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Urban Farming Growth Monitoring System Using Artificial Neural Network (ANN) and Internet of Things (IOT)

Mohamed Mydin M. Abdul Kader[1,2,*], Muhammad Naufal Mansor[2], Wan Azani Mustafa[2], Zol Bahri Razali[2], Ahmad Anas Nagoor Gunny[3], Samsul Setumin[4], Muhammad Khusairi Osman[4], Mohaiyedin Idris[4], Muhammad Firdaus Akbar[5], Premavathy Kunasakaran[2], Muhammad Zubir Zainol[2], Nor Syamina Shariffull Mizam[2]

1 Sports Engineering Research Centre, Centre of Excellence (SERC), Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia
2 Faculty of Electrical Engineering Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia
3 Faculty of Chemical Engineering Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia
4 Center for Electrical Engineering Studies Universiti Teknologi MARA Pulau Pinang, Malaysia
5 Faculty of Electrical and Electronics Engineering, Universiti Sains Malaysia, Pulau Pinang, Malaysia

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ABSTRACT

As an introduction to this project, the growth-related traits, such as above-ground biomass and leaf area, are critical indicators to characterize the growth of indoor lettuce plants. Currently, non-destructive methods for estimating growth-related traits are subject to limitations in that the methods are susceptible to noise and heavily rely on manually designed features. It is also one of the problem statements in this project. Based on this project the next problem is manual control of nutrients maycause quality issues to the lettuce plant. If the nutrient supply is too much or less, it will disturb the growth of the lettuce plant either the lettuce plant is dead or stunted. This project is about urban farming growth monitoring system using Artificial Neural Network (ANN) and Internet of Things (IoT). In this project, a method for monitoring the growth of indoor lettuce plants was proposed by using digital images and an ANN using Deep Learning Architecture. DLA is mostly developed by the software of MATLAB or Python to insert and run the coding. DLA is mostly used for image detection, pattern recognition, and natural language processing through the graph for Neural Network. Next, the Internet of Things (IoT) is a medium to store images of indoor lettuce plant growth into the Cloud (Google Drive). Furthermore, it takes indoor lettuce plant images as the input, an ANN was trained to learn the relationship between images and the corresponding growth-related traits with other fixed parameters. The pH level parameters were controlled by other fixed parameters to take the images of indoor lettuce plant growth. The parameters used in this project are temperature and humidity. This helps to compare the results of Artificial Neural Network (ANN), widely adopted methods were also used. Concisely, this project is expected to develop the Deep Learning Architecture using an Artificial Neural Network (ANN) with digital images as a robust tool for the monitoring of the growth of indoor lettuce plants every 30 minutes per day. Generally, focused on an urban farming growth monitoring system using Artificial Neural Network (ANN) and the Internet of Things (IoT).

* *Corresponding author.*
E-mail address: mohamedm@unimap.edu.my

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1. Introduction

In this ICT technology, agriculture lands are decreasing due to the conversion of land into industry and settlement reasons. It happens because of economic and social situations, limitationof land resources and the population with economic growth. Based on this scenario, agriculture technology was rapidly developed in urban areas by urban farming method. Urban farming is the agricultural practices in urban areas or their surrounding regions. Which was involving horticulture, animal husbandry, aquaculture, and other practices for producing fresh foodsor vegetables for the people around the areas. Mostly, these farming methods are delivered to rooftops, balconies, terraces, and to the walls of buildings too.

By using the development of technology now days, Artificial Neural Network (ANN) is the main technique which is used in urban farming to monitor plant growth such as lettuce plant. Artificial Neural Network (ANN) is known as a parallel and distributed processing system which consists of a vast number of simple and massively connected processes for agriculture section.

The Artificial Neural Network also consists of a deep learning architecture which may help to do coding more detail through MATLAB software. Deep learning architecture is known as deep structured learning from the part of a broader family of a machine learning method. Which was always based on the Artificial Neural Network (ANN) method. Deep learning architecture is mostly used for image detection, pattern recognition, and natural language processing through the graph for Neural Network also. It will help to show the plant growth monitoring system using deep learning architecture by the graph method for each parameter function such as pH level, temperature, and humidity.

1.1 Problem Statement

There are some problems that can have a huge effect on the growth of lettuce plants while it was not monitored properly or care. From previous research the problems that occur are based mainly on growth-related traits. As for today’s technology, critical indicators characterize the growth of indoor lettuce plants by urban farming. This research was done to find the gaps in the existing research and possible solutions to overcome these gaps in the future [1].

Moreover, the non-destructive ways for estimating growth-related traits will be subject to limit the susceptibility to the noise and heavily rely on manually designed features. It means thatthe farmer will monitor the lettuce plant growth every day and hours. Which may help the farmerto protect the lettuce plant from insects when do the indoor section monitoring system.

Besides that, the manual control of nutrients may cause quality issues to the lettuce plant is the next problem in this research. If the nutrient supply is too much or less, it will disturb the growthof the lettuce plant either the lettuce plant is dead or stunted [2-7]. So, the farmer can monitor through some parameters by preventing lack of nutrients to the lettuce plant. Next, to avoid this problem can install a camera which may help to watch the quantity of nutrients every second. By applying this method, it will help to save farmer time and energy very well without having any damage to the lettuce plant. Thus, to overcome this problem of urban farming growth monitoring system using Artificial Neural Network (ANN) and the Internet of Things (IoT) was focused and developed in this project.

1.2 Previous Study for Urban Farming Growth Monitoring System Using Artificial Neural Network (ANN) and Internet of Things (IoT)

L. Zhang *et al.,* [2] presents the growth monitoring of greenhouse lettuce based on a convolutional neural network. In this research, a strategy for observing the development of nursery lettuce was proposed by utilizing advanced images and a convolutional neural network (CNN). By taking lettuce images as the info, a CNN model was prepared to get familiar with the connection among images and the comparing development related characteristics based on leaf fresh weight (LFW), leaf dry weight (LDW), and the leaf area (LA). Then, to analyse theeffects of the CNN model, generally received strategies were likewise utilized. So, the outcomes demonstrated that CNN with advanced pictures is a powerful device for the observing of the development of greenhouse lettuce [2].

