

A Review of Design and Development of An Intelligent Groundnut Threshing Machine Using Machine Vision Technique

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Abstract – Groundnut (*Arachis hypogaea*) is a vital leguminous crop and holds great importance in Nigeria, where it plays a key role in food security and supports rural livelihoods. Traditional groundnut threshing practices including, hand shelling, stick beating, and animal trampling, are labour intensive, slow, and error-prone, thereby reducing productivity and market quality. Existing mechanical threshers, though an improvement, still face drawbacks such as seed breakage, minimal automation, and susceptibility of sensors to environmental conditions. This review focuses on the design and development of an intelligent groundnut threshing machine that applies machine vision techniques to enhance efficiency, minimize seed damage, and advance precision agriculture. By incorporating image processing, fuzzy logic control, and machine learning models, the system is designed to automatically identify groundnut varieties and dynamically adjust threshing parameters according to pod characteristics like size, shape, and texture. The review also examines recent progress in threshing technologies, noting persistent challenges in concave construction, motor regulation, and sensor reliability, while underlining the potential of artificial intelligence in agricultural mechanization. The integration of Raspberry Pi, high-resolution image camera, with the use of supervised machine learning for feature extraction and classification of the groundnuts pods that makes the machine thresher an intelligent innovation. Ultimately, this approach promotes sustainable farming practices, increases productivity, and supports the overarching objectives of precision agriculture and food security in developing nations.

Keywords: classification, fuzzy logic control, groundnut, intelligent, machine learning

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I. Introduction

Agricultural products play an important role in feeding human, livestock and industries globally. Groundnut (*Arachis hypogaea*) is one of the most important leguminous crops grown in more than 100 countries, with major producers such as Nigeria, India and China. In Nigeria, groundnut holds historical significance in agricultural exports like Kano pyramid and remains a key contributor to rural economies. However, inefficient post-harvest processing particularly threshing remains a bottleneck in production [1]. With the adoption of innovation technologies such as human orientation machines which empowered the design and development of an intelligent human-oriented machine

that coordinates and cooperates intelligently with their human users also expanded the agriculture energy of the market value of its products [1]. However, threshing is being done traditionally i.e hand method and machine method, traditional method is the process in which the groundnut pod is pressed with the first finger and thumb in order to release the groundnut seed and this method of groundnut threshing is the most popular widely used in Nigeria. These could also be used by animal or human trampling, stick beating, etc. which has a very low breakage of groundnuts seed, but with time wastage, error prone, high energy requirement, high labour intensive, fatigue to workers when large quantity are being processed with a very low productivity [2].

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As the global population continues to grow at an estimated annual rate of 1.09%, there is a rising need for increased production of food, due to the increase in urban development. This trend places greater pressure on the agricultural sector to achieve significantly higher yields. With the world population projected to hit 10.4 billion by 2050, agricultural output will need to double in order to satisfy the escalating demand this can be achieved through the adaption of machine learning to our agricultural machine especially when handling post-harvest [3]. Image processing technique refers to automated image processing and analysis of images taken with a variety of sensors, including as visible light cameras, infrared imaging equipment, and sensors that work across different electromagnetic spectrum bands [4]. Furthermore, an accurate vision technique during threshing is important contributing element to the steady growth of agricultural production.

According to [5], for a variety of processing and threshing techniques, human experts have depended on traditional methods. For example, pressing the pop with the thumb and first finger can release the groundnut seed. Other methods include stick beating, animal trampling, impact action, rubbing, compression, and shearing [6]. However, this process is highly energy demanded and labour intensive, fatigue, time consumption and very impractical in some cases [7].

To address these challenges, research into the image processing techniques, recognition, and automation threshing system has become necessary research area. Groundnut thresher that is automated in operations with machine vision technique become necessary due to technological revolution. As shown in Fig. 1, we have been experiencing from industrial revolution to semiconductor revolution, then to information revolution and now we are in the artificial intelligence revolution. The artificial intelligence is now a revolution that is giving birth to multiple innovation and proliferation of machines that are smarter, empowering design, development and support of innovative concepts for the realization of human-oriented machine [8].

