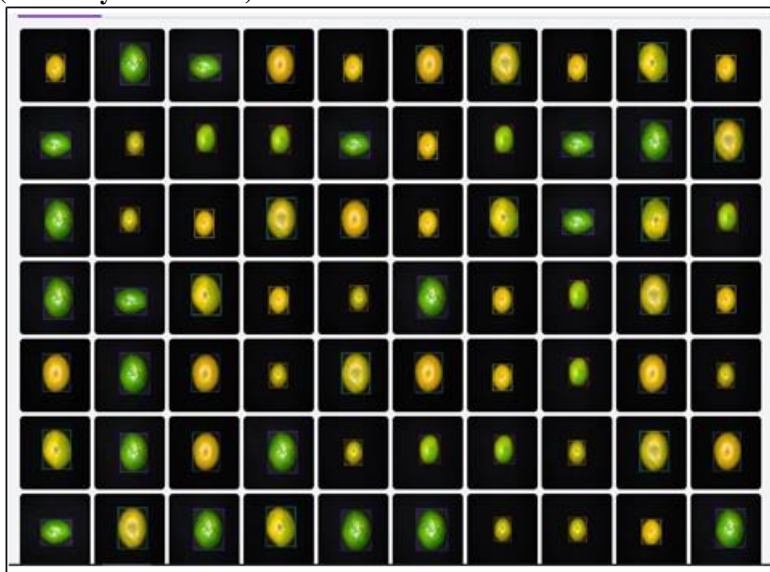


Figure 7. Orange image dataset

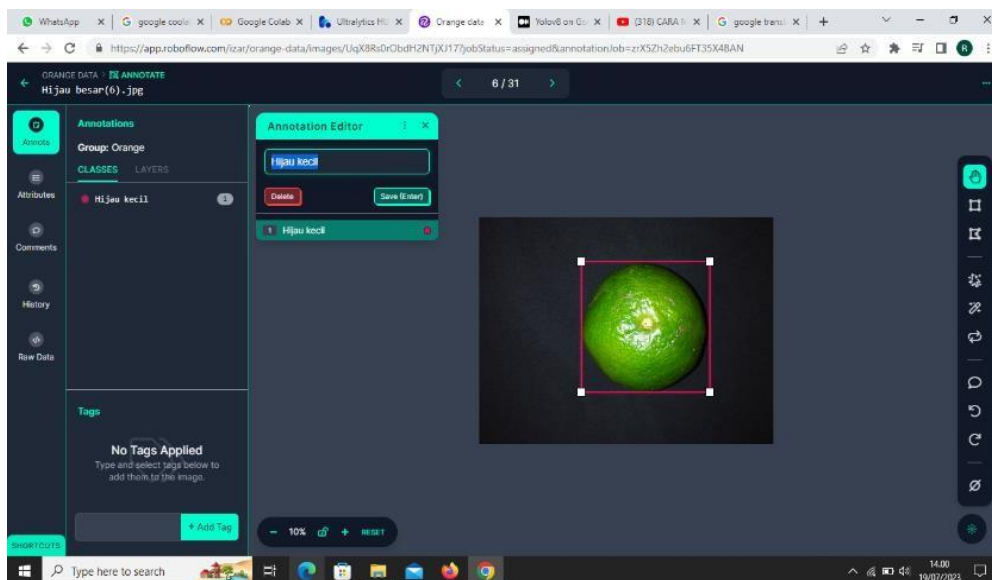
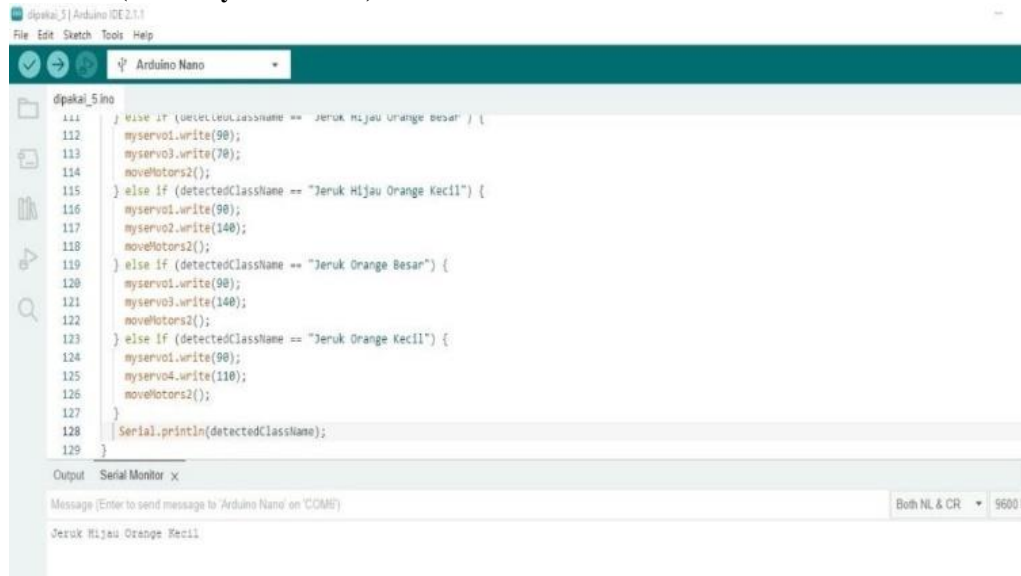


