Structure for innovations: A use case taxonomy for smart glasses in service processes

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Abstract. The evolution of smart glasses and AR technology holds potential for support of mobile service processes. Yet, little research has focused on systematic identification of potential use cases. In this article, we present a use case taxonomy derived from multiple case studies employing literature search, ethnographies, interviews and focus groups from the domains of nursing, maintenance and logistics. Building upon the identified use cases we propose a framework of task-technology fit for smart glasses. The taxonomy in combination with the framework will allow researchers and practitioners to identify smart glass use cases that are of inter-domain relevance. Moreover, our artefacts enable a structured approach for identification and assessment of potential smart glass use cases without in-depth knowledge of the technology.

Keywords: Smart Glasses, Taxonomy, Service, Health Care, Maintenance, Logistics

1 Introduction

Industrialized countries are experiencing a shift from production to services. 50% of jobs in Brazil, Russia, Japan, and Germany, as well as 75% of the labor force in the United States and the United Kingdom are currently within the service sector [1, 2]. ICTs can facilitate service innovation by playing a dual role, as both an operand (enabler) and an operant (initiator or actor) resource [3]. ICTs are used in combination with other resources (such as skills and knowledge) to leverage information use across different contexts and to create new opportunities for service exchange and for innovation [4]. Several factors complicate digitization efforts of service processes. For many use cases, hands-free interaction with Information Systems is necessary [5]. Reasons for this can be, that both hands are needed for work, hands are dirty or aseptic procedures need to be performed [6]. Thus, many mobile ICTs such as smartphones and smart watches cannot be used in many tasks [7]. As a result,

Multikonferenz Wirtschaftsinformatik 2018,
March 06-09, 2018, Lüneburg, Germany

workaround behaviors can often be observed [8, 9]. Furthermore, service processes are often mobile and require mobile networks [10].

The ongoing technological development of smart glasses such as Vuzix, Google Glass or Augmented Reality devices such as Microsoft HoloLens are a promising new direction for the digitization of flexible service processes [11]. Especially in situations where employees perform information-intensive activities, while having to work hands-free, smart glasses can show context-sensitive information in the user's field of view and thereby support employees in their daily work routine [12]. The main potentials for ICT applications to support service processes are expected improvements of performance, process quality, employee satisfaction and IT-enabled collaboration [13, 14]. One of the main problems for current research on smart glasses is to identify use cases for the emerging technology [15]. Prior research has focused on HCI and device-centered perspectives. The question is: "*Which field service tasks can be supported by innovative mobile technology such as wearable devices*" [15].

To address this research void, we have conducted multiple case studies in order to collect use cases for smart glasses in the domains of logistics, nursing and maintenance. Building upon prior research on task-technology fit of mobile devices and the use cases we identified, we propose a task-technology fit framework for smart glasses.

2 Related Work

The use of smart glasses has been investigated in the research fields of Augmented Reality (AR) and Wearable Computing. Augmented Reality focuses on changing the user's perception of the real world by adding information [16].

Table 1. Existing Research Topics for smart glasses

Research Area	*Topic*
Industry	Assembly [17]
	Maintenance & manufacturing [18]
	Technical customer service [19]
Health care	Hands-free photo and video documentation [20]
	Surgery [21]
	Diagnostics support [13]
	Displaying body structures [22]
	Education [23]
Logistics	Pick by vision [24]
	Hardware selection [25]
	Privacy [26]
	Usability [27]

Although this can be achieved through haptics, sound and odor, the majority of research has focused on adding virtual elements to the user's view [28]. In order to classify as an Augmented Reality application three criteria need to be met: The application needs to combine real and virtual, be interactive in real time and registered in 3D [29]. It is possible to implement AR-applications with Head-Mounted Displays, spatial displays like televisions of projectors and Hand-held devices such as tablets and smartphones [28].

