



Interaction and Interactivity: In the Context of Digital Interactive Art Installation

Salah Uddin Ahmed^(✉)

Høgskolen i Sørøst Norge, Ringerike, Norway
Salah.ahmed@usn.no

Abstract. Different people define ‘interaction’ in the context of digital interactive art in different ways. The confusion comes from the fact that the meaning of interaction is different in different fields. Medical science, social science, information technology all define interaction in a way that is different from the meaning in the other field.

In this article, we would like to point out how interaction and interactivity is defined in different fields that has some sort of relevance and applicability in the area of digital interactive art and how these varied definitions are related and what they mean when applied in the context of digital interactive art. In particular, we would like to identify the various types of interactions and communication that take place and have some meaning and significance in the context of a digital interactive art installation.

Keywords: Interactivity · Interaction · Digital interactive art · Digital art
Interactive art · Digital interactive art installation

1 Introduction

In the recent years, number of technology dependent artworks have increased because of the increased availability, accessibility and development of computer technology. The intersection of the two fields, art and technology, has interested many artists, researchers and theorists in the recent years. This is reflected in the recent art festivals like Transmediale (www.transmediale.de), Read_Me (<http://readme.runme.org>), ARS Electronica (www.aec.at), Make Art (<http://makeart.goto10.org>), FILE (www.file.org.br), Trondheim MatchMaking (<http://matchmaking.teks.no>), in the literature and in online artist community sites and blogs where plenty of examples of artists using technology in their artworks are visible. As a result of this trend of using more technology in artwork, more and more artists-technologists collaboration is taking place. In SArt project, we collaborated with several artists, and participated and observed the development of several digital interactive artworks (Ahmed 2011). From our experience, we have seen that definitions of different terms in the intersection of art and technology are not very well defined. While doing research in the context of digital interactive art, we have seen that interaction and interactivity in the context of artwork is defined differently by different artists and technologists. This is due to the reason that the definitions of different genres of artwork in the intersection of art and technology are overlapping and not mutually distinct. Besides intersection

of art and technology involves people from various background where the definition of a term such as interaction can get different meaning (Ahmed et al. 2009).

In this paper, we would like to see how interaction and interactivity is defined in different fields that has some sort of relevance and applicability in the area of digital interactive art, how these varied definitions are related, and what meaning they offer when applied in the context of a digital interactive art. Since digital interactive art is a multidisciplinary field that brings in people from different fields together, it will be interesting to see the different viewpoints of interactivity viewed from different discipline. In particular, we would like to identify the various types of interaction and communication, and their meaning and significance in the setting of a digital interactive art installation. Finding the different meanings and uses of interaction will remove the confusion about interaction among artists, technologists and others involved in the digital interactive art, and help them to better identify, define and design the desired interactions that they are interested in a certain context.

The rest of the article is organized in the following way. Section 2 provides some background information; a brief introduction of intersection of art and technology and digital interactive art. It also presents the inconsistencies among researchers and artists about the definition of interaction and interactivity in digital interactive art. Section 3 provides a description of how interaction and communication is defined in different disciplines. Section 4 presents interactivity in the context of digital interactive artwork.

Section 5 presents our results. We present the different kinds of interactions that are possible in the context of a digital interactive art installation. With reference to the definitions in the literature, we identify the interactions and their types and the meaningfulness and significance of them in the given context. Section 6 is the conclusion.

2 Background

2.1 Intersection of Art and Technology

As increasing number of artists are using technology and the advent of different tools and technologies enabling different kinds of collaborations between art and technology, we see various new types and genres of art in the intersection of art and technology. As an example, digital art, computer art, internet art, software dependent art, digital interactive art, generative art, interactive art installations etc. are only a few to mention in this regard. Often the distinction between different genres are not very clear; one genre collides with others. Some genres are not well defined and some overlap with others since there are no mutual exclusive criteria that distinguish them. Often, one genre is derived from another, and one can have several sub genres or sub categories; thus making the categorization and classification blurry and overlapping.

As an example, internet art is a sub-category of digital art and both of them belongs to the new media art. Many digital arts are interactive in nature; hence, they are interactive art as well. However, not all digital arts are interactive art. Again not all interactive arts are digital art. How to draw distinctions between computer art, digital art, and Internet art when they overlap and combines so much? Again, all these genres can be placed under the larger umbrella term new media art. New media art is usually defined

as a genre that encompasses artworks created with new media technologies. But defining new media is difficult; as Pereira (2015) puts it in the following way.

“What is digital art? What is new media art? What are the boundaries of new media art? I am afraid there are no clear answers to these questions,…” He continues the puzzle as, “...when we see definitions of new media art or digital art, we are left a bit confused, and with a lot of questions to be posed. New media art is usually defined as a genre that encompasses artworks created with new media technologies, including digital art, computer graphics, computer animation, virtual art, Internet art, interactive art, video games, computer robotics, 3D printing, and art as biotechnology. But, then we could pose questions such as: What is new media? What is digital art? What is the difference between interactive art and new media art?” (Pereira 2015).

