First Steps Towards Socioenactive Interactive Art

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Abstract

This technical report presents preliminary results regarding the museum research scenario developed during the first year of the *Socioenactive Systems* project. In this report, we first introduce the research scenario, with the research goals and methodology. Then, we present a preliminary literature review by looking at the intersections between the concepts of *enactive systems*, *interactive art* and *universal design*. Next, we show our preliminary results, which include two exploratory artifacts, as well as research projects and publications associated with the research scenario. Lastly, we ponder on how our efforts during this first year are aligned with the project goals, and we also present future steps for the following year.

1 Introduction

In earlier days of computing, computer use was limited to performing tasks that were well defined and most often spatially confined to individual offices. Today, digital technologies are present in many areas of our lives and are used for a variety of purposes at all times, everywhere, and by many people. Ubiquitous computing, as proposed by Weiser [19] is a concept that inspires new technological products, while at the same time turns obsolete the idea of human and computer as separate systems.

However, from a social and practical perspective, current technologies are not entirely invisible. Making them imperceptible requires a different paradigm, one that transcends goal-oriented interaction models, and the traditional mouse-keyboard Graphical User Interfaces (GUI). The work of Kaipainen *et al.* [13] hints towards such coupling, with what they call **enactive systems**. Their premise, inspired by the seminal book from Varela, Thompson and Rosch [18], is that interactions occur in an *embodied* way, that is, guided by the body's involvement and the human agent's spatial presence. They also assume unconscious control of the system is possible. Furthermore, an enactive system can pick up information, *e.g.*, physiological readings from the interaction, and respond accordingly. This, in turn, generates a response on the person, and the cycle goes on.

The concept of enactive system seems enough to promote the design of ubiquitous systems providing more explicit coupling between human and machine. In this work we also wish to turn away from interactions oriented to specific goals and tasks. In this sense, **art** presents itself as an appropriate context for us to delve into. More specifically, we wish to study the design of interactive art, a kind of system that is meant to engage the audience while at the same time not serving a purpose outside of itself.

This work is part of a five-year project, called "*Socio-Enactive systems: Investigating New Dimensions in the Design of Interaction Mediated by Information and Communication Technologies*", which we will refer to as *Socioenactive Systems* project. This technical report is organized in the

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following manner: in Section 2 we explain our research scenario within the *Socioenactive Systems* project. In Section 3 we provide an overview of related work. Then, in Section 4 we present our results thus far. Finally, in Section 5 we highlight our concluding remarks and future steps.

2 Research Scenario

The *Socioenactive Systems* project foresees three scenarios; one takes place in an educational context (a school), another in a hospital and the last one, in a museum. They all share the same goal of expanding the concept of enactive systems [13], by adding the **social** element to it. We are working on the scenario established in a museum. It describes how a blind woman would be able to appreciate an interactive art piece that was accessible to her. This meant she could *touch* a 3D reproduction of an existing painting, and while she touched it other sensations were explored. A special light would project heat on her according to the color intensity in the painting of the place she was touching. In addition, other visitors added their own impressions of the artwork, by leaving words to describe how they felt. These words are read aloud through a sound system, and become part of the blind woman's experience. At the end, she can leave her own impression, thus becoming part of someone else's experience.

This hypothetical scenario was the base of our work throughout the year of 2017. We used it as our final goal, *i.e.*, we strived to make it possible with the technology we had available. Hence, our goals and method of work are described in the following subsections.

2.1 Project Goals

The *Socioenactive Systems* project has established three main goals:

1. Characterization of the research scenario: identification of fundamental properties of (socio)enactive systems and of existing theories and methods that may represent partial foundations for the interaction design of such systems. Proposition of a research agenda for interaction design in these systems.

2. Creation of experimental environments for the study and development of interaction mechanisms based on the concepts of Tangible User Interface (TUI) and Natural User Interface (NUI) concepts, that make sharing and access to information inclusive, explicit and according to the social affordances of stakeholders.

3. Conception and implementation of system design solutions in real pilot scenarios, for the study of physical-digital world tensions, individual-collective interactions with respect to:

   - Socio-pragmatic of the human interaction with the applications;
   - Values, social and legal rules that govern the uses of information in such systems;
   - Factors that impact on the dynamics of these systems.

Even though these goals should be achieved within the five years of the project, it is important to keep the three goals in mind, so that we can work towards them since the beginning.

