Stabilization of Magnified Videos on a Mobile Device for Visually Impaired

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Abstract

The camera function in smart phones has a great potential to help visually impaired people with discerning scene details. Many apps have been developed to turn a smart phone into a handy video magnifier using digital zoom. As digital zoom normally cannot provide sufficient magnification for distant objects, optical telescopic devices attached to the smart phone cameras can be used to increase magnification power. However, image jitter of hand held phone cameras is greatly enlarged too, and can impair patients' reading efficiency, especially for distant objects. Gyro-sensor based stabilization methods are not effective for this application due to the limited precision of the gyro-sensor in common mobile devices. We have implemented an image motion based video stabilization method on iOS that is more sensitive than the gyro-sensor. The image motion based stabilization not only appeared to be able to remove most of the image jitter visually; it also improved the performance of human subjects, including 2 visually impaired, at discerning distant details.

1. Introduction

Magnification is currently one of the most effective rehabilitative ways to help visually impaired people in discerning details. Modern mobile devices equipped with high resolution camera sensors have a great potential to address such needs. A number of cheap or even free of cost, magnification applications have been developed for smart phones, such as Magnifier [1] and iCanSee [2] that utilize the built in digital zoom feature of the camera. However, the magnification power of smart phone based video magnifiers reduces quickly with object distance because of their limited digital and optical zoom capabilities. Figure 1 demonstrates that while the label close to the phone is magnified on the screen, a toy at a farther distance appears smaller than being viewed directly. For a magnifier to be useful, the images must be larger than directly viewed objects. Normally, digital zooming applications on smart phones are not suitable for reading distant messages and signs, which are frequently needed in way finding for the visually impaired.

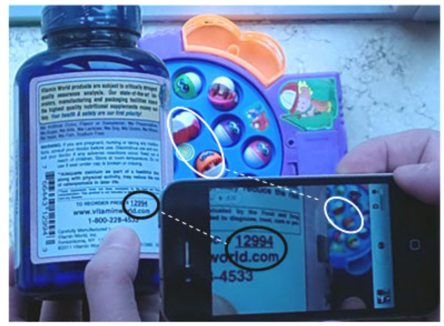

Figure 1: When an iPhone is used as a magnifier, objects at a short distance from the camera, such as the label of the bottle, can appear larger on the screen (compare text "12994" on the bottle and on the screen). Under the same zoom level, however, objects at a far distance may appear smaller on the screen than viewed directly (compare the toy indicated by white ovals).

In order to magnify objects in distance, a telescope can be attached to the phone camera. The optical telescope can provide sharper magnification than digital zooming. While images are magnified at a very high level using optical and digital zooming, image jitter due to hand shaking is enlarged too. The problem of handshaking is further compounded by the reduction in the field of view that is brought along by the magnification. The target may frequently slip out of the display, even with slight camera shaking. In order to fully utilize the magnification, effective real-time image stabilization is needed.

The built-in motion sensors in the smart phones have been used for stabilizing the videos [3, 4]. However, we found that the sensor based approach cannot accurately stabilize live magnified videos due to the limited precision of the motion sensors in common smart phones.

An alternative approach for live video stabilization is by computing motion in the acquired images. Although it is computationally expensive, stabilized video can be guaranteed regardless of the magnification level. We implement an image based approach for real-time stabilization of magnified videos on an iPhone 4S, and show that it is superior to gyro-sensor based approach in dealing with small hand shaking.

2. Method

The idea of image motion based video stabilization is straightforward: estimating the motion between the acquired frames and a reference frame, computing the cumulative shift, and shifting the acquired images accordingly. Motion estimation in the acquired images is performed by detecting and tracking sparse feature points using the OpenCV library modified for mobile platforms [5]. The average motion vector of all the tracked points gives the amount of shift that needs to be applied to the current frame to display stabilized output. The display screen size is fixed at 480x320. We acquire images at the resolution of 480x360 using the content centered mode, where the central 480x320 pixel part of the acquired image is displayed on the screen (same as the screen size). Out of this selected part of the acquired image, feature detection and tracking is done in a user selected window of 80x64 pixels. The algorithm works at a rate of 15 frames per second.

3. Experimental Results

We implemented a gyro-sensor based image stabilization application, but it was not effective visually in stabilizing the magnified video. This was also verified quantitatively. The iPhone attached to the telescope (see Figure 2) was focused on a known pattern about 10 feet away and 100 frames of the sequence along with the gyroscope data were recorded. The pattern on the recorded images was tracked (offline, on a PC) to obtain its actual movements in pixels (ground truth). In the case of small hand shaking, the RMS errors with respect to the ground truth for image motion based stabilization were found to be 34% and 80% as compared to gyro based stabilization for x and y compensation, respectively.

To evaluate the usefulness of image motion based stabilization method, we tested 8 human subjects (2 visually impaired with visual acuity of 20/125 and 20/200) in a character reading experiment. Subjects' task was to read 3 letters flashed for 0.5 second on a LCD monitor (located at a distance of about 8 to 12 feet) through the iPhone screen they hold in hands. The use of multiple letters in each trial and a short presentation is to simulate sign reading tasks in the real world, where one needs to read one or more words quickly. Each subject was tested in two conditions with stabilization function switched on and off. The condition order was randomized across subjects. Twenty trials were tested in each condition.

The angular letter size was adjusted by changing viewing distance for each subject such that they had some difficulty seeing the letters on the iPhone screen. For normally sighted subjects, the letter size ranged from

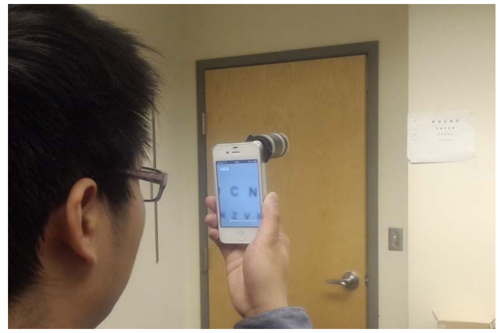

Figure 2: The stabilization app running on an iPhone 4S with an 6x optical telescope attached. The distant text on the wall is magnified and stabilized for ease of reading.

20/18 to 20/26, while for visually impaired subjects, it was 20/35 and 20/44, respectively. Since their visual acuities were 20/125 and worse, they could not see the letters at all if viewing directly. Reading performance was quantified by the percentage of letter correctly recognized. Table I lists experimental results for all subjects. On average, video stabilization improved reading accuracy from 56.7% to 67.9% with statistical significance (paired t-test, p=0.007). The relative improvement was about 20%. Video stabilization particularly helped the visually impaired subjects improve the letter recognition performance as seen from the data.

Table I: Details of the character recognition experiment for evaluation of video stabilization approach.

	Visual acuity	Age	Gender	Letter size	unstabilized accuracy (%)	stabilized accuracy (%)
Subject 1	20/200	29	f	20/35	35.0	56.7
Subject 2	20/125	49	m	20/44	11.7	30.0
Subject 3	20/20	37	m	20/26	66.7	78.3
Subject 4	20/20	31	m	20/18	68.3	70.0
Subject 5	20/20	--	f	20/18	45.0	45.0
Subject 6	20/20	45	m	20/19	65.0	83.3
Subject 7	20/20	34	m	20/19	83.3	86.7
Subject 8	20/20	32	m	20/18	78.3	93.3

References

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