CCTV and other ICT support for supervisory tasks in healthcare

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Abstract. Psychogeriatric patients are required by Dutch law to be supervised by a healthcare professional at all times during daycare. We investigated how technology can support healthcare professionals during these supervisory tasks. Our research shows that sensors and associated digital processing intelligence cannot be employed effective and efficient yet in these settings. The knowledge and the insights of the healthcare professional are of utmost importance to perform the supervision. Through repeated experimental research with a variety of sensors we found that the best sensor solution in this care context is a combination of two cameras and a microphone.

Keywords. CCTV, healthcare, supervision, incidents, sensors

1. Introduction

Psychogeriatric patients are required by current Dutch law to be supervised by a healthcare professional (HP) at all times during daycare. Daycare takes place in a communal living room usually populated by 6 to 8 patients. An HP, present in the room, is responsible for supervision of these patients, but will also need to provide care to individual patients (e.g. assisting in toilet visits or changing the clothes of an individual patient). When the HP is away to apply this individual care, the communal living room is not supervised. In practice such a situation would mean that a double staffing of HPs is required to be compliant with the law. Mostly because of various financial issues, that double staffing becomes less and less a viable option. We were therefore asked by two nursing homes to investigate how technology can support HPs during their supervisory tasks, especially when individual care is being applied and, as a result of that, the communal living room is temporarily unsupervised.

1.1 Context

The supervisory tasks of the HPs were identified using observations and interviews in four departments of two nursing homes. The applicability of various sensors was also surveyed. Then a literature study revealed which sensors would have the most added value to be included in laboratory studies. During these laboratory studies we worked with non-patients who reenacted a scene taken from the communal living room in which various common incidents took place. The results of the registrations by sensors of this reenactment were evaluated with various HPs.

1.2 Dutch documents and studies about nursing homes

In several Dutch documents we found a strong preference for a patient and HP centered implementation of new technology in healthcare. The Dutch Ministry of Health investigated home automation in 2009 ("Toepassing van domotica," 2009) and concluded

that a lot of research is carried out in pilot projects in nursing homes but a proper transfer of knowledge is often not the case. Further, only few nursing homes are capable of successfully supporting their strategic vision with new technology. The ministry also found that new technology is often purchased because of availability instead of a good fit on the care needs. Better alignment of care needs, working processes and technology is required, according to the ministry. Bierhof and Kröse (2006) share this vision.

Nijhof et.al. (2009) found that the effects of care technology on dementia patients, extramural caregivers and other HPs have not yet been studied extensively. The researchers state that more insight is required regarding the effects of technology on issues like quality of life, feeling of safety, and work satisfaction.

While reviewing these documents we found that a clear definition of supervisory tasks was not available, not even on a governmental level. We therefore had to establish a definition of these tasks. Based on desk research, observations and interviews with the HPs, we defined supervisory tasks as: *"Part of ensuring a safe living environment for the patients"*. To guarantee such an environment, supervision must make it possible, preferably pre-emptive, to detect dangerous situations in order to make a timely appropriate response possible. Such a potentially dangerous situation is defined as an *incident*.

We strive to have our work contribute to a better understanding of the need for and possibilities of alignment of working processes, technology and care needs. We further investigate the effect of this technology on HPs through a series of evaluations.

1.3 Literature review

Cox, Hayter and Ruane (2010) investigated alternative approaches to enhanced observation and, among others, stress that more research is needed into the area of mental health nursing. Authors state that ways of less intrusive monitoring should be feasible. Park and Bowers (2001) describe that nurses find special observation procedures stressful and that patients are disliking it.

Steward and Bowers (2012), while researching the procedures around special observation, see a shift towards the deployment of less qualified staff because of the high costs of special observation. Next to that, decisions surrounding special observation are usually resource based and not entirely based on the patients' need. Authors indicate CCTV as an alternative mean to ensure patient and staff safety. Because of increased patient visibility, nurses' time can be freed up and that can enable greater engagement with patients and delivery of more therapeutic activities. Steward and Bowers see the need for future research into electronic surveillance.

In a broader sense, the literature states that a clear and unambiguous policy should be implemented for observation and supervision among patient units (Khan, Rice & Tadros, 2013). Kettles and Addo (2009) stress the need for local work to be published to inform the debate and practice of special nursing interventions. We intend to contribute to both these goals.

