Interaction Design in the Active and Assistive Living Field of Practice

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Abstract. The design process of interactive systems is a multifaceted process that can lead to various forms of manifestations. Designers can draw on different interaction design styles to realize the intended, to-be designed interactive system and the corresponding HCI artifacts. This work identifies and investigates different interaction design styles based on concrete prototypes that have been designed, developed and evaluated in co-funded research project in the Active and Assisted Living domain. In total, the work presents 12 concrete prototypes which have been implemented between 2011 and 2018 and list 8 designable interaction design styles. The work lists identifies main characteristics and elaborates their relationships and dependencies which serve as basis for the future extensive research work that questions the impact of different interaction design styles on the targeted end users supposed to use the intended, to-be designed interactive system.

Keywords: Interaction design · IxD · User centered design process · UCD · Active assisted living · AAL · Maslow's pyramid of needs

1 Introduction

Human Computer Interaction (HCI) is a multidisciplinary field including, among some others, computer science, cognitive and behavioral psychology, anthropology, sociology, ergonomics, industrial design [1]. Moreover, HCI addresses a broad range of topics and has various forms of manifestations. This also applies to people that use HCI artifacts. They have different needs, different expectations, different preferences and different habits. Unfortunately, these individual characteristics are usually considered only superficially during the design process of interactive systems. This very often results in dissatisfaction and frustration in latterly use of these systems. Even if the provided functionality is perceived as valuable, user might reduce the usage time or stop using the offered systems because they leak to support individual aspects. Thus, interactive systems that target the long-standing engagement with the user are requested to address these individual aspects in order to reach the aimed goal.

The User Centered Design (UCD) process [2] contributes towards this goal and involves the user at the very early stage of the design process. Moreover, some UCD methods, for instance, the participatory design method, involve the user on such a deep level, that users become co-designers during the design phase. This in fact, can increase

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users' satisfaction about the final product, but consequently this approach, at the same time, also increases the required efforts during the development process in terms of time, costs and management.

Situated in the Active and Assisted Living (AAL) field of practice, we have been utilized the UCD process in several research projects during the development of various interactive systems. Consequently, we expected an increase of users' satisfaction and a long-standing user engagement with the offered prototype. Long-term user evaluation results, gained from these research projects, highlighted that even an increased user involvement and the linked increase of design and development efforts had some drawbacks. It was noticeable that many projects had a significant number of unsatisfied users which reduced the usage time of the developed prototype. Moreover, some users stopped using the offered solution before the end of the project period.

This represents a contradiction to the concept of the UCD approach since users have been involved from the early stage of the project. They have been involved in the user requirements analysis, in the mock-up testing, in the testing of the first functional prototype and very often also into the testing of the second functional prototype before the release of the final prototype. Since users were involved from the early stage of the project and even in the identification process of their needs, it is precluded that the functionality of the offered solution failed. Functional aspects have been explicitly requested by the users. Also, since users were involved in several design, evaluation and improvement cycles, it is precluded that the usability of the offered solution failed. The improvement of the usability was one of the key elements of every iteration step. These two aspects highlight that the applied approach could address basic user needs (in terms of problem identification and problem-solving utilizing functionality and usability) but also that the applied approach did not reach all targeting users on the individual level, considering their inner and very often unconscious values, wishes and needs.

This work contributes to the alleviation of the problem stated and represents the starting point of an extensive work that investigates whether and how far the utilized interaction design style influences the users' acceptance rate of the offered interactive system. In this work the focus is on the identification of different interaction design styles (hereinafter called as Interaction Design Opportunities - IxDOs) and on the elaboration of their characteristics, relationships, and dependencies. Future work will build upon this work and will focus on possibilities to reflection the user on the individual level. These two research areas build conclusively the basis for mentioned overall research goal, namely the investigation of the impact of different IxDOs on user's system acceptance rate. Figure 1 illustrates the workflow of the overall research and highlights in red the contribution of this work.

