Using Motion Sensing to Study Human Computer Interaction in Hospital Settings

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ABSTRACT
Tracking someone's behavior patterns, interactions with technology, social interactions, or a combination of these in a medical setting can pose significant challenges. This paper provides an example, from an evaluation of new technology in the hospital setting, of how using motion sensor technology and video capture to provide context, combined with software logs, can meet ethical and practical challenges, and improve the depth and breadth of health informatics evaluation techniques.

Author Keywords
Motion sensing, ethnography, medical informatics, user studies.

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INTRODUCTION
Many technology interventions to improve healthcare safety and efficiency are the subject of research, formal evaluations studies, and impact assessments. This is especially needed for new technologies that can be disruptive and have unintended impacts on workflow and communication [4]. For researchers studying the process of uptake and use of a new technology or researching a new protocol for technology use, observing the workplace and actions of healthcare professionals, and the actions of patients and their caregivers, is the norm. Often this involves ethnographic methods, observation, and shadowing or following participants. Researchers might be aiming to record someone's behavior patterns, interactions with technology, social interactions, or a combination of these.

The nature and structure of medical work, particularly in the hospital setting, can pose a significant barrier to carrying out such research. Often research requires:

- Tracking individuals and/or objects over a wide range of time and space such as across an entire hospital
- Recording events that are infrequent and happen at unpredictable times of the day or night
- Recording frequent discreet events such as using a particular drop down menu.

Relying on human observers to be present and record such events can be impractical, unrealistic, subjective, and may result in very little data that is quantifiable. Using video can provide a persistent record from which to sample, measure, quantify, and code, and can be accessed by multiple members of the research team. It can also be used by participants as a training aid or for process improvement as a product of the research process [7]. Video can provide a record from which measurements can be made, behaviors can be coded, or insights shared. It is a commonly used tool in other settings but presents significant problems in the healthcare environment. Some of the challenges are:

- Medico-legal environment
- Staff attitudes towards capture
- Managing consent

- Managing video data

Researchers who report on their research experiences often document challenges posed by the medico-legal environment of hospitals [3]. Staff may be resistant to having events captured in detail in case a medical error occurs and the captured event is used as evidence in court or for internal investigations.[3] The legal department may be unwilling for errors and near misses to be recorded in case, at a later date, an error is shown to have occurred more than once [3]. There are also the physical challenges of avoiding capturing data on patients, visitors and others in the hospital environment. This is especially important when using video or audio capture that is general and unspecific (field of view is not restricted) in semi-public spaces such as emergency rooms or recovery wards. The issues of how to inform participants, obtain consent, and manage communication with participants can become a barrier to research [8]. We aim to provide an example of how adding motion sensing capabilities to video capture in the hospital setting can overcome some medico-legal challenges and enhance possibilities for more focused, in–depth research.

BACKGROUND

There are an increasing number of examples of successful uses of video analyses in medical settings to analyze behavior, for education, training, quality management, and human factors and ergonomic analyses [3,7]. In this paper we describe the use of motion sensing to support video capture and analysis in an evaluation study of a new technology for blood delivery to operating rooms. The use of motion sensing together with video builds on work by other researchers to develop protocols for the successful use of video in sensitive hospital environments such as operating rooms, intensive care units, and emergency rooms.

STUDY SETTING AND DESCRIPTION

The use of "just-in-time" cross matching of blood for use in operating room settings is advocated as a patient safety practice and should provide greater process efficiency, decreasing the number of both unnecessary cross matches and transfusions [9]. The Neoteric BloodTrack® Self Serve System for remote allocation of blood is an example of a “just-in-time” system and has been installed in the OR suite of three Toronto hospitals. This device is networked to the blood bank laboratory information system and allows for point-of-care cross matching for patients who are eligible for electronic cross matching. The purpose of the research for which motion sensing was used is to evaluate the impact of the Neoteric Blood®Track Self Serve System on blood utilization, blood delivery, work practices and behavior of staff during blood issuing and delivery.

The Neoteric BloodTrack® Self Serve System consists of a database and a PC with a monitor at the blood bank/transfusion lab that is used to identify and track blood units and a remote (at the operating suite) fridge and kiosk. Once blood units have been indentified and tracked in the blood bank/transfusion lab they are loaded into a 9 drawer locked fridge (called a HemoNine) that is situated in the operating suite close to the operating rooms. Alongside the HemoNine is a kiosk with a touch screen and label printer. When blood is needed in an OR an employee approaches the fridge and identifies herself by scanning an ID badge. The software then prompts the employee for information about the patient, looks up the blood type for that patient and unlocks the fridge. The employee can open only 1 drawer and pick out 1 unit of blood (each drawer is for a separate blood type). The employee scans the unit and the software checks the unit type with the patient type. If this information matches correctly, a patient label is printed for the blood unit. The employee then performs a second safety check scan. This process is repeated if another unit of blood is needed.

Research Challenge

The study required analysis of staff using the new system both in the blood bank and in the operating suite. Loading of the remote fridge in the operating area occurs anytime between 5:00 am and 8:00 am after blood bank staff have identified blood requirements. This task can take anywhere from 20 minutes to an hour and occurs approximately once every 5 days. Staff in the operating suite use the remote fridge to obtain blood for patients between 1-20 times per week depending upon the hospital. This task takes an average of 60 seconds, between 9:00 am and 4:00 pm Monday to Friday. Using traditional observational techniques this might require a researcher to be present in the operating suite area for several weeks in order to capture a 1 second interaction with the new system. Considering that the research study required comparison across sites it was calculated that a minimum of 120 days of observations would be required to capture a comparable number of errors between sites. An observational approach without capture of errors would not be useful.

