A Wearable Handwriting System for Time-Warping Collocation

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Abstract
This paper presents our new wearable handwriting input system that tracks user's index finger in the air and the finger loci are stored to the user location as handwriting and the handwritings can be shared by users as virtual scribbles and/or messages in the air. Our proposed method detects the finger locus to the location by descending the user's head motion from finger tracking reading. Their head posture is calculated in semi real time by integrating the image processing from the head-worn camera images into acceleration/gyro sensor readings equipped with the head-mounted display.

Author Keywords
Wearable Interface, Handwriting, Finger Tracking, Memory Augmentation

ACM Classification Keywords
H.5.1. Artificial, augmented, and virtual reality

Introduction
This paper presents our new wearable handwriting input system that tracks user's index finger in the air and the finger loci are saved to the user location as handwriting and the handwritings can be shared by users as virtual scribbles and/or messages in the air. In other words, the system employs their index-fingertip

Figure 1: System image.

as a stylus on a virtual canvas in the air and they can leave their drawings and/or handwriting messages at the location they are as shown in Figure 1. When we visit a tourist site, wall scribbles often come into view (see Figure 2 left). Many people do wall scribbling because it is not only unsocial but catching activity. Virtual wall scribbling in shared AR space would be the breakthrough for solving the problem.

Figure 2: Wall besides the Julliet's House in Verona is filled with scribbles (left). Message board settled in a Japanese train station (right).

The proposed system also provides the function of "time-warping messaging" like a message board in a train station, i.e., the user can leave handwriting messages for someone visiting the location in future (see Figure 2 right).

Research Background

One of the authors has conducted research on wearable interfaces which employ head-mounted camera(s) for memory augmentation [5]. Using a memory augmentation system in general, 1) the user's viewpoint images are always observed, 2) images along with other worn-sensor readings are analyzed to detect the current context, 3) the images are stored with the context information as their augmented memories, and 4) they can recall their experiences by viewing the video retrieved from the augmented memories.

Residual Memory [2] is a kind of "location"-based memory augmentation system which retrieves the user's memory (viewpoint video) observed and stored in the past at the location they are by regarding image similarity of the scenes as same location. The Residual Memory employs a high speed image matching algorithm, HySIM [3], for the above video retrieval. In this system, each memory element is virtually tied to the location where it is recorded, i.e., it can be regarded as if it is stored there.

"I'm Here!" [7] is the object-based memory augmentation system that identifies the object held by the user. It shows them the last recorded video containing the target object given by them. They can remember where they placed it by viewing the video. A camera device "ObjectCam2" [6, 8] was developed for easy identification of handheld objects. It is a kind of active IR camera with an IR LED array in its front and is equipped with the CMOS image sensor whose frame rate is 90fps. It controls blinking in the IR LED array synchronously to the image capture, and generates both the IR reflection image and the color image of the scene at 30fps.

Ubiquitous Memories [4] is another object-based memory augmentation system that ties each memory element to real world object(s), i.e., it can be regarded as if it is stored in the object(s). In the prototype implementation of the Ubiquitous Memories, the user wears a RFID tag reader to their wrist and a RFID tag is attached to each object. The user can store/retrieve their experience to/from an object by touching their RFID reader to the tag attached to it. In the Ubiquitous Memories, real world objects can be regarded as media for memory storage/sharing/exchange.

Figure 3: Hardware configuration and user operation.

AR Handwriting System

In the proposed AR handwriting system location is regarded as media for storing/sharing handwriting scribbles/characters. Coming to a location each user would be able to view not only their scribbles they drew there but other users' ones as if they were wall-scribbles in the real world. As shown in Figure 3, the user wears an Oculus Rift DK2 head mount display and a USB camera on their face.

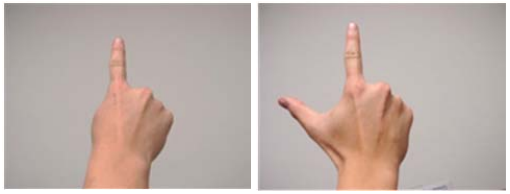

Figure 4: Hand gestures for deciding the status of the "stylus". Left gesture is "OFF" and right is "ON".

For fast and precise tracking of user intended finger loci the system should track their head posture in real time. It combines acceleration/gyro sensor readings equipped in the HMD with SURF [1] feature point tracking among frame images captured by the camera for this purpose in the following process:

1. When the difference of the current head posture from that of the precedent frame is small enough or larger than the threshold (approx. 76deg), i.e., head motion is slow or fast, the system calculates their head posture only by consulting acceleration/gyro sensor readings.
2. Otherwise the system performs feature point correspondence matching between adjacent frame images by limiting the matching area assumed from the sensor readings.

The user's index fingertip is tracked by 1) detecting hand region by extracting skin colored pixels, and 2) searching the farthest pixel in the region to the center of the gravity of the region.

For using the user's index finger as stylus, the system should distinguish whether the stylus is on or off the virtual canvas. The thumb is employed for the purpose. As shown in Figure 4 left, if only the index finger is up the stylus is regarded as off. If the thumb is additionally up (Figure 4 right), their index finger loci corrected with their head posture difference are recorded as a scribble.

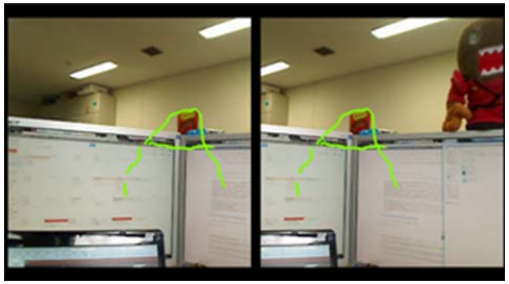

Figure 5: Reconstructed handwriting input in the air.

Figure 6: Reconstructed input from different viewpoint.

Figure 5 shows the reconstructed scribbles that are associated in the air of the location and Figure 6 shows the same scribbles from different viewpoint.

Concluding Remarks

This paper presented the wearable handwriting input system that tracks user's index finger in the air and the finger loci are stored to the user location as handwriting. The handwritings can be shared within system users as virtual scribbles and/or messages in the air, and such function enables time-warping collocation that would bring us a new collaboration.

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