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Creating real-time transparency in hospital processes

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Abstract

The complexity of modern hospitals impedes health actors' situational awareness and their ability to coordinate activities and processes effectively. We hypothesize that providing health actors with an overview of relevant patient trajectories will improve their ability to self-coordinate. We further hypothesize that such overviews can be generated automatically based on real-time detection of events. We here report preliminary results from iterative efforts to develop information technology prototypes to test these hypotheses at two university hospitals in Norway. This includes (1) results from a utility test of an indoor location tracking system for detecting events in patient physical trajectories, (2) secondary use of healthcare data for detecting events that can form the building blocks of process transparency in hospitals, and (3) visualization of patients' physical and medical trajectories.

Introduction

The flow of patients is the value stream in healthcare (Bertrand and de Vries 2005). From the perspective of healthcare providers, patients are the work pieces, but also the customers — they are what trigger work. A patient's journey through a hospital usually requires the coordination of multiple resources that often are temporally and spatially dislocated, as well as the concerted effort of a number of different clinical specialists working in many different organizational units (Hall, Belson et al. 2006).

The unpredictable aspect of dealing with patients, diseases and therapies precludes hospitals from taking the most out of rigorous planning tools and workflow systems. In the absence of a schedule where the sequence of tasks can be decided in advance, coordination must take place as the workday unfolds. In the perioperative domain, a coordinator may undertake the real-time coordination of work. Effective coordination also depends on the professionals' ability to prioritize between tasks that are imminent and others that can wait, in practice a self-coordination mechanism.

We hypothesize that providing health actors with an overview of relevant patient trajectories will improve their ability to self-coordinate. We further hypothesize that such overviews can be generated automatically based on real-time detection of events. These hypotheses form the basis for an ongoing 4-year research project called Co-Operation Support Through Transparency (COSTT) sponsored by the Norwegian Research Council.

We here report preliminary results from our iterative efforts to develop information technology prototypes to test these hypotheses at two university hospitals in Norway. This includes (1) results from a utility test of an indoor location tracking system, (2) the use of tracking data about events to infer details about ongoing patient trajectories, (3) the visualization of patient trajectories to achieve process transparency in real-time. We first visit each of these issues, and then relate them to each other in the discussion.

Utility test of indoor location tracking system

Location is an important part of context (Dey and Abowd 1999) , and Indoor Positioning Systems (IPS) may hold promises for increasing process transparency (Marjamaa et al., 2006). Such systems have previously been used to determine the

location of an in-patient (Krohn 2008)(Grey 2007), find a particular out-patient (Grey 2007), find a piece of equipment (Hagland 2009)(Grey 2007), determine the availability of beds (Krohn 2008), indicate progress for a pre-defined patient trajectory (Meyer, Seim et al. 2008), and optimization of equipment maintenance based on location and utilization (Miller 1999).

As a first step in assessing the usefulness of IPS for detecting meaningful events in a hospital and in order to gain experience with the limits of the IPS capabilities before deploying it in a real environment, we designed six separate small scale and low-cost experiments and conducted them in a controlled laboratory environment. The three overall questions addressed were how the system rated in terms of spatial granularity, temporal resolution, and concurrency. We considered these three dimensions to capture the most important functional capabilities of the system - you cannot detect spatial changes below the granularity of the system, events occurring more rapid than the temporal resolution of the system, nor reliably detect events when there are more IPS-tags in one space than the concurrency capacity of the system.

The data were collected using the server software included with the IPS. Processing and statistical analysis was performed using Microsoft Excel 2007 (Microsoft Corporation, Redmond WA.) and Minitab® 15.1.30.0 (Minitab Inc, State College PA.).

The first two experiments were used to establish a baseline for interpretation of subsequent results. This included establishing the degree of uniformity of the transmission strength by the individual tags used by the system and correspondingly whether the detectors gave consistent readings for the same transmission. We found precision and accuracy to be 99,9 % on a room-level and 95 % on a sub-room level. However, orientation of tags had a large impact on system performance for the latter, pointing to the importance of design of installation in providing reliable sub-room level event detection. Results from our final tests seem to indicate that tag concurrency is the largest limitation on the use of IPS for detecting events. After reaching a “critical” number of tags in a zone, system performance becomes highly unpredictable.

The use of data about events to infer details about ongoing patient trajectories

While the use of IPS in hospitals is increasing, there are still relatively few large-scale implementations and they are far apart. As with any other sensors, adding location-sensing equipment to hospitals comes at a cost. Similarly, the logistics of equipping staff, patients and equipment with IPS tags incurs additional costs. Moreover, an installation requires service and maintenance, just as with other technological infrastructures such as computer networks and telephone- and pager systems. Thus, re-using existing information – even information collected for other purposes than describing location – is seen as promising.

In the COSTT-project we believe that existing information systems in hospitals can be tapped for information from which one can infer status in patient trajectories and ongoing activities, incurred problems, and the location of both staff and patients. An important source of information is Operating Room Information Management

Systems (ORIMS). These typically contain operating room schedules and timestamps from ongoing perioperative patient trajectories. We believe that through adding “sensors” (using the term “sensor” in the widest possible sense) to a range of such digital sources and key equipment – possibly adding IPS for areas where one needs particularly high levels of granularity – we can unobtrusively collect sufficient data for providing transparency in perioperative processes.

There are previous examples of the use of digital information sources as proxies for direct detection of location, including detecting location based on access cards and automatic detection of location based on source of Anesthesia Information Management Systems (AIMS)-data (Epstein, Dexter et al. 2008). Systems that have augmented directly detected locations (by IPS usage) with contextual information from secondary sources such as ORIMS have been demonstrated to detect wrong patient/location situations (Sandberg, Hakkinen et al. 2005). Other examples of augmentation of physical sensors include using vital-sign-monitoring data coupled with ORIMS information to estimate remaining surgery time (Dutton, Hu et al. 2007).

Visualization of patients’ physical and medical trajectories

As a step towards designing visualizations of patient trajectories, we sought to understand what kind of information hospital actors desire for self-coordination. We conducted workshops, interviews with domain experts and performed field observations of perioperative work and processes. The main purpose of these efforts was to support our selection of the most valuable information for self-coordination and inform at what level of granularity such information should be presented to users.

Our preliminary results from these different approaches have confirmed that:

1. There is a clear need for increased transparency within the perioperative domain
2. Some activities require that actors adjust to the activity – transparency could improve timeliness of such actors’ adjustments and reduce the disruptiveness of these adjustments to actors’ work
3. Though actors depend on information to self-coordinate, the expressed need for information is relatively confined (from a self-coordination point of view)

To exemplify, one surgeon said that he would like to know approximately when he should expect to be called in for surgery, and that he would find it useful to be able to know when the patient was brought into the OR suite for preparations. Knowing the latter, he could predict when he would be needed in order to commence surgery. He already knew the details regarding this surgical intervention such as the diagnosis, the name of the patient, the planned procedure, and the operating room. He didn't need anyone telling him that again – he just wanted to update his mental model with the progress in the patient trajectory in order to stipulate approximately how much time he had left for other activities.

Conclusion

We have reported preliminary results from our work in progress on creating transparency in perioperative processes and patient trajectories. Our work has three main components: automatic detection of events, representation of patient trajectories

from the building blocks of these events, and developing visualizations that provide transparency for actors in the domain. The first and last of these are topics in this paper. We are currently in the process of combining data about location events with data from a scheduling system to infer the status of a perioperative patient trajectory. We are also conducting preclinical experiments to decide the clinical usefulness of various visualizations that build on these trajectories.

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