

# Towards a Relational Model of Co-located Interaction in Interactive Art

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## Abstract

Co-located interaction refers to situations in which there are two or more co-located audience members interacting with an interactive artwork and the interaction between the audience members is integral to the artwork. To better describe and understand co-located interaction, we propose a relational model of co-located interaction with an emphasis on how the interacting elements relate to and influence each other based on the actions performed by the elements and the various forms of communication at play. We explain the key concepts in the model and demonstrate its application with an example artwork. Our model provides a systematic approach to describe, compare, and generate new forms of co-located interaction and audience-artwork interaction in general.

## Keywords

Co-located interaction, interactive art, audience-artwork interaction, interaction models, interactivity, social interaction, mediated communication, relational aesthetics, interdependence.

## Introduction

Active audience participation is integral to interactive art. Instead of creating static artistic objects, artists aim to construct dynamic 'art systems' capable of acting and responding to the audience and the environment. [1] Interactive art transforms the audience from passive viewers into active participants, challenging the traditional conceptions of the roles of artwork, audience, and artist. Situated at the interplay of art, science, and technology, it explores and recontextualizes new technologies, contributing to novel forms of communication and the emergence of a multidisciplinary field of research. [2]

Meanwhile, the majority of research in interactive art focuses on describing the interaction between the audience and the artwork, a concept commonly referred to as audience-artwork interaction. [3] In a comprehensive study of audience-artwork interaction within interactive arts, Schraffenberger and van der Heide conducted a review of existing models and frameworks that delve into the various characteristics and types of interaction occurring between the artwork and the audience. [3][4] They further proposed a dialogue model to describe audience-artwork interaction, similar to a dialogue between two individuals, where both parties not only respond to each other's propositions but also have the freedom to change the topic or interrupt one another. The dialogue model portrays audience-artwork interaction as a

dynamic process, granting both the audience and the artwork autonomy while reacting to each other. As such, the artwork and the audience neither act in a random manner nor completely control each other.

However, as many interactive artworks are exhibited in museums and other public places, there are usually more than one audience members present, and some artworks require the presence of multiple audience members for the intended interaction to take place. The artwork Boundary Functions by Scott Snibbe is such an example. [5] In Boundary Functions, the audience are cast as seeds for generating a Voronoi diagram projected on the floor, which divides the floor into areas that are closest to each audience member. The artwork does not respond when there is only one person, as a Voronoi diagram for one seed covers the whole projection area. When there are two or more people interacting with the artwork, the boundaries of each cell are determined by the distance between each audience member and are continuously changing as they move closer or further away from each other. Here we use the term co-located interaction to describe such interaction:

*Co-located interaction takes place when two or more audience members participate in the interaction with an interactive artwork, sharing both time and physical location. Furthermore, the presence of, and the interaction between, the audience members is integral to the artwork.*

Consequently, in accordance with this definition, co-located interaction encompasses both the interaction between the audience and the artwork, as well as the interaction among audience members. It's important to note that not all interactive artworks incorporate co-located interaction. Unlike a conventional dialogue between an audience and an artwork, co-located interaction broadens the scope of interaction into a collective activity involving multiple participants and various types of relationships.

In this paper, we propose an approach to describe and model co-located interaction in interactive art. A comprehensible interaction model can help us better understand, compare, evaluate, and design interactive experiences and systems. [6] Furthermore, such a model can offer templates to assist artists in developing novel forms of co-located interaction, aid curators and experts in the comparison and classification of artworks, and, most importantly, contribute to the identification of patterns within co-located interaction, shedding light on how interactivity manifests itself in such contexts and revealing new areas for research.

In the next section, we review existing approaches for modelling co-located interaction, discussing both their

contributions and limitations. Following this, we introduce our model for co-located interaction, explain the key concepts, their properties, and provide guidelines for its application. Subsequently, we show how our approach can be applied in describing and analysing co-located interaction with an example artwork. Our general discussion, reflection and conclusion can be found at the end of this paper.