N. Mungai Bryan *et al.,* [3] presents an urban based smart IOT farmingsystem. This paper also contains a fluffy based, Decision Support System (DSS) to wisely apportion water and manure utilized in crop creation dependent on the age of the plant and information gathered from the dirt and surrounding climate with the guide of an organization of sensors. An installed equipment framework comprising of a Cartesian robot has likewise been executed to guarantee successful use of fluffy determined choices. Two Fuzzy Inference Systems (FIS) comprising of straight, non-direct Membership Functions and a 149-rule base for the PA frameworkhave been created in MATLAB, carried out utilizing Arduino micro-controllers and tried on spinach plants whereby results show that the direct FIS can accomplish more precise outcomes as far as thenature of yield acknowledged and asset utilization. Asset utilization correlation with different frameworks in writing evaluated is additionally done whereby the DSS can set aside to 2031 ml and 524 ml of water and compost separately [3].

Sensors measure boundaries like ecological stickiness and temperature, soil dampness and temperature, CO2 levels, glow, and yield presence; prepared inside an ATMEL microcontroller, which takes choices for water system dependent on crop prerequisites. This data is gotten by the distant worker through the Wi-Fi convention, which stores it in the cloud inside a data set and sends it to the customer PC or cell phone, who will want to get to this information progressively from any area where it approaches the Internet of Things [4]. G. Carrion *et al.,* [5] present the monitoring and irrigation of an urban garden using IoT. Based on the customary techniques utilized in farming regularly have impediments identified with utilization, executives, and preservation of water for the water system. The rise of new innovations, for example, the Internet of Things and data, the executives has sped up they create of "modern agriculture" by alleviating or, best case scenario, killing the issues referenced previously. In this research paper it introduced the plan and execution of an inserted framework that utilizes the Internet of Things and a bunch of sensors and actuators to permit the observing of climatic factors and the water system of an urban garden situated in the parking facilities.

A. S. Oh *et al.,* [6] presents the smart urban farming service model with an IoT based openplatform. In this research paper, it is study about the agricultural production or smart farming using IoT sensors, the big-data and cloud administration has demonstrated. In this research paper, has propose a smart urban farming model which changes TTA brilliant nursery standard to such an extent that cloud administration is incorporated with IoT sensors. The equipment plan of a coordinated regulator and the resulting programming administrations are indicated. This new model can be utilized to upgrade smart urban farming which is a top ten agricultural policy of the government [5].

A. A. R. Madushanki *et al.,* [7] presents about the adoption of the internet of things (IoT) in agriculture and smart farming towards urban greening. This paper investigated how they expect to break down as of latecreated IoT applications in farming also, cultivating businesses to give an outline of sensor, information assortments, innovations, and sub-verticals. For example, water, the executives and harvest the board. Based on the survey taken, the information is extricated from sixty companions investigated logical distributions (2016-2018) with an attention on IoT sub-verticals and sensor information assortment for estimations to settle on exact choices [6].

G. Balakrishna *et al.,* [8] presents the study report on using IoT Agriculture farm monitoring. Based on this research, the Internet of things (IoT) is modifying an agribusiness engaging farmers with the broad assortment of methodologies. For instance, exactness and acceptable cultivating to go up against challenges at the homestead. IoT advancement helps in social occasion information regarding a circumstance like an environment,clamminess, temperature, and lavishness of soil, checking the crop through web by rancher enables revelation of weed, level of water, bug acknowledgment, animal interference into the field, trim turn of events, and cultivating. IoT uses agriculturists to get related by his farm from wherever and at whatever point. Far off sensor frameworks are used for noticing the farm conditions and more limited size analysts are used to control and automate the residence structures. Then, to consider the distance conditions as picture and video, far too off cameras have been used. A high-level cell phone empowers the farmer to keep invigorated with the nonstop conditions of his rustic land using IoT at whatever point and any piece around the world. IoT advancement can diminish the expense and overhaul the efficiency of regular developing [7].

Conventional agribusiness may be helpless against environmental change. This is on the grounds that, since the yields or plants are filled in an open airfield, it was presented to the regular habitat. As it has their ideal temperature and conditions to grow, an environmental change may carry an enormous misfortune to the rancher on the grounds that the efficiency may have a huge drop as come about by the environmental change. Simultaneously, during customary horticulture, the greater part of the ranchers is utilizing their experience and forecast for agribusiness work,and this may diminish the food efficiency also. Besides, the enormous size field will require more work to deal with the field, yet this does not ensure an increment in food creation. Accordingly, indoor cultivating climate is intended to give a steady condition which is appropriate for plants or yields to develop. Next, to accomplish that, the idea of accuracy agribusiness is an "Unquestionable requirement". By executing various kinds of sensors, such as the temperature and air stickiness sensors, it will be ready to screen the field boundaries, and the information will be shipped off the Cloud for an ongoing frame show reason. If the boundaries are out of pre-characterized limit esteem, the Raspberry Pi as the IoT door which gets the information from the sensors will give the order to trigger the actuator in the field to make change or control the unusual boundary. Then again, the framework will play out the water system framework consequently by utilizing the clocks [8].

L. Chaaro *et al.,* [9] presents about the crop and weed detection using image processing and deep learning techniques. In this project, a framework for the distinguishing proof of various harvests and weeds has been created as an option in contrast to the framework present on the Farm Bot organization's robots. This is finished by getting to the images through the Farm Bot API, utilizing PC vision for image handling, and computerized reasoning for the use of move figuring out how to RCNN that plays out the plants recognizable proof self-sufficiently [9].

Next, the development of plant growth monitoring system using image processing techniques which are based on multiple images. This research mainly pointed toward the development of the plant growth monitoring systembased on image processing technique from images captured using multi-cameras (webcams). The yield of exploration was a checking framework furnished with graphical user interface (GUI) to screen the plant development and non-destructively anticipate age with the new weight of mustard. The five webcams in five distinct positions were introduced on the image capturing box to capture plant images at regular intervals up to 48 days. An artificial neural network (ANN) was utilized to anticipate the age and weight of the plants. The network architecture comprised of four layers at five input neurons, first hidden layer with five neurons, the second hidden layer by five neurons, and output layers with one neuron. Preparing the function of ANN utilized was trained and learning rate esteem was 0.001. The initiation work for fore seeing plant age and plant weight was recorded separately. So, ANN models could anticipate the plant age with a worth of 0.96 and fresh weight by a worth of 0.95 [10].

