Accessibility and affect in technologies for museums: a path towards socio-enactive systems

Elaine C. S. Hayashi
Institute of Computing, UNICAMP
Campinas, Brazil
hayashi@ic.unicamp.br

M. Cecília C. Baranauskas
Institute of Computing, UNICAMP
Campinas, Brazil
cecilia@ic.unicamp.br

ABSTRACT
The ubiquitous presence of digital technology in daily activities and our bodily immersion in such activities present new and interesting opportunities for research in Human-computer interaction. Immersive and interactive solutions for art exhibitions and museums can enhance visitors' experiences, providing for richer affective and cognitive experiences. However, most of the existing solutions are not suitable for all people, especially visitors with physical impairment. Many museums in Brazil do not even offer possibilities for visitors with visual disabilities to enter and locate themselves. 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.

Author Keywords
HCI; accessibility; Affectibility; universal design; enactive systems; socio-enactive systems; tactile floor; tactile map; information visualization.

ACM Classification Keywords
H.5.2. User Interfaces.

INTRODUCTION

Studies in Human-Computer Interaction have been undergoing many changes due to the advances in digital technologies and due to changes in the way we relate to technologies. Ubiquity and embodiment are making the interface that separates human from machine disappear. The conscious and explicit control of a machine, usually needed to perform a specific task, tend to become less conscious and explicit. The tendency is that systems will be coupled with us – as well as we will be immersed in systems – in a way that the interaction is driven simply by our physical involvements within that system. Such immersive technologies that dynamically connect humans and computers in a more transparent way have been explored within the concept of enactive systems [17].

The body experiences the world by its sensorial and motor systems and makes sense of it in an iterative process of "learn by doing" [9]. Iteration, interaction, action, perception, cognition are concepts that, coupled with: autonomy, sense-making and experience [47], constitute the base for the enactive approach [49] and enactive systems [17]. An example of enactive system is given by Kaipainen et al. [17] in which the content of a movie is changed according to the viewer's emotional response. Similarly, another example of enactive system is the immersive and interactive experience in which the sounds and projections change according to the way the participant walks inside a "cave" and according to other physiological measurements of the participant as he/she walks [13].

In enactive systems user and system are dynamically influenced by one another. These systems present varied computational challenges and constitute promising possibilities for research in HCI, especially in settings like art exhibitions and museums. However, the concepts of enaction and enactive systems could benefit from social, cultural and affective/emotional views. In addition, the potential of enactive systems could be further developed in a way to include wider parcels of the population, including people with disabilities.

How could an enactive system for museums be used by people with visual impairments as well as by people with hearing impairments or with no disabilities? Moreover, could these systems include more users? Could these systems influence and be influenced, growing in each interaction, with larger groups of people? Could the emotional responses be informed not only by physiological measurements but also by other elements of interaction and culture?

This research is part of a larger research Project entitled "Socio-Enactive systems: Investigating New Dimensions in the Design of Interaction Mediated by Information and Communication Technologies". One of the objects of the project is to build upon the enactive approach and enactive systems in order to propose "Socio-enactive systems". This article explores the context of museums and accessibility

IHC 2017, October 23–27, 2017, Joinville, Brazil

ACM ISBN 978-1-4503-6377-8/17/10…$15.00
https://doi.org/10.1145/3160504.3160543

for museums, aiming at initiating a discussion on a possible instantiation to explore socio-enactive systems.

This paper is organized as follows: The next section presents our theoretical background. Next, current norms and the state of the art on accessibility for museums are presented. Those two first sections provide the arguments for the discussion presented next, which directs towards the challenge of creating socio-enactive systems for museums for all.

THEORETICAL BACKGROUND

This section briefly informs the theoretical background that bases the discussion section.

Universal design and access to knowledge

The terms Universal design and design for all are used in varied areas of knowledge, especially in the fields of architecture and civil engineering. The principles for universal design [10] provide base for the creation of more accessible places. However, as Stephanidis e Salvendy [43] point out, while the existing knowledge on universal design might be sufficient for physical spaces, this is not the case with informational technologies: there are still challenges to be faced in this area. The authors define "*design for all in the Information Society" as "the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop IT&T products and services which are accessible and usable by all citizens, thus avoiding the need for a posteriori adaptations, or specialized design*" (p. 28 [43]).

Shneiderman [44] highlights three main challenges for attaining universal usability for web-based and other services: "*Technology variety: Supporting a broad range of hardware, software, and network access; - User diversity: Accommodating users with different skills, knowledge, age, gender, handicaps, literacy, culture, income, etc.; - Gaps in user knowledge: Bridging the gap between what users know and what they need to know*" (p. 86). Shneiderman argues that the efforts in order to accommodate the vastest extension possible of users force researchers to consider a wider variety of possibilities for design; and often this drives us towards innovations that can benefit all users.

