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Usage of Image Processing and Machine Learning Techniques in Agriculture - Fruit Sorting

Introduction

India is an agricultural nation. Gross domestic product (GDP) of agriculture sector alone is 15% in 2012-13. Due to significantly improved speed and quality of services of ICT, the percentage GDP is increased 7.8 % in agriculture (i.e. 4.9 % in 1990-91 to 12.7 % in 2010-11) compared to other modular sectors. India stands prominent among all nations in the production of milk, pulses and jute. India is leading when it comes to cultivation of spices, plantation crops, livestock, fisheries and poultry. The stakes of fruits and vegetables have taken a leap far more than traditional crops in the past few years. Considering the phenomenal changes in recent years, this segment of agriculture would drive great growth by the adaptation of proposed models from ICT studies. ICT is much useful in the development of the agricultural sectors in promising manner. Some of the ICT applications are as proposed in the following points.

- *Crop Management:* Using pest management detection of insect has been done, wireless sensor network is used for irrigation and weed detection is used for crop assessment using remote sensing.
- *Fruits quality inspection, sorting and grading:* To improve and maintain the quality of fruits and vegetables and for Classification of agricultural products, image processing and machine learning is used.
- *Identification of disease and plant content:* Disease and various content of plants have been identified from leaves and skin of product using image processing algorithms.
- *Crop and land estimation and Object tracking:* Geographic information System(GIS), colour and texture segmentation algorithms are used.

Fruit Sorting

Farmers and distributors do conventional quality inspection and handpicking to sort and grade agricultural and food products. This manual method is time-consuming, laborious, less efficient, monotonous, slow and inconsistent. Using ICT technique like image processing, computer vision and machine learning, cost effective, consistent, greater product stability, safety, superior speed and accurate sorting can be achieved. Automatic fruit sorting can improve the quality of the product, abolish inconsistent manual evaluation, and reduce dependence on available traditional inspection. Quality sorting is based on a multitude of measures like flavor such as sweetness, acidity content in the product, grading through appearance on bases color, size, shape, blemishes and glossiness of product, and texture that is assorted on its firmness or product's mouth feel. Below tables summarize some of the very recent grading and sorting systems.

Computer vision systems provide rapid, economic, hygienic, consistent and objective assessment. Difficulties

Fruits	Parameters considered	Accuracy	References
Apple	Bruises, Stem end and calyx	89%	Xu Qiabao et al., 2009
Tomatoes		94%	Dong Zhang et al., 2013
	Shape	87.5%	Md. Rokunuzzaman and Jayasuria, 2013
	Color	95%	Dah-Jye Lee et al., 2011
Mango	Size and color	> 80%	Tajul Rosli B Razak et al, 2012
	Color and FD	85.19%	Hong Zheng and Hongfei Lus, 2012
Strawberry	Size, shape and color	88.8%	Xu Liming and Zhao Yanchao, 2010
Date	Flabbiness, size, shape, intensity and defects	80%	Yousef Al Ohali, 2011
Cherries	Color	High	Qi Wang, 2012
Orange	Intensity and color	80%	F Juste and F Sevilla, 1991
Lemon	Color and size	94.04%	M Khojastehnazhand et al., 2010
Fruit*	Color, shape and size	90%	Woo Chaw Seng and Seyed Haldi, 2009
	Shape and size	90%	Mustafa et al., 2009
	Size	High	Hongshe Dang et al., 2010

* Generalized algorithm for all fruits

still exist in this field due to relativity slow commercial uptake of computer vision technology and processing speeds still fail to meet modern manufacturing requirements in all sectors. A model for sorting is proposed in order to overcome drawback of current grading systems which are,

- Current sorting systems are not accurate (max. accuracy achieved 95%)
- Very few parameters like size and color are considered for grading systems
- Still all are under research laboratories
- Most of research and development of automated agriculture product sorting has been done outside India
- The sorting of fruits is still performed manually in India
- No grading system is yet available for fruits like chikoo, sugarcane and grapes etc that are exported to other countries from India

Proposed Model

As shown in figure, firstly fruits are collected in a chamber. From the chamber it moves through escalators safely where the weight of the fruit gets estimated. It moves towards another chamber where the image of fruit is captured by more than one camera in different angle. For detecting fruit growth (raw or ripped), smell of the fruit is detected by sensors of wireless sensor network. Image is then processed where various algorithms are applied on image for finding expected features like size, depth, 3D model, texture and color.

For finding different features of fruit image following steps should be applied,

1. Image segmentation algorithm can be applied on captured image. Histogram thresolding, feature space clustering, Region based approach; Edge detection approach, fuzzy approach and neural network approach are the examples of segmentation methods.
2. From the segmented image, size parameter can be identified using machine vision by measuring projected area, perimeter or diameter.
3. Shape feature can be identified using contour based methods like chain code, B-spine, Hausdorff distance, Fourier descriptor, etc. or region based methods like convex hull, medial axis, Legendre moments, shape matrix etc.
4. On moving up to next, color feature can be identified using color features of fruits and vegetables included mean, variance, ranges of the red, green, and blue color primaries (RGB color model) and the derived hue, saturation, and intensity values (HSI color model).
5. Skin disease and defects can be found out using skin texture identification methods.
6. Image descriptors like global color histogram; Unser's descriptors, color

