A relational approach to understanding interactions in interactive art

Xu, D.

Chapter 8

Conclusions and Discussion

The research described in this thesis started from exploration, discovery, and ended with critical reflection, leading to a thorough investigation into using a relational approach to modelling interactions in interactive art. We examined different approaches to describe interactions in interactive art and came to our relational model that focuses on capturing the relational exchanges among interacting elements (Chapter 2). Building on this foundation, we developed the Relational Modelling Tool (RMT), a versatile application for describing, visualising, and generating interactive dialogues[1] (Chapter 3). To demonstrate the modelling capacities of RMT, we applied it to analyse a diverse range of interactive artworks, including co-located interaction (Chapter 4), more-than-human interaction involving both human and nonhuman participants (Chapter 5), as well as participatory artworks beyond interactive art (Chapter 6). Furthermore, we presented the outcomes and reflections from a workshop conducted to evaluate the usability and functionalities of RMT with a broader user group (Chapter 7). In this final chapter, we synthesise the key findings of this study in response to the research questions outlined in Chapter 1, reflect on the challenges and considertations, as well as propose directions for future research and development.

8.1 The Relational Modelling Approach

At the core of our study is the establishment of the relational model of interaction and the accompanying tool we developed, i.e., RMT. Together, they provide both a theoretical tool for understanding interactions in interactive art and a methodological instrument for analysing a diverse range of interactive artworks explored in this thesis. In this section, we reflect on

[1] The latest version of RMT is accessible via: https://modeltool.liacs.nl/

the foundation of the relational model, the application of RMT, and its identified benefits and limitations.

8.1.1 Key concepts

The relational model is grounded in established theoretical discourses concerning the modelling and classification of interactive artworks. It consists of three key concepts—element, action, communication—that guide the analysis and description of interactions. In this section, we elaborate on the key concepts of the relational model, focusing on addressing the first research question:

> **Q1:** How can we model interactions in interactive art in a way that effectively and structurally captures the relational exchanges between the art system and its participants?

The relational model treats various types of interacting elements—such as art systems and audience members—equally, while accounting for the diverse relationships between them. These relationships are shaped by their actions and reactions and are realised through different forms of communication. This perspective not only enables the analysis of complex interactive scenarios involving multiple participants but also expands creative possibilities by allowing elements to take on unconventional roles.

It is important to emphasise that the relational model is not a static construct, nor has it remained unchanged since its initial introduction. Its definitions and structure have evolved iteratively in response to limitations identified during the development of RMT and its application to analysing diverse interactive artworks. In the following discussion, we trace the evolution of the key concepts of the relational model, aiming to present a more comprehensive picture of how they enable us to better understand the relational dynamics within various forms of interactive dialogues.

Element

An analysis or description of an interaction using the relational model begins by identifying the main elements, defined as "the independent actors between or among whom the interactive dialogue takes place." To identify an element, it is essential to recognise both its capacity to function autonomously as a unit and its behavioural impact on other elements. Therefore, the relational model provides a 'high-level' description of interaction, focusing on the exchanges among the key actors.

Initially, we distinguish an element from others based on its type and components. In an interactive artwork, the key elements are typically the audience and the art system. To account for scenarios where external factors influence the behaviours of the art system, we also introduced an environmental element. Furthermore, over the course of this thesis, we identified additional types of elements, such as nonhuman organisms and even static objects. While these elements may not intentionally participate in the interaction—as is often the case with nonhuman organisms—or perform any active gestures—as with static objects—their presence or actions afford inputs that can be captured by other elements. These inputs, in turn, trigger behavioural changes in these elements that are essential for the interaction to occur or progress.

Moreover, elements of the same type can take on different roles within an interaction, which requires them to perform different actions. To sufficiently capture the exchanges among elements, it is important to distinguish not only their types but also their roles in the interaction. RMT employs an element profile to group descriptions of elements with the same type, behaviours, or roles. This approach produces clear and concise categorical descriptions of elements, enabling a more direct and systematic understanding of their contributions to the interactive experience.