Affect in HCI

Affect and emotions have been treated in HCI in two main distinct fronts. One of them is influenced by two of the most important references in this field: Don Norman and Rosalind Picard. Picard has coined the term Affective Computing [34], which refers to the "computing that relates to, arises from, or influences emotions" [35][36]. Affective Computing is concerned with providing means of enhancing the human interaction with a machine by allowing the user to notice that the machine is recognizing their expression of emotions [36]. "*People naturally express emotion to machines, but machines do not naturally recognize it. Emotion communication requires that a message be both sent and received.* (...) *we are building tools to facilitate deliberate emotional expression by people, and to enable machines to recognize meaningful patterns of such expression*." [35]. Norman concurs with that: "*A robot will need to have eyes and ears (cameras and microphones) to read facial expressions, body language, and the emotional components of speech.*" [26]. For that to take place, automatic detection of human emotions by a machine is needed. This approach usually demands focus on measurable affective responses. In this case, emotion is treated as objective and fixed units of information. Boehner et al. [5] refer to this kind of approach as "informational". Usually physiological measurements are taken and they can inform about users emotions. For example, certain emotional stimuli can raise the activity of sweat glands, especially in the hands. This kind of physiological response is not under our conscious control and it can be measured via the galvanic skin response. Also heart rate (electrocardiography), muscle contraction (electromyogram) and brain activity (electroencephalography) are a few of other measurements that can inform about one's emotional responses.

Another approach to investigate emotions is referred to as "interactional" [5]. This approach takes high account on cultural influences and the dynamic characteristic of emotions. As emotions are socially constructed, socially experienced, and subjective by nature, supporters of the interactional approach argue that objective measurements present a narrow view, waste rich information and does not fully represent emotional interactions. "*From the interactional perspective, affect is not a representational state to be transferred from one place to another, but rather is an aspect of collectively enacted social settings*." (p. 280 [5]).

In relation to the terminology, there is no consensus. The words "emotion" and "affection" can be seen used interchangeably or with varied and different meanings [18]. For Ortony et. al [30], affect is a superordinate concept that includes emotion. Affect is defined as "a "general construct that encompasses a wide range of psychological conditions relating to value". Discussions on the definitions and terminologies are out of the scope of this article.

'Enactive approach' and 'enactive systems'

Boehner et al. [5] point out an interesting fact on the traditional representation of cognition and emotion: Both Norman [26] and Card et al. [54] have represented emotion and cognition, respectively, as contained within the limits of the body. The critic lies on the fact that these cognitivists theorized both cognition and emotions as "*an internal, thoroughly individual phenomenon."* ([5] p. 280).

Conversely, the "enactive approach" understands cognition as an embodied action[1], meaning that "*cognition depends*

[1] While historical aspects is not in the scope of this article, it is worth noting that, according to DiPaolo and Thompson [12], first discussions on embodied cognition date from early 70's, but became more prevalent after the work of Winograd and Flores [52].

upon the kinds of experience that come from having a body with various sensorimotor capacities, and (…) *these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological, and cultural context*" ([49] p. 173). Moreover, "*The enactive approach does not view cognition and emotion as separate systems, but treats them as thoroughly integrated at biological, psychological, and phenomenological levels*" [47].

Thompson and Stapleton [47] list some of the mutually supporting concepts that base the enactive approach: autonomy, sense-making, emergence, embodiment, and experience. These concepts have roots in biology and are usually related to discussions on cognition. Thompson and Stapleton [47] define an autonomous system as "*one that generates and sustains its own activity and thereby enacts or brings forth its own cognitive domain*". According to Varela (apud [47]), autonomous organizations have two important characteristics: they are operationally closed and thermodynamically open. The organism is operationally closed when it is connected in a way that every process in it leads to another process inside the system (organism). That, however, does not mean that processes from other organizations are not involved. Hence the "thermodynamically open": it can also regulate processes of exchange with the environment.

The concept of autopoiesis was developed by Maturana and Varela [27] in order to describe the properties of living and the non-living organisms. A living system has an autopoietic organization, meaning that it is "self-producing" [28]; autopoiesis "*consists of processes of production which generate its components. These components themselves participate in the processes of production in a continual recursive re-creation of self*." ([28] p. 320).

Another characteristic of enactive systems is their sense-making activity. From a biological sense of the term, sense-making activity is the action of an organism to interact cognitively with the world in a way that it transforms the world into a place of meaning, value, and importance [47]. Besides sense-making and autonomous, enactive also encompasses embodiment. When Varela et al., [49] use the term "embodiment" to define cognition as an *embodied action*, they mean to observe two aspects: first, "*cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context"* (p. 171-173 [49]). Moreover, in "embodied action", "action" is meant to emphasize that "*sensory and motor processes, perception and action, are fundamentally inseparable in lived cognition*" (p. 173 [49]).