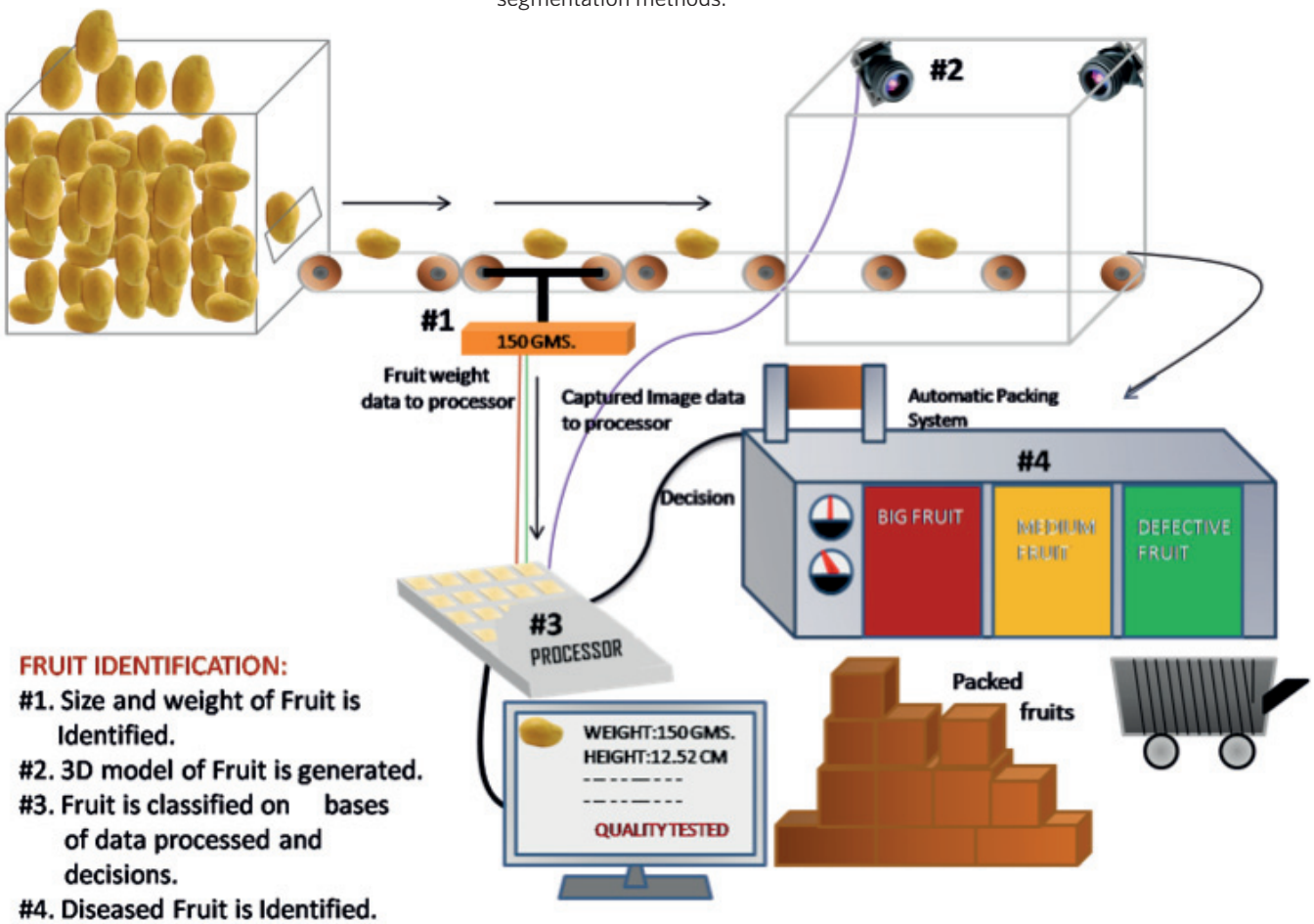

Fig: Proposed model for automated fruit sorting

coherence vectors, border/interior, appearance descriptors etc. can be used for classification of fruits and vegetables. (e.g. Mango can be Kesar, Afus, Rajapuri etc.)

7. Finally, machine-learning algorithm is used for classification of parameters. Machine learning algorithms are neural network, fuzzy logic, genetic algorithm, fractal dimensions, Support Vector Machine (SVM), K- Nearest Neighbor (KNN), Linear Discriminant Analysis (LDA) etc.

Based on the decision drawn after the process on the above steps, the fruit is classified into different categories like big, small, medium sized, ripe/unripe or defectives. Finally automatic packaging system packs the fruit according to the categories provided.

Conclusion and Future Direction

Automated fruit sorting is speedy, inexpensive, safe and accurate. Proposed model is generalized and it is considering far more feature parameters than available sorting systems. Currently, research in the automated fruit sorting and grading has been conducted by experimenting them in laboratories only. So a properly focused research and a detailed review on this research area need to be carried out.

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Sapan Naik received his Bachelor degree in 2007 from Dharmsinh Desai University, India. He received his master degree in field of Computer engineering in 2012 from Gujarat Technological University. He is working as Asst. professor at Shrimad Rajchandra Institute of Management and Computer Application, Uka Tarsadia University, Bardoli, India. His research interest includes Image Processing and machine learning. He has published eight papers at national and international level. He is currently pursuing his Ph.D. on "Smart Farming by Image Processing and Machine Learning" at Uka Tarsadia University.

Bankim Patel is Ph.D. and he has 20 years of teaching and 17 years of research experience. Under his guidance 7 research scholar have finished their Ph.D. and 2 have finished M.Phil. He is the Director of Shrimad Rajchandra Institute of Management and Computer application. He has received many awards like Significant contribution award in 2008-09 by Computer Society of India, Vikas Rattan in 2005, Jewel of India in 2005 and many more.