In this puzzle of these linked and overlapped terms, clarifying the concept of digital interactive art deserves some special attention as it touches many other categories of art. Defining a concept of something in the context of a concept that is not very clear and overlaps with several other concepts can be fuzzy and misleading. So is the case with defining interaction in the context of digital interactive art. In the next section, we describe digital interactive art tracing it from the genres: digital art and interactive art.

2.2 Digital Interactive Art

“Digital interactive artwork” or “Interactive digital artwork” as some others name it refers to a genre of artwork which are interactive and where digital technology is an essential component for the creation of the artwork. Whatever name it is called, either *digital interactive art* or *interactive digital art*, it refers to a combination of two terms: (i) *digital art* and (ii) *interactive art*.

Wikipedia defines *digital art* as “an artistic work or practice that uses digital technology as an essential part of the creative or presentation process”. British art organization Tate (<http://www.tate.org.uk>) defines the term digital art to describe “art that is made or presented using digital technology”.

Interactive art on the other hand is defined by the Wikipedia as “a form of art that involves the spectator in a way that allows the art to achieve its purpose. Some interactive art installations achieve this by letting the observer or visitor “walk” in, on, and around them; some others ask the artist or the spectators to become part of the artwork”. As Edmonds (2011) describes, “interactive art is distinguished by its dynamic behaviour in response to external stimuli, such as people moving and speaking”. Art becomes interactive when audience participation is an integral part of the artwork. Audience behavior can cause the artwork itself to change. In making interactive art, the artist not only considers how the artwork will look or sound to an observer, but the way it interacts with the audience is also a crucial part of its essence (Edmonds 2011).

In the recent years extensive use of digital technology in artwork and audience interaction gives us an impression that all digital art is interactive, or on the other way, all interactive art is digital. As an example, we can cite the artworks of Gregory Lasserre & Anais met den Ancxt. They are two artists who work as a duo under the name Scenocosme and develop the concept of interactivity in their artworks by using multiple kind of expression: art, technology, sound and architecture. In their website, they have a list

of interactive installations. It is not surprising that all of the interactive installations in their list are actually digital art considering the fact that one of the artists is a Computer Science graduate (Lasserre and Ancxt 2018). However, similar is the case with many other artists in the area of art and technology where artists are either collaborating with technologists or hiring some expertise to develop the technical part of their artwork if they do not know the technology by themselves (Ahmed et al. 2009) (Ahmed 2011). Thus in the recent lists of interactive artworks, in most of the cases, the digital and the interactive part smoothly joins as two sides of a coin.

However, the concept of interactive art is older than the concept of digital art and digital interactive art. Interactive art engages the audience with the artwork. While Interactive art became a large phenomenon due to the advent of computer based interactivity during the 1990s, but the theoretical concept of audience participation and interaction with the artwork been developed by the British artist and theorist Roy Ascott as early as 1966 (Schraffenberger and van der Heide 2012). Thus, interactive art does not necessarily have to be digital art; non-digital art can be interactive as well. At the same time, digital arts can be non-interactive too.

Besides, not all digital-interactive art is interactive in the sense of *interactive art*. As Lopes (2001) mentions, “Interactivity is a buzzword used rather indiscriminately to describe everything from computer games to Internet shopping, and it is not the case that all computer-based art is interactive in any interesting sense. Indeed”. The main idea of interactive artwork is audience’s interaction with the artwork, audience’s participation and engagement in the artwork in such a way that the activity of engagement becomes part of the artwork.

2.3 Different Approaches of Interactivity in Digital Interactive Art

Several artists and researchers define digital interactive art in different ways. In fact, the variety and richness of existing approaches are so wide that the relevance of interaction in interactive art is suggested to be a broad and interdisciplinary field of research (Schraffenberger and van der Heide 2012). Here we mention only three different approaches.

Trifonova and Jaccheri (2007) presents art installation Flyndre as an example of interactive art installation. Flyndre has an interactive sound system that has the goal to reflect the nature around the sculpture. Flyndre takes as input parameters from the environment such as the local time, light level, temperature, water level and depending on these parameters creates music by exploiting algorithmic composition techniques (Ahmed 2008). While the artwork is interactive in the sense that it interacts with the outer world by taking some sensor data, but considering interaction with the audience, it is not interactive.

While defining interactive digital art Nardelli (2012) mentions, “Digital films/videos are usually not examples of IDA (Interactive Digital Art), nor is digital music, since they both lack the contribution of the user to the content production. But when the outcome of video animations or music pieces is modified according to user interaction they are examples of *interactive digital art*”. This definition focuses on the content generation part rather than the audience experience of interaction.

Satomi and Sommerer (2007) calls “game_of_life” an interactive art installation that lets spectators walk through the virtual city by using their own eye gaze movement. Even though they call it only “*interactive art installation*”, it is a digital interactive art as it depends heavily on the digital technology. On the other hand, this is a true interactive art, as here the audience becomes a part of the artwork expression.