Figure 8. Labeling Process

Table 2. YOLO Accuracy Results

No	Method	Results Accuracy	mAP50	mAP50-95
1.	YOLO	96.8%	99.5%	95.1%

Results of the YOLO (You Only Look Once) method on Hardware



```

dipakai_5.ino
111 } else if (detectedClassName == "Jeruk Hijau Orange Besar") {
112   myservo1.write(90);
113   myservo3.write(70);
114   moveMotors2();
115 } else if (detectedClassName == "Jeruk Hijau Orange Kecil") {
116   myservo1.write(90);
117   myservo2.write(140);
118   moveMotors2();
119 } else if (detectedClassName == "Jeruk Orange Besar") {
120   myservo1.write(90);
121   myservo3.write(140);
122   moveMotors2();
123 } else if (detectedClassName == "Jeruk Orange Kecil") {
124   myservo1.write(90);
125   myservo4.write(110);
126   moveMotors2();
127 }
128 | Serial.println(detectedClassName);
129 }
  
```

Output Serial Monitor x

Message (Enter to send message to 'Arduino Nano' on 'COM8')

Jeruk Hijau Orange Kecil

Figure 9. Arduino output results

```

1 from imutils.video import VideoStream
2 from ultralytics import YOLO
3 import cv2
4 import math
5 import time
6 import serial
7
8 # Fungsi untuk mengirim data ke Arduino
9 usage
10 def send_to_arduino(data):
11     ser.write(data.encode())
12     ser.write(b'\n') # Tambahkan karakter newline untuk mengakhiri pesan
13
14 # Ganti 'COM7' dengan port serial USB-TTL yang Anda gunakan
15 port_usb_ttl = 'COM8'
16 baud_rate = 9600
17
18 # Inisialisasi koneksi serial
19 ser = serial.Serial(port_usb_ttl, baud_rate, timeout=1)
20 time.sleep(2) # Beri waktu untuk Arduino mereset
21
22 vs = VideoStream(src=1).start()
23 time.sleep(2.0)
24
25 model = YOLO("../Yolo-Weights/Hasil Training Jeruk/jeruk.pt")
26
27 classNames = ["Jeruk Hijau Kecil", "Jeruk Hijau Besar", "Jeruk Hijau Orange Besar", "Jeruk Hijau Orange Kecil",
28             "Jeruk Orange Besar", "Jeruk Orange Kecil"]
29
30 while True:
31     img = vs.read()
32     img = cv2.resize(img, (1080, 720))
33     results = model(img, stream=True)
  