Wearable computing focuses on devices that can be worn by the user. Typical devices are smart glasses, smart watches or clothes with integrated IT-devices [30]. Smart glasses integrate information in the user's field of view without an overlay of information and thereby caused limitations in the visual field [31].

The majority of existing research about smart glasses in both areas has been focused on building and evaluating prototypical applications for use cases in health care and industry [32]. Table 1 presents smart glass topics that have been researched within both domains and cites literature containing representative examples. Especially tasks with intensive information needs, that further require both hands in service delivery benefit from smart glasses-based information systems [33]. Therefore, the implementation of these systems are discussed in the fields of logistics, maintenance and health care.

3 Methodological Procedure

To investigate in which service processes smart glasses can bring benefit we carried out multiple case studies using the case study research design defined by Yin [34]. Two cases from logistics (LG), four cases within nursing (NU) and two cases from the maintenance (MT) domain were evaluated. The domain of nursing fits well to existing research from the health care field, while logistics and maintenance are typical industrial application fields. Each case relies on several sources of evidence, from which data was extracted over the last two years. Table 2 shows an overview of the project partners that were involved in our research.

As we followed a multiple method design, different methods have been applied during the inquiry to increase the breadth and range of our findings. On the strength of the specific characteristics of the different cases, we applied diverging methods for the individual problem components. Thereby four different research methods have been used with the aim of the finding's expansion [35].

Table 2. Companies involved in the Case Study

Domain	*Project Partners*	*Size*
NU	Hospitals	1 large
		1 medium
	Nursing homes	1 small
		1 medium
		2 large
MT	Machine manufacturer	1 medium
	Airport	1 large
LG	Logistics companies	1 small
		1 large

Conducting the multiple case study design, a use case was defined when an activity profited by gaining better access to information or a simpler process was achievable by the use of a smart glass application. In this section, we will briefly explain all employed methods. Starting point and supporting method during our research was a (i) literature review to find links between our findings and existing research. (ii) Shadowing served to identify potential use cases by observing workflows and every day activities. The survey was documented in the form of field notes and process models. To gain further insights on the requirements and needs of the domain experts we conducted (iii) expert interviews. We combined these interviews with evaluations of smart glass applications we were currently working on, to give the interview partners an impression of what smart glasses are capable. After the interview partners had tested one of the applications, we asked them (1) for what else they would like to use such a smart glass in their daily work routine, (2) which processes of their work were the most time consuming or difficult and (3) at what point in their daily work they would like to access information. Furthermore, we held (iv) workshops with focus groups to enable a thematic exploration of research objects from a practical perspective. We formulated a use case if it was supported by at least two independent sources from the spectrum of data sources mentioned above.

4 Taxonomy of use cases for smart glasses in service processes

In total, we found 76 use cases by applying the methodology described above. Through inductive grouping of the use cases by function and process group, we identified 11 categories of use cases, which are listed in Table 3. The inductive grouping was conducted in a group session by the authors. Use cases were printed on paper cards and rearranged into different clusters until groups emerged. In the following, we briefly describe each category in more detail and provide representative examples. A list of all use cases can be found in the Appendix.

Table 3. Taxonomy of use cases for smart glasses applications

Application Area	*Description*
Communication	Helps to get or send information to the operation location
Documentation	Provides the possibility to document processes on the fly
Process guidance	Provides guiding information
Education	Use smart glasses to teach employees
Alerts	Attracts user attention for urgent information or warning
Data Visualization	Shows helpful augmented information in-situ
Automatic Control	Reduces error rates in error-prone processes
Inventory management & automatic ordering	Automatically keep track of objects and resources to enable optimize consumption, usage and re-ordering
Resource allocation	Manage limited capacities, e.g. time, staff
Text Handling	Helps users generate or interpret written language
Navigation	Providing routes and action sequences

4.1 Description of application areas

Communication

A typical example for a communication use case can be found in maintenance. Machine manufacturers sell their machines to customers around the globe. When a machine breaks down, the entire assembly line needs to be stopped and the machine has to be repaired. Currently, maintenance technicians try to resolve problems over the phone or have to send a maintenance technician oversea. The situation could be solved more efficiently, if a worker at the assembly line could use a smart glass application with a live streaming feature. The maintenance technician can thereby see the machine over his PC and give instructions via voice or adding virtual arrows into the live stream.

