

IMPLEMENTATION OF THE YOLOV4 ALGORITHM IN MOBILE COMPUTING DEVICES FOR TOMATO MURABILITY SELECTION

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Abstract

Tomato fruit yields have a variety, not only ripe fruit but also the condition of tomatoes that are still raw or half-ripe. By naked eye, tomato ripeness can be seen by the difference in three colors, namely red, yellow and green. Each color difference describes the level of maturity. However, human decisions in distinguishing the color of ripe tomatoes can vary and are more subjective. With the help of an image processing system, the selection of tomato ripeness can be faster and more objective. This study uses the YOLOv4 algorithm which is implemented into a mobile computing device, namely the Raspberry Pi 3, to select the tomato image captured by a camera. The results of the YOLOv4 image process will be output to the actuator in the form of a conveyor equipped with a wiper that will sort tomatoes automatically. The result of this research is a prototype with the YOLOv4 algorithm that has been trained with the tomato dataset.

Keywords: *YOLOv4, Raspberry Pi 3, Tomato, Mobile Computing, Convolutional Neural Network*

1. INTRODUCTION

Tomatoes can usually be harvested between 70-100 days after planting. The optimal ripening criteria for tomato plants can be seen from the color of the skin of the fruit. Tomatoes that have ripe green maturity are marketed for marketing purposes that are far away and require a longer time, while ripe red tomatoes are marketed for close proximity (direct consumption). Separating the ripening stages of tomatoes for marketing purposes is very important to maintain the quality and freshness of tomatoes at their destination[1]. Tomato fruit ripeness based on color, according to the United States Department of Agriculture (USDA) in 1991, the standard level of tomato maturity is divided into six stages of maturity, namely green (100% green), breaker (redness less than 10%), turning (redness between 10 %-30%), pink (redness between 30%-60%), light red (redness between 60%-90%), and red (redness of more than 90%)[2]. The classification of tomato ripeness selection is carried out using the You Only Look Once (YOLO) method, an algorithm used to predict the type and location of objects in an image in real-time using a convolution network. This method can predict bounding boxes and probability classes for each box, so that it can produce accurate object predictions. This method can also process video streams in real-time with less than 25 milliseconds of latency and achieves more than double the Mean Average Precision (MAP)[3].

A related study was conducted by Feli Ramasari, Firdaus, Sri Nita and Kartika with the title "Using the You Only Look Once Method in Determining the Transfer of Large Chili Plants Notified by Telegram". The results obtained in this study were successfully implemented with the identification and calculation accuracy value of 92.85% and the inference time value for the detection of one plant was 11.88 seconds and for sending notifications was 25.29 seconds.[3]. Research was also carried out by Ravy Hayu Pramestya NRP with the title "Detection and Classification of Asphalt Road Damage Using the YOLO Method Based on Digital Image". The results obtained from this study obtained the average value of classification accuracy is 99.25%, the average bounding box detection is 74.57% while the average classification and detection speed is 0.911 seconds per image.[4]. In this study, tomato maturity was only divided into three stages of maturity, namely ripe green (if the ivory color begins to appear at the end of the fruit, it is assumed that the reddish color is less than 15%), color breaks (if the tip starts to slightly red or yellow to reddish, it is assumed that the reddish color is between 15%-50%), and ripe red (if most of the

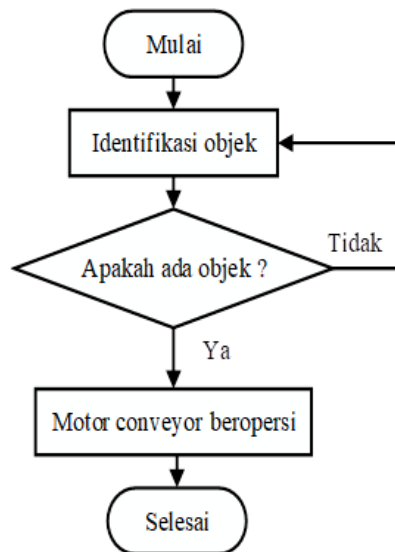
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surface is red, it is assumed that the reddish color is more than 50% and the green color is less than 10%). This research implements YOLOv4 on Raspberry Pi 3 Model B which is mobile computing.

