Interactive Image Segmentation System for Visual Simulation

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Abstract

To use photographs in visual simulation such as synthesizing new images by overlapping an object in an image onto the other, physically significant regions corresponding to objects have to be segmented. Although a lot of researches have been done on fully automatic image segmentation technique, they are not always successful when the object to be segmented is complicated. As we have to segment various kinds of objects in performing visual simulation, it is not suitable to use fully automatic image segmentation techniques. We should instead develop a series of interactive segmentation tools that can speed the segmentation processes which are very laborious if all of them are performed manually pixel by pixel. Based on these ideas, we developed an interactive image segmentation system consists of three segmentation tools. One of the characteristic of this system is the segmentation tool that use edge information selectively in accordance with the pointing specifications by the human operators, which is described in detail.

1 Introduction

Recently, simulated images such as color change simulation images and collaged images have been used in many field[1][2], not only in business applications such as the architectural design simulation, but also in special effect frames in motion pictures.

To such cases, physically significant regions corresponding to objects have to be segmented before the simulation[3][4][5][6] (**Fig. 1**). Fully automatic image segmentation techniques cannot be applied to these segmentation processes when the object to be segmented is complicated. As we
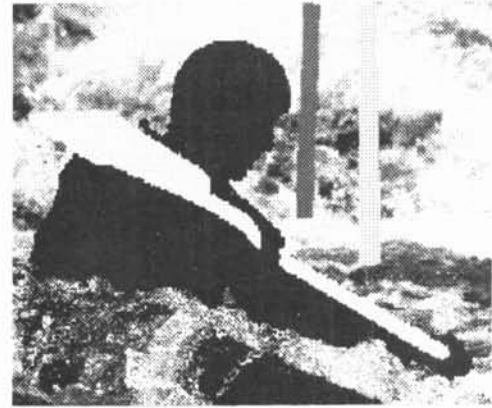
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Fig.1 An example of multi-leveled masks. A man, an oar, and two poles are sengemted in this image.

have to segment various kinds of objects in performing visual simulation, we have been developing a series of interactive segmentation tools that can speed the segmentation processes which are very laborious if all of them are performed manually pixel by pixel.

We developed an interactive image segmentation system consists of three segmentation tools and other tools of related functions. One of the characteristic of this system is the segmentation tool using edge information, which is described in detail.

2 General construction of the interactive image segmentation system

Our system consists of a series of tools (**Fig. 2**). Images and segmented masks are treated separately. Three segmentation tools cut out single-leveled mask regions that are logically manipulated and integrated into multi-leveled masks (**Fig. 1**) by the logical manipulation tool. In addition to them, image synthesis on trial can be performed to check the quality of the segmented masks.

The segmentation tool using the edge information is characteristic of this system and is described in the following section.

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                    ┌─────────────────────────────┐
                    │    color segmentation       │
                    ├─────────────────────────────┤
                    │    edge segmentation        │
                    ├─────────────────────────────┤
┌──────────────────┐│   manual segmentation       │
│ interactive image│├─────────────────────────────┤
│segmentation system││ logical mask manipulation  │
└──────────────────┘├─────────────────────────────┤
                    │  image synthesis on trial   │
                    ├─────────────────────────────┤
                    │    image input/output       │
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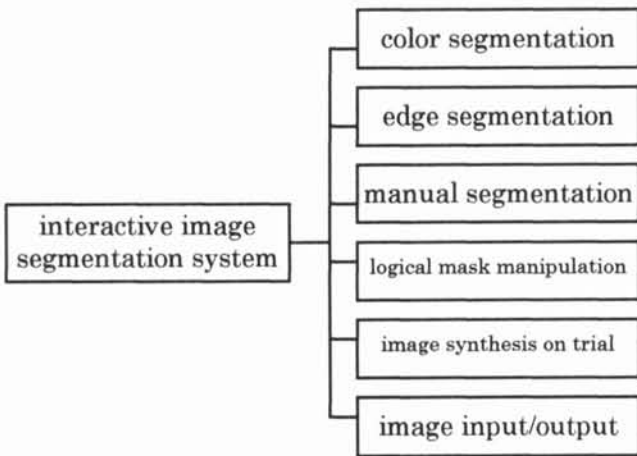
Fig. 2 Construction of the interactive image segmentation system

The color segmentation tool is suitable to segment uniform color regions [3]. By specifying a
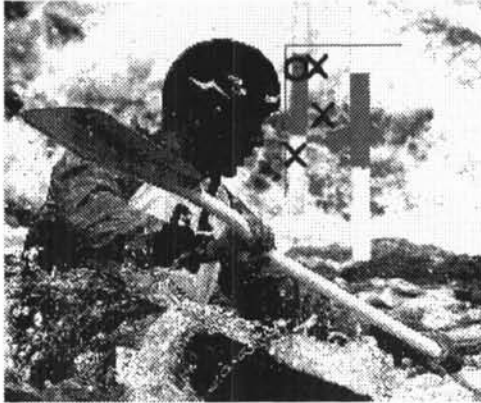

Fig. 3a The first result of the color segmentation with one representative point and three reference points.
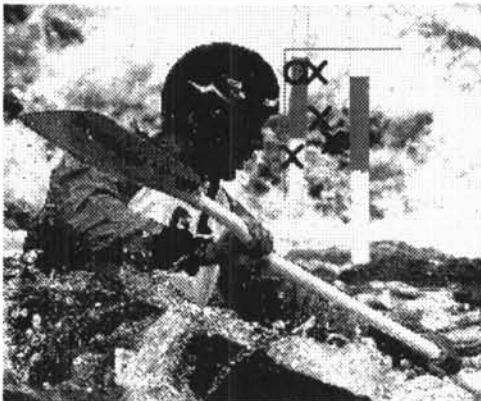