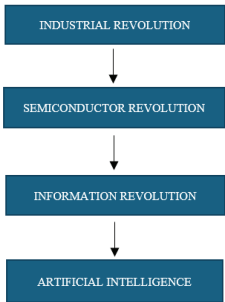


Fig.1. The progress of Technology Revolution

This research work provides a thorough analysis of current research in plant threshing identification using machine learning and visual processing methods. The study will be a useful resource for researchers with the use of image processing techniques for agriculture threshing processes. It was reported that application of Machine Learning (ML), Image Processing (IP) is attributable to the use of farm mechanization, the advancement of higher-yielding crop and livestock varieties, robotics, remote sensing, data analytics, unmanned aerial and terrestrial vehicles, fertiliser and pesticide use, and tractor navigation via the Global Positioning System (GPS) [5].

However, in response to these challenges stated above, these will bring a growing interest in Precision Agriculture (PA) to sustainably boost yields. The phrase of precision agriculture refers to any method used to make farming management easier and it is threshing more accurate and controlled through various engineering laws and principles through the application of artificial intelligence. Development of precise and accurate threshing machine with vision techniques for its operation become key pillar in precision agriculture which is recognized as a current field of study that has enormous promise for solving the issue of early enumeration on tradition, on which human specialists have previously depended. In fact, a great deal of study has been done on crop pest and disease, crop processing, crop selection recognition etc. Employing hyperspectral methods, however the equipment is costly and out of reach for many farmers, and its local manufacturer [4]. Decreasing impurity, broken, and loss rates indicate the best harvesting effect [10].

Furthermore, ML has been taken as an important factor for Industrial Revolution, because of its great potential and ability to solve problems in different areas, such as complex problem transforming it into simple problem. Over the years, machine learning has been improved and updated including python, Matlab, C++ and Java to create innovations. Machine learning models are classified as Supervised Learning, Unsupervised Learning, and Reinforcement Learning to execute task. Image processing is another important area of studies for many years, finding its applications in medicine, astronomy, biology, different areas of engineering [11]. The research aims to transform the groundnut threshing machine, where ML and engineering expertise will be used to create an intelligent threshing machine that optimizes performance, thus reducing the labour intensity. As global agriculture embraces precision and automation, there is a rising interest in intelligent threshing systems that integrate sensors, machine vision, and automated control to improve efficiency and reduce damage. Furthermore, the review explores the evolution

of groundnut threshing technologies, particularly the integration of machine vision and intelligent systems. It critically evaluates the design principles, control strategies, and performance metrics from recent studies [12].

II. Literature Review

The review on the development of peanut-shelling technologies and equipment highlights several observations. For example, some of the machines need to be improved such as the conical concave where the threshing force cannot be equally distributed, resulting in the perforated concave which can damage the groundnut seed since the groundnut is not round in shape. The conventional and semi-automatic thresher needs to be improved for better quality groundnut seeds for higher market value [13]. Through the design and implementation of an automated groundnut shelling machine, a good percentage of shelling efficiency was achieved. However, the shelling machine was started by a line of sight (LOS) sensor, or infrared (IR), which was placed at the hopper into which the groundnut pods are fed. The dust, vibration, heat and darkness can all affect the IR sensor functionality during operation, which can lead to malfunction. Another limitation is that the hopper's square shape and direct orientation additionally, the operator's detachable concave (screen) and threshing cylinder make up the threshing chamber. The ATmega328 microcontroller was chosen because it is readily available, highly efficient, and user-friendly. Nevertheless, it is unable to accomplish complicated tasks due to its limited capability [12].

Next is on the design and manufacturing of peanut sheller machine, where the groundnut pod is broken by the machine using an auger screw with round hole concave. The test was carried out with a 0.5 HP 400 rpm electric motor using dried groundnut pod of various quantities for shelling. Then, the machine was fed with a constant mass of 300g of groundnut seeds. An average shelled at 84% and average 14% broken seed of results are obtained. The designed concave was round hole which allows foreign particles in the threshed seeds. The seed and chaff outlet was in an inclined form and this causes more energy requirement and auger screw will cause more damage thus reducing its market value [14].

To improve the situation, a force sensing resistor-based longitudinal axial flow rice thresher feeding rate monitoring system was developed. The sensors were mounted on the inner surface of the thresher top cover to identify the impact and extrusion forces generated during the threshing process and to identify the feeding rates that surpass appropriate feeding levels. Three thresher speeds (1100, 1300, and 1500 rpm) and three feeding rates (0.8, 1.1, and 1.4 kg/s) were evaluated. High-speed photography was used to calculate the

testing procedure' duration. Since the force sensing resistors were placed at the inner surface of the thresher drum, high vibrations may cause physical stress, which could result in failure and an incorrect reading. Therefore, another sensor should be added to create redundancy to ensure reliable operations. The obtained results showed that the force signals collected by the thin film sensors significantly correlated with the thresher rotating speed and feeding rate. In this research, the sensing sensor concentrates only on the feeding rate, which is easily affected by temperature, humidity and dust level [15].