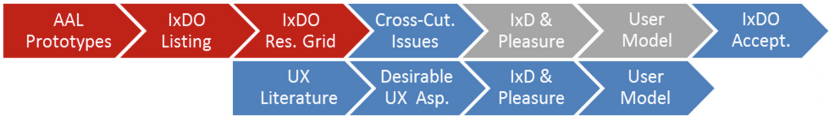

Fig. 1. The workflow of the overall research and the contribution of this work highlighted in red. (Color figure online)

The work is structured as follows: Sect. 2 summarizes the identified IxDOs, their key characteristics, and the corresponding prototypes in the AAL field of practice. Section 3 presents the so-called Interaction Design Opportunity Research Grid that supports the investigation of the identified IxDOs in a structured manner. Section 4 discusses the arrangement of the identified IxDOs based on their main purposes and user needs and based on dependencies that IxDos build upon each other. These results serve as the basis for the further work which is outlined in Sect. 5.

2 Interaction Design Opportunities

As pointed out before, the synthesis of different IxDOs emerged out of the AAL context and the fact that the UCD process in various research projects led to the development of different prototypes, each assignable to a specific IxDO class. This work is based on 12 concrete prototypes which have been implemented between 2011 and 2018. In total, we were able to identify eight different IxDO classes. The following section summarizes the key characteristics of these eight IxDOs in respect to the underlying AAL application field and the corresponding projects and prototypes, respectively.

2.1 Application IxDO

Application IxDO (App-IxDO) focuses on interaction designs that target the use of one primary interaction device and represents the classical and minimal setting that covers basic user needs regarding functionality and usability. A smartphone, a tablet device, or a wearable represent such a primary interaction device. However, the primary device aspect does not limit the number of usable devices within the system, but the interaction design opportunity rather characterizes the concept where the full functionality set of the intended application, and thus all possible interaction steps, are provided via- and accessible by one single device. In our AAL field of practice, App-IxDO was utilized in the large-scale pilot project moduLAAr [3]. The main objective of the project was to equip at least 50 flats with an AAL solution that can be adapted to the individual needs of the residents in assisted living homes. Further, App-IxDO was utilized in the project DOREMI [4, 5]. The aim of the project was to devise ICT-based home care services for aging people to contrast cognitive decline, sedentariness and unhealthy dietary habits. Both prototypes have been realized as Android applications and rendered on tablet devices.

2.2 Multi-Application IxDO

Multi-Application IxDO (MApp-IxDO) enhances the App-IxDO and offers users the opportunity to experience seamless interactions between multiple devices. The primary goal is to exploit synergies between complementary modalities used on multiple devices and to offer optimized interactions for the end user and the concrete use case. The seamless interaction aspect allows users to interrupt an existing interaction on one device and seamlessly continue the same interaction on another device. This approach

contributes towards an enhanced comfort. Similarly, complement modalities targets the increase of accessibility as well as the increase of error tolerance because users can change the interaction modality if the chosen one is inaccurate or does not fit their requirements. In our AAL field of practice, MApp-IxDO was utilized in the national co-founded project ibi [6, 8]. The main objective of the project was to develop a communication system that connects older adults in need of care, their relatives, and the formal caregivers. The prototype provided a seamless multi-device interaction experience between the used tablet device and users' TV device. Similar approach was also realized in the project YouDo [7]. The project objective was the development of a modular, extensible, and user adaptable multimodal information and training platform for informal caregivers. Again, YouDo provided a seamless multi-device interaction between users' PC, a tablet device, and user's TV device.

2.3 User Group Tailored IxDO

User Group Tailored IxDO (UGT-IxDO) focuses on optimization of traditional HCI techniques. The primary goal is to fulfill the users' wishes and meet their needs by increasing accessibility and usability. The former is related to aspects that provide equivalent user experience for people with disabilities, including people with age-related impairments, and the latter is related to the design process towards effective, efficient, and satisfying products. UGT-IxDO utilizes App-IxDO or MApp-IxDO and modifies either existing interaction techniques or generates new interaction techniques according to the users' needs. In our AAL field of practice, UGT-IxDO was utilized in the project ION4II [9]. The aim of the project was to develop an assistive system for visually impaired or blind older adults living in a care and residential facility. The prototype utilized the App-IxDO (a classical smartphone application) and modified the preexisting interaction technique (the graphical and touch-based UI) towards special user needs. The tailoring process was conducted of functionality reduction and the provision of tactile and acoustical interaction feedback for this target group.

