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Development of Machine Learning Based Grain Classification and Sorting with Machine Vision Approach for Eco-Friendly Environment

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Abstract

Grains are the consumed food in the world. The local shopkeepers divide the grains by its quality. In the first class quality, grains do not contain unwanted things in it. But it is too costly. So, the local shopkeepers buy the grains of second-class quality and remove the unwanted materials with the help of labors. Human may make mistake in sorting and they also feel tired when they do the same work regularly. This project will reduce the human work by checking its quality and sorting automatically with Eco-Friendly Environment. Here, initially it checks the quality of the grains by image processing and type of grains is detected by machine learning algorithm are proposed in this paper. First step is acquisition of grain image, segmentation, extraction of features. Then the features of grains are given to the CNN classifier for classification and identification of grains type. Different threshold air pressure is required for different types of grains to blow way unwanted grains. The result achieved through neural network will determine

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threshold pressure of air flow for that particular grain type. When grains comes out through Chute at that instant of time unwanted materials like grains with black skin and over roasted grains are identified by doing image processing using Jetson Nano with camera module. It then removes the unwanted materials by using air blow mechanism where air pressure is determined by CNN. The waste particles in the grains like chickpeas, bengal roasted gram, moong dal, kala chana, etc., and also can be identified and segregated.

Keywords: Conventional Neural Network, Machine Learning, Grain sample, Sorting, Quality.

1 Introduction

The retail shop aims to sell the high quality grain. Within the scope of the quality assurance, it is necessary to remove contaminants and eliminate extraneous materials [1]. Grain sorting is the removal of the contaminants such as stone and impurities from the grains. There are more drawbacks in the existing methods. Majority of the local stores have separate labors for sorting the grains. With the help of size and colour, labors are sorting the grains with Eco-Friendly Environment [2]. More time is required for humans for sorting the grains. Manual sorting is difficult if the quantity of the grains is more. They also feel tired when they do the same work regularly. Manual sorting requires more space and the cost of the labor is also high. Manual sorting is shown in the Figure 1. They also cannot sort the grains accurately. So we are going for machineries. Large scale industries are using colour sorter for removing unwanted materials in grains [3]. A colour sorter is a machine that is used in food processing for bulk quantity in production [4]. The items are separated by its colours, detecting the colours of items, and falling of colours within the acceptable range is not easy or separation of desired group in the rest are diverted by the use of pneumatic or mechanical ejection devices. This machine is currently used for sorting the high quantity grains. And also, it is too costly. So, we are going for automatic grain sorting system. Chute-type color sorter works with the principle of gravity. As it is working with this principle, it has less friction with the material dealt with it. So the power consumption is minimal.

Figure 1 Manual Sorting

Initially the grains are collected into the carrier container. The grains are allowed to fall down on the vibrator which helps in preventing the clustering of grains. The vibrator is followed by separator. The grains get separated in the separator with the means of the splitter provided. The schematic structure is shown in Figure 2. The camera is fixed at the opposite side of the splitter to capture the grains which are falling down from the splitter.

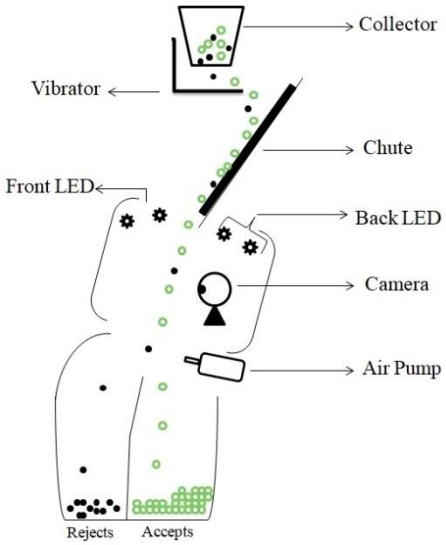

Figure 2 Manual Sorting

The capturing is done by the camera for the continuous period of time. When the unwanted materials are detected, blower motor will be turned on and it blows the waste particles. The remaining good grains are collected in the collector [5]; the collected grains are then packed. Here the waste particles are degradable so it does not pollute our Environment. So that waste can be used as a fertilizer in agriculture field for Eco-Friendly Environment.