Hence, the enactive approach can be understood as being constituted of two points: "*(1) perception consists in perceptually guided action and (2) cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided*." (p. 173 [49]).

The enactive concept, first proposed by Varela et al. [49], was taken into the context of informational systems by Kaipainen et al. [17]. The authors' intentions are to break from the classical HCI view that separates humans to one side and machines to the other. The concept of enactive systems (here systems meaning digital technology systems[2]) is "*constituted by dynamically coupled human and technological processes, that is, a dynamic mind-technology embodiment*" (…) in which "*the function of interfacing is driven by bodily involvement and spatial presence of the human agent without the assumption of conscious control of the system*" ([17] p. 433).

As mentioned before, this work is part of a bigger Project, the "Socio-enactive Systems". The objective of the Project is to develop research scenarios to investigate contemporary computational systems that are characterized by interactions in which the human agents – in their whole as cognitive/perceptor/motor beings – are an integral, extended and continuous part of the same system. it's the utmost objective is to develop upon the concepts of enactive approach [49] and enactive systems [17] into the concept of Socio-enactive Systems.

INFORMATION AND COMMUNICATION FOR ALL IN MUSEUMS

One of the scenarios of Project Socio-enactive Systems is "A window to art". Based on this scenario, researchers intend to explore the worlds of museums and art exhibitions and the opportunities contemporary technology have to enhance the experience of art appreciators, allowing access to the vastest part of the population possible, including those with visual impairment.

As a starting point to this journey into museums, this paper briefly reviews the literature on what is usually at the entrance of some accessible museums: tactile maps. Moreover, tactile floors or other ways to present accessibility in routes inside museums are presented in this section.

Tactile floors and other accessible routes

Tactile floors can help people with visual impairment, especially children [48], acquire spatial abilities and find their way through the environment [4]. Although some variation might be found – as can be seen in an example provided by Rosburg [40] –, there are technical norms and standards for tactile floors. Organizations like the International Organization of Standardization (ISO); the Brazilian Association of Technical Norms (ABNT); and the British Standards (BS 7997:2003) [7] have made their

[2] Observe that these authors (Varela, Maturana, Thompson, Stapleton) are from the fields of biology and/or philosophy and "systems" are often not meant as computational systems, but as organizations, as living organisms for example.

contribution to keep consistency in the use of tactile floors – or “tactile walking surface indicators”, as referred to by the ISO 23599:2012 “Assistive products for blind and vision-impaired persons – Tactile walking surface indicators”.

The ABNT [3] defines tactile floor as the differentiation in texture in relation to the adjacent floor intended to constitute a warning or a guide that can be noticed by those with visual impairments. The warning tiles (Figure 1a) should inform the need of caution. Use examples of warning tiles are places next to obstacles. The directional tiles (Figure 2) serve as guides that indicate a path.

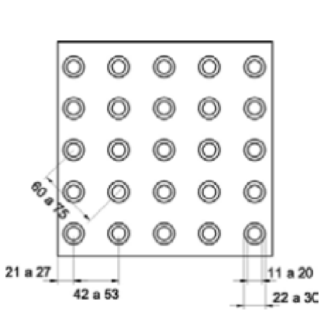

Figure 1 – From left to right: warning (a) and directional (b) tiles for tactile floors. Reproduced from [3].

The color of the tactile floor used in public spaces should provide strong visual contrast with the adjacent floor [3] so that people with residual vision can also obtain the information [40]. The norm also defines format for both warning and directional tactile tiles, as well as their dimensions, texture, usage, angles and positions. Kobayashi et al. [19], however, argue that the difference in the floor level might hinder the way non-visual impaired people walk, as they supposedly need to exert extra effort in their feet in order not to trip or stumble on the tactile tiles.

Alternatively, Papetti and Fontana [31] developed a study that indicates that auditory and vibrational underfoot cues could potentially be used to aid both visually and non-visually impaired persons to keep or find their routes in public spaces.

Other possibilities include the use of beacons[3]; RFID [25][51][21]; QR Code [2]; and wearable devices [37] to provide the blind or visually impaired with information about the surroundings. Specifically for the context of museums, there is the work of Santoro et al. [42]. The authors developed an application for PDA (Personal Digital Assistant, a handheld device precursor of smartphones) that indicated the route to a specific art work from the current location. The browsing on the options in the application could be controlled by tilt movements in the device.

A robot for indoor environments in general was proposed by Kulyukin et. al [21] that also uses RFID embedded in the environment. Unique RFID tags are set in specific and strategic points in the indoor environment: doors, turns and other objects can serve as orientation (e.g., soda machine, water fountain). A connectivity graph is manually generated and the robot can follow the tags. A person with visual impairment can hold onto the robot with a dog leash (as if the robot were his guide dog) and the robot will drive the person inside the environment.