2.4 Adaptive IxDO

Adaptive-IxDO has an analogy to the UGT-IxDO but a stronger focus on users' individuality. Adaptive-IxDO can react to changing conditions timely since the adaption process takes place during the operational and rendering time. In our AAL field of practice, Adaptive-IxDO was utilized in the project AALuis [10]. The aim of the project was to develop a middleware UI generation layer that can automatically adapt the user interface according users' wishes and needs.

2.5 Ambient Intelligence IxDO

Ambient Intelligence IxDO (AmI-IxDO) focuses on interactions that are supported by- and embedded in digital equipped environmental settings. As indicated in the work of Augusto and McCullagh [11], AmI is a concept that refers to a digital environment that pro-actively, but sensibly, supports people in their daily lives. From this point of view, AmI-IxDO represents a specialization of the mentioned Adaptive-IxDO with the focus

on the environmental setting. In our AAL field of practice, AmI-IxDO was utilized in the project RelaxedCare [12]. The aim of the project was to develop a supportive solution for informal caregivers. The goal was to reduce their burden by providing the overall wellbeing information of the person in need of care.

2.6 Personal Assistant-Based IxDO

Personal Assistant IxDO (PA-IxDO) focuses on the design of computer generated personal assistants. The focus is on the instant, direct, and personalized end user support, and on the representation of an independent and personal entity. PA-IxDO encourages a level of personality that can be uniquely named, and that people can become familiar with. Especially this characteristic, namely the aim to establish a trustful relationship with the user, shapes the PA-IxDO and differs from others. In our AAL field of practice, PA-IxDO was utilized in the project CogniWin [13, 15]. The aim of the project was to develop an integrated framework that provides personalized support to overcome eventual age-related memory degradation and gradual decrease of other cognitive capabilities. Furthermore, PA-IxDO is used in the current running project vCare [14]. The Project targets the development of a smart coaching solution grounded on personalized care pathways.

2.7 Companion IxDO

Companion-IxDO utilizes PA-IxDO techniques and enhances the previously mentioned independent entity towards a so-called artificial companion. The primary focus is on the design of virtual beings, able to support the user but also able to bear company to the user. Companion-IxDO employs activating and pleasant core affects such as curiosity, eagerness, desire, joyfulness, satisfaction to engage the user with the system, and to establish a kind of companionship with the user. In our AAL field of practice, Companion-IxDO was utilized in the project CompanionAble [16]. The aim of the project was to provide a new AAL solution through the combination of a service robot that is perceived as a companion and the seamless integration into the smart home environment. Furthermore, Companion-IxDO was also utilized in the project Miraculous-Life [7, 17]. In contrast to CompanionAble, the project used a virtual avatar as the embodied conversational agent and not a physical robot. However, both projects aimed at the same goal, namely the enhancement of PA-IxDO techniques towards an individual entity with a friend-like character.

2.8 Tangible IxDO

Tangible-IxDO focuses interactions that use physical and graspable components as the main interaction medium. As noted in [18] tangible user interfaces provide a physical representation of digital information and computation, facilitating the direct manipulation of bits. In our AAL field of practice, Tangible-IxDO is utilized in the ongoing project KithNKin [19]. The project tackles the problem of the progressive social isolation of older adults living alone and in far distance from their family members. It aims

to foster the communication and interaction with family members and friends utilizing tangible interaction objects which extend interaction capabilities of a standard tablet device.

