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MACHINE LEARNING-BASED SYSTEM, FOOD QUALITY INSPECTION AND GRADING IN FOOD INDUSTRY

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Abstract-
One of the most crucial aspects of quality assurance is checking products for faults before they are sold or distributed. For a customer to enjoy a product, a high-quality product is more crucial than having more of the same. An important factor in determining how good a product is, is the consumer. A different perspective on quality is as the whole of the factors that go into creating goods that consumers like. Recently, there has been a significant increase in the use of machine learning and image processing to improve the surface quality of fruits and other commodities. Its is mainly because these technologies greatly outperform what the human eye can do. This suggests that by using computer vision and methods for image processing can shorten the time-consuming and subjective industrial quality control processes. This article discusses using picture segmentation and machine learning to check and assess food. It is capable of both fruit classification and rottenness detection. Gaussian elimination is first used to reduce noise from photos. The quality of the photos is then improved using histogram equalization. The segmentation of the image is done using the K-means clustering technique. After that, machine learning methods like KNN, SVM, and C4.5 are used to classify fruit & Food photos. These algorithms determine if a fruit has been injured or not.

Keywords- Machine Learning; Food; Fruit; Food industry; Image Processing; SVM;

1. Introduction-

The customer's satisfaction is more dependent on quality than on the availability of additional things of the same kind [1]. A key element in establishing product quality is the customer. The sum of all the characteristics that go into producing goods that satisfy the customer is another approach to describe quality [2]. Some imported goods' quality has recently increased in importing countries. It safeguards the quality of food imported from other countries while also protecting the domestic fish industry. Agricultural products' external quality mostly indicates the direct sensory quality of those products. In order to evaluate a product's quality, exterior qualities like colour, texture, size, form, and defects are frequently used [3]. Administrators of food manufacturing companies consider the significance of the product, the social setting, and the challenges farmers confront in carrying out their agricultural duties in addition to output and revenues [4]. Finding defects in products before they are sold or exported is one of the most critical components of quality assurance[5]. Human operators have long evaluated mango quality using visual signals. The situation has changed. They take a lot of time, are monotonous, and are inconsistent [6]. In studies on agricultural engineering, this method has been employed.

Food safety and quality control are of utmost importance in the food business, one of the sectors. Important information, such as the BBD (best-before date), must be appropriately printed on the packaging so that the products can be delivered to clients whole and in great shape[7]. To guarantee that products are free of

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foreign objects and that the quality and shelf life of foods are not impaired, defective or damaged packaging must be identified and avoided. Often, quality control in the food industry is preformed manually and products are sampled and sorted out by hand[8]. These monotonous activities impair concentration. Production flaws or leaks may go undetected and items that should have been rejected might end up on grocery store shelves. Moreover, this method does not account for defects that are invisible to the human eye – for example, air that is trapped in the seams of sealed food packaging[9].

2. Literature Survey-

One of the elements influencing how consumers perceive fresh fruits and vegetables is their outside appearance. How food and agricultural products are presented to the market is crucial since the initial inspection of a consumer is visual for quality qualities including freshness, flavour, decay, and maturity. According to client expectations, computer aided vision systems are introduced as new instruments to achieve quality criteria. Shape categorization, flaw identification, quality grading, and variety classification can all be accomplished in this fashion (Brosnan, et al 2004).

Yang et al. (2012) used hyperspectral line scan fluorescence imaging to evaluate the potential for detecting faecal contaminations on the surface of Golden Delicious apples and created a straightforward multispectral method. The patches of faecal contamination on the apples formed in various dilutions were excited by a pair of violet red line lights. The method made use of four wavebands and four fluorescence densities (680, 684, 720 and 780). More than 99% of the faecal stains could be found in the uncontaminated apple sections, it was stated. It is feasible to use this system on high-speed apple processing line with the purpose of preventing food originated illness for food assurance and reduction of risks.

Kim et al. (2007) built up a rapid online scanning system which works both with hyperspectral Vis/NIR reflectance and fluorescence in the Vis with UV-A excitation. The system was combined with a commercial apple sorting machine at a processing line speed over three apples per second. Great performance was acquired with a faecal detection rate of 100% (with no false positive) and 99.5% (with 2% false positive rate only) using fluorescence imaging and near-infrared reflectance, respectively.

Another hyperspectral imaging system was developed by ElMasry et al. (2008) for detection of bruises on McIntosh apples in a recent study. The spectral region of the system was between 400 and 1000 nm however three wavelengths in the near infrared region (750, 820, 960 nm) gave promising results. It was noted that the bruised apples were successfully detected from the sound apples. Being different from previous studies, the system could recognize early bruises created just 1 hour before and could also recognize even the apples have different background colors (red, green or reddish).

Wang et al. (2011) examined the possibilities of detecting external insect infestation in jujube fruit. They utilized a hyperspectral reflectance imaging approach in the spectral region of 400–720 nm although three wavelengths (500, 650, 690 nm) gave the maximum discrimination. The results revealed that all of the intact cheeks and calyx-end regions classified correctly. More than 98.0% of the undamaged jujube fruits and 94.0% of the insect-infested jujube fruits were correctly identified and the overall classification success of the system was about 97.0%.

