

Opportunities for Blended Interaction in Emergency Rooms: Coupling Displays with Digital Pen Input

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Abstract—We use the findings from two participatory design workshops and prototype evaluation to develop the basis for designing information displays with digital pen input.

Keywords—digital pen; displays; healthcare; design.

I. INTRODUCTION

Trauma resuscitation is a complex and dynamic domain in which multidisciplinary medical teams perform lifesaving interventions. This domain poses several challenges for designing information systems to support teamwork, such as the need to rapidly enter data that cannot be automatically captured, and to synthesize and present information in an intuitive way [1][2]. The focus of our research has been to identify ways to capture and display information about patient and team activities in real time to support situation awareness. We started by exploiting digital pen and paper technology and the role of the scribe nurse, who manually records patient data onto a large, tri-fold paper flowsheet during each resuscitation event. The paper record is currently used for archival purposes, offering minimal support for real-time work [3]. By combining the virtues of physical and digital artifacts, we aim to preserve the benefits of using pen and paper [4], while expanding the role of the paper record to support medical work. In this paper, we discuss the findings from two participatory design workshops that led to a paper-digital interface prototype, and two simulation sessions in which we evaluated the prototype.

II. PARTICIPATORY DESIGN WORKSHOPS & SIMULATIONS

We conducted two workshops with members of the trauma team at a pediatric Level 1 trauma center. The workshops involved emergency medicine physicians, surgical fellows and residents, respiratory therapists, an anesthesiologist, and nurses. The participants engaged in design activities, in which they created paper prototypes for information displays to supplement current information sources in the resuscitation rooms. The design activities focused on identifying critical data that these displays should present to support shared awareness during resuscitations. Using the input from the workshops, we designed a working display prototype that was evaluated during two simulation sessions at the same hospital (Figure 1).

III. DESIGNING TO SUPPORT CURRENT WORK PRACTICES

Findings from the workshops showed that moving toward completely digital input would require a redesign of the paper

flowsheet format, investment in computer systems, system training, and a significant change to the scribe nurse’s current work practices. Altering documentation workflow can potentially distract the scribe from accurately recording patient data or from recognizing important changes in patient status and alerting the team. Workshop participants commented that coupling the digital pen and paper with information displays would minimize changes to documentation, while taking advantage of the recorded information to provide supplemental data to the team. Preserving documentation practices, however, revealed several challenges to designing the prototype.

A. Blended Interface for the Scribe Nurse

We developed our prototype using the Anoto DP-201 digital pen coupled with large wall displays. The pen, a combination of an ink pen and digital camera, records the user’s writing by recognizing a non-repeating dot pattern printed on standard paper. This pattern allows the pen to find the location on the page, while capturing written information. The data from the pen is then transmitted wirelessly for immediate processing and real-time display.

The digital pen and paper represent the minimal “interface” between the scribe nurse and the information being recorded, blending the power of digital computing with natural work practices—writing or making a checkmark on the flowsheet captures and displays the data as graphics or text in real time on the wall displays. The digital pen preserves almost effortless switching between fields on the flowsheet, allowing rapid data input while obviating the need for switching between input devices, such as keyboard or mouse (Figure 2). Even so, the use of this blended interface introduced distractions to nurses’ work, as found during the simulation sessions.

Before starting each simulation, we asked the scribe nurses to document the event as they normally would. The only instruction explicitly asking the nurses to alter their routine practices was to first mark the “arrival time” field when the patient was brought into the room. This brief, yet important task started a timer and all subsequent recorded events were displayed to the team as having occurred since the patient arrived. The scribe nurses commented that they did not need to change how they recorded information. They did note that they were occasionally distracted by the output of their documentation on the display. While recording data they heard or observed, the nurses also felt the need to check the accuracy

WEIGHT	AGE	MECHANISM	PRE-HOSPITAL	Broselow
26 kg	8	MVC: Rear passenger Hip belt only Airbag	+LOC Seizure CPR in transit, field	ORANGE
A	B	C	D	MEDICATIONS
Patent Supported Collar	Uneven rise Trachea midline	PULSES Apical: 2+ Distal: 2+ Femoral: 2+	GCS 6 08:00 8 05:00 8 02:00	Succinylcholine 26 mg 06:30 Etomidate 3.9 mg 06:30 Atropine .26 mg 06:30
	SOUNDS Decreased L		PUPILS 5/5 nonreact 4/4 sluggish 4/4 sluggish	
▶ Intubated	▶ Chest tube	▶ IV: R arm ▶ IO: R foot		
FLUIDS		RADIOLOGY	LABS	DISPO
NS 200 cc 12:00 NS 200 cc 08:00	NS 200 cc 04:00	C x-ray C-spine CT C-spine Head CT	Comp.	PICU

Figure 1: Initial display design prototype.

of the displayed information. Other team members, especially the team leader, were also concerned about inaccuracies because of their potential risk to patient safety.