3 Interaction Design Opportunity Research Grid

The goal of this work is the identification of different IxDOs and the elaboration of their characteristics, relationships, and dependencies. These results, in turn, serves as the foundation and the starting point for the before-mentioned overall research goal that investigates the impact of different IxDOs on users' system acceptance rate. Section 2 presented the identified IxDOs and sketched their main characteristics in decoupled manner. To draw conclusions regarding IxDOs impact on users' acceptance it is necessary to elaborate them in a structured manner. This task is accomplished by the so-called Interaction Design Opportunity Research Grid (IxDO-RG). Figure 2 illustrates the basic concept and structure of the IxDO-RG.

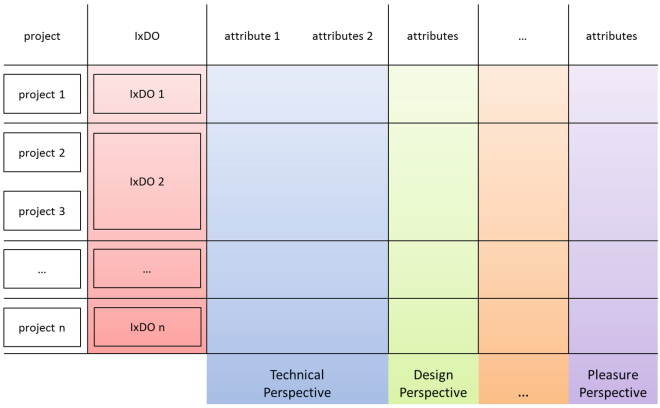

Fig. 2. IxDO-RG structure depicting the concept of information processing based on a research grid including the IxDOs, the corresponding projects and the IxDOs attribute clustered based on different perspectives.

The IxDO-RG is based on the Design Case Study Research Framework methodology which is presented in [20]. The first column of the IxDO-RG summarizes the involved projects followed by the corresponding IxDOs. The remaining columns represent co-called cross-cutting issues which highlight IxDO attributes clustered by thematic affiliations.

The IxDO-RG utilizes three cross-cutting issues, namely the technological perspective, the design perspective, and the pleasure-oriented perspective. The technological perspective characterizes IxDOs in terms of technological aspects such as software models, system architecture approaches, and concrete tools and frameworks that contribute towards the manifestation of these IxDOs. The design perspective

characterizes IxDOs in terms of interaction design purposes referred from the literature such as design for flow, design for the fast, design for the slow, design for the need, design for the pleasure [21, 22]. Finally, the pleasure perspective targets the reflection of end user experiences in respect to different IxDOs. As the name already suggests, the perspective focusses primarily on the evocation of different pleasure types as indicated in [23].

These cross-cutting issues have been developed in a successive process, started from the technological perspective in the AAL field of practice, over the design perspective to the pleasure-oriented perspective. Design results from the technological perspective (in form of dedicated arrangement of involved technological aspects) have been used for the development of the design perspective. Results from the design perspective (again in form of dedicated arrangement of interaction design purposes), have been used for the development of pleasure-oriented perspective. The pleasure-oriented perspective represents the basis for the future work that focusses on the reflection the users on their individual level. These threefold process sketches already the roadmap of the future work towards the final research goal.

However, since this work targets the first research step, namely the identification of different IxDOs and the elaboration of their characteristics, relationships, and dependencies the following Sections will neglect the cross-cutting issues and focus on the main column of the IxDO-RG that lists the eight identified IxDOs in a logical and relational order.

4 Logical and Relational Arrangement of IxDOs

The right arrangement of the IxDOs within the IxDO-RG structure is crucial step towards the final research goal. This section elaborates the arrangement of the eight identified IxDOs within the IxDO-RG based on user needs and dependencies between the IxDOs.

4.1 Arrangement Based on User Needs

In Sect. 2 it was stated that IxDOs can be described by individual sets of characteristics which form the main purpose of the IxDO. These main purposes address certain user needs that have been used for the initial arrangement within the IxDO-RG. The Table 1 summarizes the main purposes of the eight identified IxDOs and the corresponding key characteristics.