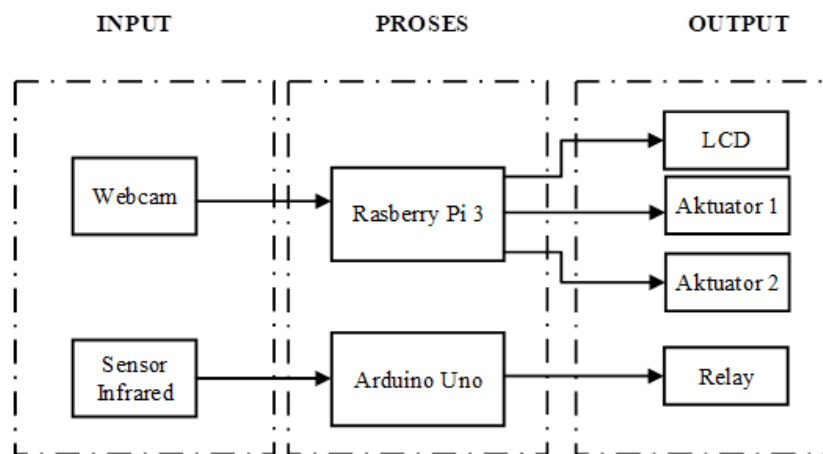
2. IMPLEMENTATION METHOD

The research method is a step to carry out and present the activities used by researchers so that research is well conceptualized and more structured. In this study, the tomato ripeness selector flow chart based on the YOLO method is shown below.



Picture 1. Tomato image detection flow chart

Block Diagram



Picture 2. System block diagram

Based on the block diagram above, the parts of each block will be explained in the points below:

- The webcam functions as a reader for the color image of the tomatoes carried by the conveyor.
- The infrared sensor serves to detect whether there are tomatoes at the fruit detection location,
- Raspberry pi 3 functions as an RGB color image data manager, YOLO V4, and provides output to the LCD, actuator 1 and actuator 2,

- d. Arduino UNO functions as a system that processes data from infrared sensors and will give output or commands to relays,
- e. The relay functions as the operation of the conveyor motor,
- f. The LCD serves to display the result data from the color of the tomatoes (red = ripe, yellow = half cooked, green = raw),
- g. Actuator 1 and actuator 2 are servo motors that function as tomato fruit sorters.

YOLOv4 Work System

In the system built, the YOLOv4 algorithm performs the process of selecting tomatoes which will become actuator decisions with the following algorithm:

- a. Tomato identification is done by infrared sensor. Where, the infrared sensor detects whether there are tomatoes at the detection location so that an action can be taken to operate the conveyor or not,
- b. The initiation of open CV functions as a real-time image color processing process,
- c. Taking pictures of tomatoes is done using a webcam. Furthermore, the captured images enter the RGB color image processing process to divide the value of each color in the tomatoes,
- d. Yolo v4 processing serves as a determinant of the results of color image processing. Where yolo v4 processing determines whether tomatoes are ripe, undercooked and unripe,
- e. If the color of the tomatoes produced is red (ripe) with a value of 60%-90% then the servo motor 1 is closed and the servo motor 2 is open, if the color of the tomatoes produced is yellow (half ripe) with a value of 10% 30% then the servo motor 2 is closed and servo motor 1 is open and if the color of the tomatoes produced is green (unripe) with a value of 10%, servo motor 1 and servo motor 2 are open.

The flow chart can be described as follows:



Picture 3. YOLOv4 tomato ripeness detection flowchart

Machine Learning

Machine Learning is a study that applies algorithms to computer systems to be able to complete certain tasks without explicit instructions. Machine Learning or machine learning is an analytical method that can handle large amounts of data by developing computer algorithms. Machine Learning tries to imitate how human processes or intelligent creatures can generalize. The hallmark of Machine Learning is the existence of a training, learning or training process. Therefore, machine learning requires data to be learned which is known as training data[5].

Another method in machine learning is the classification used by machines to sort or classify objects based on certain characteristics as humans try to distinguish objects from one another. In addition, there is a prediction or regression used by the machine to predict the output of an input data based on the data that has been studied in training. Machine Learning uses an algorithm that will make the computer to learn and perform tasks without the need for instructions from the user. Algorithms in machine learning work by building a model from input in order to

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produce a prediction or decision making based on existing data. In the development of machine learning there are three main categories, namely as follows:[5].