Immediately from these three examples, we can find three different interactions, (i) artwork interaction with non-user parameters (environment), (ii) audience interaction with artwork for content accessibility or content generation and (iii) audience interaction with the artwork for user experience and being a part of the artwork expression.

In this paper, we want to see why and how these various types of interaction finds a relevance in the digital interactive art context by investigating some relevant disciplines. Since digital interactive art brings together different genres of art and brings together people and knowledge from different disciplines, we would like to see if the variations of meaning and approaches of interaction are due to that multi-disciplinary involvements and origin. In the next section, we present how the concept *interaction* is defined in some disciplines and how it is mixed with a different concept *communication* in some cases.

3 Interaction and Communication

Encyclopedia Britannica defines *communication* as the exchange of meanings between individuals through a common system of symbols. Merriam-Webster defines communication as a process by which information is exchanged between individuals through a common system of symbols, signs, or behavior. It also defines *communications*, the plural form, as a system (as of telephones, or computers) for transmitting or exchanging information.

The Merriam Webster dictionary defines *interaction* as mutual or reciprocal action or influence. The meaning of the concept ‘interaction’ depends on the context in which it is used. As Jensen (1998) mentions, different disciplines have quite different meaning of interaction. For example, in medical science it refers to the interplay between two medications applied at the same time, whereas, in engineering it refers to the relationship between two different materials under stress. Statistics and linguistics have all different meaning of interaction. However, none of these fields are related to the context of digital interactive artwork. The fields that are more related to concept of interaction in the context of digital interactive art are the concepts of interaction in (i) social science, (ii) communication and media studies, and, (iii) information technology. In the following sections, we present how interaction is defined in these relevant fields. Besides, we also show how *interaction* is related with or different from *communication* according to the various discipline-specific definitions.

3.1 In Social Science

In social science, interaction refers to the reciprocal relationship between two or more people (Duncan 1989) who, in a given situation, mutually adapt their behavior and actions to each other. Partners involved in interaction are located in close physical

proximity and some form of symbolic interaction exists which leads to a mutual exchange and negotiation regarding meaning in that social context (Jensen 1998).

Social interaction is the process by which we act and react to those around us. Thus, a quick conversation with a friend is a kind of social interaction. Influential sociologist of twentieth century Erving Goffman argues that even though conversation with a friend may appear as a trivial and insignificant form of social interaction, but they are of major importance in sociology (Moffitt 2018). In sociology, social interactions include such large number of behaviors that interaction is usually divided into five categories: exchange, competition, cooperation, conflict and coercion (Moffitt 2018).

The difference between interaction and communication in social science is that of response, reply and reciprocity. 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. It is noted that when two people interacts according to the definition of social science, mutual exchange and negotiation regarding meaning takes place between partners as a result of the interaction. Therefore, interaction in social science includes communication.

3.2 In Communication and Media Studies

In communication and media studies, the concept of interaction is not clearly defined as in social science. Interaction in communication and media studies is used as a broad concept that covers the processes that takes place between media message and its receiver. For example, reading a text, a literary work is an interaction between its structure and its recipient (Iser 1989). In that way listening to radio, watching TV etc. and other forms of communication which take place through technologies of various kinds such as telephone, internet, presentations are also sort of interaction (Horton and Richard Wohl 1956). Thus, we can see that, in communication and media studies, the reciprocity nature in the social science sense is not required, and interaction can be one sided and non-dialectical.

When media technologies opened up for input from the user later on, media researcher still did not use the concept of interaction as reciprocity in the sense of social science for quite a while (Jensen 1998). Interaction was predominantly considered as one way by the media researchers and it referred to the actions of an audience or recipients in relation to media content. After the arrival of new media, the interactive nature of media started to gain attention of the researchers.

3.3 In Informatics

The concept of interaction in information technology refers to the relationship between people and machines, which is known as human computer interaction or man-machine interaction. The term 'interactive' historically originates from batch processing. Batch processing refers to a process where a series of tasks are executed by a computer without any human interruption. Contrary to the batch processing, interactive processing is the situation where a user can observe partial results, interrupt the program and continually influence the flow and performance of the program by giving input to the program. Thus,

‘interaction’ in the context of information technology or computer science refers to the process that takes place when a human user interacts with the machine with a goal to influence its processing. Though the reciprocity nature of interaction is taken from the social science sense, but in informatics it does not refer to the interaction between two persons, rather it refers to the interaction between a machine and a user.

There is a difference between interaction and communication in informatics. When two people communicate with each other through a machine, that is communication mediated by computer, it is not termed as interaction; rather it is called computer-mediated communication. Whereas in terms of communication and media studies that could still be called as an interaction.