2.2 Methodology

The starting point for the methodological construction of the *Socioenactive Systems* project is the set of semio-participatory techniques [1]. Built upon methods and artifacts from Organizational

Semiotics (OS) [14, 2], our methodology serves not only for the design of products, but also for all activities that permeate the design process. What we need to highlight about the methodology is that it brings different stakeholders to the design process, and that it looks at this process as a continuous cycle that cuts through three layers of the *semiotic onion*, illustrated in Figure 1. In this representation, the outer layer of the onion contains the **informal** interactions between people in society, in their daily lives and with their technological artifacts. The middle layer has the **formal** meanings and intentions through which society is organized, such as laws, models and regulations. Lastly, the inner layer represents the **technical** artifacts that mediate the actions from the other layers. Hence, the methodology we adopted in this work sees the design of systems from a social perspective, in a way that requires participation from formal and informal levels of a social group. Together, they construct a technical system, that goes back to the social world and causes impact on it.

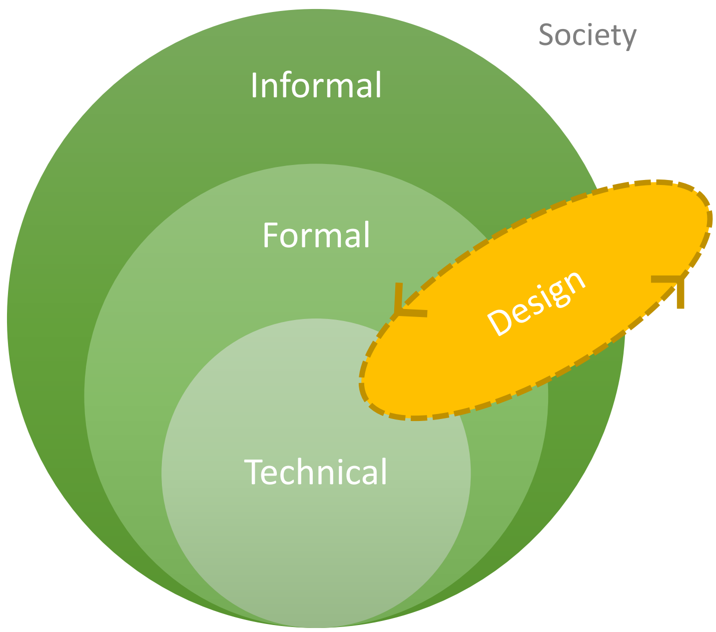


Figure 1: Design in the semiotic onion.

To put this approach into practice, we made three main efforts:

1. Monthly meetings with the work group, *i.e.*, the group responsible for the museum scenario. The goal was to discuss the actions we thought should be taken to turn into reality the hypothetical scenario described previously. The group had a leader, but all members were free to propose ideas and, hence, try to align their efforts with their research interests.

2. Create small proof-of-concept pieces of interactive art. This meant selecting an existing art piece (e.g. a painting) and making an interactive version of it. This allowed us to test different technologies and gain knowledge about them. It also allowed us to have at our disposal a set of interactive art pieces. This set is key for us to experiment with the concept of (socio)enactive systems, and also to promote practical workshops and experiments with stakeholders.

3. Establish partnerships with stakeholders. We analyzed different museums in our region, considering if and how they could contribute to our scenario; it was also important to figure out

if we could contribute with them as well. This meant they would become an active part of our design process, and, in turn, the museum could gain new attractions and knowledge.

These efforts are aligned with the project goals and methodology. In particular, separating the team into groups for each scenario is part of the project's work methodology.

3 Related Work

Considering enactive systems, interactive art and universal design as three pillars of our work, in February 2017 we carried out a preliminary search in the following databases: ACM Digital Library[1], IEEE Xplore Digital Library[2], Science Direct[3], Scopus[4], SpringerLink[5] and Web of Science[6]. The keywords used are listed in Table 1, so that items in the same column are separated by a logical operator `OR`, and for intersections, columns are separated by a logical operator `AND`. As can be seen in Figure 2, 193 works were found for the keywords of enactive systems, 650.102 for universal design and 9.508 for interactive art.

Table 1: Search keywords.

Enactive Systems	Interactive Art	Universal Design
"enactive system"	"interactive art"	accessibility
"enactive interface"	"interactive artwork"	"universal design"
	"interactive installation"	"universal access"
	"art installation"	"design for all"
	"technology and art"	"inclusive design"
	"art and technology"	"assistive technology"

These numbers reveal that the field of inquiry of enactive systems is relatively new, unexplored, and very specific (we choose not to use keywords like `enactive`, `enaction`, `enactivism` or `embodiment` because they are too generic for the scope of our work). Interactive art, in turn, has a substantial amount of published research, and the topic of universal design has hundreds of thousands of results (although approximately 90% are for the term `accessibility`, whose use is not always in line with the principle of universal design). The focus of our work, however, lies at the intersections between these concepts. As can be seen in Figure 2, 14 works were found within enactive systems and universal design, 6 within enactive systems and interactive art, 561 within universal design and interactive art, and only 1 within the three topics. When removing works in which the desired keywords do not appear directly in the text, or are not related to the definition of enactive system adopted in this work, the number drops to 5 at the intersection between enactive systems and universal design and 2 for enactive systems and interactive art. We could not filter the intersection between interactive art and universal design at the moment because it contains a relatively high number of results.

