COFI: A Framework for Modeling Interaction in Human-AI Co-Creative Systems

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Abstract

Human-AI co-creativity involves both humans and AI collaborating on a shared creative product as partners. In a creative collaboration, interaction dynamics, such as turn-taking, contribution type, and communication, are the driving forces of the co-creative process. Therefore an interaction model is an essential component for designing effective co-creative systems. There is relatively little research about interaction design in the co-creativity field, which is reflected in a lack of focus on interaction design in many existing co-creative systems. This paper focuses on the importance of interaction design in co-creative systems with the development of the Co-Creative Framework for Interaction design (COFI) that describes the broad scope of possibilities for interaction design in co-creative systems. Researchers can use COFI for modeling interaction in co-creative systems by exploring the possible spaces of interaction.

Introduction

In human-AI co-creative systems, humans and AIs collaborate in a creative process as creative colleagues, and the focus is on co-creative partnerships in contrast to creativity support tools (Davis 2013). Creative collaboration involves interaction among collaborators, and the shared creative product is more than each individual alone could achieve (Sawyer and DeZutter 2009). Sonnenburg demonstrated communication as the driving force of collaborative creativity (Sonnenberg 1991). Interaction is a basic part of co-creative systems as both the human and the AI actively participate and interact with each other. Designing co-creative systems have many challenges due to the open-ended nature of the interaction between the human and AI (Davis et al. 2016). Bown asserted that the success of a creative system's collaborative role should be further investigated concerning interaction design as interaction plays a key role in the creative process (Bown 2015).

Interaction design is often an untended topic in the co-creativity literature despite being a fundamental property of co-creative systems. In recent years, researchers designed many co-creative systems that are very intriguing and creative, yet sometimes users fail to maintain their interest and engagement while collaborating with the AI due to the unimpressive quality of collaboration. An adequate interaction model dramatically improves the quality of the collaboration and usability of a system. Therefore, as a young field, a holistic framework that captures the scope of interaction design is necessary. A good starting point to investigate questions about interaction modeling is studying creative collaboration in humans (Davis et al. 2015). Understanding the factors of human collaboration can be a tool to build the foundation for the development of systems that can augment or enhance creativity in humans (Mamykina, Candy, and Edmonds 2002). The literature on computational creativity and computer-supported collaborative work (CSCW) can also help identify interaction components related to human-AI co-creativity.

In this paper, we present the Co-Creative Framework for Interaction design (COFI) that defines interaction components in a co-creation to describe the broad scope of possibilities for interaction design in co-creative systems. These interaction components represent various aspects of a co-creation, such as participation style, contribution type, and communication between humans and the AI. COFI is informed by the literature on human collaboration, CSCW, computational creativity and human-computer co-creativity. We adopted interaction components based on a literature review and adapted the components to concepts relevant to co-creativity. We argue that COFI can be used as a guide when modeling interaction in co-creative systems as researchers can use COFI for exploring the possible spaces of interaction. COFI can also be useful while analyzing and interpreting the interaction design of existing co-creative systems.

Related Work

In co-creative systems, humans and AI both contribute as creative colleagues in the creative process (Davis 2013). Creativity that emerges from human-AI interaction cannot be credited either to the human or to the AI alone and surpasses both contributors' original intentions as novel ideas arise in the process (Liapis, Yannakakis, and Togelius 2014). Designing interaction in co-creative systems has unique challenges due to the spontaneity of the interaction between the human and the AI (Davis et al. 2016). A co-creative AI agent needs continual adjustment and adaptation to cope with human strategies. Mamykina et al. argued that by understanding the factors of collaborative creativity among humans, methods can be devised to build the foundation for the

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development of systems that can augment or enhance collaborative creativity (Mamykina, Candy, and Edmonds 2002).

In the field of co-creativity, interaction design includes various parts and pieces of the interaction dynamics between users and the AI, such as - participation style, communication, contribution type etc. Bown argued that the most practiced form of evaluating creative systems is mostly theoretical and not empirically well-grounded and suggested interaction design as a way to ground empirical evaluations of computational creativity (Bown 2014). Yee-King and d'Inverno also suggested a need for integration of interaction design practice into co-creativity research (Yee-King and d'Inverno 2016). There is a lack of a framework for interaction design, which is necessary to explain and explore the possible interaction spaces and compare and evaluate the interaction design of existing co-creative systems to improve the practice of interaction modeling.