```

Figure 10. Python output results

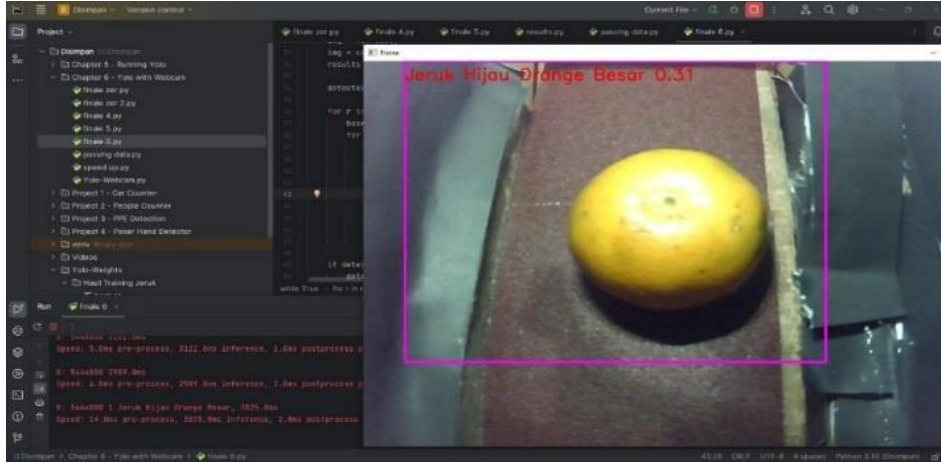


Figure 11. Test results 1



Figure 12. Test results 2

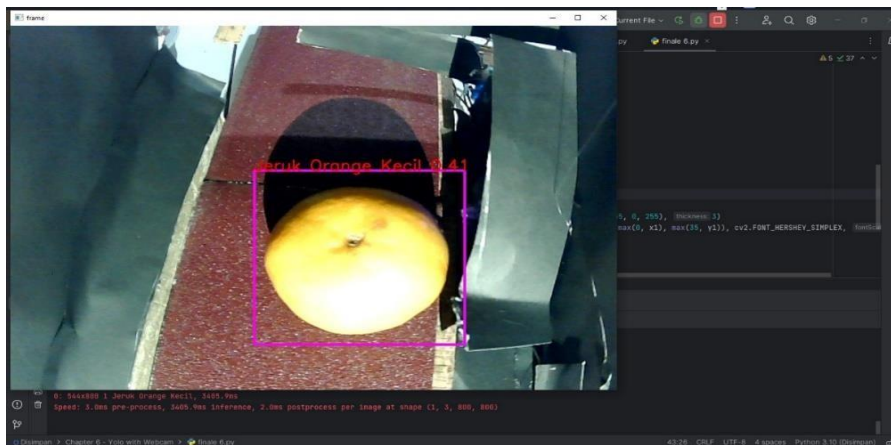


Figure 13. Test Results 3

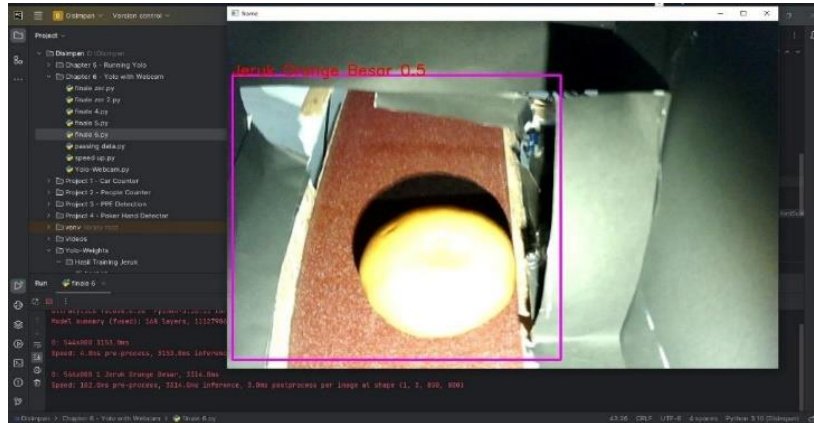


Figure 14. Test results 4

Results of the SVM (Support Vector Machine) method in the software

filename	width	height	class	xmin	ymin	xmax	ymax
IMG_20230604_141400_jpg.rf.11fad373c5cd24244f38f7b006f87d4e.jpg	640	640	Orange besar	210	144	461	469
IMG_20230604_141630_jpg.rf.038fb60cda7f46fe3cf1161e1d452d4a.jpg	640	640	Orange kecil	235	225	409	465
IMG_20230604_141008_jpg.rf.039c3ef6bd9cd7a92640f9d5bdc23bd9.jpg	640	640	Hijau besar	229	123	500	492