In the only result for the intersection of the three areas, Froese, Suziki and Ogai [10] investigate what kind of experience emerges from the use of interactive interfaces that artificially measure

[1] `http://dl.acm.org/`
[2] `http://ieeexplore.ieee.org/`
[3] `http://sciencedirect.com/`
[4] `http://scopus.com/`
[5] `http://link.springer.com/`
[6] `http://webofknowledge.com/`

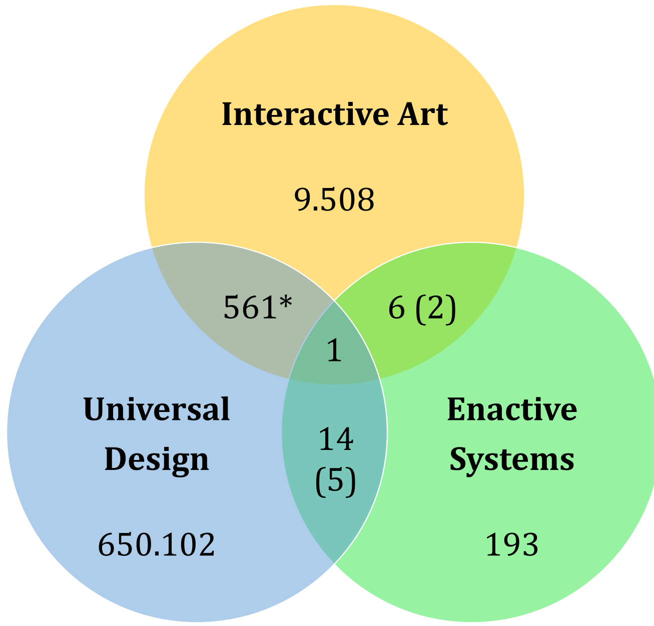


Figure 2: Numbers of works found and intersections: parentheses indicate number of results after a relevance filter, and asterisks indicate an unfiltered intersection.

a participant's sensory-motor cycle. During the study, the authors make use of an interactive installation. However, they mention the term `''assistive technology''` only peripherally, and it is not part of the scope of the work. Therefore, although we only conducted a preliminary search, our results indicate there are no works in literature exploring these three areas simultaneously.

Among the results for the intersection between enactive systems and universal design, there are the works of Frisoli and Camurri [9] and Boulic *et al.* [4] on multisensory interaction in virtual environments. In another work, Degotzen *et al.* [6] discuss the design of enactive toys focused on the use of other senses beyond sight, promoting the inclusion of visually impaired children. Finally, in a more recent publication, Bibri [3] discusses how intelligent environments can behave in ways that support the cognition of their occupants. Exploring senses beyond sight is a recurring approach in these works and consistent with the idea of universal design.

For the intersection between enactive systems and interactive art, we found only a section in the encyclopedia on creativity, invention, innovation and entrepreneurship, in which the terms `enactive systems` and `interactive art` are mentioned in distinct entries [12]. Although this suggests few efforts exploring these two areas, this search did not reach the work of Domingues *et al.* [7], which employs an enactive system in an interactive installation format. Therefore, an adjustment in databases and/or keywords may return more accurate results.

Among the results for the intersection between interactive art and universal design, we can highlight: the work of Lupfer *et al.* [15] on an integrated and interactive curatorial experience of works of art; the work of Her and Hamlyn [11] about intelligent environments that adapt and interact with their occupants; and varied works on interactive installations and artistic manifestation (*e.g.*, WishBoard from Ferreira, Anacleto and Bueno [8], a virtual mural where personal desires are shared; i-metro from Tierney [17], an installation designed to assist urban mobility; spaceDisplaced from Sun *et al.* [16], which explores the concept of telepresence in different physical spaces during an artistic performance, among others). However, in many of these works the principle of universal design is peripheral, and creation itself is strongly authorial.

In summary, this preliminary view of the state of the art suggests a lack of studies that address enactive systems, universal design and interactive art simultaneously. Although it would be necessary to conduct a systematic literature review to obtain more conclusive results, these preliminary results provide valuable insights, such as the use of multisensory stimuli and the concept of intelligent environments. We could also identify gaps that can be filled, such as greater emphasis on universal design in enactive systems and interactive art, as well as making the creation of these artifacts a less individual and more participatory process.