Action

After identifying the elements, the relational model dissects the interaction in terms of the actions performed by the elements that relate to one another. An action is defined as "an activity, behaviour, or natural response carried out or afforded by an element that has significant effects on shaping the interaction." Within the relational model, actions are the fundamental units through which elements perform their roles in the interaction and connect with one another. Consequently, every action described is directed towards (an)other element(s), making it an 'outward' action. Activities involving the reception of information—such as sensing or observing—are not explicitly listed as actions. This choice allows for a systematic tracing of the flow of inputs and information among elements, as well as an understanding of how they impact and influence one another.

Although actions may appear to be properties of individual elements, they remain relational in nature because an action's significance and meaning are determined by both the acting and the directed-at elements. The direction of an action can manifest 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 relational model, particularly through RMT, prompts us to specify the intention behind each action. This distinction is crucial, as it indicates whether an element actively or passively participates in the interac-

tion, thereby reflecting the underlying dynamics among the elements. Furthermore, an action may not initially be intended for interaction; however, as the element learns about the impact of their actions, they may choose to intentionally perform the action, thus transitioning into an active participant in the interaction—much like how children learn to interact with their environment through trial and error.

A key characteristic of an interactive dialogue in interactive art is the capacity for elements to act and react to one another. In the relational model, we initially only captured this information when describing the role(s) of an action. However, during the development of RMT, it became evident that an additional structure was necessary to specify the relationships among actions. To address this, we introduced a condition for each action, which establishes causal relationships between actions. Under this frame of analysis, an action can be initiated by the element itself ("self-initiated"), and/or triggered by another action or combination of actions. Additionally, the condition allows us to specify relationships among reactions: whether they occur concurrently (an *AND* relationship) or one at a time (an *OR* relationship). The primary aim of the condition is to capture the formal or logical relationships among actions. More nuanced influences between actions can be described in the effects of the resulting communications, which we discuss in the following subsection.

Communication

When an element performs an action directed towards (an)other element(s), a form of communication is created. In the relational model, communications are understood as "the concrete mechanisms through which elements influence one another via their actions." The same action can also be directed at different elements, resulting in multiple forms of communication. A form of communication is described by its means—whether it is direct, occurring between two communicating elements, or mediated, facilitated by a third element; its configuration—the arrangement of elements at both ends of the communication; and its access—whether it remains private between communicating elements or is publicly accessible.

Initially, the impacts of an action in a specific interaction is described by its role(s), such as its function and impact within the interaction. This information is crucial for understanding the role of the acting element in the interaction and how it relates to the receiving element. However, since an action may be directed at different elements for different purposes, this contextual information can be further decomposed into the specific effects of each resulted communication. Collectively, these descriptors for specifying a form of communication elucidate the precise mechanisms through which the actions propagate and influence one another.

Furthermore, this approach to describing communication allows us to identify diverse mediated communication forms–and even generate of new ones. As demonstrated in Chapters

4 and 5, not only can a technical system—such as an art system—be employed by humans to convey information to one another or to reach nonhuman organisms, but the human body and our communicative abilities can also be utilised by art systems to transmit information to other humans or nonhuman entities. In these processes, the communicated information is not only determined by the sender element but is also filtered and negotiated through the channels of the mediator element. The concept of mediated communication is particularly relevant in non-dyadic interactions involving multiple elements, as it enables the identification of influence pathways and the configuration of complex relationships among elements.

In conclusion, these three key concepts—elements, actions, and communications—collectively establish the relational model as a robust analytical frame of analysis for interactive art. By treating elements as role-based actors with defined autonomy yet relational interdependence, the model enables comprehensive description of multi-agent interactions while preserving each participant's distinctive contributions. Through its action-condition architecture, the model systematically captures both the causal logic of intentional behaviours and the dynamics of responsive engagement. Meanwhile, the communication form maps complex influence networks, from direct exchanges to mediated connections. The model's strength lies in its dynamic treatment of interaction as negotiated relationships rather than fixed entities, while accommodating both human and nonhuman contribution with equal treatment. Although the model's interpretive flexibility presents certain challenges, this openness enables creative adaptations and application across diverse contexts. Ultimately, the relational model advances interaction analysis by providing both an analytical tool for existing artworks and a generative tool for new forms of interaction.