2. Methodology

This chapter will describe the methods that have been planned earlier in conducting research systematically. There are some refinements based on this method [11]. The methodology starts with a literature review on the research area that has been explained in the previous chapter. On the other hand, the development of coding for Deep Learning Architecture by using an Artificial Neural Network (ANN) and MATLAB software. Then, the hardware is prepared before the project is executed fully with a combination of hardware and system. Testing will be done until the project operates according to required specifications.

2.1 Research Flow

A decent arrangement of a project is essential to get the best outcome for the project. Much research will assist by getting more data that can be utilized to design and develop a project, like exploration from any journals, magazines, articles, web searches and others. Figure 1 shows the research flow of this project.

Fig. 1. Research flow of the project

Then, research on better design for the project is needed after the planning is finished to ensure it is proper dependent on what was anticipated. The project can be conducted after settling with designing and ultimately it can produce the outcome from the testing and analysis section.

2.2 Project Workflow

The workflow of this project starts with defining the entire system through a flowchart as shown in Figure 2 below.

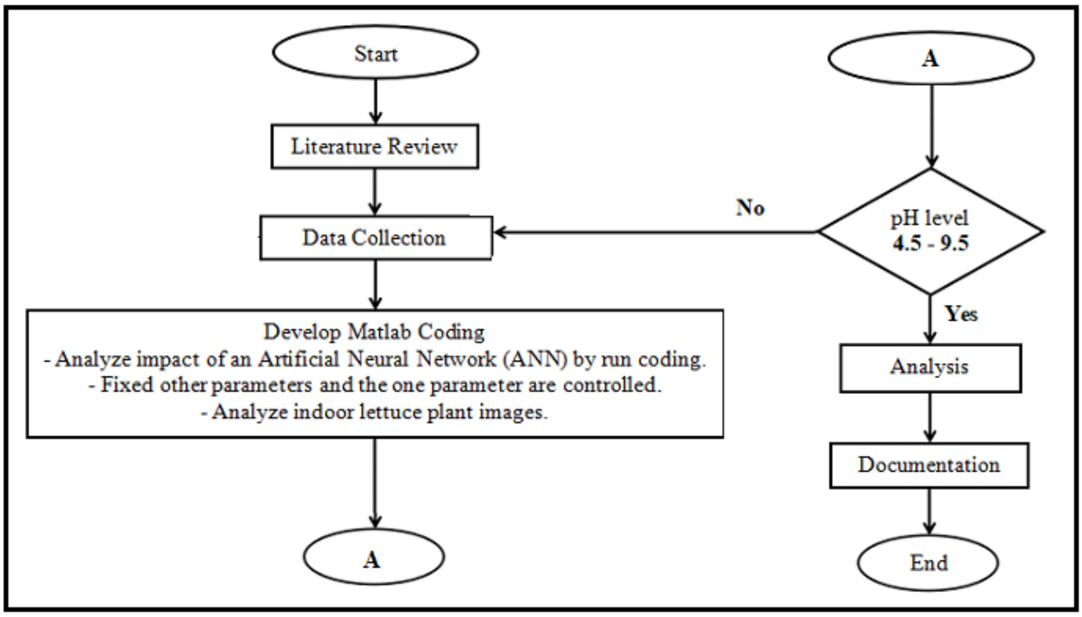


Fig. 2. Flowchart of the project

Figure 2 shows the flowchart of the overall project. A literature review is the first method in this project flow. In this literature review, the research and data regarding the project proceed. The review is more to research on an Artificial Neural Network (ANN) using Deep Learning Architecture [10,11] and the Internet of Things (IoT) technology using cloud storage (Google drive) methods are used in this project. Right after this the hardware development was emphasized. Hardware development is stages where all hardware of this research has been assembled [12]. A couple of plant factories are built using plywood for indoor farming use. One is ventilated using fans for air inlet & outlet, while the other is without fan. This approach sounds simple, however very effective [13].

Next, data collection. Which was divided into three steps such as camera installation, capture the image of indoor lettuce plant growth, and storage in the Cloud. Firstly, installing a camera that contains Wi-Fi connection in the hydroponic system may help to capture the image of indoor lettuce plant growth and save at the Cloud storage (Google drive) using the Internet of Things (IoT) technology. It helps to capture an image of the lettuce plant every 30 minutes in 24 hours by saving the data automatically in Cloud storage (Google drive).

Then, analyse the process of impact at an Artificial Neural Network (ANN). This impact is analysed through MATLAB software. The coding insert in MATLAB software will have other fixed parameters which may help to control one parameter easily. The other parameters are considered as temperature, and humidity which contain fixed values. While the pH level was considered as the controlled parameter in this project. So, the coding will run and analyse using other fixed parameters. After that, plant growth will be analysed through MATLAB software to get the graph of plant growth, every 30 minutes. The parameters used in this project have been fixed such as temperature and humidity. But for the pH level it was considered as a controlled parameter which contains with the range value such as 4.5 to 9.5. If the value of parameters is not detected, then it will go back to the data collection step and analyse images of indoor lettuce plant growth again. This method may seriously affect the diagnostic process and its outcome, especially if an automatic computer-based procedure is used to derive diagnostic parameters [14].

Finally, all the data will be analysed for the indoor lettuce plant growth, which has been saved into Cloud storage (Google drive) and MATLAB software. The hardware and software are done and integrated together to successfully finish the prototype [15]. Finally, all the data has been analysed and evaluated. All the data has been collected and documented in the report [16].

2.2.1 Parameter of the project

The parameters are numbers that can be summarized data for an entire project which is based on the urban farming growth monitoring system using Artificial Neural Network (ANN) and the Internet of Things (IoT). It may help to statistics the overall project by identifying and study the parameters shown. If other parameters such as temperature, and humidity are fixed, then the one parameter which is pH level will be controlled to see the lettuce plant growth monitoring system. Table 1 shows the study of parameters for the pH level, temperature, and humidity.

Table 1
Parameters for the urban farming growth monitoring system

Fixed Parameter	**Controlled**	**Parameter**
pH Level	Temperature	Humidity
4.5 – 9.5	0	0
4.5 – 9.5	0	1
4.5 – 9.5	1	0
4.5 – 9.5	1	1

Referring to Table 1 above, the fixed parameters are declared as temperature and humidity. Moreover, to the controlled parameter it has declare for pH level. As shown in the table above the value 0 refers to no condition and value 1 refers to have condition. If pH level declares theparameters range, but temperature and humidity are in 0 conditions means the outcome will be zero.