Tactile and other accessible maps

A tactile map is a map that can be accessed by people with visual disabilities. This map contributes towards providing more autonomy by allowing people with visual disabilities to gain spatial knowledge. As Oka [29] argues, it is no longer a matter or discussing whether or not to make this kind of resource available, but to investigate how to provide it in a way that is useful and meaningful.

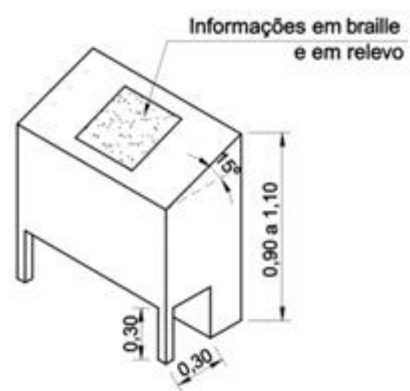

Figure 2 – Norm for tactile maps. Reproduced from ABNT:NBR 9050 [3].

The ABNT [3] has a set of norms for tactile maps, including its height, width, and the inclination of the horizontal surface (Figure 2). Besides the technical norm, diverse research has also investigated tactile maps (e.g. [46]) and some of them proposed varied solutions making use of digital technology (as exemplified later in this subsection).

According to Loch [23], a tactile map does not need to be as precise as an analogic map (i.e., visual maps made for the non-blind). In fact it is possible to notice that most tactile maps found in public spaces like bank agencies do not keep the correct proportion. Instead they only indicate the relative position of the main elements of interest. However, one can also find very precise tactile maps presenting the exact blue print in an accessible manner. There is not a specific rule on how to represent a tactile

3 http://gizmodo.com/bluetooth-beacons-will-help-blind-people-navigate-londo-1689815622 (Last access: May, 2017)

Figure 3 - Tactile map at the Pinacoteca de São Paulo (picture taken with authorization from the "Programa Educativo para Públicos Especiais – Núcleo de Ação Educativa" from the Pinacoteca).

image and each representation can be carved out or created with different materials and methods [39]. A Patent [53] claims they have a solution for low cost methods.

In 2005, Jehoel et al. [16] presented a study comparing users' preference for soft and hard material for tactile maps. The results indicate that participants prefer harder material. Moreover, they found that hard textures allows faster grasp of the content when compared to soft ones. It is important to notice, however, that the study was conducted with only 29 participants (from which only 15 were actually visually impaired). All of them were in college and none of them was Brazilian. As Perkins [33] observed in his study on tactile maps, the use context and the culture from the target users must be considered. Moreover, Bradley and Dunlop [6] argue that the information that the visually disabled people need differs from the information sighted people need.

Beside the tactile, also the auditory sense has been explored in accessible maps. Brock [8] developed a prototype in which a paper raised-line map was placed on top a touchscreen. In this interactive map, users could touch the map with both hands and whenever they needed further information, they would tap the place and audio information would be displayed. Other examples of tactile maps that provide auditory feedback include the tactile-auditory model that D'Abreu et al. [11] developed for UNICAMP and the map at the Perkins School for the Blind [15]. The model developed by D'Abreu et al. [11] has actuators that, when pressed, play audio with details from that place in the map. The map from [15] uses conductive paint to inform the place in the map that was pressed. Besides the voice that reads the name of the building and the route, the map also displays sounds to represent landmarks. For example, the sound of a bell is played when the tower is touched and the sound of water bubbles is played when the fountain is touched. This indicates that the state of the art in accessible maps goes in the direction of coupling tactile with auditory information.

Even though the audio contributes to better comprehension and to the acquisition of spatial knowledge [24], this use might not be always possible. For example, crowded public spaces and places where silence is mandatory, as in libraries and hospitals. While headsets can provide for better understanding of the audio, they do not always fit properly some dynamics of group interactions.

It is also important to have in mind that tactile or tactile-auditory maps should also be useful to people with low vision. In this case, the use of colors and letters, together with braille, is recommended. Although created for the web, one might rely on WCAG as reference for recommendations for color contrast and font size. Their tips are in line with ISO 9241-3:1992 "Ergonomic requirements for office work with visual display terminals (VDTs) - Part 3: Visual display requirements". The practical aspect of considering WCAG is that one can make use of the online tools to check if the contrast rate is within the recommended range. Similarly, a study on colors and contrasts can be found in [20].