2 Literature Review

Kolkure V.S. et al. [6] presented an automatic method for evaluating rice granular quality by analysis the morphology of the rice through neural networks .The image of the rice is captured through digital camera then the RBG image in converted to the grey scale image for image processing. The extraction of the morphological features such as minor and major axis length, color from the segmented binary image was done .The segmentation used for the region orientation is watershed segmentation. The neural network used was SVM or PNN algorithms will match the feeded pattern to different number of classification .In testing phase feature of the imaged were classified based on the space partitions. The shortest distance between the testing image and trained image were computed to find the accuracy.

Zhuo Chen et al. [7] suggested the impact of the label granularity over the classification of feeded input samples based on CNN with Eco-Friendly Environment. The advantages over the coarse grain label to the fine grain label image classification has improves the generalization capabilities which increases the accuracy of classification and the optimization of network .The result achieved through the image classification on the coarse grain label with full training dataset will be less efficient than compared through the training dataset of 40% with the fine grain label. The improvement achieved will vary differently from dataset to dataset which can be calculated by a metric called Average Confusion Ratio .Thus with less human resources and less testing dataset of fine grain label .Thus we can achieve the greater efficiency of classification of image using convolution neural network

Smita shelke et al. [8] proposed an automatic grading machine. The concept of the machine identified the material based on the colour, size, and shape along with the moisture content. This technique helps in grading of food particles especially which is exported. The technique used is color spectrum identification with the help of numerous color sensor which is used for analyzing the several parameters such as size of the food items, the license registers number of food particles. By using the photo sensor and RGB color of the light thus the material can be detected. The advantage is that it can handle hot material, fragile materials that may not undergo degradation with additional features such as heating, drying, pooling.

Timothy henry et al. [9] developed an optical sorting machine based on color sensor value. The materials will be accelerated through conveyor from the hopper to the color sensing unit. By detecting and processing the signal from the color sensor which is mounted on chute for easy step. When color matches solenoid valve will be activated for predetermined period, grains were blow and the valve will closed. The efficiency of the machine are 67.41% for recovery and 85.07% for removal.

3 Proposed Work

3.1 Materials Used

- Jetson Nano.
- USB Camera.
- Vibrator.
- LED.
- Air Pump.
- Power Supply

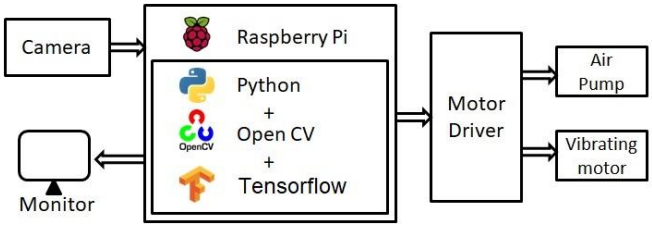

Figure 3 Block Diagram

DC 5V is given Jetson Nano board with 2.5A current rate and 12V/1A is given to the vibration and Air blow mechanism. The program is stored in SD card. OpenCV and Transorflow are installed in the Jetson Nano board for image processing [10]. Universal Serial Bus Camera is integrated with the Jetson Nano to get photos of the grains. When the Jetson Nano board is turned ON, USB camera and vibration motor will turned ON. Motor driver L293D IC is used for interfacing the Air blower [11] and vibrator with Jetson Nano. Once the impurities is detected then the motor driver is goes to logical high state by GPIO pin in Jetson Nano board and make the impurities to blow to waste box by air pump. The proposed diagram in Figure 3 is the block explanation of the project .

3.2 Conventional Neural Networks

A CNN contains of a sequence of convolutional layer along with max-pooling layers, activation layer and each layer has connected with its previous layer. Figure 4 represents the design of CNN model.Hierarchical extractor for feature which will match the feeded image pixels into the feature in terms of vector. In the next step the classification of fully connected layers.