8.1.2 Application, benefits, and limitations

Building upon the theoretical foundations of the relational model, we operationalised its conceptual foundation through the development of RMT, aiming to facilitate the application of the relational model. This process not only allows us to make the relational model more accessible and usable, but also improve and refine its frame of analysis. In this section, we address the following questions specifically with regard to the application of RMT:

> **Q4:** What benefits and opportunities does a relational modelling approach provide for understanding and creating interactive art?
>
> **Q5:** What are the limitations of a relational modelling approach for understanding and creating interactive art?

In summary, RMT demonstrates significant strengths in analysing and comparing interactive artworks. It proves to be applicable to diverse forms of interaction involving both human and nonhuman participants. Its structured approach enhances analytical precision and usability through guided descriptors, conditional links between actions, and automated visualisations. Its formalised input fields enable systematic comparisons across artworks and generate consistent datasets of interactive artworks, allowing for potential applications of statistical and visualisation analysis techniques. Furthermore, RMT shows promising generative potential through creative adaptations and data-driven exploration of novel interactions.

Meanwhile, there are some limitations with the current version of RMT. As it focuses on describing exchanges among elements, more detailed technical diagrams of art systems may be needed for applications scenarios, such as system and software development. While the generative component of RMT demonstrates innovative potential, current random generation features often produce unrealistic and non-meaningful 'interactions', highlighting the need for more context-aware generative algorithms and greater user control.

In Chapter 2, we emphasised that an effective interaction model should support the description, comparison and creation of interactions. Subsequently, we structure the detailed discussion on the benefits and limitations of RMT from these angles below.

Describing interactions

Chapter 4 and Chapter 5 demonstrate that RMT is applicable to describe a diverse range of interactive artworks involving multiple participants, including both humans and nonhumans. The main concepts of the relational model—the identification of elements, their actions and forms of communications to each other—have been shown to be applicable across all examined artworks. By employing these concepts and their associated descriptors, we were able to systematically dissect these interactions and trace how elements relate to and influence one another. As a result, this approach allows us to identify the distinct roles played by different elements and the varying types of participation they engage in within the interaction.

Compared to using the relational model alone, RMT offers distinct advantages in describing interactions. Firstly, it significantly enhances the precision of both the modelling process and the resulting interaction descriptions. By providing a comprehensive and consistent scheme for each element, along with suggestions for each descriptor based on previously described artworks, RMT not only guides users through the modelling process but also aids in formulating detailed descriptions. This lowers the learning barrier and ensures that all aspects of the relational model are thoroughly addressed.

Another notable strength of the modelling capabilities of RMT lies in its emphasis on the relational exchange between actions. Prior to the development of RMT, the relational

model did not explicitly require the specification of conditions for each action, leaving the decision of which actions to describe entirely to the modeller. RMT, however, necessitates a clear specification of triggering actions for reactions, ensuring that the relationships between audience actions and the art system are explicitly articulated through their conditional links. In doing so, RMT enforces the clear definition of all actions and reactions, leading to more comprehensive descriptions and aiding in the decision-making process during modelling.

Additionally, the formal structure of the input fields allows us to define a visual language for depicting an interaction and automatically generate a visualisation. The visualisation provides a direct visual impression of the description that facilitates the modelling process and comparisons of different interactions. It can also create easily identifiable visual patterns showing the characteristics of an interaction. Consequently, RMT enables the easy identification and contextualisation of known interaction model—such as feedback loops that can be recognised as the reverse symmetry of blue and red bars in the conditional links—within specific interactions, which also provides a broader context of how these models relate to other aspects of the interaction.

Moreover, the open and modular architecture of RMT also allows us to creatively adapt it to describe processes beyond the scope defined by the relational model. For instance, the concept of action and communication can also be applied to specify significant internal dynamics within a single element. While effective, such adaptation also raises important questions about whose and which internal actions should be considered significant in the modelling process. Therefore, if RMT is to be extended into a more versatile tool, more concrete guidelines and refinements are necessary to ensure consistency and clarity in its application.

Lastly, although RMT demonstrated potentials in different application scenarios spanning from facilitating communication to artwork conservation, it is worth emphasising again that the primary goal of both RMT and the relational model is to facilitate understanding of interactive dynamics among elements. Depending on the specific application scenario, a more detailed behavioural diagram of an art system–one that specifies internal processes and breaks down subcomponents–may prove more practical for communication during art system development, as well as for conservation and archiving purposes.

