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Design implications for Designing with a Collaborative AI

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Abstract

This paper proposes a framework for a collaborative designing system from an interaction design perspective. Using the agent-based model from the mixed-initiative interaction framework as a starting point, an ideal interaction scenario in a web design context is described and implications for designing collaborative systems are presented. Previous work on machine learning and artificial intelligence for interaction design has already looked at recognition of designers' intent and combinatorial problem-solving in design. This paper, in contrast, focuses on the interaction design perspective of designing such a system, and introduces a framework that highlights requirements in this context. The framework uses the notion of *task model* and *world model* from agent-based models as a frame, and the resulting implications call for a stronger involvement of designers in the process.

Can systems become collaborative partners in a design process? I would like to reformulate this question and ask: What does a system need to know in order to communicate and collaborate with a designer in a creative context? This formulation allows a practical view on the underlying problem. In the following I will first elaborate on the need and definition of collaborative design, which is followed by an ideal scenario illustrating how a collaborative designing system (CDS) interaction could look like. In the last part, a framework looking at the design implications for creating a CDS from an interaction design perspective is presented.

Collaborative Design

Designing is a creative approach to problem-solving. Creative thinking and approaches build the fundament of the design process. Definitions of creativity are numerous, however in this work the version of Sarkar et al.'s comprehensive work on 160 definitions of creativity is used (Sarkar and Chakrabarti 2008). They conclude that 'Creativity occurs through a process by which an agent uses its ability to generate ideas, solutions or products that are novel and valuable.' (Sarkar and Chakrabarti 2008). This is in line with recent research on creativity as an incremental process (Sawyer and others 2014), and illustrates the connection to the design process, which consists of identifying the needs and requirements of the user, generating ideas, and evaluating them to satisfy the needs and requirements (Preece, Rogers, and Sharp 2015). The uncertain, exploratory nature of designing, where neither the final goal, nor the complete design space is specified beforehand and potential solutions are created and rejected iteratively (Allen, Guinn, and Horvtz 1999) makes it a complex problem-solving task.

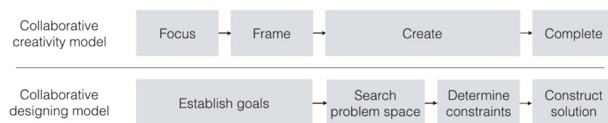

Figure 1: Collaborative creativity and design models

Creative collaboration plays an increasingly important role in solving complex interface problems (Lahti, Seitamaa-Hakkarainen, and Hakkarainen 2004). The combination of different skills in a design team extends the solution space and increases the amount of available cognitive and creative resources to find an optimal solution. It allows to overcome uncertainty through discussion and interactive evaluation of consequences and limitations.

In order to illustrate collaborative design, this paper draws from two models of the same process with different focuses. The first one (Aragon and Williams 2011) focuses on creativity in the process of collaborative design, while the second one (Lahti, Seitamaa-Hakkarainen, and Hakkarainen 2004) draws from a more practical understanding of collaborative design. The combination of both will be used in the later descriptive scenario of a CDS. For clarification, an overview is presented in Figure 1.

The first model introduces four key phases of collaborative creativity which are *focus, frame, create and complete*. Within the *focus* phase the group's rationale is explored and discovered. In the following *framing* phase, the group forms trust and common understanding within a given context to enable an effective and efficient collaboration. These more preparing phases result in the *creation* phase, where "ideas [are] generated by individuals, then shared and built upon by the group members from the perspective of their particular knowledge bases, adding aspects of information and data that may not have been apparent to the idea's originator" (Aragon and Williams 2011). In the final *completion* phase ideas converge to final structured ideas, which are evaluated and approved by the team and the client.

