Interaction and User Experiences with Multimedia Technologies—Challenges and Future Topics

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ABSTRACT

In this paper, we investigate future topics and challenges of interaction and user experience in multimedia. We bring together different perspectives from overlapping fields of research such as multimedia, human-computer interaction, information retrieval, networked multimedia, and creative arts. Based on potential intersections, we define three application domains to be investigated further, as they create high demand and good prospect for long-lasting developments in the future. These application domains are: media working environments, media enter-/edutainment, and social media engagement. Each application domain is analyzed along five dimensions, namely: information quality, presentation quality, ambience, interactivity, and user expectations. Based on this analysis, we identify the most pressing research questions and key challenges for each area. Finally, we advocate a user-centered approach to tackle these challenges and questions in order to develop relevant multimedia applications that best meet the users' expectations.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*; J. [**Computer Applications**]: Miscellaneous

General Terms

Design, Human Factors, Measurement, Theory

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Keywords

Interaction, User Experience, Multimedia, Human-computer Interaction, Information Retrieval, Networked Multimedia, Creative Arts

1. INTRODUCTION

Gaining experience through interaction with multimedia applications is an essential part of our day-to-day work with computers. In this paper, we are looking into the future topics and challenges that this experience-based interaction demands. The work is motivated by and carried out during the Dagstuhl seminar on "Contextual and Social Media Understanding and Usage"[1]. It is a joined collaboration of different researchers from different fields including multimedia, human-computer interaction, information retrieval, networked multimedia, and creative arts. The overall space that is spanned by interaction and user experience is huge and currently there exists no good overall taxonomy or classification. As a consequence, we observe today in the different fields of research a lack in understanding and being aware of the different requirements that interaction and user experiences with multimedia technologies actually involves. To alleviate this situation, there are several goals of this paper that the Dagstuhl group discussed:

(a) definitions what interaction and user experiences mean,

(b) taxonomy and classification of the problem space along two major axes, namely the application domain axis and the assessment metrics, manifested in a foundation map,

(c) characteristics and challenges of each of the elements in the foundation map, and

(d) the future topics and directions how to approach these challenges to get more rigorous and holistic solutions.

[1]Seminar homepage: `http://www.dagstuhl.de/no_cache/en/program/calendar/semhp/?semnr=2008251`

This interdisciplinary approach and multiple goals towards an understanding of the relationship between experience and interaction formed the initial starting-point of our investigation. It is reflected in the structure of this paper, which is organized as follows: In a first step, we elaborate on the different notions of interaction and user experience from the point of view of the different research fields. These are briefly described in Section 2. Based on potential intersections, we define three application domains to be investigated further, as they create high demand and good prospect for long-lasting developments in the future. Those three application domains are described in Section 3. In Section 4, we assess the application domains with respect to the different understandings of interaction and user experience apparent in the various disciplines and provide an agreed understanding of the requirements implied with these areas. In Section 5, we present the most pressing research questions and key challenges derived from the provided analyses. In Section 6, we conclude with the proposal of a user-centered approach to tackle the challenges and problems.

2. INTERACTION AND USER EXPERIENCE

Experience-based interaction between a human and a computer system, making use of a range of media, is addressed in different facets and point of views from the different fields of research. In the following, we present the notion of interaction and user experience in the fields of multimedia, human-computer-interaction, information retrieval, telepresence, and creative industry.

In **multimedia-based human-computer-interaction**, it is of interest how humans communicate with a system and how humans are connected to each other through systems [13]. Users can interactively manipulate multimedia objects and make changes. Desired changes become immediately apparent (responsiveness and feedback). User experience entails how users feel about interacting with systems, e. g., happy, efficient, or what one can do with the system.

From an **information retrieval** (IR) standpoint, users can interactively inquiry systems to retrieve (multimedia) information [26]. The users can interact with the retrieval results and browse data [16] through faceted search [10]. In contrast to multimedia-based human-computer-interaction, the overall goal in IR lies in minimizing the interaction between the human and the computer in order to provide an optimized user experience in terms of productivity and enjoyment. Thus, interaction is merely considered a means to overcome the limitations of the system's ability to exactly produce what users want. (In the ideal world, the user thinks of an object to receive and computer instantly shows it.)

