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Computer vision based method for quality and freshness check for fish from segmented gills

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ABSTRACT

The quality and freshness of a fish sample is principally hampered in the post-harvested phase due to storage, handling and processing. The quality of the sample may degrade as the days pass till it finally reaches the consumers. The quality of a post harvested fish is determined mainly by two important factors namely climatic conditions and holding time. This paper presents a completely automated computer vision based segmentation of fish gills from digital images of fish samples. Post segmentation, a statistical relationship of the segmented gill region is established to design an assessment model for fish freshness identification. The fish gills are segmented using various strategic image processing techniques like contrast enhancement, adaptive intensity threshold and active contour based methods. The model for fish freshness testing is based on the image statistical features which are derived from the gills region of the saturation channel. The variation of the statistical distribution is observed to be decreasing monotonic which is basis for design of the framework for fish quality and freshness identification. This process being non-destructive provides an efficient fish quality assessment scheme in real time.

1. Introduction

The seafood is primarily consumed after analyzing the freshness of the sample which is considered to be a characteristic feature to determine the quality of the food (Alasalvar et al., 2011). The analysis of the quality of the fish sample on the basis of freshness has been used as the primary method for evaluation (Rehbein and Oehlenschlager, 2009). Once the fish samples are harvested, the shelf life of the samples depends on various factors such as handling, storage conditions and season or climate conditions. Such factors play an important role and states the complexity involved in the assessment of fish freshness.

The post harvested fish samples have been surveyed many a times and it has been discovered that the quality of the samples is found to be compromised (Hossain et al., 2013). The biological and chemical changes that occur in the fish samples post death and during storage can result in loss of characteristics such as taste and quality of the samples (Olafsdottir et al., 1997). Such changes can also cause a degradation process of the fish samples and consumption of such food can prove hazardous for human body (Goon, 2014).

There can be many inspection procedures which are used to assess the fish freshness. The fish sample shows some clear variations during the deterioration process. These features can be mainly classified in terms of appearance, color, spots, stiffness, smell, secretions, scales, skin, eyes, gills, abdomen and flesh. These features can be used individually for freshness testing. The variation in color of various regions in food samples can be considered as an important parameter in determination of food quality and safety by means of human sensing. Thus, the colorimetric technique can be used as a determinant attribute to grade the food samples as fresh, moderately stale or completely stale (McCaig, 2002).

The fish gill is of red colored respiratory organ in fish body and the blood flows directly through them. An analysis of the color and smell of gill can be used as basic factor for freshness identification (Macagnano et al., 2005). However, the colorimetric technique which uses gill color as basis can be staple, but can also be misleading. A proper scientific validation is needed before using the gill color as indicator for freshness determination of post-harvested fish samples. Rohu (Labeo Rohita) is considered to be the most preferred consumed and commercial fish in Indian subcontinent (Das et al., 2005). So, this makes Rohu the most acceptable candidate for evaluation of freshness and quality over other fish variety.

An investigation of a food sample is non-destructive and non-hazardous if done using imaging techniques. So, the use of image

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analysis in development of tool to analyze the color variations can be considered as a critical technique for determination of exact freshness of the fish samples (Menesatti et al., 2010). Some work has already been reported which involves the application of image processing techniques to the food processing sector. Wang et al. (2013) proposed the freshness detection by applying a regression based model to the eye of the fish samples. Dowlati et al. (2013) proposed a regression and artificial neural network for determination of freshness using eyes and gills color. Muhamad et al. (2009) proposed that the fish freshness classification can be performed using a fuzzy logic method. Hosseini et al. (2008) proposed a support vector machine based classification for fish species. Zion et al. (2007) has also proposed a system for fish species identification using image processing and computer vision methods. Dutta et al. (2016) has proposed a wavelet based technique to analyze the changes in fish samples upon cypermethrine exposure. Although a lot of work has been done in this field yet there is still a need of some real time detection system which uses some scientifically approved standards for development of an image processing based fish freshness system.