Considering the available literature, we conclude that most research deals with enhanced observation (intensive nursing care) and special observation (preventing disturbed psychiatric patients from harming themselves or others). Our research focuses on supervisory tasks support in a communal living room setting. The literature further shows a need for visible practical cases regarding supported supervision.

2. Methods

The question guiding the study is: how can technology support HPs during their

supervisory tasks, especially when individual care is being applied and thus the communal living room is unsupervised. To investigate this question we had to use an iterative approach of observation in the communal living rooms, interviewing the HPs and conducting experiments. The latter are necessary because testing solutions in practice with psychogeriatric patients is rather impossible. In an exploratory pre-investigation, we became familiar with the supervisory tasks in the communal living rooms. Based on these assessments we selected suitable sensors and then experimented with this sensors in a laboratory setting. A first experiment was conducted to determine the most suitable combination of sensors, a second experiment to achieve an even better fit of the sensor combination on the tasks of the HP's and to evaluate the results. The cascading experimental setup was required because of the thin body of knowledge regarding this specific deployment of equipment.

2.1 Sensor selection

During the exploratory pre-investigation, a number of promising, affordable and commonly available sensors were selected:

- Video cameras: 2 HD webcams (Microsoft LifeCam Cinema), 2 SD video cameras (Sony DSR-PD170P), and 1 other SD video camera (Microsoft Kinect for Xbox 360)
- Microphones: 1 ordinary mono microphone and 1 ordinary stereo microphone
- 1 range camera used to construct a 2D depth image of the scene (Microsoft Kinect for Xbox 360)
- 1 infrared camera (Microsoft Kinect for Xbox 360)
- Tracking systems: 1 Ubisense tracking system and 1 EagleVision tracking system.

Monitoring a reenacted communal living room situation using these sensors, we would be able to carefully select the best fitting (combination of) sensor(s).

2.2 Experiment preparation

For each part of the experiment we assembled a unique group of non-patients to reenact the communal living room situation.

The first experiment was conducted in a laboratory with access to the advanced tracking systems "Ubisense" and "EagleVision". The results of this first part were evaluated with students in healthcare.

The second experiment was aimed at achieving a better fit of the sensor system on the tasks of the HP's and was therefore much more tailored to facilitate recognition of actual identified events in the communal living room. Our own laboratory was used during this experiment, also because it is a space that is somehow comparable with a communal living room. HPs were part of the evaluation team for this experiment.

3. Results

3.1 Exploratory pre-investigation and sensor selection

In the exploratory pre-investigation we conducted observations to analyze the tasks of HPs during daytime care in communal living rooms. We also investigated the related areas in the nursing home and how they are (supposed to be) supervised. In this way, we identified possible supervisory problems. We further looked at patient behavior, situations in a communal living room that require professional intervention, and accompanying performed actions by healthcare professionals. Both the initial sensor selection and the script for reenactment were based on these observations.

In the first experiment, non-patients reenact the drafted script containing the identified incidents while the various sensors registered the event. The preliminary conclusion was that for supporting supervisory tasks a number of the deployed sensor systems (range camera, both tracking systems and infrared) had little to none added value. Repeating the experiment we found that a combination of two camera's and an audio feed would probably suffice in most, if not all, situations.

3.2 Second experiment

A second experiment was needed to confirm the results. Using the definitions for supervision and incidents we tried to describe common behavior as shown by patients that leads to a certain kind of event. In this we did not succeed. Every patient has his or hers own markers and indications that indicate whether or not certain behavior would lead to certain incidents. Also, the entire context surrounding a patient was found to be very important: did the patient sleep well, did he have a visitor, did he eat his meal well etc. The behavior of patients is in such a way unpredictable that only the directly involved HP, which has day to day contact with the patient, can assess whether or not a certain situation will lead to an incident. The knowledge and the assessment skills of the HP were found to be of utmost importance to perform the supervision. It turned out to be impossible to compile a list of early incident warning indications. Because of these issues, deploying advanced technology to detect incidents is not useful in these situations. The interpretation whether or not something is, or can become, an incident should remain with the healthcare professional.

We decided to combine this new insight with the results from the first experiment by making live audio and video feeds from the patients available to the HP. The audio feed can trigger the HP that more examination of the situation in the communal living room is required using the video device. Using these two sensors, the HP can thus assess the remote situation and decide whether or not intervention is required.

