Analytical Study on IoT and Machine Learning based Grading and Sorting System for Fruits

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***Abstract* - In this age of modern farming, it is very important to grow in terms of quality practice and the number of products offered. As in India, many people depend on growing crops and fruits. When it comes to counting and sorting fruits and vegetables by hand it takes a much higher amount of remuneration to pay the workers and they will not be able to get a good result. So, to overcome this problem of farmers and strengthen them with a low-cost savings plan this is the IoT and Machine Learning priority and fruit planning. In this research machine learning is used to detect the fruit phase and the recording process, the IoT camera is used with the microcontroller module which will be available to connect to coding and show computer usage.**

Keyword*: *Machine Learning, Internet of things (IOT), image processing, grading, sorting.

I. INTRODUCTION

The traditional method of sorting vegetables and fruits requires a lot of work so the farmer has to use a lot of remuneration to do this work. This hands-on process is a major challenge for those who do not support the trust of others with their work and choose to make a living from their work. Sometimes further misconduct occurs in the process of downgrading and evaluation due to the lack of vigilance of employees who have to perform the task carefully.

In this case, the automated fruit planning and filtration system using IoT and machine learning are proposed to enable farmers to do their job face-to-face with effort with minimal investment and productivity and direct results compared to manual labor. In this work fruit sorting and grading can be done, and this will help all farmers to shorten their burden and save their paid remuneration for manual labor. Automatic fruit filtering is the latest and most effective method of modern agriculture. To carry out this research development of fruit planning and filtering systems with the help of machine learning technologies (CNN, ANN, SVM, and YoLo) which are considered in a comprehensive analysis of the techniques or algorithms accessible to obtain as well as extract the quality of the fruit with the help of many fruit attributes.

The main hardware required for this proposed system is the microcontroller which is the main control system where all the algorithms and structure will be stored. This will provide general instructions for other sensors. A powerful microcontroller that is widely used for better performance and results.

II. LITERATURE REVIEW

This section describes the work carried out by the researchers in the related areas.

M. Nikitha, S. Roopa Sri, B. In Maheshwari et al., [1] (2019), In this paper the author proposed a system for the acquisition and extraction of fruits using transfer learning and identification from low color perceptions to provide a percentage of fruit acquisition and scanned images, this can be used by farmers to reduce labor capacity and maintain the new quality of the product offered.

Mayar Haggag, Samama Abdelhay et al., [2] (2019), In the proposed system fruiting and visualization using machine learning and artificial visual aids (AI), a hybrid algorithm is used here to obtain 100% accuracy by accumulating i -RGB and Gray-scale predicated CNN networks. In-depth reading is used to improve the accuracy of regression. This will improve the expected result in the system.

Mayar Haggag, Samama Abdelhay, et al., [3] (2019) In this paper, the author introduces a system in which three functions are defined, in which the fruit can be identified by color, size, and shape and this determines whether the fruit is ripe, immature, and defective. In this convolution neural network (CNN) network, the artificial neural network (ANN), the study of vector quantization (LVQ), is used to determine the regression of automatic tomato arranging controllers. Vector Machine Support Machine (SVM), to develop, expand and compare sectors. This system can reduce the accuracy of fruits and vegetables.

H. Chopra et al., [4] (2021), The physical separation of ripe fruit is costly in agricultural production and mortal fault can lead to negative consequences. This paper provides an overview of intelligent AI-based programming with the help of spectrophotometry as well as the computer-based concept of automatically distinguishing fruits based on the grade of the fruits. When the fruit is included in the recommended program, the fruit is seen at 95% accuracy, with the help of a cloud-based platform which is provided by Microsoft Azure. Then, with the help of integrated viewing methods as well as mechanical integration, the fruit distance is predicted. With the help of H2O, it does not drive. AI, the proposed collection provides a value of 82% reinforcement. The model is also analyzed on

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hidden test databases including actual values of spectral as well as the accuracy of fruit classification in various categories up to 72%.