The model mentioned by Lahti et al. describes collaborative design also as a four step process of actively communicating and working together. (Lahti, Seitamaa-Hakkarainen, and Hakkarainen 2004) The aim is to jointly *establish design goals*, *search through design problem space*, *determine design constraints*, and *construct design solutions* with a common goal in mind. *Establish design goals* describes the problem-clarification phase (Cross and Cross 1995). The *search through design problem spaces* describes the exchange of different ideas and views of the design problem. In this phase all participants build on, neglect or reinterpret previous ideas in order to interactively explore the solution space. The fit of the created solutions is evaluated based on earlier identified requirements in the *determine design constraints* phase (Lahti, Seitamaa-Hakkarainen, and Hakkarainen 2004). These two steps are iterated until the groups decides to *construct certain design solutions*.

In line with the Mixed-Initiative Interaction (MII) framework (Allen, Guinn, and Horvtz 1999), a agent, here the CDS, would be a member of the design team that shares the same goals and collaborates iteratively in an designer equal manner with the designer through changing communication initiatives. In order to fulfill these requirements the intelligent system has to constantly update its understanding of the task. This equals the designer's constant rephrasing of the goal during the design process. Due to the special skills of each participant, designer and CDS, collaborative designing in this constantly changing environment opens up new possibilities within the design process. However, this creative context requires designers to be further involved in the creation of such an intelligent systems, as well as new interaction concepts that go beyond existing ones (Höök 2000).

Scenario: Designing with a Collaborative AI

Borrowing the concept of legitimate peripheral participation for the context of design (Lave and Wenger 2002), we can look at a CDS as a newcomer and the designer as an experienced mentor. Over time the system observes and learns the practices of the designer, as the designer learns new approaches from the system, until both reach a state of equal mentorship and discover their legitimate role within this process. The following scenario outlines such a collaboration.

Focus phase / Establishing goals. Consider a task of designing a new landing web page for a company. The designer approaches this task together with a CDS. First, the client's requirements are communicated to the system, like target groups, but also soft factors like the aimed impression of the page. This part is more an instruction process than an active discussion, with feedback questions for clarification.

Frame phase / Establishing goals. Aragon et al. (Aragon and Williams 2011) describes a 'framing phase' of building trust in the understanding of the underlying project aims, which is crucial for a successful collaboration. The designer "discusses" the stated requirements with the system, which in turn suggests first ideas, similar projects, or inferred information. Based on the designer's feedback, the system adapts its understanding and presents it to the designer for further discussions. This supports the system to form a better understanding of the task and to become a more equal participator in the collaboration, and can also help the designer to sharpen her understanding of the project requirements.

Create phase / Searching the problem space. Then the designer starts looking for inspiration. While similar projects, e.g from herself or competitors, can inspire new structures or interaction concepts, new impressions or innovations often come from other domains, like nature. Both are equally important for successful design solutions. The system suggests examples for inspiration, but also enables the designer to save, compare or elaborate on certain inspirations as well as rejecting them. Based on its understanding of the task, the system also presents ideas and concepts less related to the project to extend the solution space. As part of this ideation, ideas for the current project are created. The CDS offers a representation of ideas that allows the designer to navigate in the solution space by recovering, evaluating and comparing previous ideas based on given requirements.

Create phase / Determine Constraints. Every design has to be evaluated for the constraints it might cause, e.g. it increases task efficiency but decreases usability for elderly users. Instead of user testing all potential solutions, the system simulates and predicts user behavior from different perspectives and presents the supported requirements and constraints for each design. This reduces the number of conducted user tests and improves the efficiency of the process by providing decision relevant information to the discussion.

Complete phase / Construct solutions. When both, the designer and the system agree on a number of possible solutions, the design of higher fidelity prototypes starts. The system highlights e.g. aesthetic or usability estimations on the currently designed solution and compares them with the designers opinions. Together with the designer, a suitable landing web page solution for a final user test is chosen or combined based on preferred features. The system supports the designer to create such hybrids by suggesting preferred interaction concepts, structures etc. from the discussions.

After the project, the system analyzes the reasons behind selected and rejected solutions. In later projects, it will inform the designer about this analysis and both will decide how relevant they are in the new context. This helps the system to discover its legitimate participation role within the design process and leads to a more equal impact on the following projects. The system also adapts its interaction with the designer in phrasing ideas or presenting alternatives, as the designer learns how to explain certain ideas to the system. This is a natural development within design teams that improves efficiency and solution quality over time.

