GE-International Journal of Engineering Research (GE-IJER)

VOLUME NO. 12
ISSUE NO. 1
JANUARY - APRIL 2024

EIS LEARNING
No - 198, Upper Hatia, Near Mahatma Gandhi
Smarak High School, Ranchi - 834003, Jharkhand
Ph : 919097302256 / Email : info@eislearning.com

GE-International Journal of Engineering Research (GE-IJER)

AIM AND SCOPE

GE-International Journal of Engineering Research (GE-IJER) is a leading international journal for publication of new ideas founded by engineers, academicians and corporate people. The GE-IJER is not limited to a specific aspect of science and engineering but is instead devoted to a wide range of subfields in the engineering sciences. While it encourages a broad spectrum of contribution in the engineering sciences, its core interest lies in issues concerning material modeling and response. Articles of interdisciplinary nature are particularly welcome. The research results and fundamental advancement are all aspects of Engineering Trends & Technology and various engineering discipline. The journal welcomes publications of high quality papers on following areas- Cloud Computing, Mobile Commerce, Software Engineering, Software Re-Engineering, VLSI Implementation, Broadband and Cellular Network, Data Mining (Image, Text, Pattern), Networks (Wireless Sensor Networks, Mobile Computing), Software Engineering (Metrics, Quality Assurance, Testing), Adaptive filtering Mixed and Non Linear Signal Processing, Power Quality in grids with distributed generation and Renewable energies, Analysis, Design control and applications of Electrical machines and drives, E-Commerce Management and Social Issues, Brain Models, Distributed & Grid Databases, Adaptive filtering Mixed and Non Linear Signal Processing, Image Recognization in Embedded System, and allied subjects. Empirical research using primary, secondary or experimental data is also encouraged.

GE-International Journal of Engineering Research (GE-IJER)

(Volume No. 12, Issue No. 1, January - April 2024)

Contents

Identification the Appearance Quality of Rice Kernels by Vision Technology and Neural Network Classifier

Ali Dabaghi[1], Mohamad Hadi Khoshtaghaza[1*], Mohamad Reza Alizadeh[2], Hemad Zareiforoush[3]

[1] Biosystems Engineering Department, Tarbiat Modares University, Tehran, Iran

[2] Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Guilan, Iran

[3] Department of Agricultural Mechanization Engineering, University of Guilan, Guilan, Iran

*Corresponding author E-mail: khoshtag@modares.ac.ir

ABSTRACT

In this study, the appearance quality of Hashemi variety of rice grains was evaluated using image processing and artificial neural network (ANN) classifier. Non-touching kernel images of different classes in a Hashemi rice sample were acquired using a flatbed scanner. Then preprocessing, segmentation, feature extraction and effective feature selection process were done on each objects of image. To categorized grains, various structures of ANN consisting network with one and two hidden layer with different hidden nodes, different training and transfer functions were considered. Results of validation stage showed ANN with 13-18-18-5 topology and LM training and tansig transfer functions had highest mean of classification accuracy (97.33%) and the lowest value of RMSE (0.08361). It's concluded that the suggested method uses low cost equipment to identify quality of rice with acceptable accuracy. Results of this research can be used for fast and accurate grading and developing an efficient rice sorting system.

Keywords: Artificial Neural Network; Classification; Image Processing; Quality; Rice.

1. INTRODUCTION

Rice is an important and mature food product in the world especially in Asia which provides energy and considered as the main food. Rice is a major crop in Iran, too. The most important regions for producing rice are in the northern provinces of IRAN [1]. Among different varieties of rice, Hashemi variety has good marketability due to having appropriate flavor, size and cooking quality, and most widely grown by farmers in these regions. There is direct relationship between economic value and grain quality. The rice quality includes appearance quality (related to its shape, size and color), milling quality (which define as the quality of product derived from paddy) and cooking quality (that identify by some ways like the needed time for cooking grains, the elongation ratio within cooking, the amount of solid particles that remain in the water of cooked grains and the percent of water absorption of each grains) [2], [3]. Head rice yield (HRY) is one of the appearance quality factors which is related to the number of sound and broken kernels existed in a sample [4]. Broken rice kernels has less marketability and price rather than sound kernels. Rice kernels with a length of less than three fourths of healthy kernels are called as broken kernels [5]. Percentage of chalky and discolored grain are another appearance quality factors. Generally, rice kernels are translucent. If a segment of the white rice is opaque (not translucent), it is identified as chalky [6]. Although appearance of chalky kernels fade during cooking process but presence of chalky kernels decreased the quality and grain salability [7]. Discoloration (excessive browning and blacking) in rice kernels occurs due to harvesting in high grain moisture content, harvesting during presence of dew, inappropriate storage, delay or improper drying, development of fungi and biochemical process [8], [9]. Presence of some discolored kernels in sample of white rice has adverse effects on its appearance quality which effects on its economic value.

Traditionally, rice quality is determined manually by well-trained human inspectors which are tedious, time-consuming and non-consistent. Various inspectors make own their decision about what they feel. As a result, they might have high percent of error. This has generated the need for new methods that are simple, rapid, accurate, and nondestructive [10]. In recent years, researchers have been able to invented automatic methods based on camera and computer which have the ability to analyze the characteristic of the different products [11]. This methods called as computer vision system. There are five main components which are related to computer vision system such as illumination, acquisition of image, board of image capture (digitizer or frame grabber), processing and analyses of image [12].

Some of researchers have represented the computer vision application on distinguishing and classifying of grain and its relevant quality factors in case of bulk form or single kernel. Paliwal et al., [13] extracted shape and size features like compactness, roundness, ferret diameter, elongation, major and minor axis length, perimeter and area for some cereal grain like rye, barley, oats, Canadian Western Amber Durum (CWAD) wheat and Hard Red Spring (HRS) wheat. Then the extracted features were used in order to train different structures of ANN. The reported accuracy of classification was up to 88% for tested cereal grains by ANN networks with four layer structure. Visen et al., [14] categorized some Canadian cereal grains by extracting morphological features. They represented categorized accuracies of 98.7% for barley, 99.3% for CWRS wheat, 96.7% for CWAD wheat, 98.4% for oats, and 96.9 for rye which were acquired by using expert probabilistic ANN. Golpour et al., [15] developed an algorithm based on color features and ANN for identifying and classifying five Iranian bulk paddy, brown and rice varieties. Images of bulk sample were obtained by appropriate scanner. Result represented that the ANN with two hidden layers and topologies of 36-6-5-5, 36-9-6-5 and 36-6-6-5 had mean classification accuracy of 98.8, 100, and 100% for paddy, brown and white rice varieties, respectively.

Aulakh and Banga, [10] developed an algorithm for determining purity percent of non-touching brown rice samples. After segmentation of scanned brown rice images, they changed to binary images for performing other morphological operations. The mean area (in pixel) of broken grains was lower than sound grains. Thus, an area based threshold value was selected to discriminate between sound and broken grains. By counting all kernels (before threshold) and sound kernels (after threshold) in sample image, the percent of purity was determined. A same method of morphological operations was conducted by Prajapati and patel, [16] and Ajay et al., [17]. In another study, Dalen, [18] had studied on identification of the dimension, amount of sound grains, and rice dimension distribution using flatbed scanning (FBS). Also Zareiforoush et al., [19] specified the best classification methods for grading of white rice kernels based on their lengths and degree of milling. Images of four various categories of non-touching milled rice consisting low-milled broken kernels (LMB), low-milled sound kernels (LMS), high-milled broken kernels (HMB), and high-milled sound kernels (HMS) were obtained by using a CCD camera. Fifty seven features (including 5 features belong to size and shape, 4 features belong to texture and 48 features belong to color) were extracted for each rice kernel. Four various techniques of classification consisting support vector machine (SVM), decision tree (DT), artificial neural networks (ANN) and Bayesian Network (BN) were used to classify samples. Results showed that all of the classification techniques had acceptable accuracy. Among them, BN with Hill Climber search algorithm had the lowest accuracy of 96.89 % and ANN with 12-5-4 topology had the highest accuracy of 98.72 % for classification of samples. Also the classification accuracy of DT with REP algorithm and SVM with Universal Pearson VII kernel function was 97.5 and 98.48 %, respectively.

Yadav and Jindal, [20] monitored milling quality of ten Tahi rice varieties using image analyses. By a CCD camera, they calculated three size and shape features such as projected area, perimeter and length for each individual kernel. Ten Thai rice varieties were selected. At first, all of the paddy samples were dehusked. Then, dehusked samples (brown rice) were purred into a laboratory milling device in order to produce white rice. The milling time was adjusted between 0.5 to 2.5 min with intervals of 0.5 min to produce white rice with different degree of milling. The morphological features of projected area, length and perimeter were calculated for each object. For milling performance evaluation, mean gray level distribution of bulk sample was obtained from images and correlated with results of commercial whiteness meters that operate based on white rice surface reflectance of light. Results show that projected area of each kernel was useful param- eter for calculating the HRY. Also the results showed that the gray level depended to milling degree and varieties. It was changed from 70 to 190. In all varieties, with increasing degree of milling, the amount of mean gray level was increased. In another research, potential of chalkiness determination was evaluated by Yoshioka et al., [21]. The study was conducted based on chalkiness rate and chalkiness position on each kernels. A SVM classifier was used to categorize grains. Results show that SVM classifier could identify the chalkiness rate with mean accuracy of 85.5 %. Also, accuracy of 90.2 % was obtained by SVM for calculating chalkiness position on each kernel. The overall results indicated that vision technology is powerful tools for chalkiness identification.

A sample of white rice (Hashemi variety) may contain various percentages of white rice, yellow rice, gray or black rice, chalky rice and broken rice which effects on its marketability, quality and price. Literature review showed that there is no comprehensive research for determination all of the major quality parameters of rice. Thus, our research goal was to create a vision based program to determine amount of head white rice (HWR), head yellow rice (HYR), head gray rice (HGR), head chalky rice (HCR) and broken rice (BR) that existed in a sample.

2. MATERIALS AND METHODS

The steps of our vision based program are shown in Fig. 1. After preparation of samples, images of rice kernels were taken. Then the taken images were pre-processed and features related to morphology, texture and color of each object were calculated. In the next step, proper features were selected. Selected features were applied as inputs to ANN classifier for separating various classes and finally the classifier performance was evaluated.

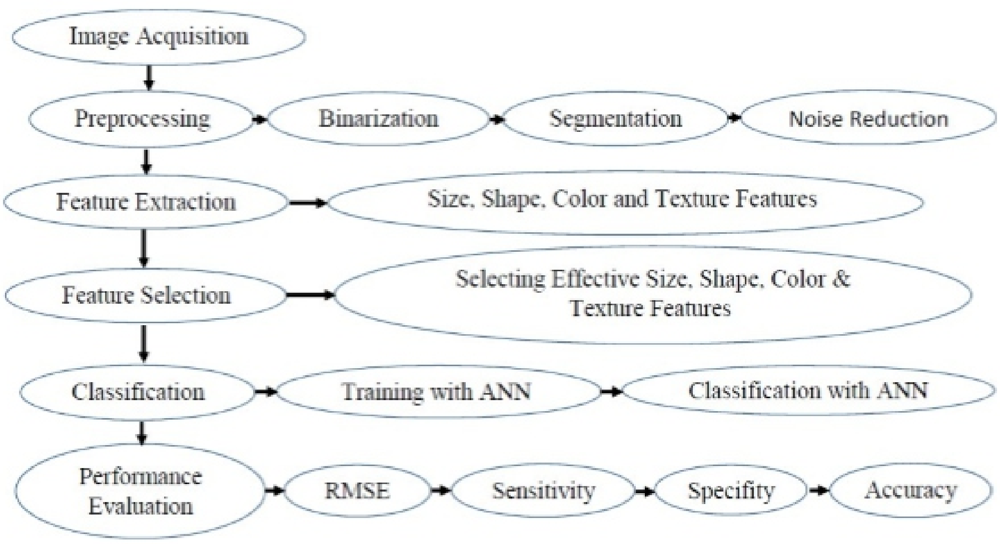


Fig. 1: Steps of Rice Image Processing Procedure.

2.1. Sample preparation

The amount of 4 kg sample of Hashemi variety containing five different classes including sound kernels (white, gray, yellow and chalky kernels) and broken kernels was prepared from the Rice Research Institute of Iran (RRII). The initial moisture content of the sample was between 11-14% (w.b.) which was evaluated by a digital moisture meter (GMK model 303RS, Korea). The sample was then divided into four parts of 1 kg and each part was given to an expert in order to separate different classes in the sample. Finally, each separated class mixed together and 300 kernels from each class were randomly selected.

2.2. Image acquisition

For taken the images of rice kernels, a flatbed scanner (HP Scanjet 3570c, USA) with 300 dpi resolution and 2528×3507 pixels in JPG format was used. Each captured image of each class containing 300 kernels. The kernels were purred on the scanner glass and separated manually from each other. Then a black sheet was placed on them and their images were taken. Totally, images of 1500 kernels were obtained from all classes. Images of various classes of Hashemi rice are represented in Fig. 2, where Fig. 2-A, shows head white rice (HWR), Fig. 2-B, shows head chalky rice (HCR), Fig. 2-C, shows head gray rice (HGR), Fig. 2-D, shows head yellow rice (HYR) and Fig. 2-E, shows broken rice (BR). In order to display visual performance of suggested algorithm, an images containing combination of all classes in non-touching form were captured (see Fig. 2-F).

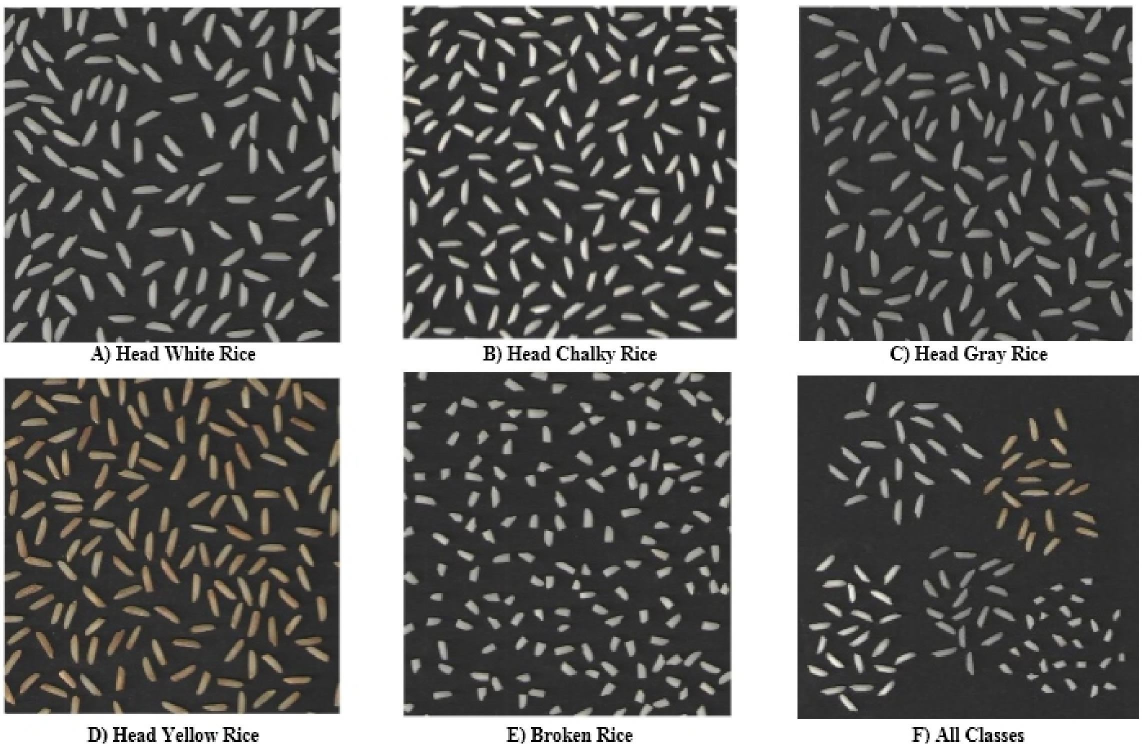


Fig. 2: Images of Different Classes Which Existed in Hashemi Rice Sample.

2.3. Pre-processing

Preprocessing is a mathematical set of operations that is performed on a digital image to fit that image for a particular purpose (for example feature extraction). In this study, preprocessing procedure consist of binarization of RGB image, noise removal, filling inside of each object (kernel), segmentation and labeling of each kernel (head or broken) from other in the image. The RGB images binarization were done based on Otsu threshold method. In this method, at first, a threshold coefficient value was applied on gray level intensity of image. Then intensity of each pixel compared with selected threshold value. If pixel intensity was greater than threshold, the pixel intensity becomes 1 (white) and vice versa. In our research, the threshold coefficient value of 0.35 was selected. At the next stage, the generated noises caused by factors such as converting color images to binary images, the presence of small particles on the scanner glass and etc., were removed from the images. Then, in order to extract correct data related to object's morphology (size and shape), filled inside of each object. Finally, all objects (kernels) in the image were separately segmented and labeled to analyze each kernel. The above steps are shown in Fig. 3.

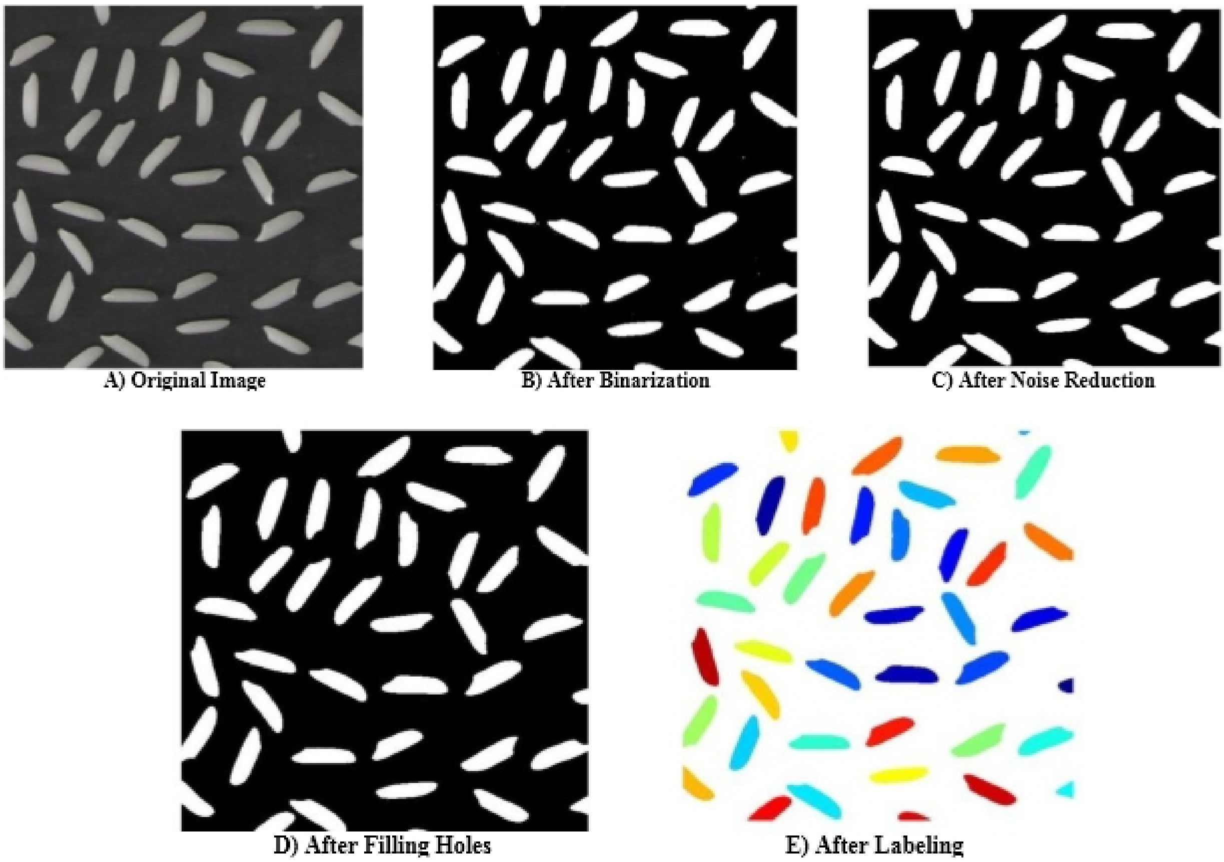


Fig. 3: Different Steps of Preprocessing of Hashemi Head White Rice.