S. Naik et al., [5] (2017), With the help of mechanical as well as testing gets produced on the basis of the research done on local photography or on the use as well as evaluation of visual images. A complete summary of the fruit and grading method is described in this paper. A detailed test of every step was performed. Other extraction methods such as "Speeded Up Robust Features (SURF)", "Histogram of Oriented Gradient (HOG)" and "Local Binary Pattern (LBP)" are studied in general fruit characteristics for example color, size, shape as well as texture. There are ongoing discussions of machine learning algorithms such as (KNN), Support Vector Machine (SVM), Artificial Neural Networks (ANN), and Convolutional Neural Networks (CNN). Procedures, benefits, disadvantages, challenges in reducing reductions, and setting the topics discussed in this paper, can provide guidance for researchers.

A. Awate et al., [6] (2015), Nowadays as there is a definite need for the agricultural sector, effective growth, and improved fruit production are vital. For this purpose, farmers need the physical labor of fruit from harvest to the time of development. But manual monitoring will not always provide satisfactory results and they always need satisfactory advice from experts. It, therefore, needs to propose an effective farming system that will help in better access and growth through minimal human effort. The authors introduce a process that will diagnose and differentiate external diseases within the fruit. The traditional system uses thousands of words that lead to the language border. While the system authors have found uses image processing methods to act as an image it is the easiest way to transfer. In the proposed project, the OpenCV library is used for implementation. The K-means clustering method is implemented for image classification, images are catalogs as well as categorized into their disease categories on the basis of the four genetic factors: color, morphology, texture, and shape of the fruit in the fruit. The program uses two photo captions, one to use question images and the other to photograph the stored disease pictures. The concept of Artificial Neural Network (ANN) is used to match pattern and disease classification.

A. Chandini and U. Maheswari B et al., [7] (2018), Eating healthy fruits and vegetables is important as it is a source of energy for all living things. There is a growing demand for quality in all processed food items. Nowadays, from consumers, retailers to food companies test food on the basis of your quality. This handicraft is more time-consuming and tedious. Therefore, there is a need for an automated process that quickly detects, defects, and filters them according to quality. There are factors like temperature, humidity that affects the quality of the fruit. In this work, the authors put in place a reliable way to diagnose fruit defects. The main purpose of this work is to identify and classify the lowest and best fruits. It is obtained through combination.

H. M. T. Abbas et al., [8] (2019), Demand for the excellent quality of the fruit is growing as the population grows. The GDP of various nations depends on fruit exports. Current acquisition and filter systems have low productivity, are time-consuming, have a high cost, and have problems. The Machine fruit filtration uses image processing to generate high-quality fruit filters, high-quality production. This is necessary for control of the machine and fast-tracking and quality systems as well as rapid fruit distribution. A complete analysis of the present work correlated to automatic filtering and sorting of agricultural products is described in this published paper. A comprehensive end-to-end system for fruit sorting and sorting on the basis of image processing. The performance of the proposed structure is indicated by the starting test outcomes.

Seema et al., [9] (2015), Fruit Grading is a very essential procedure that impacts on quality of the fruit's estimation. Nowadays, there is a requirement for an automatic fruit grading method that's why authors were built a variety of fruit filtration algorithms with the help of computerized imaging. With the help of color, textural, and morphological features researchers found the disease, maturity, and fruit phase. Image processing is used in farming has been used to give insight into the use of a theory-based system to highlight their advantage as well as disadvantage.

