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Image Processing Based Quality Analyzer and Controller

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Abstract: It is seen that in developing country like India there is no proper technique to check the quality of fruits or vegetables. A lot of time is wasted in the fields for checking the quality of the crops. There is no process with which we can check the quality of the fruits or vegetables considering their color. Also, lacking in an automated technique, which can control the speed of the grinder or any other motor required for processing the quality of the fruits or vegetables. Thus, there arises a requirement of a fully automated system by which the quality of the fruits or vegetables can easily be checked and also the speed of the process be controlled according to the quality identified. In this article an automatic technique is developed to check the quality of the apples based on color matching and controlling the speed of the motor with the help of a microcontroller to crush the apples to make apple juice. MATLAB is used for the color analysis in image processing and C language is used for microcontroller as an embedded system. We are grading the product i.e. apples according to their colour for e.g. Apple color will specify the quality of the apple i.e. more red the apple, better the quality.

Keywords: DC Series Motor, Image processing, Matlab Simulation, Universal Motor.

I. INTRODUCTION

This paper deals with developing an economic and safe way to analyze the fruit or vegetable quality which is based on colour, and to control the speed of the grinder according to the quality of the product. Here we are analyzing the quality of the product with the help of image processing toolbox in MATLAB. After checking the quality of the apples we control the speed of the grinder according to the quality of the apple. Apple of grade A being less ripe needs more speed of the grinder for converting it into juice. Thus, here we have a fully automated system with the help of which farmers and the manufacturers of juice and jam making units can easily check the quality of the fruit and vegetables and also control the speed of the process according to the quality of the fruit/vegetables. For developing the technique to check the quality of the fruit based on colour matching and controlling the speed of the motor by using a colour fundamentals in image processing. For colour matching, MATLAB is used and the motor speed is controlled by simulating it in MATLAB. The colour fundamentals are used to access the colour content of the Apples. As the Image Acquisition is not a part of this project so it is assumed that the image acquired through a Digital Camera is stored in the computer memory. Then the Image Processing Fundamentals are taken into consideration. These details out the representation of the Image in space coordinate form. The types of resolution along with the bit depth are explained henceforth in the hardware description part. The software description details out the code along with the brief description of the various commands of MATLAB. The motor in the grinders is universal motor or DC series motor. The speed of the motor is controlled with the help of armature control method. The simulation is done with the help of MATLAB and the results are displayed on the LCD. This LCD can be placed anywhere, maybe a separate cabin for the supervisor to monitor the results. This simulink not only maintains the speed of the motor but also varies the speed of the motor according to the quality of the apples. The harder the apple, the more force required to crush it, hence more will be the speed of the motor.

II. METHODOLOGY

A. The Image Processing module

This module consists of the image acquisition part through any of the modes explained in the hardware description section (this is not a part of this project and hence optional). The acquired image is stored in the PC in the JPEG format. The JPEG image is then processed for the presence of various colours, as we now know that a colour image comprises of varying amounts of the primary colours. The quantity of colour is determined and then depending on the content of the red color present the apples are categorized into the four categories, namely

1) Grade A (with more red content and hence more ripe)
2) Grade B (with less red content and hence ripe)
3) Grade C (with lesser red content and less ripe)
4) Grade D (with least red content and least ripe)

This whole is done using MATLAB version 7 (a high-performance language for technical computing.). The Image Processing Toolbox is used.

Fig.1 A Colour Image

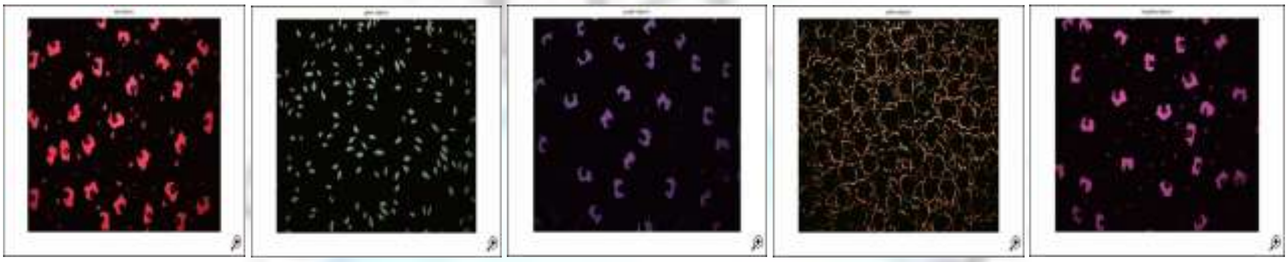


Fig. 2 Bitonal components of image

B. Motor Control Module

The motor present in the grinders is a universal motor, so in project then universal motor has been used. There are three speed control techniques for a universal motor, Flux control method, Variable resistance in series with motor, Armature control method. In this article, we are using armature control method for controlling the speed of the motor. This method is based on the fact that by varying the voltage available across the armature, the back EMF and hence the speed of the motor can be changed. This is done by inserting a variable resistance RC (known as the control resistance) in series with the armature. Due to the voltage drop in the controller resistance, the back EMF (Eb) is decreased. Since N α Eb, the speed of the motor is reduced. The highest speed obtained is that corresponding to RC = 0 i.e., normal speed. The image processing module and the motor control module have been discussed in detail. In the next heading the segmentation of defects will be studied.

III. DEFECT SEGMENTATION

Apple fruit is susceptible to numerous kinds of injuries that affect its quality. External injuries, specifically, appear on the surface of fruit and directly affect consumer’s perception. Thus, their detection is essential for the fresh fruit market. State-of-the-art for external defect detection of apple fruit includes several works using different sensing technology, among which visible/NIR imaging is dominant because of its low cost and high speed. Defect detection requires accurate segmentation first of all. In order to segment defects on visible/NIR images researchers used different techniques based on thresholding, region or classification. However most works used either global thresholding-based approaches or Bayesian classification methods. In order to segment external defects of Jonagold apples, we will use the system architecture displayed in Fig. 3. First, we will define a region-of-interest for the fruit to be inspected. Then, we will extract features and perform defect detection at pixel level. Result will be refined by removing stem/calyx areas. Finally, we will compare the result with corresponding theoretical segmentation and evaluate performance using different measures. Note that, this whole process is automatic, hence no user interaction is needed. In order to understand the region-of-interest (*roi*) that encloses the fruit area to be inspected, we successively perform background removal and adaptive erosion processes same as in our stem/calyx recognition work. Erosion process is necessary, because initial attempts showed that defect segmentation was erroneous at the far edges of fruit most likely due to illumination artifacts. Eventually, resultant *roi* defines the zone of inspection for each fruit. Segmentation of defects at pixel level requires each pixel within the *roi* to be represented by features. Thus, intensity values within the tested neighborhood of each pixel from four filter images from its local features. As the neighborhood size increases, the amount of data to be processed for segmentation increases exponentially.