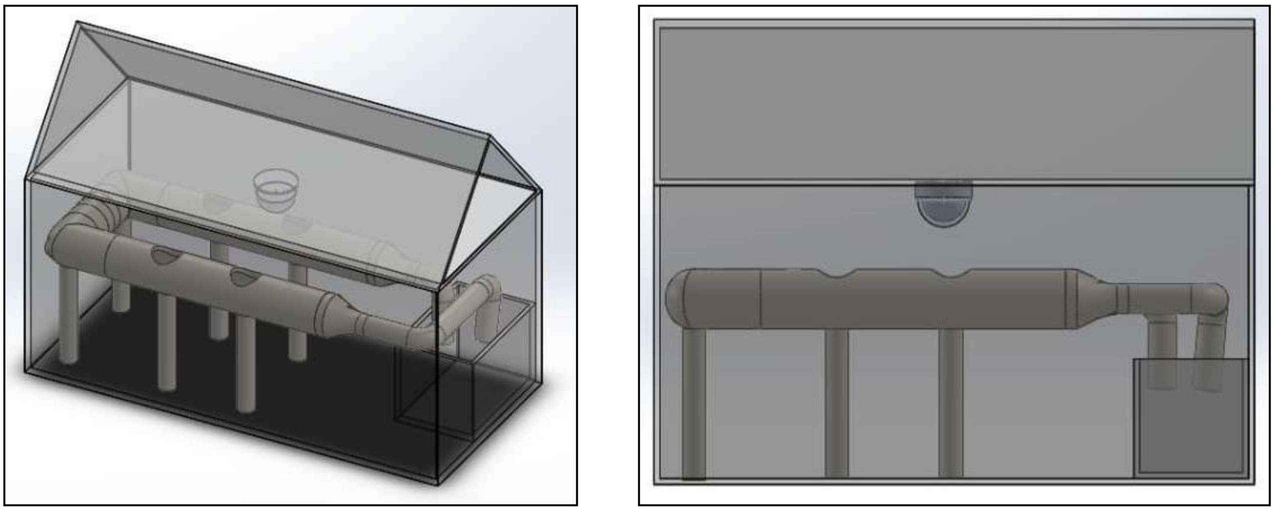
For the second row, humidity contains conditions as one, but the temperature is at 0 means it may have some growth in the lettuce plant. While the temperature contains condition as one and humidity does not have condition means the lettuce plant will face a bit difficult at growth part. At the last row, it refers to the temperature and humidity contain conditions as one and the pH level condition as well means the lettuce plant will grow healthy and gave the quality plant to users orcustomers around.

2.3 System Development

The system development is a section that is required to be used for project creation. In this section, it will be explained about the software which has been used in the project. The software is mostly used to design, program the coding, and create the interfaces from the software for outcome sources. The software lists which have been used in this project are Solid- work, Arduino IDE, and MATLAB.

2.3.1 Camera installation area using solid work software

The camera installation was done at the farming plant area system model which has been designed through Solid Work software. Figure 3 shows the farming plant area model with camera installation at the rooftop inside.



(a) (b)

Fig. 3. Farming plant area model with camera installation (a) 3D view (b) 2D view

Solid-work is defined as a solid modelling computer-aided design and a computer-aided engineering computer program. It will be useful to design the 2D and 3D modelling system. The camera was installed at the inside of the farming plant area system at the upper part. Material selection mainly depends on how easily they can be shaped [17]. Which may be able to capture the images of lettuce plant growth accurately and perfectly, while the other parameters are fixed, and one parameter is controlled.

2.3.2 Arduino IDE software

Arduino IDE is software which is mostly used for a program the coding. Figure 4 shows the Arduino IDE coding for ESP 32 CAM-MB.

Fig. 4. Arduino IDE coding for ESP 32 CAM-MB

In this project, Arduino IDE used for ESP 32 CAM-MB for capture the image of lettuce plant growth, every 30 minutes. Then, send the images to Cloud storage (Google drive). So, this section was considered asInternet of Things (IoT) for the urban farming growth monitoring system.

2.3.3 MATLAB software

MATLAB is software which contains a high-performance language for technical computing. MATLAB software can do integrates computation, visualization and programming parts which may create and be easy to use in any environment. This problem can be managed by the familiar mathematical notation. Based on the urban farming growth monitoring system needs to create a coding for image processing and graph sections. Figure 5 shows that Artificial Neural Network (ANN) by using the Deep Learning Architecture.

Fig. 5. Artificial Neural Network (ANN) using Deep Learning Architecture

The image processing through MATLAB software will help to collect the images from Cloud storage (Google drive) and add them on in the MATLAB. So, it shows the lettuce plant growth monitoring system through the MATLAB software. From the image processing it will go to the next step which is getting the graph. The graph will get through the parameter section which shows other parameters are fixed and controlled the one parameter which is pH level. While the MATLAB coding runs the program it will get a graph based on the other parameters fixed and one parameter is controlled. The same procedure is done for modified designs in the analysis software [18].

3. Results

3.1 Image Data Taken from the ESP 32 CAM Through Cloud Storage

The image data for 15 days by calculate each parameter is recorded. The parameters usedin this project are pH level, temperature, and humidity. The same procedure is done for modified designs in the analysis software [19]. The temperature and humidity are fixed parameters, while the pH level is the controlled parameter in this research project. Figure 6 shows the google drive storage from ESP 32 CAM and Figure 7 shows the data separation folder based on the pH level with days.

Fig. 6. The google drive storage from ESP 32 CAM

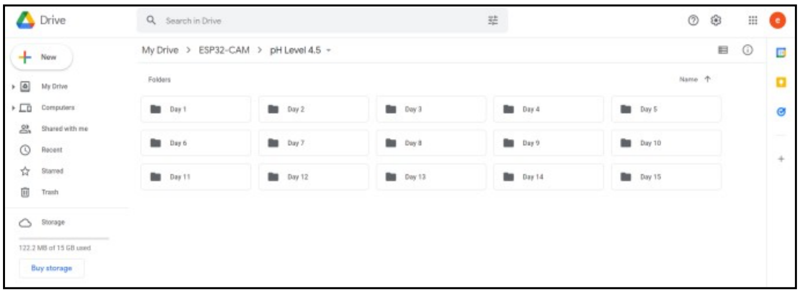


Fig. 7. The data separation folder based on the pH level with days

There are some fixed values which need to be added in lettuce plant growth monitoring system. Then, it willtransfer to the MATLAB software for image processing and analysis of the growth of lettuce plants. Thedata taken as a known image which is for 15 days the image obtained is 720. So, the overall image for estimation is approximately 4320 images for 15 days to six types of pH level. But the data is not enough for the deep learning architecture to train, or the plant growth still not fully matured yet thedata taken will be extended.