R. Pourdarbani et al., [10] (2015), In the text of the proposed program developed, machine-based concept, online filtering system, the main objective is to filter the Date fruits based on various phases of ripening, namely Khalal, Rotab, and Tamar to reach the needs of customers. This procedure includes a transmission unit, light and recording unit, as well as a filter unit. The Physical, as well as mechanical characteristics, are removed from the models given, as well as the detection algorithm is properly created. The color-based file is defined to obtain samples of date. The dates were placed on the conveyor belt in succession. When the date fruit was in the center of the camera, a photo is captured, the photo was taken instantly as well as the maturity phase of the dates was established. When the dates transmit the sensor, placed at the end of the conveyor belt, the indication is delivered to the path of the visual connector, and the appropriate actuator, driven by the car ladder, operates, leading to the Date in the appropriate port. To ensure the effectiveness of the proposed system, all samples were professionally sorted by appearance. Tamar and Khalal's acquisition rates are acceptable. Though the detection rate is not sufficient at the Rotab stage, there was no considerable difference between the correctness of the system as well as finding of experts.

Krithika J. et al., [11] (2018), This paper highlights the progress done in agricultural science. Nowadays, Digital image processing methods are broadly used to measure fruit ripening. The Proposed system aims to study and examine different algorithms as well as techniques of extraction currently utilized for the extraction characteristics in digital photographic pictures. Therefore, this is essential for providers to put a label on the quality of the fruits. In this research paper, the author evaluates the quality of the fruits by their size, shape, color as well as weight. Every algorithm is executed with the help of the RASPBERRY PI board that will be an individual and costly procedure. Every assembling of parts will be done as well as will form a useful embedded system for size, shape, and color

determination of the fruit. A similar program was able to use for other fruits as well. The good, as well as the bad of the separated dividers, are divided. It is noted that in order to achieve maximum accuracy an agreement must be reached for high computer computing.

Khatun et al., [12] (2020), Automatic fruit classification is a popular computer vision system. Traditional methods of fruit separation often rely on manual labor in terms of visual acuity and such methods are tedious, time-consuming, and inconsistent. The appearance of external appearance is the main source of fruit separation. Nowadays, computer technology, as well as image processing methods, has become very helpful in fruit production, mainly in utilizes in quality and color testing, size, screening. Researchers in the area show whether it is possible to use the systems of machine vision to enhance the quality of the product while liberating persons from conventional fruit processing. This paper deals with various image processing techniques used for fruit classification.

M. Pushpavalli [13] (2019), Agriculture plays a major role in the economic growth of India. As there is a great need for quality fruit in the process of fruit processing in the market is considered very important. Man-made fruit can cause malfunction and can also lead to some errors. Another problem is working too hard to solve the above problems the agricultural industry brings many automated measurement systems. In this paper, the idea was presented to get quality fruit by looking at its color, proportion its size, and weight. Due to cost and incorrect process, filtering tons of quality fruit to produce fruit products made from the fruit is another problem facing many in agriculture industries. Here the filtering process is introduced when the image of the fruit is captured and analyzed using image processing Defective techniques and fruits are discarded by this process. The aim of this proposed paper is to make a quality check for fruit in a short time.

Yudong Zhang et al., [14] (2012), In this study, the authors proposed a different classification technique based on the kernel support vector (kSVM) machine with the desired aim of precise as well as speedy classification of fruit. Initially, the images of the fruit were captured with the help of the digital camera, and then the background of each image was detached with separation as well as merging algorithm; Next, a histogram of color, texture as well as shape features of each image of fruit was removed to create a feature area; Then, The Principal Component Analysis (PCA) was used to decrease the size of the feature area; Finally, three types of multi-phase SVMs were developed, namely, Winner-Takes-All SVM, Max-Wins-Voting SVM as well as Directed Acyclic Graph SVM. During that time, three types of kernels were selected, namely, linear kernel, Homogeneous Polynomial kernel, and Gaussian Radial Basis kernel; lastly, SVMs are trained with the help of 5 times cross-validation and vector-reduced feature as an input. The result of the test showed that Max-Wins-Voting SVM with Gaussian Radial Basis kernel execute an excellent phase accuracy of 88.2%. At the time of calculation, Directed Acyclic Graph SVMs performed very quickly.