## Related Works

### Existing Models of Co-located Interaction

One of the main contributions in understanding co-located interaction in interactive art is the doctoral work of Oussama Mubarak. [7] In his research, Mubarak presents a taxonomy of co-located interaction in art installations based on factors influencing both the individual and the collective experience. These factors are:

- Scale: the number of simultaneous active participants. And it is classed into small ( $\leq 10$ ), medium (11 - 100), and large ( $> 100$ ).
- Interaction modality: the method by which the audience interacts with the artwork. The different modalities are direct (direct physical manipulation), facilitated (using individual remote devices) and ambient (the artwork captures external information through non-invasive technologies).
- Input and output distribution: the distribution of the input and output devices. The different distributions are centralized (the input or output is performed on shared devices), partially distributed (the input or output is split or duplicated on shared and individual devices) and fully distributed (the input or output is fully distributed across individual devices).
- Feedback attributability: how easily the audience can recognize the effect of their actions in the artwork, which is indicated as low, medium, high and variable.
- Activity type: the type of activity the audience can engage in the artwork. The different types are solitary, collaborative, or competitive.
- Participation symmetry: all audience interact with the artwork equally (symmetric) or some audience interact with the artwork differently from others (asymmetric).

This taxonomy points out some interesting aspects about the experience of co-located interaction and provides a set of vocabulary to describe them. However, it concerns less with specifying the relationships between the audience and the artwork, as well as between the audience members. Additionally, Mubarak proposes two approaches to model co-located interaction that attempts to capture this.

The first approach focuses on visualizing the system layouts of art installations. In this approach, the main elements in a model are shared or individual interfaces that are specified as either input, output, or both. The number of each interface is noted, and the organization of the individual interfaces are classified as 1) free, there is no specific order for accessing the interfaces, 2) in a queue, the interfaces are accessed by the installation in a chronological order, 3) in a looped queue, the art installation loops through all the

interfaces. The data flow between the individual interfaces and shared interfaces are indicated as either unidirectional, bidirectional, or symmetrical correspondence meaning all interfaces share the same information. This approach provides a concise language to show the technical layout of artworks, yet it offers limited insight into the roles each interface plays in the interaction and their connections to the audience. More importantly, it does not account for the interaction between audience members, which is essential to co-located interaction.

Acknowledging some of the limitations discussed above, Mubarak proposes a second approach based on Petri nets. A Petri net is often used to model information flow in systems with concurrent and asynchronous events. In this approach, Mubarak describes the spatial and material aspects of the artwork, the audience activities in the interaction as well as the transitions between them triggered by the actions of the audience. Comparing with the first approach, this approach is more inclusive and expressive of the different activities in a co-located interaction, as Mubarak noted that it “can be used to model co-located human-human, human-machine, as well as human-machine-human interactions around art installations”. [7, p.110] However, due to its early developmental phase, this approach tends to produce highly specific and complex model of an individual artwork, which limits its practical use and renders it unsuitable for comparing different co-located interactions.

### Interaction Model for Relational Interactive Art

When contemplating the promotion of audience participation in interactive artworks, Cabrita and Bernardes connects interactive arts with relational aesthetics, a concept centered on fostering social connections among audience members through an artwork's aesthetic properties. [8] They coined the term “relational interactive art” to describe interactive artworks that strive to forge and enrich social bonds between the audience members and proposed an interaction model for such artworks based on feedback loops (see Figure 1).

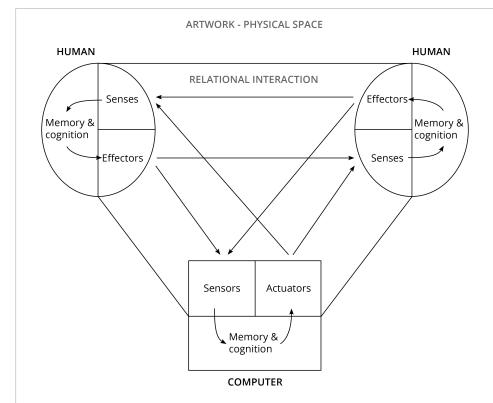


Figure 1 Model of relational interactive art. Adapted from ©Cabrita & Bernardes

In a feedback loop between a human and a computer, the actions of the human send signal to the computer, which gives feedback that guides the further actions of the human

in a continuous loop. In relational interactive art, the model includes another human participant that interacts both with the human and the computer in similar feedback loops. Cabrita and Bernardes further explain that the human-human and human-computer interaction are equally important and always present in relational interactive artworks. The actions of the audience are interdependent, and these actions are interpreted by the computer as a collaborative behaviour that “guides its response and shapes the next instance of human action” [8]. However, they did not illustrate any application of the model.