One challenge of providing effective technologies for

Figure 1. Example of video camera position in the operating suite.

medical settings is whether the new technology can meet the requirements of critical events or events in crisis situations that may not occur very frequently and are unpredictable [2]. An example in the context of this study would be an unpredicted big bleed of a patient undergoing emergency surgery at 2 am. Therefore the researchers needed to be able to capture such critical events that might occur outside of the systems typical usage pattern.

Although hospital management was supportive of a study that captures and analyzes errors in using the new system, staff were resistant to video capture particularly of faces. It was also important to avoid capturing patient identifying data such as names and medical numbers as obtaining patient consent for use of this information would be impractical in an operating room setting. In order to overcome these challenges we decided upon using motion sensing to control video capture which also had some advantages for meeting ethical requirements and meeting staff concerns.

VIDEO AND MOTION SENSING SOLUTION

Small fixed cameras (4) were installed to capture interactions continuously over the capture period of 120 days. These cameras were placed to capture paper tools, blood unit scanning, and computer screen interactions on the desk that is used most frequently for issuing to the new fridge. Cameras (4) were also installed in the operating suite area where the HemoNine fridge is in use. These cameras were Lorex CCD color cameras with 3.6mm wide angle lenses. One dome camera was also used with built in audio capture. Cameras were intended to capture meta interaction data such as time taken to issue a unit of blood, placement of blood units on desks, interruptions to the retrieval process, user errors, and number and type of tools required for the issuing process. Care was taken in the installation of the cameras to make sure that faces were not in full view i.e. camera field of view included the new fridge, kiosk, desk, computer and desk. Figure 1 shows a typical setup for the cameras in the operating suite. Cameras were connected to a Lorex security digital recorder device (DVR) with 500 GB hard drives. Lorex DVR included software for motion sensing with a motion detection area of 16 x 12 grids per camera and 4 adjustable variables for motion detection sensitivity.

RESULTS AND DISCUSSION

In the setting where we implemented the motion sensor supported video capture we faced some specific challenges related to the dynamics of the tasks usually encountered in blood bank procedure and operating suite task flows.

Working with Dynamic Tasks and Timeframes

We identified 6 different types of task that would require study. Across these tasks, task frequency ranged from once every 45 minutes to once every 7 days, task durations ranged from 55 seconds to 45 minutes, and tasks did not follow an easy pattern of working hours but could occur at any time of day or night. This is not dissimilar to task dynamics encountered in other hospital settings such as intensive care units or emergency rooms. What these hospital settings have in common is that their tasks share attributes that make traditional task observation methodologies, either using human observation or human triggered video, impractical. Some of these attributes are:

- Unpredictable start times
- Round the clock activity
- Wide ranging task durations and frequency
- Active or moving tasks that occur across work spaces

Motion sensors allowed us to trigger video capture for events whenever they occurred. This allowed us to study all task types. It also allowed us to increase the timeframe for the video capture from 5-7 days of continuous observation to 120 days of discreet task observations. In this way we have been able to capture tasks that are representative of user behavior in the early days after implementation of the new technology, as well as tasks representative of user behavior after the technology has been in place for some time and use of the system has become routine. We were also able to capture critical incidents whenever they occurred e.g. use of the remote fridge for trauma patients who were brought in to surgery during the night, or, for transfusion requests during routine day surgeries when unexpected bleeding occurs.

Ethical and Legal Challenges

Motion sensing is particularly suited to achieve research protocols for video capture. Protocols can be developed to include practices that minimize medico-legal concerns and increase staff comfort with video recording. Some of these include; limiting view angles, restricting audio recording, facilitating optional deletion of video footage, restricting duration of videoing, and targeting specific tasks or interactions [5, 7]. In our study we used motion sensors targeted to very specific segments of each of the cameras' field of view. For example, we set up small areas of motion sensitivity for each camera field of view where staff would be interacting with the technology intervention under study such a scanning area and the door handle of the blood fridge. Combined with our multiple camera coverage we were able to trigger video capture for both very short durations and for only relevant interactions. The multiple camera approach enabled us to avoid, as much as possible, capturing staff head shots (a point of sensitivity with staff members).

Managing Consent

The motion sensing technology that we used also records time and date of the video trigger. With this information an efficient optional delete/non-consent procedure can be implemented. For this to work we asked non-consenting participants to anonymously fill a request for certain date and time segments to be deleted. This procedure satisfied

both ethical review board concerns, increased staff comfort with the video, and was easily implemented**.**

Motion Sensing and Video Analysis

Motion sensors can trigger video capture over the full length of a pilot or research study. This allows more specific events to be collected for thorough analysis and interpretation including infrequent and critical incidents. Since a large number of specific events are captured it is then possible to use a sampling technique to select video clips for analysis. We have combined video clips with software log data that records user errors to identify clips for analysis.

LIMITATIONS AND FUTURE SOLUTIONS

The solution we have described was implemented using readily available technology most often used for security surveillance of commercial property such as stores and restaurants. There are other solutions that might provide more control to both the researcher and the participant. RFID tags could be used by consenting participants to trigger video capture in addition to motion sensor triggers [10]. Motion sensed event data (such a timestamp data) could be linked to software logs to provide automatic event/clip information and identification by task type, duration and participant characteristics.

CONCLUSION

The use of motion sensing to trigger video capture in hospital based studies has many advantages for the research and the participants. As well as the significant opportunities it provides for increasing the efficiency and focus of video capture (i.e. targeted to specific events/tasks), we have described the advantages to the researcher of using event trigger data to enhance analyses by providing larger more specific video clip libraries from which to sample for analyses. Whilst motion sensing has been used in other settings for many years, for health informatics research this study implementation represents a significant step towards addressing the challenges of behavioral research in the medical setting.

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