2.4. Feature extraction

This step of image processing is done in order to describe, identify or classify and separation of the objects. In this paper, features related to size, shape were extracted from each object (see Table 1) [22], [23]. The RGB and HSI color spaces were used for color feature extraction and six statistical descriptor namely mean, variance, standard deviation, skewness, kurtosis and range were extracted from each related component (Table 2-A). Totally 36 color features (6 related component × 6 statistical descriptor) were extracted from each object [24]. Texture analyze of each object was done by extracting gray level co-occurrence matrix (GLCM). For calculating the GLCM, the occurrence probability of pair of pixels with specific structure which arranged next to each other, must be calculated. This structure included a relative distance of d (in pixel) and orientation of θ (θ = 0, 45, 90 and 135) between pair of pixels that are in the neighborhood of each other. In this study, the distance of d=1 and orientation of θ=0 was selected for calculating the GLCMs. Then, ten statistical features were extracted according to Table 2-B. Thus, a total of 60 texture features (10 statistical features ×1 orientations ×6 relevant component) were extracted from each object in each relevant component of R, G, B, H, S and I [24]. In sum, 110 features including 14 size and shape, 36 color feature and 60 texture feature were extracted for each object in the image.

Table 1: The Extracted Size and Shape Feature From Each Object [22], [23]

No.	Feature name and definition	No.	Feature name and definition
1	Major axis length	8	$Solidity = \frac{Area}{Convex\ Area}$
2	Minor axis length	9	$Extent = \frac{Area}{Area of the bounding box}$
3	Area	10	$Roundness = \frac{4 \times \pi \times Area}{(Perimeter)^2}$
4	Perimeter	11	$Shape\ factor\ 1 = \frac{Major\ axis\ lenght}{Area}$
5	$Aspect\ ratio = \frac{Major\ axis\ lenght}{Minor\ axis lenght}$	12	$Shape\ factor\ 2 = \frac{Area}{(Major\ Axis\ lenght)^3}$
6	$Equivalent\ diameter = \sqrt{\frac{4 \times Area}{\pi}}$	13	$Shape\ factor 3 = \frac{Area}{\left(\frac{Major\ axis\ lenght}{2}\right)^2 \pi}$
7	$Compactness = \frac{Equivalent\ diameter}{Major\ axis\ lenght}$	14	$Shape\ factor\ 4 = \frac{Area}{\left(\frac{Major\ axis\ lenght}{2}\right)\left(\frac{Minor\ axis\ lenght}{2}\right)\pi}$

Table 2: Used Statistical Descriptor for Extracting Color and Texture Features [24]

A) Color features			B) Texture features		
No.	statistical descriptor		No.	Gray level co-occurrence matrix (GLCM)	
	Feature name	Formula		Feature name	Formula
1	Mean	$\mu = \sum_{i=0}^{L-1} Z_i P(Z_i)$	1	Contrast	$\sum_{i,j} \|i-j\|^2 p(i,j)$
2	Variance	$\sigma_2 = \sum_{L=0}(Z_i - \mu)_2 P(Z_i)$	2	Correlation	$\sum_{i,j} \frac{(i-\mu i)(j-\mu j) p(i,j)}{\sigma_i \sigma_j}$
3	Standard deviation	$\sigma = \sqrt{\sum_{i=0}^{L-1}(Z_i - \mu)^2 P(Z_i)}$	3	Uniformity (Energy)	$\sum_{i,j} p(i,j)^2$
4	Skewness	$\frac{1}{\sigma^3}\sum_{i=0}^{L-1}(Z_i - \mu)^3 P(Z_i)$	4	Homogeneity	$\sum_{i,j} \frac{p(i,j)}{1+\|i-j\|}$
5	Kurtosis (4th moment)	$\frac{1}{\sigma^4}\sum_{i=0}^{L-1}(Z_i - \mu)^4 P(Z_i)$	5	Entropy	$-\sum_{i,j} p(i,j) \log p(i,j)$
6	Range	$\max(L \times P(Z_i)) - \min(L \times P(Z_i))$	6	Maximum of probability	$\max(p(i,j))$
			7	Dissimilarity	$\sum_{i,j} \|i-j\| p(i,j)$
			8	Cluster shade	$\sum_{i,j} ((i-\mu i)+(j-\mu j))^3 p(i,j)$
			9	Cluster prominence	$\sum_{i,j} ((i-\mu i)+(j-\mu j))^4 p(i,j)$
			10	Variance	$\sum_{i,j} (i-\mu i)^2 p(i,j)$

L, μ, σ, Z_i, $P(Z_i)$ and $p(i,j)$ are dimension of image, mean of intensity, standard deviation, intensity levels, the number of possible intensity levels and GLCM matrix, respectively.

2.5. Effective feature selection

All of the 110 extracted features from each object are not appropriate for good classification and they may decrease accuracy and increase processing time of classification. The effective feature selection process is so important step and selected features must be considered as input of classifier. Several methods like wrapper methods, factor analysis (FA), sensitivity analysis (SA), correlation based feature selection (CFS) and principle component analysis (PCA) are usable for choosing best features [25 - 27]. Best features of our research was selected by CFS method. Generally, in feature selection methods, a feature evaluator and search method are needed. The feature evaluator specified which methods was used to dedicate a merit to each subset of features. When CFS method was used as evaluator, the following hypothesis was considered: "A good feature subset is one that contains features highly correlated with (predictive of) the class, yet uncorrelated with (not predictive of) each other" [28]. Also, the search method is an algorithm which determine searching style. In the current study best first search algorithm (BFS) was selected because of it allows backtracking along the search path. It was applied on the extracted shape, size, color and texture features of different classes of Hashemi variety using "CfsSubsetEval" evaluator in WEKA software [29]. The output results of CFS method indicated that the number of features decreased from 110 to 13, including 5 for shape and size features, 4 for color features and 4 for texture features. The selected features name are shown in Table 3.

Table 3: Superior Features Which Selected by CFS Algorithm

Size & shape features	Color features	Texture features
Area	S_{hsi} Mean	B_{rgb} Correlation
Shape factor 2	B_{rgb} Std	H_{hsi} Maximum of probability
Equivalent diameter	S_{hsi} Std	S_{his} Energy
Major axis lenght	B_{rgb} Variance	S_{hsi} Entropy
Perimeter		

* S and B are related to the HSI and RGB color components, respectively.

2.6. Classification

Many techniques like Decision Tree (DT), K-Nearest Neighbor (KNN), Fuzzy Logic (FL), Artificial Neural Network (ANN) and Support Vector Machine (SVM) are used by researchers for classification [26], [30]. An ANN is an idea for data processing which has been improved by biological neural system and processed data like human brain [31]. One of the most advanced neural model is multi-layer perceptron (MLP) which can simulate transitional function of human brain and were applied in various application like prediction and classification [27]. Each simple neural network consist of input and output layer which is used to solve simple problems, while in MLP, there are additional layers (or layer) called hidden layers (or layer) which helps to solve complex problems. MLP networks belong to feed forwards network. This network is trained based on back propagation algorithm. Also different back-propagation algorithm such as SCG (scaled conjugate gradient), LM (Levenberg-Marquardt), GDM (gradient descent with a momentum), GDX (gradient descent with mo- mentum and adaptive learning rate back-propagation), OSS (one step secant) and etc. are available. They are used for minimizing the error [27], [31]. For classification of our rice sample, MLP network was used.

The numbers of neurons were 13 in input layer which were same to the number of effective chosen features as represented in Table 3. The number of neurons in output layer was five, which was equal to the number of different existed classes, including head white rice (HWR), head chalky rice (HCR), head gray rice (HGR), head yellow rice (HYR) and broken rice (BR), in Hashemi rice sample. Generally, the number of hidden layer and hidden nodes are directly affected on accuracy of classification. Hence, determining these optimal numbers are crucial steps in designing classifier and usually founded by trial and error methods [15]. As well as, various transfer functions like purelin, logsig and tansig permit the network to know linear and nonlinear relationships between input and output data. Consequently they may have effect on performance of ANN and must be considered [32].

2.7. Performance evaluation

In this study, about 75% of the samples (225 kernels for each class) were randomly selected for training the network, while the rest of the samples were used as test set. Different structures includes four training algorithm (GDX, LM, OSS and SCG), one and two hidden layer with different hidden node (2- 4 - 6 - … -

18 and 2, 2- 4, 4 - 5, 5 - … - 18, 18) and three transfer function (purelin, logsig and tansig) were tested in order to determine the optimal performance for the network. The best network topology was chose based on overall accuracy and root mean squared error (RMSE) indexes [26]. All networks were run three times and the mean of overall accuracy and RMSE were considered as decision indexes. Also, to describe performance of the best selected network, three statistical indicators such as accuracy (Ac), sensitivity (Se), specificity (Sp) and confusion matrix were used. Sensitivity is related to positive objects which correctly predicted, and specificity is related to negative objects which correctly predicted. Whereas accuracy is related to both positive and negative objects which correctly predicted. Their mathematical relation are shown by Equations (1) to (4) [19], [31].

$$A_c = \frac{TP + TN}{TP + FP + TN + FN} \times 100. \quad (1)$$

$$S_e = \frac{TP}{TP + FN} \times 100. \quad (2)$$

$$S_P = \frac{TN}{FP + TN} \times 100. \quad (3)$$

$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (A_i - P_i)^2}. \quad (4)$$

Where, TP is true positive (the number of kernels whose their real class was positive and correctly classified as positive), TN is true negative (the number of kernels whose their real class was negative and correctly classified as negative by classifier), FP is false positive (the number of kernels whose their real class was negative and incorrectly classified as positive) and FN is false negative (the number of kernels whose their real class was positive and incorrectly classified as negative). Also N is total test set, Ai is actual value and Pi is predicted value.

3. RESULTS AND DISCUSSION

Results of accuracy mean and RMSE indexes obtained from different neural networks test with one hidden layer, different number of neurons, different training and transfer functions are represented in Fig. 4 and 5. According to Fig. 4, after network training and simulation of the tested data, the findings represented that structures with "purelin" and "tansig" transfer function had a passable accuracy range. Among them, the highest accuracy indexes were related to LM training function with "tansig" transfer functions, 10 and 16 number of neurons (13-10-5 & 13-16-5 topologies). These values were 96.33 and 96.67, respectively. In order to choose the best topology of one layer network, the RMSE of each topology were intended and network with lowest RMSE was selected. The value of RMSE index for 13-16-5 topology was 0.1004 which was less than the value of RMSE for 13-10-5 topology with amount of 0.11176. So neural network with 13-16-5 topology (one layer with 16 neurons), LM training function and tansig transfer functions was selected as the best structure.

The results of accuracy mean and RMSE index for ANN with two hidden layer and different number of neurons, training and transfer functions are shown in Fig. 6 and 7. The worst performance were related to networks with logsig transfer functions which had minimum accuracy and maximum RMSE in all neurons and training functions. Like the findings acquired from one layer ANN, structures with "purelin" and "tansig" transfer function had an acceptable accuracy range. As represented in Fig. 6, topologies with 18 and 20 neurons in each hidden layer (13-18-18-5 & 13-20-20-5) with tansig transfer function an LM training function had the greatest accuracy index with the values of 97.33 and 96.67, respectively. According to Fig. 7, the lowest value of RMSE was related to 13-18-18-5 topology with the amount of 0.08361. So the best two hidden layer topology was 13-18-18-5 with Lm training function and tansig transfer function.

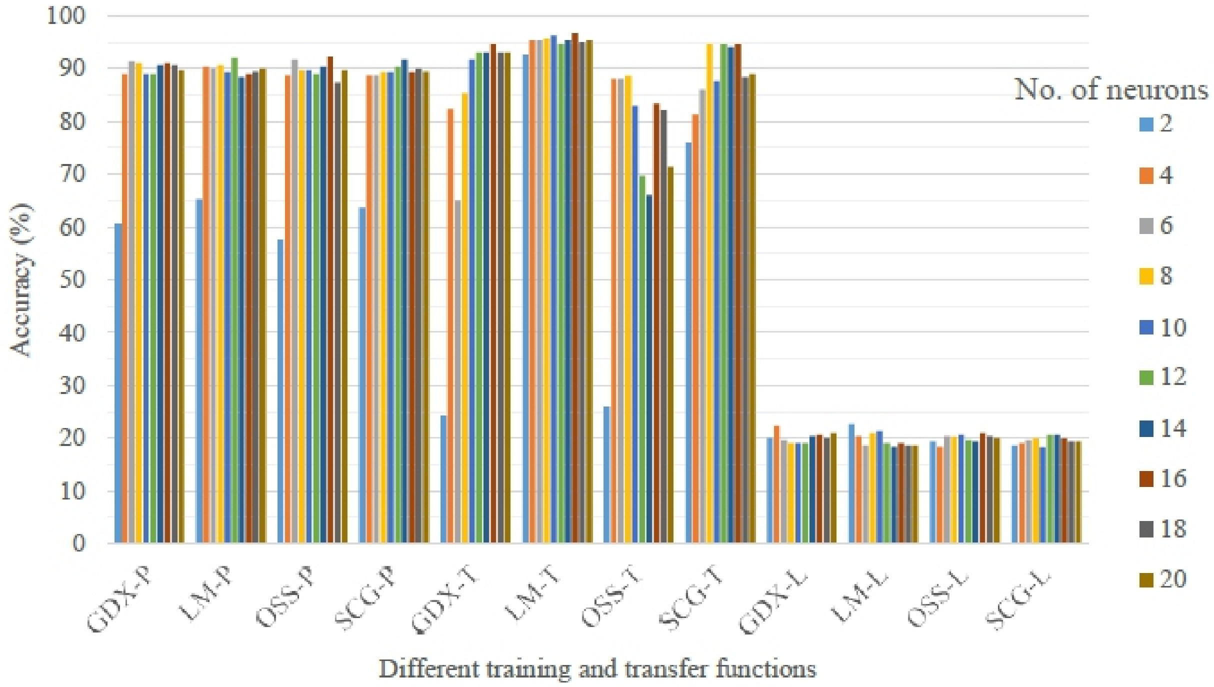


Fig. 4: Variation of Accuracy Index for ANN with One Hidden Layer and Combination of Different Number of Neurons, Training and Transfer Functions. (P, T and L Represents Purelin, Tansig and Logsig, Respectively

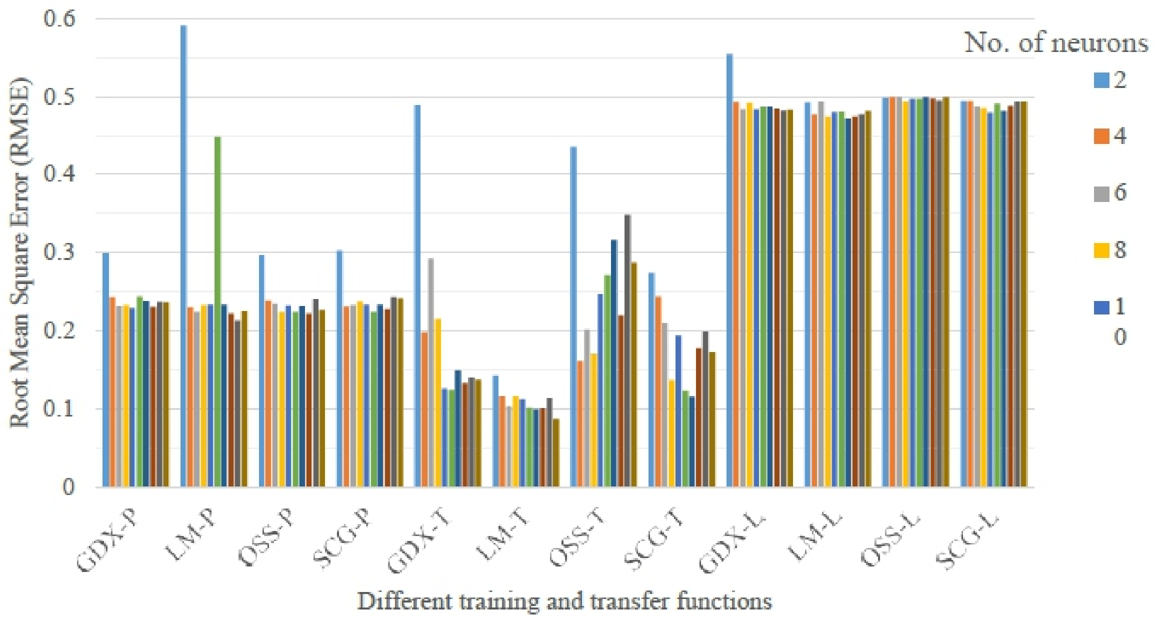


Fig. 5: Variation of the RMSE Index for ANN with One Hidden Layer and Combination of Different Number of Neurons, Training and Transfer Functions. (P, T and L Represents Purelin, Tansig and Logsig, Respectively).

Comparison between the best selected networks with one and two hidden layer showed that network with two hidden layer and 13-18-18- 5 topology had maximum accuracy and minimum RMSE. Such network was appropriate for separating different classes which existed in the samples. Similar result was reported by Golpour et al., [15]. They used one layer neural network with 36-24-5, 36-7-7 and 36-5-5 topologies, Lm training function and logsig-purelin transfer functions for input and output layer in order to recognize and categorize of bulk paddy, brown rice and white rice of some Iranian varieties and reported mean classification accuracy of 93.3, 98.9 and 100%, respec- tively. For improvement the classification accuracy, they examined network with two hidden layer and explained the mean accuracy up to 98.8%. Liu et al., [33] recognized six paddy varieties based on ANN data mining method. They used ANN with tansig-logsig transfer function for classification and reported average classification accuracy of 84.43 %. Similar studies were done by Silva and Sonnadara, [34]; Shantaiya and Ansari, [35]; Rexce and Usha Kingsly Devi, [30] and Prajapati and Patel, [16] for identification of various rice types by ANN. In another research, Zareiforoush et al., [19] specified the best classification methods for grading of white rice grain based on length and degree of milling of the white rice kernels. The 12-5-4 topology of ANN was selected as superior topology with the mean accuracy of 98.72% which was suitable for classification of different quality grades of milled rice including (low-milled sound grain (LMS), low- milled broken grain (LMB), high-milled sound grain (HMS) and high-milled broken grain (HMB)).

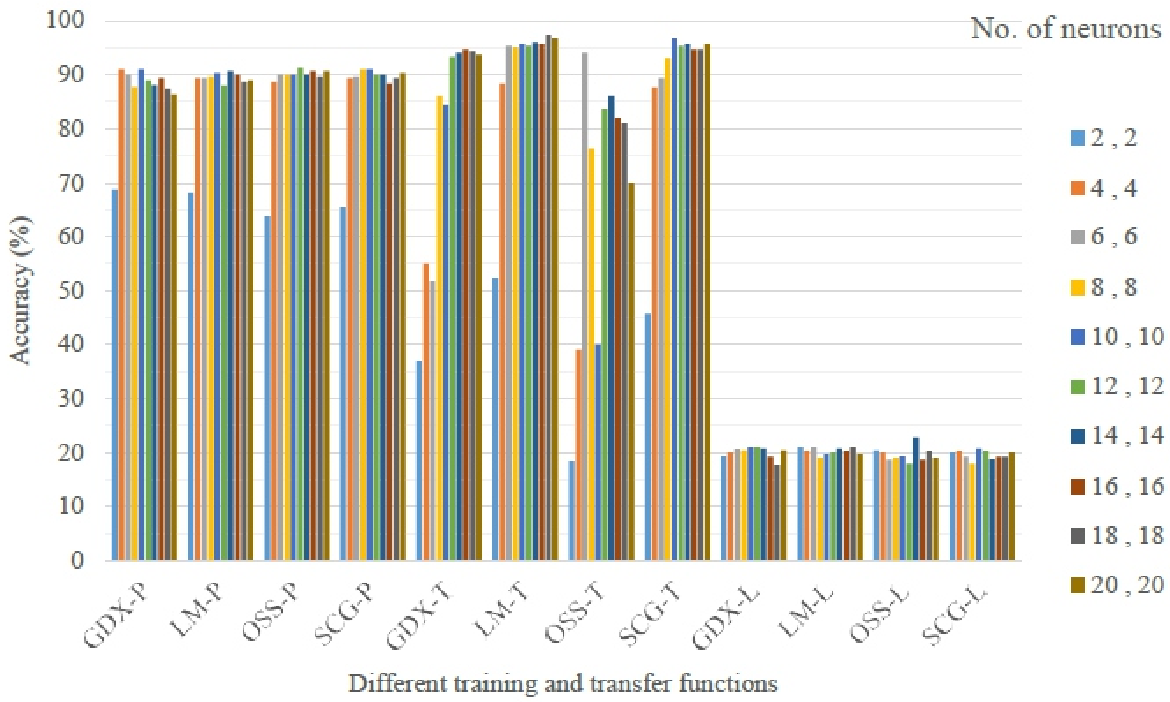
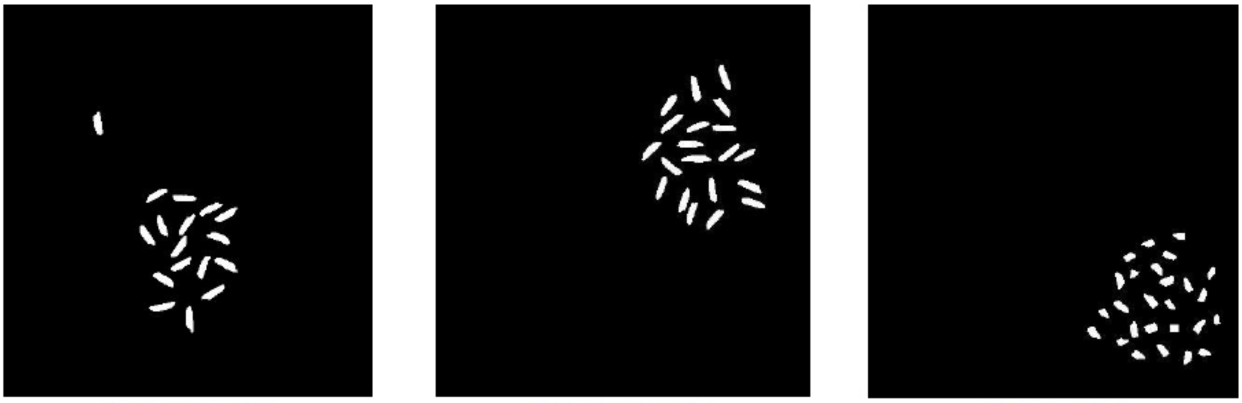


Fig. 6: Variation of the Accuracy Index for ANN with Two Hidden Layer and Combination of Different Number of Neurons, Training and Transfer Func- tions. (P, T and L Represents Purelin, Tansig and Logsig, Respectively).

Fig. 7: Variation of the RMSE Index for ANN with Two Hidden Layer and Combination of Different Number of Neurons, Training and Transfer Functions. (P, T and L Represents Purelin, Tansig and Logsig, Respectively).

The chosen topology was examined several times and the confusion matrix values and three statistical parameters (like accuracy, specificity and sensitivity) associated to the best performance were reported in Tables 4 and 5. Due to obtained results from tables 4 and 5, the classifier sensitivity index (Se) for HWR, HCR, HGR, HYR and BR classes were 97.33, 100, 96, 97.22 and 95.12 %, respectively. The classifier specificity index (Sp) for HWR, HCR, HGR, HYR and BR classes was equal to 98, 99.34, 99, 100 and 100 %, respectively. Also, the classifier accuracy index in grading of Hashemi rice grain into HWR, HCR, HGR, HYR and BR classes was 92.4, 97.26, 96, 100 and 100 %, respectively. The lowest accuracy percent were related to HWR and HGR classes which showed that the ability of created algorithm in classification of these classes was lower that other classes. Also the results indicated that the highest classification accuracy were related to HYR and BR classes using suggested classification algorithm. In order to display visual performance of suggested algorithm, an image includes all classes was captured and given as input to the algorithm. Finally, the algorithm with the selected topology was run and findings of visual classification of image are represented in Fig. 8. As shown in Fig. 8 and Table 5, the offered algorithm could be perform as a great deal of separation of classes from each other. The overall results showed that created structure was able to classify rice samples with acceptable accuracy and it can be used as monitoring tool to evaluate rice kernels.

A) All Classes B) Head White Rice C) Head Chalky Rice



D) Head Gray Rice E) Head Yellow Rice F) Broken Rice

Fig. 8: A) Image of All Classes, B) to F) Represent Results of Algorithm Classification.

Table 4: The Confusion Matrix of 13-18-18-5 ANN Topology

Predicted classes / Actual classes	HWR	HCR	HGR	HYR	BR
HWR	73	0	3	0	3
HCR	1	71	0	0	1
HGR	1	0	72	2	0
HYR	0	0	0	70	0
BR	0	0	0	0	78

Table 5: Statistical Parameters Obtained from the Evaluation of 13-18-18-5 ANN Topology

classes / statistical parameters	S_e (%)	S_p (%)	A_c (%)
HWR	97.33	98	92.40
HCR	100	99.34	97.26
HGR	96	99	96
HYR	97.22	100	100
BR	95.12	100	100

4. CONCLUSION

In the present study, a technique was suggested for identification and classification of various existed classes in Hashemi rice samples (appearance quality of rice sample) based on image processing and ANN data mining method. To select the best ANN structure, different structure of ANN (including one and two hidden layer, different hidden node, different training and transfer function) were used. Comparison of accuracy and RMSE indexes showed network with the 13-18-18-5 topology, LM training function and tansig transfer functions was the best classifier, and their values were 97.33% and 0.08361, respectively. Results of confusion matrix obtained from the best topology showed this techniques was very successful in detection of different classes existed in Hashemi rice sample. The suggested method with low equipment can be solved the problem of rapid and accurate determining rice quality. For future study, the finding of this research should be developed for other rice varieties and consequently it leads to design and development of rice inspection machine.

Acknowledgement

Authors are grateful to Tarbiat Modares University for funding and providing facilities related to image processing. Also we are grateful to Rice Research Institute of Iran (RRII) for providing the experimental samples for this study.

REFERENCES

[1] M.R Alizadeh, S. Minaei, T. Tavakoli, M.H. Khoshtaghaza, Effect of de-awning on physical properties of paddy, Pakistan Journal of Biological Sciences 9 (2006), 1726-1731. https://doi.org/10.3923/pjbs.2006.1726.1731.

[2] D. Mohapatra, S. Bal, Effect of degree of milling on specific energy consumption, optical measurements and cooking quality of rice, Journal of Food Engineering 80 (1) (2007) 119-125. https://doi.org/10.1016/j.jfoodeng.2006.04.055.

[3] M. Frei, P. Siddhuraju, K. Becker, Studies on the in vitro starch digestibility and glycemic index of six different indigenous rice cultivars from the Philippines, Food Chemistry 83 (3) (2003) 395-402. https://doi.org/10.1016/S0308-8146(03)00101-8.

[4] M.R. Alizadeh, A. Dabbaghi, F. Rahimi Ajdadi, Effect of final paddy moisture content on breaking force and milling properties of rice varieties, Elixir Agriculture 36 (2011) 3186-3189.

[5] H. Zareiforoush, M. Komarizadeh, M.R. Alizadeh, Effects of crop-machine variables on paddy grain damage during handling with an inclined screw auger, Biosystems Engineering 106 (3) (2010) 234–242. https://doi.org/10.1016/j.biosystemseng.2010.02.008.

[6] T. Tashiro, I.F. Wardlaw, The effect of high temperature on kernel dimensions and the type and occurrence of kernel damage in rice, Australian Journal of Agricultural Research, 42 (1991), 485–496. https://doi.org/10.1071/AR9910485.

[7] K. Bhavesh, Analysis of rice grains through digital image processing, International Journal of Scientific Research in Science and Technology 1 (1) (2015) 1-3.

[8] C.M. Christensen, C.M. Kaufmann, Deterioration of stored grains by fungi, Annual Review of Phytopathology 3 (1965) 69-84. https://doi.org/10.1146/annurev.py.03.090165.000441.

[9] N.M. Sahay, S. Gangopadhyay, Effect of wet harvesting on biodeterioration of rice, Cereal Chemistry 62 (2) (1985) 80-83.

[10] J.S. Aulakh, V. Banga, Percentage purity of rice sample by image processing, International conference on trends in electrical, electronics and power engineering (ICTEEP), July 15–16, Singapore (2012) 15-16.

[11] H.H. Wang, D.W. Sun, Evaluation of the functional properties of cheddar cheese using a computer vision method, Journal of Food Engineering 49 (1) (2001) 47–51. https://doi.org/10.1016/S0260-8774(00)00183-7

[12] H.H. Wang, D.W. Sun, Correlation between cheese meltability determined with a computer vision method and with Arnott and Schreiber tests, Journal of Food Science 67 (2) (2002) 745–749. https://doi.org/10.1111/j.1365-2621.2002.tb10670.x.

[13] J Paliwal, N.S. Visen, D.S. Jayas, AE-Automation and emerging technologies: Evaluation of neural network architectures for cereal grain classifica- tion using morphological features, Journal of Agricultural Engineering Research 79 (4) (2011) 361–370. https://doi.org/10.1006/jaer.2001.0724.

[14] N.S. Visen, J. Paliwal, D.S. Jayas, N.D.G. white, Specialist neural networks for cereal grain classification, Biosystems Engineering 82 (2002) 151– 159. https://doi.org/10.1006/bioe.2002.0064.

[15] I. Golpour, R. Chayjan, Identification and classification of bulk paddy, brown, and white rice cultivars with colour features extraction using image analysis and neural network, Czech Journal of Food Sciences 32 (3) (2014) 280-287. https://doi.org/10.17221/238/2013-CJFS.

[16] B.B. Prajapati, S. Patel, Algorithmic approach to quality analysis of Indian basmati rice using digital image processing, International journal of emerging technology and advanced engineering 3 (3) (2013) 503–504.

[17] G. Ajay, M. Suneel, K.K. Kumar, P.S. Prasad, Quality evaluation of rice grains using morphological methods, International journal of soft computing and engineering 2 (2013) 35–37.

[18] V.G. Dalen, Determination of the size distribution and percentage of broken kernels of rice using flatbed scanning and image analysis, Food Research International 37 (1) (2004) 51–58. https://doi.org/10.1016/j.foodres.2003.09.001.

[19] H. Zareiforoush, S. Minaei, M.R. Alizadeh, A. Banakar, Qualitative classification of milled rice grains using computer vision and metaheuristic techniques, Journal of Food Science and Technology 53 (1) (2016) 118–131. https://doi.org/10.1007/s13197-015-1947-4.

[20] B.K. Yadav, V. Jindal, Monitoring milling quality of rice by image analysis, Computers and Electronics in Agriculture 33 (1) (2001) 19-33. https://doi.org/10.1016/S0168-1699(01)00169-7.

[21] Y. Yoshioka, H. Iwata, M. Tabata, S. Ninomiya, R. Ohsawa, Chalkiness in rice: potential for evaluation with image analysis, Crop Science 47 (2007) 2113-2120. https://doi.org/10.2135/cropsci2006.10.0631sc.

[22] J.D. Guzman, E.K. Peralta, Classification of Philippine rice grains using machine vision and artificial neural networks, World conference on agricul- tural information and IT, Tokyo, Japan, (2008) 41–48.

[23] A. Pazoki, Z. Pazoki, Classification system for rain fed wheat grain cultivars using artificial neural network, African Journal of Biotechnology 10 (41) (2011) 8031-8038. https://doi.org/10.5897/AJB11.488.

[24] K. Mollazade, M. Omid, F. Akhlaghian Tab, Y. Rezaei Kalaj, S. Mohtasebi, M. Zude, Analysis of texture-based features for predicting mechanical properties of horticultural products by laser light backscattering imaging, Computers and Electronics in Agriculture 98 (2013) 34-45. https://doi.org/10.1016/j.compag.2013.07.011.

[25] A. Fielding, Cluster and classification techniques for the biosciences, Cambridge University Press, UK, 2007.

[26] K. Mollazade, M. Omid, A. Arefi, Comparing data mining classifiers for grading raisins based on visual features, Computers and Electronics in Agriculture 84 (2012) 124–131. https://doi.org/10.1016/j.compag.2012.03.004.

[27] M. Omid, A. Mahmoudi, M.H. Omid, Development of pistachio sorting system using principal component analysis (PCA) assisted artificial neural network (ANN) of impact acoustics, Expert Systems with Applications 37 (10) (2010) 7205–7212. https://doi.org/10.1016/j.eswa.2010.04.008.

[28] M. Hall, Correlation-based feature selection for machine learning, PhD Thesis, University of Waikato, Hamilton, New Zealand, 1999.

[29] M. Hall, E. Frank, G. Holmes, B. Pfahringer, P. Reutemann, I.H. Witten, The WEKA data mining software: an update, SIGKDD Explorations11 (1) (2009) 10–18. https://doi.org/10.1145/1656274.1656278.

[30] J. Rexce, K. Usha Kingsly Devi, Classification of milled rice using image processing, International Journal of Scientific and Engineering Research 8 (2) (2017) 10-15.

[31] N. Teimouri, M. Omid, K. Mollazade, A. Rajabipour, A novel artificial neural networks assisted segmentation algorithm for discriminating almond nut and shell from background and shadow, Computers and Electronics in Agriculture 105 (2014) 34–43. https://doi.org/10.1016/j.com- pag.2014.04.008.

[32] A. Khoshroo, A. Arefi, A. Masoumiasl, GH.H. Jowkar, Classification of wheat cultivars using image processing and artificial neural networks, Agricultural Communications 2 (1) (2014) 17-22.

[33] Z. Liu, F. Cheng, Y. Ying, X. Rao, Identification of rice seed varieties using neural network, Journal of Zhejiang University Science B. 6, (11) (2005) 1095-1100. https://doi.org/10.1631/jzus.2005.B1095.

[34] C.S. Silva, U. Sonnadara, Classification of rice grains using neural networks, Proceedings of Technical Sessions 29 (2013) 9-14.

[35] S. Shantaiya, U. Ansari, Identification of food grains and its quality using pattern classification, 12th IEEE International Conference on Communi- cation Technology (ICCT), Nanjing, China, 11–14 November 2010.

Designed and Implementing of Quadcopter Control Unit Capable of Tracking and Detecting Airplanes Types

Mehdi Aslinezhad [1*], Massoud Hosseinzadeh [2], Farsad Heidari [3]

[1]Department of Electrical Engineering, Shahid Sattari Aeronautical University of Science and Technology, Tehran 1384663113, Iran

[2] Babol Noshirvani University of Technology, Babol, Iran

[3] Department of Electrical Engineering, Shahid Sattari Aeronautical University of Science and Technology, Tehran, Iran

*Corresponding author E-mail: M.aslinezhad@ssau.ac.ir

ABSTRACT

The goal of this study is to design and implement a new idea for air-launched quadcopter control unit using the digital video processing. In this study, it's endeavored to transmit the captured videos by a camera embedded on the quadcopter via video transceiver and after pro- cessing, the ground station relays appropriate command to the quadcopter to tracking target. Moreover, it's desired to detect a target in the sky and both stay in one direction until detect the target when intercepting toward the target and the quadcopter intercepts the target in every direction. In order to identify the type of aerial targets, the dimensions are studied at different intervals, which makes military and non - military goals detected at different intervals.

Keywords: Quadcopter; Digital Video Processing; Video and Data Transceiver.

1. INTRODUCTION

Air defense is responsible for protecting wealth, resources and assets of marine and land. There are several types of air threats including: surface-to-air missiles, surface-to-surface missiles and drones and aircrafts. Several missile and air defense systems are used for dealing with these threats.

The aim of present study, is tracking and chasing the air target by means of heat detector sensor in a cloudy and clear sky [1].

Targets studied in the present study are tracking an air target using camera and using MATLAB software, which after receiving images, running two engines of x-axis airfoils and results in guiding missile toward the target [2].

In the present study, a missile has been tracked in the air using frame and its speed and a rectangular box is embedded in the exhausted gases section, so that the missile speed is estimated by using this box [3].

In this section, it is tried to tracking and chasing a target using camera and joystick. First, after turning the camera using joystick for searching a target, the surrounding is searched and then by appearing the target it locked on it and then missile is involved with target [4]. In the present study, a new image processing-based system was presented in order to automatic guidance of quadcopter. This system is composed of a camera embedded on the quadcopter, video and data transmitter with several kilometers ranges. The video from quadcopter is transmitted to portable computer system on the earth by transmitter and after processing the received video using software, the commands are again sent to quadcopter using long-range data transmitter for moving the quadcopter brushless motors and tracking the target. SMD, light weight and cheap components were used in the presented design. The aim of presented designs is the capability of detecting the type of air targets and automatic tracking target with help of video processing. Figure 1 shows the overall view of recommended system. Images are recorded by camera embedded on the quadcopter and are transmitted to computer system on the earth by long-range transmitter. After processing the image, the required commands are transmitted back to quadcopter using long-range data transmitter in order to guiding quadcopter. With this method, can be controlled and guiding operation can be done with high precision. Quadcopter has a camera with video signal output and PAL system.

Fig. 1: Overall View of Recommended System.

In the present study, a system was designed, implemented and investigated based on the recommended items. The recorded images of target in sight of quadcopter, by camera embedded on the quadcopter, are transmitted online to a computer system in the base station. These images are processed using LABVIEW software. This software can transmit codes, which include "X" and "Y" axis of target on the system screen, using APC220 wireless transmitter and receiver thorough USB port to Arduino MEGA. After receiving transmitted codes which include parameters related to "X" and "Y" axis, brushless motors turned on in order to tracking target by quadcopter; it means that, by each movement of target, by help of processing of transmitted images and the movement of brushless motors based on the received codes, quadcopter moves toward the target and locked on the target. Figure 2 shows the system operation during these steps from receiving transmitted images to retransmitting command to quadcopter. Figure 3 shows the overall architecture of the system.

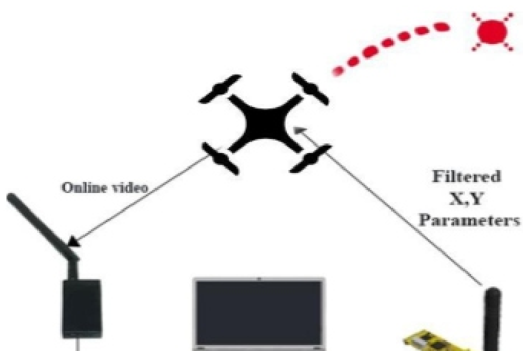


Fig. 2: Overall Operation of System.

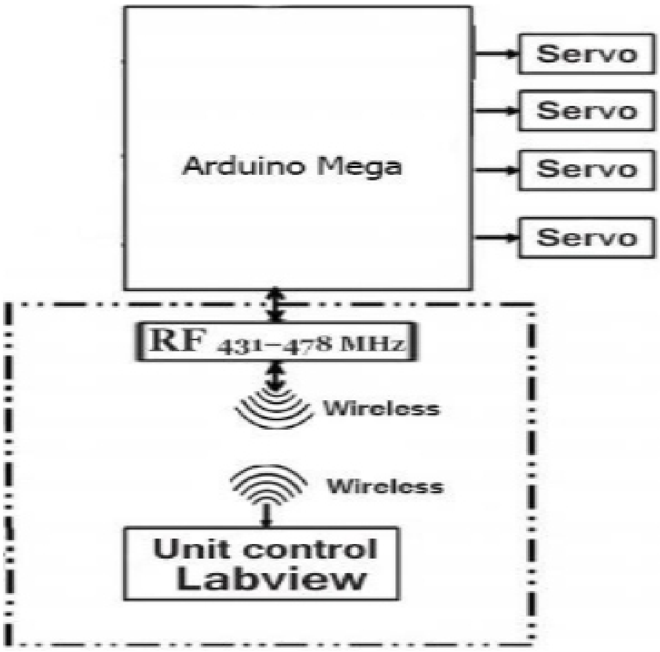


Fig. 3: Architecture of System Control Part (Quadcopter Control Part).

Figure 4 shows the architecture of system images wireless transmitter-receiver part.

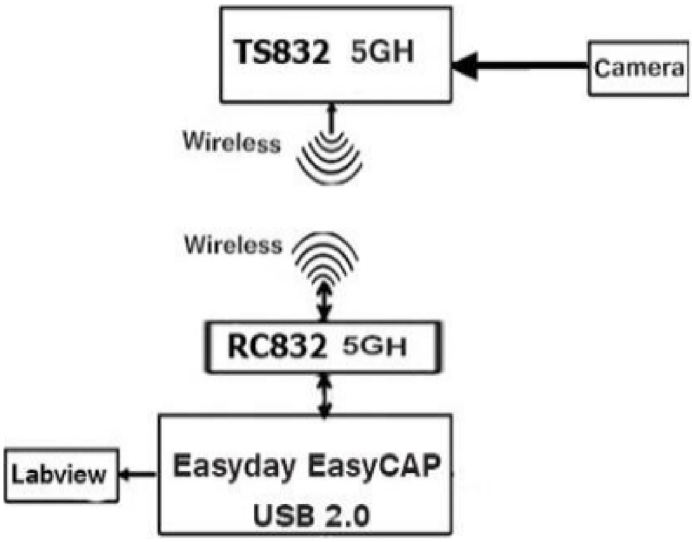


Fig. 4: Architecture of System Images Wireless Transmitter-Receiver Part.

Commands of each of "X" and "Y" axis are transmitted to quadcopter by APC220 data transmitter-receiver. Working frequency of each of these transmitter and receiver is different; for example, working frequencies of "X" and "Y" axis are 433MHz and 434MHz, respectively. Therefore, there is no wave interferences between transmitter and receiver, and transmitted data to microcontroller ATMEGA2560, which has several serial ports for transmission and receiving, are sent separately. Figure 5 shows the architecture of system images wireless receiver part.

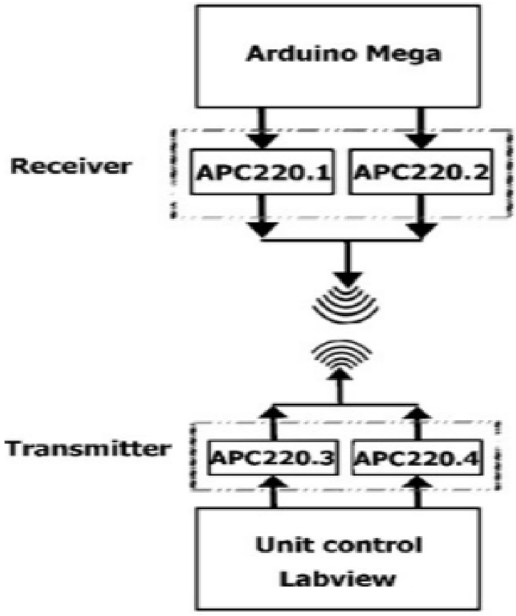


Fig. 5: Architecture of System Images Wireless Receiver Part.

Figure 6 shows the flowchart of overall operation and hardware.

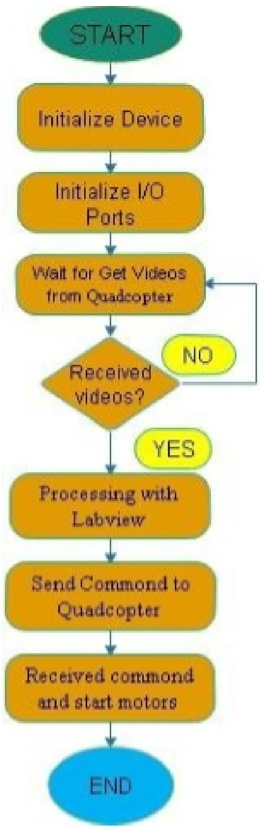


Fig. 6: System Flowchart.

For calibration we used the camera with a resolution of 492 x 510 pixels and the following standard model:

$$p = R(P + t) \quad (1)$$

Where, “p” is the point on the image plane, “R” is the rotation matrix, “P” is the point in the world frame and “t” is the translation vector and the translation vector is:

$$t = [x_{CAM}\ y_{CAM}\ 0] \qquad (2)$$

Figure 7 shows how to adjust camera calibration including axis, target and image central point calibrations[5].

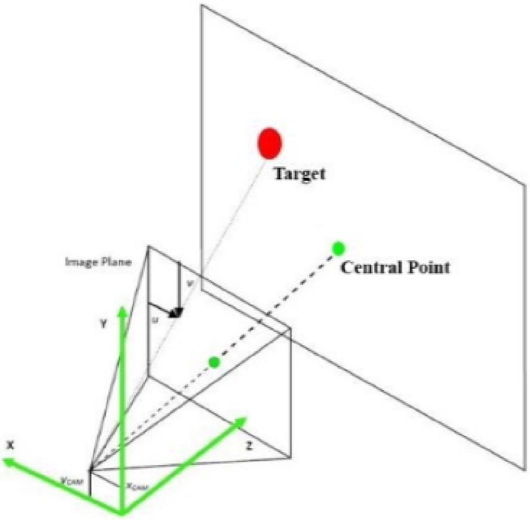


Fig7 : Adjusting Camera Calibration[5].

Figure 8 show the range of designed controller, which is the main processor embedded on the quadcopter. One of the most advantages of modular range and being metalized is that all parts can be separated or can be replaced by more advanced ones.

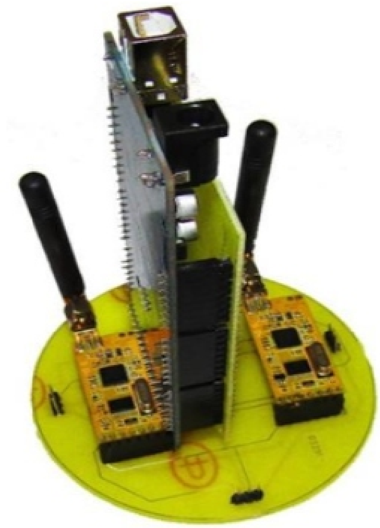


Fig. 8: Main Controller Range Embedded on the Quadcopter (Control Section).

As it can be seen from board image, after receiving Labview data by APC220 receiver-transmitter, brushless motors connected to board, rotated around “X” and “Y” directions. For moving quadcopter in right and left directions (X axis) two brushless motors are embedded and for moving quadcopter in up and down directions (Y axis), two brushless motors are also embedded. Figure 9 shows the control section.

Fig. 9: Connecting Brushless Motors to Control Section.

2. RESULTS AND DISCUSSION

Mean shift is a technique for finding maximum points in a probability distribution function. This method can be used when there are discretized samples of desired function. This technique has iterative structure and converged to a maximum point by start with an initial guess. The aim of is to find mode and the initial guess is the location "X". Now, points set which are in the neighboring of the current guess are considered, i.e. A little higher and a little smaller than "X". This neighboring points set is called "N(X)". Now, it is assumed that there is a function for better estimation of maximum location, which shows the importance of neighboring points, it means that, it allocates a weight to neighboring points. In statistics, this function is called kernel. It is clear that a kernel function can has different shapes. In following, a Gaussian kernel function is used, where its neighborhood weight of xi is defined as follows:

$$k(x_i - x) = e^{-c||x_i - x||^2} \quad (3)$$

Now, a new guess of mode can be defined as follows,

$$m(x) = \frac{\sum_{x_i \in N(x)} K(x_i - x) x_i}{\sum_{x_i \in N(x)} K(x_i - x)} \quad (4)$$

Where, m(x) is the new guess. Now m(x) can be replaced by (x) and repeat the algorithm. The finish condition is that the difference of m(x) in two consecutive iterates be negligible [6-8].

As mentioned earlier, in the present study LABVEIW and Mean shift are used for video process (Figure 10). Software has the capability that image processing and transmitting the required commands from serial port simultaneously. In the figure below, a graphical interface is shown for controlling and processing the target which tracking online the aircraft. After observing and selecting the target, a red box is draw around that by software and then information of "X" and "Y" axis which are both as code are transmitted to serial port. Brushless motors are moved by these two codes and therefore quadcopter is guidance toward target.

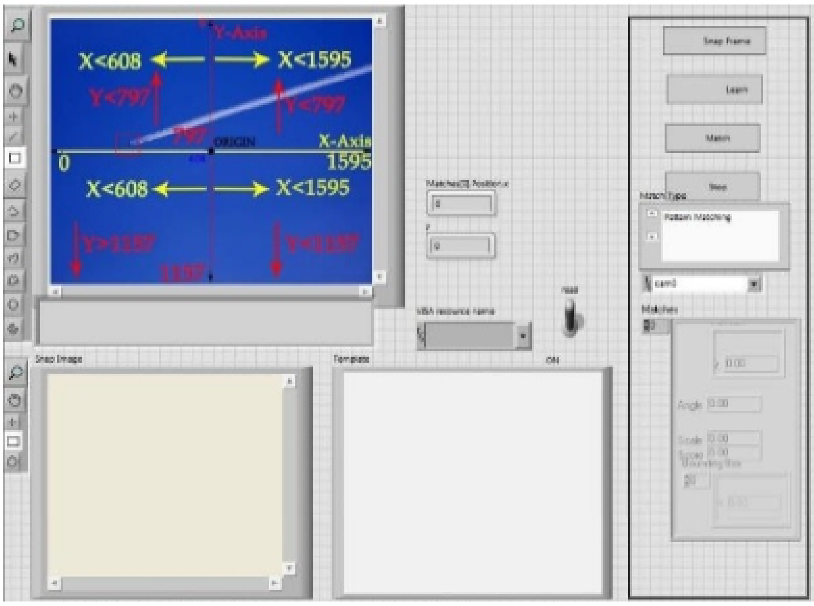


Fig. 10: User Interface for Video Processing.

As can be seen from Figure 10, received image from quadcopter is divided in to two main axis "X" and "Y" in the main frame, where the range of "X" axis is from 0 to 1595 and the range of "Y" axis is from 0 to 1157. Table 1 shows the values related to each part of image.

Table 1: Divided Parameters of Screen

Axis	Minimum value (left and up sides)	Minimum value (right and down sides)
X	0	1195
Y	0	1157

For each of these "X" and "Y" axes, two brushless motor are defined. Transmitted values of "X" and "Y" axes to serial ports, are used for guidance quadcopter to left-right and up-down, respectively. To clarify, the target motion in the sight of quadcopter is investigated using graph. Figure 11 shows the different positions of target in the marked points; air targets in these points are shown and investigated.

Fig. 11: Target Investigation in the Marked Points.

Figure 12 is related to software output, in a case which target is located in the center of screen, point “A”. The aim of present study is that with every target motion in the screen, brushless motors also moved the quadcopter and put the quadcopter in direction with target, therefore the target position is returned to “A” point in the screen.

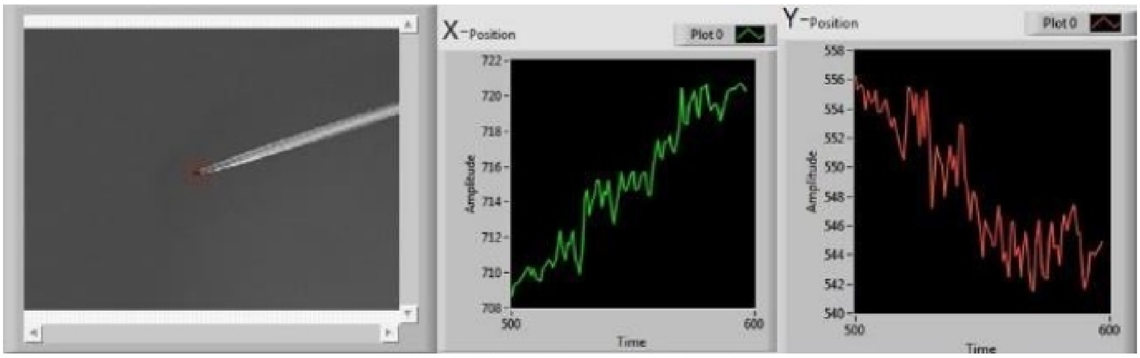


Fig. 12: Target Position at “A” Point.

“B”, “C”, “D” and “E” points are investigated in Figure 13, Figure 14, and Figure 15 and Figure 16. As it can be seen on each figure, target position has “X” and “Y” axes.

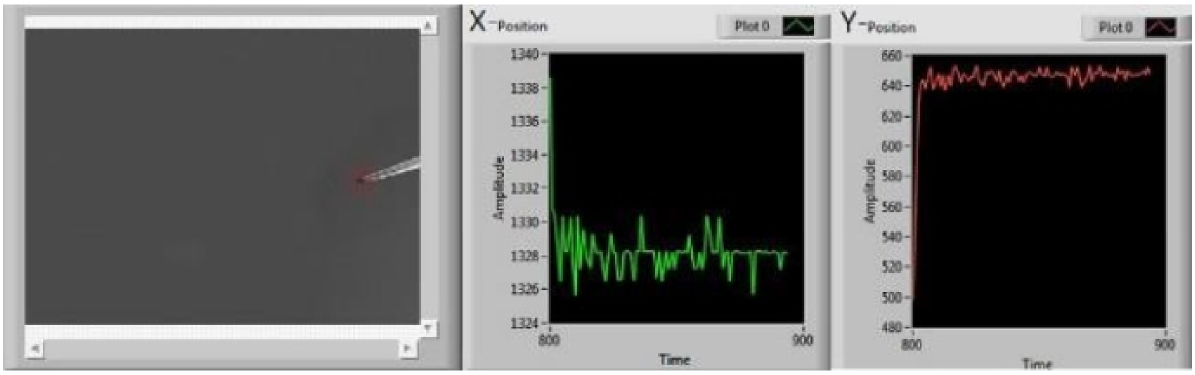


Fig. 13: Target Position at “B” Point.

During image process, blue background of sky becomes gray and target becomes dark. This led to easier detection of target. In the present study, shapes of target and background have not physical changes. At the time of presence of target at point “B”, “X” axis has value between 1328 and 1330, which is sent to microcontroller via USB port and this axis is changed and shifted with target displacement. “Y” axis has also a value between 640 and 660. In order to run the brushless motors, knowing this range of values is no enough and having a constant value is no necessary; it means that motion of brushless motors is easily done by defining the values range from 640 to 660. “C” and “B” points are related to “X” axis and the position of quadcopter is changed to right and left using this axis.

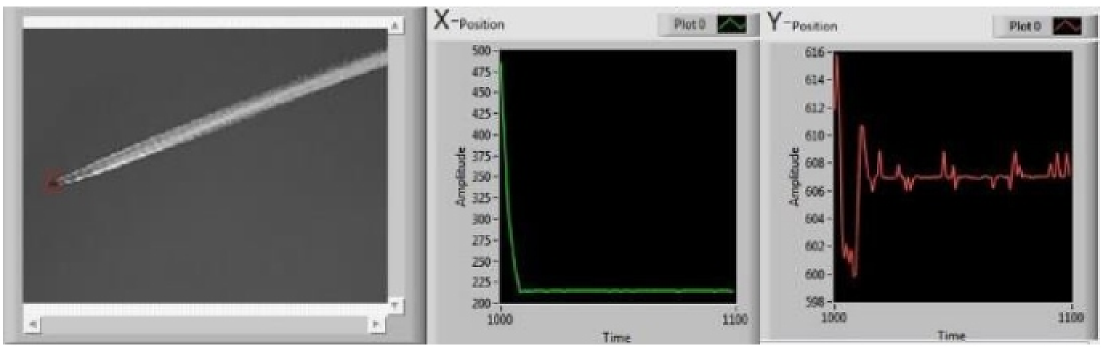


Fig. 14: Target Position at “C” Point.

Figure 15 shows the target position at point “D”. This figure is related to quadcopter variations in “Y” axis. At the moment of positioning of target at point “D”, both “X” and “Y” outputs are available. As can be seen from the figure, the range of “Y” output is between 200 to 250 and by and as it gets higher it gets closer to 0. To control the quadcopter and gets higher in “Y” direction, the parameters of this axis can be sent to microcontroller, so that the target again get back to point “A”.

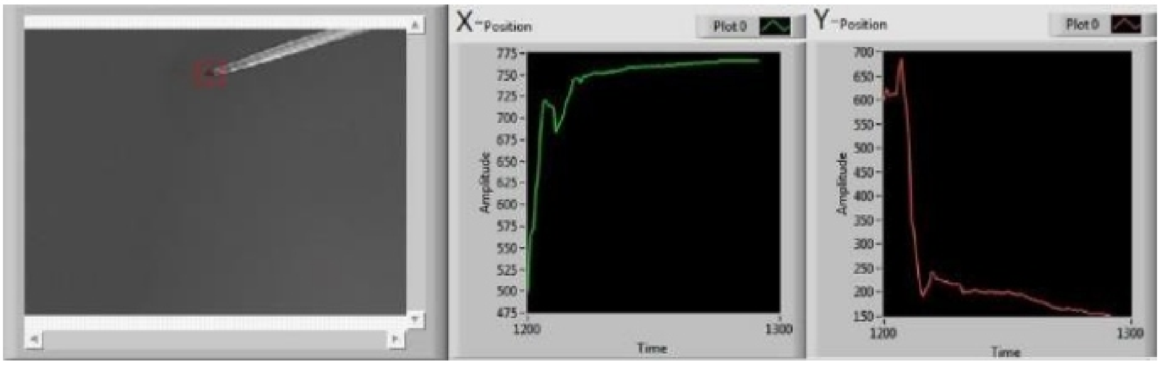


Fig. 15: Target Position at “D” Point.

Also, by positioning the target at point E, the “Y” output is the value between 985 and 986 (Figure 16). When the target positioned at this point, brushless motors dedicated for “Y” axis on the quadcopter nose turned on and the quadcopter move upward and target again get back to point “A”. if the target simultaneously changed in both “X” and “Y” axes, all brushless motors on the “X” and “Y” axes are turned on separately and the quadcopter moves in both right-left direction (X axis) and up-down direction (Y axis).

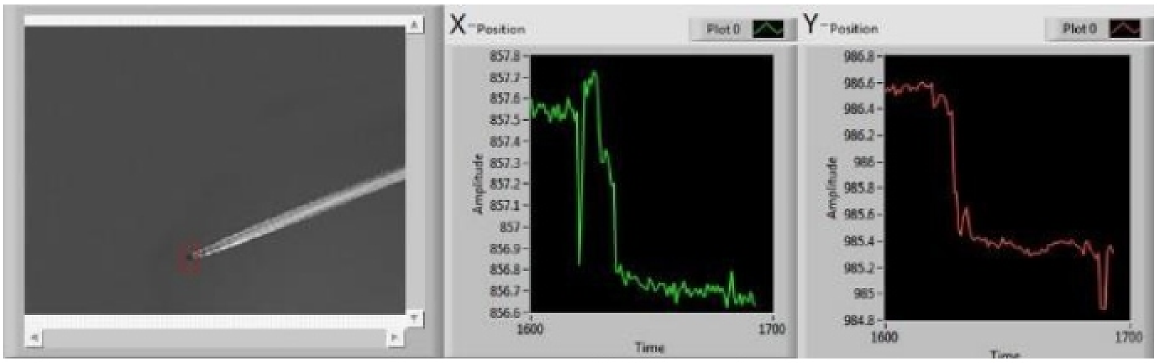


Fig. 16: Target Position at “E” Point.

Figure 17 shows the results of present study during target motion from point “A” to point “H”. Recorded data and changed values are sent to microcontroller and brushless motors of “X” and “Y” axes are turned based on the received values. Until the target is not positioned at point “A”. Until the target do not positioned at point “A”, those process for each part of screen and for each selected target is repeated.

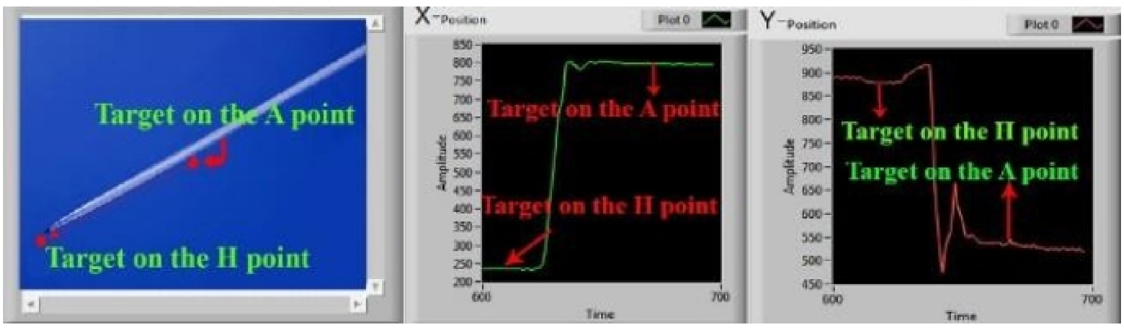


Fig. 17: Path Change of Target from Point “A to Point “H”.

As can be seen from Figure 18, after positioning target at point “A”, the values of both “X and “Y” axes are changed from 240 to 800 and from 890 to 550, respectively. This process is repeated for all image points, which means that quadcopter changes its direction until posi- tioning target at point “A”, so that quadcopter be in line with target. These values are sent to microcontroller embedded on the quadcopter by wireless. Also, microcontroller based on the predefined program, turns on the brushless motors and. In the present study, selection and tracking operations of a target were done in sunny day with temperature 30 °C.

In order to detect and define the type of air targets, the measuring body distance tab NI VISA of Labview software was used. In the present study, the targets which were defined earlier for software, were measured in different distances and were defined as a library for quadcopter, in order to detect military and civilian targets at different distances. To be able to detect the distance between target and quadcopter, long- range distance lasers was used. Figure 18 show a measured air target at distance 3Km.

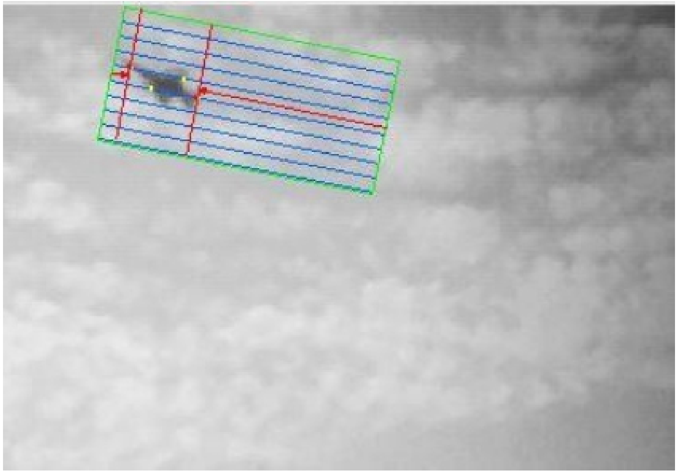


Fig. 18: Measuring A Falcon Fighter at Distance 3Km from Earth Surface.

This fighter is at distance 3Km and has the length 52.7mm. This size is different in different distances, and changes by getting closer and further of quadcopter camera sight. In Figure 19 a fighter and an airplane in a same distance with quadcopter are detected and civilian and military type is investigated.

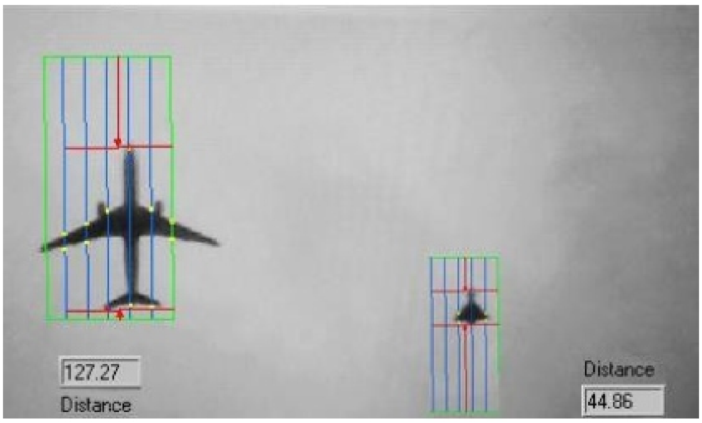


Fig. 19: Detection of Military and Civilian Aircraft.

As can be seen from Figure 20, using the object distance detection property in Labview software, the size of both aircrafts are investigated, where in this case, the length of military and civilian sample were 44.86mm and 127.27mm. In this case, the camera sight is investigated in all distances and the quadcopter has the ability to differentiate between military and civilian aircrafts based on their length and engaged with military aircraft using this information. Also, aircraft dimensions in terms of their airfoil length can be investigated.

3. CONCLUSION

In the present study, a new system was designed and implemented using image process with Labview software, in order to tracking the air target and guidance quadcopter. Target detection and selection process was done by image process and by brushless motors quadcopter directed tracked the target. As an example, a target was detected and tracked in a sunny day with temperature 30°C. The aim of study was that, in every condition, the target remained in the center of screen, so that the quadcopter and target be in line. In addition, during the quadcopter movement, quadcopter changed its path using "X" and "Y" axes brushless motors, so that the target remained at point A. also, for detecting the military and civilian targets, distance detection property was used, to measure the length dimensions of fighters and passenger airplanes and comparing them with predefined values, it engaged with military aircraft.

Acknowledgement

The authors would like to thank the Shahid Sattari Aeronautical University of Science and Technology for the support of this research project.

REFERENCES

[1] Naveenkumar. R, Pandiyan K, Prakash M, Saravanaperumal V, Jeya anusuya S," Missile Burst Prevention and Tracking System Using Image Pro- cessing In MATLAB", IJIRSET, Vol. 8, No. 2, (2019), http://www.ijirset.com/upload/2019/spl2/8.pdf.

[2] Vimal. M, Kumar. R, "Tracking of Ballastic Missiles and Velocity Measurement using Frame Distance Manipulation", Conference on Advances in Communication and Control Systems, (2013), https://pdfs.semanticscholar.org/98fe/fae92e61bafc91297ed47ffdc794860f4801.pdf.

[3] Zhongyuan. C, Xiaoming. L, Wanchun. C," Design of Real-Time Hardware-in-the-Loop TV Guidance System Simulation Platform", International Journal of Aerospace Engineering, Vol. 2017, No. 11, (2017), pp. 1-16, https://doi.org/10.1155/2017/7834395.

[4] Jing. H, Ru. X, Ming, J, Guang. Z," Application of Genetic Algorithm in Target Image Processing of TV Guided Missile", International Conference on Electronic, Information and Computer Engineering, Vol. 44, (2016), pp. 4, https://doi.org/10.1051/matecconf/20164401021.

[5] Kit. A, Ben. I, Michael. W, "A self-targeting missile system using computer vision", MTRX 4700 Experimental Robotics Major Project University of Sydney.

[6] Dorin. C, Peter. M, "Mean Shift: a Robust Approach toward Feature Space Analysis", IEEE Transactions on Pattern Analysis and Machine Intelli gence, Vol. 24, No. 5, (2002), https://doi.org/10.1109/34.1000236.

[7] K. Fukunaga, L. Hostetler," The Estimation of the Gradient of a Density Function, with Applications in Pattern Recognition", IEEE Transactions on Information Theory, Vol. 21, No. 1, (1975), https://doi.org/10.1109/TIT.1975.1055330.

[8] Xiangru. L, Zhanyi. H, Fuchao. W," A note on the Convergence of the Mean Shift", Pattern Recognition, Vol. 40, No. 6, (2007), https://doi.org/10.1016/j.patcog.2006.10.016.

Effect of Passive and Forced Aeration on Composting of Market Solid Waste

M. Atauzzaman [1]*, Q. H. Bari [2]

[1] Department of Civil Engineering, Pabna University of Science and Technology, Pabna, Bangladesh

[2] Department of Civil Engineering, Khulna University of Engineering and Technology, Khulna, Bangladesh

*Corresponding author E-mail: atauzzaman@gmail.com

ABSTRACT

This study aimed to determine the effect of passive and forced aeration on composting of market wastes. Suitable vegetable waste, waste paper and sawdust as bulking agent were mixed with the proportion 75:10:15. Temperature inside composting reactors was measured daily time to time. Total sample and volatile solids were determined before and after composting of waste mixture with both passive and forced aeration. Temperature increased to maximum 52 ºC for passive aeration and 54 ºC for forced aeration. The percentage reduction in total sample was found to be greater for forced aeration than passive aeration. The volatile solids decreased with time at the end of both processes. The extent of volatile solids degradation of waste mixture with time was determined through forced aeration for a series of composting process. Total sample and volatile solids were determined at 2, 3 or 4 days interval. The percentage reductions in total sample and volatile solids were found to be varied from 3 to 68 % and 4 to 55% respectively. The percentage reduction in volatile solids increased with time. There is a possibility of recycling the waste mixture in the form of composting.

Keywords: Composting; Forced Aeration; Passive Aeration; Recycling; Volatile Solids Degradation.

1. INTRODUCTION

The increasing quantity of municipal solid waste, decreasing landfill capacity, increasing waste management cost, public opposition to waste management facilities, and concerns for risks associated with solid waste management, etc. led to the concept of integrated solid waste management [1]. In developing countries, the increasing quantity of organic waste is one of the most environmental problems. Environmental and health problems such as disease transmission, fire hazards, odor nuisance, aesthetic nuisance, air pollution, water pollution, and economic losses, etc. arise due to mismanagement of solid waste [2]. Solid waste management is an enormous task due to poverty, population explosion, urbanization, and lack of fund, etc. There are some waste disposal methods such as incineration, landfill, pyrolysis and gasification, etc., which are efficient but have negative impacts on environment as well as public health. Composting when properly managed is a sustainable method with various advantages such as production of biofertilizer, relatively low air and water pollution, low operational cost, and income generation [3]. Environmental degradation and ecological imbalance occur continuously due to poor planning and management of solid waste. Composting is a sustainable and environment friendly way of managing the waste [4].

Composting is a biological transformation of organic content of municipal solid waste to reduce the volume and weight of material and produce compost that can be used as a soil conditioner. Aerobic and anaerobic processes both have a place in solid waste management [5]. Organic materials undergo biological degradation to a stable end product [6]. The end product remaining after bacterial activity in composting of organic waste is called compost or humus [7]. Aerobic composting is the most common in the waste treatment because of simplicity and effective treatment and needs diffusion of air through waste [8]. High microbial activity accelerates the degradation of organic matter in the thermophilic phase [9]. A minimal level of oxygen is maintained constantly to ensure high biological quality [10]. Temperature, pH, moisture content and carbon nitrogen ratio (C: N) are the main parameters that affect the composting process, contributing to the efficiency of composting process [11]. The high content of organic matter and macronutrients in waste has high potentiality in the production of organic fertilizers [12].

Composting is very effective way to treat organic wastes and produce a good soil conditioner. Market wastes consume various nutrients such as nitrogen, phosphorus, potassium, which help to grow different plants. Keeping this in mind the present study experimented with market wastes to determine the temperature variation in both passive and forced aeration composting processes, to determine the extent of volatile solids degradation of the waste mixture and to study the possibility of recycling the waste mixture in the form of composting.

2. MATERIALS AND METHODS

2.1. Waste materials

Vegetable wastes, waste paper and sawdust were selected for the waste mixture. Vegetable waste, waste paper and sawdust were collected from local market of Khulna. The large pieces of vegetable wastes and waste paper were cut into small pieces of size less than 10 mm. Vegetable wastes, waste paper and sawdust as bulking agent were mixed thoroughly with a proportion of 75:10:15.

2.2. Reactor and aerator type

Twenty fluxes were used as composting reactors. The diameter, height and capacity of each reactor were 100 mm, 270 mm and 1 litre respectively. Small pieces of polyurethane sheet were placed over reactor to protect the total system from leakage of self-generated heat of organic waste mixture during composting. Five aerators (Super Pump SP-780) were used for aeration. Air pipes of 5 mm diameter and 1000 mm length were used to connect aerator with reactors. Four air pipes from each aerator were connected with four reactors.

2.3. Measurement of temperature

Thermometers were used for monitoring temperature generated in waste mixture inside reactors during composting. Thermometers were inserted into reactors and temperature readings were taken daily time to time.

2.4. Determination of moisture content and volatile solids

The weight of can (w1) was measured using a digital balance. A small amount of waste mixture was taken into can. The weight of wet sample with can (w2) was measured. The wet sample with can was kept in Oven at 105 ± 5 ºC for 24 hours. The weight of dry sample with can (w3) was measured. Desiccator was used to control moisture content of the waste mixture. The moisture content (MC) was calculated using the following formula:

$$MC\ (\%) = (w_3 - w_2)/(w_2 - w_1) \qquad (1)$$

Oven dried sample with can was kept in Muffle Furnace at 550 ± 15 ºC for 5 hours. The weight of fixed sample with can (w4) was measured. The volatile solid (VS) was calculated using the following formula:

$$VS\ (\%) = (w_3 - w_4)/(w_3 - w_1) \quad (2)$$

2.5. Determination of temperature variation

2.5.1. Temperature variation in passive aeration composting

The first run was carried out using three reactors with passive aeration composting. Vegetable wastes (75%) after cutting into small pieces were mixed thoroughly with sawdust (15%) and waste paper (10%) and put into three reactors. The reactors were filled and shacked with the waste mixture. The openings of reactors were closed by small pieces of polyurethane sheet and thermometers were inserted into reactors for monitoring the temperature. The experimental setup for temperature variation during passive aeration composting is shown in Fig. 1. The total sample weight, moisture content and volatile solids of the waste mixture were determined before and after composting. The temperature readings were taken daily time to time for 29 days.

Fig. 1: Experimental Setup for Temperature Variation during Passive Aeration Composting.

2.5.2. Temperature variation in forced aeration composting

The second run was carried out using three reactors with forced aeration composting. Vegetable wastes (75%) after cutting into small pieces were mixed thoroughly with sawdust (15%) and waste paper (10%). Before filling the reactors with the waste mixture, air pipes of diameter 5 mm from air pump were inserted inside of each reactor. The reactors were filled and shacked with the waste mixture. The openings of reactors were closed by small pieces of polyurethane sheet and thermometers were inserted into reactors for monitoring the temperature. The experimental setup for temperature variation during forced aeration composting is shown in Fig. 2. Air was passed daily at the rate of 500 ml/min through waste mixture inside reactor for 8 hours in day time. The total sample weight, moisture content and volatile solids of the waste mixture were determined before and after composting. The temperature readings were taken daily time to time for 29 days.

Fig. 2: Experimental Setup for Temperature Variation during Forced Aeration Composting.

2.6. Determination of volatile solids degradation

The third run was carried out using twenty reactors with forced aeration composting following the procedure as described in section 2.5.2. The experimental setup for determination of volatile solids degradation is shown in Fig. 3. The temperature readings were taken daily time to time for 49 days. The total sample weight, moisture content and volatile solids of the waste mixture were determined at 2, 3 or 4 days interval.

Fig. 3: Experimental Setup for Determination of Volatile Solids Degradation.

3. RESULTS AND DISCUSSION

3.1. Passive aeration composting

The temperature inside reactor-1 increased from 26 to 42 ºC within 7 days and maximum temperature was 52 ºC. After 29 days the temperature decreased to 32 ºC. The temperature inside reactor-2 increased from 26 to 44 ºC within 7 days and maximum temperature was 49 ºC. After 29 days the temperature decreased to 28 ºC. The temperature inside reactor-3 increased from 26 to 40 ºC within 7 days and maximum temperature was 51 ºC. After 29 days the temperature decreased to 30 ºC. The temperature variation during passive aeration composting is shown in Fig. 4. Initially the temperature inside reactors increased rapidly for few days and then decreased slowly.

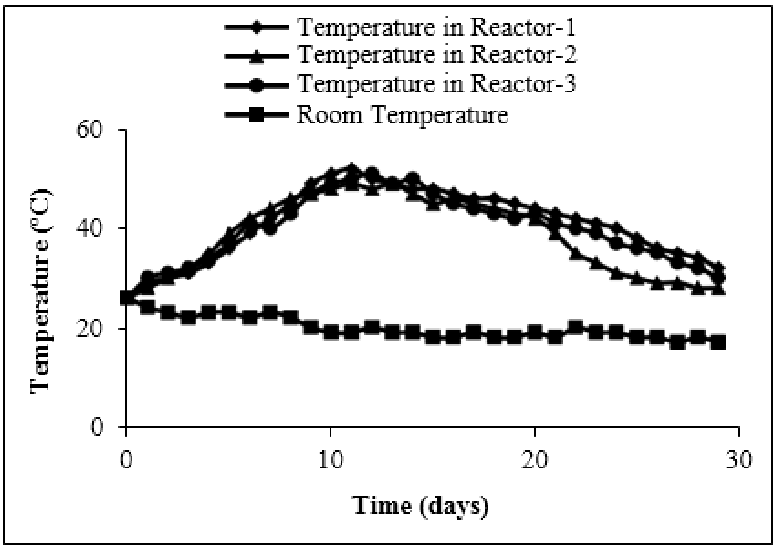


Fig. 4: Temperature Variation during Passive Aeration Composting.

Initial weight of waste mixture in reactor-1, 2 and 3 were 450, 455 and 435 g respectively and final weight were 370, 380 and 355 g respectively after 29 days of composting. The moisture content of the waste mixture was 69.4% initially and increased to 77.9%. The volatile solid of the waste mixture was 94.4% initially and decreased to 90.3%. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-1 were found as 17.78%, 7.72%, 40.60% and 43.15% respectively.

3.2 Forced aeration composting

Temperature (ºC)The temperature inside reactor-4 increased from 26 to 42 ºC within 7 days and maximum temperature was 50 ºC. After 29 days the temperature decreased to 19 ºC, near to room temperature 17 ºC. The temperature inside reactor-5 increased from 26 to 39 ºC within 7 days and maximum temperature was 53 ºC. After 29 days the temperature decreased to 20 ºC. The temperature inside reactor-6 increased from 26 to 43 ºC within 7 days and maximum temperature was 54 ºC. After 29 days the temperature decreased to 19 ºC. The temperature variation during forced aeration composting is shown in Fig. 5. Initially the temperature inside reactors increased rapidly for few days and then decreased rapidly for few days and slowly for forced aeration composting.

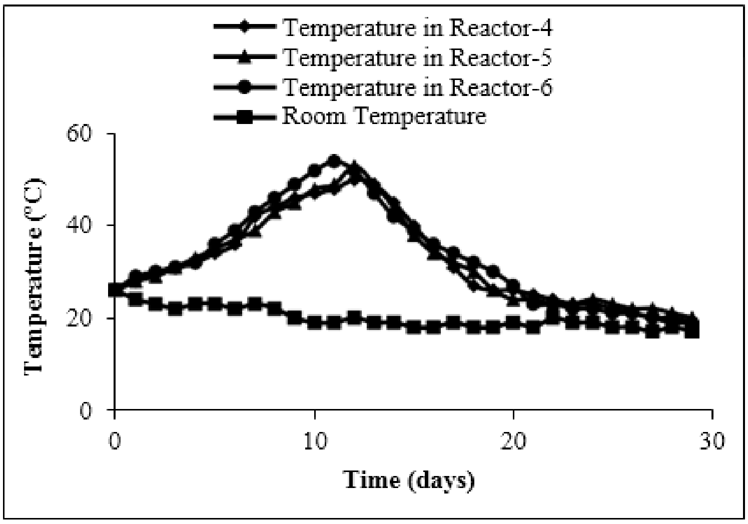


Fig. 5: Temperature Variation during Forced Aeration Composting.

Initial weight of waste mixture in reactor-4, 5 and 6 were 450, 455 and 465 g respectively and final weight were 235, 265 and 270 g respectively after 29 days of composting. The moisture content of the waste mixture was 69.4% initially and decreased to 66.1%. The volatile solid of the waste mixture was 94.4% initially and decreased to 88.2%. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-4 were found as 47.78%, 50.27%, 42.12% and 45.15% respectively.

3.3. Volatile solids degradation

The maximum temperature was in the range of composting process (below 60 ºC) in both passive and forced aeration composting processes. The percentage reduction in total sample was greater for forced aeration than passive aeration. Forced aeration composting of the waste mixture was selected to determine the volatile solids degradation with time. The temperature increased from 30 to 52 ºC. The moisture content of the waste mixture was 68% initially and increased to 69.9% and decreased to 41.7%. The volatile solid of the waste mixture was 93.4% initially and decreased to 87.4%. The volatile solids decreased with time at the end of composting process. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-1 were found as 3.85%, 2.43%, 6.99% and 7.23% respectively. The percentage reductions in total sample, moisture, dry solids and volatile solids with time are shown in Fig. 6. The percentage reductions in total sample, moisture, total solids and volatile solids increased with time.

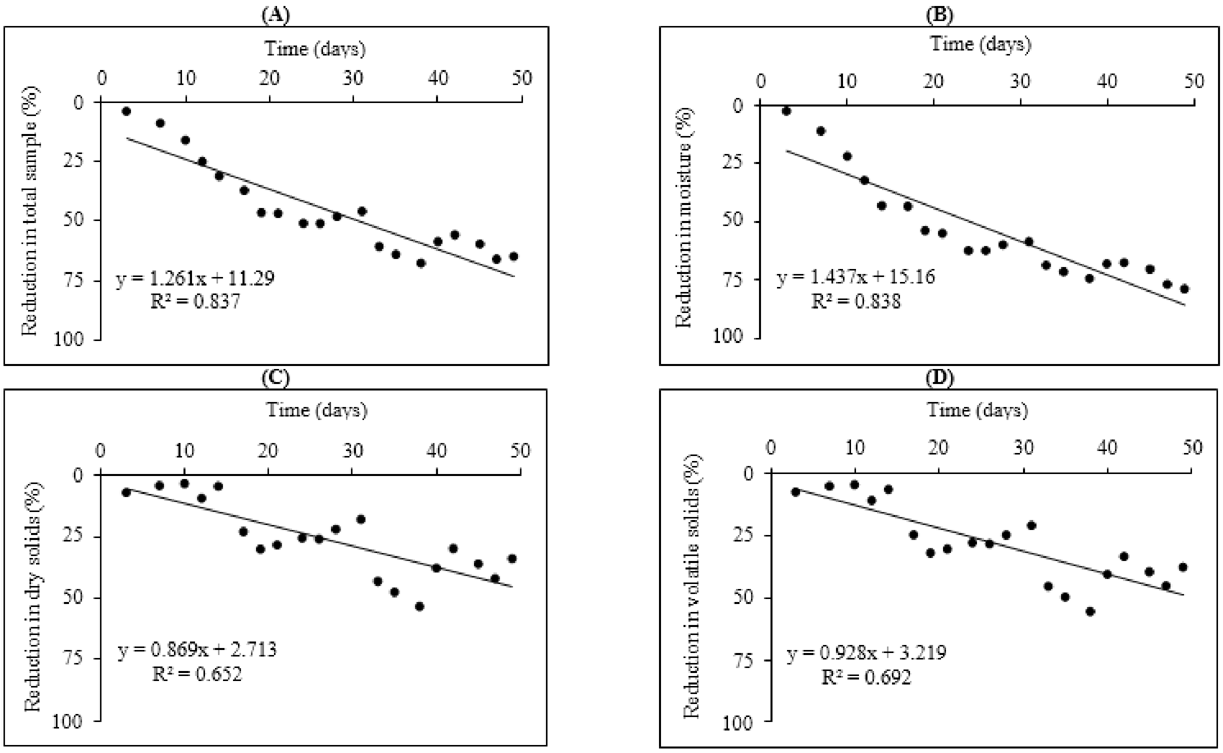


Fig. 6: Reductions in Total Sample, Moisture, Total Solids and Volatile Solids during Forced Aeration Composting. (A) Reductions in Total Sample. (B) Reductions in Moisture. (C) Reductions in Dry Solids. (D) Reductions in Volatile Solids.

4. CONCLUSIONS

In this study the first run was carried out with passive aeration and second run with forced aeration to determine the temperature variation with time during composting. The third run was carried out with forced aeration to determine the volatile solids degradation with time for a series of composting process. Initially the temperatures inside reactors increased rapidly from 26 to 52 ºC for few days and then decreased slowly to 28 ºC for passive aeration composting. Initially the temperatures inside reactors increased rapidly from 26 to 54 ºC for few days and then decreased rapidly to 26 ºC for few days and slowly to 19 ºC for forced aeration composting. During composting chemical reaction in the waste mixture generates heat, thus increasing the temperature inside reactors. The percentage reductions in total sample and volatile solids were found to be varied from 3 to 68 % and 4 to 55 % respectively. The percentage reductions in total sample, moisture, total solids and volatile solids increased with time. Vegetable waste and paper waste are degraded during composting. There is a possibility of recycling the organic waste in the form of composting.

Acknowledgments

The experimental work was conducted in the Environmental Engineering Laboratory of Department of Civil Engineering at Khulna University of Engineering and Technology, Khulna, Bangladesh. The authors would like to express thanks to the Staffs of Environmental Engineering Laboratory for their co-operation during the study.

REFERENCES

[1] U. S. Environmental Protection Agency (EPA), The Solid Waste Dilemma: an Agenda for Action, Draft report, EPA/530/SW-88-052, 1988.

[2] M. F. Ahmed and M. M. Rahman, Water Supply & Sanitation: Rural and Low Income Urban Communities, ITN-Bangladesh, Dhaka, 2000.

[3]A. M. Taiwo, Composting as a Sustainable Waste Management Technique in Developing Countries, Journal of Environmental Science and Tech- nology, 4(2), 2011, 93-102. https://doi.org/10.3923/jest.2011.93.102.

[4] S. R. Lohani, Composting: A Better Solution for Managing Nepal's Increasing Solid Waste, Journal of the Institute of Engineering, 13(1), 2017, 215-220.

[5] G. Tchobanoglous, H. Theisen and S. Vigil, Integrated Solid Waste Management: Engineering Principles and Management Issues, McGraw-Hill, Inc., New York, 1993. https://doi.org/10.3126/jie.v13i1.20369.

[6] G. Tchobanoglous and F. L. Burton, Wastewater Engineering: Treatment, Disposal and Reuse, Metcalf & Eddy, Inc., Tata McGraw-Hill Publishing Company Limited, New Delhi, 1995.

[7] H. S. Peavy, D. R. Rowe and G. Tchobanoglous, Environmental Engineering, McGraw-Hill Book Company, New York, 1985.

[8] S. J. Kulkarni, Aerobic Composting - A Short Review, International Journal of Research & Review, 4(2), 2017, 73-75.

[9] S. Sarkar, S. Pal and S. Chanda, Optimization of a Vegetable Waste Composting Process with a Significant Thermophilic Phase, Procedia Envi- ronmental Sciences 35, 2016, 435-440. https://doi.org/10.1016/j.pro env.2016.07.026.

[10] M. Neugebauer, P. Sołowiej, J. Piechocki, W. Czekała and D. Janczak, The Influence of the C: N Ratio on the Composting Rate, International Journal of Smart Grid and Clean Energy, 6(1), 2017, 54-60. https://doi.org/10.12720/sgce.6.1.54-60.

[11] S. S. Gonawala and H. Jardosh, Organic Waste in Composting: A Brief Review, International Journal of Current Engineering and Technology, 8(1), 2018, 36-38. https://doi.org/10.14741/ijcet.v8i01.10884.

[12] M. Alamgir and A. Ahsan, Characterization of MSW and Nutrient Contents of Organic Component in Bangladesh, Electronic Journal of Environ- mental, Agricultural and Food Chemistry, 6(4), 2007, 1945-1956.

Automation of Optimal Production Schedules for A Certain Class of Deterministic Inventory Problems using Dynamic Programming

[1] Ukwu, Chukwunenye & [2] TankoIshaya
[1]Department of Mathematics, University of Jos, P.M.B 2084, Jos, Plateau State, Nigeria.
[2]Department of Computer Science, University of Jos, P.M.B 2084, Jos, Plateau State, Nigeria.

ABSTRACT

This research article conceptualized, formulated and designed Excel solution templates and corresponding exposition for optimal production schedules for a certain class of deterministic inventory problems. The article also provided illustrative examples which demonstrated the efficiency, utility and processing power of the solution templates. The deployment of the solution templates circumvents the inherent tedious, and prohibitive manual computations associated with dynamic programming formulations and recursions and may be optimally appropriated for sensitivity analyses on each model.

Keywords: Automation, Deterministic, Dynamic programming recursions, Excel, Inventory, Optimal production schedules, Solution Templates.

1. INTRODUCTION

The need for automation of processes is imperative; this is especially so of optimal policy prescriptions of dynamic programming-based outputs with resulting tremendous savings in time, cost and energy. Consequently, any desired levels of sensitivity analyses can be easily undertaken and accomplished with great rapidity; needless to say that long horizon lengths can be assigned henceforth in such problems that hitherto could hardly be contemplated due to the „curse of dimensionality‟ of dynamic programming recursions.

Ukwu [1,2] designed and implemented Excel solution templates for optimal investment strategies and the corresponding optimal rewards, for the largest class of certain probabilistic dynamic investment problems for practical and realistic consideration, using backward recursive dynamic programming. It went further to optimally deploy the templates for sensitivity analysis of the problem, in just a matter of minutes. These activities could hardly be contemplated in manual computations. The templates reflected and demonstrated consistency with the base results. In the sequel, Ukwu [3] designed and fully automated the solution templates for the determination of the optimal time replacement policies for a time perspective class of machine replacement problems with pertinent dynamic data given as functions of new machine purchase year and machine age. Ukwu [4,5] went on to design and automate prototypical solution templates for batch optimal policy prescriptions for a certain stationary class of equipment replacement problems, with any set of feasible starting ages, complete with an algorithmic exposition on the interface and solution process.

Ukwu et al. [6] investigated the problem of fund allocations from certain investment portfolio and obtained the optimal investment strategies using backward dynamic programming recursive approach. In what followed, Ukwu et al. [7] conceptualized, formulated and designed Excel solution templates and corresponding algorithm for the optimal allocation of funds from the investment portfolio. The work also provided illustrative examples which demonstrated the efficiency, utility and processing power of the solutions templates. A careful study of above works among others reveals that they can be leveraged and exploited for optimal production strategies of a certain class of inventory problems.

The optimal production schedule for a certain class of deterministic inventory problems using backward dynamic programming recursions has been investigated by Taha [8] and Winston [9], among other authors. Unfortunately the related issue of computational feasibility is yet to be addressed. Iterations in dynamic programming recursions are computationally intractable and doomed to failure for practical purposes, especially for large scale applications; thus, the need for electronic implementation of optimal production schedules cannot be overemphasized.

This paper fills the above need by formulating and designing prototypical Excel automated solution templates based on dynamic programming recursions with a view to minimizing production costs in inventory problems. These templates are deployed to eliminate the computational tedium and other constraints, as well as pave the way for instant generation of optimal strategies, as soon as the pertinent data are keyed in. The optimality results will be facilitated by a robust investigation of the solution templates in the afore-mentioned works of Ukwu and others, and by sound reasoning regarding the implicit dependence of the dynamic programming recursions on stage numbers. Finally, this study will deploy the templates to obtain optimal production schedules for problem instances with specified entering inventories.

2. THEORETICAL UNDERPINNING

The production scheduling problem is the determination of what quantity to produce during each period to minimize the over-all production cost, given the following parameters:

(i) Problem horizon length
(ii) Entering (Incoming) inventory during each period
(iii) Demand specifications for the various periods
(iv) Set up costs associated with positive production quantities
(v) Holding (Storage) cost per period per unit inventory
(vi) Capacity constraints on production/demand
(vii) Production function specification

The model for the paper is backward dynamic programming recursions for the determination of optimal production levels with respect to a stated class of deterministic inventory problems.

2.1 Notations for the model parameters:

T : Horizon length of the problem; t : Stage identifier; $t \in \{T, T-1, \ldots .2, 1\}$
i_t : Entering inventory during period t; d_t : Demand during period t
I_t : The set of feasible entering inventory in stage
h: Holding cost per unit inventory per period t, $t \in \{T, T-1, \ldots, 2, 1\}$.
$x_t\ (i_t)$: Production quantity during period t, given that the entering inventory is it
$c(x) = k_0 + k_1 x + k_2 x_2 + k_3 x_3 + k_4 x_4$: Production function
$f_t\ (i_t)$: Minimum production cost for period t,t +1,....., and T given that the entering inventoryduring period t is it .

The relevant dynamic programming recursions are the following:

$$f_t(i_t) = \min_{t\in I_t}\{c(x_t(i_t)) + f_{t+1}(i_{t+1})\},\ t\in\{T, T-1,\cdots,2,1\};\ f_{T+1}(.) = 0 \Rightarrow f_T(x_T(i_T)) = c(x_T(i_T))$$

$i_{t+1} = i_t + x_t(i_t) - d_t \ge 0 \Rightarrow$ demand must be satisfied; $x_t(i_t) \ge 0 \Rightarrow$ production must be at nonnegative levels

$i_t, x_t(i_t) \in \mathbf{N}, d_t \in \mathbf{N}, \sum_{t=1}^{T} d_t \in \mathbf{N}, h \in \mathbf{R}^+, T \in \mathbf{N}, f_t(i_t) \in \mathbf{R}^+; f_t(i_t) = 0 \Leftrightarrow$ there is no production activity.

$\sum_{t=1}^{T} d_t \in \mathbf{N} \Rightarrow$ there must be at least one positive demand during the horizon, otherwise there is nothing to solve.

$$c(x_t(i_t)) = \left(k_0 + \sum_{j=1}^{4} k_j x_t^j(i_t)\right)$$

The development of appropriate solution templates is detailed below and it is based on the above backward dynamic programming model.

3. METHODS, RESULTS AND DISCUSSION

3.1 Excel Implementation Template Design and interface For Optimal Production Schedules

Terminal Stage, T							
	A	B	C	D	E	F	G
1	Excel Solution…						
2	Recursions						
3							
4	No. of periods:	T	Max Dem =	5			
5	$c(x) = k_0 \operatorname{sgn}(x) + k_1 x + k_2 x^2 + k_3 x^3 + k_4 x^4$						
6							
7		k_0	k_1	k_2	k_3	k_4	
8	Values of k_i:						
9	Demand:	d_T					
10		Stage	= [1]				
11	i	$x(i)$	$f(i) = c(x)$				
12	0	= [3]	= [5v]				
13	= [2v]	=[4v]					
…							
17							

19	Penultimate Stage, T–1						
20	Demand:	d_{T-1}					
21		Stage	= [6]	Computations			

23	0	= [8]	=[10v]	=[11v]	= [12v]	=[13v]	= [14v]
24	= [7v]	= [9v]					
…							
31							
33	1	= [8]	=[10v]	=[11v]	= [12v]	=[13v]	= [14v]
34	= [7v]	= [9v]					
…							
42							
4 4	2	= [8]	= [10]	= [11]	= [12]	= [13]	=[14]
4 5	= [7v]	= [9v]					
…							
5 3							
5 5	3	= [8]	=[10v]	=[11v]	= [12v]	=[13v]	= [14v]
5 6	= [7v]	= [9v]					
…							
6							
4							
6 6	4	= [8]	=[10v]	=[11v]	= [12v]	=[13v]	= [14v]
6 7	= [7v]	= [9v]					
…							
7 5							

77	5	= [8]	=[10v]	=[11v]	= [12v]	=[13v]	= [14v]
78	= [7v]	= [9v]					
...							
89							

Stage (*T*-2)							
91	Demand	d_{T-2}					
92		Stage	= [15]	Computations			
93	*i*	*x*(*i*)	$h(i+x-d)+c(x)$	$f(i+x-d)$	C+D	x^*	*f*(*i*)
94	0	= [17]	=[19v]	=[20v]	= [21v]	=[22v]	= [23v]
95	= [16v]	= [18v]					
...							
100							

The tabular process continues down to stage 1. Any stage number less than one indicates infeasibility. Blank cells also indicate forbidden choices.

3.2 Exposition on the Solution Template

"= [m] "indicates code segment m to be typed in the resident cell location.

"= [mv] "with letter v fixed indicates code segment m to be typed in the resident cell location followed by vertical crosshair-dragging activity.

Multiple "= [m] " or"= [mv] " indicates copying activity of the code segment from the initial cell locations.

Type the titles of the template in excel rows 1 and 2 as indicated above. Type the production cost function c(x) and its parameters in the indicated cell locations. An identifier succeeded by a colon indicates desired user input subject to the imposed restrictions.

3.3 Initialization of Stage numbering:

= [1]: Type the following code segment =$B$5, in cell location C10, <Enter> to initialize the stage number at integral input value m.

3.3.1 Stage TImplementations Incoming inventory, I :

Step 1: Input the number 0 in cell location A12.

Step 2: = [2v]: Type the following code segment =IF($A12<$B$9,1+$A12,""), in cell location A13,<Enter> to secure the next feasible higher contiguous integer. Click the cursor back on A13, position the cursor at the bottom right edge of the cell until a crosshair appears. Then drag the crosshair vertically down to cell location A17, to secure all feasible values of I.

Henceforth the act of clicking the cursor back on an indicated cell location, positioning the cursor at the bottom right edge of the cell until a crosshair appears and then dragging the crosshair vertically down to an indicated cell location will be described as clerical routine/duty.

Production Quantity,

xT (i) :
Step 1: =[3]: "=$B$9-$A12", in B12,<Enter>
Step 2.=[4v]: "=IF($A13 ="","",$B$9-$A13)", in B12, followed by the clerical duty, down to B17.

Minimum Costs,
fT (i), f (i) , for Entering Inventory
= [5v]: "=($B$8+$C$8*$B12+$D$8*$B12^2+$E$8*$B12^3+$F$8*$B12^4)*SIGN($B12)", inC12, followed by the clerical duty, down to C17.

3.3.2 Stage (T-1) Computations. Incoming inventory, i = 0:
Step 1: Input the number 0 in cell location A22.
Step 2: = [7v]: Type the following code segment "=IF(COUNT(A$22:A22)<$B$9+$B$19,0,"")", in cell location A23,followed by the clerical duty down to A31.

Production Quantity,
xT –1(i) :
Step 1: =[8]: "=MAX($B$19-$A22,0)<Enter>
Step 2. =[9v]: "=IF(OR($A23="",$B22>=$B$9+$B$19),"",1+$B22)", in B23, followed by the clerical duty, down to B31.

Implementation of C+D
=[12v]: " =IF(OR($C22="",$D22=""),"",$C22+$D22)",in E22, followed by the clerical duty, down to E31.

Implementation of x*
=[13v]: " = IF($E22=MIN($E$22:$E$31),$B22,"")", in F22, followed by the clerical duty, down to F31.

Minimum Costs,
fT –1(i) , for Entering Inventory
= [14v]: "=IF($F22="","",$E22)", inG22, followed by the clerical duty, down to G31.
Incoming inventory, i = 1:

Step 1: Input the number 1 in cell location A33
Step 2: = [7v]: Type the following code segment "=IF(COUNT(A$33:A33)<$B$9+$B$19,0,"")", in cell location A34,followed by the clerical duty down to A42.

Production Quantity,
$x_{T-1}(i)$:

Step 1: =[8]: "=MAX($B$19-$A33,0)<Enter>
Step 2: = [9v]: "=IF(OR($A34="",$B33>=$B$9+$B$19),"",1+$B33)", in B34, followed by the clerical duty, down to B42.

Implementation of h(i+x-d)+c(x)
=[10v]: "=IF(OR($A33 = "", $B33 = ""), "",0.5*($A33+$B33-$B$19)+($B$8+$C$8*$B33+$D$8*$B33^2+$E$8*$B33^3+$F$8*$B33^4)*SIGN($B33)), in C33, followed by the clerical duty, down to C42.

Implementation of f (i+x-d)
=[11v]: "=IF(OR($A33 = "", $B33 = ""), "",IF($A33+MAX($B33,0) MAX($B$19,0)=0,MAX($C$12,0),IF($A33+MAX($B33,0) MAX($B$19,0)=1,MAX($C$13,0),IF($A33+MAX($B33,0) MAX($B$19,0)=2,MAX($C$14,0),IF($A33+MAX($B33,0) MAX($B$19,0)=3,MAX($C$15,0),IF($A33+MAX($B33,0) MAX($B$19,0)=4,MAX($C$16,0),IF($A33+MAX($B33,0)

MAX($B$19,0)=5,MAX($C$17,0),"")))))))", in D33, followed by the clerical duty, down to D42.

Implementation of C+D
=[12v]: "=IF(OR($C33="",$D33=""),"",$C33+$D33)",in E33, followed by the clerical duty, down to E42.

Implementation of x*
=[13v]: "=IF($E33=MIN($E$33:$E$42),$B33,"")", in F33, followed by the clerical duty, down to F42.
Minimum Costs,
$f_{T-1}(i)$, for Entering Inventory
= [14v]: "=IF($F33="","",$E33)", in G33, followed by the clerical duty, down to G42.
Incoming inventory $i \in \{2, 3, 4, 5\}$

Step 1: Input the number i in cell location A(33+(i -1)*11)
Step 2: Replace the " 33" in the code segment " = [7v] :" with(33+11(i-1)) 1n cell location A(1+(33+11(i-1))),followed by the clerical duty down to A(9+(1+(33+11(i-1)))).
Production Quantity,
$x_{T-1}(i) : i \in \{2, 3, 4, 5\}$
Add 11(i-1) to all relative row references in steps 1 and 2 corresponding to i =1,incorporating "=[8]:" and " =[9v]:".

Implementation of h(i+x-d)+c(x): $i \in \{2,3,4,5\}$
Add 11(i-1) to all relative row references in " =[10v]:" and the ensuing clerical duty.
Implementation of f (i+x-d): $i \in \{2, 3, 4, 5\}$
Add 11(i-1) to all relative row references in " =[11v]:" and the ensuing clerical duty.
Implementation of C+D: $i \in \{2, 3, 4, 5\}$

Add 11(i-1) to all relative row references in " =[12v]:" and the ensuing clerical duty.
Implementation of x*: $i \in \{2,3,4,5\}$
Add 11(i-1) to all relative row references in " =[13v]:" and the ensuing clerical duty.
Minimum Costs,
$fT-1(i) : i \in \{2,3,4,5\}$
Add 11(i-1) to all relative row references in " =[14v]:" and the ensuing clerical duty.
Stage (T-2).
Implementations of i, xi,h(i+x-d)+c(x):
Add 69 to all row references of cells in stage T-1, for corresponding ivalues, excluding the $B$8:$F$8, with global scope. Page | 11

Implementations of f (i+x-d):
Replace the code segment in $D22 (for i = 0, in stage T-1) with the code segment below:
" =IF(OR($A91 = "", $B91 = ""), "",IF($A91+MAX($B91,0) MAX($B$88,0)=0,MAX($G$22:$G$31,0),IF($A91+MAX($B91,0) MAX($B$88,0)=1,MAX($G$33:$G$42,0),IF($A91+MAX($B91,0) MAX($B$88,0)=2,MAX($G$44:$G$53,0),IF($A91+MAX($B91,0) MAX($B$88,0)=3,MAX($G$55:$G$64,0),IF($A91+MAX($B91,0) MAX($B$88,0)=4,MAX($G$66:G$75,0),IF($A91+MAX($B91,0) MAX($B$88,0)=5,MAX($G$77:$G$86,0),"")))))))", without the quotes.

Then apply the clerical duty from the input cell $D91down to $D100.

For $i \in \{1,2,3,4,5\}$, add 11i to all relative row references corresponding to i = 0.

Implementations C+D,x* and f (i):
The code segments for C+D,x* and f (i) are invariant and hence may be copy from stage T-1 down to stage 1.
Stage t , $t \in \{T-3,\dots,1\}$.
Implementations of i, x(i),h(i+x-d)+c(x):
Add 69 $(T-2-t)$ to all row references of cells in stage (T-2), for corresponding i values, excluding the $B$8:$F$8, with global scope, bringing the exposition to an end.
By an appeal to Ukwu[3]the optimal production strategies can be obtained in respect of sub-horizon lengths $n \in \{1,2,\dots,T-1\}$ from the same solution template using a top-down horizon length count in which stage $(T+t-n)$ in the T - horizon problem corresponds to stage t ; $t \in \{1,2,\dots,n\}$ in the n-horizon problem.

3.4 EXPOSITION

3.4.1 General Application problem

A company knows that the demand for its product during each of the next T months will be as follows: montht, dtunits; $t \in \{1,2,\dots,T\}$. At the beginning of each month the company must determine how many units should be produced during the current month. During a month in which any units are produced, a setup cost of $ k0 quartic cost function: is incurred. In addition, there is a variable $c(x) = k_1x + k_2x^2 + k_3x^3 + k_4x^4$, for every x units produced.

At the end of each month a holding cost of $h per unit on-hand is incurred. Historical data reveal that demand for any period does not exceed D units during each month. The company wants to determine a production schedule that will meet all demands on time and will minimize the sum of production and holding costs during the T months.

Solve the above problem with the following pertinent data: D = 5,T = 6

Figure 1: Excel solution template outputs of optimal production schedule for a class of inventory problems using dynamic programming recursions

EXCEL SOLUTION TEMPLATE OUTPUTS OF OPTIMAL PRODUCTION SCHEDULE FOR								
A CLASS OF INVENTORY PROBLEMS USING DYNAMIC PROGRAMMING RECURSIONS								
		Max Horizon						
		Length:	6					
No of periods :	6	Max Demand:	5	***h*** :	0.75			
$c(x) = k_0 \operatorname{sgn}(x) + \sum_{j-1}^{4} k_j x^j$								
	k_0	k_1	k_2	k_3	k_4			
Values of k_j $j = 0, 1, \ldots, 4$	4	1	0.0015	0.00012	0.00002			
Demand :	4							
	Stage	6						
i	x (i)	f(i) = c(x)						i_{t+1}
0	4	8.0368						0
1	3	7.01836						0
2	2	6.00728						0
3	1	5.00164						0
4	0	0						0
Demand	2							
	Stage	5	Comp.					
i	x(i)	***h*** (i+x-d)+c(x)	f (i+x-d)	C+D	x^*	f (i)	i_{t+1}	
0	4	8.0368						0
1	3	7.01836						0
2	2	6.00728						0
3	1	5.00164						0
4	0	0						0
Demand	2							
	Stage	5	Comp.					
i	x(i)	***h*** (i+x-d)+c(x)	f (i+x-d)	C+D	x^*	f (i)	i_{t+1}	
0	2	6.00728	8.0368	14.04408				
0	3	7.76836	7.01836	14.78672				
0	4	9.5368	6.00728	15.54408				
0	5	11.315	5.00164	16.31664				
0	6	13.10584	0	13.10584	6	13.1058	4	
0								

1	1	5.00164	8.0368	13.03844			
1	2	6.75728	7.01836	13.77564			
1	3	8.51836	6.00728	14.52564			
1	4	10.2868	5.00164	15.28844			
1	5	12.065	0	12.065	5	12.065	4
1	6	13.85584	0	13.85584			
2	0	0	8.0368	8.0368	0	8.0368	0
2	1	5.75164	7.01836	12.77			
2	2	7.50728	6.00728	13.5146			
2	3	9.26836	5.00164	14.27			
3	0	0.75	7.01836	7.76836	0	7.76836	1
3	1	6.50164	6.00728	12.5089			
3	2	8.25728	5.00164	13.2589			
3	3	10.01836	0	10.0184			
3	4	11.7868	0	11.7868			
3	5	13.565					
4	0	1.5	6.00728	7.50728	0	7.50728	2
4	1	7.25164	5.00164	12.2533			
4	2	9.00728	0	9.00728			
4	3	10.76836	0	10.7684			
4	4	12.5368					
4	5	14.315					
5	0	2.25	5.00164	7.25164	0	7.25164	3
5	1	8.00164	0	8.00164			
5	2	9.75728	0	9.75728			
5	3	11.51836					
5	4	13.2868					
5	5	15.065					
Demand	3						
	Stage	4	Comp.				
i	x(i)	*h* (i+x-d)+c(x)	f (i+x-d)	C+D	x^*	f (i)	
0	3	7.01836	13.10584	20.1242			
0	4	8.7868	12.065	20.8518			
0	5	10.565	8.0368	18.6018	5	18.6018	2
0							
0							

1	2	6.00728	13.10584	19.1131			
1	3	7.76836	12.065	19.8334			
1	4	9.5368	8.0368	17.5736	4	17.5736	2
1	5	11.315	7.76836	19.0834			
1							
2	1	5.00164	13.10584	18.1075			
2	2	6.75728	12.065	18.8223			
2	3	8.51836	8.0368	16.5552	3	16.5552	2
2	4	10.2868	7.76836	18.0552			
2	5	12.065	7.50728	19.5723			
3	0	0	13.10584	13.1058	0	13.1058	0
3	1	5.75164	12.065	17.8166			
3	2	7.50728	8.0368	15.5441			
3	3	9.26836	7.76836	17.0367			
3	4	11.0368	7.50728	18.5441			

Demand	**3**						
	Stage	4	**Comp.**				
i	**x**(i)	***h*** **(i+x-d)+c(x)**	**f** (i+x-d)	**C+D**	**x***	**f** (i)	
0	3	7.01836	13.1058	20.1242			
0	4	8.7868	12.065	20.8518			
0	5	10.565	8.0368	18.6018	5	18.6018	2
0							
0							
1	2	6.00728	13.1058	19.1131			
1	3	7.76836	12.065	19.8334			
1	4	9.5368	8.0368	17.5736	4	17.5736	2
1	5	11.315	7.76836	19.0834			
1							
2	1	5.00164	13.1058	18.1075			
2	2	6.75728	12.065	18.8223			
2	3	8.51836	8.0368	16.5552	3	16.5552	2
2	4	10.2868	7.76836	18.0552			
2	5	12.065	7.50728	19.5723			
3	0	0	13.1058	13.1058	0	13.1058	0
3	1	5.75164	12.065	17.8166			
3	2	7.50728	8.0368	15.5441			
3	3	9.26836	7.76836	17.0367			
3	4	11.0368	7.50728	18.5441			

Demand	**3**						
	Stage	4	**Comp.**				
i	**x**(i)	***h* (i+x-d)+c(x)**	**f** (i+x-d)	**C+D**	**x***	**f** (i)	
0	3	7.01836	13.1058	20.1242			
0	4	8.7868	12.065	20.8518			
0	5	10.565	8.0368	18.6018	5	18.6018	2
0							
0							
1	2	6.00728	13.1058	19.1131			
1	3	7.76836	12.065	19.8334			
1	4	9.5368	8.0368	17.5736	4	17.5736	2
1	5	11.315	7.76836	19.0834			
1							
2	1	5.00164	13.1058	18.1075			
2	2	6.75728	12.065	18.8223			
2	3	8.51836	8.0368	16.5552	3	16.5552	2
2	4	10.2868	7.76836	18.0552			
2	5	12.065	7.50728	19.5723			
3	0	0	13.1058	13.1058	0	13.1058	0
3	1	5.75164	12.065	17.8166			
3	2	7.50728	8.0368	15.5441			
3	3	9.26836	7.76836	17.0367			
3	4	11.0368	7.50728	18.5441			
4	0	0.75	12.065	12.815	0	12.815	1
4	1	6.50164	8.0368	14.5384			
4	2	8.25728	7.76836	16.0256			
4	3	10.01836	7.50728	17.5256			
4	4	11.7868	7.25164	19.0384			
5	0	1.5	8.0368	9.5368	0	9.5368	2
5	1	7.25164	7.76836	15.02			
5	2	9.00728	7.50728	16.5146			
5	3	10.76836	7.25164	18.02			
5	4	12.5368					
Demand	**1**						
	Stage	3	**Comp.**				
i	**x**(i)	***h* (i+x-d)+c(x)**	**f** (i+x-d)	**C+D**	**x***	**f** (i)	

0	1	5.00164	18.6018	23.6034			
0	2	6.75728	17.5736	24.3309			
0	3	8.51836	16.5552	25.0735			
0	4	10.2868	13.1058	23.3926	4	23.3926	3
1	0	0	18.6018	18.6018	0	18.6018	0
1	1	5.75164	17.5736	23.3252			
1	2	7.50728	16.5552	24.0624			
1	3	9.26836	13.1058	22.3742			
2	0	0.75	17.5736	18.3236	0	18.3236	1
2	1	6.50164	16.5552	23.0568			
2	2	8.25728	13.1058	21.3631			
2	3	10.01836	12.815	22.8334			
3	0	1.5	16.5552	18.0552	0	18.0552	2
3	1	7.25164	13.1058	20.3575			
3	2	9.00728	12.815	21.8223			
3	3	10.76836	9.5368	20.3052			
4	0	2.25	13.1058	15.3558	0	15.3558	3
4	1	8.00164	12.815	20.8166			
4	2	9.75728	9.5368	19.2941			
4	3	11.51836					
5	0	3	12.815	15.815	0	15.815	4
5	1	8.75164	9.5368	18.2884			
5	2	10.50728					
5	3	12.26836					
Demand	**5**						
	Stage	2	**Comp.**				
i	**x**(i)	***h* (i+x-d)+c(x)**	**f** (i+x-d)	**C+D**	**x***	**f** (i)	
0	5	9.065	23.3926	32.4576			
0	6	10.85584	18.6018	29.4576	6	29.4576	1
0							
0							
0							
0							

1	4	8.0368	23.3926	31.4294			
1	5	9.815	18.6018	28.4168	5	28.4168	1
1	6	11.60584	18.3236	29.9294			
1							
1							
1							
2	4	8.7868	18.6018	27.3886	4	27.3886	1
2	5	10.565	18.3236	28.8886			
2	6	12.35584					
2							
2							
2							
3	3	7.76836	18.6018	26.3702	3	26.3702	1
3	4	9.5368	18.3236	27.8604			
3	5	11.315					
3	6	13.10584					
3							
3							
4	2	6.75728	18.6018	25.3591	2	25.3591	1
4	3	8.51836	18.3236	26.842			
4	4	10.2868					
4	5	12.065					
4	6	13.85584	15.3558	29.2117			
4							
5	1	5.75164	18.6018	24.3534	1	24.3534	1
5	2	7.50728	18.3236	25.8309			
5	3	9.26836					
5	4	11.0368					
5	5	12.815	15.3558	28.1708			
5	6	14.60584					
Demand	**5**						
	Stage	1	**Comp.**				
i	**x**(i)	***h* (i+x-d)+c(x)**	**f** (i+x-d)	**C+D**	**x***	**f** (i)	
0	5	9.065	29.4576	38.5226	5	38.5226	0
0	6	10.85584	28.4168	39.2726			
0	7	12.66268	27.3886	40.0513			

0	8	14.48936	26.3702	40.8595			
0	9	16.3402	25.3591	41.6993			
0	10	18.22	24.3534	42.5734			
0							
0							
0							
0							
1	4	8.0368	29.4576	37.4944	4	37.4944	0
1	5	9.815	28.4168	38.2318			
1	6	11.60584	27.3886	38.9944			
1	7	13.41268	26.3702	39.7828			
1	8	15.23936	25.3591	40.5984			
1	9	17.0902	24.3534	41.4436			
2	4	8.7868	28.4168	37.2036	4	37.2036	1
2	5	10.565	27.3886	37.9536			
2	6	12.35584	26.3702	38.726			
2	7	14.16268	25.3591	39.5218			
2	8	15.98936	24.3534	40.3428			
2	9	17.8402					
2	10	19.72					
2							
2							
2							
3	3	7.76836	28.4168	36.1852	3	36.1852	1
3	4	9.5368	27.3886	36.9254			
3	5	11.315	26.3702	37.6852			
3	6	13.10584	25.3591	38.4649			
3	7	14.91268	24.3534	39.2661			
3	8	16.73936					
3	9	18.5902					
3	10	20.47					
3							
3							
4	2	6.75728	28.4168	35.1741	2	35.1741	1
4	3	8.51836	27.3886	35.907			
4	4	10.2868	26.3702	36.657			
4	5	12.065	25.3591	37.4241			
4	6	13.85584	24.3534	38.2093			
4	7	15.66268					

4	8	17.48936					
4	9	19.3402					
4	10	21.22					
4							
5	1	5.75164	28.4168	34.1684	1	34.1684	1
5	2	7.50728	27.3886	34.8959			
5	3	9.26836	26.3702	35.6385			
5	4	11.0368	25.3591	36.3959			
5	5	12.815	24.3534	37.1684			
5	6	14.60584					
5	7	16.41268					
5	8	18.23936					
5	9	20.0902					

Using Ockham"s razor, the optimal solutions are encapsulated in the following optimalitytable

Tables 1, 2 and 3: Optimal Inventory policies for specified pertinent data

Table 1

Optimal Inventory Policy Table for $T = 6$, $h = 0.75$, $k_0 = 4$, $k_1 = 1$, $k_2 = 0.0015$, $k_3 = 0.00012$, $k_4 = 0.00002$					
Stage T	**Demand**	**Vector of entering inventory levels i_t**	**Corresponding vector of optimal prod. Levels $x_t(i_t)$**	**Corresponding vector of minimum cost from stage t to stage 6**	**Vector of ending inventory levels i_{t+1}**
1	5	(0, 1, 2, 3, 4, 5)	(5, 4, 4, 3, 2, 1)	(38.52, 37.49, 37.20, 36.19, 35.17, 34.17)	(0,0,1,1,1,1)
2	5	(0, 1)	(6, 5)	(29.46, 28.42)	(1, 1)
3	1	1	0	18.60	0
4	3	0	5	18.60	2
5	2	2	0	8.04	0
6	4	0	4	8.04	0

Interpretation: If the entering in period 1 is 0, then the optimal production policy is to produce 5, 6, 0,5, 0, and 4 units in periods 1, 2, 3, 4,5 and 6 respectively with total minimum cost of 38.52 monetary units. A similar interpretation applies to the entering inventories 1 to 5.

Table 2

Optimal Inventory Policy Table for $T = 6$, $h = 0.6$, $k_0 = 4$, $k_1 = 1$, $k_2 = 0.001$, $k_3 = 0.0001$, $k_4 = 0.00001$					
Stage t	**Demand**	**Vector of entering inventory levels** i_t	**Corresponding vector of optimal prod. levels** $x_t(i_t)$	**Corresponding vector of minimum cost from stage 1 to stage 6**	**Vector of ending inventory levels** i_{t+1}
1	5	(0, 1, 2, 3, 4, 5)	(5, 4, 4, 3, 4, 1)	(37.983,36.964,36.537,35.525,34.517,33.5136)	(0,0,1,1,1, 1)
2	5	(0, 1)	(6, 5)	(28.9393, 27.9125)	(1, 1)
3	1	1	0	18.2687	0
4	3	0	5	18.2687	2
5	2	2	0	8.02496	0
6	4	0	4	8.02496	0

Table 3

Optimal Inventory Policy Table for $T = 4$, $h = 0.5$, $k_0 = 3$, $k_1 = 1$, $k_2 = 0$, $k_3 = 0$, $k_4 = 0$					
Stage t	**Demand**	**Vector of entering inventory levels** i_t	**Corresponding vector of optimal prod. levels** $x_t(i_t)$	**Corresponding vector of minimum cost from stage 1 to stage 6**	**Vector of ending inventory levels** i_{t+1}
1	1	(0, 1, 2, 3, 4, 5)	(4, 0, 0, 0, 0, 0)	(19.5, 16, 15.5, 15, 12.5, 12.5)	(3, 0, 1, 2, 3, 4)
2	3	(0, 1, 2, 3, 4)	(5, 4, 3, 0, 0)	(16, 15, 14, 11, 10.5)	(2, 2, 2, 0, 1)
3	2	(0, 1, 2)	(6, 5, 0)	(11, 10, 7)	(4, 4, 0)
4	4	(0, 4)	(4, 0)	(7, 0)	(0, 0)

The solution templates act as a supervisor program for problems in the same class. In particular they reveal, as observed from the last table, the sub-optimality of Winston"s solution, Winston ( ), with respect to the entering inventory 0 in period 1,with $f_1(0) = 20$.

4. SUMMARY

So far, this study has shown that manual computational process for optimal production scheduling problems is quite tedious and prone to errors. Also, it is virtually impossible to solve problems with increasing horizon length in manual computations. Electronic implementation is the only way forward for solving practical problems of reasonable sizes and the undertaking of sensitivity analyses. This is imperative for contract bidding and subsequent execution where the utility and power of the solution template can be easily demonstrated in just a matter of minutes, subject to correct data inputs and any modifications or revisions thereof.

5. CONCLUSION AND RECOMMENDATIONS

This article designed and automated prototypical solution templates for optimal policy prescriptions for a certain class of inventory problems, with an algorithmic exposition on the interface and solution process.

Consequently, relevant practical problems of any conceivable size can now be solved instantly as soon as the pertinent data have been organized and stored at the appropriate Excel cell locations, resulting in tremendous savings in time, cost and energy. Furthermore, any desired levels of sensitivity analyses can be easily undertaken and accomplished with great rapidity, needless to say that long horizon lengths can be assigned henceforth in inventory problems that hitherto could hardly be contemplated due to the „curse of dimensionality" .

Finally, this study deployed the templates to obtain optimal production schedules for three problems with entering inventory in the set $\{0, 1, 2, \ldots, 5\}$, in just a matter of minutes.

Optimal production inventory problems should never be manually solved because it is quite tedious, cumbersome, and prone to errors, especially for large problem instances. Furthermore it does not lend itself to sensitivity analyses. Therefore, for practical purposes it is recommended that electronic solution templates be deployed in the search for, and the implementations of optimal production policy prescriptions for the stated class of problems; thanks in particular to the breakthrough research results in Ukwu[1-5] and Ukwu et al. [6, 7].Furthermore, it is recommended that further research should be carried out on the feasibility of devising solution templates for optimal production schedules with respect to other relevant classes of inventory problems.

REFERENCES

[1] UkwuChukwunenye (2016). Optimal investment strategy for a certain class of probabilistic investment problems.International Research Journal of Natural andApplied Sciences. 3(2): 92-105.

[2] UkwuChukwunenye (2016). Sensitivity Analyses and Electronic Implementations of Optimal Investment Strategies and Rewards for a Certain Dynamic Class of Probabilistic Investment Problems.International Research Journal of Natural and Applied Sciences.3(2): 153-163.

[3] UkwuChukwunenye (2016). Design and Full Automation of Excel Solution Templatesfor a Time-perspective Class of Machine Replacement Problems with Pertinent Dynamic Data.Archives of Current Research International. 4(1): 1-15.

[4] UkwuChukwunenye (2016). An Algorithm for Global Optimal Strategies and Returnsin One Fell Swoop, for a Class of Stationary Equipment Replacement Problems with Age Transition Perspectives, Based on Nonzero Starting Ages. Advances in Research. 7(4):1- 20.

[5] UkwuChukwunenye (2016l). Zero-Based Batch Starting Age Algorithm for GlobalOptimal Strategies and Returns, For A Class Of Stationary Equipment Replacement Problems with Age Transition Perspectives. International Journal of Advanced Research in Computer Science. 7(3): 166-186.

[6] UkwuChukwunenye, ManjelDanladi&Kutchin Stephen (2017d).Optimal FundAllocation from Certain Investment Portfolio Using Backward Dynamic Programming Recursions.International Research Journal of Natural and Applied Sciences. 4(7): 308- 326.

[7] UkwuChukwunenye, ManjelDanladi&Kutchin Stephen (2017c).Optimal FundAllocation from Certain Investment Portfolio Using Backward Dynamic Programming Recursions with Electronic Implementations.International Research Journal of Natural and Applied Sciences. 4(7): 283-299.

[8] Handy A. Taha (2007): "Operations Research: An introduction." 8th Edition Pearson, Prentice-Hall,New Jersey.

[9] Wayne L. Winston (2004): "Operations Research: Applications and Algorithms", Duxbury Press, Boston.

The Struggle for the Soul of the City; Whose City? A Study of Owerri Capital Territory, Imo State, Nigeria

Agoha, Basil Onyekozuru, MNIA, Ph.D
Senior Lecturer,Department Of Architecture, Faculty of Environmental Sciences, ChukwuemekaOdumegwuOjukwu University, Uli campus, Anambra State, Nigeria

A B S T R A C T

The masterplan for the comprehensive development of Owerri Capital Territory did not sufficiently carrythe residents along in the planning and design of the emerging capital territory. The stage therefore was set for the struggle for the soul of the city and whose city it was? The struggle encompassed environmental, physical, socio-political, socio-economic and socio-cultural aspects and more importantly that of heritage and identity. This is so because the cultural identity expresses the philosophy of life, the passion, history and heritage of the people.The paper examines these dimensions of this struggle for the soul of Owerri Capital Territory. It develops a framework for the integration of the community squares in Owerri capital territory so as to improve the quality of life in the city. It identifies differences in conditions and socio-economic indicators in the community squares in Owerri capital territory. It therefore answers the questions on the differences in conditions and relevant socio-economic indicators of the community squares in Owerri capital territory?. Data were collected using Geographic Information Systems, GIS, Geographic Positioning System,GPS, questionnaires, interviews and visits. Analysis of variance and Spearman rank correlation were used to analyse the data. It was discovered that the struggle is not only real but needs an inclusive multidisciplinary and multidimensional intervention to integrate the community squares, create order and harmony in the midst of this struggle and confusion so as to improve the quality of life in the emerging Owerri Capital Territory.

Keywords; City, multidimensional, people,soul, struggle

INTRODUCTION

Community squares are informal traditional public open spaces transmitted from generation to generation as a heritage. Previous research, Agoha (2016), showed that, the design and evolution reflects the needs, perception and prompting of the people in response to perceived environmental, socio-cultural and socio-economic demands of the time. The people imputed their soul, feelings and perception artistically into physical forms of the community squares. These manifest in hierarchy of open spaces, junctions which adorn the community squares as symbols, meanings, languages and concepts that mean much to the people. These features are not only transmitted but are read and interpreted as part of the informally recorded history in environmental language. They therefore 'speak, smile, cry' in the languages the people hear and interpret, thus reflecting emotions, responses and solutions to the environmental, socio- economic and socio-cultural challenges that confront them from time to time and transmitted to future generations. They are therefore, perpetuated through various cycles that make them live for a long time and almost 'immortal' like a human soul,(wiki/Christian-mortality,2017). This makes the community squares responsive, and adaptable to the demands of the moments they pass through as they reflect the very life of the people. The decimation or disuse the squares through formal planning evokes emotions and generates conflict. This paper therefore not only seeks the framework for the integration of community squares in formal planning but the preservation of the very values inprinted in the artistic patterns in the community squares. The community squares are identified with the elements that create the values using questionnaires, geographic information system, GIS, geographic positioning system,GPS, visits and observations.

BACKGROUND

Community squares provide communal spaces for recreation, environmental control, socio- economic, socio-cultural activities and therefore not only a symbol of the artistic ingenuity of the people but the source of the activities that sustain the life of all in the area. At the creation of Imo State in 1976, the government in order to improve the quality of life in the city, developed a masterplan with changes without identifying and integrating the community squares so as to carry the people along. This stirred the struggle for the control of the 'soul' of the urban environment. Within the formal groups are informal organisations with different identities, passions and aspirations to be met by the socio-economic conditions of the city. The indigenous people felt alienated from their culture not only eroded but the socio- economic life embedded and in-printed in the community squares were being encroachedupon. Thus touching the very life and soul symbolised in the urban fabric. This therefore led to identity crisis and unending struggle for the control of the city by the formal and informal groups resulting to the question, of whose city?

PROBLEM STATEMENT

At the creation of Imo state in 1976,the Owerri masterplan did not identify and integrate the informal traditional community squares. They were decimated with the creation of new public open spaces not in line with the socio-economic and socio-cultural aspirations of the indigenous people. Hence in the core Owerri urban, the formal public open spaces were converted to other uses. The very locations of the informal community squares are still being used for communal activities and private functions leading to street trades, blockades of streets and abuse of the formal open spaces. This results to disenchantment and at times conflicts amongst the people and development control authorities. Since the capital territory has urban, semi-urban/sub-urban and rural components, conflicts in the emerging Owerri capital territory can be reduced if these are identified, integrated and developed formally into public open spaces and parks in the emerging Owerri Capital Territory. This will not only preserve the environmental heritage of the people but lead to inclusiveness and reduce identity crises. This therefore is what the research sets out to address.

SCOPE OF THE STUDY AND STUDY AREA

Owerri Capital territory covers seven,(7) local government areas of Owerri Municipal, Owerri West, Owerri North, and parts of AbohMbaise, Ngor Okpuala, Mbaitoli, Ohaji/Egbema with thirty nine,(39) community squares. The community squares where socio-economic indicators were studied were AforEnyiogugu, Ugwuekwema, Nkwo- UkwuOrodo, OrieMbieri, Idem Ogwa, NkwoUbomiri, AforIrete, Eke Amakohia-Ubi, Amaocha shed, AmaochaAfara, Umuokpo and Okolochi. The indicators studied were; sizes,locations, and mixed use residential buildings.

RESEARCH METHODOLOGY

Survey questionnaire, Geographic Information System, (GIS), Geographic Positioning System, (GPS),visits and interviews were used in data collection. Since the community squares were relatively homogeneous, random sampling was used to reduce the local government areas from seven (7) to four (4) while the community squares were reduced from thirty nine, (39) to thirteen,(13).Out of the three hundred and ninety (390) copies of questionnaires administered, 350 were retrieved. Geographic information system, GIS, Geo- eye satellite images 2015 and Garmin V72 hand held GPS, spot 2.5

instrument were used todetermine the exact locations, sizes of the community squares. The analysis of data was done with analysis of variance,ANOVA for nominal, ordinal, interval and Spearman rank correlation for the ordinal data using the Statistical Programme for Social Sciences, SPSS.

THEORETICAL FRAMEWORK

With the Socraterian belief in the immortality of the soul, Dennis,(2000),that the community square is rooted in the mind of the people explains its sustainability and why it has evolved over the years and is transmitted from generation to generation. While the community life concept of the African emphasises sharing, inclusiveness its offshoot; the extended family system is built on interaction and care. It is therefore superior to the concept of natural selection of evolution,Denis(2000) and the survival of the fittest of capitalism. This is therefore the bane of urbanism whe,re everyone who comes to the city is not only looking for survival strategy but how to exclude and exploit both human and material resources as a means of survival. The community square is not only traditional and sustainable socially, economically and environmentally but provides a good alternative to the 'top to bottom' approach of formal planning which excludes traditional community square to trigger off exclusive and elitist planning. The inclusive nature and bottom to top approach of the African community square is therefore a good ingredient of inclusive and sustainable planning for emerging urban areas.

LITERATURE REVIEW

Community squares asinformal outdoor environmental elements shows the philosophy of open life style of the people symbolised in egalitarianism and democratic values,(Oguejiofor and Onah,2005). The community square has the core nodes, with social, economic and environmental activities such as shops, arts and crafts, with churches, schools and green areas with trees, forest areas, heritage sites and farms. This is synonymous with the three levels of platonic soul; themind(reason),emotion(spiritedness-masculine) and appetitive(desire- feminine),(wiki/plato,2013). For Aristotle the levels of soul are associated as; vegetative for plants, movement (passionate) for animals and reason for humans,(wiki/faculties,2016). These not only identify living things but as soul, transmitted and used to organise living things, activities of man and the built environment. Meetings, dialogue, dialectics of life, socio-political, socio-economic, religious, socio-cultural questions concerning social groups are raised, critically debated and resolved for the progress of the society. Community squarestherefore not only provide sustainable opportunity for intellectual,intercultural and multidisciplinary study of philosophy to advance knowledge but represent the life, beliefs, culture and tradition of the people in artistic forms.

As organizing elements in physical planning, the central business district, where socio- political, socio-economic and socio-cultural activities take place in the community squares form the nucleus with the adjoining villages as multiple nucleic nodes aggregating around the nuclear area,(Donald, Alan and Robert,2003). While the nucleic theory talks of a dominant centre of development, the multiple nucleic advocates several simultaneous centres of development which could merge into a megacity in the future. These generally follow the classical concentric circle theory which formed the basis of the development of the Owerri Capital Territory masterplan,(Imo State Government, 1977). Although each of these has its limitation, they find expression in traditional arrangements of community squares and settlements of the communities in Owerri Capital Territory.

ANALYSIS AND DISCUSSION

The condition of the community squares as the soul and centre of activities is analysed and discussed as;

i).Location of community squares

Most of the community squares in Owerri capital territory were located in centre or heart of suburban, rural and semi-urban areas of Owerri capital territory in the proportion of 39.8%, 29.5% and 26.1% respectively while core urban area was 4.6%. This is given in Table 10.1.

Table 1: Aggregated Location of community squares

Value label	%	Cumulative %frequency
Suburban	39.8	39.8
Semi-Urban	26.1	65.9
urban area	4.6	70.6
Rural areas	29.5	100
Total	100	

Source: Agoha, 2015

Particularly of note was, Amaocha Afara 100% rural with junctions, forest and green areas.

ii).Size of community squares

Cumulatively, 90.7% of the community squares in Owerri capital territory situated on more than 5 plots of land and only 9.3% in less than 5 plots of land, the combined 95.3 percent, (Table 10.2) rural, semi-urban and suburban as above, occupy the heart of the settlement and provided the impetus integration.

Table 2: Size of community square Aggregation

Value label	%	Cumulative % frequency
Less than 5plots	9.3	9.3
More than 5 plots	90.7	100
	100	

Source: Agoha, 2015

The large sizes of most of the community squares provided opportunity for robust integration of community squares as public open spaces in the emerging Owerri capital territory to accommodate and take care of various interest groups.

iii). Mixed use residential buildings

With 41.4% of the community squares having 2 to 10 number mixed use residential buildings 32.4% having 11 to 20 mixed use residential buildings and 26.2% with more than 20 mixed use residential buildings, the community squares have substantial mixed use residential activities at the heart of settlements that encouraged robust socio-economic and socio-cultural activities.

Table 3: Aggregated Mixed use residential buildings in the community squares

Value	%	Cumulative% frequency
(2-10)	41.4	41.4
(11-20)	32.4	73.8
(>20)	26.2	100
Total	100	

Source: Agoha, 2015

Mixed use residential buildings with shops, restaurants, hairdressing, barbing salons, meeting places are part of the activities in the community squares as centre of life of the people.

Table:4.ANOVA for condition against size, location and mixed use residential buildings.

		Sum of Squares	df	Mean Square	F	Sig.
Location of community squares	Between Groups	42.212	2	21.106	23.078	0
	Within Groups	305.467	334	0.915		
	Total	347.68	336			
Size of community squares	Between Groups	4.412	2	2.206	12.84	0
	Within Groups	54.635	318	0.172		
	Total	59.047	320			
Rented residential Buildings	Between Groups	40.839	2	20.42	41.831	0
	Within Groups	152.303	312	0.488		
	Total	193.143	314			

Source; Generated from Agoha,2015

Table;5.Result of Spearman rank correlation bivariate analysis of the relationship between location and mixed use residential buildings

		Mixed use residential building	Remarks	
Location community of squares	Spearman correlation rank coefficient	0.319	significant at confidence level	0.05
	sig.(2-tailed)	0.000		
	N	311		

Source: Generated from Agoha, 2015

Summary of Findings

Differences in the conditions of community squares exist within rural, semi-urban/suburban, and urban areas and between urban and semi-urban/sub-urban, urban and rural, semi- urban/semi-urban and rural areas at the centre of life of the people

ii). There is significant relationship between location and socio-economic activities in mixed use residential buildings.

CONCLUSION

Being at the centre of activities, the differences in the green areas and sizes of the community squares provide opportunity for the accommodation of all interest groups to encourage inclusiveness, sustainability, communal and socio-economic mixed use activities in the emerging Owerri capital territory and indeed other emerging cities in Africa and the black world where blacks practice communal life style, planning and extended family system.

REFERENCES

1. Agoha, B. (2016). Integration of Community Squares into Urban Milieu in Oweri Capital Territory of Imo State, Nigeria. Uli: Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.
2. Anthony, J., & James, C. (1979). introduction to Urban Planning. New York: McGraw - Hill.
3. Camillo, C. (2003). City building according to artistic principles. In W. Donald, P. Alan, & S. Robert, Time-Saver Standards for Urban Design (pp. 2.1-11). NewYork: McGraw-Hill.
4. Dennis, J. (2000). The Creative Impulse;an introduction to the arts. London: Prentice-Hall.
5. Donald, W., Alan, P., & Robert, S. (2003). Time - Saver Standards for Urban Design. New York: McGraw - Hill.
6. Engel. (1990). Introduction: The Ethics of Sustainable Development. In J. a. Engel, Ethics of Environment and Development; Global Challenge, International Response (pp. 10-11). London: Belhaven Press and Tuscan University of Arizona, Press.
7. Grayling, A. (1998). Phylosophy1;A Guide through the Subject. London: Oxford University Press.
8. Gunderson, L., & Holling, C. (2002). Panarchy: Understanding transformation in human and natural systems. Washington, D.C.: Island Press.
9. https://www.khanacademy.org/science/biology/her/evolution-and-natural-selection/a/darwin- evolution-natural- selection?utm_account=Grant&utm_campaignname=Grant_Science_Dynamic. (n.d.). https://www.khanacademy.org/science/biology/her/evolution-and-natural-selection/a/darwin-
10. evolution-natural-selection? Retrieved November 10, 2019, from https://www.khanacademy.org/science/biology/her/evolution-and-natural-selection/a/darwin- evolution-natural- selection?utm_account=Grant&utm_campaignname=Grant_Science_Dynamic&gclid: https://www.khanacademy.org/science/biology
11. Imo State Government. (1977). Imo State Official Gazette; the Owerri capital development Authority, Edict. Owerri: Imo State Government.
12. Marxist.org. (2013). communist-manifesto. Retrieved February 4, 2017, from https://www.marxist.org
13. Oguejiofor, J., Onah, O., & Igwebuike, G. (2005). African Philosophy and the Hermeneutics of Culture; Essays in honour of Theophilous Okere. In African Philosophy and Hermeneutics of Culture; Essay in Honour of Theophilous Okere. Rome: Lit Verlag Munster.
14. Teichmann, J., & Evans, K. (1999). Philosophy;A Beginner's Guide. London: Blackwell.
15. Wiki/christian. (2017, February 17). en.wikipedia.org/wiki/christian-mortalism#imortality-of-
16. the-soul. Retrieved February 22 at 23.20, 2017, from en.wikipedia.org/wiki/christian- mortalism#imortality-of-the-soul
17. wiki/christian. (2017, February 20 at 20.13). en.wikipedia.org/wiki/plato. Retrieved February
18. 22 at 02.05, 2017, from en.wikipedia.org/wiki/plato
19. wiki/Faculties. (2016, November 26 at 07.02). en.wikipedia.org/wiki/Faculties-of-the-soul.
20. Retrieved February 22 at 02.08, 2017, from en.wikipedia.org/wiki/Faculties-of-the-soul

Instructions for Authors

Essentials for Publishing in this Journal

1 Submitted articles should not have been previously published or be currently under consideration for publication elsewhere.

2 Conference papers may only be submitted if the paper has been completely re-written (taken to mean more than 50%) and the author has cleared any necessary permission with the copyright owner if it has been previously copyrighted.

3 All our articles are refereed through a double-blind process.

4 All authors must declare they have read and agreed to the content of the submitted article and must sign a declaration correspond to the originality of the article.

Submission Process

All articles for this journal must be submitted using our online submissions system. http://enrichedpub.com/ . Please use the Submit Your Article link in the Author Service area.

Manuscript Guidelines

The instructions to authors about the article preparation for publication in the Manuscripts are submitted online, through the e-Ur (Electronic editing) system, developed by **Enriched Publications Pvt. Ltd**. The article should contain the abstract with keywords, introduction, body, conclusion, references and the summary in English language (without heading and subheading enumeration). The article length should not exceed 16 pages of A4 paper format.

Title

The title should be informative. It is in both Journal's and author's best interest to use terms suitable. For indexing and word search. If there are no such terms in the title, the author is strongly advised to add a subtitle. The title should be given in English as well. The titles precede the abstract and the summary in an appropriate language.

Letterhead Title

The letterhead title is given at a top of each page for easier identification of article copies in an Electronic form in particular. It contains the author's surname and first name initial .article title, journal title and collation (year, volume, and issue, first and last page). The journal and article titles can be given in a shortened form.

Author's Name

Full name(s) of author(s) should be used. It is advisable to give the middle initial. Names are given in their original form.

Contact Details

The postal address or the e-mail address of the author (usually of the first one if there are more Authors) is given in the footnote at the bottom of the first page.

Type of Articles

Classification of articles is a duty of the editorial staff and is of special importance. Referees and the members of the editorial staff, or section editors, can propose a category, but the editor-in-chief has the sole responsibility for their classification. Journal articles are classified as follows:

Scientific articles:

1. Original scientific paper (giving the previously unpublished results of the author's own research based on management methods).
2. Survey paper (giving an original, detailed and critical view of a research problem or an area to which the author has made a contribution visible through his self-citation);
3. Short or preliminary communication (original management paper of full format but of a smaller extent or of a preliminary character);
4. Scientific critique or forum (discussion on a particular scientific topic, based exclusively on management argumentation) and commentaries. Exceptionally, in particular areas, a scientific paper in the Journal can be in a form of a monograph or a critical edition of scientific data (historical, archival, lexicographic, bibliographic, data survey, etc.) which were unknown or hardly accessible for scientific research.

Professional articles:

1. Professional paper (contribution offering experience useful for improvement of professional practice but not necessarily based on scientific methods);
2. Informative contribution (editorial, commentary, etc.);
3. Review (of a book, software, case study, scientific event, etc.)

Language

The article should be in English. The grammar and style of the article should be of good quality. The systematized text should be without abbreviations (except standard ones). All measurements must be in SI units. The sequence of formulae is denoted in Arabic numerals in parentheses on the right-hand side.

Abstract and Summary

An abstract is a concise informative presentation of the article content for fast and accurate Evaluation of its relevance. It is both in the Editorial Office's and the author's best interest for an abstract to contain terms often used for indexing and article search. The abstract describes the purpose of the study and the methods, outlines the findings and state the conclusions. A 100- to 250-Word abstract should be placed between the title and the keywords with the body text to follow. Besides an abstract are advised to have a summary in English, at the end of the article, after the Reference list. The summary should be structured and long up to 1/10 of the article length (it is more extensive than the abstract).

Keywords

Keywords are terms or phrases showing adequately the article content for indexing and search purposes. They should be allocated heaving in mind widely accepted international sources (index, dictionary or thesaurus), such as the Web of Science keyword list for science in general. The higher their usage frequency is the better. Up to 10 keywords immediately follow the abstract and the summary, in respective languages.

Acknowledgements

The name and the number of the project or programmed within which the article was realized is given in a separate note at the bottom of the first page together with the name of the institution which financially supported the project or programmed.

Tables and Illustrations

All the captions should be in the original language as well as in English, together with the texts in illustrations if possible. Tables are typed in the same style as the text and are denoted by numerals at the top. Photographs and drawings, placed appropriately in the text, should be clear, precise and suitable for reproduction. Drawings should be created in Word or Corel.

Citation in the Text

Citation in the text must be uniform. When citing references in the text, use the reference number set in square brackets from the Reference list at the end of the article.

Footnotes

Footnotes are given at the bottom of the page with the text they refer to. They can contain less relevant details, additional explanations or used sources (e.g. scientific material, manuals). They cannot replace the cited literature.
The article should be accompanied with a cover letter with the information about the author(s): surname, middle initial, first name, and citizen personal number, rank, title, e-mail address, and affiliation address, home address including municipality, phone number in the office and at home (or a mobile phone number). The cover letter should state the type of the article and tell which illustrations are original and which are not.

Address of the Editorial Office:

Enriched Publications Pvt. Ltd.
S-9,IInd FLOOR, MLU POCKET,
MANISH ABHINAV PLAZA-II, ABOVE FEDERAL BANK,
PLOT NO-5, SECTOR -5, DWARKA, NEW DELHI, INDIA-110075,
PHONE: - + (91)-(11)-45525005

Note