Documentation

Documentation is a vital part of many processes within logistics, maintenance and health care. In many cases, documentation is needed to fulfill legal requirements.

For instance, chronic wounds of patients need to be documented on a regular basis. In the health care facilities we visited, health care professionals were not satisfied with the current process. It is time-consuming and the documentation is not perceived as accurate. A smart glass application could reduce the time required for documentation and improve its quality. Health care workers could wear smart glasses during the wound care management and fill out the wound protocol via voice commands or hand gestures without breaking the aseptic chain.

Process Guidance

In all three domains, we encountered processes, in which practitioners needed information in-situ for accurate process execution. Maintenance technicians need to know the sequence of maintenance steps and how to perform them. Health care professionals need to make sure they administer the right dosage of the right medication to patients. In logistics, small parts often need to be picked from shelves and placed in boxes, which are then send to the customer.

Education

A well-trained work force is crucial for workplace safety and efficient process execution. Teaching takes up significant time and effort within organizations. With smart glasses, it is possible to design standardized lectures that new employees can work through in the real world environment. For example, in the maintenance domain technicians often need to learn how to maintain machines they do not already know. Augmented Reality smart glasses are very adequate to support such teaching processes, because they can display step-by-step tutorials or show spatial information about hidden parts while the user has both hands free to interact with the machine.

Alerts

Process-related dangers may occur in the daily routine of the workforce. If not taken into account, these dangers may damage the worker or the goods treated. Safety alerts in wearable devices such as smart glasses can be used to remind workers of process-related dangers such as treating a patient with an infectious disease or handling hazardous goods with forklifts in warehouses.

Data Visualization

Stored data, which describes properties of goods treated, may support the working process. E.g. in maintenance displaying names of machine parts can support communication. When treating patients, it can be helpful to know biographic details, medication, diagnoses, written advice from colleagues or food preferences while talking to the patient. In logistics the loading process can be visualized to optimize the load mass. Smart glasses can provide such information in an unobtrusive manner.

Automatic Control

Automatic control of goods can be relevant to all domains in which goods have to be ordered. This is true for maintenance, healthcare and logistics. In logistics centers, incoming freight needs to be checked for damages and completeness. This can be automated by taking a picture of each parcel and scanning its barcode while being able to continue working hands-free.

Inventory Management & Automatic Ordering

Every domain with an inventory may use an inventory management and automatic ordering process if goods have to be replaced regularly. During maintenance, parts of machines often need to be replaced while maintenance workers hands are smeared with oil. Smart glasses could automate this process by simply scanning the product code of the defective part and sending an ordering request.

Resource Allocation

Limited resources like time, space, human capacity and goods are allocated through smart glasses, as the user captures distribution problems, gets informed about available capacities, or retrieves new tasks to compensate an inequitable distribution. For instance, a nurse can get the location of their colleagues displayed. This information can be used if the nurse needs help for a specific task. It may be of special relevance in case of an emergency.

Text Handling

Since many nurses, maintenance and logistics workers work in foreign countries in which other languages than their native language are spoken, smart glass applications capable of translating written text into their first language would be helpful. Moreover, such an application could be helpful for processing shippings and machine parts from other countries or translating Latin medication and body nomenclature.

Navigation

In all three domains, workers often need to navigate from one workplace to another. The optimal route can thereby depend on differing variables. For instance, nursing pathways in health care facilities can be complex. During work, nurses have to consider what needs to be brought to the patient's room, what has to be carried away and in which order patients should be visited. Medication and hygiene essentials like towels have to be present in the patient's room at the right time. However, these objects may be stored in different locations. A smart glass can calculate the shortest way and provide the result as a proposal to the nurse.