As indicated in Table 1, the App-IxDO represents the classical and minimal setting for the design of interactive systems. Thus, the App-IxDO can be used as the initial candidate for the order of IxDOs. The remaining seven IxDOs are arranged according their main purposes and the satisfaction of the underlying user needs that they aim at. This task is supported by Maslow's pyramid of needs [24].

Maslow's pyramid of needs was introduced 1943 and is based on believe that people are motivated to achieve certain needs. Maslow distinguishes between five different classes of needs which are arranged in a hierarchical order. Maslow assumed that a person needs to fulfill a lower ranked need before she or he can seek for a higher one. The

Table 1. Main purposes of the eight identified IxDOs and their key characteristics.

IxDO	Main purpose	Key characteristics
App-IxDO	Classical setting	Covers basic needs regarding functionality and usability
MApp-IxDO	Comfort setting	Targets the enhancement of usability aspects such as accessibility and error tolerance
UGT-IxDO	Supportive setting	Targets the enhancement of accessibility aspects for target groups with special needs
Adaptive-IxDO	Dynamical supportive setting	Targets the dynamic adjustment of the system according to the changing users' wishes and needs
AmI-IxDO	Environmental setting	Targets the support of users in managing daily life routines via utilization of their living environments
PA-IxDO	Assistive setting	Targets the personal and cognitive support of daily life activities
Companion-IxDO	Friendship setting	Targets the evolvement of the PA-IxDO toward individual entity with a friend-like character
Tangible-IxDO	Graspable setting	Targets the inclusion and emphasis of graspable artifacts in user-system interaction

classical illustration of Maslow's pyramided of needs with sharp borders is illustrated in Fig. 3 on the left. These sharp borders are often used as an aspect against the theory since it is understood (as it is in this work) that an entity, such as a software application, can satisfy several needs at once. This led to the developed of alternative versions with dynamic borders as depicted in Fig. 3 on the right [26]. These dynamic borders form overlapping need areas and highlight that the personal development is a continuous process and that users seek to fulfill more than one need at a certain point of time.

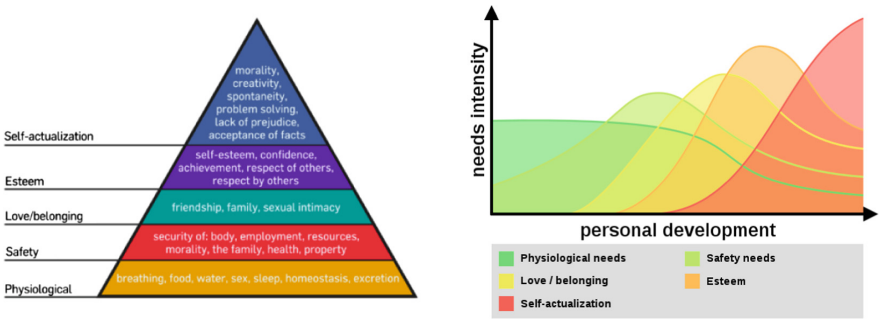

Fig. 3. Maslow's pyramid of needs highlighting distinguishable levels of user needs with sharp borders between levels on the left [25] and the needs with dynamic and overlapping levels [26].

Maslow's pyramid of needs was, beyond the mentioned sharp border problem, discussed controversially. Abulof Uiel presents in his work "Introduction: Why We Need Maslow in the Twenty-First Century" [25] an excerpt of the controversial debate.

However, regardless the controversial discussion, the basic concept of different needs matches very well the listing of main IxDO purposes and the satisfaction of user needs they are aiming at. Thus, it is reasonable to arrange IxDOs according to user need classes as defined by Maslow.