Interaction among the individuals in collaboration makes the process emergent and complex. For investigating human collaboration, many researchers stressed the importance of understanding the process of interaction. Fantasia et al. proposed an embodied approach of collaboration that considers collaboration as a property and intrinsic part of interaction processes (Fantasia, De Jaegher, and Fasulo 2014). Schmidt defined CSCW as an endeavor to understand the nature and characteristics of human collaboration to design adequate computer-based collaborative technologies (Schmidt 2008).

Co-Creative Framework for Interaction Design (COFI)

We develop and present Co-Creative Framework for Interaction design (COFI) as a guiding tool that describes the broad scope of possible spaces for interaction design in co-creative systems. This framework describes various aspects involved in the interaction between the human and the AI. COFI is informed by research on human collaboration, CSCW, computational creativity, and human-computer co-creativity.

The primary categories of COFI are based on two types of interactional sensemaking of collaboration as described by Kellas and Trees (Kellas and Trees 2005): interaction between collaborators and interaction with the shared product. Interaction with the shared product, in the context of co-creative systems, describes interaction aspects related to the creation of the creative content. Interaction between collaborators explains how the interaction between the human and the AI is unfolding through time which includes turn-taking, roles, timing of initiative, communication, etc. Thus, COFI characterizes relational interaction dynamics between the collaborators (human and AI) as well as functional aspects of interacting with the shared creative product. We choose the Kellas and Trees framework for the primary categories of COFI because they used their framework as a tool for explaining and evaluating the interaction dynamics in human creative collaboration in joint storytelling.

As shown in Figure 1, we further divide the two primary categories of COFI, interaction with collaborators and interaction with the shared product, into four subcategories. Interaction between collaborators is divided into collaboration style and communication style, inspired by research in CSCW and HCI. Interaction with the shared product is divided into the creative process and creative product, inspired by research in creativity and, more specifically, computational creativity. CSCW literature discusses collaboration mechanics among humans to make effective CSCW systems, whereas creativity literature talks about creative process and product. The interaction components are child categories of the four main subcategories and are adapted to the context of human-AI co-creativity. COFI is not a complete ontology and can continue to expand as new interaction components emerge.

Interaction between Collaborators (Human and AI)

This section presents components related to the relational interaction dynamics between the human and the AI as co-creators. As shown in Figure 1(a), interaction between collaborators is divided into two subcategories which are collaboration style and communication style.

Collaboration Style Collaboration style is about different parts and pieces of interaction between humans and the AI, related to the nature of the co-creation. The following subsections describe each interaction component in this category.

Participation Style: Participation style in COFI refers to whether the collaborators can participate and contribute simultaneously, or one collaborator has to wait until the partner finishes a turn. Therefore, participation style in COFI is categorized as parallel and turn-taking. Categorization of participation stems from work on cooperation in the literature (Johnson and Johnson 2005; Liu, Saito, and Oi 2015).

Task Distribution: Task distribution refers to the distribution of tasks among the collaborators in a co-creative system. In COFI, there are two types of task distribution, same task and task divided. When it is same task, there is no division of tasks among collaborators and the collaborators take part in the same task. For example, in a human-AI co-creative drawing, both co-creators do the same task, generating the drawing. In a task-divided distribution, the main task is divided into specific sub-tasks and the sub-tasks are distributed among the collaborators. For example, in co-creative poetry, the user can generate a poem while the AI agent can evaluate the poetry. This component of COFI emerged from discussions of the two interaction modes presented by Kantosalo and Toivonen: alternating and task divided co-creativity (Kantosalo and Toivonen 2016).

Timing of Initiative: In a co-creative setting, the timing of both parties' initiative taking can be scheduled beforehand, or it can happen naturally in real-time. If the timing of the initiative is fixed in advance, in COFI, it will be addressed as planned. If collaborators initiate their contribution naturally without any prior plan or fixed rules, it will be addressed as spontaneous. Timing of initiative should be chosen based on the motivation. Spontaneous timing is suitable for increased emergent results, whereas planned timing is suitable for systems where users want inspiration or help in a specific way for a particular aspect. Salvador et al. discussed tim-

