Swiftlet Detection with Computer Vision and Machine Learning (Swiftlet Surveillance System)

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***Abstract*—The aim of this project is to help swiftlet house owners to check the situation and condition of the swiftlet house. Swiftlet house owners have to constantly check out the swiftlet house to ensure that there is swiftlets in the house. This is not convenient for them, as it takes a lot of time because swiftlet house are often far away from the living neighborhood. This project uses image processing, image classification and object detection to detect the amount of swiftlets in the swiftlet house. It uses cameras and sensors to identify the condition and situation of the swiftlet house without physically going to the place. The system is connected to the internet via router. With this system, owner can check the swiftlet house through website with internet access. The website will show the data about the swiftlet house, and owner will be able to view the camera. The prototype of this project are made with 2 cameras, 2 Raspberry Pi, 1 Arduino Uno, 1 DHT11 sensor, and 1 router. The prototype swiftlet detector will use Support Vector Machine (SVM) as the machine learning method with Histogram of Gradient (HOG) as the method of image feature extraction. Other than that, the prototype website will show the real time temperature and humidity of the place, and 1 camera is accessible through the website.**

***Index Terms*—Image Classification, Image Processing, Internet of Things, Object Detection.**

I. Introduction

This project separate devices into units. The indoor unit consists of 1 Arduino Uno, 1 DHT11 sensor, 1 Raspberry Pi, and 1 infrared camera. On the other hand, the outdoor unit consists of 1 Raspberry Pi, and 1 normal camera. The cameras act as the "eye" of the units, and the Raspberry Pi act as the "brain" of the units. In this prototype, there is only 2 units, which is 1 indoor unit and 1 outdoor unit. The indoor unit act as the main unit. The Raspberry Pi of the indoor unit act as the server of the website, and the server for communications between units. The units communicate within the local network. In the indoor unit, the Arduino Uno act as a bridge for the communication of sensor and Raspberry Pi. The Arduino Uno read the data from sensor, and send it to Raspberry Pi via serial communication.

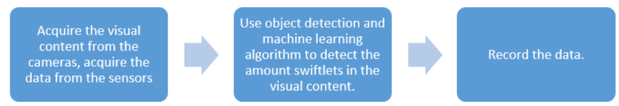

Fig. 1. The simplified overall project structure

II. Methods

The overall structure of the project is shown in Figure 1. First, the data are obtained from the units. Then, the data are processed. At last, the data are recorded and shown in the website.

A. Image Processing

Every images that is acquired from the camera are processed before putting it into the object detector. First, every frames that is get from the camera is changed to grayscale. This is to eliminate the noise of the images. For example, an image with color channels has 3 layer, which is Red, Green and Blue. Not all color channels are needed, so all this 3 channels are combined into a channel, with the range of 0 to 255.

After that, the blurring is apply to the images. This is to further reduce the noise of the images. Then, the image processing method is different for indoor units and outdoor units.

Eventually, the contour of the objects are detected, and it will go through the swiftlet detector.

1) Indoor Units

For indoor units, the images are the go through background subtraction method. This is to find the moving objects in the scene. Background subtraction with KNN is used because it provided a better result [1].

After that, the resultant images go through dilation. This is to make sure that the pixels that are close together are combined. Then, it is changed into binary form through image thresholding, and the contour of the objects are found.

2) Outdoor Units

For outdoor units, the images are changed into binary form through image thresholding. This is because the visual contents of the outdoor units are not as complex as indoor units, so a

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simple thresholding is enough. Then, the resultant image goes through dilation, and the contour of the objects are detected.

B. Histogram of Gradient (HOG) with Support Vector Machine (SVM)

HOG with SVM is chosen because even though it has high latency for real time object detection, but it has higher accuracy [2].

86 images of swifts are prepared, and 102 images of interior of swiftlet houses are prepared. The images of swifts are labelled as "Swifts", and the images of swiftlet house interiors are labelled as "Non-Swifts".

90% of the images are used for training, and 10% are used for testing. The testing is necessary, because it can evaluate how well the model does.

When importing the images, the images are pre-processed too. The images are resized into 90 pixels times 90 pixels square, and then changed into grayscale images.

The images then go through HOG and the feature vectors are returned. The feature vector of each image represent the features of the image. These features vectors are then used to train the detector.

