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Augmented Reality in Nursing: Designing a Framework for a Technology Assessment

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Abstract

During the last decade, research emphasized the wide range of possibilities of augmented reality (AR). At the same time, Information Technology usage in nursing increased. The question occurs if AR can have reasonable fields of application in nursing. Nursing hinges strongly on the emotional and physical relationship between patients and their nurses. This may lead to ethical conflicts while implementing AR leading to special challenges. Therefore the realization of a technology assessment (TA) seams to be reasonable. We designed a framework for a TA of AR in nursing through workshops with nursing scientists and practical partners. The framework is designed to address ethical aspects of AR in nursing through techno-ethical scenarios, a plausibility assessment, and a participatory approach.

Keywords:
Nursing; Technology Assessment; Ethics

Introduction

Usage of Information Technology (IT) in nursing is constantly increasing [1]. While technology in nursing may have some positive effects on nursing processes, the special characteristics of nursing should be considered when designing technology for nurses. These characteristics are: high emotionality, physical contact, and the importance of the relationship between the patients and their nurses. Within these characteristics the nurse has to take the specific situation of the patient into account and act on an individual basis [2].

The special characterization of nursing, the nursing environment, and the developments and trends in nursing technology shall be taken into account when designing the framework for Technology Assessment (TA) in nursing.

During the past decade technological advancements in augmented reality (AR) have been significant. Thus, AR received a lot of attention, e.g. in the field of architecture, construction, and engineering [3]. No consistent definition of AR exists [4; 5], however, the definition by Azuma et al. is most established [6]. Azuma defines AR as any system that has the following three characteristics:

1. Combines real and virtual
2. Is interactive in real time
3. Is registered in three dimensions

Milgram and Kushino described the virtuality continuum which reaches from the real environment to the virtual environment. AR as part of mixed reality is placed closer to the real environment, whereas augmented virtuality is closer to the virtual environment [7]. Although that definition is conceived as too generic [4], for the goal of our approach we used it because it includes the widest range of possible applications.

Both definitions share a common concept, they are independent of any technology. They do not refer to special input and output methods as well as tracking procedures. Research in the field of healthcare focuses on the usage of smart glasses without using the term “augmented reality” [8; 9]. In this paper, possibilities of augmented reality are taken into account without limitation to any device such as smart glasses. Whereas, a broad field of prototyped applications exists and a high potential is assumed in different areas. In healthcare most of the implemented use cases are in the field of surgery [10]. For example, anatomic information can be visualized during surgery without interrupting the procedure [9].

Nursing AR research focuses on implementing and evaluating prototypes. For example the implementation and evaluation of a system for hands-free image capture [8] or a sytem for organizing tasks and monitoring vital signs [11]. These and other studies focus on specific applications without considering the future perspective and ethical aspects. To our knowledge no research on AR in nursing in general exists.

As part of this project, the possibilities and limitations of AR in nursing will be examined. This paper presents a framework for realizing a TA. TAs take intended and unintended consequences of technology into account [12]. One of the challenges of realizing a TA with the aim of influencing technology development is to find the right starting point. If you start the TA in the early stage of an emerging technology, the shape of the technology is very unspecific. In contrast, a TA on a completed technology offers no influence on the technology. The challenge to find the right time to start the assessment is called the Collingridge dilemma [12; 13]. Whereas von Gleich claims that this should not be a problem, he argues that it is most important to find a good way to deal with the lack of information [14]. One way to deal with this lack of information is the usage of appropriate methods.

For conducting a TA, multiple methods may be appropriate. As an example, Grunwald describes two ways just to get prospective results. One way is the exploration of trends and the other is the model based simulation [12]. Djanatliev and German describe a model based simulation supporting prospective healthcare decision making by using an agent-based simulation [15]. Exploration of trends as well as model based simulation rely on available data and allow a quantitative perspective on future trends. For the case of AR in nursing, only prototypes and short-term data exist [16]. Using applications in real life is necessary to produce data, which can be used in model based simulations. Therefore these methods cannot be used.

In contrast, the construction of scenarios allows for the exploration of ethical concerns without the need of previous data. Furthermore, with this approach certain patterns of moral argumentation about new and emerging technology may be included, which are missed in other types of TAs. These aspects are called ethics of new & emerging science and technology (NEST-ethics) [17]. In addition, there is a mutual change of technology and society [18], which Boenink et al. includes in their framework of techno-ethical scenarios [19]. This framework will be described later on.