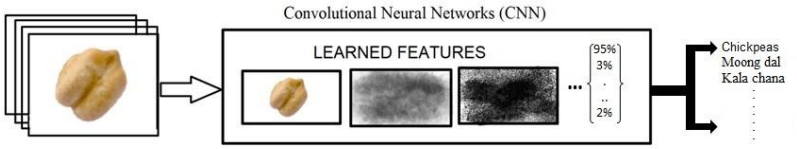

Figure 4 CNN Architecture

All modifiable parameters are enhanced by minimizing the misclassification by declining an error in the training dataset. Each layer of CNN performs a two dimensional convolution of its feeded data is mapped with a filter of different size 3 x 3, 5 x 5, 7 x 7.The suivant activations of the outcome mapping is given by an average of previous convolutional responses gone into an a activation function of non-linearity. Max pooling layer performed the reduction of dimensionality. The outcome of a thin layer is given by over non-covering areas of rectangular. Max-pooling makes invariance of location and samples are downed the image pixel along every orientation over larger surrounding. Filter size of convolutional layer with max pooling convolutional layers are chosen in such a way that entirely connected layer would integrate the output into a vector of single dimension. The final layer will entirely connected layer which contains single output unit in all type of class. Here rectification linear unit would be used for function of activation. Stochastic slope will be used to train the data to the machine along with negative similarly criterion as function for loss.

3.3 Deep Learning Libraries and Frameworks

3.3.1 Tensorflow

TensorFlow is an machine intelligence library platform in open-source uses an data flow structures for numerical computation. TensorFlow was created and managed by the Google Brain team within Google's Machine Intelligence research organization for Deep Learning. TensorFlow is designed for training and testing inference in large-scale. Combining the nodes graphically represent an operation like maths. While the graph edges shows the multidimensional dataset arrays would be communicated between the nodes. The TensorFlow architecture consists of kernel implementations with the distributed master services. The standard operations such as mathematical functions, array manipulation, flow of control and state management operations are usually done in C++ language. Tensorflow can be run on Central Processing Unit systems , mobile devices and on hundreds of nodes of large-scale distributed systems.

3.3.2 Keras

Keras runs on framework named TensorFlow which is an library of Neural Network programmed on Python language. It is designed in the way of easy way to use as an module. Low-level computation of datasets is difficult in Keras. Keras is high-level Application Programming Interface wrapper for the low-level Application Programming Interface, efficient to run TensorFlow or Theano . Keras High-Level Application Programming Interface handles the way for defining models and layers and to set multiple input and output model. Keras uses loss and optimizer functions for compiles model, and fit function for training datasets.

3.3.3 Theano

Theano is frameworks programmed with Python library. Theano helps end users to determine, optimize, and appraise deep learning models efficiently. Thanos is combined with NumPy module for numerical libraries programmed in Python language and helps effective differentiation symbolic. The computer algebra system is provided by source which designed Theano with an optimizing compiler. Thus, basic C codes for major mathematical function can be auto generated in Theano to easily perform complex mathematical computation.

3.3.4 Flow Chart of Image Classification

The working process of image classification based on the CNN is shown on the Figure 5. Object detection algorithms typically use extracted features and learning algorithms to recognize instances of an object category. It is commonly used in applications such as classification of images with localization, object segmentation and object detection.

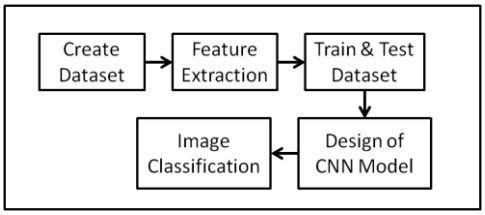

Figure 5 Flow chart of Image Classification

3.4 Training the Networks

The Network must be defined with all required parameters for the application of object detection; the network is ready for training. The training

algorithm for network is classical stochastic slope descent algorithm .After every iteration, the network will train by decline the error rate. The loop of iteration of dataset training will end when the error rate reaches a minimum value of 0.02. The recording of every single object weight value is made as an backup file.

3.5 Testing the Networks

The weight of the pre-trained value for the testing phase will be obtained from the training phase. The feeded datasets parameters were detected by passing the datasets through all layers of network. These weight values are cross verified along with the pretrained weight value and detect an one which provides the highest matching with the classes.

