# Literature Review

## 1 Introduction:

As far as image processing techniques to detect defective food are concerned there have been a wide variety of approaches that try to solve the problem. One of them being the Bicolor segmentation of food products for quality measurement.
Also another method included K-means algorithm to detect infected fruit parts.

### 1.1 Computer Vision Approach:

A setup where the food sample under observation is kept in a controlled environment, with frames of the sample is captured using a camera and appropriate light source.

#### 1.1.1 Light Source and Setup

Lighting plays a very important role in the field of computer vision. Different sources like

- Incandescent
- Fluorescent
- X-Ray
- Laser
- Infrared

The setup is such that the source of natural light is completely cut off to get a uniform collection of images for easier analysis.

#### 1.1.2 Basic Steps:

1. Image Acquisition:
   a. Setting up the appropriate light source, taking care of the illumination.
   b. Setting up the chosen camera appropriately to get good quality images, which provide maximum information gain
2. Preprocessing:
   . To reduce noise and better the results.
   a. Correct distortion, if any.
   b. Processing blurred images and
3. Segmentation:
   . To determine color, texture and other features to apply image processing techniques onto it.
   a. Thresholding can easily take care of the light absorbed and reflected by the surface.
   b. Edge Detection identifies the edges, so that the item under observation can be extracted and the image normalized for easier analysis.
   c. Region based segmentation can group parts of similar images.
4. Image Processing Techniques:
   . Recognition and identification of the images.
   a. Machine learning techniques which can learn through manually annotated images and classification into rotten or fresh food.
5. Artificial Intelligence:
   . Once enough training data has been obtained, models need to be generated to apply the learning algorithm on test data sets.
   a. One of the majorly used nature inspired techniques is broadly Swarm Intelligence. Some examples include Moth Flame Optimization, Gravitational Search Algorithm, Particle Swarm Optimization and several other such algorithms.

### 1.2 Image processing Techniques:

1. Artificial Neural Networks: Inspired from the biological neural system, this machine learning technique tries to simulate the human intelligence. Here, the physical properties extracted from the images can act as quality factors. It results in near human level performance in areas of color, content, shape, and texture inspection. This has been applied in many food categories like fishery, fruits, vegetables, grain and meat and has resulted in accuracy of detection nearly 90%

2. Optimization Techniques: Classification can also be done using optimization techniques. Appropriate fitness function needs to be chosen and optimized accordingly. Rule sets can be generated in order to do classification of test data.

#### 1.2.1 Color Space:

Color spaces are representations of different colors using different models. There are wide variety of color spaces to choose from each having its own benefits.

1. RGB: Widely used color space, since it works in a way similar to human vision. Views each color as a mixture of red, green and blue in different proportions.
2. HSV: Unlike RGB it separates luma(illumination information) from chroma(color information). Mainly used when dealing with variable illumination. HSV images can be easily segmented.
3. LAB: The components of this color space are Luminance, a and b(color opponent dimensions). This color space is efficient in digital image manipulations i.e. handles shadows, noise etc well.

## 2 Previous Research in Food Safety:

Shape, size, and position can be consistently and rapidly measured using computer vision. With the recent developments of algorithms and the improvement of computer hardware, the sensitivity and ranges have been widened for samples of larger size and more complex shapes. Therefore, computer vision has been extensively applied for food-quality assessment.
Mechanisms for food safety already exist in almost all countries but most of them involve manual inspections which in turn take time and resources. Below are examples of food products that have been studied extensively.

Apples: Quality of bicoloured foods has been evaluated extensively. Multispectral imaging has been employed to evaluate the quality of bicoloured apples (Unay et al., 2011). Geometrical and textural properties are invaluable in identifying defects in food. Kang and Sabarez have also worked on a new segmentation algorithm to analyze dried apple slices. There has also been research to predict the color changing process of a freshly cut apple.

Oranges: Skin defects especially help in identifying defects in oranges. Multivariate image analysis approach has been combined with computer vision to detect skin defects in oranges. Blasco et al, 2009 identified 11 types of defects in five spectral areas.

Bananas: During ripening process bananas exhibit a gradual transformation in colour and texture. At a rapid speed, banana peel degrade form greenish-yellow to dark spotting. (Quevedo et al, 2008) showed that fractal texture analysis based on spectral Fourier analysis was a potential and promising method for evaluating spots in banana peels.

There has been research going with respect to various other food products such as Potatoes, Meat, Berries, Dates Mangoes, Pears etc.

### 2.1 Nature Inspired Algorithms:

There has been research going on in this area for a long time now and there have been several algorithms that are inspired from nature like the human mind, ants, bees, Geo sciences etc. A subset of nature inspired techniques in Swarm Intelligence. Swarm Intelligence refers to the collective behavior of several individual agents communicating with each other. It is a totally decentralized mechanism. Agents share knowledge among themselves by communicating. This is one of the most used techniques for optimization. There are algorithms like Ant Colony Optimization, Swarm Particle Optimization, Bee Clustering Algorithm, Gravitational Search and Moth Flame Optimization each algorithm mimicking the swarm behavior found in nature.