In summary, we can say that, ‘interaction’ in the sociological sense refers to reciprocal relationship between two people, but in informatics sense, it refers to the relationship between people and machine. Communication mediated by computer is not interaction in the informatics sense, whereas, according to communication and media studies it can be interaction. In social science, since interaction is between two human beings, it is not possible to have interaction without communication, but communication without interaction is possible for example reading a text, paper, watching TV etc. In media and communication study, interaction is possible even with static information or one-way flow of contents; interaction and communication is somewhat similar here. Finally, in informatics, interaction happens only when a user interacts with a machine, and is not between two human beings, so it is possible to have interaction (with machine) without human-human communication.

4 Interactivity

The concept of interactivity extends from the concept of ‘interaction’. Interactivity refers to the extent to which something is interactive. The Merriam Webster dictionary defines interactive as (i) “mutually or reciprocally active”, or (ii) involving the actions or input of a user; especially: of, relating to, or being a two-way electronic communication system that involves a user’s orders or responses. Oxford English dictionary defines it as, “(of two people or things) influencing each other”. It also includes a definition from the viewpoint of computing as below:

“Allowing a two-way flow of information between a computer and a computer user; responding to a user’s input”. In the following sections, we present the concept of interactivity of media artefacts and digital interactive artworks.

4.1 Interactivity of Media Artefacts

Social science does not usually use the term interactivity, but in informatics and media studies, the concept of interaction and interactivity is used synonymously (Jensen 1998). In this section, we put some notable definitions of interactivity that researchers used to define whether a media artefact is interactive or not. The definitions in this section were mainly used in the context of media artefact or communication systems.

Interaction is a style of control, interactive systems exhibit that style and interactivity defines the level/extent to which the system is interactive. Rogers (1986) defines interactivity as the ability of the communication system to talk back, and he considers it as a variable: some systems are low interactive and some are highly interactive.

Jensen (1998) argues that a large number of new media artefacts can be addressed if we consider interactivity as a continuum rather than a criteria and the interactivity can be presented in varying degrees. As an example, Klaus Schrape's five levels scale of interactivity which considers a TV/radio with only the user functions of turn on and off and changing channels as level 0 interactive and video phone which offers two way communication is given level 4, the highest level on the scale (Schrape 1995). Thus, the level of interactivity in media refers to how much control the user has over it.

Laurel (1990) has argued that "interactivity exists on a continuum that could be characterized by three variables" specifically: (1) "frequency" in other words, "how often you could interact", (2) "range", or "how many choices were available" and (3) "significance", or "how much the choices really affected matters".

Sheizaf Rafaeli's concept focuses on the responsiveness of the media in dialogue with the user and distinguishes between level of responsiveness: reactive and fully interactive. Rafaeli (1988) mention three progressive levels: (i) Two way communication- message flows in both ways but do not depend on previous message, (ii) reactive - a later message reacts to a previous message but does not consider history (iii) full interactivity- later message responds to a sequence of previous messages, i.e., history of interaction.

Based on Bordewijk and Van Kaam (1986) matrix of information traffic pattern, Jensen (2008) defines four types of interactivity of a media considering who controls content creation and distribution or, in other way, user's influence on creation and distribution of content:

- (1) *Transmissional interactivity*, where information is both produced and distributed by center. It is a one-way flow of information where user has no influence except choosing for example a channel in multichannel TV.
- (2) *Conversational Interactivity*, where information is both produced and distributed by consumer. For example, chat, news groups, emails etc.
- (3) *Consultational interactivity*, where information is produced by center, distributed by consumer. User can choose from an existing selection of pre-produced information in a two-way media system with a return channel. For example, true video on demand, online information services, WWW etc.
- (4) *Registrational interactivity* is where media allows the user to register information but does not allow distribution control to the user. For example, home-shopping, surveillance systems, intelligent agents etc.

From the above discussion, it is clear that, there are not only various concepts of interaction but also various concepts of interactivity. The levels of interactivity of media artefacts address several aspects, such as media's ability to talk back, degree of reciprocity, user's level of control on the media, user's level of control on content of the media etc. In this scenario, it will be interesting to see which definitions and aspects of interactivity suits the context of digital interactive art.

4.2 Interactivity of Digital Interactive Artworks

In the previous section, we have listed some concepts of interactivity in the context of media. Here we will present some definitions that is more relevant for interactive artworks and multimedia installations.

Digital interactive art is part of new media art. As Steinkamp (2001) puts it, “They obviously can be considered part of the new media art genre because of their origins in, and reliance upon, computer-based technology”. Therefore, it is interesting to see how interactivity is defined in the sense of new media. Particularly we will see how the digital interactive art positions its definition of interactivity compared to the media studies and new media. We will note the differences of aspects in the definitions along the way as we go from a general multimedia application to the more specific digital interactive artwork.

Interactivity is one of the main characteristic of the new media. As mentioned in (Jensen 1998), interactivity of new media is defined as the ratio of response or initiative on the part of the user to the offer of the source or sender.

In the context of multimedia applications, Hannington and Reed (2002) discusses three distinguished types of interaction: passive, interactive and adaptive. *Passive* interaction is where the content has a linear presentation and users interact by only starting and stopping the presentation; *interactive* is when users are allowed to choose a personal path through the content; *adaptive* is the interaction in which users are able to enter their own content and control how it is used.