Implications for designing a Collaborative AI

The scenario above illustrates a negotiated, mixed-initiative collaboration (Allen, Guinn, and Horvtz 1999) that describes the active initiation of dialog and reasoning on a equal stand. Due to the complexity of the task, the system must dynamically update its model of the task and the world around and

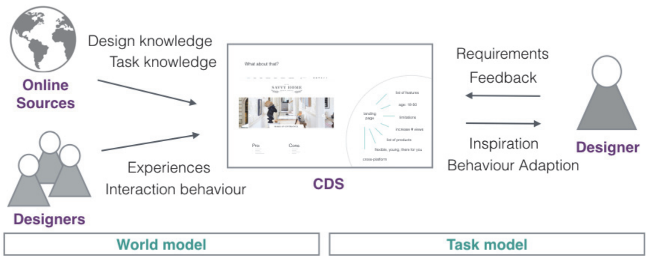

Figure 2: Framework for designing a CDS

be able to act upon it. (Allen et al. 2001)

In line with the agent-based models, two model views can be distinguished when looking at a CDS - the task view and the world view. In this section I present a framework for designing a intelligent system that collaborates with designers from an interaction design perspective. The framework highlights requirements drawn from the scenario described above, and their implications for designing a CDS.

Task model view

The task model view of this framework is composed of three interaction-relevant requirements to enable a system: *Understanding task requirements*, *Providing inspiration*, and *Adapting interaction behavior*. Those interact with a designer on equal stand within a design project.

Understanding task requirements. Task requirements includes information like type of web page, target group, but also soft factors like aimed impression of the web page or brand management. Having a conclusive understanding of the given task helps the system communicate and act efficiently with the designer. Expressing this knowledge not only increases his trust in the system, but also increases the system's predictability, which is crucial for its usability (Shneiderman 1989) and effectiveness.

Providing inspiration. Supporting inspiration and using inspiration from within and without the task's context is often done by formulating associations/bisociations. While associations related to connections within a domain, the term *bisociation* describes associations or connections of ideas beyond the current domain (Koestler 1964). Both are important tools for inspiration within the creation phase. Further, it allows systems to create suggestions for current issues that go beyond the replication of previous ideas or obvious links in a transformational creative way (Boden 1998).

Adapting interaction behavior to the designer is an essential feature of a collaborative interaction. In line with the behavior adaption among group members during creative collaboration (see 'framing' phase in (Aragon and Williams 2011)), the agent's task model should also consider preferences and behavior characteristics of the current designer. These preferences include the way of communicating (e.g. visual or abstract), preferred approaches of ideation or prototyping, and general preference of design styles (e.g. straight lines or figurative). This enables the system to adapt the way it organizes and expresses its communications with the designer. Further, it enables 'outside the box' ideas and designs which would otherwise be in the designer's 'blind spot'.

World model view

The world model view highlights requirements outside the current task. There are two potential sources of knowledge for the CDS, previous interaction with designers and online available information. To enable a system to collaborate in a design context four requirement are highlighted: *Task domain knowledge, Design domain knowledge, Experiences* and knowledge about *Human interaction behavior*.

Task domain knowledge includes features and challenges that are specific to the current design domain. Such information can be retrieved from behavior data, online data, or analysis of support tickets. In the landing page scenario above, this knowledge would e.g. include the diversity of the target group. A diverse target group, e.g. in age, implies certain design constraints due to the different cognitive abilities of different age groups. This information can be discussed in the focus phase as well as highlighted by the system during the create phase. Cognitive workload models based on this information could be used in the final evaluation phase. With every project this knowledge increases and helps the system and the designer consider more possible challenges early on.

Design domain knowledge includes general descriptions of design relevant approaches, concepts and tools. It includes the understanding of the design process, concepts like ideation, applied knowledge like device specific interaction concepts or visualization techniques as well as knowledge about current design trends in graphics, technologies and interaction concepts. Those can be retrieved from online sources and analyzed for their differences with existing designs. The design domain knowledge allows the system to actively create, suggest and evaluate potential solutions for a given design problem in a designer-like manner.