4 Preliminary Results

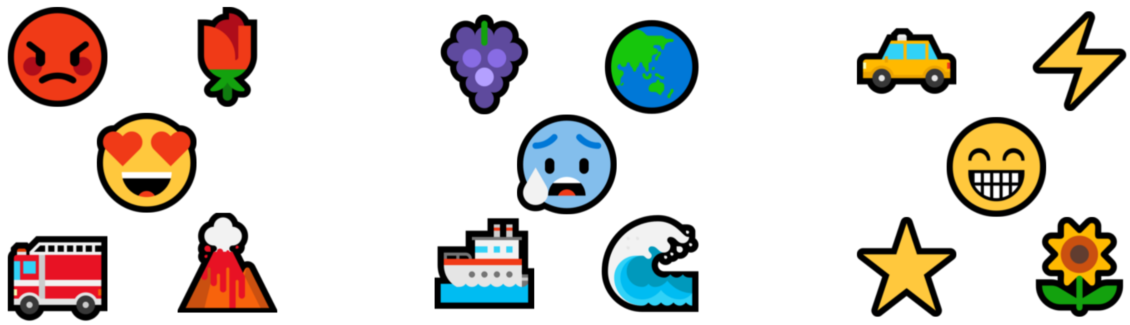
To explore both conceptual and technical challenges inherent to the museum research scenario, and aligned with the goals from the *Socioenactive Systems* project, during the year of 2017 we designed and built some proofs-of-concept and prototypes. Furthermore, we also submitted to academic forum research projects and papers related to the *Socioenactive Systems* project. The following subsections present each of these preliminary results.

4.1 Exploratory Artifact: Interactive "Mondrian"

One of the central challenges of the "Window for Art" research scenario is to allow Art to be appreciated by the widest possible extent of people. In other words, to apply the concept of Universal Design [5] to the context of a museum or art gallery. This is by no means a trivial challenge, and we decided to first approach the subject with the following question: "Can we transform a classic painting, such as 'Composition with Large Red Plane, Yellow, Black, Gray, and Blue (1921)' by Piet Mondrian, into a multisensory artifact to be experienced by all?" This specific painting was chosen for its relative simplicity, being composed only by rectangles and primary colors. This simplicity is an important quality in allowing us to experiment with reproductions and representations of the original artwork. We do, however, acknowledge that this "technical" simplicity does not imply that the painting is simple in terms of intention from the author, neither in meaning interpretation from the audience.

As a first step towards answering our question, we built a small proof-of-concept. We applied Mondrian's signature minimalism to a composition made with affordable materials such as Ethylene-Vinyl Acetate (EVA) copolymer, as illustrated in Figure 4. For each color, the rectangles had different heights and textures, e.g. the blue had tiny perforations, and the red had vertical stripes. We added a little bit of interactivity: three rectangles of different colors could be pushed, triggering a text-to-speech sound that informed the color of the rectangle, and some arbitrary feelings, places or experiences that can be associated to that color – similar to the hypothetical scenario described in Section 2. The circuit behind this first iteration consisted of three push-buttons, an Arduino Uno and a Bluetooth module, to allow the microcontroller to communicate with the Android app that took care of the text-to-speech translation.

The second iteration of the artifact is illustrated in Figure 5. For it, we chose the "Composition II in Red Blue and Yellow" (1930), because it had less elements and, hence, demanded a smaller effort to be built. We experimented with different materials and ended up using LEGO, due to its flexibility for assembling and disassembling rectangles – the geometrical form predominant in this chosen art piece. We also improved the hardware with a more recent microcontroller, a NodeMCU 1.0, which is based on the ESP8266 chip. Now, instead of Bluetooth, communications were made through the Internet, since this microcontroller has built-in Wi-Fi. This leads us to what is perhaps the main addition of this iteration: a virtual representation of the painting. It was made with HTML and JavaScript, and programmed to respond to the input (pressing the push-buttons) on the physical artifact. For instance: by pressing the physical red rectangle, the corresponding virtual red rectangle will become highlighted and filled with an arbitrary emoji related to the red color. The emojis used to represent each color are illustrated in Figure 3.



(a) Red. (b) Blue. (c) Yellow.

Figure 3: Emojis used in the second iteration of the Interactive "Mondrian".

The third and most recent iteration is illustrated in Figure 6. This time, the artifact was rebuilt with foam board, a sturdier craft material. Also, now all seven rectangles can be pressed, in contrast with the sole three colored ones in the earlier versions. We also took the circuit out of the breadboard, making the prototype more permanent and portable. We again used a different microcontroller, this time the D1 Mini, also based on the ESP8266 chip. It also has built-in Wi-Fi and enough digital ports to accommodate all seven push-buttons. We chose it because it is smaller than the NodeMCU 1.0 and can get the job done just as well.