In the context of interactive artwork and edutainment, Mignonneau and Sommerer (2005) identifies two types of interaction that they have observed in existing interactive artworks: *pre-designed* or *pre-programmed*, and *evolutionary*. *Pre-designed* or *pre-programmed* paths of interaction refers to interaction as in interactive CDs where the viewer can choose his/her path, but the possibilities are limited. *Evolutionary* refers to situation in which the artwork’s processes are linked to interaction and is evolving continuously.

Based on the relationship between the artwork, artist, viewer and environment, Edmonds et al. (2004) discuss four categories of artwork: *static*, *dynamic-passive*, *dynamic-interactive* and *dynamic interactive (varying)*.

In static, the art object is mainly static and does not change itself in respect to its context. There is no interaction between the viewer and the object. Even though the viewer may experience personal psychological or emotional reactions, but that is internal and personal to the viewer. Example of this type of art are traditional art such as painting or sculpture. Art consumers can view a painting or a sculpture, listen to an audio tape and talk to one another about an art on the wall.

Dynamic-Passive type artwork changes with time but remains passive in response to user interaction. The change mechanism of the artwork is pre-designed and the change is controlled by an internal mechanism (algorithm or mechanical/physical process etc.). Environmental factors such as temperature, sound, light etc. can play a role in the changes. Sculptures such as George Rickey’s (1979) kinetic pieces that move according to internal mechanisms and also in response to atmospheric changes in the environment fall into this category.

In **Dynamic-Interactive**, the user has an active role in the change of the artwork. Usually artwork has some sensors that take values such as touch, movement, gestures, proximity etc. from the user, which serve as an input for the artwork changes based on a predefined algorithm.

Dynamic-Interactive (Varying) artworks are similar to dynamic interactive with the addition that artwork evolves over time and changes from its original specification. In this case, all the changes of the artwork due to the interactions are accumulated and the state of the artwork at a particular time depends on the history of the interactions. The future status of the artwork is therefore unpredictable.

From the above discussion, we see that from the static digital art to dynamic multimedia applications and to the highly interactive art installations, artworks at the lower end of the interactivity spectrum uses interaction in the sense of media and communication studies, mainly to refer to the degree to which user can have control on the media or its contents. In the higher end, in the interactive art installations, interactivity is used in the sense of informatics, to refer to the degree to which a user can control the output of the system and the reciprocity nature of the artefact.

5 Identifying the Interactions in Digital Interactive Art Installation

Now that we have some idea about the interaction and communication, and interactivity of artwork, we would like to identify the different kinds of interactions that can take place in the context of a digital interactive art installation. However, before describing the possible meaningful interactions with a digital interactive artwork, we give an example of a digital interactive art installation from where it will be easy to understand the components of the artwork and the relationships and interactions between them.

5.1 A Digital Interactive Art Installation

Sonic Onyx is an exemplary project of digital interactive art installation in public space in which we participated as researcher and collaborated with the artists and technologists. This artwork brings into many sought after interactions and aspects that artists are interested in public space installation.

Sonic Onyx is an interactive sound sculpture that is placed in front of a secondary school (Ahmed 2012). The sculpture has seven loudspeakers located in seven arms and a subwoofer located in ground at the center making it possible to provide 3D sound effects within the space created by the sculpture (Fig. 1). People can communicate with the sculpture by sending text, image, and sound files from their Bluetooth enabled handheld devices. These media files are processed and converted into unrecognizable sound by mixing with randomly selected algorithms. The converted audio is then played by the sculpture. Audience interact with the sculpture by sending files and try to reflect how their files are modified and converted into different sound files. A website archives previously sent and modified files that were played by the sculpture. Students from music class can create an account and upload the music composed by them to be played by the sculpture in its idle time, i.e., when no one interacts with it by sending files via Bluetooth.

The sphere on the top contains a light bulb that dynamically changes its color based the outside weather condition such as light, dark, gloomy etc. We find the example of Sonic Onyx very interesting as it covers many aspects of interaction with the artwork. Audience can directly interact with the artwork, it allows inter-audience communication within the space, and audience can communicate indirectly via the website. Artist can even get ideas and insights about the audience interactions through the website.



Fig. 1. Users interacting with Sonic Onyx

5.2 Components of a Digital Interactive Art Installation

As we can see from the previous example, there are essentially four components in an art system they are: (i) Artwork, (ii) Audience, (iii) Environment, and (iv) Artist (Fig. 2).

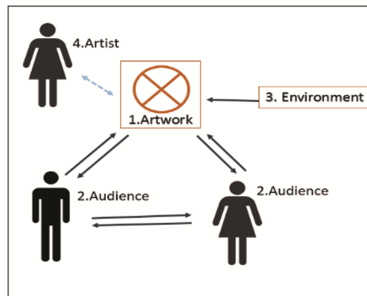


Fig. 2. Components of an artwork system

There could be several relationships between different components which might be meaningful and interesting in respect to interactive artwork such as:

1. audience – artwork,
2. audience–audience,
3. artwork–environment.