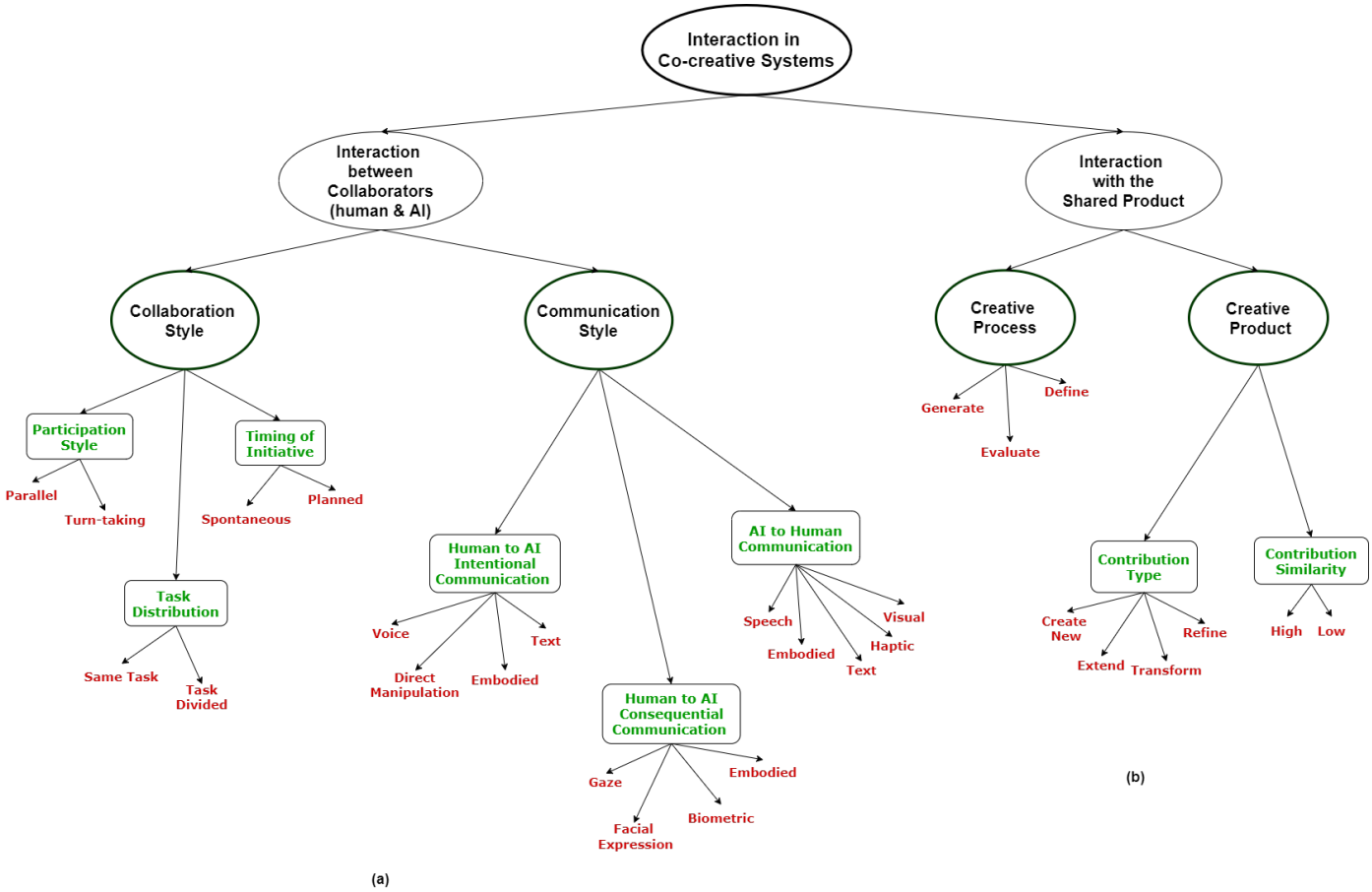

Figure 1: Co-Creative Framework for Interaction Design (COFI): On the left (a) Components of Interaction between the collaborators. On the right (b) Components of Interaction with the Shared Product

ing of initiative in their framework for evaluating groupware for supporting collaboration (Salvador, Scholtz, and Larson 1996).

Communication Style Communication is a vital component in any collaboration for the co-regulation between the collaborators and helps the AI agent make the proper decision in a creative process. Communication style includes different kinds of channels to communicate between users and the AI.