In the construction of scenarios, one challenge is to assess the plausibility of the technological change. To address this issue Lucivero constructed a plausibility assessment [20]. The single step of the plausibility assessment are described in the construction of our framework. First, exploratory results for the construction of the framework were figured out in workshops. Based on these workshops, we designed a framework for a TA for AR in nursing to address the wide range of possible conseqences of using TA in nursing.

Parts of the framework are techno-moral scenarios. The advantage of scenarios is the possibility to take morality change into account [19]. In combination with a plausibility assessment and a participatory approach, these scenarios serve as starting points for future research.

The paper contains four sections: Section one describes the design and the results of the workshops. Section two presents the framework for a TA of AR in nursing. Section three discusses limitations and possible next steps. Finally, section four summerizes the results.

Methods

As shown, many approaches for TAs already exist. All these approaches take different aspects into account. In order to get insights to which kind of TA is needed for AR in nursing, three workshops were designed. As part of the workshops, use cases for AR in nursing were developed. Designing use cases allows us to estimate expectations according to the usage of AR in nursing.

As an introduction to a diversity of perspectives, the workshops had different participants, scientists (workshop I) and practical partners (workshop II and workshop III). All three workshops started with the explanation of AR. The participants and the use cases are described in detail in the following sections.

Workshop I - Scientific Approach

Workshop participants included researchers in the field of nursing and related scientists skilled in nursing practice (n=8). The first part of this workshop was designing a nursing process landscape. The second part discussed use cases in the context of the most relevant nursing processes.

The researchers discussed the characteristics and special aspects of nursing, and confirmed the results of the literature review. They emphasized communication, emotional, physical contact, and priorities of nursing being dependent on the setting. In addition, they identified ethical aspects and privacy concerns as possible obstacles to AR in nursing. Furthermore, hygiene was identified to be an important aspect to take into account when developing an AR application.

Wound care management, food and liquid management as well as drug management were identified as processes with the highest potential for AR in nursing. Furthermore, a possible reminder function was seen as an advantage. In addition, the possibility of getting legal security was questioned.

Possible use cases of AR in wound care management and drug management will be described later on, as they were part of the other workshops as well. For food and liquid management, AR systems should take into account special diets, give advice if a patient has some intolerance, and measure how much has already been eaten and drunk.

Workshop II and III – Practical Approach

The participants of workshop II (n=7) and III (n=5) had a vareity of different backgrounds in the field of nursing (nursing director, IT specialist in a nursing home and operative nurses), IT, and science. The nurses' workplaces involved a nursing home as well as an ambulatory care unit.

In the two workshops of the practical approach, use cases were designed based on the experiences of the participants as well as on advice of the IT experts.

The workshops identified potential processes where AR could offer support. Processes included documentation, contact with experts, physicians and patients' relatives, drug management, handover for the next shift, wound care management, inclusion of new residents, training new employees, reminder function, medical prescriptions, knowledge transfer and care sequences. We further describe the use cases, shift handover, wound care management, and drug management.

Supporting the process of the shift handover is especially relevant for nurses working in ambulatory care units. There is no personal handover as nurses from different shifts do not meet on a daily basis.

Currently, the nurses write down relevant information for the next shift into a book, which does not belong to the regular documentation system. This book should be replaced by a tablet. In addition, the important information should be readable on smart glasses. One of the advantages of this application is the organization of the entries. It should be possible to view entries of one specific shift as well as entries according to one patient. In addition, it should be possible to search within the entries. Furthermore, the tablet offers the possibility of a speech-to-text transcription and of taking pictures. The application on the glasses should allow observing relevant information in the field of view. Which entries are relevant has to be marked at the time of making the entry. Another feature of the digitalized version for the handover should be the possibility of making entries, which are relevant in the future and appear as an entry for the relevant day.

For wound care management, the first documentation of the wound requiers nurses to describe the reason for the wound, , the kind of wound, the location of the wound, additional actions, and information for other professionals regarding relevant patient data. In addition, the progression of the wound care has to be documented. Relevant aspects are length, width, depth, etc. In addition, it is necessary to take a picture of the wound. With the help of the wound management application it could be possible to take care of the patient and perform wound documentation at the same time.

Furthermore, possible features of an AR application for wound care management could be the serving of therapy proposals and the availability of these proposals at the time of care. In addition, depth and length of the wound should be calculated automatically and be compared to earlier documentation.

