IMAGE EDITING TOOLS BASED ON MULTI-SCALE SEGMENTATION

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Abstract. In this paper we propose important improvements to the most common image editing tools (namely the pencil, the magic wand and the lasso) that are implemented in most commercial image editing software. The improvements are based on a multi-scale segmentation approach that relieves the user from the exact definition of contours while obtaining an accurate result.

Key words: Image Editing, Multi-scale Segmentation, Mathematical Morphology, Pencil, Magic Wand, Lasso.

1. Introduction

In the last few years, the use of digital image has been growing worldwide. The reasons are on the one hand the decreasing price of electronics (digital cameras, computers,...) and on the other hand the development of powerful software applications that offer interesting possibilities of image edition. Image editing permits, for instance, to correct some acquisition errors (lighting problems, red-eyes,...), to introduce special effects and to combine different pictures. Professionals take advantage of these features. For instance, advertisers are able to produce more impressive advertisements at lower costs. General public will also use these tools if they have a friendly user interface, if they are simple and effective enough and if their price is reasonable.

The success of digital imaging can be measured in terms of the amount of image manipulation softwares that is available on the market. Today we notice an important expansion of such tools.

In this paper, we review the most common image editing tools included in commercial software. We focus on the tools allowing to select a given object from a generic image. We analyze the strong and weak points of these tools and we propose several improvements based on a multi-scale segmentation.

The rest of the paper is organized as follows: section 2 reviews the existing image editing tools. Section 3 reminds the concepts of multi-scale segmentation and details the technique used in the rest of the paper. Section 4 presents the improvements that the multi-scale segmentation brings to the image editing tools. Finally in section 5 we conclude.

2. Existing tools

In this section we review the most common selection tools implemented in commercial image editing applications.

The simplest way to select a part of an image is based on predefined shapes (rectangle, circle, ellipse,...). Then this selection can be moved, replaced by another pattern, copied and pasted into another image, ... The edition possibilities of such a tool are very restricted.

2.1. Pencil

Another possibility to edit an image is to use a pencil. The idea behind this tool is to consider the mous pointer as a pencil. Its size as well as its shape can be chosen. The user brings the mouse over the zones of the image that must be painted. Zooming the image may be necessary in order to obtain an accurate result, because the user should exactly follow the border of the painted object. This is an edition tool, but if we consider the set of pixels that have been modified as a mask, it can be seen as a selection tool.

2.2. Magic Wand

The magic wand is a tool designed to select objects that are uniform in color. The user clicks inside the object to be selected. The pixel value (or color) is obtained (V) and a range of values centered around V with a tolerance T (V-T, V+T) is selected. The result is the set of connected pixels containing the one clicked by the user and verifying the tolerance criterion. The tolerance is a parameter given by the user. If the selection does not yield the whole object, there are two possibilities:

- to increase the tolerance. The color range selected becomes wider and consequently the selected object is larger.
- to click on the part of the object that is not yet selected. Then the magic wand algorithm is applied to the clicked pixel and the result is added to the previous one. Thus, the object is selected as the union of several color ranges.

The magic wand requires less interaction than the pencil, because the user just clicks inside the object and the contour of the object is produced by the algorithm. Nevertheless, this contour is often inaccurate. Indeed, the object boundary is located in a transition zone between the object and its background. Color changes are expected in this zone that do not fit with the color uniformity hypothesis. Trying to obtain this zone by several clicks is a difficult task because the transition zone may be narrow. On the other hand, increasing the tolerance will lead to uncontrollable leaks before obtaining the whole object. In section 4 we will present a technique that avoids this drawback.

2.3. Lasso

The lasso tool allows the user to draw the contour of a given object. Three different implementations are generally available:

- freehand lasso: The user freely moves the mouse over the image directly determining the selection.
- polygon lasso: it is used to select polygonal objects. The user selects the vertices of the polygon and these vertices are joined by straight lines.
- adaptive lasso: This tool highly differs from one implementation to another. In some implementations the user provides an approximation of the desired contour (freehand generated or by polygons) and the algorithm adapts it to the local gradient near this contour. According to our experience it usually leads to several connected components that do not correspond to the user expectations. This implementation is named "magnetic lasso". Another implementation, named "intelligent scissors" [4], is based in the "live-wire" technique: the user introduces an anchor point of the contour and then moves the mouse. The path of lowest cost between the cursor position and the anchor point is found. When the user clicks again, the cursor becomes a new anchor point and the process is iterated. Thus, the user progressively defines the contour of the object. This tool leads to satisfactory results with reduced user interaction as long as the contour is simple. In section 4 we present an example where neither the magnetic lasso nor the intelligent scissors produce satisfactory results.