Here we see a great overlap between Cabrita and Bernardes account of relational interactive art and co-located interactive artworks. We agree that the interaction between the audience members and the interaction between the audience and the artwork are of equal importance and the two forms of interaction also inform and influence each other. However, the feedback loop model is often used in HCI to describe how a user can control a system and neglects the possibilities for novel behaviours and independent actions, whereas if we understand interaction as a dialogue, there is freedom on both sides to break the loop and go in another direction. Moreover, contrary to Mubarak’s approach based on Petri nets, the feedback model runs a risk of oversimplification, and cannot capture the characteristics of individual interactions.

## Considerations

Taken together, the existing models of co-located interaction tend to be either too generic or too specific. A useful model should be descriptive, in that it can provide enough structural information to describe the individual system or situation being modelled; comparative, in that it contains metrics for comparing different systems or situations; and generative, in that it can guide the creation of new systems or situations. [6]

Meanwhile, although interaction is by nature a relational process, the existing attempts to model co-located interaction do not sufficiently describe the relationships between audience and the artwork, and between the audience members. In all above-mentioned models, the term ‘interaction’ is used to describe the activities between the audience members and between the audience and the artwork. In discussing forms of interaction in the context of interactive art installations, Ahmed pointed out the difference between interaction and communication: “In communication, the receiver may or may not respond, whereas in interaction, there is requirement of a response for it to be an ‘inter’action”. [9] This also coincides with our understanding of interactivity as a form of mutual responsiveness. Although the experience of co-located interaction is interactive, this does not mean that each interacting partner should be mutually responsive to each other. If the interaction between an artwork and an audience can be seen as a dialogue of actions and reactions, we can try to understand co-located interaction by looking at the actions (and reactions) of all the interacting participants. By following the directions of actions, we can start to identify the different forms of communication at

play. In doing so, we can specify a network of influences between the audience members and the artwork that serves as the foundation for understanding co-located interaction.

Moreover, the same action of an interacting element can yield different outcomes in different interactive artworks. For instance, the waving of an audience member’s arm may change the colour of a visual display in one artwork, while in another, the same gesture may cause the artwork to move away. Therefore, it is crucial to consider the function(s) of an action performed by an interacting element and how it affects and relates to other elements, or the role(s) of the action in the specific context of a co-located interaction. Existing models of co-located interaction have generalized the role(s) of actions as either ‘triggers’ for activity transitions or ‘feedback’ while ignoring the fact that an action can also be to initiate the interaction or a new proposition. Therefore, we posit that specifying the role(s) of the various actions performed by the elements is critical for comprehending the dynamics of co-located interaction and further identifying the role(s) of individual elements. This not only aids us in distinguishing and comparing different artworks but also unveils patterns that can stimulate the creation of novel forms of co-located interaction.

Therefore, we need a balanced model of co-located interaction that can describe the various forms of communication between the audience and the artwork, as well as between the audience members, while considering the roles of the actions of the audience and the artwork. Next, we present our attempt to model co-located interaction, taking these considerations into account.

## A Relational Model of Co-located Interaction

Here, we introduce a relational model for describing co-located interaction. A visual diagram of this relational model is provided in Figure 2. The relational model begins by identifying the elements with distinct behaviours and proper within a co-located interaction. An element is regarded as an independent actor in the interaction, with their actions forming the foundation of the interaction. Common elements encountered in co-located interactions are audience members or art systems. The model is relational in that it does not only depict the behaviours and properties of individual elements, but also specify how their actions influence and relate to other elements through various forms of communication. In the following sections, we will elaborate on the attributes we use to describe the elements and the different forms of communication with the relational model. For each element, we describe its:

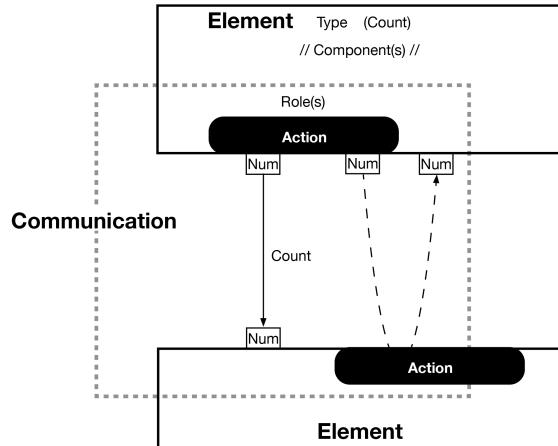


Figure 2 Visual diagram of the relational model.

