A Region-Based Interpolation Method for Mosaic Images

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Morphological Interpolation

Interpolation

- Definition
- Morphological interpolation

Previous other works

- Morphological interpolation based on Hausdorff-distance
- Morphological interpolation based on median set
- Interpolation functions
- Morphological interpolation based on weighted erosions and weighted dilations

A Summary of Our Morphological Interpolation Technique

Characteristics

- Inclusion property
- Using median set as interpolator
- Objects shapes are preserved

A Summary of Our Morphological Interpolation Technique

Inclusion Property

Inclusion property establishes the recursive interpolation of shapes with internal structures (pores and grains).

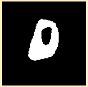
If A_i and B_i are two sets of input slice 1, such that $B_i \subset A_i$, and A_j and B_j are two sets of input slice 2, such that $B_j \subset A_j$, and we want to interpolate A_i with A_j, and B_i with B_j, then the following condition should be satisfied:

$$Inter(A_i \setminus B_i, A_j \setminus B_j) = Inter(A_i, A_j) \setminus Inter(B_i, B_j)$$

A Summary of Our Morphological Interpolation Technique

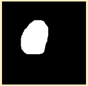
Inclusion Property

(a) Input set 1



(b) Interpolated set

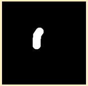
(c) Input set 2



(d) Filled grain 1

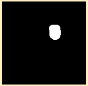
(e) Interpolated filled grain

(f) Filled grain 2



(g) Hole 1

(h) Interpolated hole



(i) Hole 2

A Summary of Our Morphological Interpolation Technique

Binary Image Interpolation Algorithm

- It has three main sections:
  (1) separation of outer CCs from each slice,
  In the first step, the outer filled CCs of the input slices are identified and separated. The outer filled CCs are the filled CCs surrounded by the background pixels that touch the border of the image.
  (2) matching of CCs,
  The matching step establishes correspondences between CCs from the different slices, and
  (3) interpolation of matched CCs.
  CCs that match are aligned in order to overlap them and, after that, interpolated using a median set computation.

Treatment of Border CCs in Binary Images

Binary Border Image

A "binary border image" is an image that has a CC that touches its border.

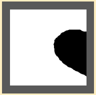
Examples


Type 1


Type 2


Type 4


Type 6


Type 7


Type 8

Interpolation of Border Images

Definition

Let X_1 and X_2 be two binary CCs in two different slices:

Case 1

If X_1 and X_2 are border CC and if $X_1 \cap X_2 \neq \emptyset$ then interpolate with X_1 and X_2 in their original location (without previous alignment).

Interpolation of Border Images

Case 2

If just X_1 or X_2 is a border CC and if $X_1 \cap X_2 \neq \emptyset$ then interpolate with X_1 and X_2 in their original location.

Interpolation of Border Images

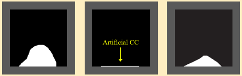
Case 3

If either X_1 or X_2 is a border CC and $X_1 \cap X_2 = \emptyset$ but $\delta_{\lambda_1}(X_1) \cap X_2 \neq \emptyset$ or $X_1 \cap \delta_{\lambda_2}(X_2) \neq \emptyset$, i.e. these CCs satisfies a proximity test, then interpolate X_1 and X_2 normally.

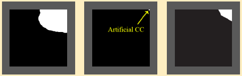
Interpolation of Border Images

Case 4

If either X_1 or X_2 is an empty set, for example, let us suppose that X_2 is the empty set, so that X_1 vanishes from slide 1 to slide 2. X_1 must be interpolated with the so-called "artificial" CC in slide 2.

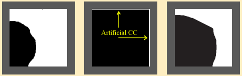


(a) Type 1

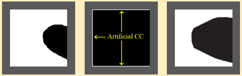


(b) Type 2

(c) Type 4



(d) Type 6



(e) Type 7

(f) Type 8

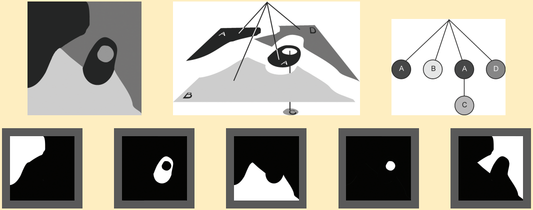
General aspects

Introduction

- Mosaics are the gray-level images better suited to be treated by a region-based interpolation technique.
- In the literature, the treatment of shapes in region-based interpolation problems have been frequently involved a conversion to binary images as strategy to treat shapes.
- The general algorithm of our region-based interpolation method is divided in 3 main parts:
  (1) detection and separation of regions in each slice,
  (2) matching and interpolation between regions, and
  (3) final adjustment.

Region separation

- A region corresponds to a set of connected pixels with the same gray-value.
- Our algorithm extract regions and store it as binary images.
- The gray-level value for each region is also stored
- The hierarchical level of each region is store too.



Matching and interpolation

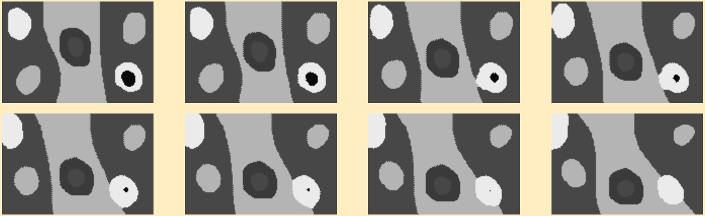
- Regions to be matched must have an identical gray-level value as a prerequisite.
- Regions to be matched must have the same hierarchical level
- The criteria used in the matching step are the proximity test and the minimal distances between their MSP
- The proximity test consists in the computation of the *proximity zone*. The proximity zone of X is a dilation of X with a disk-shaped structuring element of radius λ_X. $\delta_{\lambda_X}(X) \cap Y \neq \emptyset$ or $X \cap \delta_{\lambda_Y}(Y) \neq \emptyset$
- X's radius is computed as $\lambda_X = \text{mín}\{\alpha : X \subseteq \delta_\alpha(MSP_X)\}$, where MSP_X is the MSP of X.

- Interpolated regions $\{R_i\}$ pose two problems:
  1. $\cup_i R_i$ does not necessarily cover the whole image support (i.e., there are empty spaces that do not belong to any R_i); and
  2. In general, interpolated regions can overlap (i.e., pixels can belong to more than one interpolated region)
- Pixels that belong to empty spaces or to overlapped spaces must be assigned to *one* region.
- This is performed by using a simple watershed procedure.
- The image to be flooded is the complement of the image constituted by the interior of $\cup_i R_i$ minus the overlapping regions.

Example 1: human-like mosaic

We have used synthetic images that permit to emphasize some relevant aspects of our method.

Example 2



Conclusions

- We have presented a region-based interpolation method for mosaic images.
- It is based on a previous interpolation technique of ours for binary images.
- There exist some substantial differences between both cases.
  - The matching and interpolation operations are performed level by level of the hierarchical region-based tree that represent the region structure of the image.
  - It is necessary a new final adjustment step for mosaic interpolation.

Thanks!!