4.2 Towards a framework for evaluating fit of process and smart glass technology

Having identified use cases for smart glasses in logistics, maintenance and nursing, we looked for common characteristics, that make them viable for support via smart glasses. We especially looked for differentiating characteristics to existing ICT like smartphones, PCs and smart watches. Figure 1 displays our framework. Smart glass use cases are only feasible when **timely access** to information is required. If timely access to information is necessary to execute a potential use case, **mobility** requirements can make support via PC infeasible. These characteristics have already been proposed by Liang et al. for mobile technology in general [36] and therefore should also apply to smart glass use cases.

Figure 1. Framework for task-technology fit of smart glasses

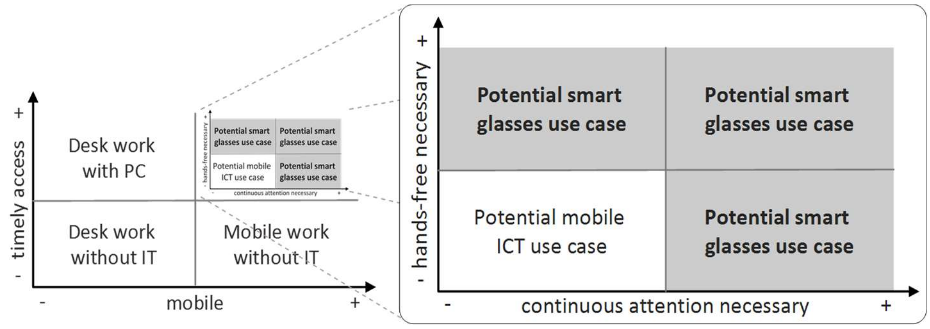

Table 4. Questions for task-technology fit evaluation

Question	*No*	*Yes*
Are both hands necessary for execution of the process?	--	++
Do the activities require timely information access?	--	++
Do the activities demand high mobility?	--	++
Is continuous attention needed?	--	++
Can in- and outputs be depicted visually and/or auditory?	**-**	+
Is a simple visualization possible?	**-**	+
Is network-connectivity possible throughout the site?	**-**	+
Is the amount of information needed also displayable?	**-**	+
Are speech-commands possible?	**-**	+
Is content already digitally available?	**-**	+
Can GPS and localization improve the process?	**o**	+
Can video-communication support the process?	**o**	+
Is the social environment open towards new technology?	**-**	**o**
Can technology-harmful external factors (e.g. dust) be eliminated?	**-**	**o**

-- prohibitive **-** obstructive **o** neutral + favorable ++ required

By comparing the smart glass use cases listed in the Appendix, we found that the following characteristics can help to differentiate smart glass use cases from mobile digitization use cases in general.

Digitization via smartphones and wearable devices like smart watches becomes infeasible when **continuous attention** is required or **hands-free** interaction constraints exist. For instance, it is not advisable to interact with a smartphone while operating a forklift, because the user's attention is diverted through technology interaction. On the other hand, use of smart glasses would be possible in such cases because, similar to navigation systems in cars, information is augmented in to the field of view, which allows users to keep their focus on the task at hand. Hands-free interaction constraints occur whenever a person cannot use either of his hands to interact with an ICT. Examples of such constraints are to hold an object with both hands or to perform an aseptic procedure. Smart glasses can be used under such circumstances, because applications can be designed to support interaction by voice commands.

Furthermore, we propose additional criteria for task-technology fit building upon our experiences from developing several smart glass applications with project partners. Table 4 presents the criteria as a set of questions. Using this question set, the functional scope can be further explored.