Figure 15. CSV image data results

Nama Gambar	Rata-rata Red	Rata-rata Green	Rata-rata Blue
IMG_20230604_141347_jpg.rf.c5f8715e2b5b69afabf041fb3be393.jpg	43.34055419921875	34.648129828125	15.6316552734375
Hijau-besar-1_jpg.rf.32e0603595e2c6bdac7a1ff8daaba7e.jpg	38.0619970703125	48.6246044921875	32.3739306640625
Hijau-besar-5_jpg.rf.847a6f943fa656b75b0808494c6dc5ad2.jpg	37.32974365234375	47.496318359375	30.6017822265625

Figure 16. Results of RGB image data

filename	width	height	class	xmin	ymin	xmax	ymax	Rata-rata Red	Rata-rata Gri
IMG_20230604_141400_jpg.rf.11fad373c5cd24244f38f7b006f87d4e.jpg	640	640	Orange besar	210	144	461	469	43.34055419921875	34.648129828125
IMG_20230604_141630_jpg.rf.038fb60cda7f46fe3cf1161e1d452d4a.jpg	640	640	Orange kecil	235	225	409	465	38.0619970703125	48.6246044921
IMG_20230604_141008_jpg.rf.039c3ef6bd9cd7a92640f9d5bdc23bd9.jpg	640	640	Hijau besar	229	123	500	492	37.32974365234375	47.4963183593

Figure 17. Combined data results

Table 3. SVM accuracy results

No	Data Sharing Name	Accuracy Results	Precision Results	Recall Results	F1-Score Results
1.	Training Data	98.8%	98.9%	98.8%	98.8%
2.	Validation Data	95.8%	96.5%	95.8%	95.8%
3.	Test Data	91.6%	87.5%	91.6%	88.8%



DISCUSSION

Discussion of the YOLO method in software and hardware

In the process of classifying the quality of local citrus fruit using the YOLO and SVM methods in real time, it is carried out continuously or interconnected even though these two methods are different. In the classification process the YOLO method uses a process called a bounding box, this can be seen in figures 4.1 and 4.2 above. In Figures 4.1 and 4.2, there is a process carried out in RoboFlow where the dataset used is 120 images and the classification class has gone through a labeling process of 6 classes including large green, large green, large green orange, small green orange, large orange, and orange. small. In this labeling process there will be something called a bounding box which comes from coordinates that determine the corners of the bounding box of an object in the image.

The bounding box is used to identify the location and size of objects in the image where there will be an xmin value (minimum X) representing the lowest horizontal coordinate (smallest X value) of the bounding box. This shows the leftmost position of the object along the X axis. The ymin value (minimum Y) represents the lowest vertical coordinate (smallest Y value) of the bounding box. This shows the rightmost position of the object along the Y axis. The xmax (X maximum) value represents the highest horizontal coordinate (highest X value) of the bounding box. This shows the rightmost position of the object along the X axis. The ymax (Y maximum) value represents the highest vertical coordinate (highest Y value) of the bounding box. This shows the leftmost location of the object along the Y axis. In this case, object detection using Yolo, bounding boxes helps in recognizing, tracking, and visualizing objects in the image. Furthermore, after feature extraction in the bounding box, the information obtained is converted into CSV form so that it can also be used in the classification process using the SVM method later.