3.2 Data Taken from the MATLAB

3.2.1 Layers used in the deep learning architecture

Figure 8 shows the layer list after training progress and layers in deep learning architecture.

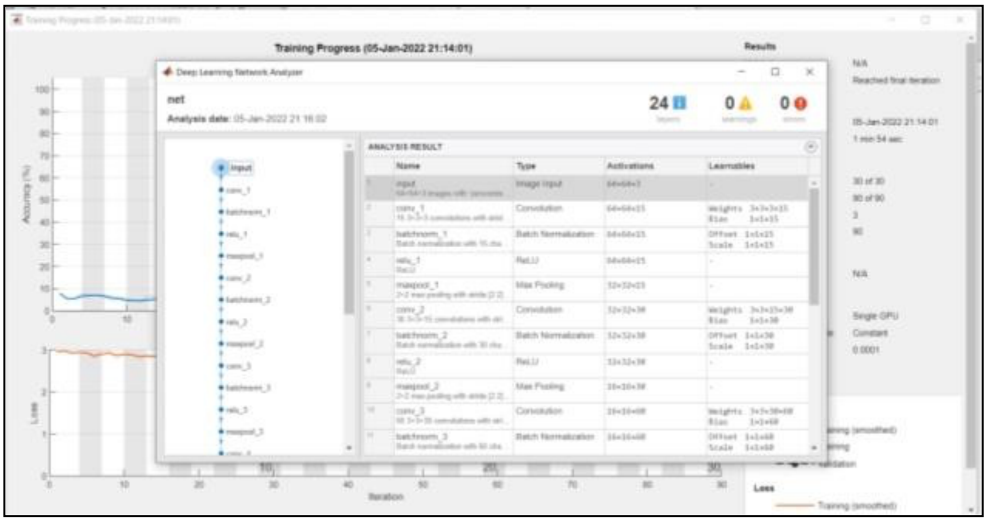


Fig. 8. The layer list after training progress and layers in deep learning architecture

The layers used in deep learning are input layer, convolutional 2D layer, batch normalization layer, maxpool 2D layer, fully connected layer, classification layer, which will make the deep learning architecture training become perfect and good.

3.2.2 Data split to 6 classes according to the pH level

The images were split into six classes which are 4.5, 5.5, 6.5, 7.5, 8.5, and 9.5 pH level. It shows the growth rate of all plants in each pH level class. The best pH level for lettuce plants is 6.5. It is the most suitable pH level to get a healthy and wider lettuce. The 4.5 pH level is the unhealthy lettuce compared to the other pH levels. The network successfully read the images in per classes which have been created. Figure 9 shows the randomized images from the overall image taken in the folder.

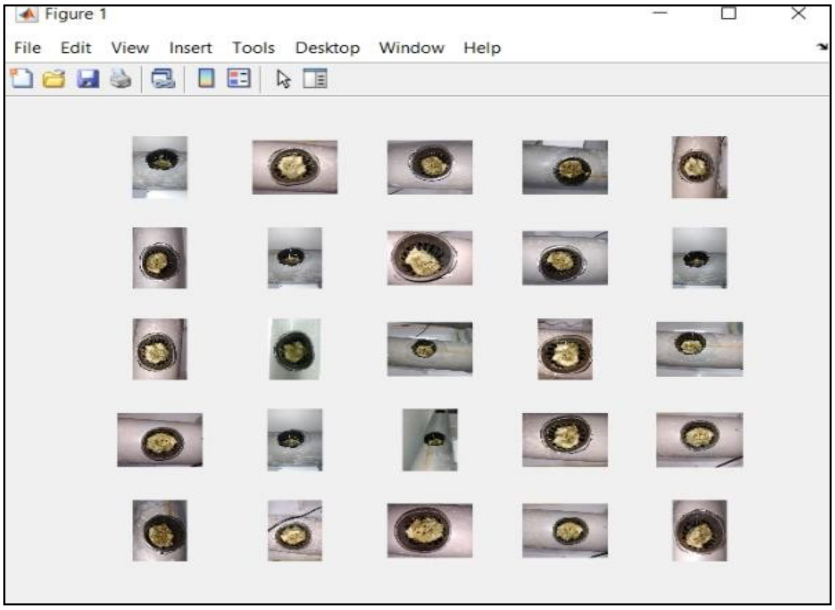


Fig. 9. Randomized images from the overall image taken in the folder

Then, the training and validation graph was the next deep learning architecture in the MATLAB software section. The training progresses from processing the images for every pH level class which have been created. In this experiment, the same step has been taken from previous assessment [20].

Based on the training progress accuracy was 87.5%. So, it shows that the loss will become near zero value. However, the deep learning architecture was still not in perfect section, yet as the accuracy was not achieved to 100%. Figure 10 shows the training and validating graph after processing the images in each class.

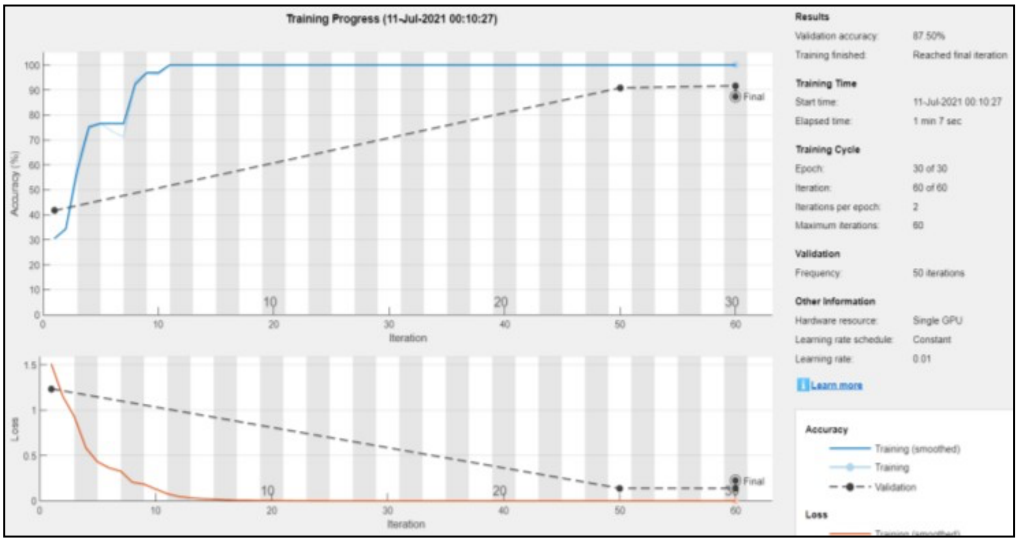


Fig. 10. The training and validating graph after processing the images from every class

