RECURSIVE INTERPOLATION TECHNIQUE FOR BINARY IMAGES BASED ON MORPHOLOGICAL MEDIAN SETS

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Abstract Interpolation is an important step in many applications of image processing. This paper presents a morphological interpolation technique for binary images based on the median set concept. A characteristic of our method is that it treats recursively the connected components of input slices. This technique uses the minimal skeleton by pruning (MSP) as reference points for translating connected components; this fact guarantees the non-empty intersection between them.

Keywords: Mathematical Morphology, Image Processing, Image Analysis, Interpolation, Median Set.

Introduction

In many applications of imaging, data are composed of different slices. In particular, this situation occurs when we process volumetric images and video data. In the first case, slices arise when the spatial dimension is sampled, whereas in the second case slices correspond to different instants of time. Frequently, the distance between adjacent elements within adjacent slices is much larger (until 10 times) than the distance between adjacent image elements in a slice. Thus, it is often useful to be able to interpolate data between adjacent slices, and many interpolation techniques have been developed [5] for this purpose.

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The objective of interpolation techniques is normally to produce a set of intermediary slices between two known ones. Particularly, there exists a recent category of interpolation techniques, called shape-based interpolation [13], which attempt to incorporate knowledge about the image structures to the interpolation process. In mathematical morphology [7][8][12][2], interpolation is considered as a particular case of shape-based interpolation techniques [13] [1][6][9][10][3][4].

This paper presents a morphological interpolation technique based on median sets [11][1][3][4]. Our algorithm is characterized by the recursive treatment of the *connected components* (CCs) of input slices. Besides, due to the fact that the CCs to be interpolated must overlap, our technique uses minimal skeleton by pruning (MSP) as reference points for translating them and force the overlapping of the CCs. MSP points are also used for matching purposes.

This paper is organized as follows. Section 1 provides some definitions and concepts about median sets. In Sec. 2, we present our technique, including a description of its main steps, and Sec. 3 discusses and compares some experimental results.

1. Theoretical Background

In this section, we provide some definitions and the basic concepts about median sets.

Binary images, Slices and Connected Components. As mentioned above, our technique interpolate *binary images*, which are functions $f : \mathbf{D} \rightarrow \{0, 1\}$, where $\mathbf{D} \subset \mathbf{Z}^2$, 0 defines a background point, and 1 defines a foreground point.

The term *slice* refers to each bi-dimensional image used as input or generated as output by the interpolation method. Each slice can contain 0 or more disjoint *connected components* of image pixels. We will see that our interpolation technique processes both the CCs of the foreground ("grains") and the CCs of the background ("holes"). In this work, 8-connectivity is assumed.

Median Set. The notion of *median set* is an extension of the *influence zone* (IZ) concept, which is defined in the following. Let us consider two sets X and Y, where $X \subseteq Y$. The influence zone of X with respect to Y^C (which is also called the influence zone of X inside of Y) is:

$$\text{IZ}_Y(X) = \{x : d'(x, X) \leq d'(x, Y^C)\} \tag{1}$$

where d' is the distance between a point and a set. The distance $d'(p, A)$ is equal to min$\{d(p, a) : a \in A\}$, where d is the Euclidean distance between two points.