In **networked multimedia** such as telepresence [29] the system is seen as the mediator that enables better human-to-human communication and interaction. One goal of networked multimedia is to provide support for (nearly) natural interaction among the users through computers [20] in applications such as virtual meeting systems [14]. As a consequence, latency needs to be minimized so that people can converse like in a real world (avoid potential social interaction barrier by the computer). With respect to user experience, telepresence deals with, e. g., "out of body" experiences where the user is seeing oneself in a cyber space like in a virtual dancing scenario [30].

In the **creative industry**, interaction is seen user-driven [17, 18]. Users can do whatever they want to do. The computer systems are in the background and possibly do not interfere with the users' "workflow". Thus, the human-to-computer interaction is responsive but non-intrusive. In the creative industry, the goal is to develop adaptive and responsive systems that "know" what they are doing and how they should respond to the users. This raises the question whether the users expect deterministic system behavior or want to explore their creative side. In general, having control is essential to the users and the users need to understand what the system does. However, depending in which stage humans are in their processes, non-deterministic behavior and even imperfections in the multimedia systems (e. g., delays) are desired to get the creative side of it and produce something that is not anticipated. Thus, the users want to be challenged by the system and want to experience something new by using the system [1].

3. APPLICATION DOMAINS

The views on interaction and resulting user experiences of the considered fields of research are different. However, the elaborated discussion about these views in the different disciplines distilled distinct applications. These applications could demonstrate that the different disciplines could provide (in a collaborative effort) a holistic solution that far better suits the changing user needs then current more single-task oriented approaches. We cluster these applications in three application domains, which we outline below.

Media Working Environment.

This application domain deals with any kind of interactive multimedia applications used at work. The goal of the media working environment is to support the users to be productive at their workplace. To this end, the media working environment is designed to be task-oriented. The overall expectation of the users is to accomplish their tasks effectively and efficiently. We distinguish two kinds of media working environments, namely the *functional* and the *exploratory*. The functional working environment minimizes the iterations of user interaction with the system, as environmental, temporal, or personal reasons require punctual termination of the tasks to be done. Users expect the system to provide precise answers to their queries, to exhibit a deterministic behavior, and to support intuitive use. The system shall provide the information the user needs and do it fast. Such a system can be intended for engineers and helps them in finding specific construction parts needed for the design of a new engine. The system can also be for story developers in the creative industries who need to solve a problem in the ending of a soap episode. Thus, the functional working environment primarily (but of course not exclusively) relates to the understanding of interaction and user experience as in the research field of IR (see Section 2).

An exploratory system works in a similar fashion. However, the temporal constraints are less rigid or the general work purpose is to develop something that has not been created before. Thus, the tasks are rather creative and can be the development of a complete new car engine with drastically reduced consumption or searching for specific media assets to be included in the design of a new presentation

or exhibition. The key is to "surprise" the users, i. e., to show the users media assets and to suggest compositions that have so far not been done. Here, users expect a kind of system assistance that helps them in finding these new assets and experiencing the surprise (challenging factor). As a consequence, creative media working environments can show a non-deterministic behavior. In fact, such an non-deterministic behavior is expected by the users in order to develop new ideas. Thus, for the exploratory working environment we see the strongest relation to the understanding of interaction and user experience as in the creative industries.

The challenge is to provide systems that can adapt their strategies to the current user needs, thus be able to oscillate between functional and exploratory states. Such systems can only be achieved based on an interdisciplinary collaboration. Each discipline by itself will not be able to solve the integration challenge alone (achieve a goal in a particular time frame).

Media Enter-/Edutainment.

In this application domain, we consider the spare time activities of users for the purpose of entertainment and edutainment. Thus, in contrast to the media working environment, the main purpose is to be entertained and edutained by using media. In the media entertainment, users want to get emotionally involved, intellectually challenged, or physically engaged by consuming the content and using the application. With media edutainment, the main purpose is to learn and train using and understanding media. The users expectations here are mainly experience-driven and through this experience users learn about a (new) situation, e. g., learning about pollution or global warming via gaming. As such, the understanding of interaction and user experience in the media entertainment and edutainment domain mainly relates to the research fields of multimedia-based human-computer-interaction and creative industries and also makes strong use of networked multimedia.

The challenge is to provide systems that can sense human experience, which also mean that they are able to represent it accordingly. Only through the integration of the various disciplines described earlier as well as the additional integration of, e. g., psychologists and ethnographs, we will be able to establish interactive systems that can retrieve and present the adequate media in time.

Social Media Engagement.