Taghizadeh et al. (2010) focused the evaluation of shelf-life of fresh white mushrooms (*Agaricus bisporus*) stored in different packaging materials. At the end of the study they managed to determine superiority of packaging materials compared to each other using hyperspectral imaging system. They were able to reduce the color inspection time less than 1 minute without touching samples and also determined the distribution of quality in a batch which is not possible with classical colourimeters.

3. Basic Steps Of Image Processing And Analysis

A system called computer vision is built using a few pieces of hardware and algorithms to gather data on things of interest. The data could be used to define categorization, quality sorting, feature identification on the inside and outside, etc[10-12].

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Object specialties are recognised through a procedure that involves several steps. The basic steps of computer vision operations include image acquisition, pre-processing, segmentation, representation and description, recognition and interpretation, and each step must be carefully implemented or the results may not be satisfactory[13].

Image acquisition is the stage for turning electronic signals from sensing device into numeric form. Ultrasound, X-ray and near infrared spectroscopy, displacement devices and document scanners, solid state charged coupled device (CCD) cameras[14] are some of the sensors used to create images .Thermal imaging cameras and terahertz cameras are also used in image analyses systems . In order to get a high quality image which is a vital factor for sequent steps[15], illumination[16] and lighting arrangement[17], high quality optics[18] and electronic circuitry[19] must be prepared properly. Light sources vary according to purpose of using such as incandescent, fluorescent, lasers, X-ray tubes and infrared lamps[20].

Pre-processing stage includes one or more operations of noise reduction, geometrical correction, grey-level correction and correction of defocusing and aims to improve image quality[21]. Image segmentation is one of the most important stages because accuracy of following step deeply related with this step[22,23]. It is intended to separate the image into parts which have a strong relation with the object[24]. After segmentation[25], the image generally represents a boundary or a region[26]. First types of images are suitable for size and shape analyses while the latter one is used for determination texture and defects. The image representation should be chosen according to planned application[27].

Recognition and interpretation are generally performed using statistical classifiers or multilayer neural networks to provide information that is useful for process or machine control needed for quality sorting and grading. Fuzzy logic, decision tree and genetic algorithm are also used as learning techniques the same purposes[28,29].

4. METHODOLOGY-

The proposed methodology consists of five main stages. It is shown in Figure 1. These stages are as follows:

- Step 1: Input dataset of various images related to foods
- Step 2: Using Gaussian elimination to preprocess images.
- Step 3: Image enhancement by equalizing the histogram.
- Step 4: K-means algorithm is used to break up an image into parts.
- Step 5: Applying classifiers to a set of already processed images.

There are three different ways to do classification: C4.5, Support Vector Machine (SVM), and KNN. The detailed description of the proposed methodology is available in the following sections

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Figure 1: Block diagram of food grading and inspection

Image Preprocessing- Noise Removal. It is essential that the image be filtered and improved in order to get the best results. As a result, the segmentation results from images taken with cell phones may differ. Image scaling, noise reduction, and picture enhancement are all steps in the preprocessing of an image. Digital images may contain a variety of artifacts, including noise. As a result of poor capture, a simple thresholding task may become difficult. As a result, it is vital to get rid of any visible noise from the image.

Image Enhancement- In order to boost the human eye's capacity to perceive information in a picture, images are enhanced after they have been filtered. The histogram equalization boosts contrast by communicating the intensity value of pixels in the input picture, such that the output image has a consistent intensity distribution and a constant histogram. When the image's practical data is defined by tight contrast values, this technique enhances the image's overall contrast on a regular basis. Using this method, the histogram's intensities will be more evenly distributed.

Image Segmentation- There are two stages to this process: first, the image is sharpened using dynamic fuzzy histogram equalization, and then, it is segmented to get the suitable ROI. Extracting useful information from these segments is done via feature extraction.

Classification of Images- The most prevalent job for sickness prediction and data categorization is classification. Classification is essentially a decision-making process. The three unique classifiers applied in this work to categorize the sick leaves are Naive Bayes, support vector machine, and k-nearest neighbor. A lot of research has utilized the K-NN classifier for classification. Numerous methods are utilized for the categorization of the objects in pattern recognition. K-NN is one of the classification algorithms that classify objects based on the closest training examples. Event-based learning incorporates K-NN. Calculations are held off until after the classification when employing a locally approximated function [27]. When there is very little prior knowledge about the data's circulation, KNN is the central and most straightforward categorization strategy. KNN is one of the most well-known classification algorithms for pattern recognition. Numerous analysts have noted that the KNN calculation generates great outcomes in their studies on a range of datasets.

Detecting inclusions in sealed seams -

Airtight packaging ensures that food does not perish until it ultimately reaches the customer. Any packaging flaws can cause foods to spoil quickly. Until now trapped air or food inclusions in sealed seams went undetected in products that are packaged in printed film or foil. Hyperspectral imaging sees

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through sealed seams of film or foil packaging to ensure that damaged or contaminated products are detected and removed during packaging or production. Hyperspectral imaging guarantees that every product is fully inspected and passes quality control.