In several experiments that have been carried out, it is necessary to pay attention to the lighting used when carrying out the test so that object detection can be carried out optimally in detecting orange objects because when carrying out the test, the Yolo method will very easily detect other objects around it so that the data obtained by the camera can be read. by python will coincide. Therefore, the background color used in the tool is very influential when carrying out testing by adjusting the image data used to make it easier to detect objects later.

Discussion of the SVM method in software

The classification process in the SVM algorithm uses a dataset that has been extracted first on Yolo. The extraction process goes through a labeling process in which there is information that can be used for the orange classification process. This information will later be saved in CSV form so that it can be processed by the SVM algorithm. Figure 4.9 shows the results of object detection in images in the training dataset. Each row represents the results of object detection in one image, with information such as image file name, image size (width and height), type of object detected (class), as well as bounding box coordinates (xmin, ymin, xmax, ymax) which identify the location. objects in the picture. For the first row of image 1 there is an image size of 640 x 640 pixels, the object type is large orange with a bounding box (xmin = 210, ymin = 144), (xmax = 461, ymax = 469). Next, in the second column, there is an image size of 640 x 640 pixels, the object type is small orange with a bounding box (xmin = 235, ymin = 225), (xmax = 409, ymax = 465).

At this stage the SVM model has been trained using a labeled training dataset which aims to measure the extent to which the model is able to understand the patterns in the training data.

Discussion of the comparison of the YOLO and SVM methods

Local orange image classification using the Yolo and SVM methods has slightly different accuracy. Yolo has an accuracy for training data of 96.8%, while for real-time tested data it succeeded in detecting objects well at 100% and for SVM itself it has an accuracy of 98.8% for training data and 91.6% for test data. This result shows that Yolo has better performance. both in classification and object detection on local citrus fruit datasets compared to SVM. Precision is a metric that measures the level of accuracy of the model in classifying all the positive classes it should. Yolo's precision is 99.5% and recall is 100%, indicating that Yolo succeeded in detecting almost all objects from the expected class with few false positives. These results show that Yolo has very good abilities in classifying objects and provides very accurate prediction results. Meanwhile, SVM precision was 87.5% and SVM recall was 91.6%, indicating that SVM had a good level of accuracy in identifying positive classes and succeeded in detecting as many positive classes as it should. Even though SVM's performance is not as good as Yolo, the results are still very good and reliable in object classification on local citrus fruit datasets. The accuracy results of the two methods can be seen in table 4.3.

Table 4. Accuracy of YOLO and SVM

METHOD	Accuracy	
	Training Data	TEST Data
YOLO	96.8%	100%
SVM	98.8%	91.6%



For mAP50 (Mean Average Precision) is a metric that measures the accuracy or quality of the model at various threshold values. mAP50 calculates the average accuracy of all predicted class objects by taking the average of the area under curve (AUC) on the precision-recall curve at each threshold. mAP50 on yolo is 95.5%, which shows that yolo has very good abilities in detecting objects at various threshold values. These results confirm that YOLO can consistently and accurately detect objects of the expected class. Meanwhile, for SVM, what is obtained is not the mAP50 value, but the F1-score, which is a metric that combines precision and recall, and provides an idea of the balance between these two metrics. F1-score is useful for measuring model performance in cases of class imbalance or when it is important to obtain both high precision and recall. For the SVM method, the F1-score of 88.8% shows that the classification model has a good balance between precision and recall, where the model is able to provide accurate predictions (high precision) and is able to detect most of the true positive samples.

CONCLUSION

Based on the results of research regarding the Quality Classification of Local Orange Fruit using the YOLO (You Only Look Once) and SVM (Support Vector Machine) methods in real time, the conclusions are as follows:

1. The results of comparing the quality classification of local orange fruit using the Yolo and SVM methods showed that the Yolo method had better performance in classification and object detection in the local orange fruit dataset compared to SVM. Yolo has an accuracy of 96.8% for training data, while for data tested in real time it succeeded in detecting objects well at 100% and for SVM itself it has an accuracy of 98.8% for training data and 91.6% for test data.
2. In real time, the method used is only the Yolo method.
3. In the process of sending data, Arduino can receive data submitted by Python and vice versa so that it can work as expected.

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