3. Multi-scale segmentation

This section describes the multi-scale segmentation used in section 4. It is a technique that establishes a hierarchy among the regions produced by the watershed algorithm [1] [3]. It has been used in the context of interactive image segmentation [6] [2].

This technique produces a family of nested partitions: the finest level contains all the regions of the watershed and the coarsest one considers the whole image as only one region. Going from a finer level to a coarser one, neighboring regions are merged. The order of these mergings is established by the volumic extinction value [5]. This criterion is a combination of the size and contrast of the regions and gives a good estimation of their visual significance.

The hierarchy is obtained during the flooding process of the watershed algorithm. Thus, the complexity of the algorithm is similar to the complexity of the watershed algorithm. However, instead of having a single partition, a family of nested partitions is obtained.

All the information required to produce a given level of the hierarchy from the watershed result is stored in a very condensed data structure: a minimum spanning tree (N nodes and N-1 edges for a partition of N regions). Thus, the manipulation of the hierarchy is very efficient and interactive applications can be addressed.

4. Implemented tools

This section describes the improvements that a multi-scale approach brings to the image editing tools presented in section 2 and included in most image editing commercial softwares.

4.1. Adaptive pencil

The adaptive pencil is an advanced pencil that follows the image contours. Instead of having a predefined shape and size, it relies on the segmentation contours. The user chooses a level of the multi-scale segmentation and then going through a region completely paints /selects it. When changing the segmentation level, smaller or larger regions can be obtained.

Figure 1 illustrates the behavior of the adaptive pencil. First the user selects a partition from the hierarchy (figure 1 (b)). This can be done by means of a sliding bar [6]. This partition determines the characteristics of the pencil. The shape of the pencil depends on its positions and it is adapted to the image contents. Then the user moves the pencil over the object. For each mouse position, the region of the partition containing the mouse is selected. Imagine that the user draws the line superimposed on the original image in figure 1(a). The result produced by the standard pencil is presented in figure 1(c) while the adaptive pencil obtains a much better result (figure 1(d)). In order to obtain a result similar to the one shown in figure 1 (d) with the standard pencil, the user would have had to combine different pencil sizes and the drawn line would have been much more complicated.

4.2. Magic wand based on a multi-scale segmentation

This tool consists of two stages:

- The classical magic wand: a threshold centered around the value of the selected pixel with a given tolerance.
- Extension of the result to the regions of the segmentation in order to avoid the problem of the transition zones seen in section 2

The level of the hierarchy used in the second step can be chosen by the user as in the previous section. However we propose here an automatic selection that simplifies the interaction.

The automatic selection of the hierarchy level is performed in two stages:

- selection of the regions of the fine partition (the lowest level of the hierarchy containing all the regions of the watershed algorithm) that have a non void intersection with the classical magic wand result.
- The set of regions selected in the previous step should be merged, because they are in the color range selected by the user. In order to combine the magic wand with the multi-scale segmentation approach and not only with a partition, the algorithm looks for the lowest level of the hierarchy (L) in which all those regions are merged. The final result is the region of this level (L) that contains the initial pixel selected by the user. In other words, the set of regions of the fine partition selected in the previous step is extended to similar neighboring regions that are merged in the hierarchy until the set of regions is included in only one region.

Figure 2 illustrates the comparison between the classical magic wand and the one proposed in this paper. The goal is to select the apple from the fruits image (fig. 2(a)). Then the user clicks inside the apple. Figure 2(b) shows the

(a) Original image with drawn line

(b) Underlying partition chosen by the user

(c) Standard pencil

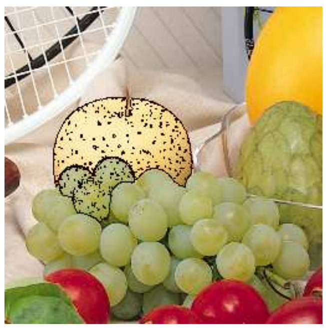
(d) Adaptive Pencil

Fig. 1. Comparison between the standard pencil(c) and the adaptive one (d) relying on the partition (b).

result obtained by the classical implementation of the magic wand. We see that a lot of holes remain in the selection and that the contour is not accurate. Trying to improve the result, the tolerance is increased and the result is shown in figure 2(c). The number of holes has been reduced and the contours have been slightly improved but an important leak occurs and part of the grape has been selected. Figure 2(d) shows the result of the magic wand based on a multi-scale segmentation with the hierarchy level chosen automatically. We can see that the result is much better without any supplementary input by the user.