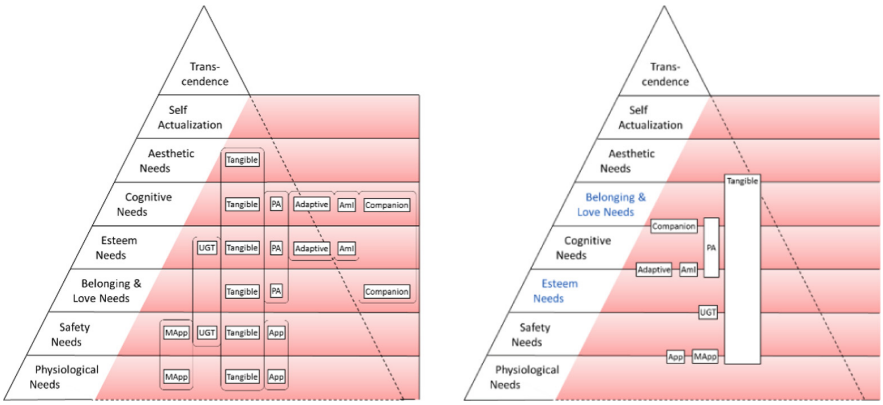

Fig. 4. Initial arrangement of IxDOs within Maslow's classes of need on the left and the simplified version on the right.

However, even if we use these Maslow's classes of need it is not wise to adapt the prioritization concept where users need to fulfill the lower ranked needs before they can seek for higher ranked needs. Following argumentation justifies this decision. From the end user perspective, the overall goal of an interactive system is the right treatment of the current appearing problem and consequently the right treatment of the current appearing needs. Thus, from this perspective the priority level (as indicated by pyramid shape) is regardless. Thus, in this work we will arrange IxDOs according to Maslow's need classes, but we will decouple their relations among each other.

As outlined before, the arrangement of IxDOs among different need classes is based on the main purposes and the underlying user needs that they aim at. These aspects have been presented in Table 1. However, at this point it needs to be mentioned that the neither the main purposes nor the underlying needs are meant to be holistic or universal applicable. They rather represent a cumulative view of the presented projects and prototypes in our field of practice. It is understood that different IxDOs can target different needs. The App-IxDO, for instance, can be designed to target rather users' cognitive needs instead of physiological and safety needs. An ordinary app-based game is a stereotypical example for such a setting.

Figure 4 illustrates the initial arrangement of IxDOs within the pyramid classes to the left. It is noticeable that certain IxDOs can be assigned to several classes. App-IxDO, for instance, can be assigned to the physiological need class as well as to the safety need class. Similar applies for other IxDOs. To reduce the complexity of the illustration, this initial setting can be rearranged. The following two actions provide a simplified version: (a) IxDOs can be placed between need classes. This is valid since

needs do not have a sharp border as depicted in the Fig. 3 to the left but rather fuzzy borders as depicted in Fig. 3 to the right, and (b) need classes within the pyramid can be rearranged. This is also valid since the need levels build not upon each other as argued before. The simplified arrangement is illustrated in Fig. 4 to the right. As one can see, two need classes ("esteem needs" and "belonging & love needs") swapped their places. Moreover, it is noticeable that the PA-IxDO and Tangible-IxDO span multiple need classes. This highlights that these IxDOs target the satisfaction of multiple needs. Conclusively, the arrangement within the pyramid of needs provides the following ranking: App-IxDO, MApp-IxDO, UGT-IxDO, Adaptive-IxDO, AmI-IxDO, PA-IxDO, Companion-IxDO, and in parallel to this listing the Tangible-IxDO that over spans all other IxDOs. This ranking is also influenced by the dependency structure of IxDOs as described in the following section.

4.2 IxDO Dependencies

The arrangement of IxDOs based on Maslow's pyramid of needs was performed in respect to their dependency structure. As indicated in Sect. 2, IxDOs build dependencies upon each other. They build dependencies on the technological complexity level, but they also inherit from each other on the conceptual level. Dependencies on the technological complexity level derive from the fact that more complex IxDOs utilize and extend technological concepts and methods that are used in less complex IxDOs. Inheritance on the conceptual level results from the continuous reuse of IxDO concepts. This is comparable to generalization and specialization of classes in the Object-Oriented Paradigm (OOP). Using this analogy leads to argumentation that higher ranked IxDOs specialize lower ranked IxDOs. Table 2 summarizes this concept applied on all eight IxDOs including their specialization and their inheritance.

