MotionSPHERE

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1 Introduction

In the near future, digital cameras will be smaller and smarter, and will be more ubiquitous. A camera will be embedded in places where it was considered to be impossible. When embedded in a basketball, people can see the game from the ball's viewpoint. In sports, the ball is spinning, so is the camera. Even if images are captured from inside the ball, the acquired image is vigorously rotating and thus hard to see what is in there. With our technology, rotating and vibrating images can be stabilized so that people can comfortably watch the scene from inside the spinning ball or from trembling vehicle. Also, people can keep watching the player they like. This way, new kinds of visualization, entertainment, and artistic imagery might be possible.

2 Technology

As the digital camera become ubiquitous, a camera system which has multiple cameras to capture a wider field of view will become common. Conventionally, one camera with a special lens or a mirror is used to get an omni-directional image. This solution is simple but the image quality is low. However, a multi-camera system can produce a higher resolution image than a single camera solution. The problem is, the amount of data produced by such multi-camera system is quite huge. Also, if the camera system is subject to vibration or rotation, the output images will make people dizzy. Moreover, because the multi-camera system covers almost the entire field of view, it is hard to find the object the viewer is interested in.

With our technology, we can solve these problems – stabilizing the entire image and tracking objects from the multi-camera system in real time. We use Ladybug – a spherical camera product by Point Grey Research (http://www.ptgrey.com). The Ladybug has 6 cameras, each camera having resolution of 1024 x 768 pixels. All the images are synchronized and digitally captured at 15 frames per second with no compression. Thus, the transfer rate is almost 70Mbytes/s. Our system tries to process this vast amount of data in real time. Also, pixel-wise geometric information can be easily acquired because all the cameras are well calibrated and the lens distortion is compensated in advance. With all the 6 raw images and the geometric information mapped on a sphere, you can obtain a spherical image in real time with the help of high-end graphics board (Figure 1.)

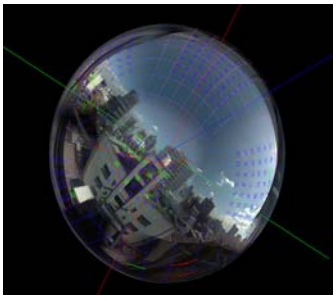

Figure 1: Spherical image captured with Ladybug

For stabilization, we use an optical flow based approach – it is simple, fast and stable. Pattern matching is used to obtain the relative disposition of templates. For robustness, the disposition is calculated for more than one hundred templates on a sphere. Then, using statistical approach, the rotation parameters are estimated. The input images can then be stabilized by rotating backward using the estimated parameters. This process is repeated for every successive frame in real time.
Our experiment shows that estimation works correctly even if the camera is vigorously and randomly shaken by a hand. Also, it works well when the camera is attached on a rotating wheel.

For object tracking, we use a hybrid approach combining background extraction and color extraction. We found background extraction quite effective especially when the field of view is very wide like our sphere camera and the target is assumed to be moving. After the moving area is extracted, color extraction is conducted and the final target is extracted. In our experiment, two balls with different colors moving around the fixed camera are tracked simultaneously in real time. It should also be noted that tracking multiple objects like in this case is impossible with the camera equipped with pan-tilt mechanism.
By combining the above two technologies – stabilization and tracking – it will even be possible to track objects from a moving camera.

3 Application

When an era of ubiquitous digital camera came, new problems will arise; how to handle the huge amount of images from many cameras and how to present the viewer the interesting images. MotionSPHERE will help to solve these problems. Especially, it will give an impressive and exciting view in sports entertainment. (Figure 2, 3) Video surveillance system is a big potential, too. Mixed Reality (MR) researchers will be interested in the MotionSPHERE's capability of handling the 'atmosphere.'

Figure 2: Ladybug attached on a bat

Figure 3: Bat's view