F. Femling et al., [15] (2018), This paper explains how to create a fruit and vegetable identification program on the market of selling using pictures taken through a video camera connected to the system. This program support clients to list the fruits as well as vegetables they want at an amount based on their weight. The aim of the program is to reduce the amount of human and computer interactions, increase the procedure of identification as well as expand the usableness of the graphical user interface differentiate with present manual systems. The system components are made up of Raspberry Pi, a camera, a display, a loading cell, and a case. To object separation, various convolutional neural networks were tested as well as re-trained. Performance testing, heuristic testing was executed with some users, concluding that the system used was relatively easy to use compared to existing systems.

S. Lu, et al., [16] (2018), Automatic fruit classification is a very tough problem because there are different types of fruit and so many similarities in categories. In this paper, the author proposes to use the convolutional neural network (CNN) for fruit division. the author designed CNN with six layers that include convolution layers, integration layers, and fully integrated layers. Test results suggested that their method achieved promising performance with 91.44% accuracy, better than three standard methods: voting-based vector, wavelet entropy, and genetic algorithm.

Risdin, et al., [17] (2020), In this paper, the author introduced a good way to get fruit using convolutional neural networks. The goal is to construct an exact, quick as well as consistent fruit identification system with the help of machine learning facts. The proposed system utilized a convolutional neural network (CNN) for fruit imaging activities. Due to the wide variety of fruit types, finding fruit images is often very difficult. However, in-depth reading shown recently is a very powerful way to get a picture, and CNN is a modern way of deep learning. A database containing the most common fruit in the public fruit cutting system was created, and it was used to test the effectiveness of the acquisition. CNN has shown higher accuracy than vector-based methods with hand-crafted features. In order to get an image of fruits, CNN as well presented a high accuracy compared to the standard process. Otherwise, this method is too fast to deliver fresh fruit. In this study, the model is re-trained to obtain four fruits depending on a new database containing 2403 data comprising 4 classes of the fruit. Every data present in the dataset is composed with the help of the camera of the smartphone as well as is supposed to be single in all ways. The paper showed 99.89% accuracy which proved to be promising. In addition, the study was conducted on the basis of real-life conditions, and the results were not marked. The desire of this work is to cover the program to other things as well as applications for actual life.

Behera et al., [18] (2020), Fruit recognition and variety is important part of the research. This research is valuable in observing as well as classifying fruits by species of the fruits with the certainty of a quick manufacture chain. In this paper, the author has developed a new high-quality database of images comprising five of the very common egg-shaped variety of fruits. Current work on deep neural networks has directed the growth of various new accurate agricultural-related applications, as well as fruit recognition. This study proposed a

separation model of 40 Indian fruit types with a vector support (SVM) machine using in-depth features removed from a completely integrated layer of the convolutional neural network (CNN) model. Similarly, other methods depending on assignment studies are proposed to recognize Indian Fruits. The test was performed on six powerful learning platforms like AlexNet, GoogleNet, ResNet-50, ResNet-18, VGGNet-16, and VGGNet-19. Therefore, six in-depth study structures are assessed in two ways, making a total division model of 12. The classification of model performance is evaluated in terms of accuracy, sensitivity, false rating (FPR), F1 score, Mathew's relationship (MCC), and Kappa. Test outcomes display that an SVM separator that uses an in-depth reading feature offers the best outcomes compared with its transmission complement. The in-depth learning feature of VGG16 and SVM results in 100% accuracy, sensitivity, clarity, accuracy, F1 score, and MCC at the maximum level.

Pallavi U Patil et al., [19] (2021), In this paper, authors developed grading and filtering techniques for dragon fruit using machine learning algorithms based on detailed reviews of available techniques or algorithms to determine and categorize fruit quality using different fruit and vegetable features. The functionality of these algorithms is based on, shape, size, weight, color, and dragon fruit diseases. The performance of Raspberry calculates the total amount of fruit found in a fruit basket and these are categorized by their ripening level using machine learning algorithms.