Deep Learning

Deep learning is part of machine learning that uses Deep Neural Networks to solve problems in the machine learning domain. Deep learning imitates human thinking. Deep learning is a method that utilizes multi-layered Artificial Neural Networks. Artificial Neural Networks are made similar to the human brain, where neurons are connected to each other to form a very complex network of neurons. Deep learning or deep structured learning or hierarchical learning or deep neural is a learning method that utilizes multiple non-linear transformations. For now it is well known that deep learning can be viewed as a combination of machine learning and Artificial Intelligence (AI).[6].

Image processing

Image processing is image processing or image processing, especially by using a computer to produce better quality images. Image processing is done by input (input) in the form of an image (image) and the result (output) is also an image (image). Initially image processing was carried out to improve image quality, but with the development of the computing world which is marked by the increasing capacity and speed of computer processing, as well as the emergence of computer sciences that allow humans to retrieve information from an image, image processing cannot be separated from the computer field. vision. Image processing that utilizes image processing technology, to manage general purpose input/output[7].

Open CV

Open Computer Vision (Open CV) namely Application Programming Interface (API). Familiar library in computer vision image processing. Computer Vision itself is a branch of the field of image processing that allows computers to see like humans. With this vision, the computer can recognize an object being observed. Some of the implementations of computer vision are face recognition, face detection, face/object tracking, and road tracking. Open CV library for computer vision and C/C++. Open CV is designed for real-time applications, good acquisition functions for image/video[8].

Python

Python is a multipurpose interpretive programming language with a design philosophy focused on code readability. Python is claimed to be a language that combines capabilities, capabilities, with a very clear code syntax, and is equipped with a large and comprehensive standard library functionality. Python is also supported by a large community. Python supports multiple programming paradigms primarily, but not limited to, object-oriented programming, imperative programming, and functional programming[9].

3. RESULTS AND DISCUSSION**Training**

YOLOv4 can run and detect objects with 80 default classes on the darknet. To be able to detect objects other than the default object, training is carried out using a dataset consisting of a tomato image file in JPG format and three new classes to distinguish the level of ripeness of tomatoes. For each type of ripe tomato, annotations are given to raw tomatoes, half ripe tomatoes, and ripe tomatoes. Annotations are made in Python-based software, namely LabelImg. The training process is carried out on Google's cloud platform, namely Google Colab. Google Colab is a Jupyter Notebook software that can be accessed online to run Python programs and the Linux kernel. In Google Colab, there are GPU features with specifications that need to be used in the training process, where the GPU is not on the Raspberry Pi 3.

The training stage is cloning the darknet repository with git into the Google Colab virtual machine, creating a darknet build, configuring the YOLO-cfg file for training, uploading the training dataset file to the VM via Google Drive, downloading the pre-trained weight file, and

finally doing the training. YOLOv4 with a tomato dataset, called a custom object detector. The training results are in the form of a custom.weight file that will be used to detect tomato ripeness. The YOLOv4 training will be carried out by uploading the dataset and files of tomatoes that have been prepared to the VM. The training process also prepared a darknet training configuration file yolov4-obj.cfg with the following parameters:

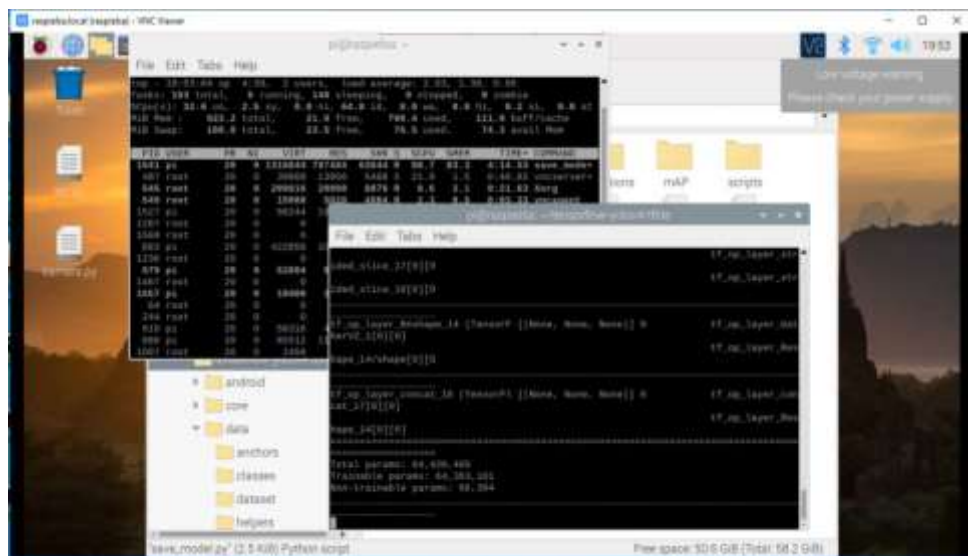
Table 1. YOLOv4 training parameters

No	Parameter	Score
1	Width	416
2	Height	416
3	Max_batches	6000
4	Filters	24

definition(SD). This is an attempt to prevent training from running for a very long time. In the max_batches parameter, the value of 6000 is obtained from the formula for the number of classes multiplied by 2000. So that 3 classes are multiplied by 2000, so 6000. For filters, the following formula is used.

$$(Jumlah\ class + 5) \times 3$$

So, filters are worth 24 from the results of the above formula. The filter parameters above will be included in the yolov4-obj.cfg file in each convolutional layer before the yolo layer (there are three layers). The yolo layer is also assigned the value classes=3. To be able to run on Raspberry Pi 3, then use Tensorflow[10] Lite (tflite). The darknet weight model is converted to tflite with the Python save_model.py script. This conversion was performed on the Ubuntu 20.04 LTS operating system on a Virtualbox machine. This conversion process is also to test YOLOv4 which has been trained before being implemented on the Raspberry Pi 3 on all devices.



Picture 4. Convert darknet model to tensorflow lite

Test

Functional testing of the system is carried out to determine the extent of the function and performance of the tool. The tests carried out in this study include camera functional tests, servo motor functional tests and device modules.

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No	Component		Test			
			Servo 1		Servo 2	
			Voltage	Current	Voltage	Current
1	Servo operating	1	4.9v	1A	4.9v	1A
2	Servo operating	2	5.1v	1A	5.1v	1A

No	Test	Console Command	Results	
			Workin g	Doesn't work
1	Raspberry Pi serial connection with Arduino	Hello	<input type="checkbox"/>	
2	Relay on (manual)	"relays on"	<input type="checkbox"/>	
3	Relay off (manual)	"relay off"	<input type="checkbox"/>	
4	Servo open (manual)	"servo open"	<input type="checkbox"/>	
5	Servo close (manual)	"servo close"	<input type="checkbox"/>	
6	Conveyor (manual)	Conveyor operating	<input type="checkbox"/>	

No	Tomato Test	LCD		Servo 1		Servo 2		YOLO V4	
		Workin g	Doesn' t work	Workin g	Doesn't work	Workin g	Doesn't work	FPS	Response Time
1	Ripe Tomato	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>		0.9	5ms
2	Half Ripe Tomato	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>		1.1	6ms
3	Raw Tomato	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>		0.9	7ms

4. CONCLUSION

The YOLOv4 algorithm can accurately detect image objects, both on tomatoes and other objects. Although it is called one of the fastest algorithms, it requires good hardware to run YOLOv4. The Raspberry Pi 3 device is not good at running YOLO-based image detection, because it can only process on the CPU, cannot use the GPU features. Suggestions for future research, the use of YOLOv4 or the latest version is carried out on mobile computing devices that support GPU for images such as Nvidia Jetson, or Raspberry Pi 4 with the help of additional modules such as the Intel Neural Compute Stick.