Finally, under this application domain we subsume applications that aim at helping users to be socially engaged and stay socially engaged. These can be applications for assisted living and smart buildings [19]. Examples are checking on elderly relatives, shared living, and providing a better family bonding, e. g., during a long-term separation of mother and child [7, 4]. For this application domain, we mainly see a connection to the research fields of multimedia-based human-computer-interaction and networked multimedia that target at gaining a better understanding of human-to-computer communication and enabling better human-to-human communication and interaction through systems.

Applications of this kind are by nature ambient as well as presence-oriented. Even though here the retrieval is—as one of the few application cases—not the driving factor, these type of applications require a high amount of interdisciplinary collaboration as various aspects of interaction as well as experience need to be addressed.

4. ASSESSMENT DIMENSIONS

Quite a substantial part of human activity can be encompassed by the three application domains outlined above. Humans will pass from one area to the other and they will expect that a computer system understands where the current focus of interaction and the level of experience currently stands. Yet, the three different application domains have different requirements with respect to application aspects such as the environmental and temporal context in which they are used, user background and knowledge, and so on. Therefore, we see the need to identify dimensions that allow to establish means for a system to identify these levels and to accordingly adapt to the context. We identify five dimensions that are apparent in each application domain and facilitate to establish a first set of requirements for defining what interaction and experience for a domain means. The dimensions are defined based on our understanding of interaction and user experience in Section 2 as well as the characteristics of the three application domains described in the previous section. The assessment dimensions are:

1. **Information quality**: In this dimension, we consider at what level of quality the knowledge and content should to be offered by the application. It can range from very accurate or real-time information to more general statements such as enjoyable content or the content should approximately show the sensor data of the application. Thus, the knowledge and content quality is about the accurateness of the information provided by the application. However, it does not deal with how the knowledge and content is actually rendered and presented to the users. This is part of the presentation quality described next.

2. **Presentation quality**: With the presentation quality, we consider the communication of the knowledge and content by the system to the user. Thus, it addresses how content is presented, in which resolution, color depth, bitstream quality, and so on.

3. **Ambience**: With ambience (or presence, immersion), we consider how important it is that the users can immerse into the use of the system while interacting with it or immerse in the content provided by the application.

4. **Interactivity**: With interactivity, we valuate the importance of a system's response based on user input. This quality feature also deals with how users act upon system feedback.

5. **User experience and expectation**: With this characteristic, we consider the kinds of experience a user has. It especially incorporates the expectations with which the application is used. Thus, we consider how to meet the user expectations and requirements with respect to, e. g., the system response time or how the system otherwise behaves.

We use these five dimensions on the three application domains to establish a first and still very simple foundation

	Media Working Environment	Media Enter-/ Edutainment	Social Media Engagement
Content Quality	High, explicit quality	Enjoyable content	Medium, approx. sensor data
Presentation Quality	Simplistic, functional, task-appropriate	Depends on location and source (context)	Medium, facilitate communication
Ambience	Task-appropriate (single user task vs. collaborative)	High, engaging	Ambient, but not immersive
Interactivity	Time-efficient	Amount / modality depends on user	Natural interaction
User Expectations	Intuitive, fast, precise	Be entertained, become engaged	Invisibility of the system

Figure 1: Foundation map for describing the influence of application dimensions (assessment metrics) on the application domains of media working environment, media enter-/edutainment, and social media engagement.

map (the term ontology would be an exaggeration) that explains basic differences between the application domains. The foundation map is described in Figure 1.

We are, of course, aware that the provided foundation map should not be viewed as detailed and ready to be implemented. Our goal is rather to identify and generalize functionality that the application domains provide with respect to their interaction as well as experience capabilities. In fact, this is a multidimensional space we address here through which an adaptive system can only navigate if other models are incorporated such as the model of canonical processes of semantically annotated media production [9, 8], the model on (multimedia) semantics as described in [22, 21], or the event model as presented in [28, 27]. However, we believe that the current version of the foundation map is a first step toward a proper modeling of interaction and experiences in adaptive systems.

