MULTIDIMENSIONAL NON SUPERVISED ANALYSIS (TEXTURAL AND SPACIAL) IN MRI TOMOGRAPHY FOR WATERCORE DETECTION

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Abstract

This work has been carried out in the frame of the European project InsideFood (Integrated sensing and imaging devices for designing, monitoring and controlling microstructure of foods). The aim of this project is to provide technological solutions for exploring the microstructure of foods, by the combination and application of different non-destructive techniques such as X-ray CT, OCT, MRI, NMR, TRS and SRS, aimed at online sensing of food microstructure, water status, texture and optical properties.

Magnetic Resonance Imaging (MRI) has been used in order to detect watercore disorder in three different varieties of apples, which are non commercialized due to their watercore development problems. These three varieties are: Ascara2, Rebellón and Tempera, which were grown under favourable conditions for the development of such disorder.

At first step, MRI has been used for screening the apples population in order to detect those ones which had watercore problems. Then, an image analysis has been done in all these apples, in order to check the evidences of such disorder. Several methods have been used: Texture analysis, Principal Components Analysis (PCA) and Cluster Analysis

Keywords - Magnetic Resonance Imaging, Image Analysis, Cluster Analysis.

INTRODUCTION

Non destructive Tomography is a most powerful tool for assessing internal quality and disorders in living tissues.

Magnetic Resonance Imaging (MRI) as tomographic tool is not only a device but a complete set of instruments since acquisition parameter lead to a wide possibility for identifying structures, textures, compounds, water mobility.

Therefore, not only spatial but a multi layer information can be acquired and needs to be treated by means of chemometrics.

In the case of apples, internal disorder is referred to as watercore, which is developed in cultivars growing in arid and semi-arid climates, though it can be developed under other conditions. Lots of cultivars in Mediterranean countries, such as Spain, are affected by this disorder which is a problem when growing some varieties.

Watercore is a physiological disorder affecting apples in which intercellular air spaces in flesh adjacent to vasculature become filled with fluid [1]. Although fruit affected by watercore disorder is susceptible of being consumed, it may develop some associated symptoms that can

decrease the quality of the fruit, such as the development of alcoholic flavours, core browning or core breakdown. Except in very particular situations, in which affected flesh is close to the skin, external symptoms signalling the presence of the disorder are essentially absent in all cultivars [1].

There is whole history in the identification of internal disorder with MRI [2-6]. A main idea points that before being able to isolate deeply affected areas in the apple, there is a complete set of slight textural changes which would be of major interest for multidimensional non supervised analysis and diagnosis on MRI tomographies.

If it is expected to expand the use of multilayer tomography, there is a need for automated exploration of massive data.

MRI and other imaging techniques, such as X-Ray, are the most extended for evaluating global internal quality in a non-destructive way [2]. MRI is a useful method for detecting internal disorders in food industry, especially in fruits.

At the initial development stages of watercore in apples segregated structures are not achievable and only texture changes can be assessed, and thus the analysis of image histograms (texture analysis) can be of major interest (Figure 1).

