Augmenting a pH Medical Study with Wearable Video for Treatment of GERD

Thad Starner and Daniel Ashbrook
College of Computing
Georgia Institute of Technology
Atlanta, GA 30332
{thad,anjiro}@cc.gatech.edu

Abstract

In this paper we present an augmentation to the wearable computers typically used to determine if a patient is a candidate for surgery to correct problems associated with Gastroesophageal Reflux Disease (GERD). A wearable camera was used by the first author while participating in a 24–hour stomach acid pH study. After the study's conclusion, an examination of the captured video and pH record revealed some results that allowed the first author to avoid many of the activities that result in symptoms related to GERD.

1 GERD and Medical Testing

Gastroesophageal Reflux Disease is a medical condition that affects 2% of the adult population of the United States. GERD refers to the reflux of stomach acid into the esophagus and can lead to complications such as esophageal cancer and lung damage. The most common symptom of GERD is heartburn. Typical treatments for GERD include diet modification and medication; however, for some patients these treatments may prove ineffective, and the patient may be evaluated for more drastic measures such as surgery.

If surgery to correct GERD is considered an option, the patient usually undergoes a 24– or 48–hour pH study to measure the percentage of time that the patient is in reflux during normal daily activities. In the 24–hour study, a pH probe is inserted into the subject's nose and lowered through the esophagus to a position above the stomach. Since the probe is attached to a line that is retained in the patient's nose and throat, several pH sensors can be placed at varying locations along the patient's esophagus. The probe is attached to a wearable computer which records the patient's pH levels for 24 hours. The patient typically uses the wearable computer to record times of meals, periods spent in a supine position (e.g. sleeping), and occurrences of symptoms.

The first author suffered from severe and relatively uncommon symptoms of GERD in 1999. Symptoms persisted for eight months and included uncontrolled vomiting, sudden and severe weight loss, hoarseness, coughing, diarrhea, and anxiety after waking. Symptoms disappeared after corrective surgery in 2000, but resumed in 2003 in the form of uncontrolled retching. After a change in diet and treatment for a bacterial stomach infection, the symptoms again disappeared, and a pH study showed a low rate of reflux.

Figure 1. *Medtronic pH monitor and CharmIT Pro wearable computer with video camera.*

In 2004, the author's symptoms appeared again to a lesser degree. A 24–hour pH study was performed. Two pH sensors were placed in the esophagus and readings were recorded by a Medtronic Function Diagnostics Polygram 98 (version 2.01) wearable computer. In addition, the subject wore a small camera mounted on his chest, facing forward. The subject attempted to work and perform normal activities as much as possible during the study.

The wearable camera, a Logitech QuickCam Pro 4000 (removed from its housing) was equipped with a wide–angle lens, and 160x120 images were captured and timestamped by the patient's CharmIT Pro wearable computer once per second. With JPEG compression, 160MB is required to store the 86,400 images captured during the 24–

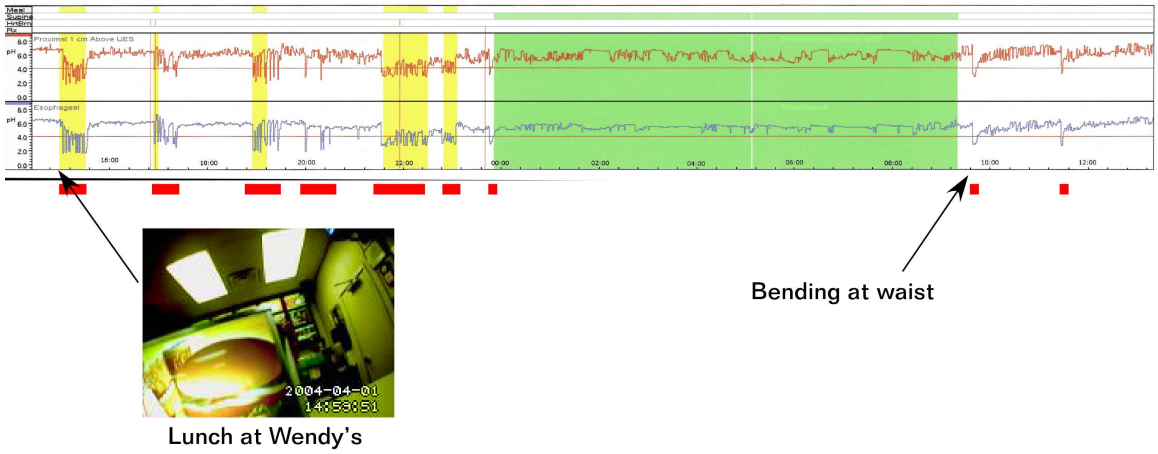

Figure 2. *Recorded pH levels in two locations in the esophagus. Values below 4 (horizontal midline) are considered reflux episodes. Light shaded regions (yellow) indicate meals and dark shaded regions (green) indicate sleeping. The red boxes below the timeline draw attention to reflux episodes.*

hour study. Figure 1 shows an image of the apparatus. The data from the Medtronics and CharmIT computers were synchronized after the study by subtracting the differences between the systems' clocks. Figure 2 shows traces from both pH sensors during the study, and a sample image captured by the wearable camera during a reflux episode.

2 Results

The results of the study were surprising. While the subject was in reflux 4.3% of the time, almost all of this occurred when he was in the upright position (7.3% of the upright time). Reflux often occurs while sleeping, and the subject was sleeping sitting upright to avoid the problem. However, the pH study indicated that backflow of stomach acid into the esophagus did not occur even when the patient slept horizontally. Even so, the total percentage of reflux while using acid stopping medication was abnormal and indicated that repeat surgery was appropriate. However, repeat surgeries of this type have a reduced success rate and may lead to complications.

Examining the images captured during reflux episodes revealed useful correlations and helped the patient make an informed choice against the surgery. For example, reflux occurred during every episode of eating. While the Medtronic wearable computer has an interface for the user to indicate meals, the image record may be more accurate as the subject may forget to indicate his meals and snacks. In addition, the video revealed that reflux occurred during episodes of physical activity, especially when the subject bent at the waist. This correlation would not have been observed by either of the two current pH study methods without video augmentation.

Given this data and a subsequent consultation with his physician, the subject opted for a course of medication and behavior modification where he avoids putting mechanical stress on his stomach (such as when bending at the waist) and is careful during meals. The subject is otherwise living a normal life and has returned to his usual diet. Symptoms have gone into remission, and surgery has been averted.

3 Future Work

Wearable image capture provided significant information during the pH study and allowed the subject to make a more informed choice about surgery. However, the system could be improved significantly. Given the resolution and image capture frequency needed, the same functionality could be obtained from a combination of a small camera and flash disk. Such a design could be pinned onto the subject's clothes in the form of a broach, making the system practical for many more pH study patients.

Privacy of the subject's colleagues remains a concern. However, Clarkson showed that a hyper–fisheye lens could be added to a wearable camera that caused individual faces to be unrecognizable in the image due to lack of resolution and detail [1], while still allowing the wearer to recognize the recorded video. A similar design could be used in conjunction with the pH study to preserve the privacy of the subject's colleagues while still allowing the subject to reconstruct his activities during reflux episodes.

Acknowledgements

Many thinks to Dr. Patrick Waring and his team at Digestive Healthcare of Georgia, Inc. for their good humor during this technology exploration.

References

[1] B. Clarkson and A. Pentland. Unsupervised clustering of ambulatory audio and video. In *ICASSP*, 1999.