3.3 Performance and evaluation

We put together a quick prototype using a mobile phone as a camera / audio source and a tablet to receive this streamed information remote. The main idea is that when the HP leaves the communal living room the mobile phone / camera stays in the communal living room, pointing towards the part of the communal living room where the HP expects possible events taking place, e.g. a location where patients reside that act restless. This mobile phone / camera is also performing the audio streaming. The HP takes the tablet, places an earpiece and leaves the room. When an incident occurs, the HP recognizes this from the in-ear audio and uses the tablet to further investigate the situation in the communal living room and to assess whether or not an intervention is required.

We experimented with this setup in our HCI laboratory, once again choosing to have non-patients reenact observed situations and incidents from a communal living room. This time the incidents, as deducted from interview and observations, were carefully selected. The data from the mobile phone / camera was recorded and afterwards made available to the evaluators.

The feeds from the device were assessed by 5 HPs and 5 healthcare students. The practice of working on a different task was simulated with an artificial distraction: playing a videogame. The results (table 1) show that each of the incidents was detected by every evaluator using the audio feed only. The maximum response time for an incident based on audio was 8 seconds. After being triggered by the audio, the assessors consulted the tablet to judge the severity of the incident in the communal living room.

Table 1: Incident description and response times

Incident		Response time in seconds		
#	Description	Min	Max	Mean
1	patients having verbal and physical arguments	2	7	5.6
2	a patient has fallen down; other patients are trying to help him to his feet	2	7	4.1
3	a patient has dropped his cup	1	4	1.9
4	a patient is calling the health worker because an other patient is pulling him from his chair	2	8	4.7
5	a patient is choking	1	2	1.5

Over these 50 positive detections, five false positives were given. Looking at the tablet, all of the evaluators did recognize the false positive. Evaluators argued not to mind a false positive rate of 10%. They would rather check on false positives then miss an incident on false negatives.

Afterwards, the concept and the results were discussed in depth with a manager from the nursing home that asked explicitly for advise. She was positive about the fact that the decision to intervene, and to what effect, remains the full responsibility of the HP. Furthermore she was positive about the simplicity of the technical concept. She pointed out issues regarding privacy and procedures in the workplace to make such a support tool also legally substantiated.

4. Discussion and Conclusion

Although we had to work with several limitations, the findings from this research already result in a valuable insight into the possibilities of a cost-efficient and feasible provision to support HPs tasks during supervision when they are absent from the communal living room. It was shown that a combination of a continuous audio feed and a portable display device not only supports the HP by supplying a set of “remote eyes”, but also support the HPs’ perception of being in control of a situation with supervision.

The described combination of sensors turned out to work best in this specific case, supporting this specific set of tasks. The bottom line is that ICT-support only works properly if based on careful task analysis in the situation to be supervised.

Interesting in this context are the results of recently finished comparable research where a General Practitioner (GP) has contact with patients also using rather simple video/audio support (Bennis & Lenior, 2014). We found that during this consultation, the GP actually can perform certain diagnoses and make arrangements for follow-ups.

Both the GP and the HP from this research use video/audio support to be able to have an extra pairs of ears and eyes at a distant location. But, because the GP has to be able to perform a correct diagnosis using the system, the demands for the system differ from the demands of the HP. Where the HP is mostly concerned about flexibility, the GP will only accept a system that is able to deliver a very clear image. Again, careful task analysis is the key for success.

This study had several limitations. Only a relative small number of interviews and observations were conducted. The results of the phase in which we investigated incidents and concluded that automated detection is not feasible yet are also based on these interviews and observations. Nevertheless we expect the conclusion to be sound and applicable in the investigated communal living rooms.

In a proof of concept study we will apply this audio/video configuration in one of the communal living rooms. When this evaluation should deliver the same results, this care organization will apply it at all her care houses.

The care organization which asked explicitly for advise wants to work further with this solution because of the following advantages. It is based on available software and hardware; it is composed of a number of proven reliable and usable components and therefore quickly deployable. The solution also has an open structure, meaning that improvement of individual parts is possible, directly contributing to a better overall solution. In software this could mean better recognition of faces or objects and in hardware this could mean sensors with higher sensitivity. We started follow-up research in this field.

The main advantage of this solution is the fact that the HP is supported and not directed by technology. The HP retains a great amount of freedom in performing his tasks. The earpiece and the display device offer a form of remote ears and eyes, almost as if being physically present.

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