The three iterations for this artifact were important to explore with both materials and technology. For further iterations of this artifact, we intend to focus on more conceptual aspects. For instance, how to turn the artifact into an enactive system, and, more importantly, how to promote socioenactive interactions. In this sense, we already collected, through an online form, music and words people would associate to this art piece, and to the "Mona Lisa" painting, by Leonardo da Vinci. The idea is to work towards the social feedbacks described in the hypothetical scenario in section 2. We also intend to capture more forms of input besides the pressing of rectangles. Based on the work of Kaipainen *et al.* [13], physiological readings and image recognition are possible forms of input that are in tune with the concept of enactive system.

4.2 Exploratory Artifact: Emojic Mirror

The Emojic Mirror artifact is an attempt to answer the following question: "Can we infer a person's emotional state in real time while she appreciates a work of art?" As a possible approach, in light of numerous advances in the fields of Machine Learning and Computer Vision, we explored the Emotion API from Microsoft Cognitive Services[7]. The Emotion API detects faces in a picture and analyzes it to infer the presence of the following emotions: anger, contempt, disgust, fear, happiness, neutral, sadness, or surprise. Hence, the Emojic Mirror, illustrated in Figure 7, is a web application that constantly captures pictures from a webcam and sends them to the Emotion API. Then, a person in front of the webcam has her facial expression detected by the Emotion API and

[7] `https://azure.microsoft.com/en-us/services/cognitive-services/emotion/`

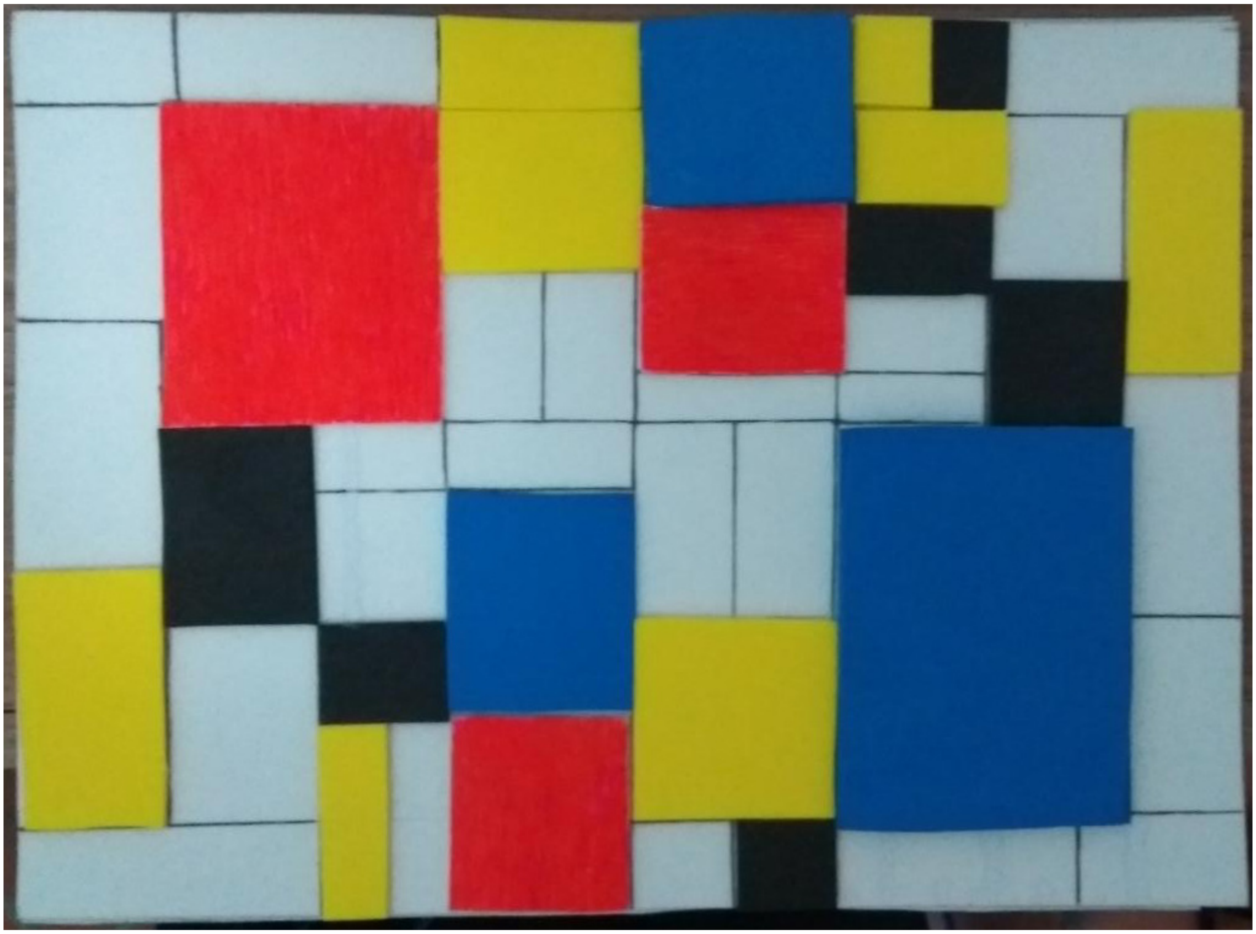
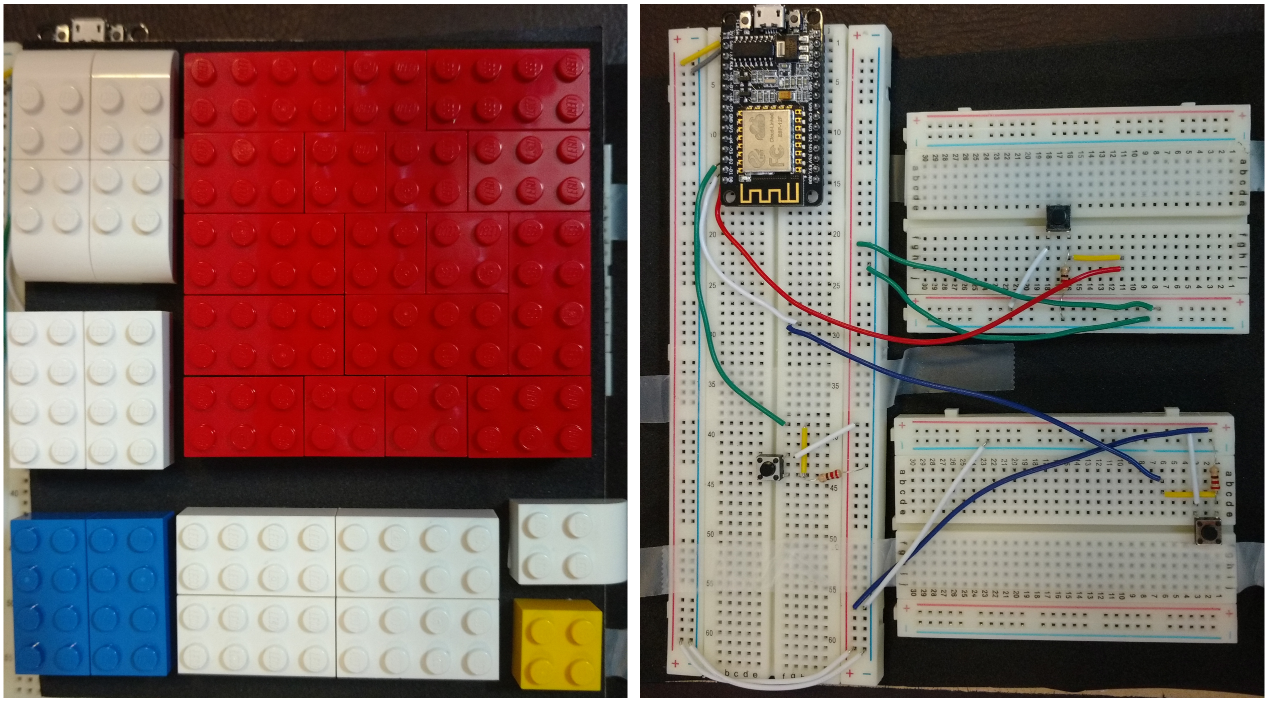