5. RESEARCH TOPICS AND KEY CHALLENGES

Besides the already mentioned necessary improvement of the foundation map and its integration with other relevant models regarding interaction and experience, a number of additional research issues and challenges were identified. Each of them will help to provide a more unified model that can allow adaptive systems to provide adequate interaction as well as experience gaining. The research issues are:

1. Explore use of new forms (combinations) of multiple media and modalities in interactive environments that facilitate learning and training, entertainment, and fulfill (immediate) information needs of users. Such interactive environments may make use of gaming metaphors, mixed use of physical and cyber space, and so forth.
2. Explore the use of existing multiple media in combination with new technologies for new applications. These can be use of video streams and sensors in smart homes for assisted living. Another example are working environments for meeting support such as virtual conference systems.
3. Investigate in systems for automatically detecting the user context (such as individual foreground knowledge, preferences, interests, needs, location, time, used end device, and social situation [2, 15, 5, 23, 6, 3, 24]) and properly act upon it. Such applications can be in both the working environment and entertaining environment. In addition, we have to address the problem of users constantly switching between different contexts, a currently ignored problem.
4. Dealing with huge amounts of data while ensuring appropriate system response time. One approach to alleviate this problem is prioritizing information and by this reducing the data set. This topic is tackled, e. g., by contests such as the Billion Triple Challenge [25] that aims at optimizing performance and quality of the information for very large data sets.

To summarize, we think that the future challenges to be researched and solved are:

1. Learn how to computationally model, capture, process, and use context in multimedia systems. To this end, we need to identify the relevant aspects of context (depth of modeling), accurately capture this context, and being able to recognize fast changes in context (e. g., in surveillance and emergency response).
2. We need to leverage and bring in new modalities and media in social interaction and social collaboration.

Thus, we need new forms of social media like blogging, better understanding of user context, and encourage use of new forms of media.

3. Finally, we need to develop systems that users can intuitively access so that they can concentrate on the experience. To this end, it is necessary that the system is aware of the users expectations and reacts appropriately to it.

6. FUTURE TOPICS AND DIRECTIONS

In order to address and tackle the challenges identified above, we propose the following approach. We assume that a number of iterative cycles between the two items will be needed to carried out.

- We need a holistic approach towards harmonizing different models for capturing, processing, and using context as well as experiences in interactive multimedia systems. The different modalities and media in applications for social interaction and social collaboration are to be combined. We further see a high demand for design and implementation techniques for enabling interactive performance. This approach indicates in a bottom-up approach what is feasible with state of the art technology.

- We require user-centered design of applications and understanding users through interaction with the system. Thus putting users first when aiming at designing and implementing interaction and user experience in multimedia systems. As this approach takes into account the users' needs and expectations as the main means for designing applications a top-down view to system development needs to be applied.

The further, we need to consider and study models and approaches from other disciplines. For example, if we want experiences and user impact in the area of teaching tools, we should tap into educational theories. Other major disciplines where we need to investigate in as a community are psychology, social science, and others that have developed for many years communication theories. The discipline of economy also studies people and has theories how people behave due to economical factors. To summarize our approach, we believe in the need for a human-centered design and computing [11, 12] in order to address and tackle the research topics and key challenges identified in Section 5.

Applications from the domains outlined in Section 3 that could possibly benefit from our approach are: video surveillance, emergency response, tourist guides, enterprise information search, business intelligence (e. g., consumer intelligence, and others), creative content creation aid, games and creative arts, ambient and smart environments, and folk computing.

7. CONCLUSIONS

In this paper, we investigated future topics and challenges of interaction and user experience in multimedia based on different perspectives from overlapping fields of research such as multimedia, human-computer interaction, information retrieval, networked multimedia, and creative arts. We defined three application domains to be investigated further, as they create high demand and good prospect for long-lasting developments in the future, namely: media working environments, media enter-/edutainment, and social media engagement. Each topic is analyzed along five dimensions, i. e., information quality, presentation quality, ambience, interactivity, and user expectations.

The result of the analysis established is the main contribution of this paper, i. e., a foundation map that explains basic differences between the three application domains with respect to user interaction and user experience gained from interaction. Of course, we are aware that the provided foundation map should not be viewed as detailed and ready to be implemented. Our goal is rather to identify and generalize functionality that application domains provide with respect to their interaction as well as experience capabilities.

Based on this analysis, we identified the most pressing research topics and key challenges for each topic. We concluded the paper with the claim that only a user-centered approach can achieve to tackle these research challenges and questions in order to develop relevant multimedia applications that best meet the users' expectations. We believe that the overall goal of our research and the applications we are developing is to make the best combination of user(s) and system(s). The goal is to make users happy and productive.

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