Human to AI Intentional Communication: Human to AI intentional communication channels represent the possible ways a human agent can intentionally communicate to the AI agent to provide feedback and convey important information to each other. Gutwin and Greenburg proposed a framework for groupware that discusses the mechanics of collaboration and it includes intentional communication as a major element of collaboration mechanics (Gutwin, Greenberg, and Roseman 1996). In COFI, human to AI communication channel includes direct manipulation, voice, text and embodied communication. The user can directly manipulate the co-creative system by clicking buttons for giving instructions or feedback or inputs and providing user preferences by selecting from AI-provided options. Using the whole body or gestures for communicating with the computer will be referred to as embodied. According to HCI modalities, intentional communication from human to AI includes direct manipulation, gesture, text, and voice (Nigay 2004).

Human to AI Consequential Communication: In COFI, human to AI consequential communication channels represent the ways a co-creative AI agent can track and collect unintentional or consequential information from the human user, such as eye-tracking, facial expression tracking and embodied movements. Tracking consequential details from the human is essential to perceive user preference, user agency and engagement. Gutwin and Greenburg reported consequential or unintentional communication as a major element of collaboration mechanics, in addition to intentional communication (Gutwin, Greenberg, and Roseman 1996).

AI to Human Communication: Humans expect feedback and evaluation of their contribution from collaborators. Therefore, if the AI agent can communicate their status and feedback for a contribution, it would make the co-creation more balanced as the AI agent will be perceived as an equal partner rather than a mere tool. The AI to user communication can include text, voice, visuals (icons, image, animation), haptic and embodied communication according to HCI modalities (Nigay 2004).

Interaction with the Shared Product

Interaction components related to the shared creative product in a co-creative setting are discussed in this section and illustrated in Figure 1(b). Interaction with the shared product is divided into two subcategories, creative contribution to the product and creative process.

Creative Process Creative process characterizes the sequence of actions that lead to a novel, and creative production (Lubart 2001). In COFI, there are three types of creative processes that describe the interaction with the shared product: generation, evaluation, and definition. During a creative generation, creative artifacts and ideas are produced in a specific conceptual description. In a creative evaluation, produced ideas, artifacts or concepts get assessed to be more refined and appropriate for the creative objective. In a creative definition process, collaborators determine and prepare the creative conceptual space. For example, a co-creative AI agent can define the attributes of a fictional character before a writer starts to write about the character. The basis of this categorization is the work of Kantosalo et al. that defines the roles of the AI as generator, evaluator, and concept definer (Kantosalo and Toivonen 2016).

Creative Product The creative product is the idea or concept that is being created. Creative product has two interaction components, contribution type and contribution similarity. for example (Boden 1992)

Contribution Type: In a co-creation, an individual can contribute in different ways to the shared product. Co-creators can generate new elements, extend the existing contribution, modify or refine the existing contribution. The primary contribution types in COFI are: 'create new', 'extend', 'transform' and 'refine'. 'Extend' refers to extending the contribution of the partner or adding on to the partner's contribution. Generating something new or creating new objects is represented by 'create new', whereas 'transform' conveys turning the partner's contribution into something totally different. 'Refine' is evaluating and correcting the partner's contributions with a similar type of contribution. Contribution types are adopted and adapted from Boden's categories of computational creativity based on different types of contribution: combinatorial, exploratory, and transformational (Boden 1998).

Contribution Similarity: Contribution similarity refers to the degree of similarity or association in terms of the contribution compared to the partner's contribution. Both convergent and divergent exploration have value in a creative process. Basadur et al. asserted that divergent thinking is related to the ideation phase and convergent thinking is related to the evaluation phase (Basadur and Hausdorf 1996).

Conclusions

As a growing field, human-computer co-creativity lacks significant research on interaction models and their implications in co-creative systems. Human-AI co-creativity research needs a holistic framework that captures aspects and components of interaction to design effective co-creative systems. In recent years, a few frameworks have been developed about interaction design in co-creative systems. However, they lack a focus on interaction components related to the interaction between collaborators as distinct from interaction components related to the shared product. We develop and describe COFI as a new framework to provide a way for researchers to explore the design space of interaction for a specific system. COFI will provide useful guidelines for interaction modeling while developing co-creative systems. COFI can also be beneficial while investigating and interpreting the interaction design of existing co-creative systems. As a framework, COFI is expandable as other interaction components can be added to it in the future. By establishing COFI, we can look for the relationship between different interaction designs in co-creative systems and different creative outcomes. COFI can be also used to develop co-creative systems that can improve user engagement with effective collaboration strategies through adequate human-AI interaction.

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