## Type

As mentioned before, there are two common types of elements in co-located interaction: the audience and the art system. In Cabrita and Bernardes' model of relational interactive art, they view the interactive system of the artwork as simply a 'computer' [8]. However, we find this term misleading, as an interactive artwork often involves more than just a computer; other components of the artwork can be equally, if not more, significant in the interaction. Additionally, interactive artworks do not always require the use of computers. Therefore, we propose the term 'art system' to describe an independent functional unit within an interactive artwork. An art system can consist of input units, output units, and processing units, similar to the computer element in Cabrita and Bernardes' model, or it could be made of physical materials that react to the environment and can be used by the audience. An interactive artwork might include a single art system or several art systems, each with its own behaviour and the capacity to establish connections with the audience. When multiple art systems exhibit distinct behaviours, we need to analyse them individually.

The audience element refers to the individual audience members. In an interactive artwork, there are often audience members interacting with the artwork while others remain in the background to observe the interaction, sometimes they have the freedom to switch between the two modes of participation. As our focus is on describing interaction, the model includes only the audience members who are directly participating in the artwork and whose actions have an impact on the art system and other audience members. Looking at the definition of co-located interaction, there are often two or more audience members in a co-located interaction. Similar to the case of the art system, when different audience members exhibit distinct behaviours and have different functions in the interaction, we need to specify each of them with the model.

In certain instances of interactive artworks, the art system is influenced not only by the audience but also by other environmental factors [1]. For example, an art system might change its behavioural states in response to the exhibition space's temperature or internet traffic data. When such

factors come into play, we categorize them as types of environmental elements.

## Components

The components of an element refers to the devices, materials, and apparatuses that the element incorporates and employs during interactions. If an art system is computer-based, it typically encompasses both hardware components, like sensors, computers, actuators, or displays, to sense the environment and execute actions, and software components such as tracking and control programs for processing data and generating commands. For the audience, their interaction often involves using their bodies to perceive, act, express, and communicate with both the art system and each other. Depending on the interaction modalities, they can also utilize objects like accessories or personal devices. The components of an element describe its material basis and help us differentiate it from other elements.

## Count

Count refers to the number of elements that can simultaneously participate in the interaction. This is similar to the 'scale' attribute in Mubarak's taxonomy; however, he only focuses on the number of simultaneous active audience members, whereas we extend this notion to all types of elements. In certain instances, there might be a requirement for a minimum number of elements in a co-located interaction. For example, the previously mentioned artwork 'Boundary Functions' requires the participation of a minimum of two audience members. Moreover, a co-located interaction can take place among a fixed number of elements, or the elements can join or leave the interaction at any moment. In the latter scenario, we often denote the minimal required number of elements for the interaction with a '+' to indicate potential additions.

## Actions

An action is a concrete step performed by an element or a group of elements to bring about changes within themselves or in the surrounding environment. An action can be a movement, such walking or pressing a button, or it can be an update on a display mode, such as presenting data on a screen or generating an audio. In the relational model, we view actions as the foundational components that elements use to establish connections with and influence other elements. Consequently, the actions included in the description of an interaction are always directed towards other elements. Activities that are receptive, such as sensing or observing are not explicitly mentioned. The direction of an action can manifest itself in two ways: first, the acting element intentionally performs an action directed at the receiving element; second, the receiving element actively captures aspects of the action performed by the acting element, even if the action is not initially intended for the interaction. The latter is often the case when the art system detects and responds to specific actions of the audience.

In a taxonomy of interactive artworks made in the context of the Prix Ars Electronica, Kwastek points out that the key

actions that may be performed by the audience are: “observe, explore, activate, control, select, participate, navigate, leave traces, co-author, collaborate, exchange information and create” and the corresponding actions made by the art system are “monitor, serve as an instrument, document, enhance perception, offer a game, enable communication, visualize, sonify, transform, store, immerse, process, mediate and tell/narrate”. [10] However, we find these terms are more suitable to describe the functions of an action instead of the concrete actions performed by the elements. We agree that it is important to specify the functions and roles of an action in the interaction. Yet when it comes to describe the co-located interaction in a specific artwork, we first need to identify the individual, concrete actions performed by the elements.

## Communication

As we discussed earlier, a form of communication is created when an element performs an action directed at another element. For each form of communication, we specify:

**To** - To which element the action is directed at. The same action can be directed at different elements and creates different forms of communication.

