CLASSIFICATION OF DYNAMIC SPECKLE SIGNALS THROUGH GRANULOMETRIC SIZE DISTRIBUTION

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Abstract— **In this work we present a method based on granulometry, a tool derived from mathematical morphology, to classify dynamic speckle signals. Through the use of morphological operators we obtain a granulometric size distribution. From this distribution we obtain the related moments used as parameters to classify the image.**

This technique enables the detection of differential activity in samples of sequences of dynamic speckle in space-time coordinates. The analysis of the method is illustrated through the detection of bruised regions in fruits. Finally, we present a discussion of the results.

Keywords — **Dynamic speckle, mathematical morphology, granulometry, opening based granulometric size distribution.**

I. INTRODUCTION

When the surface of an object, which has physical or biological activity, is illuminated with a coherent wave of light, the scattered light presents an aspect of granular structure, that is, spots of light and darkness randomly distributed, that change with time.

This phenomenon can be used to detect physical or biological changes in biological samples such as fruits (Pajuelo *et al.*, 2003) and seeds (Braga *et al.*, 2003), as well as in other non biological processes such as corrosion of steel and the process of drying of paint. The dynamics of the speckle effect is usually too complex to be described due to the multiple physical mechanisms that take place in it (Dainty, 1975; Erf, 1978), but the evaluation of this activity is a promising tool to monitor the evolution of the processes that take place in a biological sample and it is currently very used in medicine. It is then of great interest the development of techniques that allow to extract useful information from a sequence of images of dynamic speckle, also called bio-speckle.

This work presents an application of the granulometric size distribution to analyze the differential activity present in a sequence of bio speckle images. That analysis was applied to biological samples of apples with the purpose of studying the viability of the technique in the early diagnosis of damages on the surface of the fruit, before they were visible at plain sight.

This work is organized in the following way: in section II there is a brief description of the dynamic speckle phenomenon, the fundamentals of mathematical morphology (MM) and granulometric size distribution. At the end of that section we describe the steps to implement the proposed method and the experiments. In section III we analyze the results and compare them to other standard techniques for the analysis of these types of sequences. Finally in section IV we present the conclusions to this work.

II. METHODS

A. Dynamic speckle

When a surface presenting a certain physical or biological activity is illuminated by a wave of coherent light, as a laser beam, the scattered light presents a granular structure, i.e. bright and dark spots randomly distributed, that change along time, producing a visual effect such as that of a boiling liquid. Figure 1 shows a typical image. This effect is known as "dynamic speckle" – because of its changing dynamics – and it is the result of the coherent light dispersion through objects that exhibit some kind of activity. A sequence of images of this kind will present local intensity variations corresponding to the level of biological activity existing in the surface under observation.

Figure 2 shows a signal that corresponds to the evolution in time of the intensity or grey levels, of a pixel of the sequence of speckle images under study. Given the stochastic nature of the signal, it would be impossible, at plain sight, to recognize the correspondence of this signal to any particular area of the apple.

B. Mathematical morphology: Morphological operators

The two basic morphological operators in MM are erosion and dilation. Other operators can be defined by combination of the two basic operators (Matheron,

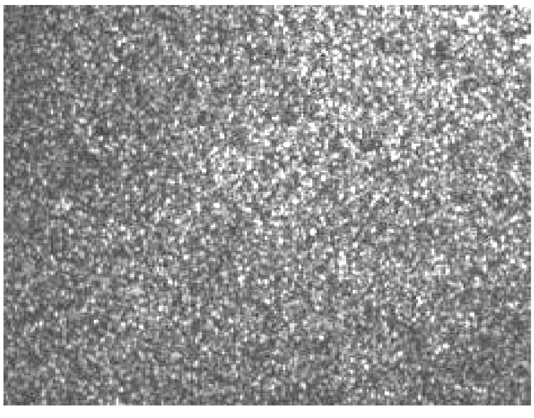

Fig. 1. Typical speckle pattern