Fig. 3b An improved result of the segmentation after one reference point is added.

few points on the object region with a mouse as representative points, and specifying a few points outside the object region as reference points, we can decide the rough color distribution of the pixels in the object region. We can discriminate the region pixel by pixel according to this color distribution (Fig. 3a). It is possible to improve the segmented results by specifying new points (Fig. 3b). Let us consider a region $\Omega(i,j)$, such that each of pixels in the region is closer to the representative point i than to the reference point j in color space. Then, the discriminated result in this algorithm can be written as follows, where $\cup_i$ and $\cap_j$ denote logical summation and product respectively.

$$\cup_i \cap_j \Omega(i,j) \qquad (1)$$

Next tool is a manual segmentation and correction tool which has various functions, such as polygon fill, brushes ,erasers, dilation, erosion, and linking detection, etc. This manual segmentation tool is indispensable because the shapes of the objects segmented by semi-automatic tools are not always complete, though they can speed the segmentation processes.

3 The interactive segmentation tool based on detection and search for edges of selective orientation

Although color segmentation tool described in the previous section can cut out uniform color regions efficiently, they cannot be applied to the objects that consists of several color regions, and they cannot work well when the background contains the same color as the object has, too.

Generally speaking, most of the segmentation tools using edge information have difficulties such that too many edge segments may be detected, or the detected contours may have too many discontinuities. SNAKE [7] is an active contour model that can overcome these difficulties to some extent, but cannot choose the proper edge segment when there are several good candidates of edges.

To avoid these difficulties, we thought it better to develop an interactive segmentation tool that use edge information selectively in accordance with the pointing specifications by the human operators.

The basic process of the segmentation by this tool is as follows.

(1) The operator specifies the first point on

Fig. 4a The contour between the first and the second specified points is extracted.

Fig. 4b The next contour is extracted.

Fig. 4c The final result of the extracted contour.

the contour he wants to extract (At the top of the head in Fig. 4a).

(2) The operator makes a rough specification of the next point around the contour (represented by X in Fig. 4a). It is 100 - 200 pixels apart from the last point, typically.

(3) The contour between these two specified points are extracted automatically (Fig. 4a).

(4) At this point he can either (a) specify the next point, (b) undo the specification he has just made, (c) change the mode between the automatic and the manual. The automatic mode is described in (3), and it simply draw a line segment between the two specified points in the manual mode.

(5) Repeat (2), (3), and (4) (Fig. 4b) and the segmentation process ends when the contour cross itself and makes a closed line (Fig. 4c).

The third step of the above process is the essence of this tool. Our basic idea is that the contour is probable to lie in the direction that connects the two specified points. According to this direction, one of the edge detection operators that is sensitive to the edges of that direction is selected from a list of convolution operators (Fig. 5). In this example, each operator takes in charge of each 45 degree. Then this program searches the contour from the former point to the direction of the next specified point by using the selected edge detection operator. This selection reduces unnecessary edge

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+ + +        o + +        - o +
o o o        - o +        - o +
- - -        - - o        - o +


- - o        - - -        o - -
- o +        o o o        + o -
o + +        + + +        + + o


+ o -        + + o        + :  1
+ o -        + o -        - : -1
+ o -        o - -
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Fig. 5 An example of a set of edge detection operators.

segments around the contour.

As we mentioned in section 2, single-leveled mask regions are logically manipulated into the multi-leveled mask (Fig. 6). One of the example of
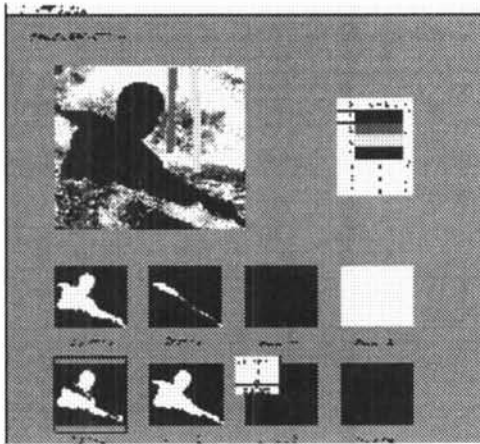
Fig. 6   Logical mask manipulation.

the multi-leveled mask has already shown in Fig. 1.

4 Discussions

Although one of the most important goal of studying computer vision is to understand the human sight, and most of the important applications of the image processing are fully automatic systems such as inspection systems in the factory lines, we believe, however, that it became important to apply image processing technique to enhance human activities in interactive systems.

We designed our segmentation system under the concept that it can extract exact contours or regions in accordance with rough position specifications by the human operator. We specify rough positions in the segmentation tool based on edge information, and specifies colors of the object by clicking on the image when we use the color-segmentation tool.

We learned that responses in its manipulation are very important in interactive systems, too. Our treatment in the edge-segmentation tool, for example, is so simple that we have to wait almost no time to get the segmented contour after every clicking on personal computers.

Another lesson we learned is the importance of adjustabilities in interactive systems. The extracted contour varies with the relative direction and distance of the newly specified point to the point that is specified immediately before in the step (3) of the section 3.

We believe that it is an indispensable basis for constructing visual simulation and other advanced multimedia applications to develop useful interactive tools using image processing techniques as is discussed in this paper.

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