Experience is gathered by learning from previous projects. It includes the connection of successfully applied ideation approaches, interaction concepts, color schemes and so on with requirements and tasks. Those could be used as preferred actions in similar occurring contexts or as inspiration for new projects. At the same time systems could learn from earlier rejected ideas. This emulates the human understanding of experience and allows systems to react faster with appropriate suggestions, especially in the focus, frame and creation phase of the design process. As for the human designer, this knowledge will not necessary lead to the optimal solution, but allows a faster exploration of possibilities.

Human interaction behavior refers to the general understanding of human communication and argumentation. Effective communication between a designer and a system is crucial at every step of the process. Allen et al. identify three dimensions of human communication behavior, which ask 'what','when' and 'how' to communicate (Allen, Guinn, and Horvtz 1999). While the previous described requirements focused mainly on 'what' to communicate, a certain understanding on 'when' and 'how' to communicate is necessary. A system has to decide when to engage with the designer for more information, when to act proactively, and when to pass on the control in a collaborative manner. Further, it needs to be able to apply different interaction strategies to different interaction preferences to improve and harmonize the overall communication during the design process.

Discussion

The framework above lists requirements for designing a Collaborative Designing System (CDS). It looks at the interaction between a system and a designer at different granularity and highlights some of their most important aspects. Some of these requirements can be considered extremely challenging to implement, for example the adaption of interaction behavior. This requires complex psychological models of human preferences and mental models combined with the ability to transform communication structures for supporting them. Another challenge is gathering design knowledge for generating designs. While explicit knowledge of design is still underrepresented in research, even less is known about the tacit knowledge of design (e.g. empathy, impression or mood). However, the collaborative nature of a CDS allows the use of certain strengths of each collaborator, which could be an approach to address the above mentioned challenges.

Some of the presented implications, though, can find inspiration from interrelated areas of research. Detailing them all is beyond the scope of this paper, but this section presents an overview of the most interesting approaches.

One is adaptive communication strategies for education. Understanding design requirements during the discussion shares characteristics with general knowledge collection, where knowledge is created at the moment of clarification. Through adaptive questioning strategies students can explore the solution space guided by intelligent tutoring systems, which showed great advancements (Burns et al. 2014). A similar approach could be used for designing adaptive communication strategies of a CDS.

An increasingly represented topic is design inspiration. One example is Gross et al.'s work on associative system (Gross et al. 2012), which outplays humans on creativity tests. Word-based inspiration requires interpretation, which would extend the solution space in the creation phase.

Lastly, the field of design generation and evaluation introduced new approaches ranging from interactive wireframing tools (Todi, Weir, and Oulasvirta 2016) to evaluating aesthetic qualities of web pages (Miniukovich and De Angeli 2015). However, most of these systems to not consider a real design scenarios and more research is needed for CDS to become equal collaborators for designers.

While this framework highlights implications for designing a CDS, it does not elaborate on how to communicate with a designer like communicating intents, allowing others to follow thought chains; or communicating reasoning behind a design decision. Even though the self-expressiveness of artificial intelligence algorithms increased recently, e.g. (Lei, Barzilay, and Jaakkola 2016), more research is needed. While current research is often driven by technical communities, I argue for including designers in projects related to the creation of CDS to ensure the above mentioned interaction-related requirements.

Conclusion

This paper presents an analysis of the requirements that collaborative, creative systems should meet to be accepted, adopted and useful in creative pursuits, based on an analysis of their ideal role in a design process. It also introduces a framework of how to develop a CDS, and presents currently-overlooked research directions related to expression strategies for intelligent systems.

I also argue for stronger involvement of interaction designers in the process of developing designing systems. Designers' ability to envision human understanding and knowledge about expressing information in uncertain, exploratory environments can lead to new intelligent algorithms and systems, in which designer and AI work on par in more efficient and creative design processes.

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