In the traditional sense, artist might not be a part of the artwork system, but as researchers consider that the artist and the audience play integral participant roles in today's interactive art (Edmonds et al. 2004), therefore we have put the artist as part of the system. We have shown artist in the artwork system as loosely connected and the interaction between artist and artwork system is shown with dashed line. In one hand, artist is not an integral part of the system as like an audience (unless the artist him/herself takes part as an audience), but on the other hand, in the context of today's digital interactive artworks, artist might be interested in getting feedback about audience interaction with the artwork. Considering artist as part of the system, two other relationships:

4. artist–artwork, and
5. artist–audience,

appears in the scenario. Artist and audience relationship can take place either as a direct artist-audience interaction or through the artwork as artist-artwork-audience interaction (in the sense of communication). With the ability of the artwork to register its audience input, the artist can get direct contact with its audience and uses the feedbacks from audience as like a co-creative process. As it is mentioned in (Beyl and Bauwens 2010).

“Thinking about art as a process of social communication, i.e. an exchange of symbolic content between the meaning creator and the meaning receiver, we explore how the relationship between the artist and his audience is shaped and potentially altered in an interactive Internet environment. On the one hand, this media technological advancement could allow the artist to engage in a more direct contact with his audience. On the other hand, it permits the beholder to inspire the artist from a co-creative point of view.”

Considering the artwork as a system that evolves and changes with time depending on audience feedback and participation, there could be one last relationship,

6. artist-artwork system,

that includes artist's all other relationships with the audience, artwork and the environment as a whole system.

5.3 Identifying the Interactions

In this section, we identify the possible interactions that can happen between two or more components of the artwork. We identify all possible interactions and categorize them according to the definitions. If there are more than one type of interactions, we mark which ones are prominent in the context of an interactive art installation. Among the six possible relations in the artwork system, there could be several meaningful or interesting interactions as noted below:

- (i) *Audience - Artwork*: The interaction between artwork and audience is in the sense of informatics, in the form of human machine interaction. This is the dominant type of interaction in a digital interactive artwork. In the Fig. 3, this is shown in capital “D”.

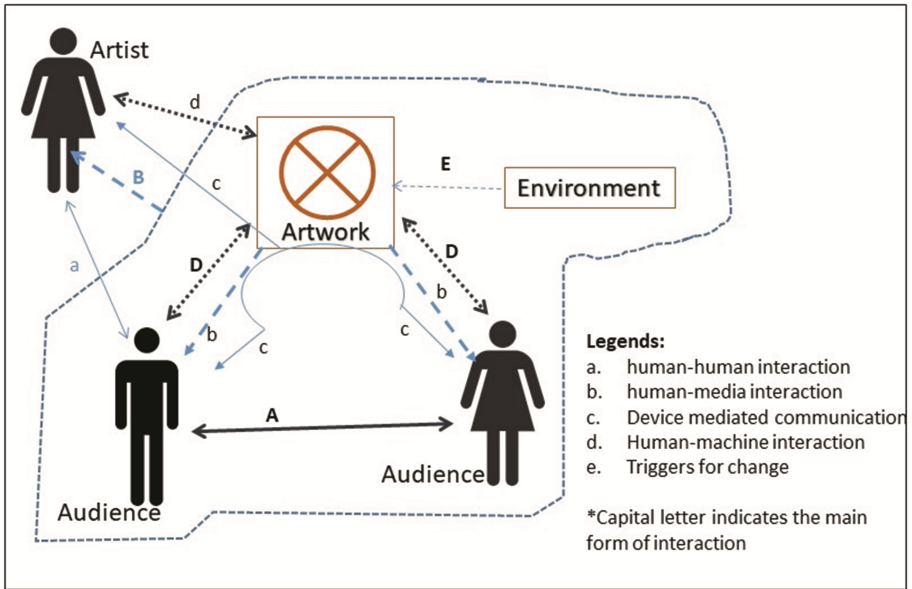


Fig. 3. Interactions in a digital art installation

Interaction in the sense of media studies is also possible, for example, analogous to the mental and psychological effect of reading a book or article, a user can have similar the mental and psychological effect by observing and interacting with the artwork. However, this interaction is less prominent at least when interactivity of the artwork is talked about. In the Fig. 3, it is shown as small letter “b”.

(ii) *Audience - Audience:* This sort of interaction is the interaction in the sense of social science which is otherwise called social interaction. Social interaction between audiences can take place even in the case of a traditional non-interactive art such as painting or photography while visiting a museum or a gallery. However, in case of an interactive art, artists often carefully design and observe the social interaction so as to make the interaction an integral part of the artwork system. In Fig. 3, this is marked as capital “A”.