An example of tactile map is shown in Figure 3, from the "Pinacoteca de São Paulo". That museum has a permanent exhibition exclusive for people with visual disabilities. At the entrance of that section, the tactile map informs the location of the sculptures, their names and the names of the artists. Bright and contrasting colors, together with representations of the sculptures in relief were present in the first tactile map at Pinacoteca. That map was substituted by a new one, made with a 3D printer. The tactile map now is monochromatic and with squares to represent the sculptures, as shown in Figure 3. The "Memorial da América Latina", also in the city of São Paulo has a similar tactile map. In this map, the buildings (which are

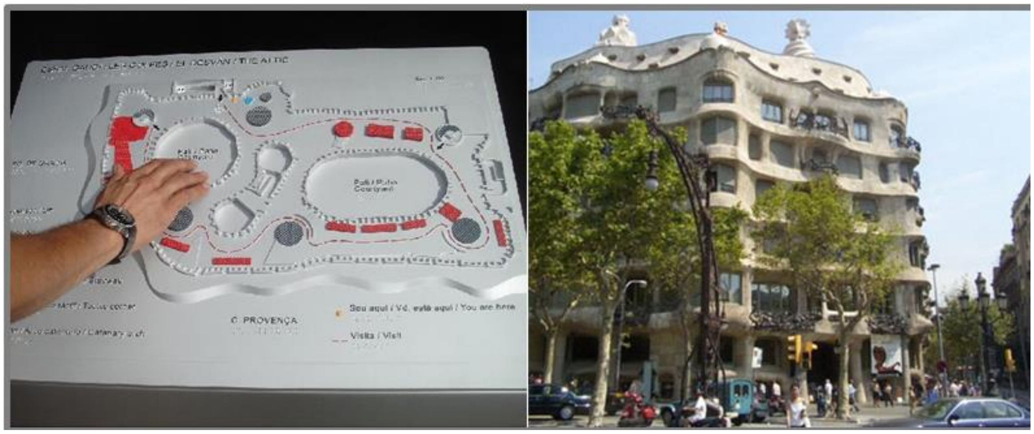

Figure 4 - Tactile map of the attic floor at Museum La Pedrera, in Barcelona, and the facade of the museum.. Image reproduced from http://www.accessfriendly.es/en/what-we-do/accessible-communication (access: May, 2017)

considered architectonic art pieces) are represented in 3D miniatures. In the USA, the Golden Gate Bridge is also represented in a 3D model; and in Barcelona, the tactile map represent not only the floor but also the shape of the museum's external walls (Figure 4). Studies on tactile maps can be useful in other contexts. For example is can aid school children with visual impairment to learn geography and cartography [50].

Communication and expression of affect

The act of appreciating a piece of art can evoke different affective responses in the viewer. Scherer [45] calls this kind of emotions "aesthetic", in opposition to the utilitarian ones. Being an emotional experience, informational systems for museums should reflect it and consider emotions and the visitors' affective responses. Some work can be found that already take emotion in consideration. Park et al. [32] proposed an interactive system in which an agent (virtual avatar) guides visitors by helping them search and browse the content of artwork. The agent, AMARA, asks simple questions in order to include users' preferences and emotions during the art collection search process.

Alelis [1] is interested in the investigation of emotional connections that museum visitors make in response to the art pieces. The author plans to develop a mobile application that will allow users to reflect upon their emotional responses: "After carefully thinking about how an object makes them feel, recalling a related memory, or connecting it to something personal in their lives, users will be able to understand how it connects to their emotional response" (p. 1022).

Salo et al. [41] also proposed a mobile application. In this tool, visitors can interact with curated audio stories and also with their own stories. Users can share stories and enrich existing ones. The authors emphasize that the main difference from their work to other storytelling tools is that visitors are able to indicate emotions. The story can be marked with positive or negative emotions. In order to allow for easier recognition and remembering, emotions are coded both with text and colors.

Emotions could also be explored in relation to the physical space of the museum, its rooms and hallways. A combination of the three works mentioned above could result in an interactive museum that invite visitors to reflect on their emotional responses and further propagate or share their emotional experience with others.

DISCUSSION

The examples presented in the previous section constitute important initiatives in the direction of universal design for museum routes and maps. However, visitors could benefit from more natural interaction and from accessibility throughout the entire environment. Moreover, information on affective responses of museum visitors – not only as an individual but as a group or society – could also be explored for richer experiences.

Interaction/enaction for all

The state of the art and ongoing research on accessible maps and routes for museum or for other public spaces are still germinating. In face of all possibilities that today's technology offer, the field has space for a lot of growth. However, in terms of accessibility, even the basic needs are not yet met in museums in Brazil. Most of the museums are devoid of tactile floor and maps. In our city – which is a rather large one, with 1 164 098[4] inhabitants – none of the museums visited had either tactile maps or floors indicators.

The technology shown in the last section could already be of great benefit for visitors. However, ubiquitous technology has the potential of enhancing even more the experiences in museums. Together, the use of lights, color, surround soundings, heat and texture could provide for interesting routes for indoor spaces. Inspired on Varela's definition for enactive, transparent interactivity or extended

[4] IBGE 2015

body experiences could be part of a viable and non-expensive museum route. But one could go even further, as detailed next.