3.6 Image Processing

Initially camera gets ON then starts capturing the video. The camera captures the image for the continuous period of time. The captured video is converted into fixed resolution of 720x720. Captured video is in the format of BGR that have separate 0-255 value to indicate a pixel colour Figure 6.A. BGR is converted into gray scale video. In Gray scale, three values are converted into a single 0-255. Here 0 indicate White colour and 255 indicate Black colour Figure 6.B. Gray scale video is helpful to select the threshold value of grains while conversion of binary video.

$$g(a,b)=\begin{cases} 1 & if\ f(a,b) \geq T \\ 0 & otherwise \end{cases} \quad (1)$$

This gray colour is again converted into binary format. In this format it indicate gray image into black and white video format (logic 0 and logic 1). Here f(a,b) is the grayscale pixel value at (a,b)and g(a,b) is the threshold pixel value at (a,b).

If the intensity of the image is lesser than some fixed constant value or if image intensity is larger than that constant, the image will be converted into a black and white image. In this project light colour is presented back side of the screen, so processor can easily identify the impurities colour.

For testing purpose, we have used chickpeas and detected the impurity in it. Figure 6.C indicates the dark coloured impurity in the chickpeas is getting detected and eliminating the other objects. The gray image that was captured is then converted into binary image format. The Binary image format is then inverted to detect the dark colour easily. After inversion, the

light colour is detected as a black colour and dark colour is detected as a white colour.

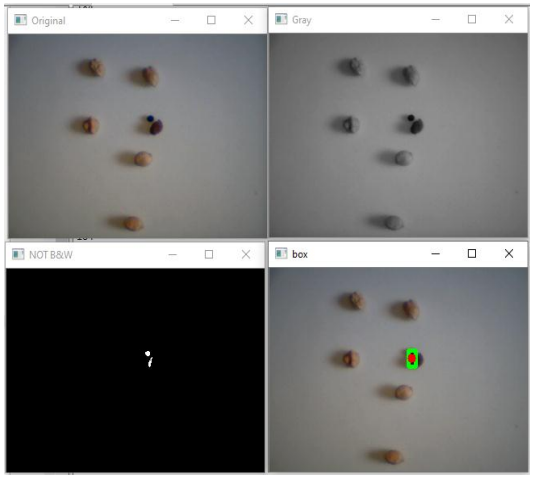

Figure 6 Simulation output A) Original image captured by camera. B) Gray scale image. C) Inverted Binarized Image. D) Boundary boxed

The boundary box shows the position of the impurities. Since the impurities are viewed as white colour, we can easily draw the boundary in the live video. The boundary box is shown in Figure 6.D.

Rectangle = cv2.rectangle (Bin_image, start_point, end_point, color_rectangle, thickness_rectangle) (2)

Here start_point denote the starting coordinates of the boundary box and end_point denote the ending coordinates of the boundary box. With the value of bounding box height and width, ending coordinate value is added.

Circle = cv2.circle (Bin_image, center coordinates, radius_circle, color_circle, thickness_circle) (3)

Center coordinate is added with the value of bounding box height and width to get the circle in prefect center of the boundary box. This boundary pixel value is used to identify the position of the impurities. Based on the boundary value, the air blower is activated. The impurities are rejected and the good grains are collected.

4 Operation of the prototype

Before the grains are feed into the collector, the images of the sample grains are captured using camera and it classified using machine learning concept by tensorflow platform [12] With the help of grain classification result, the pressure of the air blow will controlled at the final step. Automatic grain sorting system is shown in Figure 7. At first, make the front and back LED to turn ON. The LED is provided in the setup to prevent the shadow falling while capturing of image [13]. Then, Jetson Nano board sends PWM signal to the motor through L293D driver IC.