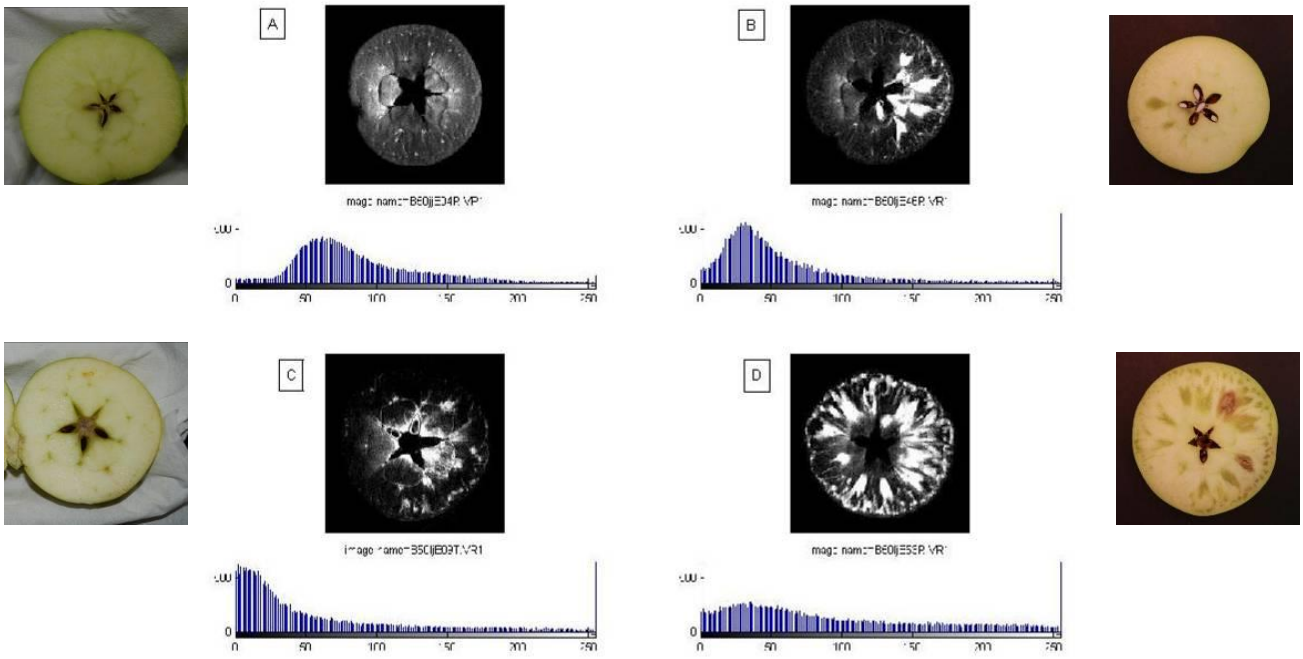

Figure 1: MRI images of apples affected by watercore at different stages, and their histograms. A. Sound Apple. B. Early stage. C. Light watercore. D. Strong watercore

In this work, experiments have been carried out with a wide number of samples (179 apples). Due to this large data number, and to the purpose of outstanding information extraction, a non supervised variables anlaysis has been performed. A Principal Component Analysis (PCA) has been chosen as it allows to decrease the number variables (in this case gray levels in the image histogram) without loss of information.

This histograms set, obtained from the MRI images corresponding to the 179 apples has been analyzed by PCA. Each Principal Component is a linear index that correlates with limited regions in the histogram. The complete set of PCs refers to a new discrete dimension which will be referred as relevancy-subliminality, since the PC order decreases together with corresponding relevancy (amount of explained variance) that is to say subliminality level increases with decreasing PC order for such (delimited areas of the histogram gathered in such PC). Moreover, highly relevancy PCs also correspond to lower complexity, while going farther in

the relevancy axis implies that a more complex histogram pattern is generated. Sometimes it is difficult to determine the boundary between subliminality and noise.

Nevertheless, the aim of this work is going to achieve a global approach and not only a particular application; Multidimensional techniques are required for semi-automatic index generation (PCA) and its semiautomatic association to individuals, by cluster.

On the other hand, it is possible to explore the usage of the so called butterfly techniques which allow to combine spectral and spatial parameter extraction (Figure 2). Such technique was originally developed for hiperespectral images, yet some devoted modifications it can be applied to this particular case: texture evolution of apples.

At current stage algorithms are to be modified and evaluated.

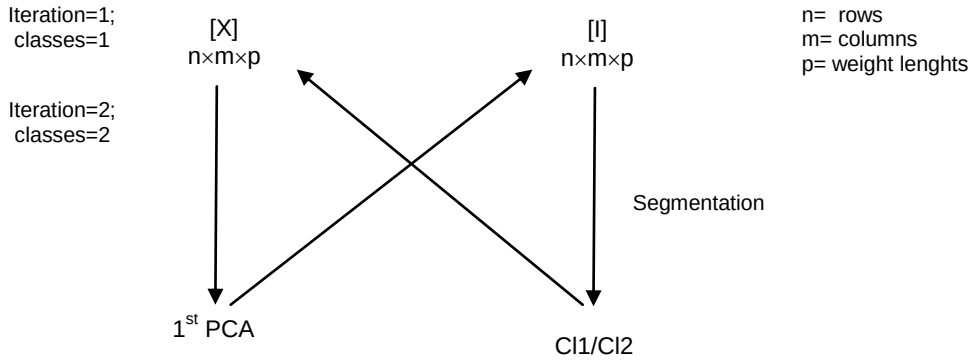

Figure 2: Butterfly technique diagram

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