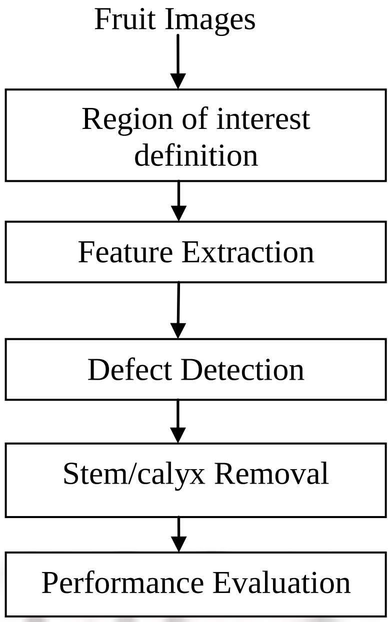


Fig. 3 Architecture of system used for defect segmentation

IV. FRUIT GRADING

A quality inspection system for apple fruit will be incomplete, if it does not take decisions at fruit level by assigning them to corresponding quality categories. Therefore, in machine vision-based inspection systems defect segmentation and stem/calyx recognition stages provide defected skin by low-level processing, while a fruit grading stage should extract information from the defected skin provided and classify the fruit to its correct quality category. This system introduces a fruit grading system that extracts/selects several features from defected skin (found by the defect segmentation and stem/calyx recognition systems), and classifies apples into quality categories by statistical and syntactical classifiers. Classification is first performed into two quality grades (healthy or defected) and then a more realistic (in terms of quality standards for apples), innovative classification is achieved by multi-category grading.

Feature Extraction: Segmentation result of a fruit may contain several unconnected objects (with different shape and size). In order to provide a decision for the fruit, one can either handle each object separately or process them together. In the former case, it is intricate to reach a global decision about fruit from individual decisions. Therefore, the latter approach is used here. As segmented objects are composed of pixels, the most straight-forward feature extraction approach is to use individual pixel intensities. First-order spatial statistics measure the probability of observing a gray-value at a randomly chosen location, and therefore depend only on the individual pixel values. They can be computed from the histogram of pixel intensities of a pattern.

Feature Selection: A total of 67 statistical, textural and geometrical features are extracted for grading fruits. A subset of these features has to be selected because irrelevant/redundant features add noise to the system and degrade its performance. Using all available features is computationally infeasible.

GRADING: In order to classify fruits into quality categories, following statistical and syntactical classifiers are used.
1) Linear Discriminant Classifier (LDC, statistical-discriminative): assumes data is separable by a linear boundary. Nearest Neighbor (k-NN, statistical-partitioning): assigns data to the most represented category within its closest k neighbors.
2) Fuzzy Nearest Neighbor (fuzzy k-NN, statistical-partitioning): similar to k-NN. Benefits also from distance information of neighbors.
3) Support Vector Machines (SVM, statistical-discriminative): using kernel functions SVM maps data to a higher dimensional space, where a linear discrimination is performed.

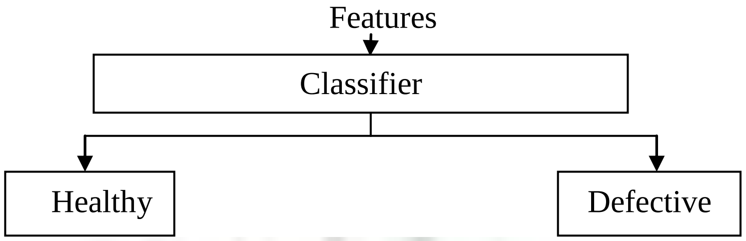
TABLE 1: MULTI-CATEGORY GRADING

Code	explanation	# of fruits
D1	defect leading to rejection of fruit(e.g. rot)	60
D2	bruised fruit	55
D3	seriously defected fruit(e.g. scar tissue)	55
D4	slightly defected fruit(e.g. small russet)	76
overall		246

Defect categories provided by expert and their relation with our database.

A realistic fruit grading system should not just sort fruits as defected or healthy but provide a more detailed classification. In order to permit such a multi-category grading, experts from Gembloux Agricultural University manually classified the defected fruits in our database into four quality categories 5 taking severity and size of defects into account.

Two-Category Grading: Marketing standard of European Commission [2] defines three acceptable and one rejects quality categories for apple fruit. However, half of the literature consists of works with two-category (acceptable/reject, healthy/defected or bruised/non-bruised) grading, which is most likely because of the difficulty of database collection and grading process. Therefore, we will first introduce fruit grading results with two quality categories.



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Direct approach: These four categories are related to defects. So, if we add an additional category for healthy fruits, then we can perform multi-category (5 grades) fruit grading using a single classifier (direct approach) as in Figure:

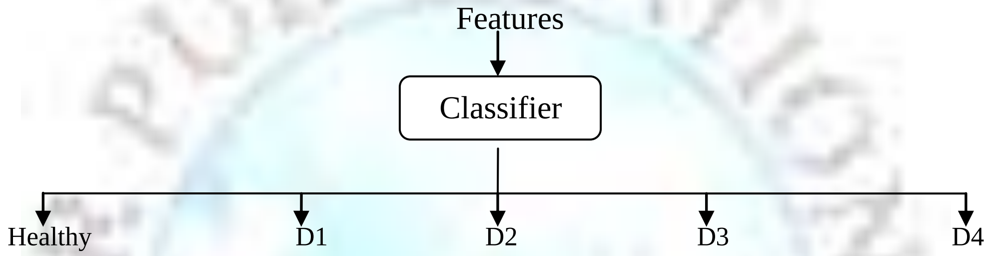


Fig. 4: Architecture of the direct multi-category fruit grading approach.