The third use case is drug management. AR could assist nurses in preparing drugs for every patient by showing a picture of the correct sample of medicine for every patient. In addition, the system could offer information about where to find the relevant drug. It would no longer be necessary to change view for medication plans while searching for the drug because all relevant information could be provided directly.

Results

The described use cases are diverse. Applications like shift handover, wound care management, and drug management would be needed in specific situations. In contrast, applications to support the whole process of documentation as well as applications for reminder functions need to be used the whole working day.

To examine the relationship between type of application and consequences, a good assessment is needed. According to Halloran et al. ethical aspects will be expressed as soon as stakeholders are working with prototypes and models [21]. According to the wide range of possible applications for AR in nursing using prototypes and models to assess all of them does not seem to be reasonable. As a result this approach is not prefered here.

However, ethical aspects are important for integrating AR in nursing, especially because of the special features of this field, and were explicitly mentioned in workshop I but were not discussed further. In addition, the workshops showed how difficult an imagination of AR technologies can be.

In order to take ethical aspects into account, a framework for a TA to AR in nursing was designed. As the research on AR in nursing is just in its beginnings and no data according to usage of AR in nursing is known, it is necessary to start the research with a prospective method. To shape the future development of the technology it is necessary to conduct a TA in an early stage of the process.

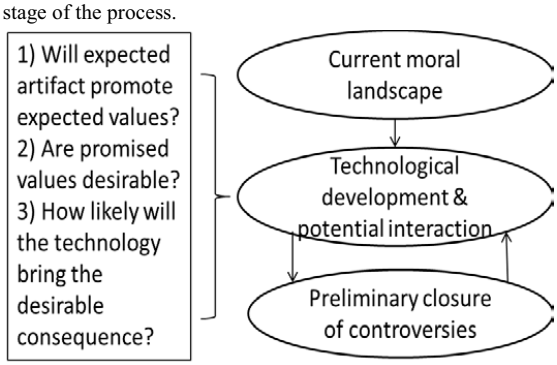

Figure 1 -Framework for a TA to AR in nursing

This framework is a consolidation of three approaches. These are the framework for constructing techno-moral scenarios [19], the plausibility assessment [20] and a participatory approach [12]. Whereas Boenink et al.[19] describe the approach to design techno-moral scenarios in three steps, we integrated a plausibility assessment into the second step and claimed that the development of the scenarios should take place in participatory workshops.

Techno-Moral Scenarios

As previously noted, TAs often miss ethical aspects. One method to address ethical aspects in an emerging technology are scenarios [22; 23]. As a prospective method, using scenarios allows addressing ethical aspects at an early stage of the development.

To assess ethical aspects of a nascent technology, techno-ethical scenarios are a useful tool because they allow the inclusion of morality change into the considerations [20; 22]. Scenarios can lead to a more reflexive co-evolutionary process and create openings for responsible innovation [22]. Furthermore, scenarios allow reflection on long-term-changes. This is important because “morality normally evolves on the long term” [19].

Boenink et al. describe a framework for developing techno-moral scenarios [19]. Their special focus is on the interaction between technology and morality. In contrast to other scenarios and ethical TAs, their framework takes this interaction into account [19]. The framework consists of three steps. Firstly, the current moral landscape is identified. Secondly, the technological development and its potential interaction with the moral landscape are introduced. Thirdly, a preliminary closure of the controversies based on a historical and sociological analysis is constructed. According to requirements and to evolve the scenarios further step two and three can be repeated [19].

The scenarios describe possible usages of AR in nursing. One possible controversy, which was discussed in the conducted workshops, is the usage of AR in direct contact with the patient. Whereas AR may have the highest usage in this situation, in the current moral landscape the privacy of the patient would have to be protected and AR cannot be used to its full potential. To close this controversy technological developments, which allow data protection or a change of the value of privacy, has to be considered.

Plausibility Assessment

Detailed research is recommended for the construction of scenarios to be able to design plausible scenarios [20; 22]. In addition to the plausibility Rip and Te Kulve consider an informed moderator to be important for being able to intervene in the discussion and offer reasonable arguments [22]. In contrast, Lucivero focuses on plausibility and designed a plausibility assessment. Lucivero argues that following the plausibility assessment allows a grounded construction of scenarios [20]. Scenarios are controlled or grounded through empirical research, they also have a speculative aspect as they explore a potential future in order to trigger imagination [20].