REFERENCES

- A. Ahmad Hania, "Mengenal Artificial Intelligence, Machine Learning, & Deep Learning," *J. Teknol. Indones.*, vol. 1, no. June, pp. 1–6, 2017, [Online]. Available: <https://amt-it.com/mengenal-perbedaan-artificial-intelligence-machine-learning-deep-learning/>
- A. F. López Camelo and P. A. Gómez, "Comparison of color indexes for tomato ripening," *Hortic. Bras.*, vol. 22, no. 3, pp. 534–537, 2004, doi: 10.1590/s0102-05362004000300006.
- A. R. Putri, "Pengolahan Citra Dengan Menggunakan Web Cam Pada Kendaraan Bergerak Di Jalan Raya," *JIPi (Jurnal Ilm. Penelit. dan Pembelajaran Inform.*, vol. 1, no. 01, pp. 1–6, 2016, doi: 10.29100/jipi.v1i01.18.
- A. Rahayuningtyas, M. Furqon, and D. Sagita, "Rancang bangun perangkat sortasi tomat berdasar sensor berat tipe strain gauge dan pengolahan citra warna design of tomato sortation device based on strain gauge type weight sensor and color image processing," *J. Ris. Teknol. Ind.*, vol. 14, no. 1, pp. 65–78, 2020.
- A. Roihan, P. Abas Sunarya, and A. S. Rafika, "Pemanfaatan Machine Learning dalam Berbagai Bidang: Review paper," *IJCIT (Indonesian J. Comput. Inf. Technol.*, vol. 5, no. 1, pp. 75–82, 2019.
- Bustani, B., Khaddafi, M., & Nur Ilham, R. (2022). Regional Financial Management System of Regency/City Regional Original Income In Aceh Province Period Year 2016-2020. *International Journal of Educational Review, Law and Social Sciences (IJERLAS)*, 2(3), 459–468. <https://doi.org/10.54443/ijerlas.v2i3.277>.
- D. N. Zuraidah, M. F. Apriyadi, A. R. Fatoni, M. Al Fatih, and Y. Amrozi, "Menelisik Platform Digital Dalam Teknologi Bahasa Pemrograman," *Teknois J. Ilm. Teknol. Inf. dan Sains*, vol. 11, no. 2, pp. 1–6, 2021, doi: 10.36350/jbs.v11i2.107.
- F. Ramasari, F. Firdaus, S. Nita, K. Kartika, and others, "Penggunaan Metode You Only Look Once dalam Penentu Pindah Tanaman Cabai Besar Ternetifikasi Telegram," *Elektron J. Ilm.*, pp. 45–52, 2021.
- Falahuddin, F., Fuadi, F., Munandar, M., Juanda, R., & Nur Ilham, R.. (2022). Increasing Business Supporting Capacity In Msmes Business Group Tempe Bungong Nanggroe Kerupuk In Syamtalira Aron District, Utara Aceh Regency. *Irpitage Journal*, 2(2), 65–68. <https://doi.org/10.54443/irpitage.v2i2.313>
- Geovani, I. ., Nurkhotijah, S. ., Kurniawan, H. ., Milanie, F., & Nur Ilham, R. . (2021). Juridical Analysis of Victims of The Economic Exploitation of Children Under the Age to Realize Legal Protection from Human Rights Aspects: Research Study At The Office of Social and Community Empowerment In Batam City. *International Journal of Educational Review, Law and Social Sciences (IJERLAS)*, 1(1), 45–52. <https://doi.org/10.54443/ijerlas.v1i1.10>
- Ilham, Rico Nur. *et all* (2019). Comparative of the Supply Chain and Block Chains to Increase the Country Revenues via Virtual Tax Transactions and Replacing Future of Money. *International Journal of Suplly Management*. Volume 8 No.5 August 2019.
- Ilham, Rico Nur. *et all* (2019). Investigation of the Bitcoin Effects on the Country Revenues via Virtual Tax Transactions for Purchasing Management. *International Journal of Suplly Management*. Volume 8 No.6 December 2019.
- Lasta Irawan, A. ., Briggs, D. ., Muhammad Azami, T. ., & Nurfaliza, N. (2021). The Effect of Position Promotion on Employee Satisfaction With Compensation As Intervening Variables: (Case Study on Harvesting Employees of PT. Karya Hevea Indonesia). *International Journal of Social Science, Educational, Economics, Agriculture Research, and Technology (IJSET)*, 1(1), 11–20. <https://doi.org/10.54443/ijset.v1i1.2>
- Likdanawati, likdanawati, Yanita, Y., Hamdiah, H., Nur Ilham, R., & Sinta, I. (2022). Effect of Organizational Commitment, Work Motivation And Leadership Style on Employee Performance of Pt. Aceh Distribus Indo Raya. *International Journal of Social Science, Educational, Economics, Agriculture Research, and Technology (IJSET)*, 1(8), 377–382. <https://doi.org/10.54443/ijset.v1i8.41>.