Figure 4: Cover for first iteration of the Interactive "Mondrian".

"mimicked", through emojis, by a digital representation. The response from the API determines the corresponding emoji to be displayed in the screen, along with an animated background. This is conceptually similar to the minimalistic enactive system described by Kaipainen *et al.* [13]. Our setup, however, is technologically simpler and less ambitious than that of Kaipainen *et al.*, since is does not gather psycho-physiological data nor generates a realistic facial expression. In contrast, the Emojic Mirror is able to detect and represent more than one person at a time (*e.g.*, for three people, three emojis are displayed, and the background is chosen by averaging between the three). This is an important feature for our intentions of exploring the social component of enactive systems.

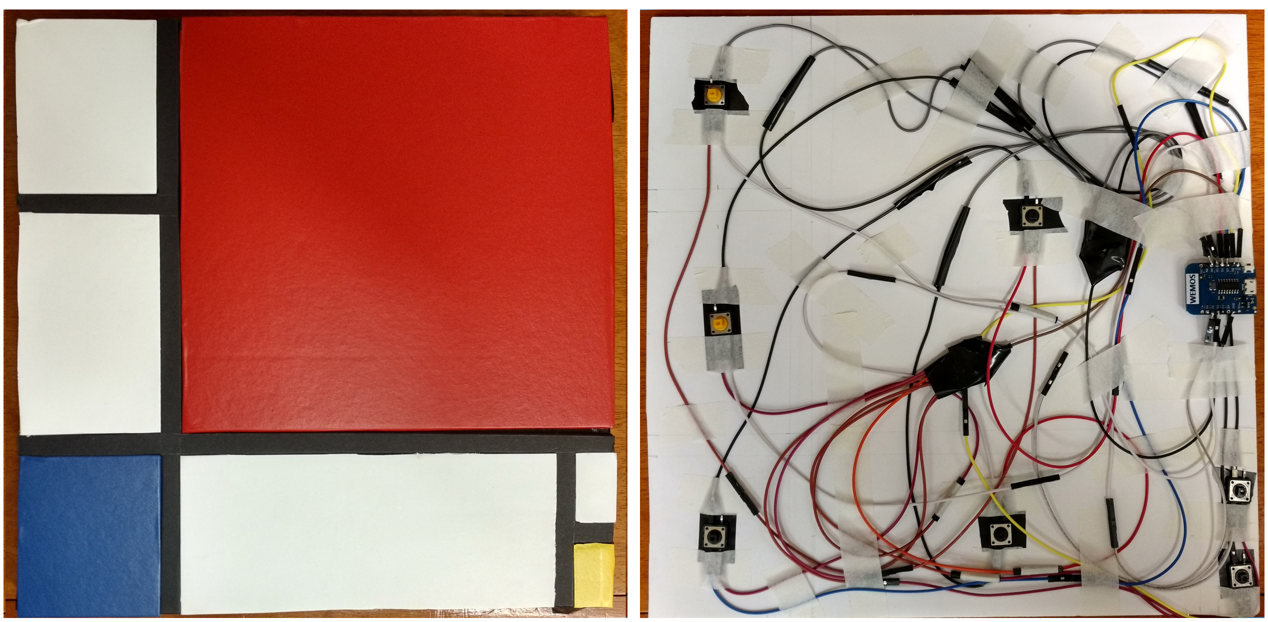
As a result of experimenting with the Emotion API, we found it insufficient to infer emotions in natural contexts: with the exception of neutral and happiness, the detection of every other emotion requires overly exaggerated facial expressions. However, we concluded that the Emotion API could still be used in a playful context. While showing the Emojic Mirror to at least three different groups of people, it became a game trying to have the mirror display all emotions. It was interesting to note how while some people were making faces to the webcam, the rest who were watching tried to give incentive or provide suggestions. Although limited, it was a social experience.

Therefore, the initial question about inferring a person's emotional state in real time while appreciating a work of art is still open for investigation. Perhaps alternative approaches, such as using heartbeat and galvanic skin response sensors could lead to useful insights. In turn, even though



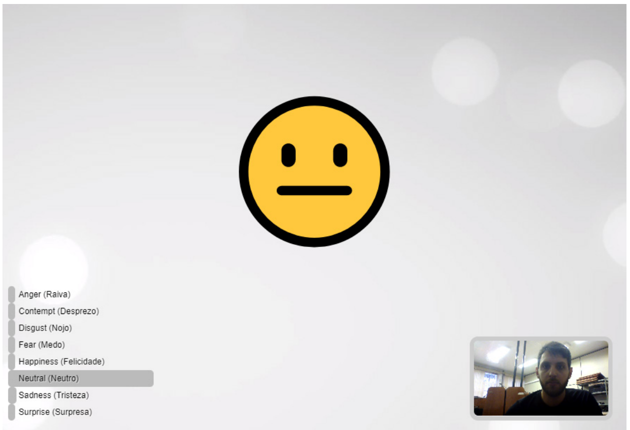
(a) Prototype built with LEGO. (b) "Under the hood."

Figure 5: Second iteration of the Interactive "Mondrian".

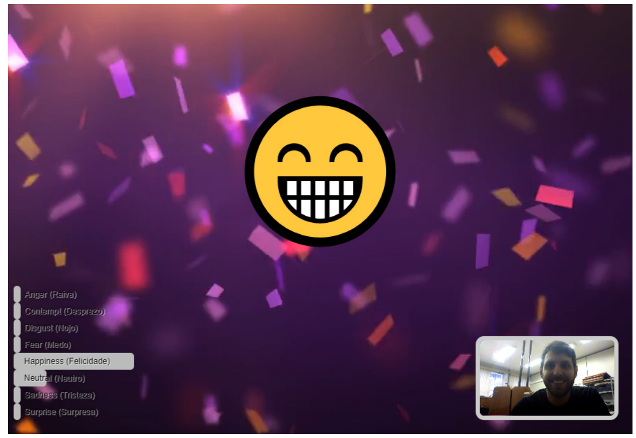


(a) Prototype built with craft material. (b) "Under the hood."

Figure 6: Third iteration of the Interactive "Mondrian".



(a) Response from Emotion API: Neutral.



(b) Response from Emotion API: Happy.