**Means** - The means of a communication refers to how the action reaches the receiving element. We identify two different means of communication:

- Direct: the action is performed to the receiving element directly. There is no intermediate element.
- Via (intermediate element): The action is performed to an intermediate element and reaches the receiving element via the intermediate element. This type of communication is frequently termed mediated communication.

**Configuration** - In a communication, an action can be carried out by one or multiple elements together and it can be directed at one or multiple elements simultaneously. Configuration refers to the arrangement of the elements at both ends of the communication. We consider the possible configurations in a co-located interaction as:

- One to one: from one element to one element only.
- One to many: from one element to one or more elements.
- Many to one: from one or more elements to one element.
- Many to many: from one or more elements to one or more elements.

Besides the number of elements, we also identify two settings in which the communication takes place: private and public. In a private setting, the communication can only be perceived by the communicating elements. In a public setting, the communication can also be perceived by other elements and/or observers.

**Count** - Here the count refers to the number communications that can take place in parallel. It is important to note that this does not necessarily imply that all communications must happen strictly simultaneously. Rather, we are examining the capacity of the element to perform the action. For

instance, an art system may detect the audience members one at a time and emit an audio response. While the communication of the audio response might be sequential, the art system has the ability to repeatedly perform such action. Therefore, we consider that there are multiple instances of such communications happening in parallel.

## Role(s) of the Action

For every action performed by an element, it's essential to define its role(s) within the interaction. The role(s) of an action pertain to the function(s) it serves and how it relates to other actions performed by the same or different elements in the interaction. An action can be initiated by an element or triggered by the actions of other elements. In the latter scenario, it functions as a response and can be termed a ‘reaction’. As we discussed before, the ‘actions’ identified by Kwastek provide a rich vocabulary to describe the functions of an action in an interaction. However, in Kwastek’s description, the actions of the audience tend to play more active roles such as “explore, activate, control”, whereas the artwork tends to be at the service of the audience. In our view, we do not make any arbitrary differentiation between the roles of the audience and those of the artwork. We consider that both can perform the same roles, and that this perspective opens up possibilities to create new forms of interaction. As an action can create multiple forms of communication, it can also serve diverse functions across different communications.

## Application

Given a co-located interactive artwork, we can apply the model to describe its co-located interaction by inspecting the documentations and description of the artwork, as well as observing the actual interaction taking place. First, we need to identify how many distinct element profiles to include in the model. We can do so by examine the elements according to the general types (e.g., art system, audience, environment) and further distinguish whether the elements of the same type exhibit distinctive behaviours that require separate analysis. For the element(s) sharing the same profile, we can then specify its properties and behaviours based on its ‘components’, ‘counts’ and ‘actions’. Following each actions of the element, we can start to describe the various forms of communication created by the element: to which element(s) the action is done to (‘to’), whether the information is communicated directly or via other element(s) (‘means’), how many elements are involved in both ends of the communication and whether it is in a public or private setting (‘configuration’), how many of such communications can take place concurrently (‘count’) and what role(s) the action plays in the context of the interaction (‘role(s) of the action’). This should give us an adequate description of a co-located interaction focusing on how the elements relate to and influence each other.

## Example Artwork

### Body Movies (2001) by Rafael Lozano-Hemmer

Body Movies is an interactive projection installation for public spaces (see Figure 3). [11] A set of portraits is projected on a surface and washed out by lights positioned at a distance on the floor. The audience enters the interaction space and their shadows are displayed on the projection surface to reveal the portraits. The artwork tracks the edges of the shadows, and once they overlap with a portrait, a hotspot is activated for a few seconds and an audio track is triggered. When all portraits are revealed, the artwork blacks out the projection and displays a new set of portraits at the different locations from the previous ones. Meanwhile, the software interface is displayed in real-time via a plasma display next to the projection.



Figure 3 Body Movies (2001). © Rafael Lozano-Hemmer.

### Apply the Relational Model

In Body Movies, there is one art system consisting of: projector, portrait, projection surface, Xenon light, plasma display, camera, software program, speaker, robotic controller. As all audience members participate in the interaction equally, we can describe them in one element profile. One

or more audience members can participate at the same time, and they mainly use their bodies to interact. A visual diagram of the co-located interaction in Body Movies based on the relational model can be seen in Figure 4.