III. IMPROVEMENTS IN EXISTING METHODOLOGY

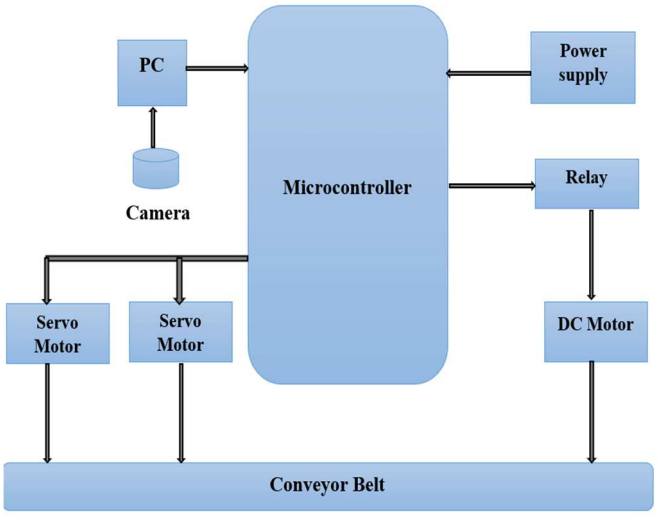

Fig. 1. Hardware Model

As shown in the above diagram of hardware system with conveyor belt, microcontroller, camera module, Relay, DC motor, and servo motor is used where the entire fruit sorting and grading process can be done using the Machine Learning Technique and Internet of Things (IoT).

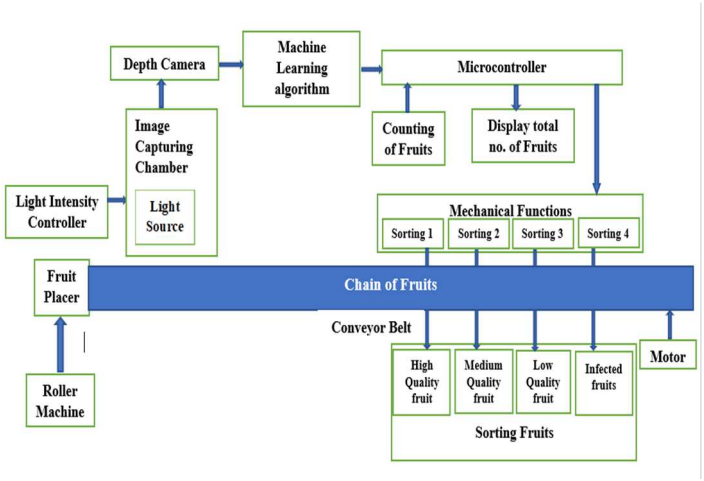

Fig. 2. System Architecture of IOT and Machine Learning based grading and sorting system for fruits

The program steps will be as follows:

Step 1: First the fruit is placed on a moving belt placed directly in front of the camera module.

Step 2: Then the process of identifying the fruit by extracting its size and shape and color will be determined by the distinct classification of the fruit. All of these tasks are performed using machine learning technologies (CNN, ANN, SVM, and YoLo) algorithms.

Step 3: After processing the first and second steps, the fruit will be reduced to a basket in each category, and the findings found in the process are made in step 2.

All three of these steps will work indefinitely until all the fruit is sorted and placed on a conveyor belt.

IV. ANALYTICAL RESULT

Analytical results of the accuracy of an algorithm of the literature review described above have been tabulated in Table I.

TABLE I. Algorithms and Accuracy

Algorithm	Accuracy
CNN	90.00%
SVM	80.00%
KNN	82.00%

Fig. 3. Different algorithms and their Accuracy

CNN algorithm gives an accuracy of 90%, whereas the SVM algorithm gives an accuracy of 80% and the KNN algorithm gives an accuracy of 82%.