Comparing interactions

The key concepts and descriptors of the relational model and RMT not only facilitate the analysis of interactions but also establish a consistent frame of analysis and shared vocabulary for making meaningful and systematic comparisons between different interactive artworks. In Chapters 4 and 5, we illustrate how RMT enables the identification of common patterns across diverse forms of interaction, specifically in co-located interaction and more-than-human inter-

action, respectively. Additionally, as demonstrated in Chapter 6, RMT provides a powerful tool for translating insights from other participatory artworks that are not necessarily considered interactive into actionable inspirations for the creation of interactive art.

Additionally, datasets of interactive dialogues generated using the formal input fields of RMT present opportunities to develop novel analytical and comparative approaches. The unified data structure not only facilitates straightforward comparison and rigorous analysis across diverse forms of interaction but also enables the application of statistical and visualisation techniques to extract insights from large collections of interactive artworks, which are not always possible to achieve manually. For instance, we could explore methods to visualise and quantify stored artwork collections, generating an overview that highlights the distribution of data points across various descriptors. At an applied level, such techniques could support the automated curation of artwork collections, as well as enable advanced computational and visual analysis of larger datasets of interactive artworks, thereby enhancing our ability to interpret and engage with extensive collections systematically.

Generating interactions

Besides its application in describing various interactive artwork, RMT also showed potentials in inspiring the creation of new forms of interaction. Here we discuss our attempts to harvest the generative potentials of RMT as well as the lessons we learned through these exercises. This section also serves as a response to the research question:

> **Q3:** Can a relational modelling approach support the discovery and creation of new interactive dialogues?

In short, we believe that our relational modelling approach—the relational model and RMT—can support the discovery and creation of new interactive dialogues. As RMT treats humans, nonhuman organisms and art systems with equal terms, it allows us to view an interaction from the perspectives of all elements involved, including the nonhuman ones. Drawing on the patterns of interaction uncovered in Chapters 4 and 5, we can envision novel forms of interaction by reconfiguring the roles of these elements and experimenting with diverse combinations of existing communications and conditions. Additionally, similar to the comparative approaches enabled by RMT, we can also apply statistical and computational methods to explore and discover new forms of interaction. This line of inquiry directly inspired the development of the generative component of RMT, which seeks to provoke discussions about the generative possibilities of RMT through innovative, data-driven approaches.

Currently, the generative component applies random generation features to explore new combinations of element types and behaviours based on the collection of existing interactive

dialogues, and draw new connections between them in terms of generating new forms of communications and conditions. While randomness may inspire the discovery of new elements, behaviours, or connections, we noted that a completely random configuration of elements is unlikely to produce a meaningful interaction. In complex scenarios involving multiple elements, it may be the case that not every pair of elements are responsive to each other. However, the overall configuration of the interaction should still enable a mutually responsive dynamic between two elements, potentially mediated by a third element. Thus, in the future development of generative features, the focus should not only be on exploring combinatory novelty, but also on identifying the interactive dynamics within the generated ideas.

Furthermore, feedback from the workshop participants highlighted the necessity of providing users with more control during the generative processes. For instance, instead of using the whole artwork collection, users could select artworks with shared characteristics or combine different forms of interaction that are more aligned with their creative goals. This tailored approach would allow the generative functions to explore more coherent and purposeful combinations. Additionally, we can also leverage machine intelligence further to facilitate greater customisation during the generation process. For instance, data mining and machine learning algorithms could be employed to generate new forms of interaction based on statistical patterns identified within the artwork collection. This could be complemented by allowing users to adjust the level of randomness in the generation process, similar to adjusting the *temperatures* in generative AI systems, thereby offering a balance between structured guidance and creative exploration.

8.2 Insights into Interactive Art

Another central focus of this thesis is to uncover insights into diverse forms of interaction within interactive art through the application of the relational modelling approach. In this section, we summarise these insights in response to the following research question:

> **Q2:** What insights into interactions in interactive art can be gained from a relational modelling approach?