Figure 7: The Emojic Mirror.

the Emojic Mirror artifact does not address this initial question, it does provide other promising investigation possibilities. These include understanding the high level of captivation we observed in people who interacted with the Emojic Mirror, and the implications of allowing multiple people to interact with it simultaneously.

4.3 Publications and Research Projects

Publications:

- HAYASHI, E. C. S., BARANAUSKAS, M. C. C. **Accessibility and affect in technologies for museums: a path towards socio-enactive systems**. Full paper published in the proceedings of the 16^{th} Brazilian Symposium on Human Factors in Computing Systems (IHC 2017). *This paper informs norms and solutions for accessibility in museums and starts a discussion on new opportunities for investigation in HCI, especially in accessible information visualization and socio-enactive systems.*

Accepted papers (pending publication):

- DUARTE, E. F., BARANAUSKAS, M. C. C. **InterArt: Learning Human-Computer Interaction Through the Making of Interactive Art**. Full paper accepted to be published in the proceedings of the 20^{th} International Conference on Human-Computer Interaction (HCII 2018). *This papers reports the experience of co-creating meaning on the subject of Interactive Art and co-designing nine Interactive Art projects in a Human-Computer Interaction (HCI) classroom context.*

Submitted papers (pending review):

- DUARTE, E. F., BARANAUSKAS, M. C. C. **Articulating Art and Science in HCI: Revisiting Interactive Art**. Full paper submitted to the ACM SIGCHI Conference on Designing Interactive Systems (DIS 2018). *This paper discusses the potential benefits of articulating Art and Science in HCI through the study and practice of Interactive Art, seeking out the formulation of a research agenda.*

- MAIKE, V. R. M. L., BARANAUSKAS, M. C. C. **Person, World and Action: Revisiting Natural Interaction**. Full paper submitted to the ACM SIGCHI Conference on Designing Interactive Systems (DIS 2018). *This paper discusses the concept of Natural Interaction, presenting a theoretical basis and a practical case study.*

Research projects:

- DUARTE, E. F., BARANAUSKAS, M. C. C. ***Arte Factus*: Study and Socially Aware Design of Socioenactive Digital Artifacts**. FAPESP Doctorate Proposal, Grant #2017/06762-0. This proposal is bound to the Socioenactive Systems project. *This project has the objective of articulating the concepts of Enactive Systems, Universal Design and Interactive Art to support the study and design of Socioenactive Digital Artifacts in a socially aware manner.*

- HAYASHI, E. C. S, BARANAUSKAS, M. C. C. **Affect in interaction design of socio enactive systems**. Postdoctoral Research (CAPES PNPD). This research is related to the Socioenactive Systems Project. *The objective of this research is to propose, based on the concept of Affectibility, a conceptual framework and methodology to aid designers of socioenactive systems. Speech Act Theory, Image Act Theory, Organizational Semiotics and Universal Design are the theoretical references of this project and the Socially Aware Design forms its methodological basis.*

5 Conclusions

In this technical report we presented our first steps towards the conception of what we intend to call Socioenactive Interactive Art. Considering the goals of the *Socioenactive Systems* project, presented in Section 2.1, we consider that our first steps correspond to important accomplishments in goals 1 and 2, as we worked on understanding the research scenario and creating experimental artifacts for it. In turn, these accomplishments, are informing the design of solutions to be implemented in a real museum context.

Furthermore, we can highlight how the project goals are highly interrelated. This happens because a characterization of the research scenario (goal 1) informs experimental artifacts (goal 2), at the same time that experimental artifacts help us in characterizing the research scenario. Developments on goals 1 and 2, in turn, inform the conception and implementation of design solutions in real scenarios (goal 3), at the same time that implementing design solutions can provide new insights on problem characterization and experimental artifacts.

Therefore, the preliminary results presented in this technical report shed light on some paths we can take to reach socioenactive systems, within the context of art. The experiments with the Mondrian pieces helped us gain experience with different sensors, microcontrollers and the *do-it-yourself* (DIY) or *maker* culture. This is key if we wish to bring stakeholders into the design process: we must know the practical details (nitty-gritty) so we can pass it on to those who are less technically savvy. Furthermore, the resulting Mondrian is an interactive art piece that we can experiment with, towards making it socioenactive. Finally, the Emojic Mirror gave valuable insights into playful social experiences, which we can definitely use in future interactive art pieces, including the Mondrian. The experience with the Emotion API also showed that inferring emotional states from facial expression might not be so simple to implement for an art exhibition, so we certainly need to explore other psycho-physiological sensors and data.

5.1 Next Steps

- Organize workshops and design activities with stakeholders from a real museum, to construct with them the concept of socioenactive interactive art.
- Further improve our existing artifacts, to explore new possibilities that can help us figure out what does and what does not make a socioenactive system.
- Design new artifacts, exploring more technologies and concepts.

Acknowledgements

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