Next, MATLAB started to train and validate at the accuracy section. The accuracy in this part mostly depends on the mini batch accuracy, epoch, and iteration. The iteration at each epoch was several training samples which will be divided by the mini batch size. Figure 11 showsthe epoch, iteration, mini batch accuracy and validation accuracy.

Training on single GPU.
Initializing input data normalization.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:04	21.09%	26.67%	1.4074	1.3880	0.0100
25	50	00:00:56	100.00%	100.00%	3.5695e-05	0.0111	0.0100
30	60	00:01:08	100.00%	100.00%	2.6226e-05	0.0084	0.0100

Fig. 11. The epoch, iteration, mini batch, and validation accuracy for thirty times

In this validation part the network is being trained with the same data thirty times. As a last step, evaluating the deep learning architecture with training and validation accuracy. Figure 12 shows that the prediction is based on random image selection in training and validation accuracy.

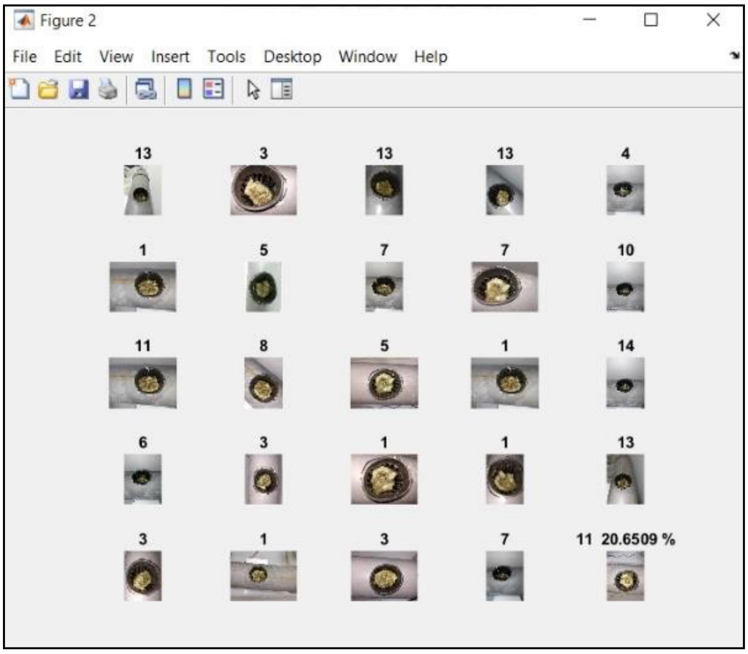


Fig. 12. Prediction based on random images selection in the training and validation accuracy

The images used to test are different from the images used to training and validation accuracy. It provesthat the deep learning architecture was successfully created and programmed in this section.

3.2.3 Growth-related traits based on ANN using DLA

The lettuce plant had been analysed through performs each parameter. The parameters mentioned in this project are pH level, temperature, and humidity. The pairs of parameters will include with the image features by design through MATLAB software. Figure 12 shows the estimating results of the growth-related traits based on ANN with one parameter controlled which is pH level and the other parameters are fixed such as temperature and humidity.

Based on the table below (at an appendix page 40), it shows the pH level range with temperature and humidity condition which have been fixed. The pH range can detect the growth of lettuce plant. It may also help to identify the accurate pH level range for the lettuce plant which was kept at indoor section. So, identify the accurate range of pH level, the lettuce plant must be kept indoor, and needs monitor every day. Based on the table the value 0 declare as no condition and value 1 declare as have condition. This table may help to do the comparison betweenthe lettuce plant growth for the pH level range shown.

Figure 13 shows the graph for ANN through the growth monitoring system.

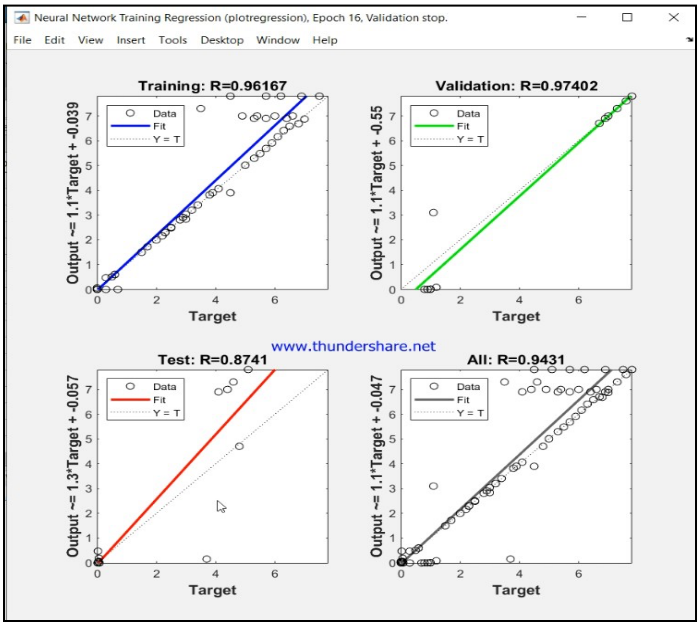


Fig. 13. Results of growth-related traits based on the ANN

It shows the estimation results for the growth-related traits based on the ANN model. The dashed line indicates the 1:1 line at the graph of ANN section.

3.3 Data Taken for the pH Level

The data was taken for 15 days and each pH level with the measurements of height for lettuce plant growth every day. There are six types of pH levels selected to monitor. Table 2 and Table 3 show the data for the urban farming growth monitoring system.