Towards a socio-enactive system for museums

Enaction in the form of extended body experiences could be further developed into socio-enactive experiences. While the "socio-enactive" concept is still under construction within Project "Socio-enactive systems", this section provides some preliminary thoughts on a scenario in which first attempts towards it could be explored.

Often, a sighted person visiting a museum – or park, zoo or a walk in the woods – walks about the space and is guided towards what most calls their attention. Especially when different options of paths are offered, unless you are following a guided group, you go toward what calls your attention and your personal interest. Zones or paths of heat, color and even ambient smell could add to the experience and provide the blind or visually impaired with similar cues that can awake or provoke their senses and interest. This information would provide a richer experience than simply showing the possible paths via tactile tiles. In addition, it does not discriminate, being there for the experience of any visitor.

Translating images, painting, sculptures, collections or rooms to other "languages" – the language composed of varied nuances of colors, smells, sounds and/or temperatures – implies the same problems that the translation of spoken languages brings. When translating, for example, a book from English to Portuguese, often part of the meaning is lost. The vocabulary of a language, of a country, or group of people has absorbed a lot of its culture and values. Likewise, when "translating" the information present in images, paintings, etc. into colors, smells, sounds and/or temperatures, important information or even the original purpose of the art piece might end up being lost.

Passing the meaning and the affective affordances of the art into the "translated" piece can be a difficult task. One possible way to face this challenge is to consider the concepts involved when differentiating "translation" from "interpretation". A good interpreter does not translate word by word, but transfers the meaning of the entire message.

Interpretation is also a dynamic, social action; which is enriched by the variances of a community's set of culture and values. The museum scenario could therefore be further enhanced with systems that could not only present multimodal interpretational accessible routes. This system could also provide flexible, adaptive, autopoietic, autonomous, sense-making experiences that could feel as if coupled to our own bodies.

Borrowing from informational approaches to affect in design, devices could get physiological measurements from visitors as they follow their chosen paths at the museum and the system could dialogue with them. At the same time, interactional approaches to affect could allow users to experience unique visits to the museum, by enriching the experience with their own background (memories, feelings, sensations).. Each interaction would be different from the other, in a similar way that each visit to the museum is different for each person.

Affectibility in the visualization for all

The term "Affectibility" [14] is related to the degree to which a digital system or artifact can evoke intended (consciously by the designer) affective responses in the user. Hence "Affectible information visualization" would refer to the visualization of information that is intended to evoke specific affective responses. A wall that projects passerby's affective responses relating them to images, colors and sounds; with the intention of evoking other affective responses (e.g. funny images could be presented if the overall mood of the group of passerby is negative). This setting is an example of Affectible information visualization

It is consciously intended that a socio-enactive system for museums – or other scenarios – is capable of (re)presenting the affective responses from users. The system should not only (re)present the affective responses but also allow development or growth tied to the singular, subjective characteristics of the interactions and enactions of a particular group of people.

The "enactive" part of the socio-enactive system calls for informational approaches; the "socio" part of the system calls for interactional approaches; and the "socio-enactive" demands Affectibility and a Socially Aware Design to create a living and affectible socio-enactive information visualization system for all.

A museum as a socio-enactive system would be one in which visitors, museum, art pieces and experiences are all one single and same thing. The emotions shared in each visit sums to the whole experience of all visitors. The cycles of interactions are infinite and unpredictable. In the case of adapting existing museums, for them to be accessible for all, the exposed elements that had been conceived in only one media format (e.g., painting is to see, sound is to listen to) would demand some kind of "translation" or better, interpretation. In this scenario, a collective constructed – yet still undergone curatorship - interpretation is probable needed. Next steps f this work include the investigation of means to achieve accessible visualization of information. The objective is to have visual information interpreted and communicated or shared. This process involves the need to identify and reveal the purposes, the affective affordances, and the intentions that compose the visual information.

The investigation of accessible and affectible information visualization presents an interesting an promising research challenge. The findings from such investigation have the potential to inform socio-enactive systems for museums. This challenge calls for new models and frameworks to understand the communication and visualization of information.

The speech act theory explores the ways in which words can be used, not only to carry information. The words alone have little fixed information. The context, speaker and hearer influences in the meaning and might evoke actions. Speech act theory has influenced other authors, including Stamper who proposed a classification framework for illocutions (apud Liu e Li [22]). In the scenario of museums, the element of communication is usually an image. The analogue theory of speech act theory for this case could be the Image Act Theory [38]. In order to advance the investigation on accessible and affectible information visualization of information we propose to build upon the image act theory towards a framework for understanding the communication of information and the possible ways of interpreting, translating or conveying it.