In this article grading of apple have been obtained depending upon the quality i.e., A Grade Apple, B Grade Apple, C Grade Apple and D Grade Apple. In the next heading the simulation of the work and the results obtained will be summarized. This article involves two sections which require developing individually and combining to produce the final project. Each part requires research and understanding before being carried out. The design methods used are discussed in the following sections.

V. DESIGN ANALYSIS

To produce a good design, there needs to be some amount of modeling or simulations done to avoid aimless trial and error techniques with the actual equipment (the Universal motor). For this article, a number of specifications were needed to be obtained and established. The specifications of the Universal motor were obtained from the engraving on the metal tag attached on to the motor casing. It includes the power, speed, voltage, frequency etc. All these specifications are given in the Table 2.

TABLE 2 SPECIFICATIONS OF UNIVERSAL MOTOR

PARAMETERS	SPECIFICATIONS
Voltage	110V - 240V
Frequency	50/60 Hz
Power Draw	1500 Watts
Speed RPM	1500 – 2500 RPM
Coulomb friction Torque	5161 Nm
Armature Resistance	11.2Ώ
Armature Inductance	0.1215 H
Field Resistance	2.813Ώ
Field Inductance	56 H
Total Inertia	0.02215 kg.m^2
Field-Armature mutual inductance	1.976 H

The speed control of the motor is done by preparing a MATLAB /Simulink model for the motor. The method used in this article for speed control is the Armature Control Method. The simulink model for the speed control of the motor is as shown below:

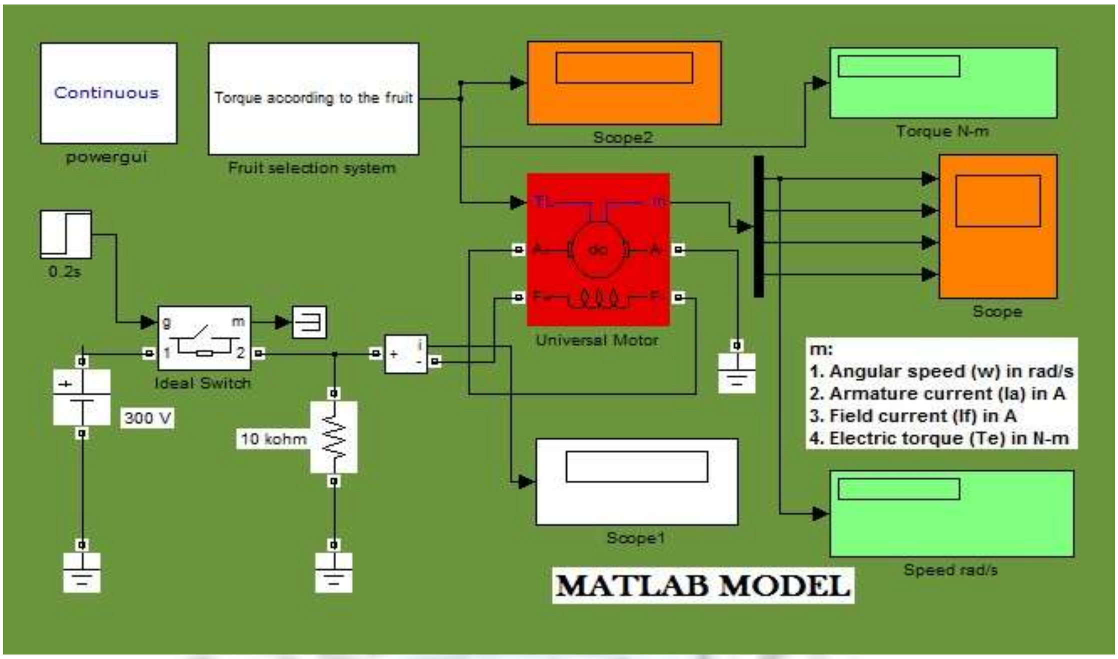


Fig. 5 Motor Control model

VI. RESULTS

A. Image Processing part

A typical machine vision based inspection system is composed of mechanical, optical, image acquisition and image processing parts. Components of each part add certain complexities to the system and make it harder to compare two proposed systems. In this part, coding has been done to analyze the quality of apple. On the basis of the code four quality categories of apple have been obtained. These quality categories depend upon the range of the output obtained in the form of a graph.

- If output is less than or equal to 2
  ie, if 1<=2

Then the apple is A Grade apple.

- If the output is greater than 2 but less or equal to 5
  ie, if 2<1 &1<=5

Then the apple is B grade apple.

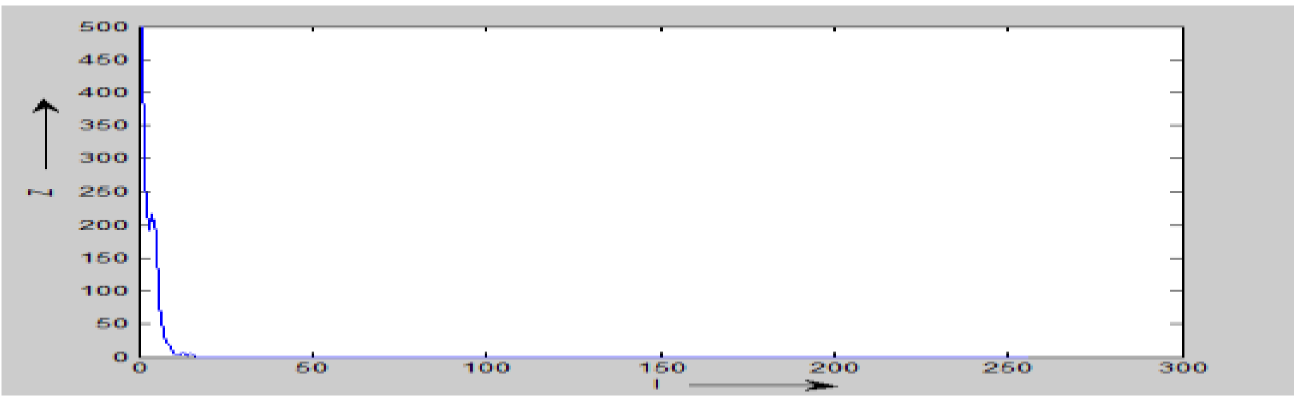
- If the output is greater than 5 but less than or equal to 10
  ie if 5<1 & 1<=10