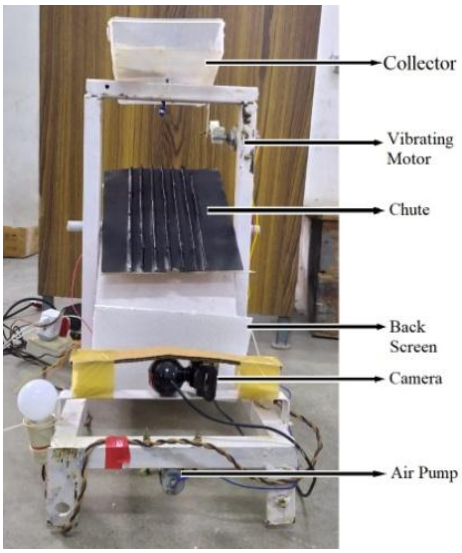

Figure 7 Hardware setup

Then the motor starts to rotate, which gives the vibration movement for the splitter. The gear motor of 100 rpm is fixed for vibration. When Jetson Nano sends the signal to the motor driver, it will convert the low voltage into 12v to run the motor. Here, the gear motor converts the rotational movement into vertical vibrating movement. The motor is used to pour the grains slowly to the chute. The grains are allowed to fall down on the vibrator which helps us in preventing the clustering of grains. The vibrator is followed by splitter. The camera is fixed at the opposite to the splitter to capture the grains which are falling down from the splitter.

4.1 Vibrator

Grains will continuous flow into the machine. The necessity of Vibrator is to pass the grains in the uniform manner. The grains will be uniform

distribution minimizes the grouping and overlapping of grains. This process is necessary because, when the grains are overlapped, the unwanted materials in the grains cannot be detected. Moreover, more clumping results in too much good grains being inadvertently rejected as unwanted materials. By the PWM signal DC gear motor makes vibration effect with different speed. Here rotating motion is converted into vibrating motion in for uniform flow of grains on the chute [14]. The grains from the vibrator are passed onto the chute. Chute helps to pass the grains through the camera and ejector. The ejected waste particles are degradable waste so it is not affect the environment. There is no pollution rise by this machine.

5 Result and Discussion

The Convolution Neural Network had trained with dataset containing 250 images for individual different type of grains. The Accuracy rate of tested dataset was 84% with the help trained dataset. If the input image is not classified under any classification the constant air flow pressure will be blown from air blower. The output classification of grain is shown in Figure 8.

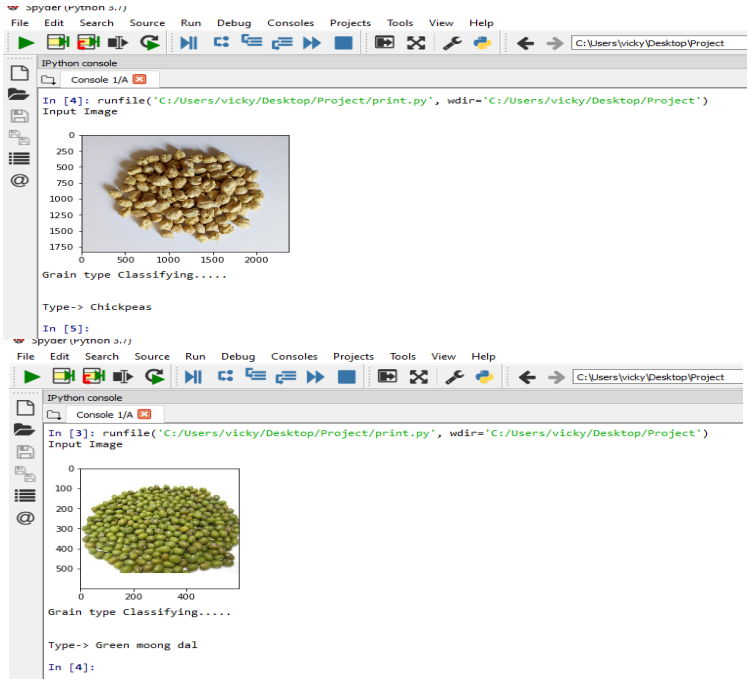

Figure 8 Output: classification of grain

Once the machine was completely built, it was examined to measure the capability of colour identification, material ejection, and overall sorting. The test was to obtain machine capability in identifying the colour. The experiments were conducted by passing 100 grain samples without impurities through the colour sensor to check how the good grains are detected. That 100 chickpeas is shown in Figure 9. And, then passing another 100 impurities or unwanted materials that shown in Figure 10. To check how the bad grains are detected by the machine.