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- M. L. Aziz, "Perancangan Sistem Deteksi Objek Secara Real-Time Menggunakan Metode YOLO pada Robot AL-Mubarak_MK4," vol. 2020, p. 196, 2020.
- Majied Sumatrani Saragih, M., Hikmah Saragih, U., & Nur Ilham, R. (2021). Relationship Between Motivation and Extrinsic Motivation to Increasing Entrepreneurship Implementation from Spp Al-Falah Group At Blok 10 Village Dolok Masihul. *Morfai Journal*, 1(1), 1–12. <https://doi.org/10.54443/morfai.v1i1.11>.
- N. Ramadijanti, S. Kom, and M. Kom, "Pembuatan Game Puzzle Gambar Dengan Gerakan Tangan dan Perintah Suara Pembuatan Game Puzzle Gambar Dengan Gerakan Tangan dan Perintah Suara Pembuatan Game Puzzle Gambar Dengan Gerakan Tangan dan Perintah Suara," *Politek. Elektron. Negeri Surabaya Inst. Teknol. Sepuluh Nop.*, 2010.
- Nur Ilham, R., Arliansyah, A., Juanda, R., Multazam, M., & Saifanur, A. (2021). Relathionsip Between Money Velocity and Inflation to Increasing Stock Investment Return: Effective Strategic by Jakarta Automated Trading System Next Generation (Jats-Ng) Platform. *International Journal of Economic, Business, Accounting, Agriculture Management and Sharia Administration (IJEBAS)*, 1(1), 87–92. <https://doi.org/10.54443/ijevas.v1i1.27>
- Nur Ilham, R., Heikal, M. ., Khaddafi, M. ., F, F., Ichsan, I., F, F., Abbas, D. ., Fauzul Hakim Hasibuan, A. ., Munandar, M., & Chalirafi, C. (2021). Survey of Leading Commodities of Aceh Province As Academic Effort to Join and Build The Country. *Irpitage Journal*, 1(1), 13–18. <https://doi.org/10.54443/irpitage.v1i1.19>
- Nur ilham, R., Likdanawati, L., Hamdiah, H., Adnan, A., & Sinta, I... (2022). Community Service Activities "Socialization Avoid Study Investment" to The Student Bond of Serdang Bedagai. *Irpitage Journal*, 2(2), 61–64. <https://doi.org/10.54443/irpitage.v2i2.312>.
- R. H. Pramestya, "Deteksi dan klasifikasi kerusakan jalan aspal menggunakan metode yolo berbasis citra digital," *Inst. Teknolgi Sepuluh Nop.*, p. 91, 2018, [Online]. Available: http://repository.its.ac.id/59044/1/06111650010019-Master_Thesis.pdf.
- Rahmaniar, R., Subhan, S., Saharuddin, S., Nur Ilham, R. ., & Anwar, K. . (2022). The Influence of Entrepreneurship Aspects on The Success of The Chips Industry In Matang Glumpang Dua and Panton Labu. *International Journal of Social Science, Educational, Economics, Agriculture Research, and Technology (IJSET)*, 1(7), 337–348. <https://doi.org/10.54443/ijset.v1i7.36>
- Sandi, H., Afni Yunita, N., Heikal, M., Nur Ilham, R., & Sinta, I. . (2021). Relationship Between Budget Participation, Job Characteristics, Emotional Intelligence and Work Motivation as Mediator Variables to Strengthening User Power Performance: An Emperical Evidence from Indonesia Government. *Morfai Journal*, 1(1), 36–48. <https://doi.org/10.54443/morfai.v1i1.14>
- Sinta, I., Nur Ilham, R., Kumala Sari, D., M, M., Khaidir, K., & Ekamaida, E. (2021). Training The Processing of Tomato Sauce For A Home-Based Business The Scale of SMES. *Irpitage Journal*, 1(1), 26–28. <https://doi.org/10.54443/irpitage.v1i1.24>
- Sinurat, M., Heikal, M., Simanjuntak, A., Siahaan, R., & Nur Ilham, R. (2021). Product Quality on Consumer Purchase Interest with Customer Satisfaction as A Variable Intervening in Black Online Store High Click Market: Case Study on Customers of the Tebing Tinggi Black Market Online Store. *Morfai Journal*, 1(1), 13–21. <https://doi.org/10.54443/morfai.v1i1.12>
- Yusuf Iis, E., Wahyuddin, W., Thoyib, A., Nur Ilham, R., & Sinta, I. (2022). The Effect of Career Development and Work Environment On Employee Performance With Work Motivation As Intervening Variable At The Office Of Agriculture And Livestock In Aceh. *International Journal of Economic, Business, Accounting, Agriculture Management and Sharia Administration (IJEVAS)*, 2(2), 227–236. <https://doi.org/10.54443/ijevas.v2i2.191>.