Recently nature inspired algorithms which comprise of algorithms modelling the human mind, artificial immune system, swarm intelligence and geo science based computing have emerged as efficient techniques to handle a diverse set of problems. Fuzzy Set Theory, Genetic Algorithms, Swarm Intelligence based Algorithms, etc are examples of Nature Inspired Techniques. Nature Inspired Algorithms have been applied to a wide variety of fields ranging from Computer Vision, Clustering, Learning, General Optimization Problems to name a few.

Nature Inspired Metaheuristic Algorithms have been used extensively for Partitional Clustering. Genetic Algorithms and Swarm Intelligence based algorithms have been proven to give good results in partitinal clustering. An in depth survey of nature inspired metaheuristic algorithms used for partitional clustering can be found in [1].

There have also been approaches like [2] where the Gravitational Search Algorithm has been used for for data clustering. In this algorithm, some candidate solutions for clustering problem are created randomly and then interact with one another via Newton's gravity law to search the problem space. The performance of the presented algorithm is compared with three other well-known clustering algorithms, including k-means, genetic algorithm (GA), and particle swarm optimization algorithm (PSO) on four real and standard datasets. Experimental results confirm that the GSA is a robust and viable method for data clustering.

There have also been hybrid approaches combining nature inspired algorithms with the classical algorithms like in [3] where a combined hybrid approach of the famous K-means algorithm along with Gravitational Search Algorithm is presented. The quality of the clusters and convergence speed of the GSA has been enhanced by incorporating a k-means algorithm in generating the initial population for GSA. It is important to create a good initial population because the performance of GSA and most of the population-based algorithms are affected by the quality of the initial population. In the proposed algorithm, we try to incorporate the advantage of the k-means algorithm into GSA. K-means is a simple and fast algorithm that is able to find a near optimal solution in a reasonable amount of time. The generated solution by k-means later will be used by GSA as one of the candidate solutions.

Nature Inspired algorithms also have found applications in computer vision and related areas, Multi Threshold Segmentation for example. There have been approaches where segmentation process is considered as an optimization problem, [4], approximating the 1-D histogram of a given image by means of a Gaussian mixture model whose parameters are calculated through the DE, the PSO and the ABC algorithm. The statistical analysis of the results showed a superior performance of DE not only in minimizing the Hellinger distance between the original and the candidate histogram but also performing such a minimization in less evaluations of the mentioned cost function based on distance.

# 3 Literature Survey:

## 3.1 Previous Research in Food Safety:

With consumer concerns increasing over food quality and safety , the food industry has begun to pay much more attention to the development of rapid and reliable food quality estimation systems. Computer Vision, being a non intrusive, non destructive approach has the potential to estimate the characteristics of food products with advantages like speed, ease of use and minimal sample preparation. Specifically with Computer vision systems are capable of classifying foods into different grades, detecting defects and estimate properties like color, shape, texture and surface defects etc.

### 3.1.1 Nanotechnology:

[5] discusses the use of low-cost portable Nanoparticle -based technology for rapid assessment of food safety. The use of Gold, Silver, Cerium Oxide Nanoparticles as well as Low cost platforms for the detection of biological and chemical contaminants Methods for detecting Microbial Contamination, Pesticides, Metal Contaminants and Mycotoxins has been explained.The challenges for practical implementation as well as the direction of future research have also been discussed.

[6] also discusses about the uses of Nanotechnology in Food packaging and food safety. Several applications of nanomaterials for food packaging and food safety are reviewed. Silver nanoparticles as potent antimicrobial agents, and nanosensors and nanomaterial-based assays for the detection of food relevant analytes (gasses, small organic molecules and food-borne pathogens). Techniques involving surface based raman scattering for identification and detection of organic molecules have also been discussed. SERS using

nanoscale substrates has proven to be a useful platform for the detection of food-related analytes. For instance, Mengshi Lin and coworkers have pioneered the use of fractal-like or patterned gold nanostructures as substrates to detect compounds of interest to food safety.

[7] speaks about recent progress in food safety analysis using nano biosensing. The paper talks about the various roles nanomaterials can play in food safety analysis. Toxins, Pathogens, Pesticides and Antibiotics are some of the many contaminants detected by nano biosensing .
Various books have also been written on this topic like [8].

### 3.1.2 Computer Vision:

[9] paper talks about a variety of sensors such as hyperspectral and multispectral imaging, vibrational spectroscopy, as well as biomimetic receptors. Data is acquired by any or a mixture of the above methods. The resulting data acquired from the above-mentioned sensors require the application of various case-specific data analysis methods for the purpose of simple understanding and visualization of the acquired high-dimensional dataset, but also for classification and prediction purposes.
Vibrational Spectroscopy, Hyperspectral Imaging and Multispectral Imaging , Biomimetic Sensors are nature inspired array of sensors designed to mimic the olfactory and gustatory systems of humans called E-nose and E-tongue respectively. Acquiring data from one or more of the previously introduced sensors results in multivariate datasets, i.e. a large number of variables (x-data) connected to an observed value or category (y-data).