Then the apple is C grade apple

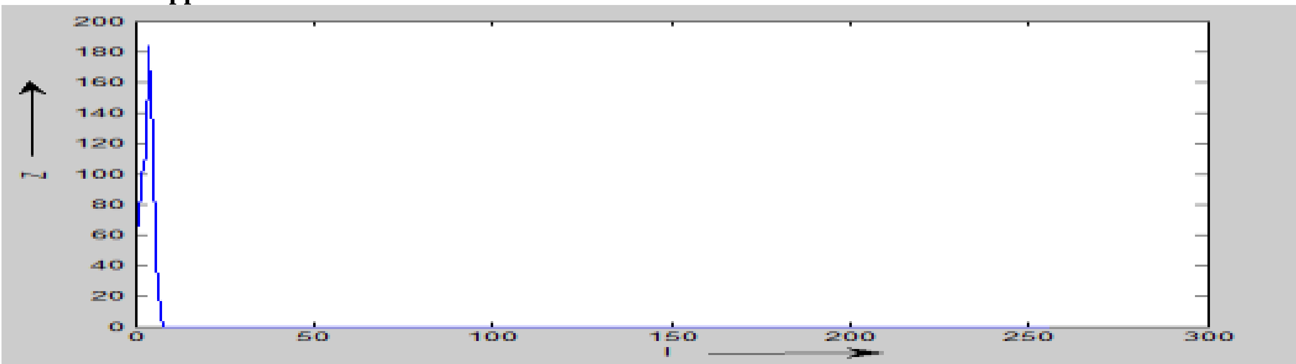
- If the output is greater than 10 and less than or equal to 15
  ie, if 10<1 &1<=15

Then the apple is D grade apple

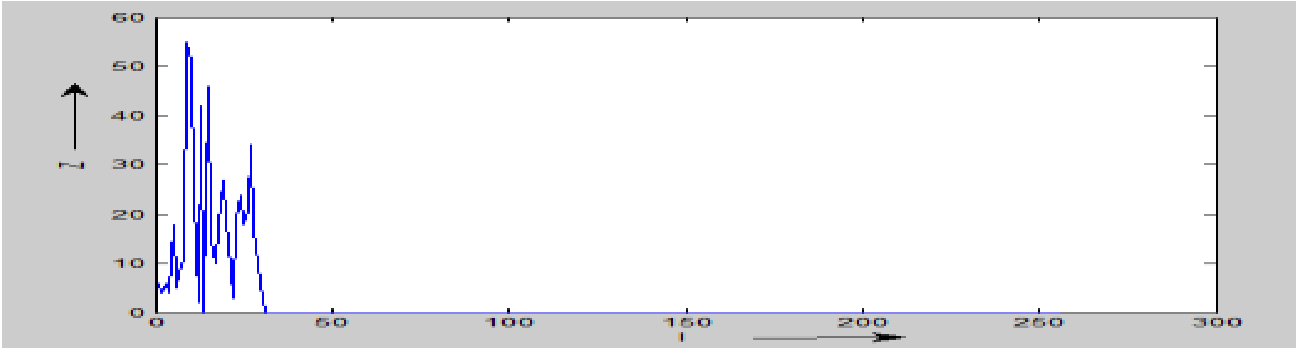
For A Grade Apple



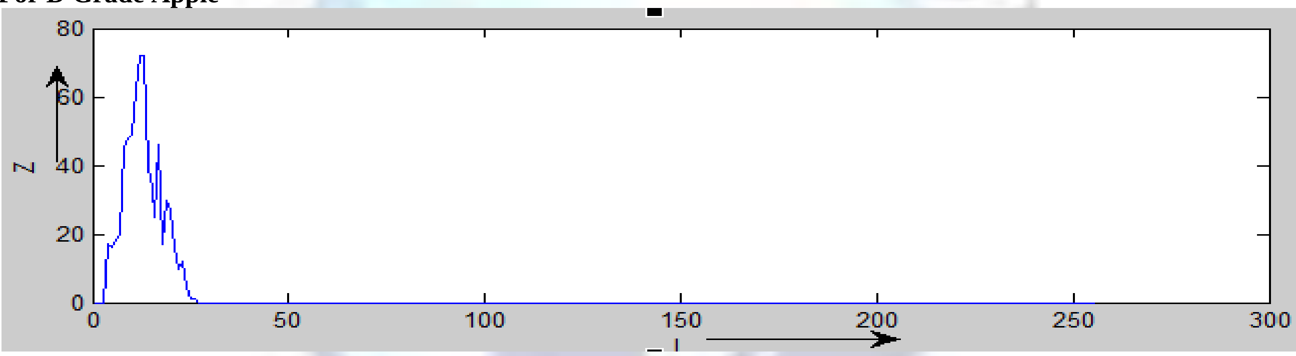
For B Grade Apple



For C Grade fruit



For D Grade Apple



The above are the results obtained from the image processing toolbox after analyzing different images of apple.

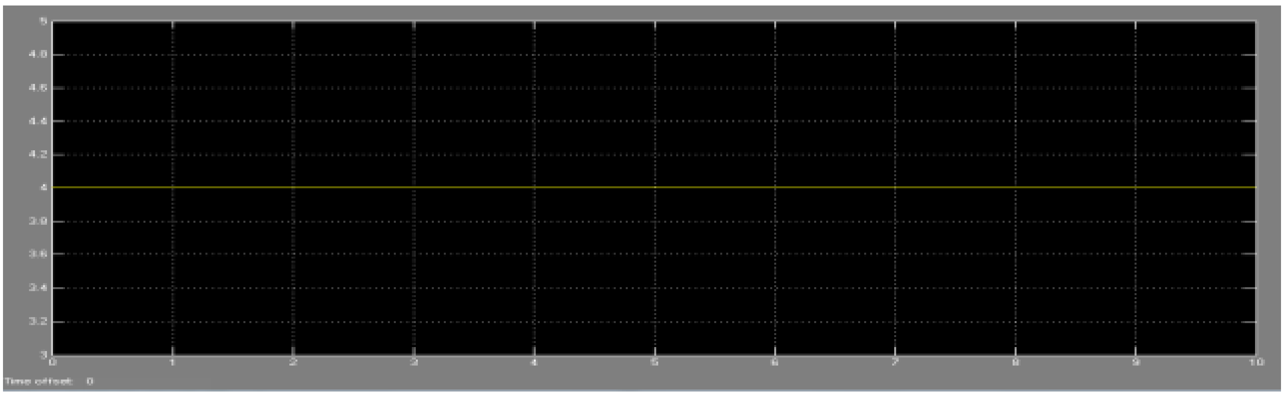
B. Motor Control Part

On the basis of the quality of the apple obtained in the image processing part, the speed of the motor of grinders is controlled. The results obtained in this section are as under:

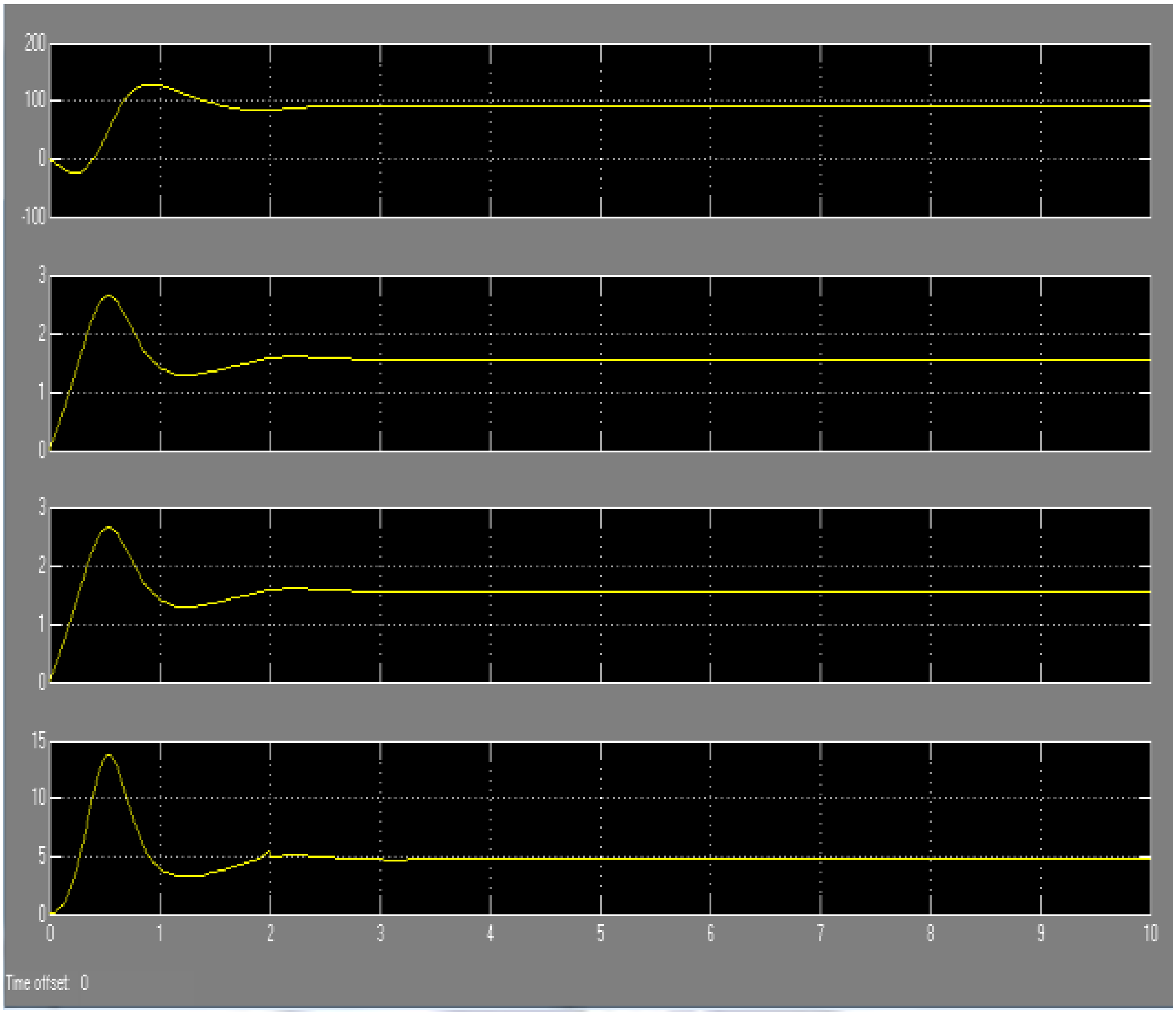
Results

For A Grade Apple

Torque = 4 N-m; Speed of motor = 90.49 rad/s; The graph for torque is as below:

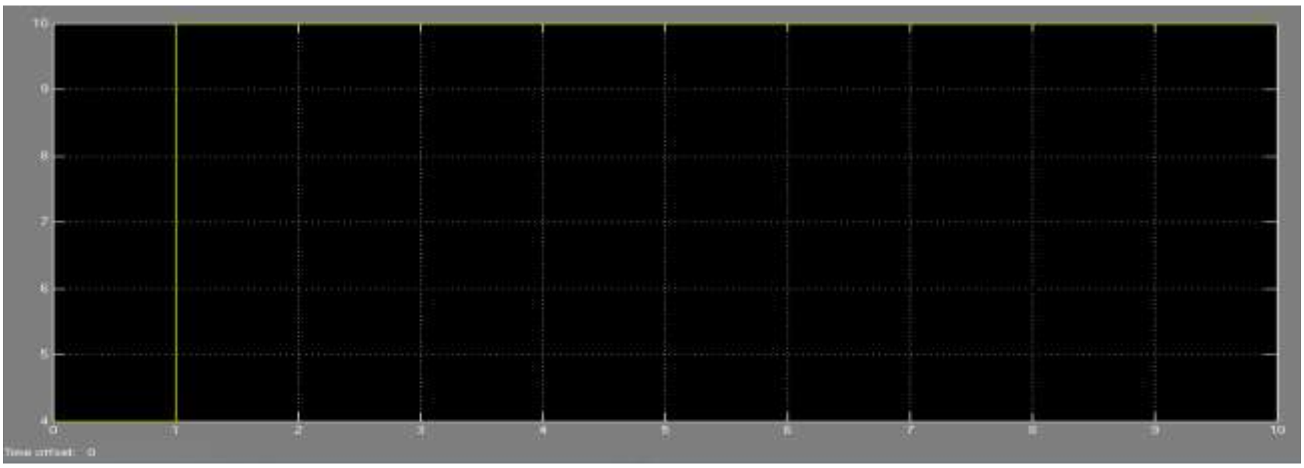


The graph obtained for speed of motor in case of A grade apple is

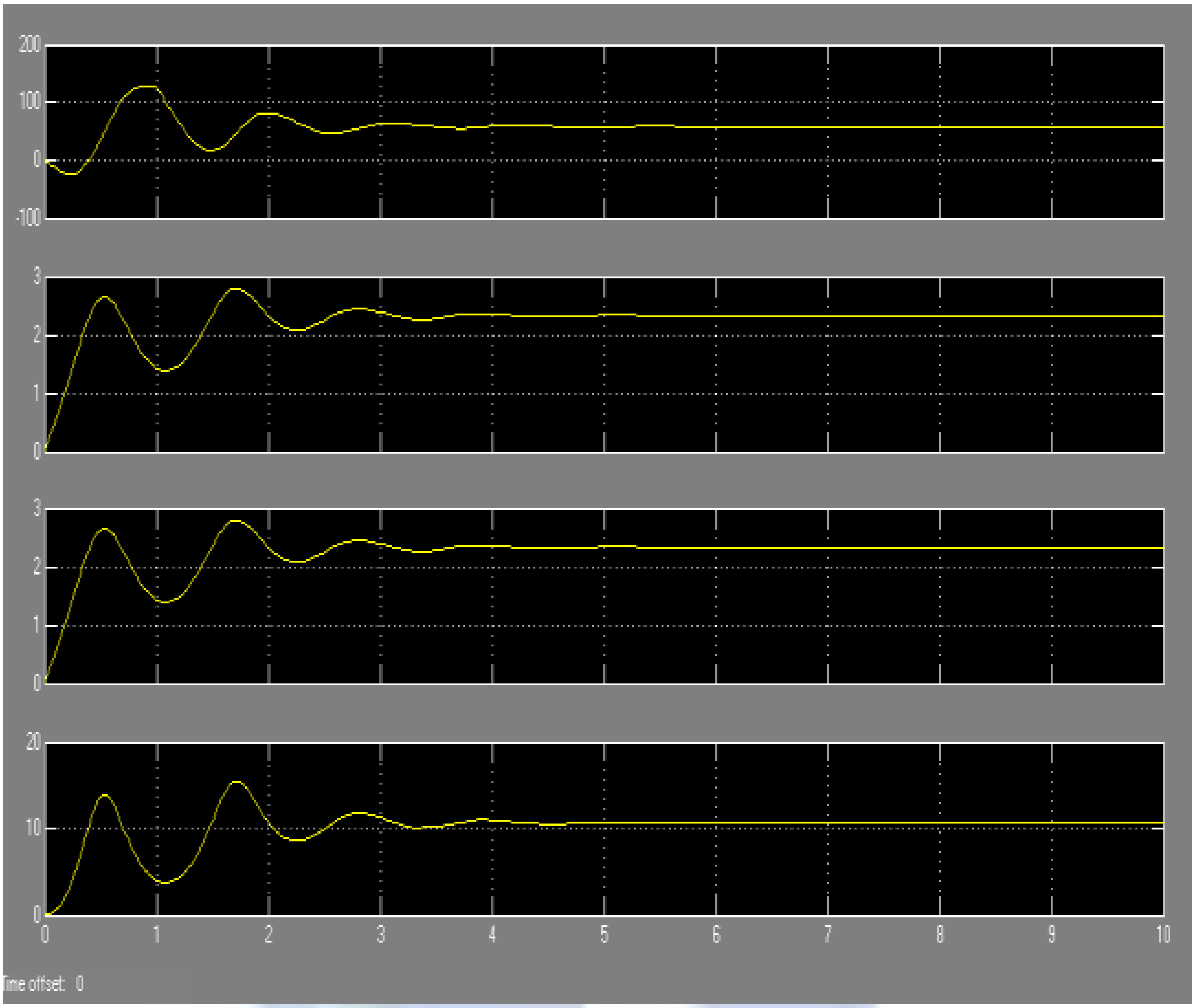


For B Grade Apple

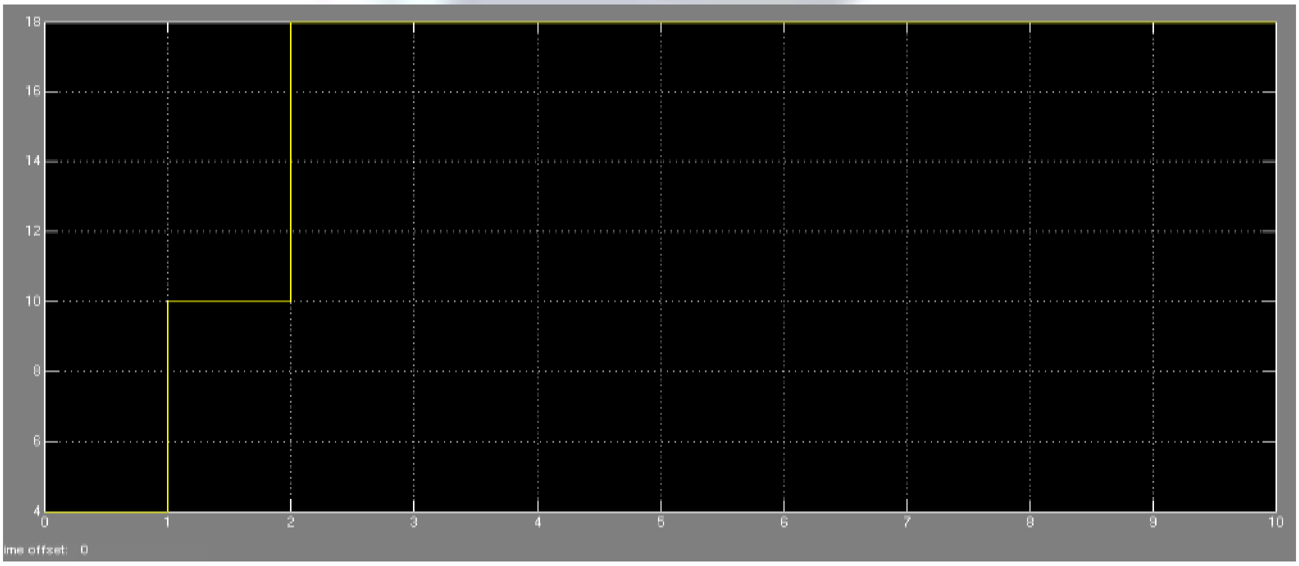
Torque = 10 N-m
Speed of the motor = 58.2 rad/s
The response for torque of the motor is as shown



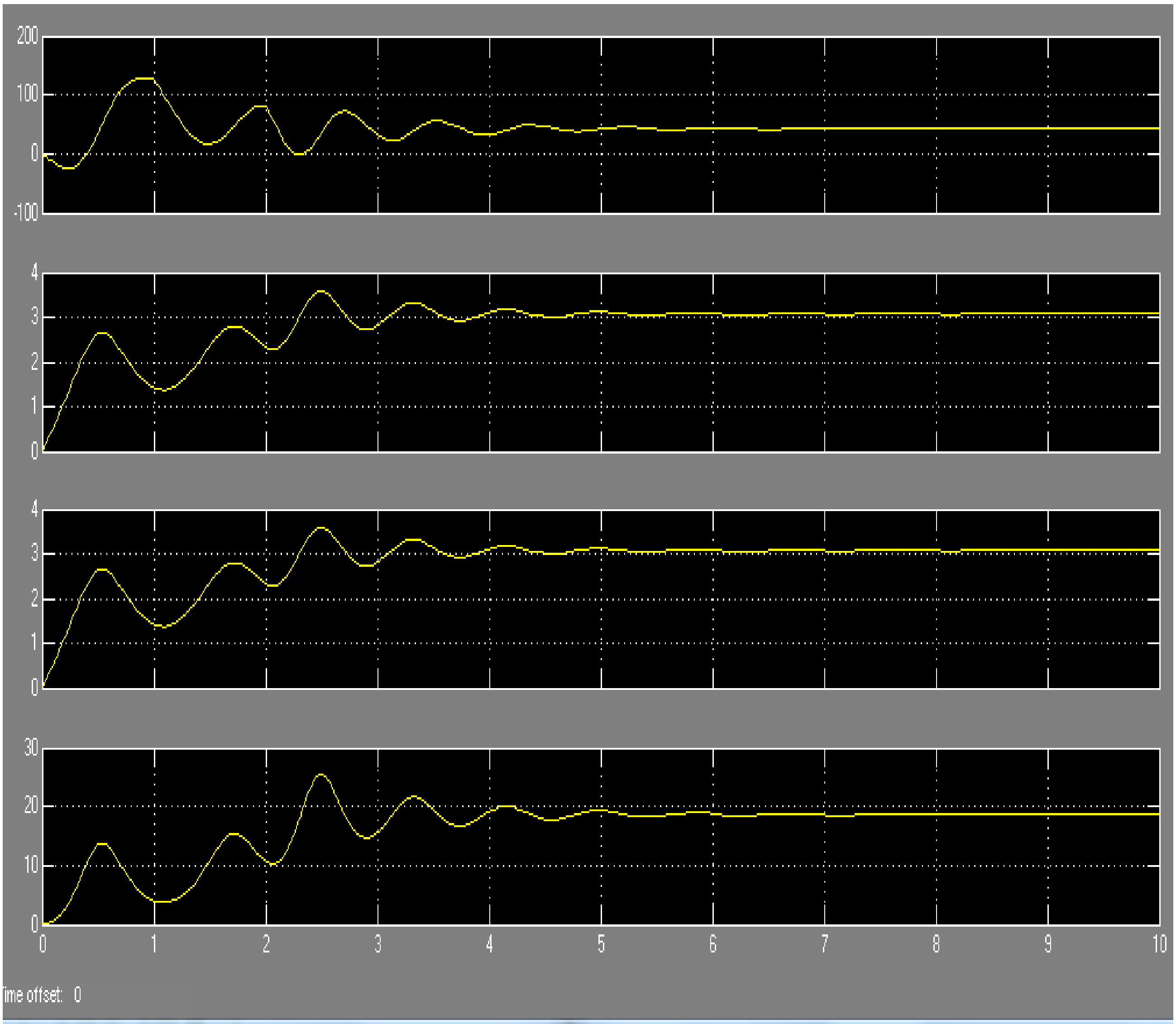
And the response for the speed of motor for B grade Apple is:



For C Grade Apple
Torque = 18 N-m
Speed of the motor = 42.35 rad/s
The torque response is:

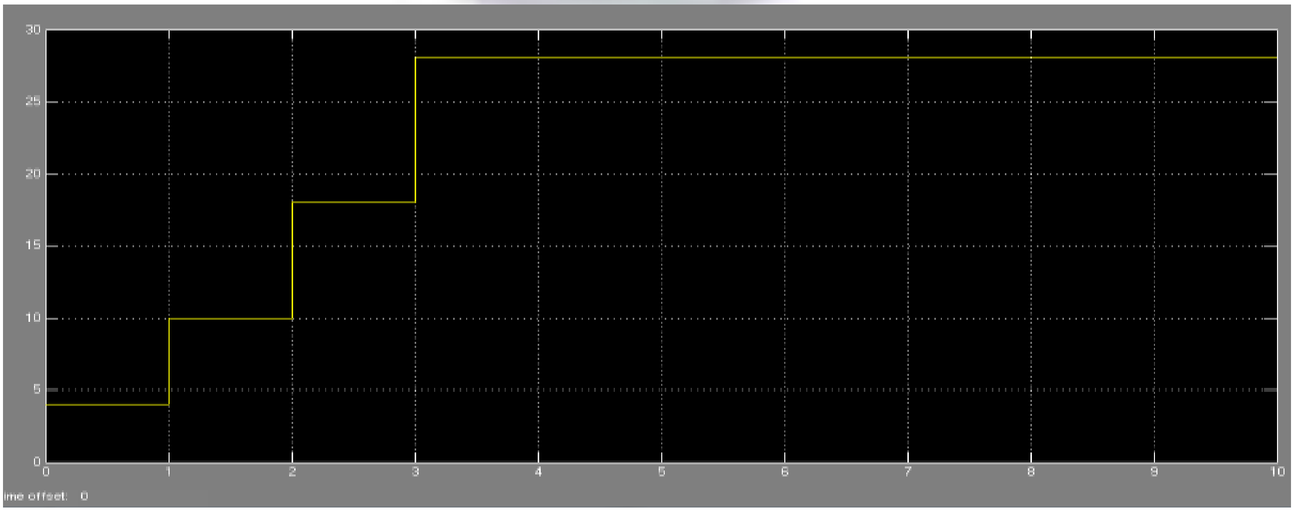


The response for the speed of motor in this case is:

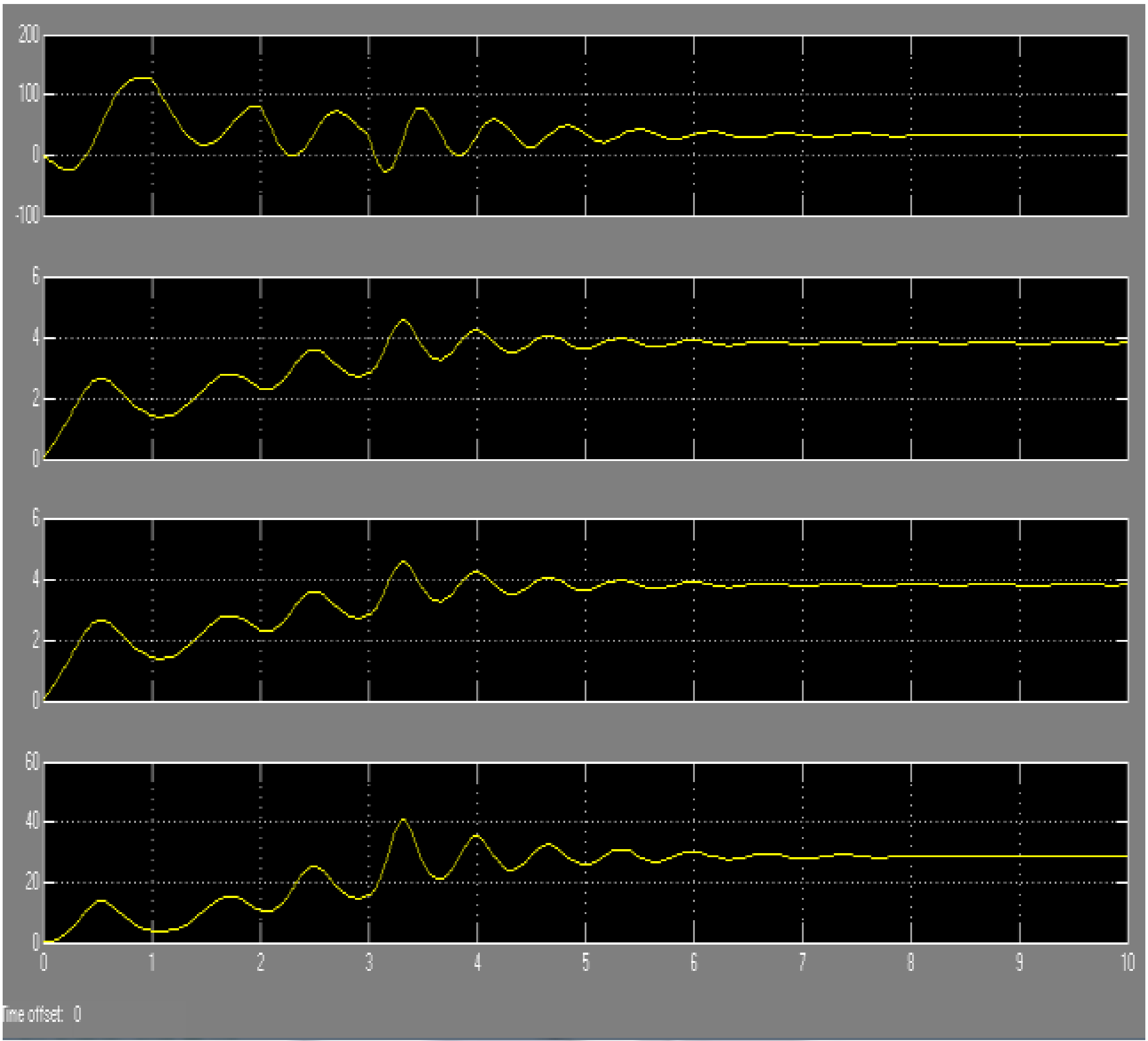


For D Grade Apple

Torque = 28 N-m
Speed of motor = 32.34 rad/s



The graph for speed of the motor in this case is:



Thus, this article presents the simulink model of the universal motor and the results obtained from it. It has been seen that the speed of the motor goes on increasing from A grade apple to D grade apple. For A grade apple, speed of the motor is maximum and for D grade apple the speed is minimum. Thus, the results which were expected in the beginning of the work have been obtained successfully.

VII. CONCLUSION

Industrial system benefits more and more from machine vision in order to provide high quality products to the consumers. Accuracy of such systems depends on the performance of image processing algorithms used by machine vision**.** Food and beverage industry is one industry where machine vision is very popular and widely employed. Apple fruit in particular are even more problematic due to high natural variation of their skin colour and numerous defects presents. Hence quality inspection of apple fruit by image processing is still a challenging problem for the industry. A Scientific & Economical analysis of the quality of a fruit or any product whose quality depends on the colour is developed. By using this project we are not only analyzing the product but also controlling the final product quality with the help of which one can check the quality of the fruit and can easily control the quality of the final product. So, this project can be a good tool in the hands of the farmers who are dealing with fruits or vegetables business. Moreover, the accuracy of this is better than the manual process and above all the speed of operation is very high. This system can be useful tool for both the buyer and the seller in order to increase the efficiency and quality of the product. Due to the low cost of the system it can be used in small scale industries-juice and jam making units. It is a great boon for agriculture and horticulture.

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