Next is the research on the creation and performance assessment of a groundnut shelling machine that was made from locally accessible materials and intended to shell and clean the groundnut. The shelling was tested three times to determine its shelling efficiency, cleaning efficiency, and material efficiency, which came out to be 97.94%, 56.2%, and 90.13% respectively. The machine's mechanical damage and shelling capacity were 9.87% and 192.86 kg/hr, respectively. However, the device is driven by electrical motor without any form of speed control that will cause damage to the groundnut seed if the texture of the pod is soft and another limitation is that the outlet of the chaffs was inclined up at an angle of 29° which requires more energy to push out the chaffs [16].

On the groundnut decorticator's design, construction and performance assessment, two varieties were tested for the threshing of groundnuts using two different energy consumption of 0.0018 and 0.0016 kWh/kg with threshing efficiency of 92.6% and 95.1%. The researched work lacks the mechanism to separate the groundnut seed from its chaffs, such separation mechanism need to be incorporated to the groundnut thresher for quality production. A glued rubber pads/lining was also used for the decorticating of the groundnut which will cause wear and tear quickly due to the constant frictions with the groundnut pods and may require frequent maintenance [17].

The work in [1] presented the design and built of an automated groundnut threshing machine, which produced an increase in threshing efficiency. As for the concave clearance, Ex-Dakar had 98%, Samnut 26 had 97%, Nasarawa had 97% and Jarma had 98.5%. The Arduino (Uno) software and the programmed microcontroller (ATmega 328p) were used to implement the control system. However, the research work used IR sensor at the hopper that is sensitive to environmental factors such as dust and debris, temperature, range limitation and light interference. Such factors can lead to inaccurate or false readings. Microcontroller (ATmega 328p) of 8 bit, operates at a speed of maximum clock of 20MHz which may be insufficient for

real-time image processing. The replacement or swapping of concave screen for the threshing of various varieties of groundnuts is done manually.

III. Methodology

In this section, the design procedure and the methods to be employed for the realization of this research on an intelligent threshing machine is executed through the use of data collection, image processing and application of data science.

A. Structure of the Threshing Machine

The threshing machine is made of the following components, such as the threshing unit and the control unit. The threshing unit consists of frame, hopper, threshing chamber, separation chamber and collection of seed unit powered by a prime mover. The control unit consists of software, electronics components such as the controllers, camera, sensors etc. The machine will be powered by electricity using automation mode and manual mode for its operation. The hopper receives the groundnut pods with raspberry pi (camera) for image capturing/processing and automatic selection of concave screen for threshing purpose. The process has a feedback system aided by intelligent control section. The seeds and their chaff are separated in the separation chamber where the seed will be collected at the collection unit. The operational block diagram of the intelligent threshing machine is shown in Fig. 2.

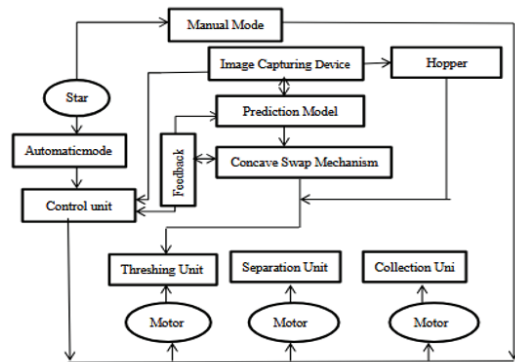


Fig. 2. The operational block diagram of the intelligent threshing machine

B. Components and Materials

1. Camera Module

A camera module compatible with Raspberry Pi is chosen for the system, such as the sensor camera due to its higher resolution, able to capture clear images of the

groundnuts during threshing for the purpose of identification.

2. Raspberry Pi Module

The Raspberry Pi (Raspberry Pi 4.0 Model B) functions as the main processing component for processing images of the groundnut, monitoring and control the machine operations through its high resolution camera for capturing images of groundnuts with consistent illumination for machine vision and storage. It is flexible and has powerful computing system to process the images of various groundnuts from the camera and running the machine learning algorithm for groundnuts and concave identification. The Broadcom BCM2711 quad-core cortex-A72 (ARM v8), 64-bit SoC processor in this component operates at 1.5GHz. It has 8GB of LPDDR4-3200 SDRAM, 2 USB 3.0 ports and two micro-HDMI connections.