Automated and contact-free inspection systems offer quality benefits-

Camera systems can be directly integrated into the production workflow to ensure seamless processes at early on in the value chain. Visual and manual controls can be replaced by image processing systems to guarantee a comprehensive automated quality control. The systems are virtually maintenance-free, have a low susceptibility to interference and are available 24 hours a day, 7 days a week. When high quality products are the key to success in your company, cutting-edge image processing technology significantly contributes to your success.

Applications in hygienic areas-

Combined with special enclosures and system components industrial imaging systems can also be used in hygienically demanding environments that are often found in the food industry. Adequate technology is used to protect imaging systems from spray water and extreme temperatures to ensure reliable quality control in areas that are generally off-limits to employees. The same applies to process monitoring applications, for example, in the field of proactive maintenance where the maintenance staff needs to receive automated alerts or error messages when process parameters change.

5. RESULTS-

Figure 2: e.g. Plastic particles in Flour & Cane-Sugar

Hyperspectral imaging makes hidden food properties visible. It reveals, for example, information about the fat and water content of a piece of meat. Plastics, for example, can be clearly differentiated from organic materials, to precisely detect foreign objects during production. Even the quality control of bulk foods like salt or sugar can be substantially enhanced using hyperspectral imaging. Hyperspectral imaging uses the absorption signature of the monitored wavelength range (visible light, UV or infrared range) to detect the smallest impurities, even when their color is nearly indistinguishable from the color of the actual product.

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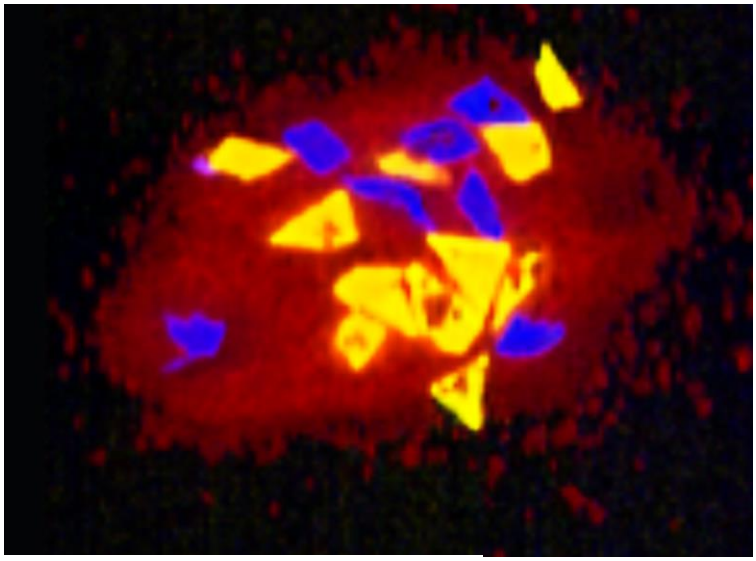

Figure 3: Plastic particles using MATLAB

The Performance analysis of different algorithms used for food inspection is shown in figure 4 on the factors of Accuracy, Sensitivity and specificity.

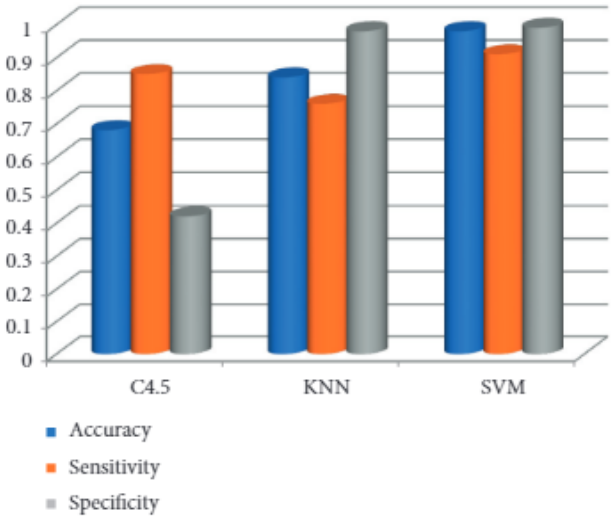

Figure 4: Performance comparison of C4.5, KNN, and SVM algorithm.

6. CONCLUSION-

The fundamentals of ML systems used in the food business are covered in this paper, along with generic imaging processing and analysis steps and some examples of applications. Machine Learning enables the estimation of some internal and exterior quality indicators, improving the safety and quality of food and agricultural goods. These technologies enable automated, quick, sanitary, non-destructive, and objective inspection. Imaging systems are more appealing due to their flexibility, wide range of application fields, and affordability and usability of in-line processes. It appears that continuing technological advancements

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and advancements in computer imaging technology will result in a better knowledge of these systems' deployment and the ability to meet the expanding demands of the food business. Industrial image processing systems enable the automatic recording of both product and process data in addition to quality control. The data are primarily used to monitor production operations in real time and conduct thorough quality control in order to ideally prevent any interferences or failures.

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