Chapter 6
Automated Ripeness Assessment System of Tomatoes Using PCA and SVM Techniques

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ABSTRACT

One of the prime factors in ensuring a consistent marketing of crops is product quality, and the process of determining ripeness stages is a very important issue in the industry of (fruits and vegetables) production, since ripeness is the main quality indicator from the customers’ perspective. To ensure optimum yield of high quality products, an objective and accurate ripeness assessment of agricultural crops is important. This chapter discusses the problem of determining different ripeness stages of tomato and presents a content-based image classification approach to automate the ripeness assessment process of tomato via examining and classifying the different ripeness stages as a solution for this problem. It introduces a survey about recent research work related to monitoring and classification of maturity stages for fruits/vegetables and provides the core concepts of color features, SVM, and PCA algorithms. Then it describes the proposed approach for solving the problem of determining different ripeness stages of tomatoes. The proposed approach consists of three phases, namely pre-processing, feature extraction, and classification phase. The classification process depends totally on color features (colored histogram and color moments), since the surface color of a tomato is the most important characteristic to observe ripeness. This approach uses Principal Components Analysis (PCA) and Support Vector Machine (SVM) algorithms for feature extraction and classification, respectively.

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INTRODUCTION

Fruits and vegetables development is characterized by a short period of cell division followed by a longer period of cell elongation by water uptake. The final fruit size mainly depends on initial cell number, rather than cell size (Cowan, Cripps, Richings, & Taylor, 2001). Fruit ripening on the other hand is characterized by the development of color, flavor, texture and aroma. The actual time from anthesis until full maturity can vary tremendously among species/cultivars due to genetic and environmental differences. Even between fruit on the same plant, fruit development and ripening can take more or less time depending on local microclimate conditions and differences in sink/source relations within the plant. In addition, when a fruit is harvested, the time of anthesis of a particular fruit is generally unknown, as is its full history.

Monitoring and controlling produce (fruits and vegetables) ripeness has become a very important issue in the crops industry, since ripeness is perceived by customers as the main quality indicator. Also, the product’s appearance is one of the most worrying issues for producers as it has a high influence on product’s quality and consumer preferences. However, up to this day, optimal harvest dates and prediction of storage life are still mainly based on subjective interpretation and practical experience.

Hence, automation of this process is a big gain at agriculture and industry fields. For agriculture, it may be used to develop automatic harvest systems and saving crops from damages caused by environmental changes. On the other hand, for industry, it is used to develop automatic sorting system or checking the quality of fruits to increase customer satisfaction level (Brezmes, Llobet, Vilanova, Saiz, & Correig, 2000), (Elhariri, El-Bendary, Fouad, Plato, Hassani, & Hussein, 2014). So, an objective and accurate ripeness assessment of agricultural crops is important in ensuring optimum yield of high quality products.

Moreover, identifying physiological and harvest maturity of agricultural crops correctly, will ensure timely harvest to avoid cutting of either under- and over-ripe agricultural crops (Elhariri, El-Bendary, Fouad, Plato, Hassani, & Hussein, 2014), (May & Amaran, 2011).

Every fruit shows one or more apparent signs when it reaches physiological maturity or ripeness. Tomatoes, with their continuously prevailing daily nutrition and dietary value, are taking a dominant place among the vegetables all over the world. In Tomatoes, over maturity or over ripening is the stage when the fruit softens and loses part of its characteristic taste and flavor (Cameleo, 2004). At this point, it is necessary to differentiate between two types of fruits: climacteric and non-climacteric. Tomato belongs to the group of climacteric agricultural products, which means that it is capable of generating ethylene, the hormone required for ripening even when detached from the mother plant and they reach full red color even when harvested green (Cameleo, 2004). On the other hand, bell pepper for example, belongs to the group of non-climacteric agricultural products, which means that ripeness (full red color) is only obtained while fruit is attached to the plant and slight changes in color take place after harvest [(Cameleo, 2004), (Coates & Johnson, 1997)].

Tomato maturity has been related to quantifiable parameters that reflect the biochemical changes during ripening. Color is used as a major method in determining maturity of tomato. However, skin color of tomato varies from cultivar to another cultivar even at the same maturity stage [(Molyneux, Lister, & Savage, 2004), (Zhang & McCarthy, 2011)]. During ripening, tomatoes go through a series of highly ordered physiological and biochemical changes, such as chlorophyll degradation and increased activity of cell wall-degrading enzymes, bring on changes in color, firmness, and development of aromas and flavors (Prasanna, Prabha, & Tharanathan, 2007). For tomatoes, ripeness issue is often handled via classifying harvested produce according to discrete
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