Table 2. Specialization of IxDOs on the conceptual level highlighting the specialization attributes and the lower ranked IxDOs that serve as the source for the inheritance.

IxDO	Specialization	Inheritance from…
App-IxDO	–	–
MApp-IxDO	Collective	App-IxDO
UGT-IxDO	Tailored	App-IxDO or MApp-IxDO
Adaptive-IxDO	Re-adjustable	UGT-IxDO
AmI-IxDO	On demand	Adaptive-IxDO
PA-IxDO	Supportive	AmI-IxDO or Adaptive-IxDO
Companion-IxDO	Personality enriched	PA-IxDO
Tangible-IxDO	Physical	App-IxDO, MApp-IxDO, UGT-IxDO, Adaptive-IxDO, AmI-IxDO, PA-IxDO or Companion-IxDO

Figure 5 illustrates the final dependency structure of the eight identified IxDOs including Maslow's classes of need (to the right), including the dependencies on the technological complexity level (to the left) and including IxDOs inheritance on the conceptual level (arrows between IxDOs). It is noticeable that three IxDOs over span multiple technology complexity levels, namely the UGT-IxDO, the PA-IxDO, and the Tangible-IxDO. This is in line with the ranking based on Malsow's classes and based on the inheritance on the conceptual level as presented in Table 2.

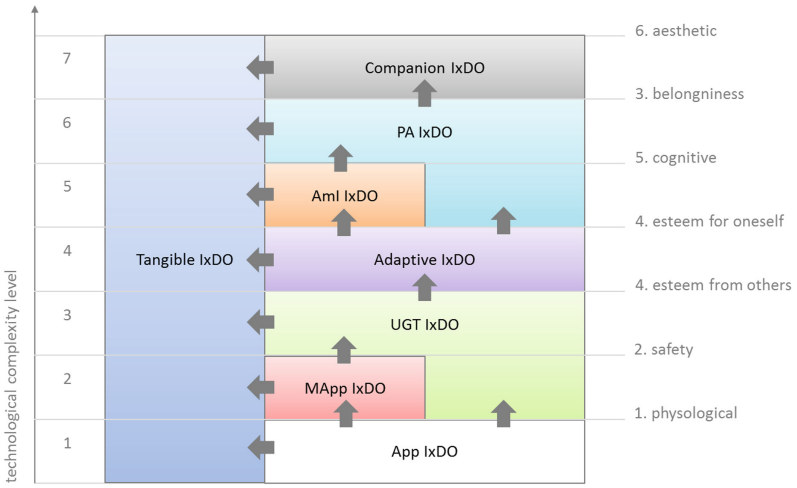

Fig. 5. Dependency structure of the eight identified IxDOs

This dependency structure represents the preliminary result of this work that can be used within the IxDO-RG.

5 Summary and Outlook

This work emerged out of the Active and Assisted Living (AAL) context and the awareness that prototypes developed in various research projects shared similarities regarding their interaction design styles. This led to the development of the overall research question which targets the investigation whether and how far different interaction design styles impact users' system acceptance rate. This work contributes towards answering this research question and represents the starting point of future research work.

The aim of this work was the identification of different interaction design styles which we further named as Interaction Design Opportunities (IxDOs), and the elaborate of their characteristics, relationships, and dependencies. In Sect. 2 the focus was on the identification of the eight IxDOs. Section 3 presented the so-called Interaction Design Opportunities Research Grid (IxDO-RG) that builds the working space for the identified IxDOs with the aim to investigate their characteristics from different perspectives.

These perspectives have been further named as cross-cutting issues. The Sect. 4 focused on the development of the logical and structural arrangement of IxDOs within the IxDO-RG. This represents the ground work for the further elaboration of the cross-cutting issues.

As pointed out earlier, this work is the starting point of an extensive research. The future work will focus on the development of a dynamic user model that considers users' inner values, wishes and needs. The IxDO-RG combined with this dynamic user model will build the research framework and the toolset that targets the investigation of the overall research question, namely whether and how far different IxDOs impact users' acceptance of the offered interactive system.

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