5 Conclusion

Smart glasses are an emerging technology with many potential use cases in the service sector. Their main potential lies in providing mobile information access while being able to use both hands. In this research, we have proposed a cross-domain classification framework for use cases. The framework can be used by domain experts and researchers for identification of digitization potentials in existing services and implementation of assistive systems. Our research contributes to the fields of Augmented Reality, Wearable Computing and Service Science by providing a cross-domain classification taxonomy for smart glass applications and a framework for assessing task-technology fit. Practitioners and researchers can use these artefacts to identify use cases that are of practical relevance to several domains. Our taxonomy provides a structured approach for digitization efforts of service processes. Practitioners from different service domains can identify use cases in their domain by looking at the categories and individual examples of our taxonomy. Starting from there, they can find similar digitization potentials in their domain without needing prior knowledge about smart glasses.

Once potential processes have been identified, our task-technology fit framework for smart glasses can help to assess the viability of smart glass support for a given task. Future research should empirically investigate, whether our frameworks can help practitioners identify service tasks that can be supported by smart glasses. Furthermore, throughout our research we noticed, that in all three domains data security is of central importance. Services in industry and health care often work with highly sensitive data that needs to be kept confidential. This is a complicated task, since most of the use cases we have listed imply use of cameras and networking technology. Sometimes even with external partners, such as machine suppliers or doctors. The recent advances of smart glasses technology holds promising potentials for improving service processes by providing ubiquitous access to information while working hands free.

However, the advances in smart glass technology also raise long-term impact questions. Future generations of these devices will probably have built-in cameras that are constantly recording, using computer algorithms for tracking humans and displays that only show information to its user. Diffusion of such technology into the consumer market will likely have an impact on our daily lives. Future research on privacy and ethical requirements for this pervasive technology is needed. This research may be part of a technology assessment, which allows addressing technological change as well as changes in morality. Furthermore, participative design of use cases is of high importance for being able to develop technology needs-driven. Thus, application of the framework shall imply inclusion of potential users into the discussion.

6 Acknowledgement

This research study is based on the projects ARinFLEX (grant number 02K14A080) and GLASSHOUSE (grant number 02K14A090), funded by the German Federal Ministry of Education and Research (BMBF) within the Program "Innovations for Tomorrow's Production, Services and Work" and managed by the Project Management Agency Karlsruhe (PTKA).

7 Appendix

Table 5. Complete List of use cases from the domains of nursing (NU), logistics (LG) and maintenance (MT)

Use Case	Explanation	Domain(s)
	Communication Use Cases	
Streaming	Hold videoconferences from the user's perspective	NU, LG
Internal Support	*Receive process guidance from internal experts*	NU, LG
External support	*Receive process guidance from external experts*	NU, LG
Teleassistance	*Show live-stream of machine for far distance maintenance*	MT
Client communitation	*Real-time video-documentation from a user's perspective*	NU, LG
Remote Support	*Get help instructions in emergency situations*	NU
Patient Hand-off	*Display recent patient-specific information*	NU
Fire-resistant sealing	*Show modifications for external certification*	MT
	***D*ocumentation Use Cases**	
Swich infusion needle	*Reminds the nurse and documents replacement process*	NU
Digitize patient data	*Support documentation while performing health care*	NU
Patient admission	*Provide step-by-step guidance for patient admission*	NU
Measure blood sugar	*Automatically transmit data to electronic health record*	NU
Document damages	*Document damages via camera and transmit to record*	NU, LG, MT
Process execution	*Document processes from the user's perspective*	NU, LG, MT
Monitor processes	*Track processes and monitor KPIs*	LG, MT
	***P*rocess Guidance Use Cases**	
Display plans	*Show inspection plans (e.g. in multiple languages)*	LG
Display and control package	*Support of picking-process*	LG
Drug management	*Support of drug management with a result control and an overview about drugs and relevant information*	NU
Patient discharge	*Support discharge of patients via checlists*	NU
Checklists	*Support standardized processes via checklists*	NU
Step-by-step guidiance	*Provide guidance for processes or emergencies*	NU
Machine maintenance	*Instructions can be displayed and visualized*	MT
Control cabinet maintenance	*Provide step-by-step guidance*	MT
Fire detector maintenance	*Documentation of fire detector maintenance during maintenance.*	MT
Display instructions	*Instructions to deal with goods can be displayed*	NU, LG, MT
	Education Use Cases	
Support of new employees	*Onbording of new employees can be supported by step-by-step guides*	LG, NU, MT
Integration into the facility	*support integration of newcomers by placing information at locations in facilities*	NU
Transfer perspective	*Allows others to view your actions from the viewer's perspective.*	NU, MT
Use Case	**Explanation**	**Domain(s)**
	Communication Use Cases	