Table 2
Data for the urban farming growth monitoring system

Days	pH Level 4.5	5.5	6.5	7.5	8.5	9.5
	Plant Height (cm)					
1	0	0	0	0	0	0
2	0	0.01	0.01	0.01	0	0
3	0.02	0.05	0.08	0.06	0.04	0.03
4	0.3	0.5	0.7	0.6	0.6	0.3
5	0.9	1	1.2	1.1	1	0.8
6	1.5	2.3	2.5	2.2	2	1.7
7	2.3	3.4	3.8	3	2.8	2.5
8	2.9	3.9	4.5	3.5	3.2	3
9	3.7	4.8	5.1	4.6	4.4	4.1
10	4.1	5.3	5.7	5	4.9	4.5
11	5	5.9	6.2	5.7	5.4	5.3
12	5.5	6.5	6.9	6.3	6	5.7
13	6.1	7	7.5	6.8	6.6	6.4
14	6.7	7.6	7.8	7.3	7	6.9
15	7.2	8.1	8.5	8	7.7	7.3

Figure 14 shows the graph for six types of pH level height (cm) measurements.

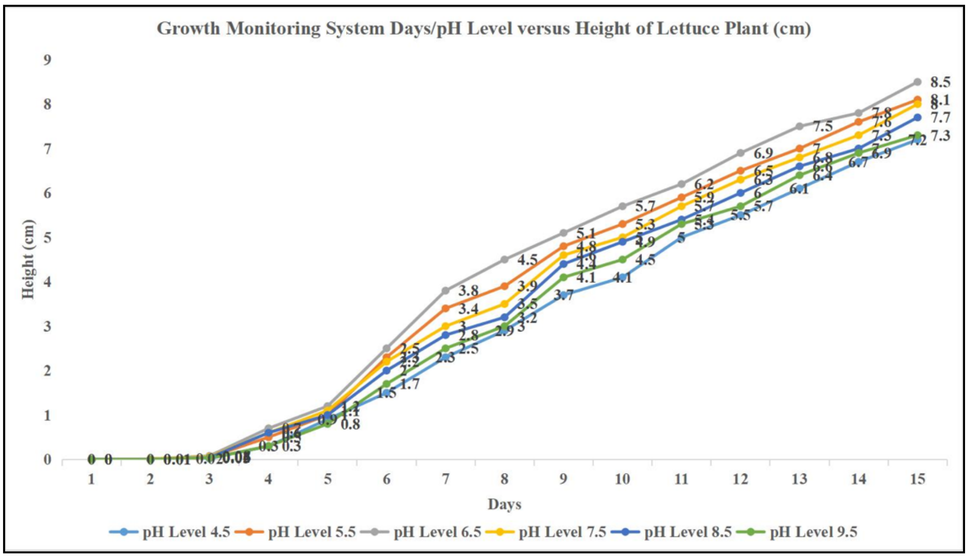


Fig. 14. Graph of lettuce plant height (cm) versus days for different pH levels

The value for pH levelis 4.5 until 9.5, the temperature is among 19°C to 33°C and the humidity are start from 65% to 85% for indoor lettuce plant growth.

Table 3
Growing lettuce with different pH level

pH Level	4.5 (Strong Acid)	5.5 (Medium Acid)	6.5 (Very Slightly Acid)	7.5 (Very Slightly Alkaline)	8.5 (Medium Alkaline)	9.5 (Strong Alkaline)
Results	Good, the leaves are open up	Better growth from 4.5 pH Level			Good, same as 4.5 pH Level	
	Leaves growth nice, Low pH level (Centre), Less roots, A little bit yellowish, feel smelly at the roots, 3/4 water level	Leaves growth nice, Normal pH Level (Centre), Less roots compared 8.5 pH Level, Healthy, White roots, 3/4 water level			Leaves growth nice, Higher pH Level (Centre), Roots white, Healthy, White roots, 3/4 water level	

The measurements of lettuce plant height were taken several times from early morning until midnight. The timing to measure height of lettuce plant are between 12am - 2am, 3am - 5am, 6am - 8am, 9am - 11am, 12pm - 2pm, 3pm - 5pm, 6pm - 8pm, and 9pm - 11pm. The temperature was changed based on the cold and hot surrounding air. At early morning, the temperature was between 19°C to 21°C. When the sun rises the temperature changed to 22°C to 25°C. The afternoon time around 12pm until 4pm the temperature increases to 26°C until 33°C. Then, at evening time above 6pm the temperature started to decrease between 26°C - 21°C. At nighttime, the temperature stick to 21°C - 19°C.

Based on the temperature value, the humidity has been declared. If the temperature was too high as 33°C means the humidity was shown less value as 65% to 70%. When the temperature of indoor section was too cold as 19°C means the humidity was increased among 78% until 85%. Either the indoor section temperature contained the same level of hot and cold surrounding meansthe humidity was between 71% until 77%.

4. Conclusions

The experimental data is about the development of an urban agriculture growth monitoring system using artificial neural network (ANN) and Internet of Things (IOT). This project is based on artificial intelligence (AI). This project has successfully achieved its goal. First, a deep learning architecture (DLA) using artificial neural networks (ANN) has been successfully developed to monitor the growth of indoor lettuce plants in urban agriculture. An inexpensive hydroponic growing system has been developed and then installed the ESP 32 CAM MB on that hardware project. The second goal of this project has been successfully achieved. Allows analysing lettuce plant growth images with height or parameters from available data. It can help to save available data to cloud storage (Google Drive), continue to acquire images, and transfer images to MATLAB software encoding systems using the Internet of Things (IOT). Also, the final goal is the evaluation part. This can help to evaluate the effect of growth when other parameters such as temperature and humidity are fixed and parameters such as pH are controlled.