In Chapters 4 and 5, we systematically analyse distinct forms of co-located interaction and more-than-human interaction using carefully selected interactive artworks as case studies. Through this analysis, we uncovered key insights emerging from these two types of interaction, highlighting common themes such as the interplay between actions performed by elements, the roles assumed by different elements, the ways in which art systems configure relationships among participants, and the various forms of mediated communication. In the

following discussion, we further elaborate on these insights in relation to these two forms of interaction. These insights not only reveal patterns in existing interactive artworks, but also point to directions for creating new forms of interaction.

8.2.1 Insights into co-located interaction

In co-located interaction, two or more audience members engage simultaneously with an interactive artwork within a shared physical space. The interaction takes place not only between the audience and the artwork, but also between the audience members themselves. In Chapter 4, we selected eight artworks representative of a diverse range of co-located interaction and applied RMT in describing and analysing the relational dynamics within these artworks. Based on the similarities and differences across the generated descriptions, we derived insights into co-located interaction, addressing the following sub-question:

> **Q2a:** What insights into co-located interaction can be gained from a relational modelling approach?

In summary, our analysis revealed that co-located interaction extends the concept of an interactive dialogue between two elements into a network of intertwined actions and reactions among multiple elements. Specifically, in a co-located interaction: elements can relate to each other in various ways via their actions; art systems play different roles in mediating and establishing connections among human participants; both art systems and audience members can be a mediator in a communication. Below, we elaborate on these key insights.

Firstly, elements can act and react to one another in diverse ways. The reactions from art systems frequently provide feedback on the effects of audience actions, or deliver additional sensory feedback—such as auditory or visual cues—on these actions. In doing so, they enable the audience to grasp the intended interaction mechanisms and use the additional sensory cues to express themselves and communicate with others. Notably, in some instances, the art system simply reacts to the presence of the audience, signalling interactive possibilities and thereby initiating the interaction. This dynamic highlights the role of the art system not only as a responsive entity, but also as an active agent in shaping the interactive experience.

In addition to the action-reaction relationship, actions performed by elements can also influence one another in various ways. For instance, an action may serve as a prerequisite for subsequent actions, requiring an element to execute it either prior to or concurrently with other actions. Furthermore, a parallel action can disrupt, enhance, or facilitate the execution of other actions. A distinctive feature of co-located interaction is the ability of the audience to communicate directly with one another due to their co-locatedness. Since this communication frequently occurs alongside other audience actions, it can be configured to either facilitate or

disrupt other actions, adding a layer of complexity to the relational dynamics. Alternatively, in some cases, the art system responds directly to the joint actions of the audience, making their direct communication a key mechanism driving the interaction.

A recurring theme across all the selected artworks is the active role of art systems in establishing or facilitating connections among audience members during the interaction. These connections can be formed arbitrarily, such as by selecting and pairing audience members to perform specific tasks together. This strategy often fosters collaboration among participants, encouraging them to engage with one another. Additionally, the art system can create interdependencies among audience actions, for example, by reacting to the joint actions of the audience members. A particularly intriguing approach observed is one that may initially appear counterintuitive: isolating an individual from the rest. In such cases, the art system deliberately focuses on a single participant, placing them in the spotlight. This heightened focus amplifies the actions of the chosen individual, prompting them to express themselves and connect with others.

Lastly, we highlight the various forms of mediated communication identified within the selected interactive artworks. The most prevalent example involves audience members communicating with one another through art systems. In such instances, the art system often serves as a platform or provides additional sensory channels, enabling participants to express themselves and perform in front of others. Another form of mediated communication occurs when the audience communicates with the art system, or vice versa, via another audience member. These audience-mediated interactions can leverage the properties of the human body as a conductive material or rely on our innate communicative abilities to express and convey information, challenging conventional assumptions about the roles of humans and technical systems within interactive contexts.

8.2.2 Insights into more-than-human interaction

More-than-human interaction reflects the growing interest in developing interactive technologies that engage animals and other nonhuman life-forms, emphasising the agency and influence of nonhuman entities in interactive contexts. In Chapter 5, we selected five artworks that exemplify diverse approaches to shaping interspecies relationships between humans and nonhuman life forms and applied RMT to examine the more-than-human interaction within them. Through the generated descriptions, we identified recurring patterns and biases in these artworks, thereby addressing the following sub-question:

> **Q2b:** What insights into more-than-human interaction can be gained from a relational modelling approach?