3. Python Programming Language

Python is a high-level, open-source programming language that is widely used for its simplicity, readability and versatility. It has extensive libraries that can advance the features to improve the efficiency, productivity and ease of user by developing an algorithm to process the groundnut images captured by the camera that identifies and classifies groundnut based on their visual features for an intelligent threshing system. The application of python can be widely used for development of web, automation, science computing and machine learning.

4. Fuzzy Logic Controllers

Fuzzy logic controllers are widely used in various applications, which provide an alternative approach to developing and implementing intelligent control systems that are flexible and robust to handle imprecise data. It also allows a handling of real-world uncertainties effectively. This concept of fuzzy allows a mapping of practical decision making processes from human mind and into groundnut threshing machine.

5. Groundnut

Groundnut is one of the data input object to be considered during this research where three varieties of groundnuts; Ex-dakar, SAMNUT 26 and Jarma (local name) will be used for the model training.

6. Metal sheets

The mild steel material will be used in developing the hopper, threshing chamber, separation cabinet and tray of the threshing machine.

7. Angle Iron

The angle bar iron would be used in constructing the frame of the threshing machine.

8. Sensor

Input from the physical world can be detected and responded to by a device called a sensor. The specific inputs in this research are moisture, motion, weight and pressure, where the outputs signals will be converted for human display through LCD. These sensors can be an electronic component, module and sometimes a subsystem whose purpose is to detect an event.

9. Shaft, belt drive and pulley

A shaft is a rod which is employed in mechanical systems to connect two bodies which will be used to transmit power. A belt is a flexible loop of material that is looped over pulleys to physically connect two or more spinning shafts. It is often used in parallel and serves as a source of motion to convey power. The wheels and the fixed axel which has a groove along its edges to guide the belt, make up the pulley system. The belt drive and pulley act in between the prime mover respectively.

The power transmission through the belt is given as [18],

$$P = (T_1 - T_2)V \quad (1)$$

Where,

V : belt velocity (m/s)

T_1 : tension of the belt upper side (tighter side) (N)

T_2 : Tension of the belt lower side (slacker side) (N)

C. Method

The main objective of this research is to develop a smart image processing system for groundnut pod identification and classification. The proposed system is intended to have a model with efficient object capture, detection, identification and able to process the input data for intelligent operation through various methods. The device starts by obtaining groundnut images with a good sensor (camera) when the groundnut is fed into the machine. When the images are being taken, the images data will be pre-processed in order to eliminate the unnecessary factor from the images obtained. The next stage is the extraction features and other processes which use morphological, textural, size, length, width are important properties of the groundnut pod images. It provides the best information for the classification or categorization of groundnut through the aid of algorithm for the output predicted result.

1. Digital Images by Algorithm

Digital image analysis can be used to detect different dimensions and properties of groundnut using colour analysis RGB to process images such as sizes from the pixel resolution, shape using index-k value, thickness, width all centered at region of interest etc. This process uses high-speed computer algorithm code that makes it one of the fastest and accurate method that have been developed over a time for image analysis.

Camera will be used to capture the image of the groundnut pod and transport it to the IDE platform of the algorithms (code) that will be built for the image analysis. First, the type of resolution refers to as pixel count which is the number of pixel that form on photo (pod images). Secondly is about the distribution of total amount of pixel density, i.e number of image pixels per inch. Thirdly the size of the image depends on the resolution chosen which cannot be resized but can be reorganized. Fourthly, to discretize the image into pixels which can be valued based on its shape, colour and texture. Furthermore, this discretized image pixels will then be used to generate a matrix form of either 2D matrix, 3D matrix, up to a,n matrix. Based on the assignment of specific filter of a selected region due to the image to be detected for specific pattern related to each features like the line, texture, edge, shape per snap that will determine the number of rows and columns in a given matrix. All the steps can be summarized as follows.