B. First Occurrences and Error Recovery

The current flowsheet design provides the structured space for documenting only the first occurrences of events (e.g., initial evaluation findings), with follow-up information (e.g., changes in the patient status) being recorded as free-form progress notes in a dedicated, unstructured space on the sheet or in the margins. Because the digital pen works best with structured data input, capturing and interpreting free-form data is now limited. This limitation also makes it harder to correct previously recorded information, making the problem of recovering from errors challenging. Discussions with team members following simulations suggested having multiple people input or remove information, a solution analogous to the properties of a whiteboard where multiple people can easily add or erase the content. Distributing the task of entering and correcting data for information displays requires further study and will be part of our future work.

C. Thinking Outside the Checkbox

Compared to structured computer-based input, pen and paper allow the user to take notes in the margins. Although the flowsheet has a tabular structure with specified checkboxes and areas to input information (Figure 2), additional information that could not be predicted beforehand found its way onto the margins. Nurses emphasized the need to see the entire flowsheet at once and selectively record data as they occur. Nurses also noted that they often document information that is easy to remember (e.g., initial findings) after they record changing information such as the vital signs. These findings further supported the idea of having multiple people inputting the information to enable timely and accurate data capture.

During simulations, we also observed nurses unintentionally marking nearby checkboxes on the flowsheet. These stray marks activated adjacent fields, displayed incorrect information and caused confusion. For example, one of the nurses marked the checkbox for “Trachea: Midline” in the “Breathing” section of the flowsheet while also accidentally marking the “Kussmaul” (deep and labored breathing pattern) checkbox above. The display consequently showed “Kussmaul” even though this finding was not reported or mentioned during patient evaluation.

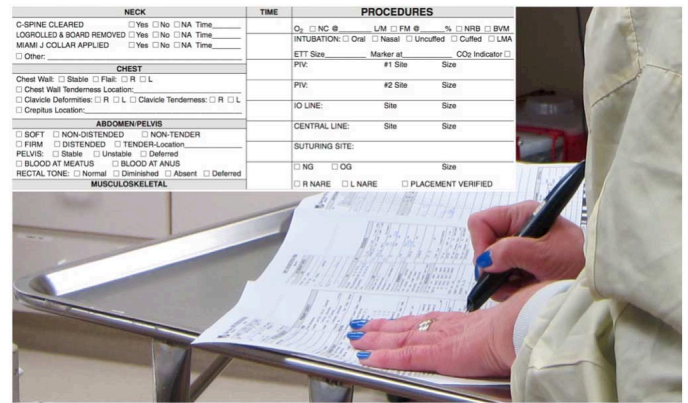


Figure 2: Scribe nurse using the digital pen during simulation. An excerpt from the paper flowsheet (upper left corner).

IV. CONCLUSION AND FUTURE WORK

Our initial experimentation with a paper-digital interface for emergency medical work revealed several challenges to designing and using such an interface during the fast-paced and dynamic process of trauma resuscitation. Based on these initial findings we believe that it may still be necessary to redesign the paper flowsheet to enable: (1) structured data input for handwritten and follow-up information that is now found in free-form progress notes or in the margins; (2) rapid correction of previously recorded information; and (3) rapid correction of errors caused by stray and accidental pen marks. Redesigning the paper flowsheet will also require additional training for the scribe nurses, although not to the extent that would be necessary with a completely digital system.

Despite the challenges, our findings showed that interactions enabled by combining the power of digital computing with natural work practices—such as the use of digital pen and paper—have the potential to improve medical teamwork and patient care. With Bluetooth capabilities and battery-powered operation, users can be positioned in different areas around the resuscitation room. Digital pens are also relatively affordable, making their introduction into the real-world care feasible. We will continue experimenting with digital pens as well as with other blended technologies that can supplement dynamic data capture from the environment.

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