(a) Original Image

(b) Classical magic wand



(c) Classical magic wand with higher tolerance

(d) Magic wand based on a multi-scale segmentation

Fig. 2. Comparison between the classical magic wand and the one combined with the multi-scale segmentation.

4.3. Lasso based on a multi-scale segmentation

In section 2 we have presented two different implementations of the adaptive lasso: "magnetic lasso" and "intelligent scissors". In this section we propose a lasso based on a multi-scale segmentation and we compare their results. We suppose that the user provides an approximation of the contour. The real contour is supposed to be inside the approximated one.

The lasso based on a multi-scale segmentation consists of two steps:

– Finding in the different levels of the hierarchy, the largest regions completely included in the contour.
– If one of these regions covers a given percentage of the surface inside the drawn contour, it is selected as the result. If it is not the case, the inner regions are merged in the order indicated by the hierarchy until the surface criterion is verified.

Figure 3 illustrates the comparison between the so named magnetic lasso and the one that we present in this paper. Figure 3(a) shows the approximated contour provided by the user. Figure 3(b) shows the result of the magnetic lasso where a leak appears at the top of the sunflower and another one on the left hand. Also a second connected component is present on the right. In figure 3(c) the result of the lasso based on a multi-scale segmentation is presented. We can see that these leaks have been avoided and that a single connected component is obtained.

(a) Drawn contour (b) Magnetic lasso (c) Lasso based on a multi-scale segmentation

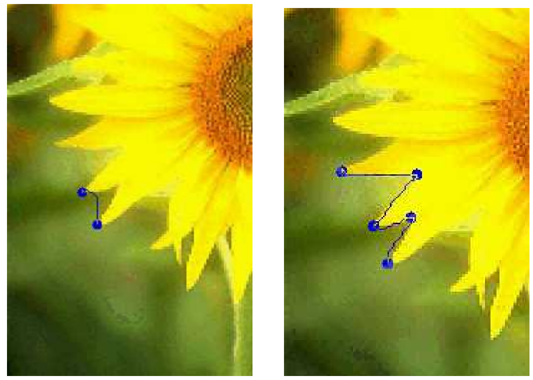
Fig. 3. (a) Drawn approximated contour. (b)(c) Comparison between the standard lasso (b) and the one based on a multi-scale segmentation approach (c).

The extraction of the sunflower with the intelligent scissors would require a lot of interaction. If the user clicks "only" on the petal extremities (which is already quite a lot of work) the result is not satisfactory (figure 4(a)). Clicking on the petal extremities and junctions (figure 4(b)) the result is satisfactory but the user intervention is too intensive. The lasso implementation that we propose produces a single connected component and is flexible enough to be adapted to any kind of shape.

5. Conclusion

This paper presents three of the most common image editing tools available in the market: the pencil, the magic wand and the lasso. The existing tools present the following drawbacks:

- the pencil requires a precise user input in order to produce an accurate contour.
- the magic wand produces inaccurate contours due to the fact that the color homogeneity hypothesis is not verified in the transition zones, where the contours are located
- the different implementations of the adaptive lasso either require a lot of interaction for complicated shapes or generate several connected compo-



(a) Click on petal extremities

(b) Click on petal extremities and junctions

Fig. 4. Intelligent scissors.

nents where only one is expected.

We propose a new version of these tools based on a multi-scale segmentation approach. Instead of working at a pixel level we work at a region level. Furthermore, dealing with a multi-scale approach, the size of these regions can be chosen according to the desired selected object. We also propose an automatic selection of the resolution level simplifying the user interaction.

The proposed tools are much more powerful than the existing ones. They relieve the user from the exact definition of contours while obtaining an accurate result.

Moreover, the tools presented in this paper can be extended to 3D images or sequences using the results of [7].

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