1. Firstly read the input image pixel containing the groundnut pods
2. Convert the image pixel to grayscale
3. Define the thresholds for each groundnuts variety (Ex-Dakar, Samnuts 26, Jarma). These thresholds determine the image pixels of each variety
4. Iterate over the threshold and count the number of pixels exceeding each threshold using Open CV's `cv2.countNonZero()` function
5. Lastly each variety is determined with maximum count based on its pixels in the region of interest (ROI)

The sampling results with the quantization in the matrix real data numbers when predict that the image of $f(x,y)$ is a sample so that can be resulted into a digital image in rows and columns of m and n with their corresponding values of the coordinates (x,y) which become discrete quantities to the value of the coordinates (x,y) at origin. Thus, the right matrix represents a digital element i.e pixel is written in the following (2).

$$f(x,y) = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \ddots & a_{2n} \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \quad (2)$$

Other properties of the groundnut pod that can be determined are the number of gray level L and number of bit b required to store a digital image. Especially when the digital image is transformed into a 2D function with integer coordinates and amplitude values and gray levels to the power of 2 as in the following (3) and (4) [19].

$$L = 2^k \quad (3)$$

$$b = M \times N \times k \quad (4)$$

Where L is the gray level, b is number of storage size, k is the bit image, M and N are the number of pixel of the digital image.

The following (5) to (7) are the pre-sample of the various sizes of the groundnut pod being captured and analyzed using the algorithm on python IDE.

$$\text{Geometric diameter} = (LWT)^{1/3} \quad (5)$$

$$\text{Sphericity \% (shape)} = \frac{(L \times W \times T)^{1/3}}{L} \quad (6)$$

$$\text{Roundness \% (shape)} = 0.33 \frac{W+T+T}{L+L+W} \quad (7)$$

Where,

L = Length of the seeds (mm)

W = Width of the seeds (mm)

T = Thickness of the seeds (mm)

2. Proposed Model Architecture for Image Identification

When it comes to the identification of the groundnut pod images, the application of computer vision techniques and the machine learning models will be employed. This is where a great-level of an overview of the process are being considered. These images should cover various angles, lighting conditions and stages of the pod development under the following as adapted from [20]. However, the Open Character Recognition (OCR) will be used to enhance image processing, automation, improve the accuracy as well as streamlining the operations of the groundnut threshing machine as shown in Fig. 3.

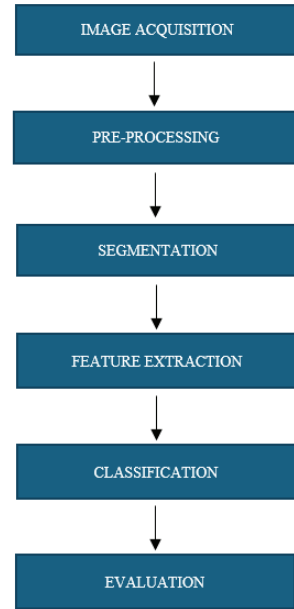


Fig. 3. Groundnut Image Processing System

3. Image Acquisition

Generally, image acquisition is the initial stage in visualization scheme. The process begins by capturing images of groundnut pods using cameras ensuring with consistent lighting conditions and sitting the camera in a good position for obtaining clear and uniform pod images when the images are being acquired. Various processes are applied to the groundnut images. Furthermore, the image acquisition can be said as a process where images are being recovered from other sources.

4. Image Pre-processing

The image capture generally includes the unwanted noise, such as dust, shadow, unwanted background etc., during the capturing of the groundnut pod. This can be filtered with the use of image enhancement for groundnut quality pod images with noise reduction. Also, image resizing is used to reduce the computational complexity of the pod after capturing to a standard size and to ensure consistency in subsequent processing steps. Colour correction will adjust and balance the pod colour by removing the colour casts to a standard appearance of groundnut pods across different images.

5. Image Segmentation

Segmentation of groundnut pods refers to the process of dividing them into smaller parts or sections for

quality assessment, yield estimation and edge detection that identifies and separates the specific regions of interest within the images. The technique helps in achieving the separation of groundnut pods from the background through setting a threshold value based on pixel intensity, edge detection i.e boundaries of the groundnut pods. The region based segmentation can also be implemented according to pixels based on their similarity in colour, textures, sizes and measurement of the groundnut pods.

6. Image Feature Extraction

An essential stage in image processing is feature extraction. The groundnut pod has multitude of variables that characterize various aspects such as pixel values, shape, color channels, texture and sizes. These analysis and decision-making look into eccentricity measurements on how elongated or stretched the shape of the groundnut pod. The system also checks the ratio of width-to-height and breath length for proper character of the pod. In simple term feature extraction of groundnut pod extracts geometric properties such as area, perimeter, spherical shape and aspect ratio to characterize the shape and calculate texture descriptors that capture specific textural properties of groundnut pod.