In summary, our analysis revealed a recurring tendency to cast nonhuman organisms as passive participants and humans as active. Additionally, we identified various ways art systems mediate communications and (re)configure relationships between them. Taking a more-than-human perspective, we challenge these conceptions of element roles and propose directions for new forms of interaction that highlight the agency of nonhuman elements, including art systems. Below, we further discuss these key insights in details.

Firstly, in the described more-than-human interactive artworks, humans often take on an active role in the interaction, while nonhuman organisms play a passive one. In most cases, humans are aware of how their actions impact the interaction and participate voluntarily. Meanwhile, although the nonhuman participants often trigger the art system to initiate interaction, we would argue that these actions are not intended for participation, and they may not be aware of how they affect the interaction. Although they receive feedback about their actions either directly from the art system or indirectly via the humans' actions, it remains unclear whether they could eventually learn about the interaction mechanisms and become active participants.

For future inquiries, it may be interesting to explore ways to engage nonhuman organisms as active participants and consider scenarios where they interact with humans who participate passively. However, since we lack direct access to the cognition of nonhuman organisms, assessing whether nonhuman participants willingly participating in the interaction remains speculative from a human standpoint. Clearly, such a proposal requires careful ethical consideration, as it inevitably necessitates humans interpreting the actions and responses of nonhuman organisms.

Similar to the cases observed in co-located interaction, we identified various forms of mediated communication in this context. The most prevalent is communication from nonhuman organisms to humans via art systems. In these instances, the art system typically detects the actions of nonhuman organisms and actively relays information relevant to the interaction to human participants. Additionally, art systems can also mediate another form of communication from humans to nonhuman organisms by providing food or physical stimuli to nonhuman participants triggered by actions of the humans. Furthermore, we also observe a form of human-mediated communication directed towards nonhuman organisms. In this case, the art system instructs the human to engage with the nonhuman, leveraging human abilities and skills to attend to and adapt to the nonhuman. This is particularly interesting as it encourages humans to reflect on the implications of the nonhuman's involvement in the interaction, fostering a deeper awareness and responsibility of interspecies relational dynamics.

Finally, art systems not only facilitate interspecies communication, but also reconfigure relationships between humans and nonhumans in various ways. Here too, art systems can provide a collaborative context for both groups of participants, prompting interdependences

between their actions. In such scenarios, both parties—especially the humans—must actively engage with one another, negotiate and work together to achieve specific tasks. Alternatively, art systems can establish and mediate connections between humans and nonhumans by providing mechanisms that translate the actions of one party into sensory cues or physical stimuli perceivable by the other. In doing so, art systems allows both participants to influence and communicate with each other in ways that were previously unattainable. However, it is important to note that while art systems facilitate these connections, it also imposes constraints on the type of information that can be transmitted and may even limit the agency of the elements involved in shaping such processes.

8.3 Challenges and Considerations

In addition to reflecting on the key insights gained in this study, it is also important to acknowledge the challenges encountered in relation to the approaches and process. First and foremost, although RMT facilitates the modelling of interactions by providing structured guidance and encouraging relational thinking among elements, the decisions made during the modelling process—such as determining which elements to include, identifying significant actions, and describing the effects of the resulting communications—remain largely subjective to the modeller. In this thesis, we have acted as the primary modellers and users of RMT. The generated descriptions and insights are inevitably shaped by our own interpretative frameworks, habits, and assumptions. It is conceivable that different modellers would describe the same artworks in varied ways, potentially uncovering insights that we may have overlooked.

Additionally, as there are no formal criteria or established benchmarks for evaluating the accuracy or completeness of the generated descriptions, the effectiveness of RMT as a modelling tool has been assessed primarily based on our own judgment. While we have demonstrated its applicability across different cases, a more rigorous validation process—such as comparative studies involving multiple modellers or user studies assessing its consistency —would be beneficial to further substantiate its reliability. Future research could explore methods for standardising the evaluation of RMT, potentially through expert reviews, inter-modeller agreement studies, or even computational benchmarking techniques.

