ISSN: 0975-766X
CODEN: IJPTFI
Available Online through ***Research Article***
www.ijptonline.com

PALM OIL FRUIT -AUTOMATED GRADINGUSING IMAGE PROCESSINGAND FUZZYLOGICTECHNNIQUES: ANIMPRESSION AND SURVEY

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Received on: 18.10.2016 *Accepted on: 11.11.2016*

Abstract

The Agriculture sector is the main area that serves the food needs of the entire human beings. Research in agriculture is aimed towards increase in the productivity, quality and reducing the probability of error introduced by human beings. Although Malaysia is the largest producer and exporter of palm oil in the world, India is the largest palm oil importer. This resulted India into Palm Oil cultivation and production in various states like Andra Pradesh, Gujarat, Tamil Nadu, Kerala and Goa. The palm oil fruit shows variation in color of its exocarp starting from base to apex. The Unripe fruit has a purplish color while the Ripe fruit has a reddish orange color. In order to increase the productivity of palm oil fruits, palm oil industry uses various machine-vision techniques. This paper explains different category of fruits, climatic conditions, field management, diseases and pests and harvesting methods. It also explains various Image processing and fuzzy logic techniques used automated palm fruit grading.

Index Terms - Fuzzy Logic, exocarp, Machine-vision, Steralization, weeding

1. Introduction

Modern processing of palm oil fruit bunches into edible oil using various Image Processing techniques is practiced in some industries. The traditional methods are also available, small scale mechanical units, medium and large scale palm oil mills.It is agreed that traditional methods of extracting palm oil were tedious and inefficient for making oil for sale.Thus current demand for small-scale palm oil mills is shifting from simple stand-alone unit operational machines to a more integrated and sophisticated computer integrated system which is easy to operate and maintain. This helps in increase in productivity and reduces the human effort which may result in introduction of error. A by-product of palm oil extraction is the palm nut which, when cracked, yields a kernel containing a completely different kind of oil which can be used as a valuable substitute for cocoa butter.

2. Oil Palm Fruit – Environment for Better Survival

(a). History: Oil palm (Elaeis Guineensis) is a native of west Africa and is commercially cultivated in Malaysia, Nigeria, Indonesia, Zaire, Ivory coast, etc. and to a limited extent in India, Ghana and south and central America. It is considered to be the highest oil yielding crop per unit area, capable of producing up to 8 tonnes of oil per hectare. The total world production of palm oil is 8.5 million tonnes. There is a good scope for large scale cultivation of oil palm in India, particularly in Kerala, Karnataka, Tamil Nadu, Maharashtra, Goa, Assam and Orissa. Its cultivation is now restricted to the government owned plantations and public sector undertaking located in Kerala and Andamans. There is a good scope for large scale cultivation of oil palm in India. The total area under oil palm in Kerala is 3705 ha and that in Andamans is 1500 ha. It can also be successfully grown in parts of Karnataka, Tamil Nadu, Maharashtra, Goa, Assam and Orissa.

(b). About the Fruits:

It is that the Oil Palm (Elaeisguineensis) originated in the tropical rain forest region of West Africa [1]. Processing oil palm fruits for edible oil has been practiced in Africa for thousands of years, and the oil produced, highly colored and flavored, is an essential ingredient in much of the traditional West African cuisine. The traditional process is simple, but tedious and inefficient. Palm Oil or Palmolein is the oil produced from the red oil palm tree (ElaeisGuineensis). Palm Oil is extracted from the pulpy portion (mesocarp) of the fruit of Oil Palm. The Crude Palm Oil is deep orange red in color and is semi solid at a temperature of 20 degree centigrade. Palm Oil contains an equal proportion of saturated and unsaturated fatty acid containing about 1-40% oleic acid, 5-10% linoleic acid, 40-44% palmitic acid and 3-5% stearic acid. The unprocessed palm oil is used for cooking in various countries. Palm Oil is a very rich source of Beta Carotene, an important source of Vitamin A and it contains Tecopherols and Tocotrienols, a natural source of Vitamin E. Vitamin A and Vitamin E contents are the highest in palm oil in comparison with any other types of oil and hence consumption of the same boosts health [2].

(c). Structure of the Fruits:

The fruits are usually spherical to ovoid or elongated and bulging at the top. It is about two to five cm long and weight may vary from 3 to 30 gram. It consists of an outer thin skin (exocarp), oil bearing pulp (mesocarp) and a shell endocarp.

The shell together with kernel form the seed. The kernel consist of layers of hard oil endosperm, which is grayish white in colour surrounded by a dark brown testa (skin) covered with a net-work of fibers. Palm oil is extracted from the mesocarp. Kernel also yields oil known as kernel oil, though the quantity is only about 1/4 of that obtained from mesocarp. Oil palm bunch consist of outer and inner fruits. The inner fruits are less pigmented, somewhat flat, undeveloped and non-oil bearing. Bunch weight various from a few to 100 kilograms. The average being around 30 kg. Well set bunches carry 1000 to 3000 fruits. Ripening is usually from tip downwards. A bunch takes about five to six months for ripening. Oil formation in the kernel and mesocarp takes place towards the end of a period of maturation during which shell hardens and then embryo becomes visible.

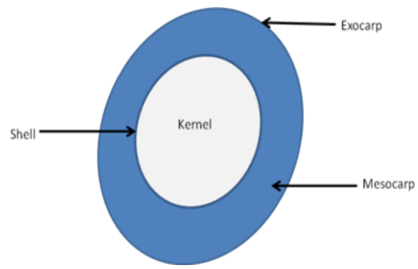

Figure 1: Structure of palm oil fruit.

(d). Varieties of palm oil fruit: Three oil palm varieties have been identified based on the difference in fruit structure. They are Dura, Tenera and Pisifera. Dura has a thick shell(usually two to eight mm) with low to medium mesocarp content (35 to 55%). This variety is not commercially grown now. Tenera variety is a hybrid obtained by crossing Dura (female) and pisifera (male).

It has a thin shell usually measuring 0.5 mm to 4 mm and a medium to big mesocarp content of about 69 to 95 per cent. There is prominent fiber ring in the mesocarp. This is the widely cultivated type all over the world due to the high mesocarp content and resultant oil output. pisifera variety is characterized by a shell-less fruit pea like kernel inside. Often the kernel is also absent. Since many of the fruits do not have embryo, seed propagation is almost impossible.

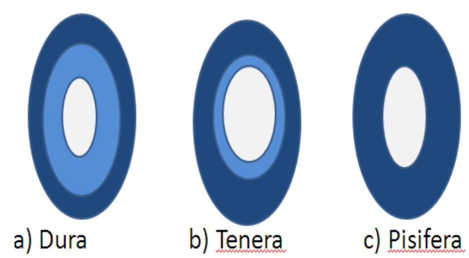

Figure 2: Varieties of palm oil.

(e). Climatic Conditions: Oil palm requires well distributed rainfall of 2500 to 4000 mm per annum with an annual temperature ranging between 200 to 350 Centigrade. A constant sunshine of 5 hours per day is found to be best for oil palm cultivation. It is sun loving plant and does not yield well under heavy shade.It is reported to be growing up to a height of 900 m but 450 m is considered to be the best. Although it can withstand three to four months of dry period, continued moisture stress affects the yield. Since drought affects the yield, supplementary irrigation is necessary during summer months and in low rainfall areas.

(f). Soil: Oil palm can grow on a variety of soils. But a moist deep loamy and alluvial soil rich in humus with good water permeability suits best. Land preparation for planting oil palm consists of clearing of trees, bushes and other weeds. If the field is in forest land, pullout all the bushes and burn them. Burning these bushes helps to control certain diseases which might attack the root of the oil palms and it also makes the soil more fertile. Spread the ashes all over the plot. Hence, the land for the plantation can be cleared by fife and the soil is prepared for the plantation of seedlings.

3. Field Management – Finest Practices

Many traditional practices should be done as and when the oil palm needs. Following are the few cultural practices adopted for the efficient field management.

Figure 3: Oil Palm Fruit Field Management System.

3.1. Intercropping

In young plantations intercrops like oil seeds, cereals, pulses, vegetables, grasses or any other annual crops suitable for the area can be grown for the first three years. This helps the farmer to get some extra income till the oil palm yields. In full grown plantations, shade loving crops like cocoa can be successfully grown. Adequate care should be taken to manure the intercrops also.

3.2. Cover crops: In case where intercrops are not raised, cover cropping oil palm plantation is advantageous. A mixture of three species of legume viz. CalpagoniumMucunoides, Puerariaphaseoloides, Centrosemapubescens (2:2: 1) is recommended. Seeds are mixed and sown by seed drills in between the rows of palms at 5 kg per hectare. Velvet bean is another useful cover crop. These cover crops can suppress the weed growth, conserve soil moisture and have a good soil cover.

3.3Weeding

The base of the palm should be kept clean by hand weeding and pruning the cover crops. Alternatively, suitable weedicides can be sprayed around the base to control weeds.

3.4 Leaf Pruning

All inflorescence, dead and diseased leaves should be cut off regularly up to three years after planting. When the palm starts yielding, judicious pruning to retain about 40 leaves in the crown is advocated. In such cases care should be taken to avoid over prunning. In addition, all dead and excess leaves should be cut off and crown be cleaned at least once in an year, usually during the dry season.

3.5 Irrigation

Oil palm needs 120 to 150 mm of water to meet its monthly evapo-transpiration needs. Irrigation during dry period has to be provided, where the facilities exist so as to achieve the yield potential of oil palm.

4.DISEASES AND PESTS [15]:

Some of the major diseases and pests are discussed here.Most common disease of oil palm occurring in India and their remedial measures are given here.

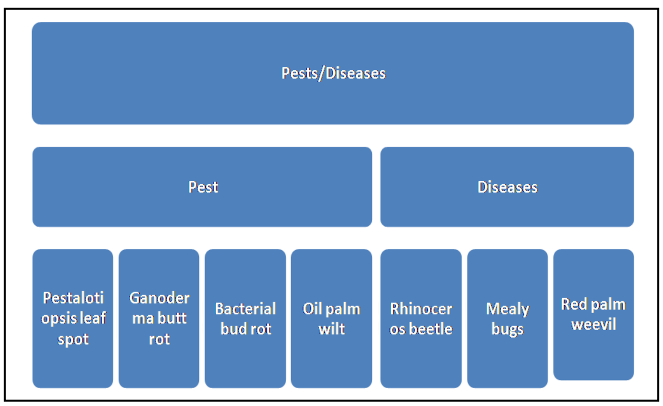

Figure 3: Diseases and pests in oil palmfruit.

4.1 Pestalotiopsis Leaf Spot: Tiny black spots on leaves which enlarge into 2 mm long elliptical, elongated lesions; lesions may expand and be surrounded by black tissue and chlorosis between lesions; lesions may be present on leaf petioles and rachis. It cause because of Fungi.Control-If palm is severely diseased, it should be removed from plantation and destroyed; palms should be planted with adequate spacing to allow air to circulate between trees; remove weeds from around palms; applications appropriate broad spectrum foliar fungicides can help to protect the palms from disease.

4.2 Ganoderma butt rot:

Reduced growth of palm, pale green foliage, older fronds turning chlorotic or necrotic; drooping fronds; on mature oil palms, spear leaves do not open, seedlings may exhibit a one-sided chlorosis or necrosis of the lower fronds; cross-sections of lower portion of trunk reveal a discoloration and softening of the central area and a distinct boundary is present between healthy and diseased tissue. It cause because of Fungi. Control-There are currently no fungicides recommended for protecting palms from Ganoderma butt rot; palms should be monitored closely for signs of disease, especially if a palm has died or been removed nearby as fungi can colonize old stumps and release spores; infected trees should be removed as once symptoms are present in foliage, a large portion of the trunk is already rotted and the palm is unstable; do not replant palm in soil where an infected palm has been removed.

4.3 Bacterial bud rots:

Parts of spear leaf petiole or rachi turning brown; discoloration may be associated with a wet rot; spear leaf may be wilted and/or chlorotic; leaves may be collapsing and hanging from the crown; infection of the bud results in buds becoming rotten and putrid, leading to death of the palm. It cause because of Bacteria.

Control-Plant oil palm varieties with resistance to the bacteria; rotting tissue on spear leaves should be removed to prevent bacteria spreading to buds; palm buds can be protected using copper-based fungicides.

4.4 Oil palm wilt: Symptoms of the disease vary with age of host; disease can affect seedlings and mature trees; seedlings exhibit retarded growth, reduced leaf size, chlorosis of older leaves and tip necrosis; field palms may exhibit a bright yellow chlorosis of leaves in the mid-canopy which starts at the tip of the pinnae and moves towards petioles before affecting adjacent fronds and spreading to older leaves in the canopy; in older palms, lower leaves wilt and dry out and fronds break close to the base of the trunk; new fronds are chlorotic and stunted; the palm shows decline on one side and develops symptoms in the lower canopy; infection spreads rapidly upwards and infects the bud, killing the palm. It cause because of Fungus. Fungus infests palms through the root system. Control-International quarantine procedures have limited the spread of the disease between major palm oil producing countries; dead or dying trees should be felled and burned to prevent spread in plantations; if palms are replanted then new palm should be planted a distance of 3.9 m from infested stump; soil within a 3 m radius of infested stumps should be treated with dazomet and covered for a period of 30 days.

4.5 Rhinoceros beetle:

V-shaped cuts in palm fronds or holes in leaf midribs caused by beetles boring into crown to feed; adult insect is a large black beetle with a curved spine on its head; larvae are creamy white grubs with brown heads and 3 sets of prolegs at the anterior (head) end. It cause because of Insect. Beetles are nocturnal and fly at night; also a damaging pest of oil palm.

Control: Destroy any decaying logs in plantation by chopping and burning to kill any larvae that may be inside; remove any dead trees from plantation and destroy by burning; plant a cover crop to deter egg laying by females as they do not lay eggs in areas covered by vegetation; hooked wire can be used to extract larvae that are boring into young crowns

4.6 Mealybugs: Flattened oval to round disc-like insect covered in waxy substance on tree branches; insects attract ants which may also be present; insect colony may also be associated with growth of sooty mold due to fungal colonization of sugary honeydew excreted by the insect. It cause because of Insect. Insects have a wide host range; often tended by ants which farm them for their sugary honeydew secretions; transmit Cocoa swollen shoot virus. Control-Mealybugs can potentially be controlled by natural enemies such as lady beetles but are commonly controlled using chemicals; chemical pesticides may also decrease populations of natural enemies leading to mealybug outbreaks.

4.7 Red palm weevil:

The red palm weevil (Rhynochophorusferrugineus) is a major pest of oil palm in India. These weevils lay their eggs in the end of the petioles, the emerging larvae make tunnel into the crown and feed on the growing tissues, Palms infested by red palm weevil start wilting and leaves show gradually increasing chlorosis and fracture in strong winds.

5. Remedies and Control:

If detected early, treatment of affected palm with 0.2% solution of endosulfan or one per cent carbaryl would save the palms.Many birds such as forest crows, house crow and the common Indian myna are the major pests causing severe damage to oil palm fruit bunches. These birds feed on the mesocarp of the oil palm fruits, Bird damage can be severe, if it is not checked effectively.Rats, Porcupines, squirrels, monkeys, wild boars and dogs are the common mammalian pests.

5.1 Harvesting Method:

A chisel is used for harvesting bunches from young palm. The stalk of the bunch is struck hard with the chisel to cut-off and pushes the bunch out. When the palms become taller (from year onwards) a harvesting hook has to be used. This is made by tying a sickle shaped knife on to a pole, with binding wire, the length of the pole depending on the height of the palms. When the palms are too much, it is necessary to climb the palms for harvesting.

5.2 Processing: For oil palm plantations, oil mills capable of processing three tonnes of FFB per hour are available. A minimum of 200 hectare are required to make a unit viable. For plantation not exceeding 40 hectares, a hand operated hydrenchi hand press can be operated with 12 men at a time and it possess about 3.5 tonnes of bunches per day. The fruits should be processed within a few hours after harvest to obtain good quality oil. Over ripening, damage of fruits, storage etc. result in deterioration of oil. The usual method of processing (dry process) involves following stages.

5.3 Sterilization: It is done by heating with compressed steam for about 20 minutes in cylindrical vessel. This helps to soften the fruits for easy ponding.

5.4 Stripping: The fruits are separated from the sterilized bunches by passing through a revolving inclined slotted steel drum.

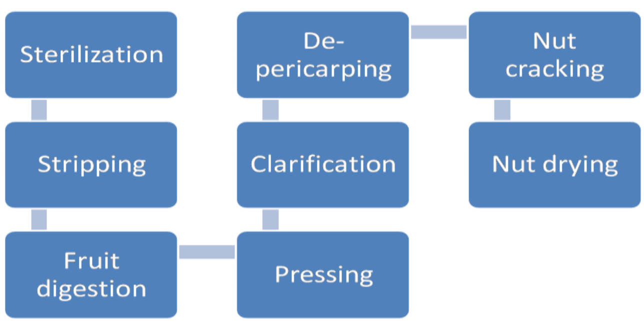

Figure 5: Oil extraction process.

5.5 Fruit Digestion

The digester comprises of a cylindrical vessel in which rotating knives pulverize the fleshy part of the fruit to a pulp and at the same time gets heated with injected steam. This releases the oil from the pulp and raises the temperature of the pulp to 95°C to increase the fluidity of the oil.

5.6 Pressing: The pulp passes through the press where the liquid component is separated from the solid. In small scale semi commercial operations small hand operated hydraulic press are sufficient. The hydraulic press which can process upto three tonnes of FFB/hour has largely been superseded by the continuous screw press capable of handling 10 to 20 tonnes. This consists of one or more screws turning within a perforated cage through which the oil is expelled.

5.7 Clarification

The crude oil from the press contains a mixture of oil, water, cell debris and particles of the fibre and shell. Hot water is then added and the oil is allowed to separate in clarification tanks from which it is continuously decanted.

5.8 De-pericarping

This process separates the nut and fibre. The cake passes through a "matte braker" where it is lacerated and dried by passing along a steam jacketed conveyor fitted with paddle like agitators. In the depericarper, the nuts are separated by blowing off the lighter fiber in an air steam within a vertical cylinder.

5.9 Nut cracking and drying

The nuts are shelled in a rotary cracker and the light fraction removed in an air stream to be used as fuel. Separation of shell from kernel is done and the kernel is passed through a drying silo and oil is ready for packing.

Crude palm oil is deep orange/red and semi-solid at a temperature of 20^{o} Centigrade. It is composed mainly of fatty acids which are present in glycerides. Unrefined palm is also edible. But one available in Indian market at present is the refined palm oil imported from Malaysia.

6. Benefits:

Palm Oil is used in formulation of margarine and cooking fats such as Vanaspati and shortening. It is also used in the manufacture of biscuits, ice-cream and shampoos,as a frying fat where its low foaming and longer keeping quality stand out,to yield vitamin, protein and antibiotic by fermentation process using selected micro-organisms, and kernels are generally used as fuel in the boilers or may be converted to charcoal or otherwise used for metalling roads.

7. Image Processing and Fuzzy Logic Methods

Z. May, M. H. Amaran [3] developed oil palm fruit Automated ripeness system using RGB color model and artificial fuzzy logic. The purpose was to distinguish between three classes of palm oil fruit namely Underripe, Ripe and Overripe. Camera is used to collect the raw data from fruits and then color intensities are calculated using mean method for RGB color model. Then artificial fuzzy logic is used to classify the three categories namely Underripe, Ripe and Overripe. According to the researchers the system showed 86.67% efficiency.This project provides a very good technique to standardize the oil palm fruit grading system. Meftah Salem M. Alfatni, [4] developed automated grading system using RGB color model. The maturity index depends on the different color intensity. The system used camera to capture the pictures and analyzed, interpreted images according to human eye. The colors namely Red, Green and Blue (RGB) were investigated using the system. The program developed could be used to differentiate the different three categories of palm oil fruit bunch using mean value calculated from RGB. NursuriatiJamil, Azlinah Mohamed, Syazwani Abdullah [5] in their paper investigated Neuro fuzzy method to grade palm oil fruits. W.I. Wan Ismail, M.Z. Bardaie, and A.M. Abdul Hamid [6] according to them HIS color model is very good for deriving the proper intensity and color from the perceived light. The hue optical properties for the three categories of palm oil fruits were calculated to grade the fruits. They concluded that Hue value is the best color digital component for grading since it has highest optical properties. A.Nureize, J. Watada, built multi-criteria evaluation model to categorize the criteria of oil palm fruits. Regression model is used to decide the criteria of these fuzzy models.Z Abdullah, L.C Guan and B.M.N MohdAzemi showed the relationship between the oil content and the HSI model using four categories of plam oil fruits. Manza R.R., Gaikwad B.P. and Manza G.R. used different edge detection operators and proved that they can be used to categorize the mango fruits to evaluate the quality and grade.

NorasyikinFadilah, JunitaMohamad-Saleh,[11] thispaper presents the application of color vision for automated ripeness classification of oil palm FFB. Images of oil palm FFBs of type DxPYangambi were collected and analyzed using digital image processing techniques. Then the color features were extracted from those images and used as the inputs for Artificial Neural Network (ANN) learning. The performance of the ANN for ripeness classification of oil palm FFB was investigated using two methods: training ANN with full features and training ANN with reduced features based on the Principal Component Analysis (PCA) data reduction technique.AhmedJaffar, RoseleenaJaafar, NursuriatiJamil[12] presented a computer assisted photogrammetric methodology which correlates the color of the palm oil fruits to their ripeness and eventually sorts them out physically. FatmaSusilawatiMohamad, Azizah Abdul Manaf and SuriayatiChuprat, [13] exploited the use of Distance Measurements for histogram based oil palm ripeness identification. In this study HSV color model is employed. Sunilkumar and D. S. SparjanBabu[14] Stated thar L*a*b color model is better than RGB color model for maturity prediction of palm fruits.Similar results were also reported in other studies of correlation between the color of oil palm FFBs and their oil contents [16].Thus, red component was not able to distinguish between unripe andunderripe categories, and could not be an attribute for ripeness classification. Choonget al. [17] investigated the correlation between the color of oil palm fruits and their oil content.However, a later study by Ghazaliet al. [18] discovered that the red components for unripe and underripe categories were almost the same.

8. Conclusion

The paper presents the overview of fruit, categories, diseases and pests and lastly different Image Processing and fuzzy logic techniques used for Palm oil fruit grading. Even though some researchers say that the algorithm and methods proposed by them is good and perfect but still there is scope for proper methodology and comparison. Since color of fruit varies from region to region, same method cannot be adopted to all the cases. Now a day's computer vision system is used everywhere to reduce the error and increase the efficiency and productivity, it is a necessity that Palm oil extraction mills should be adopted. Thus image processing and fuzzy logic tools are powerful tools which will help in designing effective machine-vision system for agricultural domain.

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