When the artwork is considered as a media device, there could be also device mediated communication between two audience, like computer mediated communication. In the Fig. 3, it is shown as small letter “c”. However, this is not interactivity in the sense of reciprocity between the audience and the artwork, or in the sense of social interaction between audience and audience, rather it is a non-prominent communication that can take place between audience – audience or artist - audience.

(iii) *Artwork - Environment:* Some artworks interact with some environmental factors or events. For example, artwork may change based on light, temperature, wind or other changes of the environment.

The interaction between the environment and artwork is not an interaction. It is not interaction in the sense of neither social interaction, nor media studies or informatics - since there is not at least one human being (as the user) involved in the interaction. But some artists and researchers still call it as interactive artwork as the nature and the technical design of the artwork is quite similar to an interactive artwork that would otherwise interact with similar inputs from an audience instead of from the environment (for example, by reading similar values from sensors). It can be grouped as dynamic-passive artwork according to Edmonds et al. (2004). However, if the user can, in no way, change or control the output of the artwork, for a user this would rather appear as a dynamic passive artwork where the rules for changes are triggered by some environment factors. In Fig. 3, this is marked as capital “E”, as this is the only and prominent interaction between artwork and environment. Since this is not any true interaction in the sense of any relevant disciplines that we have discussed in this article, we have named this relationship as “triggers for change” instead of calling it interaction or communication.

- (iv) *Artist - Artwork*: This is very similar to *audience-artwork* interaction only except the fact that artist is the creator of the artwork. Artist’s personal interaction with the artwork may give him insight about the audience interaction and feedback for future changes or modification of the artwork. However, this is not a sought after interaction in a digital interactive art installation, since the artwork is supposed to have main interaction with its audience rather than the artists him/herself. In Fig. 3, it is shown with small letter “d”.
- (v) *Artist - Audience*: Most of the cases, artist is not directly interacting with the audience unless the artist is actively participating in the artwork for the sake of the artwork expression. However, in some cases, if the artist wants, or if that is planned in the artwork expression, this can happen in the sense of social interaction.

Apart from direct interaction, the artist- audience interaction can also take place in the sense of media studies interaction (rather, we can say it, communication) via the artwork. This is device mediated communication that is already mentioned in *audience - audience* interaction in point (ii). In the Fig. 3, this is marked with small letter “c” between artist and audience.

- (vi) *Artist - Artwork system*: In an interactive artwork artist not only considers audience as an integral part of the artwork, but also considers the artwork as an evolving agent which changes and updates over time. Artists carefully design the interaction between artwork and audience, and between audience-audience, and over time, considers the feedback and responses of the audience to make future changes and improvements of the artwork system. Artists are more interested in this approach and this is the prominent communication pattern they look after from the whole system. This is an interaction in the sense of media and communication studies, and it is shown in Fig. 3 as capital “B”. The artwork system is shown as dotted outline that includes all the components of the figure except the artist.

6 Conclusions

In this article, we have presented the concept of interaction in different fields and shown what it means when we refer to interactivity of digital interactive art. We have presented different kind of interactions that are possible in the context of an artwork or art installation and compared different concepts of interactivity. We narrowed down the definitions from the context of a general media artefact to new media artefacts and then drew towards more specific digital interactive artworks. We have presented the interactions in the context of a digital interactive art installation in an open space, since this kind of artwork gives the opportunity to have the most possible interactions considering spatial and environmental factors.

As we have seen that different artists, technologists, researchers define interaction and interactivity of artwork differently, finding the different meanings and uses of interaction will thus remove the confusion and make clear the blurry concepts about interaction among them. As we have noticed in the article, the concept of interactivity in digital interactive art gets the influence of interactivity concepts from several fields like: media artefacts, new media, digital art and interactive art. We have noticed that the approach and depth of interactivity changes from field to field. In the context of media artefacts, interaction refers to some sort of user control over the media artefact, whereas in highly interactive new media artefacts interactivity refers to user's ability to the creation and distribution of contents. In digital art, it refers to user's control over the processing or the output of the system, whereas in pure interactive art it refers to user's participation and being a part of the artwork. These variations are linked to the various meanings of interaction that we have found in different disciplines for example, control over a process, reciprocity, communication via a media, and interpretation of some communication. In this article, we have defined and identified all these various meanings in context of digital interactive art to make it clear and unambiguous. We believe that our work will help the artists and technologists to better classify their artwork, define the concepts of interactivity of an artwork from a particular viewpoint, and help them to identify, define and understand the desired interactions that they are interested in a certain artwork from a certain context. It will also help the multidisciplinary stakeholders of an artwork to understand each other better. Besides that, since interaction and user experience is the main idea in a digital interactive art, it will help the different stakeholders in designing, developing and evaluating their artworks.