Machine training	*View instructions and the machines at the same time.*	MT
	Alert Use Cases	
Warnings	*Context sensitive acoustic, visual or haptic warnings and safety instructions*	LG, NU
Reminder	*Proactive or controlled notification of crucial events*	NU
	Data Visualization Use Cases	
Visualizations	*Capture information and visualize it in meetings with patients and relatives*	NU
Show optimal load	*Show parcel loading order to optimize space usage*	LG
Vital signs	*Show recently measured vital signs of patients*	NU
Show progress	*Film motions of patients and show it to them afterwards*	NU
Visualize body parts	*Improve health care treatment by visualizing body parts*	NU
Manage nutrition	*Document nutrition consumption and incompatibilities*	NU
Stacking information	*Show how to optimally stack objects*	LG
Object information	*Show additional information about the object*	LG
Show machine configuration	*Help maintenance technicians customize the maintenance to the machine at hand*	MT
Show wiring plans	*Display hands-free visualization of wiring plans next to the machine*	MT
Show patient data	*Show patient data in the patient's room*	NU
Measure objects	*Measure and document the length or size of objects*	LG
Support simulations	*Simulate real world situations for training*	NU
	Automatic Control Use Cases	
Recognize and input errors	*Input-based recognition and feedback to the user in case of errors or mistakes*	LG
Automatic monitoring	*Camera-based recognition and feedback to the user in case of errors or mistakes*	LG
Automatic monitoring for picking	*Camera- or sensor-based checking of picking, e.g. whether workers use the correct compartments*	LG
Automatic checking of promotional displays	*Camera-based checking of the assembly of promotional displays according to the specifications*	LG
Object monitoring	*Camera-based checking of damages or integrity of different objects*	LG
Automatic monitoring of dangerous goods	*Camera-based checking of the goods-handling with dangerous or hazardous goods*	LG
Checking of medication compartments	*Support examining personnel through a display of the correct compilation of medication.*	NU
Predictive Maintenance	*Data visualization on predictive actions in maintenance*	MT
	Inventory Management & Automatic Ordering Use Cases	
Automatic reordering	*The smart glass tracks consumption and re-orders material*	HC
Order parts	*Display availability of machine parts during maintenance*	MT
Material overview	*Display location and amount of existing material*	NU, LG, MT
	Resource Allocation Use Cases	
Monitoring	*Capture and analyze workflow data*	LG
Reward System	*Gamification approaches to reward efficiency*	LG
Workforce distribution	*Prioritization of tasks and workforce based on process metrics*	LG, NU, MT
Monitor workload	*Capture data and prioritize tasks and assistance based on individual performance*	LG
Use of space	*Allocate storage locations efficiently*	LG
	Text Handling Use Cases	
Translation of text	*Camera-based recognition of text followed by a translation*	HC, LG, MT
Speech-to-Text	*Enabling technology for speech-based documentation*	HC, LG, MT
	Navigation Use Cases	
Navigation instructions	*Guide employees by displaying navigation information.*	LG
Real time maps	*The smart glass displays the map with real time traffic information.*	LG
Optimize pathways	*Optimized pathways for nurses could be provided.*	NU
Find place of action	*Employees could be navigated to their workplace.*	MT

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