There is a form of direct many (1+) to one communication from the audience to the art system in a public setting and there can be one or more of such communications. In this, one or more audience members can cast a shadow on the projection surface and the camera captures and tracks the shadow contours, which allows the audience to initiate and participate in the interaction.

There are four forms of direct one to many (1+) communication from the art system to the audience in a public setting. First, the art system displays the shadows of the audience as a response, to provide feedback about their movements, and a stage for communication. And there can be one or more of such communications. Second, the art system also displays the tracking interface to provide feedback and inform the audience of their performance and the states of interaction. Third, when a shadow overlaps with a portrait, the art system activates a hotspot and plays an audio clip as a response and to provide feedback about the achievement. And there can be one or more of such communications. Last, once all hotspots are activated, the art system blacks out the projection and updates the portraits as a response and initiates a new session.

Throughout the interaction, the audience can communicate with each other through their shadows. It allows them to express and perform with gestures and movements. This creates a form of many (1+) to many (1+) communication via the art system in a public setting and there can be one or more of such communication forms. Due to their co-location, the audience can also converse with each other both verbally and non-verbally to exchange information and coordinate actions. As there are two or more audience members, there can be one or more of such direct many (1+) to many (1+) communications in a public setting.

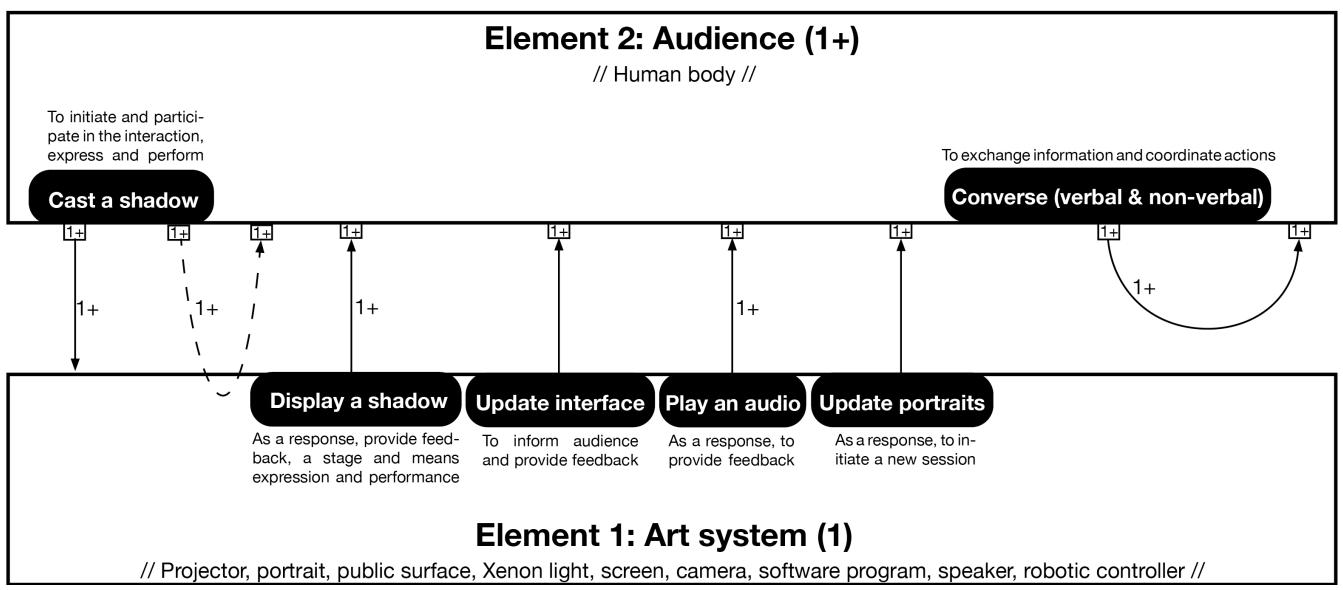


Figure 4 Visual diagram of the co-located interaction in Body Movies.

## Discussion

In this paper we propose a relational model to describe co-located interaction in interactive art. Our approach drew several connections to concepts discussed in Mubarak's taxonomy, such as scale and participation symmetry. We situate them in context with relation to other elements and supplement the description of the individual element and their communication with each other. Compared to Mubarak's models, our approach looks beyond the technical aspects of the artwork, and not only describes the activities and actions of the audience and the art system, but also specifies the relationships between them. The model also provides a systematic method that can be used to easily compare different artworks. Instead of viewing all forms of communication and potential interaction as feedback loops, we specify the organizations of the elements, the flow of information and the roles of the actions performed by the elements. In doing so, we have a better understanding of how the elements influence each other and distinguish different forms of co-located interaction.

