A Gesture-based Tool for Sterile Browsing of Radiology Images

Abstract

The use of doctor-computer interaction devices in the operation room (OR) requires new modalities that support medical imaging manipulation while allowing doctors' hands to remain sterile, supporting their focus of attention, and providing fast response times. This paper presents "*Gestix*," a vision-based hand gesture capture and recognition system that interprets in real-time the user's gestures for navigation and manipulation of images in an electronic medical record (EMR) database. Navigation and other gestures are translated to commands based on their temporal trajectories, through video capture. "*Gestix*" was tested during a brain biopsy procedure. In the in vivo experiment, this interface prevented the surgeon's focus shift and change of location while achieving a rapid intuitive reaction and easy interaction. Data from two usability tests provide insights and implications regarding human-computer interaction based on nonverbal conversational modalities.

Introduction

Computer information technology is increasingly penetrating into the hospital domain. A major challenge involved in this process is to provide doctors with efficient, intuitive, accurate and safe means of

interaction without affecting the quality of their work. Keyboards and pointing devices, such as a mouse, are today's principal method of human—computer interaction. However, the use of computer keyboards and mice by doctors and nurses in intensive care units (ICUs) is a common method for spreading infections.[1] In this paper, we suggest the use of hand gestures as an alternative to existing interface techniques, offering the major advantage of sterility. Even though voice control also provides sterility, the noise level in the operating room (OR) deems it problematic.

The operation of the gesture interface was tested at the Washington Hospital Center in Washington, DC. Two operations were observed in the hospital's neurosurgery department and insights regarding the suitability of a hand gesture system was obtained. To our knowledge, this is the first time that a hand gesture recognition system was successfully implemented in an “in vivo” neurosurgical biopsy. A sterile human—machine interface is of supreme importance because it is the means by which the surgeon controls medical information avoiding contamination of the patient, the OR and the surgeon.

Medical Gesture Interfaces

By the early 1990's scientists, surgeons and other experts were beginning to draw together state-of-the-art technologies to develop comprehensive image-guidance systems for surgery, such as the *StealthStation.* [3] This is a free-hand stereo-tactic pointing device, in which a position is converted into its corresponding location in the image space of a high-performance computer monitor. In a setting like the OR, touch screen displays are often used, and must be sealed to

prevent the buildup of contaminants. They should also have smooth surfaces for easy cleaning with common cleaning solutions. These requirements are often overlooked in the busy OR environment.