7. Image Classification

Classification uses machine learning model to utilize the classifiers such as Support Vector Machines (SVM) to classify groundnut pods based on extracted features. It serves as an input to the classifier to learn how to differentiate between different types of pods. Due to the challenges of groundnut pods variation especially in term of sizes, shapes, appearances, overlapping pods and varying lighting conditions, a robust segmentation algorithm is essential.

8. Evaluation

In order to provide a good prediction, quality evaluation of the groundnut pod processing for accuracy, precision, recall etc is carried out to enhance the outcomes of the image processing systems.

9. Supervised Machine Learning Model

This type of model indicates that the algorithm processes a labeled dataset as shown in Fig. 4, where each variety of groundnut pods is labeled and trained with all the properties of image which is referred to as supervised model. Here, all the given input data of the pods will be explained and with the right mapping output that is stored in the training dataset. For example, image classification duty takes each groundnut pod image previously been annotated receiving a certain

category label through the use of the machine learning model. The machine learning model will be used for the feature extraction and classification where each variety that formed the dataset is being quantified based on its ratio difference for the purpose of data training, validation and testing in a standard procedure into a distinct subset of datasets for model evaluation.

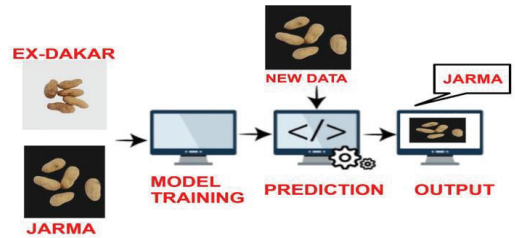


Fig. 4. Supervised Machine Learning Model

D. Fuzzy Logic Controller

Fuzzy logic controller uses the principles of fuzzy logic to control a systems performance by making decisions based on the imprecise or uncertain inputs to control e.g. the speed of the dc motor and other matching process. Once the mathematical representation of the features images of groundnut is obtained, it is stored in the database, then whenever an external input is taken, the exact or closest match is searched in the database. The database may be used to train a mathematical model, and all these matching processes involve a fuzzy logic through the following fuzzy rules as follows.

- i. Fuzzification is the process of crisp input of certain information from data groundnut features pixel such as size, shape, and texture etc. Each of these features will be transformed into fuzzy sets. For example, "small," "medium," and "large" for size, "spherical," "rough," and "crunchy" for texture etc.
- ii. Fuzzy set of rules define all the basic rules set for the varieties of the groundnut for identification. For example, the rules may define a statement like "IF groundnut is small, average range of size between setting value AND shape is spherical, texture is crunchy THEN it is Ex-dakar".
- iii. Inference processes the fuzzy input values such as small size, spherical shape and crunchy texture are evaluated against the set of rules defined. The degree of membership of each input variable in the fuzzy sets determines the strength of each rule's applicable.

- iv. Defuzzification process determine the predicted output result i.e. fuzzy output is converted into a crisp output. This stage involves in the determination of a single value or class that represents the overall assessment of the groundnuts variety either Ex-dakar, Jarma or Samnut 26 (Mai borgo).

Fig. 5 shows the block diagram of the fuzzy logic controller architecture.

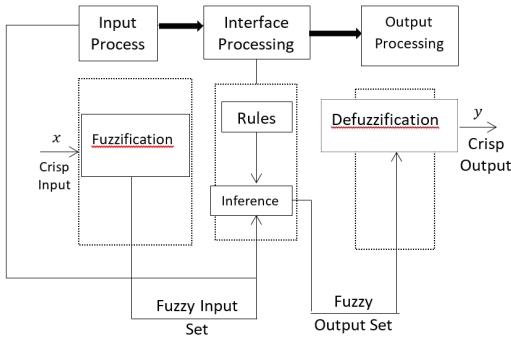


Fig. 5. Fuzzy Logic Architecture

E. Threshing Machine Design

1. Frame of the Thresher

The frame has a trapezoidal shape and is designed to support the load of the threshing components as shown in Fig. 6. Area of the frame is given as

$$A = \frac{1}{2}(a + b)h \quad (8)$$

$$\text{Stress of frame} = \frac{\text{Total load}}{\frac{1}{2}(a + b)h} \text{ N/m}^2 \quad (9)$$

Where,

- W = the weight (N)
- m = mass of threshing drum (kg)
- g = acceleration due to gravity (m/s^2)
- p = the density of the (kg/m^3)
- V = the volume of the (m^3)

The following are the loads on the thresher frame.

