Abstract:
Techniques of the Object Movies (OMs) have been widely applied to various areas. At the same time, many interactive image segmentation techniques of object movie are developed for removing backgrounds of hundreds of images. However, there are still no user interfaces for background removal of object movies which can help user to step in for the modification of large amount of images. In this paper, we propose a user friendly software for removing background of object movies. We bridge the computer and user intervention by three stages: initialization, correction/verification, and update. Furthermore, to speed up the process of removing backgrounds, a “boundary auto-viewing” function is combined with image modification which helps the user to easily determine the boundaries of the images. It is found that by using this software, users can save enormously 95% of time. This is the first software for object movie background removal with auxiliary 3D model reconstruction semi-automatically.

Keywords:
Object movies; image segmentation; background removal; software; user intervention;

1. Introduction
Image-based techniques for modeling and rendering high-quality and photo-realistic 3D objects have become a popular topic of research lately. Having the advantage of being photo-realistic rendering, object movie is especially suitable for delicate artifacts and thus has been widely applied to many areas, for example, E-Commerce, digital archive, and digital museum [3]. An object movie (OM) is a set of 2D images taken from many different viewpoints of a 3D object. This technique was first proposed in Apple QuickTime VR [2]. When captured, each image is associated with distinctive pan and tilt angles of the viewing direction.

Recently, an OM can be acquired in less than one hour by automatic shooting equipment. However, OM segmentation would take more than 30 man-hours by segmenting the images manually because there are generally hundreds of images in an OM. Therefore, if the usability of the designed method is not carefully evaluated, even a patient expert would be tired of the tedious segmentation tasks.

Ko et al. [1] had made an improvement on helping the user obtain a quality OM segmentation result. Using the OM including camera parameters calibrated for each view, the method starts from the automatic initial segmentation. After selecting a subset of acceptably segmented images, the 3D model reconstruction from these selected images is followed.

Many interactive segmentation algorithms like Ko’s brought in user intervention to make up the deficiency of computer’s result and to reach their goal. Even so, if the process of user intervention is not suitable, it would still be time-consuming. A well-designed user interface is needed no matter how well the method is. Due to the lack of specific integration for interactive image segmentation especially for OMs, we propose a software for background removal of OMs.

The overview and procedures of software is introduced in Section 2. The details of each stage are described in Section 3. In Section 4, the experimental results are discussed, while conclusions follow in Section 5.

2. The Overview of Software
Interactive image segmentations based on graph cuts have been extensively studied [5, 8, 9]. A user manually gives some foreground and background hard constraints, the rest of the images will be automatically classified into foreground or background. These approaches are often quite successful for single image segmentation, but fail in OM segmentation because of the tedious task of manually refining hard constraints on all images of the OM. The most intuitive method to mitigate this difficulty is to propagate the user interventions or segmentation results from some
representative images to other images [5, 6, 10]. For OMs, the problem of 3D reconstruction and background separation are combined in [7].

Figure 1. The flow of our procedures.

Based on Ko’s method, our software has three Stages: Initialization, Correction/Verification, and Update. Normally, a set of OMs is acquired by using a motorized object rig, AutoQTVR, developed by Texnai Inc. Then, a method in [4] is needed for calibration. This is essential for our software, but can be performed automatically in advance. In Initialization, we apply automatic initial segmentation on these OMs to produce the first result of background removed images. During the Correction/Verification, user can view all the images with all kinds of display, and edit images that have undesirable segmentations. By a quick modification and selection of the qualified images, a 3D model can be reconstructed by these images, and feed back to generating a new result of removed background of OMs in Update stage. After a few iterations, both the segmentation and 3D reconstruction of the object would be robust. The flow of the software is illustrated in Figure 1.

The advantage of this software is that it can help the user view, store the status, and fix large amount of images any time. Users will not have to execute programs separately.

3. Procedure for Background Removal

As said in last section, the framework of the software has three main stages: Initialization, Correction/Verification, and Update. The functionalities of each stage are described as follows.

3.1. Initialization

Once a set of OMs is selected by user, the automatic initial segmentation will be executed. Trimap labeling will be done based on prior knowledge of the OMs. Then the trimap will be passed on to graph cuts image segmentation for background removal of OMs. Here, considering that automatic segmentation could be very challenging, we are not interested in successfully segmenting all the images here; on the other hand, we aim at obtaining a subset of acceptably segmented images only.

The labeling method automatically generates the trimap of each image. A trimap is consisted of \{F, B, U\}, abbreviations of foreground, background, and unknown. The regions with labels F and B correspond to the foreground and background hard constraints respectively. By observing the characteristics of the OM, some regions are labeled F and B, and others remain with label U.

Graph cuts image segmentation requires the trimap of each image. The U regions are segmented automatically by finding the most reasonable silhouette considering with color distribution. The flow of initialization stage is illustrated in Figure 2.