Figure 9 classification of grain(chickpeas)

Figure 10 Output: classification of grain(impurities)

Table 1. Sorting Capability Test Result for Chickpeas

S. No.	GG	GB	BG	BB
1	84	16	2	98
2	92	08	1	99
3	93	07	0	100
4	89	11	0	100
Mean	89.5	10.5	0.75	99.25

The machine has been tested by taking three different types of grain samples. Table 1 shows the test result of the chickpeas sample. Table 2 shows the test result of the Bengal gram sample. Table 3 shows the test result

of the Moong Dal sample. GG represents the number of good grains identified as good (out of 100) and GB represents the rest of the good grains that were not identified as good. BB represents the number of bad grains that was identified as bad (out of 100) and BG represents the rest of the bad grains that was not identified as bad.

GG – Detecting good grain as good
GB – Detecting good grain as bad
BG – Detecting bad grain as good
BB – Detecting bad grain as bad

$$\text{Mean} = \sum X/N \quad (4)$$

Where,
X - Output of samples
N - No of samples taken

The Table 1 and equation 1-4 shows the test result of the Chickpeas sample. Here, we have taken few chickpeas to test the machine's capability. The same chickpeas sample is passed through the machine for four times and the results were noted. The mean value is calculated from equation 4, summing up the four values and dividing that value by four. For the chickpeas, on an average, the detection of good grain as good is 89.5% and the detection of good grain as bad is 10.5%. The detection of bad grain as bad is 99.75% and bad grain as good is 0.25%.

Table 2. Sorting Capability Test Result for Moong Dal

S. No.	GG	GB	BG	BB
1	94	06	2	98
2	93	07	0	100
3	93	07	1	99
4	96	04	1	99
Mean	94	6	1	99

The Table 2 shows the test result of the moong dal sample. The test result is taken same as that of chickpeas. The mean value is calculated by summing up the four values and dividing the value by four. For the moong dal, the average value for the detection of good grain as good is 94% and the detection of good grain as bad is 6%. The detection of bad grain as bad is 99% and bad grain as good is 1%.

Table 3. Sorting Test Result for Bengal Gram

S. No.	GG	GB	BG	BB
1	86	14	0	100
2	88	12	0	100
3	83	17	2	98
4	85	15	0	100
Mean	85.5	14.5	0.5	99.5

The Table 3 shows the test result of the Bengal gram sample. The test result is taken same as that of chickpeas and Moong Dal. The mean value is calculated by summing up the four values and dividing the value by four. For the Bengal gram, the average value for the detection of good grain as good is 85.5% and the detection of good grain as bad is 14.5%. The detection of bad grain as bad is 99.5% and bad grain as good is 0.5%.

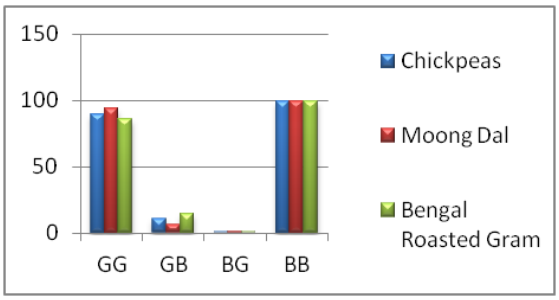

Figure 11 Comparison chart of three different grains

The expected value for correct detection is higher, while that for incorrect detection is lower. Figure 11 shows the comparison chart of three different grains. From the test result, it could be seen that there is minimum false detection i.e. the value of the good grains detected as bad and the bad grains detected as good is lower.

Because the purpose of sorting is to separate good from the bad grains, thus the frequency of wrong decisions such as accepting the bad material or vice versa should be minimized. Thus the frequency of wrong decisions such as accepting the bad material or vice versa should be minimized. The accuracy of the setup is calculated by the formula,

$$\text{Accuracy} = \sum \frac{Mean}{No\ of\ Samples} \quad (5)$$

Here, Accuracy (equation 5) is calculated by summing up the mean value of all the samples and dividing that value by the number of samples.

6 Conclusion

The automatic grain sorting system checks the classification of grains using Conventional Neural Network and detects the unwanted/inedible particles from the grains with an accuracy of 94.45%. The existing modal for this kind of automation is expensive and only used in large scale industries. Thus it reduces lot of manual work and thereby reducing cost of the grains. Also, since the removal is done by this system, the grains are pure and ready to use.

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