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References

[1] Mustafa, Wan Azani, and Mohamed Mydin M. Abdul Kader. "Contrast enhancement based on fusion method: a review." In *Journal of Physics: Conference Series*, vol. 1019, no. 1, p. 012025. IOP Publishing, 2018. https://doi.org/10.1088/1742-6596/1019/1/012025

[2] Zhang, Lingxian, Zanyu Xu, Dan Xu, Juncheng Ma, Yingyi Chen, and Zetian Fu. "Growth monitoring of greenhouse lettuce based on a convolutional neural network." *Horticulture research* 7 (2020). https://doi.org/10.1038/s41438-020-00345-6

[3] Bryan, Njoroge Mungai, Ka Fei Thang, and Thiruchelvam Vinesh. "An Urban Based Smart IOT Farming System." In *IOP Conference Series: Earth and Environmental Science*, vol. 268, no. 1, p. 012038. IOP Publishing, 2019. https://doi.org/10.1088/1755-1315/268/1/012038

[4] Vijayakumar, N., and and R. Ramya. "The real time monitoring of water quality in IoT environment." In *2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS)*, pp. 1-5. IEEE, 2015. https://doi.org/10.1109/ICIIECS.2015.7193080

[5] Carrión, Gabriela, Mónica Huerta, and Boris Barzallo. "Monitoring and irrigation of an urban garden using IoT." In *2018 IEEE Colombian Conference on Communications and Computing (COLCOM)*, pp. 1-6. IEEE, 2018. https://doi.org/10.1109/ColComCon.2018.8466722

[6] Oh, A. S. "Smart urban farming service model with IoT based open platform." *Indones. J. Electr. Eng. Comput. Sci* 20, no. 1 (2020): 320-328. https://doi.org/10.11591/ijeecs.v20.i1.pp320-328

[7] Madushanki, AA Raneesha, Malka N. Halgamuge, WAH Surangi Wirasagoda, and Ali Syed. "Adoption of the Internet of Things (IoT) in agriculture and smart farming towards urban greening: A review." *International Journal of Advanced Computer Science and Applications* 10, no. 4 (2019): 11-28. https://doi.org/10.14569/IJACSA.2019.0100402

[8] Balakrishna, G., and Moparthi Nageshwara Rao. "Study report on using IoT agriculture farm monitoring." In *Innovations in Computer Science and Engineering: Proceedings of the Sixth ICICSE 2018*, pp. 483-491. Springer Singapore, 2019. https://doi.org/10.1007/978-981-13-7082-3_55

[9] Chaaro, Lina, and Laura Martínez Antón. "Crop and weed detection using image processing and deep learning techniques." (2020).

[10] Mansor, Muhammad Naufal, Syahrull Hi-Fi Syam, and Muhammad Nazri Rejab. "Pain assessment using neural network classifier." In *2012 International Symposium on Instrumentation & Measurement, Sensor Network and Automation (IMSNA)*, vol. 2, pp. 377-379. IEEE, 2012.

[11] Junoh, Ahmad Kadri, and Muhammad Naufal Mansor. "A Comprehensive Study of Crime Detection with PCA and Different Neural Network Approach." In *Advances in Information Systems and Technologies*, pp. 611-618. Springer Berlin Heidelberg, 2013. https://doi.org/10.1007/978-3-642-36981-0_56

[12] Mustafa, Wan Azani, Mohamed Mydin M. Abdul Kader, and Zahereel Ishwar Abdul Khalib. "Improved wolf algorithm on document images detection using optimum mean technique." *Bulletin of Electrical Engineering and Informatics* 8, no. 2 (2019): 551-557. https://doi.org/10.11591/eei.v8i2.1426

[13] Kader, MM MA, Z. B. Razali, W. A. Mustafa, S. A. Saidi, AA Nagoor Gunny, S. Setumin, M. K. Osman *et al.,* "Automotive mechanical vehicle starter." In *Journal of Physics: Conference Series*, vol. 2107, no. 1, p. 012021. IOP Publishing, 2021. https://doi.org/10.1088/1742-6596/2107/1/012021

[14] Mustafa, Wan Azani, and Mohamed Mydin M. Abdul Kader. "Document Image Database (2009-2012): A Systematic Review." In *Journal of Physics: Conference Series*, vol. 1019, no. 1, p. 012024. IOP Publishing, 2018. https://doi.org/10.1088/1742-6596/1019/1/012024

[15] Wan Mustafa, Wan Azani, Haniza Yazid, and Mohamed Mydin M. Abdul Kader. "Luminosity correction using statistical features on retinal images." *Journal of Biomimetics, Biomaterials and Biomedical Engineering* 37 (2018): 74-84. https://doi.org/10.4028/www.scientific.net/JBBBE.37.74

[16] Kader, Mohamed Mydin M. Abdul, Wan Azani Mustafa, Zol Bahri Razali, Syahrul Affandi Saidi, Ahmad Anas Nagoor Gunny, Muhammad Firdaus Akbar, Muhammad Khusairi Osman *et al.,* "Renewable energy driven exhaust fan for use in laboratory via IOT." In *2021 International Conference on Technology and Policy in Energy and Electric Power (ICT-PEP)*, pp. 208-212. IEEE, 2021. https://doi.org/10.1109/ICT-PEP53949.2021.9600969

[17] Kader, Mohamed Mydin M. Abdul, Zol Bahri Razali, Wan Azani Mustafa, Muhammad Naufal Mansor, Ahmad Anas Nagoor Gunny, Muhammad Firdaus Akbar, Muhammad Khusairi Osman *et al.,* "Development of a Multi-Fan System (MFS) in a Plant Factory with Artificial Light." In *2022 IEEE International Conference on Power and Energy (PECon)*, pp. 269-274. IEEE, 2022.

[18] Kader, M. M. A., Z. B. Razali, N. S. M. Yasin, and M. H. Daud. "Formation of Maximum Eddy Current Force by Non Ferrous Materials." In *IOP Conference Series: Materials Science and Engineering*, vol. 318, no. 1, p. 012055. IOP Publishing, 2018. https://doi.org/10.1088/1757-899X/318/1/012055

[19] Kader, M. M. M. A., Z. B. Razali, S. K. W. Hwooi, and M. H. Daud. "Analysis on the fundamental of engineering mechanics for sorting multi-materials robotic arm." In *AIP Conference Proceedings*, vol. 2030, no. 1. AIP Publishing, 2018. https://doi.org/10.1063/1.5066770

[20] Aihsan, M. Z., N. Kimpol, Liew Hui Fang, M. I. Fahmi, W. A. Mustafa, J. A. M. Jobran, and M. M. A. Kader. "Solar powered multiple output buck converter." In *IOP Conference Series: Materials Science and Engineering*, vol. 932, no. 1, p. 012075. IOP Publishing, 2020. https://doi.org/10.1088/1757-899X/932/1/012075