The descriptive capacity of the relational model is illustrated in the example of Body Movies. Given the description of the co-located interaction in Body Movies generated using the model, we can see that there are multiple forms of communication between the audience and the art system. The audience members initiate the interaction by casting their shadows on the projection surface. In response to this, the art system performs multiple responses, each with different functions and takes place corresponding to different scenarios, for instance, it plays a sound when the audience members activate a hotspot or updates the portraits when all hotspots are activated. These various forms of communication enrich the interactive experience and engage the audience to explore the possibilities the artwork affords.

Moreover, we also observe two forms of communication between the audience members. They can communicate with each other directly due to their co-location and/or via the art system using their shadows. The shadow play allows the audience to communicate with gestures while concealing their appearance. This anonymity lowers the threshold for public performance. Additionally, they can move closer or further away from the lights to drastically alter the size of their shadows, which creates dramatic and symbolic effects in the shadow play. These forms of communication can either facilitate the audience's interaction with the art system or become an aesthetic experience in their by itself.

Meanwhile, our approach also provides a template to conceive new forms of co-located interaction. For instance, we can combine different forms of communication or swap the roles of actions performed by the elements to create new structures for co-located interaction. Given the identified forms of communication, we can also start thinking about new forms of communication. For instance, an audience-mediated communication in which an audience member can interact with an art system through another audience member, or an audience-group communication in which an audience member acts on and responds to other audience

members and art systems as a group. Besides, we can also speculate new ways for the different forms of communication to influence each other. For instance, a mediated communication can disrupt or supplement to a direct communication.

### Future Works

In this paper we can only partially illustrate how our approach can be applied to analyse and describe co-located interaction due to space constraints. In a follow-up publication, we will analyse and compare a variety of co-located interactive works to further test the capabilities of our approach and the diversity of co-located interaction.

For the current approach, we identified several common roles of actions in co-located interaction. This serves as a starting point to see co-located interaction through the lens of these concepts and points at a direction for future studies to examine and develop more conclusive inventories of the roles, which can be applied to describe, compare, and conceive new forms of co-located interaction.

As our approach focuses on examining the relational aspect of a co-located interaction, it is limited in accounting for other aspects such as the scale and feedback attributability according to Mubarak's taxonomy. Moreover, it cannot show the temporal development of an interaction. The audience may be more exploratory at the onset, as they discover and master the interaction mechanism they may act and react differently. Future studies can combine different frameworks and taxonomies with our approach for a more comprehensive description of co-located interaction.

## Conclusion

Co-located interaction in interactive art provides challenges and opportunities for developing new forms of interaction and relationships between the audience and artwork. In this paper, we present a relational approach to model co-located interaction with a focus on describing the various forms of communication between the interacting elements, while considering the effect of their actions in their context and relation to each other. Looking at co-located interaction with a relational perspective helps us to better understand the dynamics of co-located interaction and to conceive new forms of relation and organization between the audience and an art system.

Furthermore, despite its original focus on co-located interaction, the relational model does not impose specific prerequisites for the nature of the interaction or the elements under analysis. The model can also be effectively extended to describe various other types of audience-artwork interaction. This extension includes artworks featuring distributed audience participation and/or asynchronous communications, as well as interactions involving diverse entities encompassing both human and non-human participants. We believe that the relational model represents a pivotal step towards comprehending the complex network of relationships intrinsic to interaction.

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Dan Xu is a creative researcher and PhD candidate at Leiden Institute of Advanced Computer Science (LIACS), Leiden University, NL. Her current research explores co-located

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Maarten H. Lamers is a creative computer scientist and Assistant Professor at Leiden University (LIACS). Themes that reappear in his research and lecturing are artificial intelligence, human-robots interaction, hybrid bio-digital systems, and scientific playfulness.

Edwin van der Heide is an artist and researcher in the field of sound, space and interaction, and a part-time Assistant Professor at Leiden University (LIACS, ACPA). His work comprises installations, performances and environments. The audience is located in the middle of the work and challenged to actively explore and interact with the artwork.