

Application of Artificial Intelligence

for on-farm recognition of matured pineapple for harvesting

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Agriculture is seeing rapid adoption of Artificial Intelligence (AI) in terms of agricultural products and in-field farming techniques. AI in agriculture is emerging in three major categories i.e. agricultural robotics, soil and crop monitoring, and predictive analytics. This article presents a comprehensive application of artificial intelligence to recognize the matured pineapple for harvesting in the field. Pineapple fruit has a crucial maturity period. The skin of the fruit changes from pale green to a golden or yellowish color at maturity. However, this maturity level often makes farmers confused and results in wrong decision, and many resulting loss in yield. Therefore, an Artificial Intelligence (AI) based automatic system has been designed and developed for identifying the most matured pineapple. This technique involves computer vision and machine learning techniques based algorithm using Haar-like features. Python language has been used to evaluate the features of a matured pineapple. The developed detection system works in two steps namely, (1) by extracting the Haar-like features of grey scale image and classifying with the AdaBoost classifier; to identify the pineapple; (2) the HSV colour space limits setting to identify the matured pineapple colours calculated by the algorithm. The developed system was field tested and found to succeed in the identification of 93% the correct fruits.

Key words: Artificial intelligence, Computer vision, Image processing, Pineapple, Raspberry Pi

Artificial Intelligence (AI) is one of the key areas of research in computer science. With its rapid technological advancement and vast area of application, AI is becoming pervasive very rapidly because of its robust applicability in the problems particularly that cannot be solved well by humans as well as traditional computing structures. Such an area of extreme importance is agriculture where about 30.7% of the world population is directly engaged on 2,781 million ha of agricultural land. Such a venture is not so smooth running, it faces several challenges from sowing to harvest. In the harvesting operation fruit and vegetable are the major issues and needs the special attention of the researchers.

Pineapple (*Ananuscomosus* L. Merr) is one of the most important

commercial fruits of the world. Pineapple is a family of bromeliad species originally cultivated in Brazil. Pineapple has been placed as the third most produced tropical fruit in the world after banana and citrus. In India, commercial cultivation of pineapple started only three or four decades ago and now India is one of the top ten pineapple producing countries in the world. Pineapple is grown in 89 thousand ha with an annual production of 14.15 lakh tonnes and a productivity of 15.9 Mt/ha which contributes about 7% of the total pineapple production in 2017. At present, the total area under pineapple cultivation is only 2.15% of the total area under fruits and the production is 2.75% of total fruit production in India. During the harvesting season farmers have to face a lot of problems like hot

weather, heavy and deficient labour requirement, short harvesting period, and injuries due to sharp leaves of pineapple trees but most importantly the correct recognition of the matured pineapple for higher production.

The maturity of pineapple can be determined based on the change of color of the skin of the fruit. This fruit matures when its skin color changes at the base of the fruit from green to yellow. As the fruit ripens, the index of maturity is classified into seven stages. Index 1 represents the early stage of maturity and Index 7 represents the fully ripened stage. For Index 1 and Index 2, the fresh pineapple is suitable for export purposes because it can survive a long transit period. Index 3 and Index 4, are suitable for use as domestic fresh pineapple where Index 5 to Index 7,

are suitable for production of fruit-based products such as juice and canned products. Therefore, there is a need for an intelligent machine system to recognize pineapple condition and to maximize the quality of production. Such a system will also reduce human subjectivity and inconsistency.

In this context, advanced technologies like Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning (DL) can be used as a useful tools for automatic recognition of fruits and vegetables. Artificial intelligence is a branch of computer science that aims to create intelligent machines. It has become an essential part of the technology industry. Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning (ML) focuses on the development of computer programs that can access data and use it learn for themselves. Deep learning (DL) is part of a broader family of machine learning methods based on learning data representations, as opposed to task-specific algorithms. Automated harvesting is an emerging field that utilizes artificial intelligence and machine intelligence in order to gather useful information about the growth and ripeness of fruits and vegetables, and other aspects of farming. In this paper, an efficient and less resource intensive artificial intelligence based approach for pineapple recognition has been proposed.

METHODOLOGY

Training of Haar cascade

Haar Cascade is basically a classifier which is used to detect the object for which it has been trained for, from the source.

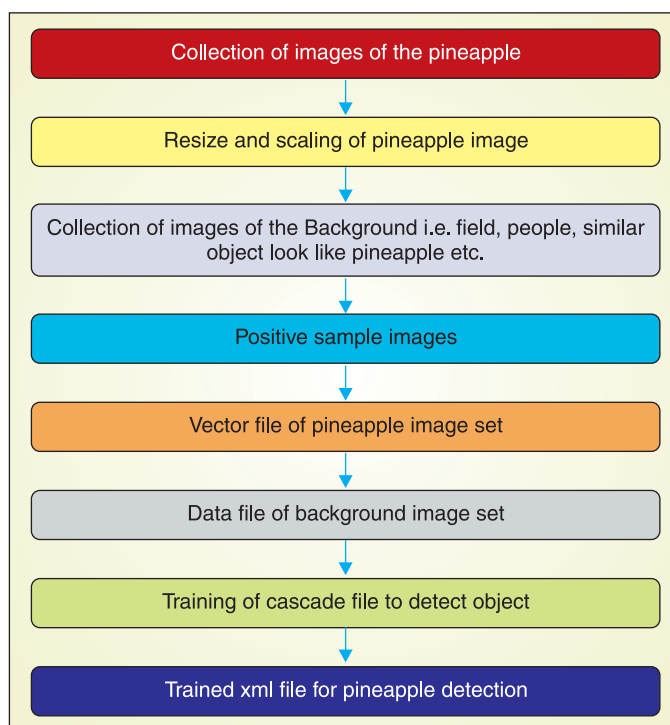


Fig. 1. Flow chart of Haar cascade training procedure

The Haar Cascade is formed by superimposing the positive image over a set of negative images. The Haar like features based cascade has higher accuracy, fast detection rate and less computational cost of the memory as compared to other methods. The Haar cascade detection procedure is presented in Fig.1. To train the classifier a large number of samples of both positive and negative images were required. The positive sample are the images with the objects (pineapple) while negative samples are the images without the objects. These images helps in true recognition of the pineapple in the field.

Image Acquisition unit

The major components of the application system include laptop and Raspberry Pi installed with Python, OpenCV and Numpy libraries. A camera was connected to both PC and the Raspberry Pi. The cameras were activated in continuous mode and images were taken at a certain interval. The Pi camera captures the images of the pineapple using the command “raspistill -o my_image.jpg” and saves into a JPEG image as my image to the root directory of the Raspberry Pi. Image acquisition unit for capture images in field is shown in the Fig. 2.

Digital Image processing unit

An image may be defined as a two-dimensional function, $F(x, y)$, where x and y are spatial (plane) coordinates, and an amplitude of F at any pair of coordinates (x, y) is called the intensity or grey level of the image at that point. When (x, y) and the amplitude values of F are all finite, discrete quantities, the image is known as a digital image. There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider three types of computerized processes in this continuum: low, mid, and high-level

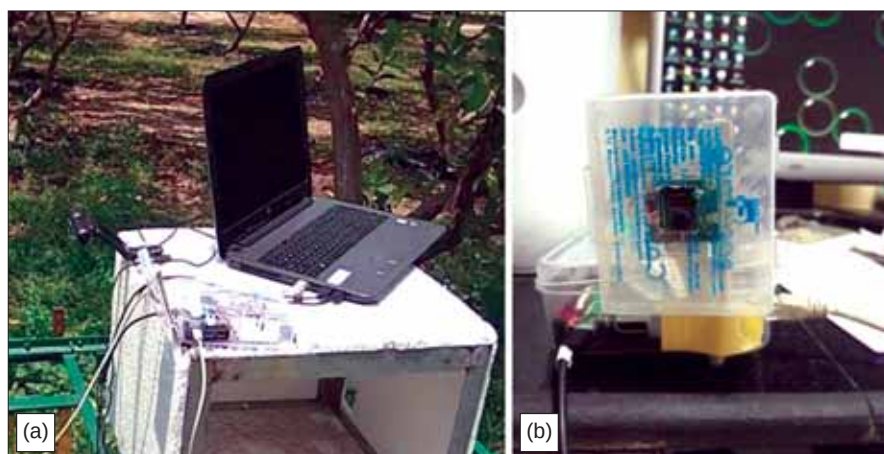


Fig. 2. (a). developed Image acquisition unit (b). Pi camera

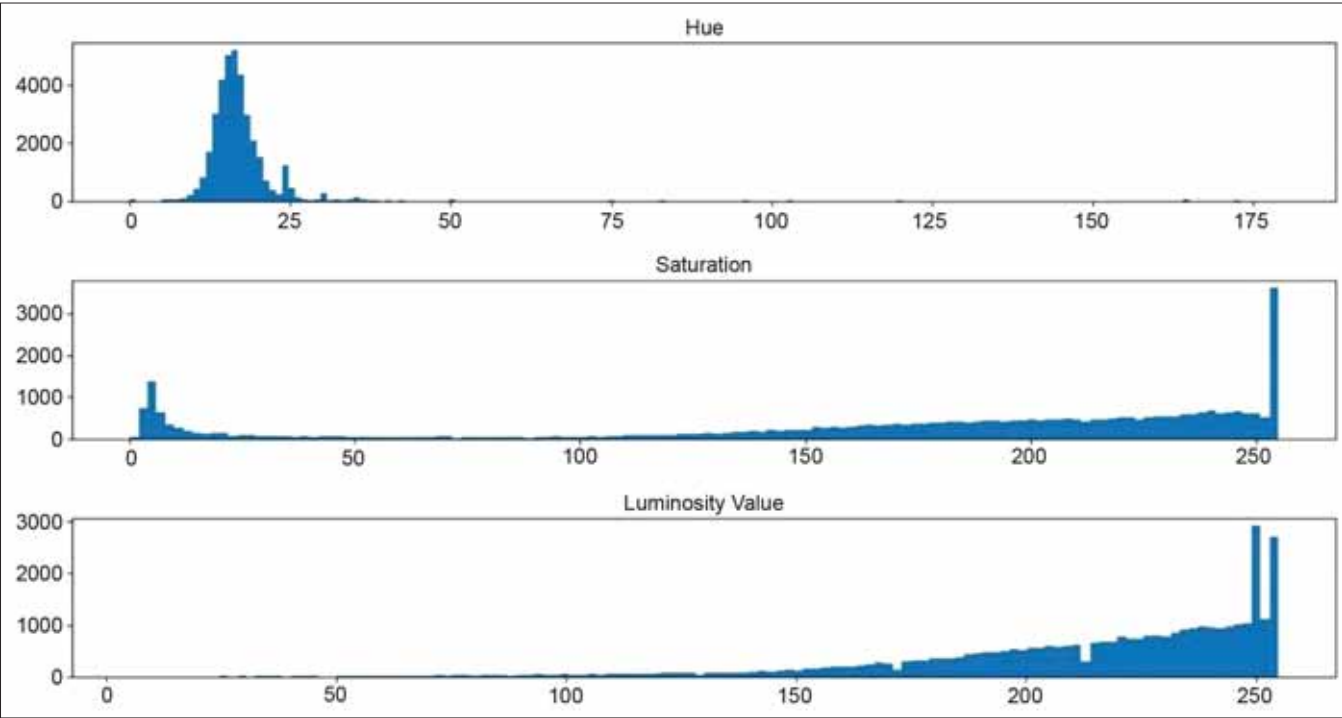


Fig. 3. HSV plot of a pineapple image

processes. Low-level processes involve primitive operations such as image pre-processing to reduce noise, contrast enhancement, and image sharpening. A low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing, and classification (recognition) of individual objects. A mid-level process is characterized by the fact that its inputs generally are images, but its outputs are attributes extracted from those images (e.g., edges, contours, and the identity of individual objects). Finally, a higher-level processing involves “making sense” of an ensemble of recognized objects and at the far end of the continuum, performing the cognitive functions normally associated with vision.

Extracting HSV color range from pineapple

The pineapple images are obtained using an RGB charge-coupled device (CCD) camera. However, the human vision sensing is based on the HSV color values. Moreover, the HSV color mode is dependent on the

hardware features, and it has little sensitivity to the light source. Therefore, using cropped images HSV color values from all pineapples were extracted and used for defining the range of color pixel values. HSV color plot of pineapple image is shown in Fig. 3.

RESULTS

HSV color distribution for complete and mature region of pineapple

It was found that the distribution of HSV components was overlapping for H, S and V for both mature and complete pineapple region. As presented in Fig 4. HSV color range

for mature region of pineapple is to detect mature region of pineapple, for whole pineapple the color range value of H exceeds the mature region because it also covers the green region of pineapple, and V for pineapple region is slightly lower to cover more dark colors for whole pineapple region.

Testing of the developed Haar cascade programme for pineapple detection

HAAR cascade was trained for successful detection of pineapple.

True detection of pineapple fruit

Pineapple fruit were successfully detected by developed cascade as

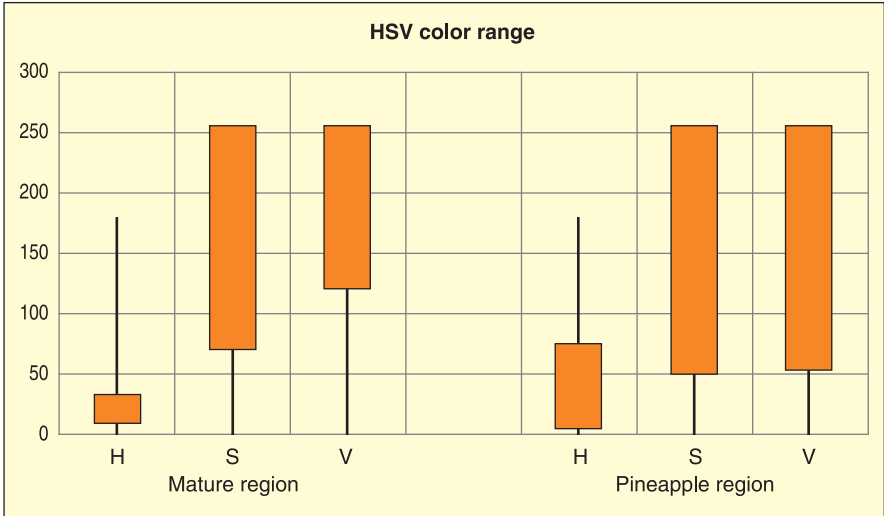


Fig. 4. HSV color distribution plot for mature and complete pineapple region



Fig. 5. Pineapple detected in field by Haar cascade

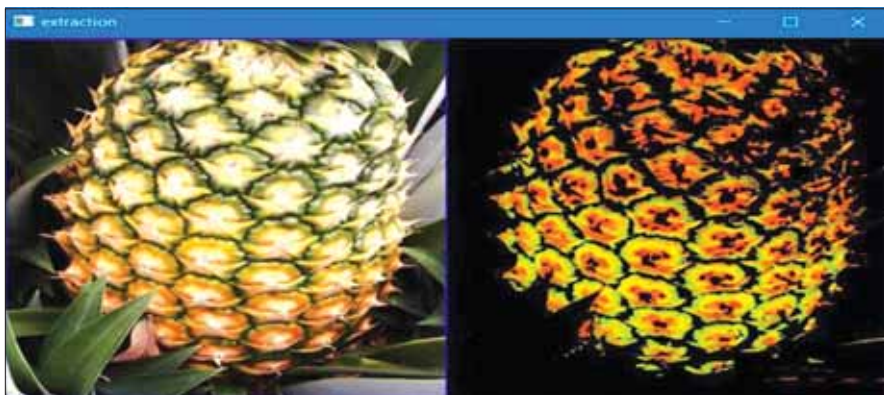


Fig. 6. Mature region extracted by algorithm

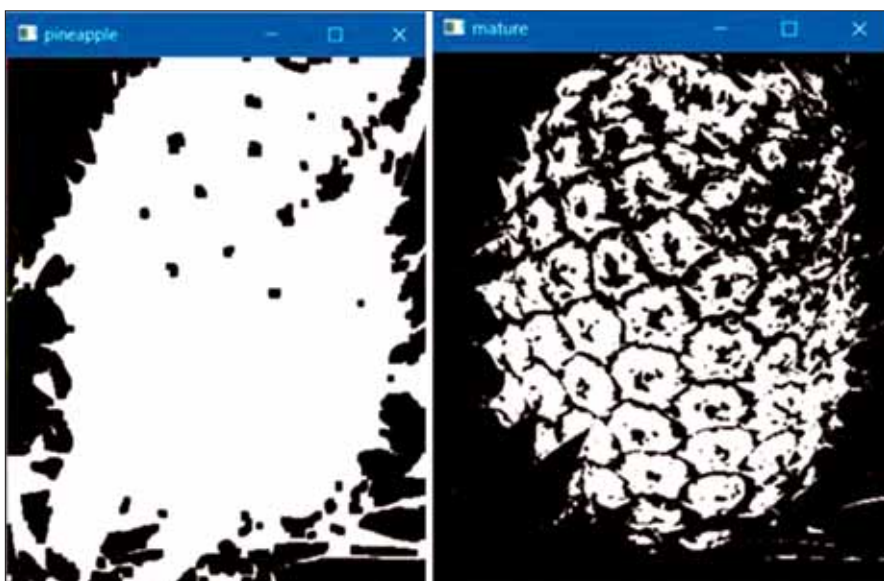


Fig. 7. (a) Threshold pineapple pixels image (b) Threshold mature pixels image

shown in Fig. 5 based on their unique features of shape, texture and color of the pineapple fruit, using Haar features.

While the proposed algorithm yielded successful results for most pineapple by leaves and twigs, some much-occluded pineapple regions

could not be detected successfully. There were also some false negatives existing in the detection results. Some reasons for misclassifications were occlusion, uneven illumination, and varying fruit sizes. Illumination changes affected both color and texture features of the images.

Table 1. Results of detection of pineapple by Haar cascade

Pineapple detection		
Performance Parameter	Detected	Detection rate %
No. of total test pineapple count	100	-
True Positive	100	100%
False positive	6	6 %
False negative	2	2 %
Haar cascade performance		
Performance Parameter		
Accuracy	92.59	
Error	7.40	

Sometimes shapes of some leaves and leaf clusters were very similar to pineapple and this resulted in inaccurate detections. Table 1 presents the result of pineapple detection.

Pineapple indicated their ripeness based on their skin color change from green to full yellow. Fig. 6 and 7 shows these varying level of identification.

CONCLUSIONS

Computer vision and image processing techniques have been found increasingly useful in the fruit industry, especially for applications in quality inspection and defect sorting applications. This research presents a method for automatic grading of pineapple using machine vision techniques. Automated pineapple grading system helps both consumers and farmers by providing good quality fruits and higher market price. HSV color space camera could successfully recognize pineapple color in real time condition. Developed Haar cascade could successfully detect pineapple upto an accuracy of 93 %. The developed Raspberry Pi based embedded system was found effective and could be used for other field applications of fruit or vegetable harvesting.

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