The plausibility assessment consists of three steps. According to Lucivero these steps can be summarized in the following questions:

“How likely is it that the expected artifact will promote the expected values?

To what extend are the promised values desirable for society?

How likely is it that a technology will instrumentally bring about a desirable consequence?” [20]

To answer these questions, relevant data has to be collected. The methods of collecting data in this case are described later on. As one important point Lucivero recommends to describe the technology in detail to reject implausible scenarios and describe two possibilities where appropriate [20].

Participatory Approach

Defining the development of a scenario includes a description of the data resources [24]. In this case, the scenario should be

developed during a workshop. For the preparation of the workshop results from the earlier workshops can be used. Based on these workshops in combination with the literature an overview about the current moral landscape will be handed to the participants. The first step of the workshop is to develop a technological application and potential interaction with it.

To yield ideal results, a participatory approach is used. Nursing IT experts, nursing scientists, ethical experts, elderly people/patients, relatives, nurses and nursing directors shall have the necessary experience for this assessment. In this stage ethical controversies can be detected and discussed. Possible closures have to be included. If AR is able to promote expected values, if these values are desirable, and how likely the technology will bring the desired consequence needs to be discussed when the last controversies could be solved.

The design of scenarios in workshops is a participatory approach which allows the inclusion of stakeholders in the process. For responsible innovation this approach is recommended [25]. Furthermore, a participatory approach is recommended for requirements engineering in general [26].

Discussion

This paper presents a framework for a TA in nursing with the goal of assessing intended and unintended consequences of using AR in nursing. In contrast to existing approaches to ethical aspects in software engineering, this framework shall consider changes in morality and take the plausibility of technological developments into account.

Our empirical results show the necessity of conducting a TA for using AR in nursing. One of the main results was the diversity of imaginable use cases. The early stage of the considerations make it hard to examine ethical controversies. By using a participatory approach in the constructed framework we follow a widely approved method.

Implications for Research and Practice

Due to the growing possibilities of AR and the actual challenges in the field of nursing, the application of AR technologies in nursing seems to be reasonable. The constructed framework provides a starting point to assess intended and unintended consequences of using AR in nursing. The results can be used to shape AR technology in nursing and may serve as a starting point for further research.

The development of AR nursing applications is just in its beginnings. Conducting a TA with the described framework at an early stage of the process may influence the development of the technology positively. Constructed scenarios may be useful for everyone who wants to develop AR applications for the field of nursing. Furthermore, they may lead to interesting results for continued development of AR in other areas.

Directions for Future Research

As a next step the framework has to be implemented and evaluated. An improvement of the framework as well as an examination of ethical controversies shall be the result. Furthermore, this framework may be used to evaluate AR applications in other fields and with other emerging technologies.

The framework has no specific elements for the domain of augmented reality or nursing. Other researchers can therefore adapt and use it for any software development if the development of the software is in an early stage and the field of application has a high ethical relevance.

Limitations

As the conducted workshops were not evaluated systematically, the presented results have limited impact. Furthermore, due to the small number of participants in the workshops generalization may be limited. Nevertheless, the presented workshops are a first exploratory approach to get knowledge about the complex field of nursing and AR. As nursing and technology follow different logics, the usage of technology may influence the work of nurses negatively [2]. Hülsken-Giesler considers objective information as an obstacle to perceive subjective recognized data which is claimed to be very important to take the specific situation of the patient into account [27]. Whereas this aspect was not directly mentioned in the empirical setting, it was pointed out from the participants with describing communication, emotionality and physical contact as important aspects of nursing. The unspoken question was if technology can support nursing in these aspects.

Furthermore, the proposed TA may require additional methodological steps in order to be applicable to AR that has undergone further development beyond the early stages. This method may be the construction of vignettes based on the scenarios. In contrast to scenarios, vignettes describe not a story but a picture of one possible situation. Vignettes may enhance the discussion about a wide range of ethical concerns. They are more useful if the usage of the technology is already more defined [20]. The vignettes could again be discussed in workshops. The additional usage of vignettes would meet the statement of the Association of German Engineers that a good TA consists of different methods which are used together [28].

Conclusions

The conducted workshops show a need for TA of AR in nursing. The complex topic addresses the need of a framework for a TA which has to take different aspects into account. These are the techno-moral development, the plausibility of expected advantages and disadvantages and the participation of stakeholders. As a next step the TA framework should be evaluated.

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