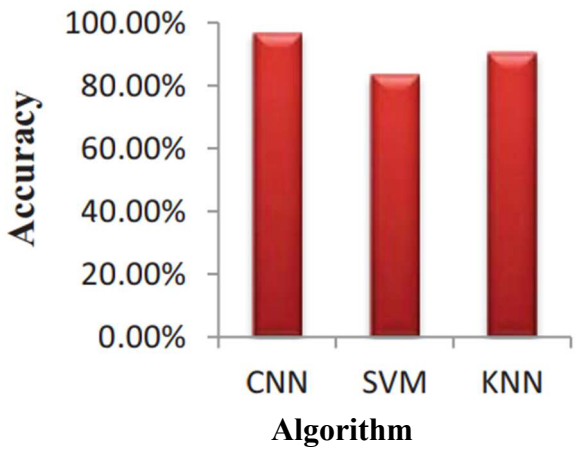

Fig. 4. Analytical Results of Different Algorithm.

Analytical results of the accuracy of the Architecture of the literature review described above have been tabulated in Table II.

TABLE II. Architectures and Accuracy

Architecture	Accuracy
AlexNet	92.60%
GoogleNet	80.00%
ResNet-50	87.59%
ResNet-18	82.37%
VGGNet-16	97.34%
VGGNet-19	87.48%

Fig. 5. Different Architectures and their Accuracy

AlexNet gives an accuracy of 97.60%, whereas GoogleNet gives an accuracy of 97.37%, ResNet-50 gives an accuracy of 97.59%, ResNet-18 gives an accuracy of 97.37%, VGGNet-16 gives an accuracy of 97.34% and VGGNet-19 gives an accuracy of 97.48%.

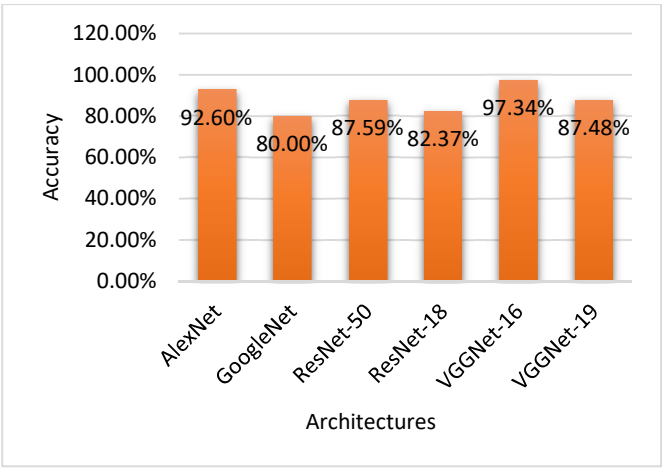

Fig. 6. Analytical Results of Different Architectures

V. CONCLUSION

The traditional method of grading and sorting of fruits requires a lot of work so the farmer has to use a lot of money to do this work. This method is very difficult for the farmers who are not able to a pay high amount of money. That's why an Automatic Grading and Sorting of Fruits based on Machine learning algorithms could be of immense use in this field of research. There are many machine learning algorithms such as Artificial Neural Network (ANN), Support Vector Machine (SVM), Convolutional Neural Networks (CNN) as well as YoLo algorithms that have been discussed in the literature. The existing researches show to discuss the process through which it will identify and classify fruits with the help of fruit features. From these researches, we have observed that the different algorithm performs with different accuracy at a given dataset. Like, the CNN algorithm gives an accuracy of 90%, whereas the SVM algorithm gives an accuracy of 80% and the KNN algorithm gives an accuracy of 82%.

From the study, we observed that machine learning has performed really well in the field of grading and sorting of fruits. But, the implementation of such a system in the real field may not result in the same manner. Thus, we feel that if the machine learning based approach is coupled with IoT it may make the system more reliable and accurate in the real time environment as well. Hence in this paper, we also discussed a brief idea about the system involving IoT and Machine learning working together.

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