Identification of object characteristics using the fusion sensor method in wireless sensor network environments

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Abstract. This paper contains an explanation of the research results to solve the problem of selecting the category of mangosteen fruit in a grading process using method image processing through geometry measurements of flat areas, color measurements, shape and texture characteristics. The aim is to implement the selection process through a grading machine to be able to sort two categories of mangosteen fruit based on the characteristics that are trained using the Linear Discriminant Analysis method. The proposed method is the use of four image sensors which are perpendicular to each other in the grading process line. Each sensor provides a decision on the group of objects it identifies, "accepted" if it meets all the requirements or "rejected" if one of the requirements is not met. The results of each sensor decision are sent to the sink node in the wireless sensor network environment to be jointly decided using the method of redundant cooperative sensor whether the objects identified together can be "accepted" or "rejected". The results of grouping give an error rate of ± 9.8%. The biggest identification error comes from the measurement of colors caused by light noise.

1. Introduction
This paper explains the results of testing instrumentation measuring the quality of mangosteen using image sensors and the sensor fusion method in the sorting and grading process on the wireless sensor network platform [1-3]. The purpose of this research activity is to find parameters of object characteristics using the application of non-invasive measurement methods using digital RGB image sensors through measurement and geometric testing of flat areas, colors, object quality, and feature and size feature extraction.

Method of the systematic derivation of a set of knowledge-based object recognition heuristics has been developed in the pattern of resolving spatial structures of object specifications that are orderly to those that do not have regular structures in complex visual environments where problem-solving is in the uncertainty of the imaging environment [4]. Perceptual grouping for generic recognition using a single intensity image using pure geometric methods with the assumption that a geometrically and precisely designed model has been developed and updated with the use of feature descriptions and qualitative geometric relationships using organizational criteria of perception such as closeness, symmetry, parallelism, and closure [5]. Object detection can also be extracted from the relationship between context and object properties based on statistical correlations [6]. A single image of the algebraic surface fully determines the projective surface geometry. The results apply to a generic perspective view from the surface of algebra [7]. Texture synthesis can be done by non-parametric
methods. This method aims to maintain as much local structure as possible and produce good results for a variety of synthetic textures [8]. The texture segmentation algorithm without using the Gabor filter is based on the reconstruction of the input image through the filter. The texture feature is obtained by making each filtered image transformed nonlinearly and calculating the size of "energy" around each pixel. The quadratic-error grouping algorithm is used to integrate images and produce segmentation. The relative index is used to estimate the number of correct texture categories [9].

Previous studies, the VoxNet architecture related to cloud integrates the Occupancy Grid volumetric representation with Convolutional Neural Network 3D (CNN 3D) developed using LiDAR, RGBD, and CAD data [10]. The characteristic curve analysis method (simple curve) was developed as an algorithm analysis and introduction of curve types as a basis for object recognition [11]. The GLCM feature is used to determine the effect of the drying method of two varieties of macadamia beans KRG-15 and MRG-20 for contrast features, Angular Second Moment (ASM), homogeneity and correlation regarding texture quality [12]. Identification of human physiological features using the Regions of Interest (ROI) approach, extraction using the gray-level GLCM method based on the Haralick Local feature to analyze image textures, and extraction with the SVM method showed effective results [13].

2. Method

Measurement and testing include parameters of area, color, object quality, shape, and size. Measurement of the geometric estimate of the volume through a flat area can be done by measuring bwarea the number of pixels of a bw image which is then converted to a volume constant k_volume to obtain a unit of volume.

$$\text{volume}_\text{object} = k_\text{volume} \times \text{bwarea}(bw)$$  \hspace{1cm} (1)

The object color testing is done through the Hue component of the HSV image (Hue, Saturation, Value). Converting RGB rgb_image to HSV image hsv_image is done through the rgb2hsv function in Equation (2). This function converts the color space of the image that was originally in the RGB color space to HSV (Hue, Saturation, Value).

$$\text{hsv}_{\text{image}} = \text{rgb2hsv(rgb}_{\text{image}})$$  \hspace{1cm} (2)

To obtain the extraction of h, s, v from HSV image hsv_image uses Equation (3), Equation (4) and Equation (5).

$$h = \text{hsv}_{\text{image}}(:,:,1)$$  \hspace{1cm} (3)

$$s = \text{hsv}_{\text{image}}(:,:,2)$$  \hspace{1cm} (4)

$$v = \text{hsv}_{\text{image}}(:,:,3)$$  \hspace{1cm} (5)

The im2bw thresholding process for saturation s component images to obtain binary images of bw segmentation results can be done using Equation (6) at a certain threshold level value.

$$bw = \text{im2bw}(s,\text{level})$$  \hspace{1cm} (6)

To improve the bw image, morphological operations in the form of filling holes imfill with holes and opening imopen in bw binary images with se, can be done with Equation (7) and Equation (8).

$$bw2 = \text{imfill}(bw,\text{,'holes'})$$  \hspace{1cm} (7)

$$Bw2 = \text{imopen}(bw,se)$$  \hspace{1cm} (8)

The process of labeling bwlabel binary images that are connected as num times is done using Equation (9).

$$[bw,num] = \text{bwlabel}(bw);$$  \hspace{1cm} (9)
The parameters used to represent the shape characteristics are metric and eccentricity, while the parameters that represent the size characteristics are area and circumference. Analysis of texture parameters is one of the characteristics of a digital image that can be extracted information. In this research, the Gray-Level Co-Occurrence Matrix (GLCM) method and Equations (1) through Equation (9) are used in image processing of the objects that are trained and tested [14,15]. While the object grouping will use a Linear Discriminant Analysis (LDA) method [16,17].

Figure 1. The image sensor configuration in WSN and Sensor Fusion environments [18].

Figure 1 explains the method proposed in this paper, namely the use of four image sensors where each image sensor applies the equation described in the introduction to identify the characteristics of the object. Each image sensor in the context of the wireless sensor network functions as a sensor node and processes the "accepted" or "rejected" decision of an object based on the learning outcomes that have been given. The results of the decision are sent to the sink node for joint decision processing. Sink node functions besides collecting decision data from the sink node, it also processes sensor fusion algorithms.

Figure 2. The distribution of learning data and test data.

3. Results and discussion

Figure 2 explains the results of the sensor fusion algorithm process on the grouping criteria by using the color testing function, grouping object quality, extracting shape and size characteristics arranged in certain steps to provide a decision about the object whether it falls into the category of "accepted" or "rejected".

The sensor fusion algorithm process grouping criteria are divided into two stages, the first stage of learning and the second stage of the decision by using the Linear Discriminant Analysis (LDA) method which divides the two groups namely "accepted" and "rejected". The test results shown in Figure 3 show
an average error rate of 9.81% and the composition of error contribution shown in Figure 4. Color measurement contributes to the biggest error. Color measurements give the biggest contribution, based on observers experimentally caused by the light produced around the object being tested.

![Figure 3](image1.png)

**Figure 3.** The results of testing the error rate in each sample.

![Figure 4](image2.png)

**Figure 4.** The composition of the error distribution.

4. **Conclusion**
This research concludes that the use of parameter characteristics of digital RGB image objects through measurement and geometric testing of flat areas, colors, object quality, and feature and size extraction using four image sensors with GLC and LDA methods show an average error rate of 9.81% and the biggest error contribution comes from the color measurement and geometric testing of flat areas, colors, object quality, and feature and size feature extraction.

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4. **References**
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