References

- Ahmed, S.U.: Achieving pervasive awareness through artwork. Paper presented at the Proceedings of the 3rd International Conference on Digital Interactive Media in Entertainment and Arts, Athens, Greece (2008)
- Ahmed, S.U.: Extending Software Engineering Collaboration towards the Intersection of Software and Art. NTNU, Trondheim (2011)
- Ahmed, S.U.: Developing software-dependent artwork: artist and software developers' collaboration. *Leonardo* **45**(1), 92–93 (2012)

- Ahmed, S.U., Jaccheri, L., Sindre, G., Trifonova, A.: Conceptual Framework for the Intersection of Software and Art. In: Handbook of Research on Computational Arts and Creative Informatics, pp. 26–44. IGI Global (2009)
- Beyl, J., Bauwens, J.: Understanding the social meaning of art on the internet. Univ. Melb. Refereed E-J. **1**(5) (2010)
- Bordewijk, J.L., Van Kaam, B.: Towards a new classification of tele-information services. *Intermedia* **14**(1), 19–21 (1986)
- Duncan, S.J.: Interaction, Face-to-Face International Encyclopedia of Communications. Oxford University Press, New York (1989)
- Edmonds, E.: Interactive Art. In: Candy, L., Edmonds, E. (eds.) *Interacting: Art, Research and the Creative Practitioner*, pp. 18–32. Libri Publishing Ltd, Faringdon (2011)
- Edmonds, E., Turner, G., Candy, L.: Approaches to interactive art systems. Paper presented at the Proceedings of the 2nd International Conference on Computer Graphics and Interactive Techniques in Australasia and South East Asia, Singapore (2004)
- Hannington, A., Reed, K.: Towards a taxonomy for guiding multimedia application development. Paper presented at the Ninth Asia-Pacific Software Engineering Conference (APSEC 2002), Gold Coast, Queensland, Australia, 4–6 December 2002 (2002)
- Horton, D., Richard Wohl, R.: Mass communication and para-social interaction: observations on intimacy at a distance. *Psychiatry* **19**(3), 215–229 (1956)
- Iser, W.: Interaction between text and reader. In: Hawthor, J.C.J. (ed.) *Communication Studies. An Introductory Reader*. Edward Arnold, London (1989)
- Jensen, J.F.: Interactivity: tracing a new concept in media and communication studies. *Nordicom Rev.* **19**, 185–204 (1998)
- Jensen, J.F.: The concept of interactivity – revisited: four new typologies for a new media landscape. In: Proceedings of the 1st International Conference on Designing Interactive User Experiences for TV and Video, pp. 129–132 (2008). <https://doi.org/10.1145/1453805.1453831>
- Lasserre, G., Ancxt, A.: met den (2018). Scenocosme. http://www.scenocosme.com/index_e.htm. Accessed 3 Feb 2018
- Laurel, B.: Interface agents: metaphors with character. In: Laurel, B. (ed.) *The Art of Human-Computer Interface Design*. Addison-Wesley, Reading (1990)
- Lopes, D.M.M.: The ontology of interactive art. *J. Aesthetic Educ.* **35**(4), 65–81 (2001)
- Mignonneau, L., Sommerer, C.: Designing emotional, metaphoric, natural and intuitive interfaces for interactive art, edutainment and mobile communications. *Comput. Graph.* (Pergamon) **29**, 837–851 (2005). <https://doi.org/10.1016/j.cag.2005.09.001>
- Moffitt, K.: Social Interactions: Definition and Types (2018). <https://study.com/academy/lesson/social-interactions-definition-types-quiz.html>. Accessed 3 Feb 2018
- Nardelli, E.: A classification framework for interactive digital artworks. In: Alvarez, F., Costa, C. (eds.) *User Centric Media. UCMEDIA 2010. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*, vol. 60, pp. 91–100. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-35145-7_12
- Pereira, L.: Why is it So Difficult to Define New Media Art? (2015). <https://www.widewalls.ch/new-media-art-definition/>. Accessed 3 Feb 2018
- Rafaeli, S. (ed.): *Interactivity: From New Media to Communication*, Newbury Park (1988)
- Rickey, G.: *A Retrospective*. Guggenheim Museum, New York (1979)
- Rogers, E.M.: *Communication Technology*. Free Press, New York (1986)
- Satomi, M., Sommerer, C.: “game_of_life”: interactive art installation using eye-tracking interface. Paper presented at the Proceedings of the International Conference on Advances in Computer Entertainment Technology, Salzburg, Austria (2007)

- Schraffenberger, H., van der Heide, E.: Interaction models for audience-artwork interaction: current state and future directions. In: Brooks, A.L. (ed.) ArtsIT 2011. LNICSSITE, vol. 101, pp. 127–135. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-33329-3_15
- Schrape, K.: Digitales Fernsehen Marktchancen und ordnungspolitischer Regelungsbedarf, München (1995)
- Steinkamp, J.: My only sunshine: installation art experiments with light, space, sound and motion. *Leonardo* **34**(2), 109–112 (2001)
- Trifonova, A., Jaccheri, L.: Towards good software engineering practices in interactive installation art. Paper presented at the International Conference on Software Engineering (ICSE) 2008, Leipzig, Germany (2007)