The SVM that is used to train the swiftlet detector is a linear SVM. A linear SVM are able to classify the objects linearly. The parameter that is controlling the SVM is the C. The larger the C value, the larger the margin. Figure 2 shows how the SVM works when classifying 2 objects. The default value of C in this particular detector is 1. The trained model is then saved to a file.

C. User Interface

In the prototype, the indoor unit is the main server. The outdoor unit will then act as a web server and a communication server. The outdoor unit will send its visual content to the indoor unit. The indoor unit will receive the visual content from the outdoor unit, and show it on the screen. The indoor unit will show its visual content and the sensor data to the website. The front page of the website will refresh every 2 seconds, this is to get the latest temperature and humidity, and show it on the website. The router will forward all the http request of it to the indoor unit Raspberry Pi.

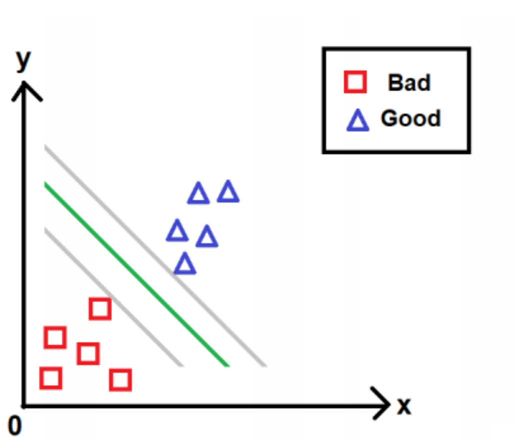

Fig. 2. Linear SVM visualization

III. RESULTS

The prototype indoor unit and outdoor unit is shown in Figure 3 and 4.

The internal IP address of the Raspberry Pi 4 of indoor unit and the Raspberry Pi Zero of outdoor unit is shown at Figure 5 and 6. The port forwarding of http is shown at Figure 7.

A. Evaluation of the model

From Figure 8, it is shown that the model has an accuracy of 80% during the testing and it shows the confusion matrix. It is shown that the model is acceptable. Figure 9 show the output of the test images. The title of each images in figure 9 is in the form of "Real label, Predicted label".

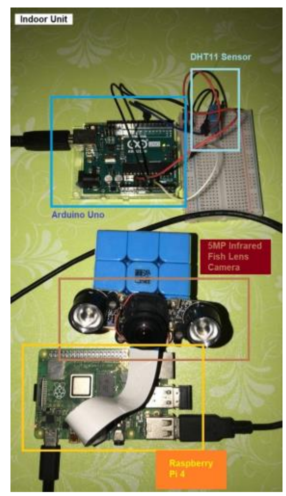

Fig. 3. Prototype Indoor Unit

Fig. 4. Prototype Outdoor Unit

ID	Name	IP Address
1	raspberrypi4	192.168.0.167

Fig. 5. Raspberry Pi 4 (Indoor Unit)

3	desktoppi	192.168.0.172

Fig. 6. Raspberry Pi Zero (Outdoor Unit)

	ID	Service Type	External Port	Internal IP	Internal Port	Protocol	Status	Modify
	1	HTTP	80	192.168.0.167	80	ALL		

Fig. 7. Port Forwarding

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*Python 3.7.1 Shell*
File Edit Shell Debug Options Window Help
Python 3.7.1 (v3.7.1:260ec2c36a, Oct 20 2018, 14:57:15) [MSC v.1915 64 bit (AMD64
)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
 RESTART: C:\Users\user\Desktop\InnovateMalaysia_SSS\InnovateMalaysia_SSS\Outdoor
Detector.py
>>>
 RESTART: C:\Users\user\Desktop\InnovateMalaysia_SSS\InnovateMalaysia_SSS\HOG_SVM
.py
Preparing training data...
Preparing testing data...
Confusion Matrix (Training)
[[77  0]
 [ 0 91]]
Accuracy:1.0

Confusion Matrix (Testing)
[[8 1]
 [3 8]]
Accuracy:0.8

-----Classification report (Testing)-----
              precision    recall  f1-score   support

  Non-Swifts       0.89      0.73      0.80        11
      Swifts       0.73      0.89      0.80         9

    accuracy                           0.80        20
   macro avg       0.81      0.81      0.80        20
weighted avg       0.82      0.80      0.80        20