CONCLUSIONS

Wearable and tangible computing, artificial intelligence, virtual reality, and all the ubiquitous interactions are changing the way we interact with and understand digital technology. The interface that separates human from computer is soon going to be so transparent that it will be as if it were not there at all. These types of immersive, embodied interactions – sometimes referred to as enactive – can provide improved affective and cognitive experiences for users, especially in the context of art exhibitions and museum. The enactive systems for museums, however, are often not accessible. Actually, many museums do not even provide minimum accessibility in terms of welcoming people with disabilities.

The contributions of this paper are threefold: 1) it presents a quick access to basic norms and brief literature review of the state of the art for tactile floors and maps, which constitutes a guide for accessibility that can be useful also for other contexts beside museums; 2) it sheds light into other forms of accessibility in terms of routes and maps; 3) it foments early discussions on new opportunities for investigation in HCI, especially in accessible information visualization in socio-enactive systems.

Next steps include further investigation of the discussed themes and the proposition of a conceptual framework on intentions and interpretation of information for all. Moreover, this work only treats the question of moving around the museum space. Accessing the works of art is another research problem that presents rich possibilities for investigation and shall be addressed in future steps of the research Project.

ACKNOWLEDGEMENT

We would like to thank our colleagues from InterHad for insightful discussions. We also thank the financial support of CNPq (308618/2014-9); CAPES (1644511); and process grant # 2015/165280 from São Paulo Research Foundation (FAPESP).

REFERENCES

1. Genevieve Alelis. 2013. Exhibiting emotion: using digital technologies to discover emotional connections. *CHI'13 Extended Abstracts on Human Factors in Computing Systems*, 1017-1022.
2. Hend S. Al-Khalifa. 2008. Utilizing QR code and mobile phones for blinds and visually impaired people. *International Conference on Computers for Handicapped Persons*, 1065-1069.
3. Associação Brasileira de Normas Técnicas. 2004. NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos. Rio de Janeiro.
4. Nikola Banovic, Rachel L. Franz, Khai N. Truong, Jennifer Mankoff, and Anind K. Dey. 2013. Uncovering information needs for independent spatial learning for users who are visually impaired. *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility*, 24.
5. Kirsten Boehner, Rogério DePaula, Paul Dourish, and Phoebe Sengers. (2007). How emotion is made and measured. *International Journal of Human-Computer Studies*, 65, 4, 275-291.
6. Nicholas A. Bradley, Mark D. Dunlop. 2005. An experimental investigation into wayfinding directions for visually impaired people. *Personal and Ubiquitous Computing*, 9, 6, 395-403.
7. British Standards BS 7997: 2003 UK.
8. Anke Brock, Christophe Jouffrais. 2015. Interactive audio-tactile maps for visually impaired people. *ACM SIGACCESS Accessibility and Computing*, 113, 3-12.
9. Jerome Seymour Bruner. 1966. *Toward a theory of instruction*. Belknap Press of Harvard University Press, Cambridge, MA.
10. Bettye Rose Connell, Mike Jones, Ron Mace, Jim Mueller, Abir Mullick, Elaine Ostroff, Jon Sanford, Ed Steinfeld, Molly Story, and Gregg Vanderheiden. 1997. *The Principles of Universal Design*, Version 2.0.Raleigh. The Center for Universal Design, North Carolina State University.http://www.design.ncsu.edu/cud/about_ud/udprinciples.htm (June, 2017)
11. João Vilhete V. d'Abreu, et al. 2011 Concepção e Modelagem de Mapa Tátil Sonoro de Uma Rota Acessível. *VI Congreso Iberoamericano de Tecnologías de Apoyo a la Discapacidad - IBERDISCAP*, 2, 43-50.
12. Ezequiel Di Paolo, Evan Thompson, E. 2014. The enactive approach. Lawrence Shapiro, ed., *The Routledge Handbook of Embodied Cognition*. Routledge Press.
13. Diana Domingues, Cristiano Jacques Miosso, Suélia F. Rodrigues, Carla Silva Rocha Aguiar, Tiago F. Lucena, Mateus Miranda, Adson F. Rocha, Ramesh Raskar.

2014. Embodiments, visualizations, and immersion with enactive affective systems. *IS&T/SPIE Electronic Imaging*, 90120J-90120J.