The main objective of this work is to propose a framework that is capable enough to assess the fish freshness using image processing techniques. The chemical investigation of fish samples is a damaging and harmful technique as some foreign agent is added to sample making it superfluous for any use in future. The image processing, being a non-destructive and safe technique, can be beneficial as this will only capture the image of samples using a camera without causing any physical, biological or chemical changes. This technique promotes the reusability of the sample. The images of food samples can be subjected to various segmentation and classification algorithms available in image processing modules and a detailed investigation of the preferably distinguishable features can be used as a basis for evolution of some feasible tool in this regard.

The main contribution of the method proposed in this work is the application of non-destructive image processing techniques to determine the freshness of fish samples. This has been achieved by studying the saturation plane of the color space transformed fish sample images. The freshness test is well supported by studying the statistical distribution of pixels in the gills region of the sample images. A prediction of the freshness of samples is done by studying the monotonous behaviour of the statistical features obtained during the study.

Another valuable contribution of the proposed work is the usage of active contour method for accurate segmentation of pixels belonging to gills regions in fish images. The proposed active contour method is based on the energy minimization technique and result in accurate identification of the gill boundary from the digital fish images. Also, the use of LAB color space to segment the gills has also improved the segmentation accuracy. The fish gills of red color are discriminated easily from the background in the 'a' channel and this property has been the basis of the segmentation method used in the proposed work.

1.1. Justification of using image processing techniques for fish freshness assessment

The fish freshness assessment is usually performed by various procedures. The fish samples show a clear degradation in the quality and freshness. The color of various body parts and regions of the fish samples can be used as a basis for determination of freshness in fish samples. However, the colorimetric technique can be misleading and must be properly scientifically validated. So, there is a need for development of an image processing based framework for freshness test of samples. Some efforts have been made and the image processing techniques have been used for determination of presence of some poisonous and harmful substances like acrylamide in potato chips (Dutta et al., November 2015). Some image processing techniques have been used to detect the plant disease using some visible symptoms (Camargo and Smith, 2009). The most important feature of using image processing techniques is its non-damaging and flexible nature to identify the parameters that affect visual quality (Gowen et al., 2007). A fish freshness assessment technique has been proposed using colorimetric and image processing techniques (Dutta et al., 2016). Such encouraging results using image processing techniques pave the path for exploration in different fields to provide some cost-effective solutions. An efficient image processing based framework has been proposed in this paper which can be used for assessment of freshness of fish samples.

1.2. Design challenges in image processing based freshness assessment of fish samples

There are many challenges associated with the computer based assessment of freshness that has made it difficult to find an optimal solution. A few commonly faced problems are listed below:

- The accurate and consistent segmentation of the region which will be used for feature extraction is important. As the images used can be of different quality, the segmentation should be accurate and computationally efficient and less complex and invariant of illumination and other imaging properties.
- The accurate rejection of noise such as fins and scales is also an important challenge. The fins and scales can be of similar color, texture and intensity when the sample image is analyzed in various channels of the color space transformed images.
- The extraction and choice of the domain analysis for features is also an important task and plays a significant role in extracting textural, wavelet, statistical features from the segmented regions of the image.
- Out of the many extracted features, the choice of features having a discriminatory variation is important as this would reduce time complexity and also result in accurate determination of the objective involved.

The structure of the remaining part of the paper is as follows. Section 2 discusses the materials and techniques which have been used in the proposed work. This part of the paper gives an introduction regarding the sample collection and various techniques which have been used for their analysis. Section 3 discusses the observations and results obtained during the experimentation. Section 4 is related to the conclusions inferred from the results obtained during the experimentation.

2. Materials and methods

2.1. Data collection

The proposed method is applied to the Indian Rohu (L. rohita) fish samples which were collected from the fish ponds of National Institute of Abiotic Stress Management (NIASM), Baramati, Pune, Maharashtra, India. The institute is situated in the northern hemisphere of the earth and to the east of the prime meridian with coordinates as 18°09′30.62′N and 74°30′03.08′E and at an elevation of 570 m from the mean sea level. Before commencing the experimentation on the samples, the fishes were usurped from the pond and placed in an aquarium for a day. The samples used for experimentation were found to have a mean length and weight of 21.60 ± 0.50 cm and 90.40 ± 1.20 g respectively. The pond water, in which the fishes were harvested, was kept free from infestation