Model saved as: SWIFT_HOG_SVM.pickle

Ln: 7  Col: 0
```

Fig. 8. Model Report

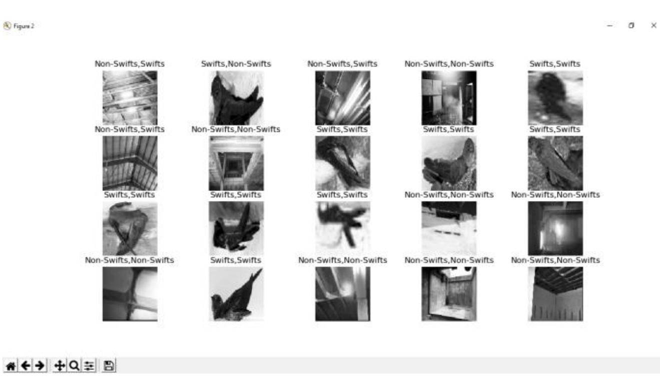

Fig. 9. Testing output

B. *Indoor Unit Testing*

A footage is get from Youtube to do the testing of the system. The footage is in infrared mode, so it is suitable for the testing. Figure 10 shows one of the frame of the video.

C. *Outdoor Unit Testing*

A footage is get from Youtube to do the testing of the system. The footage shows swiftlets flying in the sky. Figure 11 shows one of the frame of the video.

D. *Website Testing*

The website is then tested too. Figure 12 and 13 shows that the website successfully shows the sensor data and the camera is accessed.

E. *Communication Testing*

The outdoor camera is facing a wall with 6 spots on it. Figure 14 shows that the visual content of outdoor camera is sent to the indoor Raspberry Pi 4.

Fig. 10. Indoor Unit Testing

Fig. 11. Outdoor Unit Testing

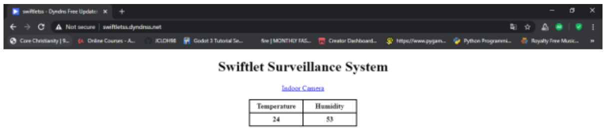

Fig. 12. Website Testing

Fig. 13. Website Testing (Indoor Camera)

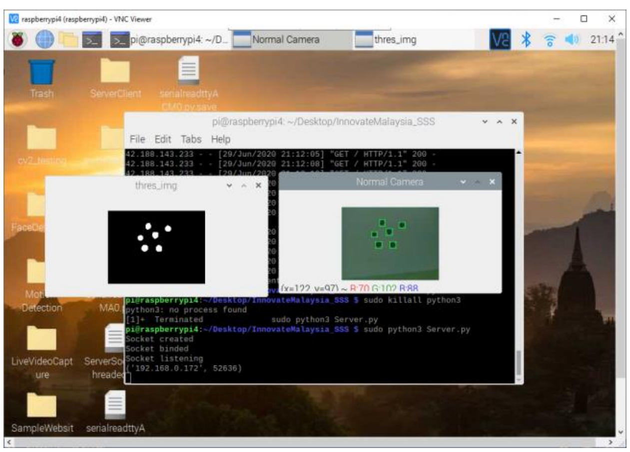

Fig. 14. Communication Testing

IV. Discussion

From the indoor unit test and outdoor unit test output, it is found out that sometimes the model cannot detect the swiftlets. This might due to the lack of sufficient data and the imbalanced data.

On the other hand, the result is acceptable, as it detects most of the swiftlets successfully. There is a disadvantage about this model, which is that when it runs on real time, it might cause latency.

Other than that, the website is working as intended, as the real time temperature and humidity is shown on the index page. Besides, the indoor camera is successfully accessed. This indicates that the serial communication between Arduino Uno and the Raspberry Pi 4 is good.

The communication between the outdoor and indoor camera is successful too. The visual content of the outdoor camera is successfully shown in the indoor Raspberry Pi 4.

V. Conclusion

In conclusion, the prototype of the project is working well, as it can solve the problem of physically going to the swiftlet house constantly. However, there is room for improvement too. For example, the outdoor camera should be able to show on the website too. Other than that, scalability need to take in consideration too as there might be more units in the system. In future, the machine learning model can be trained with more data, and with balanced data to increase the accuracy.

Acknowledgment

We would like to thank Mr. Ling Ting Soon to be the supervisor of this project. V. D. H. Ting would like to thank her parents for the support.

References and Footnotes

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