Chemometrics, Machine Learning and Evolutionary Computing methods are used to extract information from the data extracted. Supervised as well as Unsupervised learning is applied to generate models which are then validated later on. The paper then goes on to talk about the sensor quality, external features, bruise detection and other quality parameters.

[10] talks about the kind of hardware used for a standard computer vision setup and goes on to talk about the computer vision techniques used for food safety of Bakery products, Vegetables, Fruit, Grain, Prepared Consumer foods.

#### *3.1.2.1 Bakery Products:*

The appearance of baked products is an important quality attribute, correlating with product flavour and influencing the visual perceptions of consumers. There have been a variety of approaches in this regard. For example, Scott (1994) described a system which measures the defects in baked loaves of bread, by analysing its height and slope of the top. The internal structure (crumb grain) of bread and cake was also examined by machine vision. Automated visual inspection of muffins has also been performed by use of a system developed by Abdullah, Aziz, and Dos-Mohamed (2000)[11]. In a more recent study, digital images of chocolate chip cookies were used to estimate physical features such as size, shape, baked dough colour and fraction of top surface area that was chocolate chip (Davidson, Ryks, & Chu, 2001). Four fuzzy models were then developed to predict consumer ratings based on three of the features examined.

#### *3.1.2.2 Meat and Fish:*

Visual inspection is used extensively for the quality assessment of meat products applied to processes from the initial grading through to consumer purchases. McDonald and Chen (1990) investigated the possibility of using image-based beef grading in some of the earliest studies in this area. They discriminated between fat and lean in longissimus dorsi muscle based on reflectance characteristics, however poor results were reported. Greater accuracy was found in a study by Gerrard et al. (1996) where R2 (correlation coefficient) values of 0.86 and 0.84 for predicted lean colour and marbling were recorded, respectively, for 60 steaks using image analysis. Li et al. (1997) measured image texture as a means of predicting beef tenderness. Colour, marbling and textural features were extracted from beef images and analysed using statistical regression and neural networks.

#### *3.1.2.3* Fruit*:*

Computer vision has been used for such tasks as shape classification, defect detection, quality grading and variety classification. Defect segmentation on Golden Delicious apples was performed by CMV (Leemans et al., 1998). A colour model developed was used as a standard for comparison with sample images.. The transform converts a spherical object image to a planar object image allowing fast feature extraction, giving the system an inspection capacity of 3000 apples/min from the three cameras, each covering 24 apples in the field of view.

#### 3.1.2.4 Vegetables:

The necessity to be responsive to market needs places a greater emphasis on quality assessment resulting in the greater need for improved and more accurate grading and sorting practices. Computer vision has shown to be a viable means of meeting these increased requirements for the vegetable industry. Shape, size, colour, blemishes and diseases are important aspects which need to be considered when grading and inspecting potatoes. Machine vision systems have been developed for grading potatoes using a HSI (hue, saturation, and intensity) colour system. The system was able to differentiate between good and greened potatoes with an accuracy of 90% by representing features with hue histograms and applying multivariate discriminant techniques. Computer vision has also been applied for the automated inspection and grading of mushrooms. The features considered were colour, shape, stem cut and cap veil opening.

Similarly [13] presents a review of various computer vision approaches applied for food safety of meat, fish, vegetables, fruits etc.

[12] - This paper especially talks about the kind of learning techniques applied in food safety algorithms. They range from Artificial Neural Networks used for classification of cereal grains, fruits especially apples and fish and meat and vegetables, Segmentation is discussed as a preprocessing step where in ANN is applied on the segmented image. Statistical Learning, Decision Trees and their applications to various food products has been discussed.

#### 3.1.2.5 LabVIEW IMAQ Vision Imaging System [13]:

LabVIEW IMAQ Vision is potentially useful for inspecting food and agricultural products since it combines the merits of both LabVIEW and IMAQ Vision, which have graphical programming environment and rich image processing functions. This paper provides profound introduction to LabVIEW IMAQ Vision: the principal components of LabVIEW IMAQ Vision, calibration, and image processing and analysis using VIs functions are described. In addition, recent advances in the application of LabVIEW IMAQ Vision to food and agricultural products inspection are reviewed, such as defects detection, shape classification, fruit grading and quality evaluation, etc. Finally, current limitations and likely future development trends are discussed. And the results of discussion showed that the utilization of IMAQ Vision module is restricted by the hardware environment, and mixed programming with LabVIEW and MATLAB is the development trend of LabVIEW IMAQ Vision.

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