14. Elaine C. S. Hayashi, M. Cecília C. Baranauskas. 2013. 'Affectibility' and design workshops: taking actions towards more sensible design. *Proceedings of the 12th Brazilian Symposium on Human Factors in Computing Systems*, 3-12.
15. Charlotte Hsu. 2014. *A 3-D, talking map for the blind (and everyone else).* News Center, University of Buffalo. Disponível em: http://www.buffalo.edu/news/releases/2014/11/029.html (last access: May, 2017).
16. Sandra Jehoel, Simon Ungar, Don McCallum, Jonathan Rowell. 2005. An Evaluation of Substrates for Tactile Maps and Diagrams: Scanning Speed and Users' Preferences. *Journal of visual impairment and blindness*, 99, 2, 85-95.
17. Mauri Kaipainen, Niklas Ravaja, Pia Tikka, Rasmus Vuori, Roberto Pugliese, Marco Rapino, Tapio Takala. 2011. Enactive systems and enactive media: embodied human-machine coupling beyond interfaces. *Leonardo*, 44, 5, 433-438.
18. Paul R. Kleinginna, Anne M. Kleinginna. 1981. A categorized list of emotion definitions, with suggestions for a consensual definition. *Motivation and emotion*, 5, 4, 345-379.
19. Yoshiyuki Kobayashi, Takamichi Takashima, Mieko Hayashi, Hiroshi Fujimoto. 2005. Gait analysis of people walking on tactile ground surface indicators. *IEEE Transactions on neural systems and rehabilitation engineering*, 13, 1, 53-59.
20. Cínthia C. Kulpa, Fábio Gonçalves Teixeira, Régio Pierre da Silva. 2010 Um modelo de cores na usabilidade das interfaces computacionais para os deficientes de baixa visão. Design & Tecnologia, 1, 01, 66-78.
21. Vladimir Kulyukin, Chaitanya Gharpure, John Nicholson, Grayson Osborne. 2006. Robot-assisted wayfinding for the visually impaired in structured indoor environments. *Autonomous Robots*, 21, 1, 29-41.
22. Kecheng Liu, Weizi Li. 2014. *Organisational semiotics for business informatics*. Routledge.
23. Ruth Emilia Nogueira Loch. 2008. Cartografia tátil: mapas para deficientes visuais. *Portal de Cartografia das Geociências*, 1, 1, 36-58.
24. Kris Lohmann, and Christopher Habel. 2012. Extended verbal assistance facilitates knowledge acquisition of virtual tactile maps. *Spatial Cognition*, 8, 299-318. Springer Berlin Heidelberg.
25. Vanessa R. M. L. Maike, Samuel B. Buchdid, M. Cecília C. Baranauskas. 2016. A Smart Supermarket must be for All: a Case Study Including the Visually Impaired. *Proceedings of the 12th Brazilian Symposium on Human Factors in Computing Systems, IHC'16*.
26. Don A. Norman, 2004. *Emotional design: Why we love (or hate) everyday things*. Basic Civitas Books.
27. Humberto R. Maturana, Francisco J. Varela. 2001. *A árvore do conhecimento: as bases biológicas da compreensão humana*. Palas Athena.
28. John Mingers, 1991. The cognitive theories of Maturana and Varela. *Systemic Practice and Action Research*, 4(4), 319-338.
29. Oka, C. M. 2001 Importância do mapa e do mapa tátil. *Anais do Primeiro Simpósio Brasileiro sobre o Sistema Braille*, Salvador, MEC. Disponível em: http://saci.org.br/?modulo=akemi&parametro=5413 (último acesso: Jan.15)
30. Andrew Ortony, Donald A. Norman, William Revelle. 2005. Affect and proto-affect in effective functioning. *Who needs emotions*, 173-202.
31. Stefano Papetti, Federico Fontana. 2012. Effects of audio-tactile floor augmentation on perception and action during walking: Preliminary results. *Proceedings of the 9th Sound and Music Computing Conf.*, 17-22.
32. S. Joon Park, Gunho Chae, Craig MacDonald, Robert Stein, Susan Wiedenbeck, Jungwha Kim. 2012. Amara: The affective museum of art resource agent. *CHI'12 Extended Abstracts on Human Factors in Computing Systems*, 1035-1038.
33. Chris Perkins. 2001. Tactile campus mapping: Evaluating designs and production technologies. *20th International Cartographic Conference*, 5, 2906-2913.
34. Rosalind R. Picard. 1997. *Affective Computing*. Cambridge, MIT Press.
35. Rosalind R. Picard. 1999 Affective Computing for HCI. *Proceedings of the 8th International Conference on Human-Computer Interaction* (HCI International 1999), Munich, Germany.
36. Rosalind R. Picard. 2003. Affective computing: challenges. *International Journal of Human-Computer Studies*, 59(1-2), 55-64.
37. Lisa Ran, Sumi Helal, Steve Moore. 2004. Drishti: an integrated indoor/outdoor blind navigation system and service. *Proceedings of the Second IEEE Annual Conference on Pervasive Computing, PerCom*, 23-30.
38. Carson J. Reynolds. 2007. Image act theory. *Seventh International Conference of Computer Ethics: Philosophical Enquiry*, 12-14.
39. Elisabeth Romani, Juliana Harrison Henno, