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CLASSIFICATION OF AGRICULTURAL PRODUCTS BY PHOTO IDENTIFICATION USE ARTIFICIAL INTELLIGENCE AND INGAAS SENSOR

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ABSTRACT— Automation in agriculture is increasingly popular; more and more AIoT applications are applied to reduce human labor. In this paper, we share a study on classifying agricultural products by image processing based on artificial intelligence. Each agricultural product will be put through the feed system and identified for size, color, sweetness and sour before evaluating quality.

KEYWORDS: color sorting machine, NIR, Color sorter

1. INTRODUCTION

Classification systems are pervasive today, ranging from rudimentary mechanical systems to sensor-automated mechanisms and to simple image processing systems (Fig. I-2) or the use of AI.

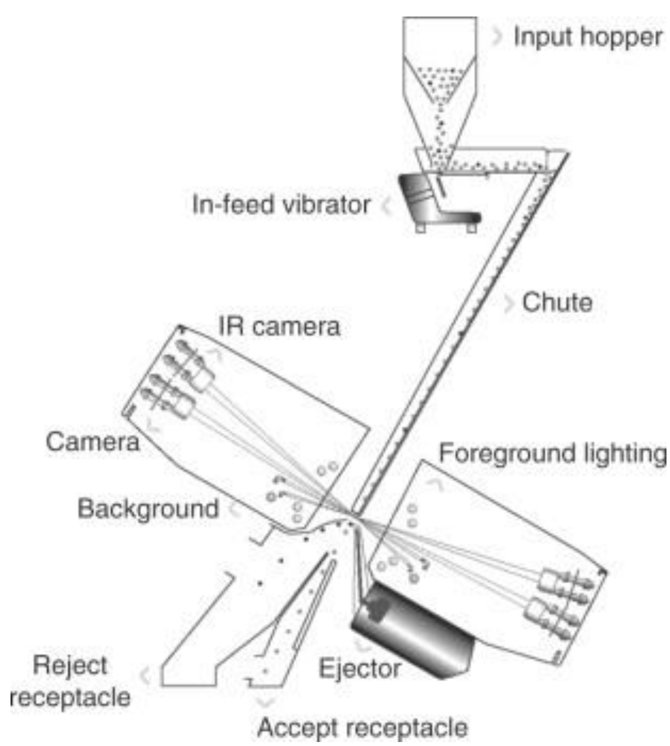

Figure I-1 High-speed sorter using camera line [1]

The advantages of the classification system using a camera line (Figure I-1) are fast speed >50-100k line/s, directing handling when objects fall in the air, low signal delay; often combined high-speed pneumatic valves, widely used for sorting machines for rice, coffee, beans, plastic seeds, pepper ... but the disadvantage of cost, requires high-speed valve structure, processing board fast processing, the composite image has a variable translation amplitude.

Figure I-2 Automated carousel using camera area [2]

The classification system using the camera area (Figure I-2) has a slower processing speed, usually 30-90 images/s, does not require high-speed hardware, is low-cost, has a medium capacity, and often runs medium-speed conveyor form, directly processing an image area, less prone to change in amplitude.

Based on the actual conditions in the Vietnamese market, we researched the camera area model so that it can be easily deployed in practice and quickly to the farm. With some special camera areas like InGaAs, we can analyze the food from the inside, determine the quality, acidity, sweetness… however the cost of these cameras is quite high (~ 30k$), will not suitable for Vietnamese farm conditions, but it is able to classify agricultural products from within we must have similar sensors.

We use the Hamamatsu G12180-020A [4] (InGaAs PIN Photodiode 2.0mm dia, non-cooled peak 1.55um) sensor, which is a form of point measurement but represents certain evaluation results.

The G11135 [5] series InGaAs linear image sensor is designed for foreign body inspection equipment. These linear image sensors consist of an InGaAs photodiode array and a CMOS chip that contains a charge gain array, offset compensation circuit, shift register, and a timing generator. Indium collisions electrically connect the InGaAs photodiode array and CMOS chip. The charge gain array comprises CMOS transistors connected to each pixel of the InGaAs photodiode array. The signal from each pixel is read out in charge-integrated mode to achieve high sensitivity and stable operation in the near-infrared spectral range. The signal processing circuitry on the CMOS chip provides two levels of conversion efficiency (CE) that can be selected according to the external voltage to meet the application.

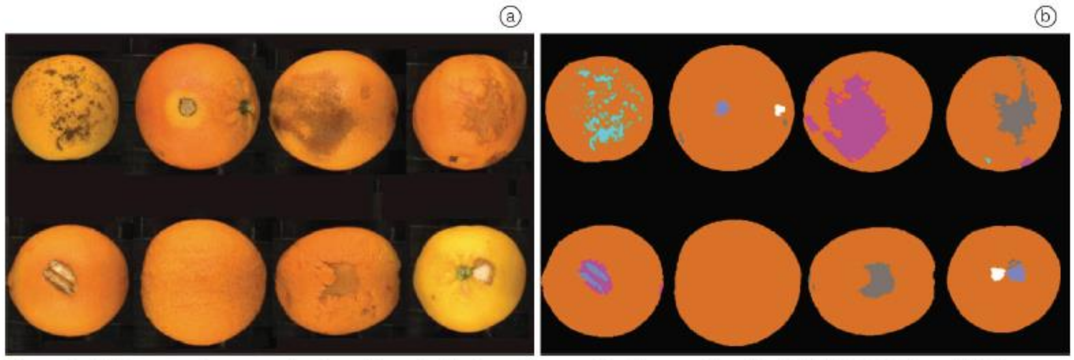

Figure 4. (a) Images of oranges showing different defects, colours and textures on the skin (CUBERO, 2012) and (b) the same images segmented to show the defects found by Cubero (2012).

Figure I-3 Oranges showing different defects normal camera and hyper camera [3]

2. Building a classification system

2.1 Design basis

In this paper, we select fruits with sizes 30-200mm for classification, such as tomato, apple, Thang long fruit, mangosteen... The system model will include:

- Base conveyor
- Lighting chamber
- Two cameras on both sides of the conveyor
- InGaAs sensor.
- System of proximity sensors, motors, and pneumatic valves.

Simple image processing design platform:

Figure II-1 is a conveyor model I used for testing mid-2021, with a simple image processing background. We evaluate the color ratio over the entire left dimension, as shown in Figure I-2.

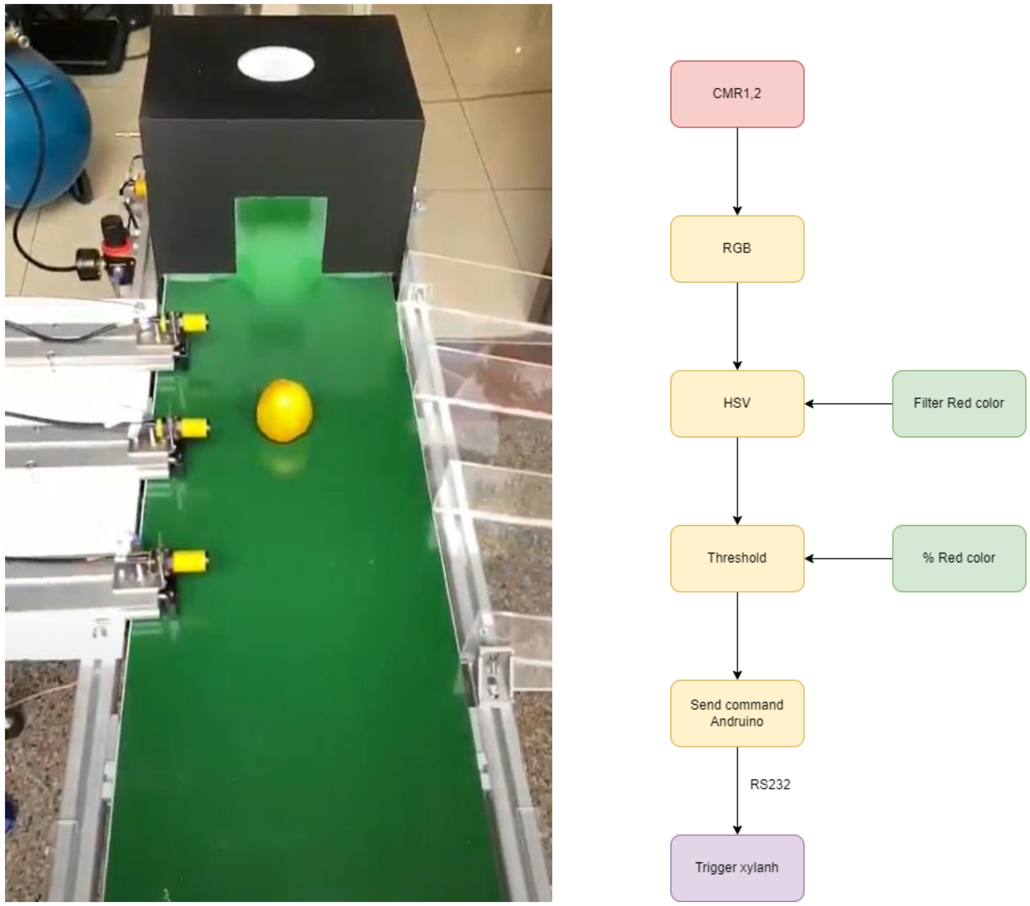

Figure II-1 Model of tomato sorting conveyor in 2021

Upgrade:
- With testing on a simple image processing platform, I found shortcomings such as: not easy to diversify fruits, can't measure the inside of agricultural products, and 2D images do not create the exact size as photos 3D in metrology. Therefore, we have used a 3D camera system, Ingas sensor, in this article to overcome those shortcomings.

2.2 3D image processing platform

- the 3D camera will have many advantages that a 2D camera cannot provide, such as accurate size, measurement on the surface, and simple mass imaging. We use intel's D435i [5], a low-cost consumer 3D camera product.

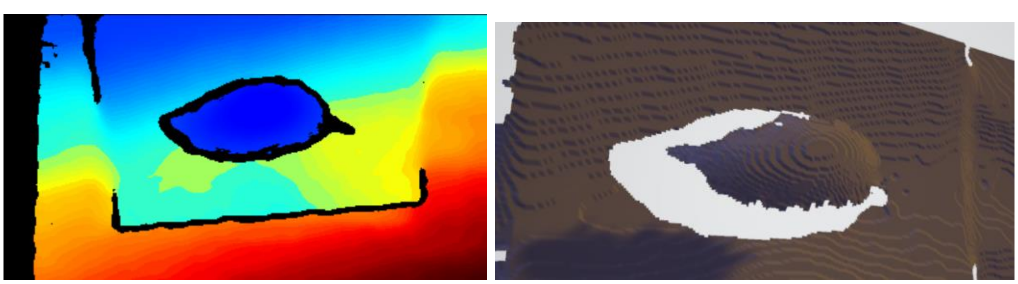

Figure II-2 3D point cloud image of the D435i. [6]

2.3 InGaAs sensor

Some characteristics of the InGaAs sensor.

- Water absorbs 1,550nm and other SWIR wavelengths, making it appear dark in the resulting image. In product classification, bruises, as shown below, appear as dark spots based on the increase in water content at that location.
- Highlights of SWIR light when the water is concentrated, making the image easier to bruise
- Water or liquid detection can also determine if the item is dry or wet and ready for further processing, such as testing for grain moisture, textile moisture, and chipboard moisture. We are handling and checking the sealing/packaging of damp goods.

Figure II-3 a) Properties of sensor layers and wavelength [7]

Compare images of different types of cameras [8]

Since our sensor is a single point, it only represents an area; in the future when InGaAs sensor technology is more common, we will upgrade the sensor to a higher resolution.

To analyze sweet and sour, we combine the change of light wavelength with the same receiver signal as follows:

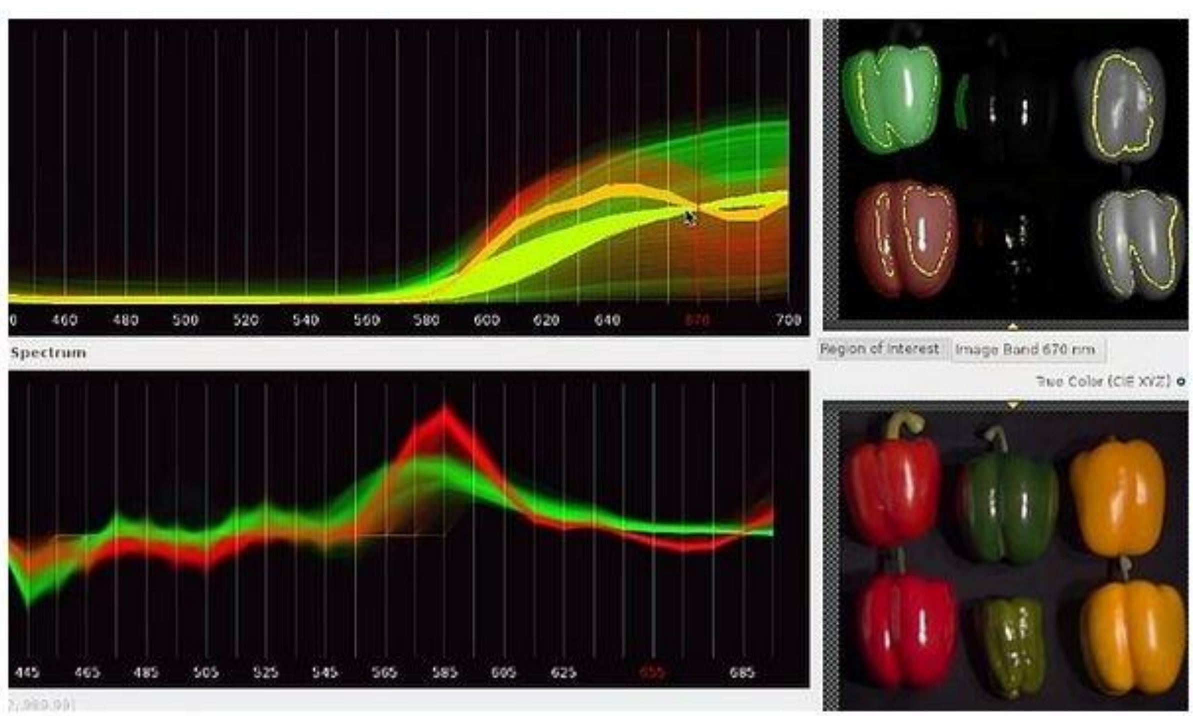

Figure II-4 Hyperspectral imaging for internal analysis of food. [9]

ML technology in classification assessment

- By color data on 2D/3D image background, 3D size, single point Hyperspectral image. We do clustering: a machine learning method that groups data points by similarity or distance. This is an unsupervised learning method and a popular technique for statistical data analysis.

- Depending on the type of fruit, the data set is different; here we present a simple GMM algorithm using the scikit-learn library in Python, based on a GMM reference in Halcon.

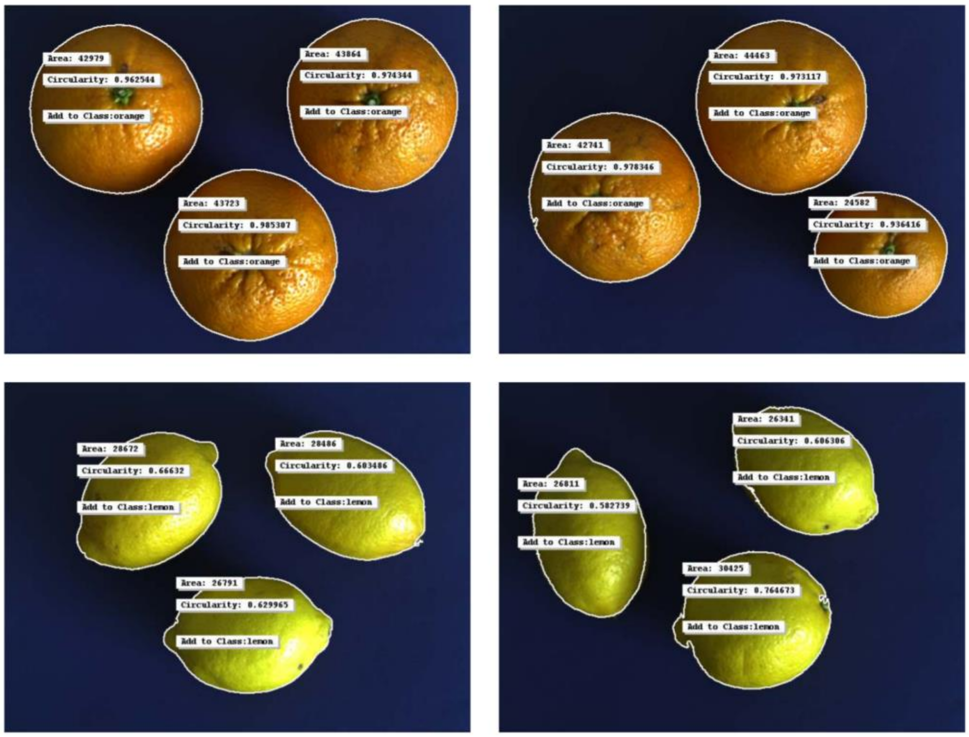

Figure II-5 GMM classifies oranges and lemons. [10]

GMM Algorithm [10]

The theory for the classification with Gaussian mixture models (GMM) is a bit more complex. When dealing with classification, one of the basic theories is the Bayes decision rule. Generally, the Bayes decision rule minimizes the probability of erroneously classifying a feature vector by maximizing the probability for the feature vector x to belong to a class. This so-called 'a posterior probability' should be maximized over all classes. Then, the Bayes decision rule partitions the feature space into mutually disjoint regions. The regions are separated by hypersurfaces, e.g., by points for 1D data or by curves for 2D data. In particular, the hypersurfaces are defined by the points in which two neighbouring classes are equally probable. The Bayes decision rule can be expressed by

$$P(w_i \mid x) = \frac{P(x \mid w_i) \times P(w_i)}{P(x)}$$

With $P(w_i \mid x)$: a posteriori probability

- $P(x \mid w_i)$: a priori probability that the feature vector x occurs given that the class of the feature vector is w_i
- $P(w_i)$: Probability that the class w_i occurs
- $P(x)$: Probability that the feature vector x occurs

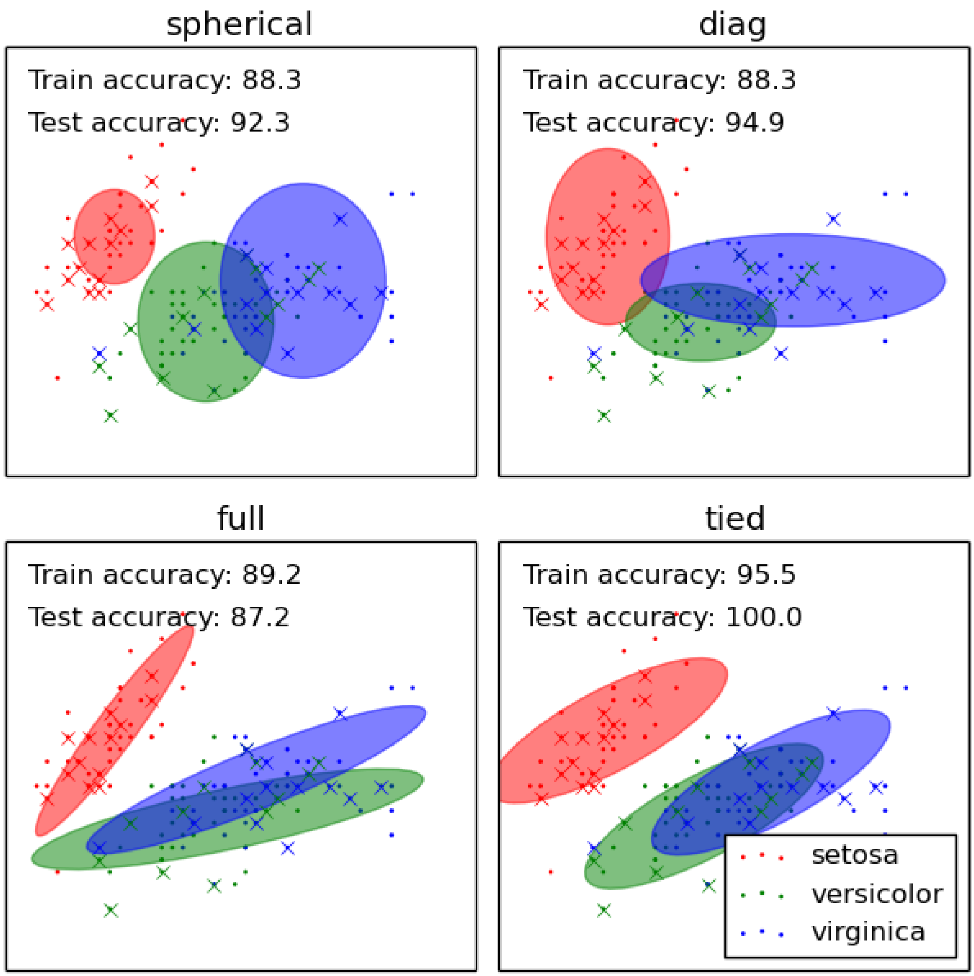

Figure II-6 Different GMM Models

Algorithm Flowchart

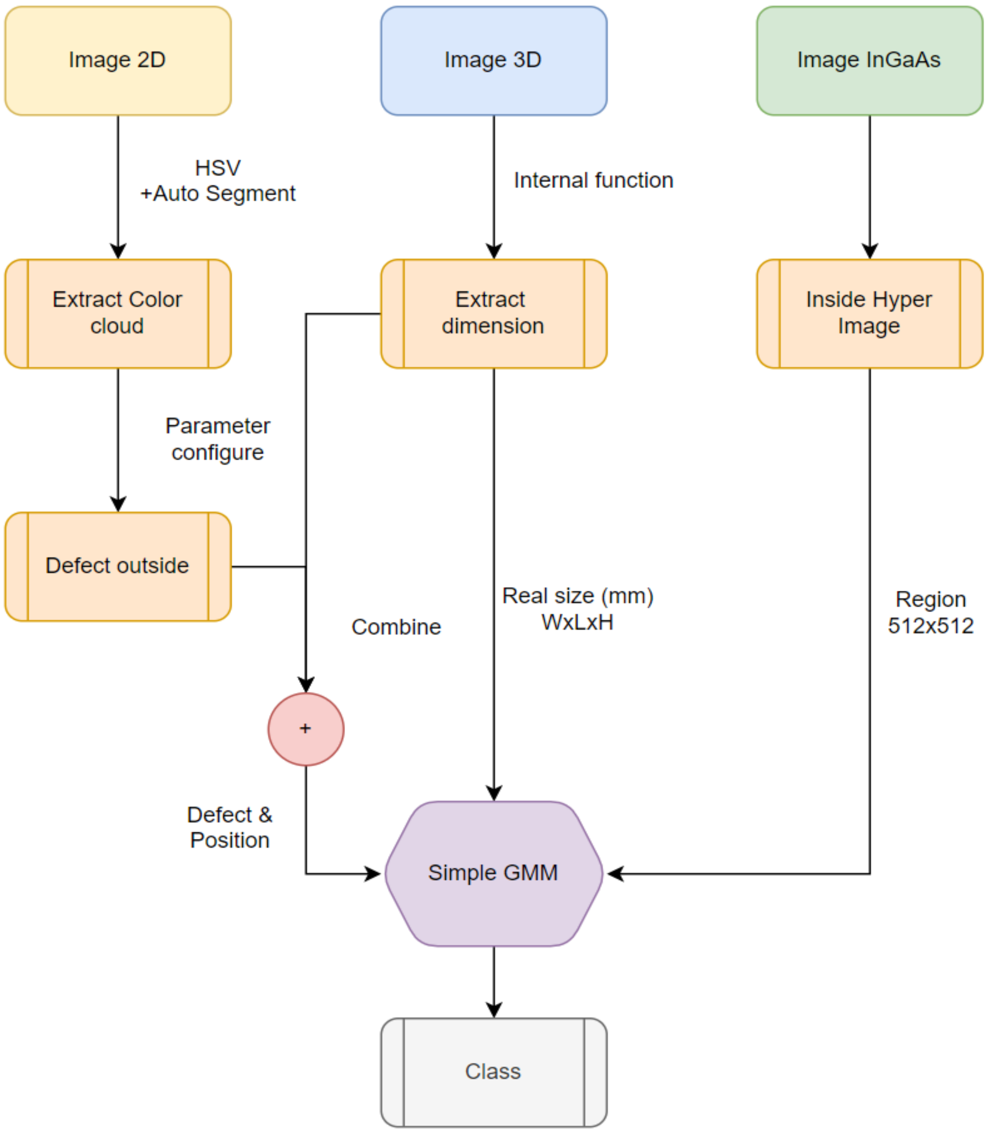

Figure II-7 Process flow chart of the classification system

D435i data provides 2D, 3D images that make it easy to analyse object size, and error area size; These two parameter variables are included for classification by GMM; in addition, linear sensor data is linearized to 512 pixels x 512 pixels (suitable conveyor speed configuration). So with 03 parameters of 2D image, 3D size, InGaAs image, we can easily use classification algorithms such as SVM, GMM, MLP... here we choose GMM method as mentioned above because: easy to train Trained, group-weighted, GMM observers are more suitable for selective classification applications.

3. Conclusion

- With the idea of overcoming common 2D camera defects, we have expanded the possibilities:
o Real-time object size recognition on 3D point cloud model.
o Calculate the exact area of product defect area using the surface 3D object.
o Identify colors and properties of objects from the inside with InGaAs sensors.
o Product classification by simple effective machine learning model GMM, flexible for different fruits, without changing data structure, program structure.
- In the future development direction, we bring the 2D/3D+InGaAs camera model to apply to many different

types of food and apply it to food factories to see the great role of the combination. Multi-sensor integration, in addition, in some seafood directions, we also think about magnetic sensors, detecting metals in fish and shrimp when exporting; we want a LabOnChip solution to be convenient and meet real needs.

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