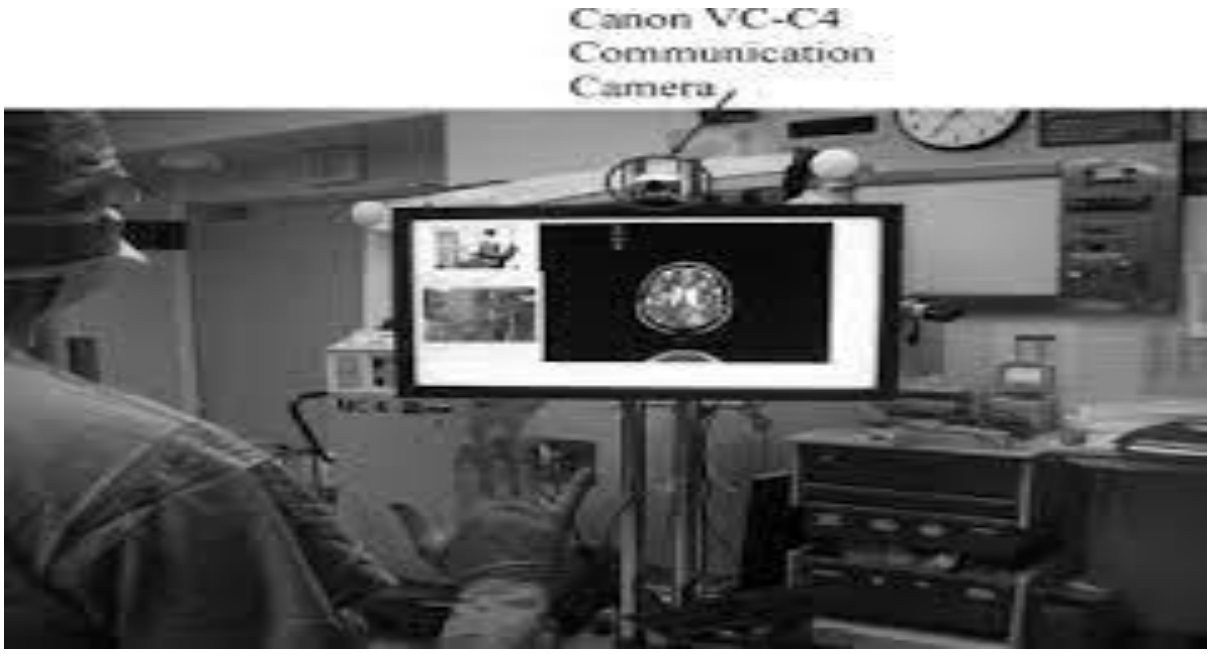
Method

In two brain surgeries at the Neurosurgery OR at the Washington Hospital Center, procedures were observed by the authors to gain insights about the use of current technologies and how they affect the quality of the surgeon's performance. We found that: (a) surgeons kept their focus of attention between the patient and the surgical point of interest on the touch-screen navigation system; (b) a short distance between the surgeon and the patient was maintained during most of the surgery; (c) the surgeon had to move close to the main control wall to discuss and browse through the patient's MRI images.

The hand gesture control system "*Gestix*" developed by the authors helped the doctor to remain in place during the entire operation, without any need to move to the main control wall since all the commands were performed using hand gestures.

Architecture

The sterile gesture interface consists of a Canon VC-C4 camera, whose pan/tilt/zoom can be initially set using an infrared (IR) remote. This camera is placed just over a large flat screen monitor. Additionally, an Intel Pentium IV, (600MHz, OS: Windows XP) with a Matrox Standard II video-capturing.



The Tracking Algorithm:

After a short calibration process, where a probability color model of the doctor's hand is built, images of the surgeon's hand gesturing are acquired by video-camera and each image is back-projected using a color model. The hand is then tracked by an algorithm which segments it from the background using the color model back-projection and motion cues.[7] This is followed by black/white thresholding, and a sequence of opening and closing morphological operations resulting in a set of components (blobs) in the image. The location of the hand is represented by the 2D coordinates of the centroid of the biggest blob in the current image.

Hand Tracking and Operation Modes:

Gesture operations are initiated by a calibration mode in which a skin color model of the user's hand or glove, under local lighting, is constructed. In a browse mode, superimposed over the image of the

camera's scene is a rectangular frame called the “neutral area.” Movements of the hand across its boundary constitute directional browser commands. When a doctor/surgeon wishes to browse the image database, the hand is moved rapidly out of the “neutral area” toward any of four directions, and then back again. When such a movement is detected, the displayed image is moved off the screen and replaced by a neighbor image. To evoke a zoom mode, the open palm of the hand is rotated within the “neutral area” clockwise/counterclockwise (zoom-in/zoom-out). To avoid the tracking of unintentional gestures, the user may enter a “sleep mode” by dropping the hand. To re-arouse the system the user waves the hand in front of the camera. The selection of these gestures was designed to be intuitive, expressing the “natural” feeling of the user. For example, the left/right/up/down gestures evoke the actions used to turn pages in a book left/right, or flip notepad pages up/down. The rotation gesture (zoom-in/zoom-out commands) reminds one of a radio knob to increase or decrease volume. Dropping the hand (stop-tracking command) is associated to the idea of ‘stop-playing', while the waving gesture (“wake-up” command) is associated with ‘greeting a new person

CONCLUSION:

Prior to the initiation of the surgery, the “*Gestix*” system was placed in front of the main surgeon, midway between the patient's bed and the main control wall. The VC-C4 camera was attached over a large flat screen. Before the use of “*Gestix*,” a calibration process is conducted to capture a sample of the gamut of colors of the hand or surgical glove. The setup time for the whole “*Gestix*” system was approximately 20 minutes. Instead of a nurse assistant, the “*Gestix*” system was used for the biopsy planning procedure during the time that the biopsy results were being obtained in the lab.