$$\text{Stress} = \frac{\text{Load}}{\text{Area}}$$

i. Weight of threshing Drum

$$\begin{aligned} W_c &= mg \\ m &= \rho V \end{aligned} \quad (10)$$

The circumference of drum = πD (mm)

Circumference of drum = mm

$$\text{Volume of curve section} = L_d \times C_d \times T_d \quad (11)$$

$$\begin{aligned} V_c &= mm^3 \\ V_d &= mm^3 \end{aligned}$$

$$\text{Volume of side} = \frac{\pi D^2 t}{4} = mm^2 \quad (12)$$

$$\text{Total volume of drum} = V_s + V_c = mm^3$$

$$W_d = mg = \rho V g$$

ii. Pulley

$$W_p = mg \quad (13)$$

$$m = \rho V$$

$$V = A \times L_p$$

$$A = \frac{\pi d^2}{4}$$

iii. Weight of Shaft

$$W_s = mg \quad (14)$$

$$m = \rho V$$

$$V = A \times L_s$$

$$A = \frac{\pi d^2}{4}$$



Fig. 6. Thresher Frame

2. Hopper

The hopper as shown in Fig. 7 is used to feed groundnut pods into the threshing unit.

Upper hopper

$$\text{Area} = \text{length} \times \text{width} \text{ (mm}^2\text{)} \quad (15)$$

$$\text{Volume} = \frac{1}{3}(\text{area} \times \text{height}) \text{ (mm}^3\text{)} \quad (16)$$

Lower hopper

$$\text{Area} = \text{base} \times \text{width} \text{ (mm}^2\text{)}$$

$$\text{Volume} = \frac{1}{3}(\text{area} \times \text{height}) \text{ (mm}^3\text{)}$$

$$\text{Volume of hopper} = \text{upper hopper} - \text{lower hopper} \text{ (mm}^3\text{)}$$

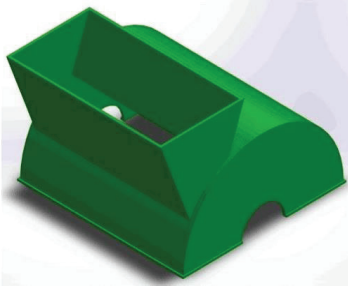


Fig. 7. Hopper

3. Threshing Unit

i. Concave radius (screen)

Concave clearance is the gap between the threshing drum and the concave, which determines the effectiveness of the threshing process as shown in Fig. 8.



Fig. 8. Concave clearance

The radius of curvature rc can be determined by

$$rc = rd + hp + Cc \quad (17)$$

Where,

rc = Concave radius (mm)
 rd = Radius of cylinder drum (mm)
 hp = Peg height above the drum (mm)
 Cc = Concave clearance (mm)

ii. Rupture force of groundnut

$$Fc = \frac{f}{A \times g} \quad (18)$$

A = area of groundnut pod m^2
 g = gravitational force m/s^2

iii. Power requires to threshing is given by

$$P = W \times x \times FR \times \log \frac{L_1}{L_2} \quad (19)$$

F_R = Rupture force of groundnut
 K_k = Kick's constant
 W = Average weight of unshelled groundnut
 L_1 = Average length of unshelled groundnut
 L_2 = Average length of shelled groundnut

iv. Shaft and Pulley

Shaft cylinder was given as;

$$d_s = \frac{16}{\pi \tau} \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad [22] \quad (20)$$

Torsion moment of the shaft was give as;

$$M_t = \frac{60P}{2\pi N} \quad (21)$$

Where,

P = Power require for threshing
 N = Speed of the cylinder drum (rpm)
 d_s = Shaft diameter (mm)
 K_b = Shock and fatigue factor applied to bending moment
 K_t = Shock and fatigue factor applied to torsional moment
 M_t = Torsional moments
 τ = Allowable stress of the steel shaft

For the pulley

$$N_1 D_1 = N_2 D_2 \quad (22)$$

Where,

N_1 = Speed of driving pulley prime mover (rpm)
 N_2 = Speed of driven pulley of thresher (rpm)
 D_1 = Diameter of driving pulley prime mover (mm)
 D_2 = Diameter of driven pulley thresher (mm)

4. Design of Separation Unit

The major components of this unit is fan as shown in which blows the air.

i. Blower

$$\text{Discharge of air through the blower} \\ Q = (V \times D \times W) \quad (23)$$

Where,

Q = Air flow rate m^3/s
 W = Width over which the air is required (m)
 V = Air velocity for cleaning (m/s)
 D = Depth of air stream (m)