Meanwhile, although we have devised a rigorous process for selecting artworks for analysis, we acknowledge that the chosen artworks do not encompass the full spectrum of co-located interaction and more-than-human interaction. Consequently, it is reasonable to assume that there are other artworks that can not be fully captured by RMT, which would require further refinement and adjustment of the relational model and RMT. Moreover, given the relatively small sample size of selected artworks, the general trends and patterns observed in this study

may not be universally applicable and could be contradicted by other artworks that were not considered in this thesis.

Another limitation in describing the artworks is that we lacked first-hand experience with most of them, relying instead on textual and audiovisual documentation for our analysis. Unlike static artistic objects, the dynamic and interactive processes between artworks and audiences in interactive art are notoriously difficult to capture fully using traditional documentation methods. This is where interaction modelling tools such as RMT prove particularly valuable, as they offer a structured approach to archiving and describing such artworks. Consequently, it is important to acknowledge that certain aspects of the described artworks may not have been fully captured in the available documentation, potentially resulting in incomplete descriptions.

Lastly, as most participants in the evaluation workshop had backgrounds in HCI research and interaction design, their feedback and discussions naturally gravitated towards the design and modelling implications of RMT. Since the relational model and RMT were specifically developed for the study of interactive art and inspiring the creation of new interaction forms, evaluations involving artists and researchers in this field could provide more significant and diverse insights into its applicability and potential within the field and a more comprehensive understanding of its strengths and limitations.

8.4 Future Directions

Before concluding the thesis, we outline several key directions for future research and development. Firstly, we emphasise again that the relational model and RMT are not definitive or finalised products. Rather, they function as research instruments to explore the benefits and potential of such modelling tools within the context of interactive art. On a practical level, future developments of RMT could draw inspiration from the well-defined notation systems of established interaction modelling languages, such as the Unified Modelling Language (UML) (Bell, 2023). This could enhance clarity and facilitate easier adoption of RMT by a broader user group. Additionally, organising co-design sessions with practitioners and researchers in the field of interactive art could provide valuable insights to refine the design of RMT, generate ideas for new features, and ensure its functionalities align with their creative processes.

Another promising direction for the future development of RMT and the relational model is to refine the description of actions and their interrelationships. Currently, the concept of action encompasses both actions and reactions of elements. Although we have refined the definition of action and incorporated its intention and conditions, it can still be conceptually challenging to differentiate various types of actions at a glance. Future iterations of RMT could explore alternative methods to specify actions and reactions more clearly, as well as different ways

to indicate how they influence one another. This could involve developing more nuanced categorisations or visual representations to enhance the clarity of different types of actions, thereby supporting more precise analysis and interpretation of interactive dynamics.

In this thesis, we applied RMT primarily to model existing interactive artworks and explored its potential for generating new interactive dialogues. An interesting avenue for future research would be to integrate RMT throughout the entire development cycle of an interactive artwork—from initial ideation and conceptualisation to technical development and final evaluation. This holistic application could further demonstrate the versatility and utility of RMT, as well as reveal its limitations, in supporting the creation and analysis of interactive art.

Moreover, while we have demonstrated that RMT is applicable for describing participatory processes beyond interactive art, it is interesting for future studies to explore how its key concepts and descriptive approach can support the development of metrics to distinguish and evaluate interactive artworks. For instance, the conditional links between actions could be employed to evaluate the mutual responsiveness of an artwork and its audience–a defining characteristic of interactive art–while also enabling comparisons of levels of interactivity across different artworks. Such metrics could not only facilitate the curation and archiving of interactive artworks but also contribute to the conceptual advancement of interactive art by outlining the unexplored territories.

Meanwhile, our investigation into interactive art using RMT and the relational model also opens up avenues for exploring new forms of interaction. In our analyses of both co-located interaction and more-than-human interaction, art systems frequently function as a mediator or tool, facilitating connections and communication among participants, including both humans and nonhumans. One particularly intriguing direction is to explore how art systems might be created as participants in their own right. Given that RMT and the relational model treat all types of elements equally, they provide a valuable tool for conceptualising such scenarios. We could begin by assigning roles typically associated with human participants to art systems, specifying the behaviours that support these roles, and evaluating their technical feasibility. This line of inquiry not only points toward the creation of novel forms of interaction in interactive art, but also challenges our assumptions about the roles of technical systems and explores alternative ways to relate to these systems.