3.2. Correction/Verification

Correction and Verification can change the status of any images. When seeing undesirable image segmentation on an image, user can wait for improvements by running the procedures in Update Stage, or directly edit the image in
Correction Procedure. Those that are qualified can be labeled “qualified” in Verification Procedure. When all the images are corrected or verified, it means that all backgrounds of OMs are finely removed.

This is the main part of our software. It is also the only stage which needs user intervention. To carry out the ability of Correction and Verification, this stage contains helpful functions and windows. In Correction/Verification Stage, the background removed images are easily shown in quick view. Also, many sub-functions can be performed in this stage. User can edit specific image in user editing window, observe the reconstructed model, browse playing object movies in 3D viewpoint window, or head over to the Update Stage for better segmentation.

Each image is labeled as “qualified” or “unknown”. It means the image is segmented successfully if it’s labeled as “qualified”. For the first time in this stage, all images are labeled “unknown”, meaning not knowing if the image is perfectly segmented or not. While verifying specific image, user can decide to make a correction on the image, or directly verify it as a “qualified” image.

In the user editing window, which includes the Correction Procedure, shows the present result of background removal for specific image. Similar to other image showing and editing software, it can zoom in/out and alter any pixels to background/foreground easily by user’s mouse clicking. The snapshot of this procedure is shown in Figure 4.

In respect of different objects with various colors require diverse backgrounds and other details of images to point up the segmentation result, features as follows are for helping user. The main window in this stage is shown in Figure 3, images appearance can be altered variously. The background color and transparency can be easily changed by user. Furthermore, the status of each image is shown with different frame color, and can be changed by clicking on the image. The user can also decide whether to show, and the color of boundaries, which separates the foreground and background for the present result. This helps user to determine how well the segmentation is.

All of these features are arose in respect of different objects with various color require diverse backgrounds and other details of images to point up the segmentation result.

In 3D viewpoint window, the spinning of object is broadcast automatically, but can also be controlled by user by gliding the mouse. This helps the user to knowledge the consistency and correlation of OMs.

3.3. Update

After correcting some images and verifying qualified ones, the user can decide to call for computer’s help in Update Stage. While processing, these images with good segmentation results can influence others.

From qualified images that are labeled “qualified”, reconstruction of the model will be performed according to these images. In Figure 5, it is illustrated how the advanced background removal result is improved. Those images that
are labeled “qualified” build up the reconstructed model. The graph cuts image segmentation is similar to the on in Initialization Stage, but the input trimap here is revised based on the reconstructed model.

Once the Update is done, new background removed images are brought back to Correction/Verification Stage. This cycle combines computer’s and user’s strength. From the concept of complementing each other, user can aid the deficiency that computer made, and computer can save user’s time.

![Figure 5. The flow of Update Stage.](image)

Some arguments should be specified for 3D reconstruction. Figure 6 is the view of setting arguments window.

![Figure 6. The snapshot of setting arguments window.](image)

4. Experimental Results

We compare this tool with traditional method on a 2.4 GHz Pentium 4 desktop with 1GB memory. Each OM is composed of 360 images with image size about 1000 x 900 pixels. The user intervention is controlled by a proficient user on image and photo editing software.

Traditionally, a user has to run Photoshop to take a look at every single image and outline the object boundaries. After longsome and tedious work, for 360 images, it takes more than 30 man-hours by estimate.

On the other hand, it takes about 65 minutes to conquer the task with this tool, including on 45 minutes of user intervention, which user needs to sit in front of the computer. User made some small modification in the edit viewing window for about 40 images in total with running two iterations of Correction/Verification and Update. It is much faster than pure-and-manual OM segmentations on every single image. As a result, it performs the fastest with our software. In addition, testers in this experiment showed high interests and positive feedbacks for the software.

There are three critical reasons for enormous time difference. Foremost, the user can interact with computer and acquire information fluently, the user interface offer clear and handy features. Second, Even if the results of computer’s segmentation are in round figures, it still saves user’s time of segmenting all images. The “auto-viewing boundaries” function also rapidly increases the speed of modification and verification on images.

The results show that the users intend to manipulate on this interface much better than traditional ones. It is obvious that integration for image segmentation of object movies can ease the difficulty of user intervention. Relative demonstration and further information will be found on [http://ippr.csie.ntu.edu.tw/](http://ippr.csie.ntu.edu.tw/).

5. Conclusions

This is the first software for background removal of object movie. With our software, it can largely increase the efficiency which makes the duration from 30 hours down to somewhere around 60 minutes. The interaction between computer and user intervention are integrated smoothly.

The OMs in Initialization of the software require calibrations; therefore, it needs about 20 minutes or more than acquiring un-calibrated OMs which can work in traditional method. But the calibration executes automatically, and this trade-off is of great worth.

We believe that with user-friendly interface and robust core algorithm, our software would be useful to advance the use of OMs.

References