5. Driven System

Considering the pulley of radius (r) in meter acts upon a circumferential force F in Newton which causes it to rotate at N rpm and generate a torque τ in Nm, the following (24) to (29) are adopted from [23].

$$\tau = F \times r \text{ (Nm)} \quad (24)$$

The work done, W by this force for one revolution can be shown as

$$W = F \times d = F \times 2\pi r \text{ Joule} \quad (25)$$

Therefore, for N number of revolution, the work done can be expressed as

$$W = F \times 2\pi r \times N \text{ Joule} \quad (26)$$

The power developed, P is determined from

$$P = \tau \times \omega \text{ Watt} \quad (27)$$

Where,

ω = Angular velocity (rad/s)

and

$$\omega = \frac{2\pi N}{60} \text{ rad/s} \quad (28)$$

Therefore

$$P = \tau \times \frac{2\pi N}{60} \text{ watt} \quad (29)$$

6. Conveyor System

The conveyor will be used to transport clean groundnut seeds as shown in Fig. 9. The belt speed and its capacity of conveyor were adopted from [24].

$$\begin{aligned} \text{i.} \quad V &= d \times \pi \\ V &= m/s \end{aligned} \quad (30)$$

$$\begin{aligned} \text{ii. Belt capacity (kg/m) is given as} \\ B.C &= 3.6 \times A \times \rho \times V \end{aligned} \quad (31)$$

Where,

C = conveyor capacity (kg/m)

V = belt speed (m/s)

A = belt sectional area (m²)

d = roller diameter (mm)

ρ = material density (kg/m³)

$$\begin{aligned} \text{iii. Torque } (\tau) &= \frac{60P}{2\pi N} \\ \tau &= Nm \end{aligned} \quad (32)$$

iv. Belt length

The effective belts length of conveyor

$$L_b = \frac{\pi}{2} (D_1 - D_2) + \frac{(D_1 - D_2)^2}{4c} + 2c \quad (33)$$

Where,

D_1 = Diameter of driving pulley (mm)

D_2 = Diameter of driven pulley (mm)

C = Centre distance between driving and driven pulley (mm)

$$\begin{aligned} C &= \left(\frac{D_2 \times D_1}{2} \right) + D_1 \text{ (mm)} \\ N_1 D_1 &= N_2 D_2 \end{aligned} \quad (34)$$

Where,

N_1 = Speed of driving pulley prime mover (rpm)

N_2 = Speed of driven pulley of conveyor (rpm)

D_1 = Diameter of driving pulley prime mover (mm)

D_2 = Diameter of driven pulley conveyor (mm)

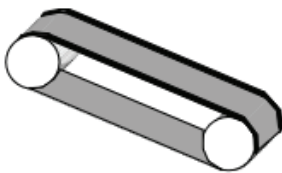


Fig. 9. Conveyor

IV. Conclusion

The design and development of an intelligent groundnut threshing machine using machine vision techniques represent a significant breakthrough in the innovation in agricultural post-harvest operations. This review has examined various existing machine threshing technologies and methodologies, and has identified the limitations in traditional systems, such as inefficiencies in sensors performance, absence of intelligent feedback mechanisms, absence of modern control technologies and mechanical damage to seeds. The integration of machine vision and fuzzy logic control provides a more adaptive and precise approach to threshing machine, enabling automatic identification of groundnut pods varieties, assessment of pod texture, shape and size, in real-time adjustment of operational parameters. The application of image processing, feature extraction and supervised learning machine learning model enhances efficiency, minimizes groundnut seed damage, and supports consistent robust output quality. However, challenges such as semi-automation, limited microcontroller capabilities, and sensors durability must still be addressed. Future efforts should focus on improving the accuracy of vision systems, more robust computing research and developing affordable, locally adaptable solutions for farmers. The adaptation of intelligent threshing machines driven by artificial intelligence with vision technique that holds the transformed groundnut processing has also contributed significantly to the advancement of precision agricultural production.

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Conflict of Interest

There is no conflict of interest in regard to the publication process of this research work.

Author Contributions

Author 1 is responsible for conducting research experiments, machine models design, and writing the research journal. Author 2 provides research leadership and ensuring contribution to knowledge is given. Author 3 is in charge for the technical design aspects of the machine design and integrating the engineering

principles into the realization of intelligent groundnut threshing system. Author 4 ensure relevant publications were consulted and all observation during the research is implemented.

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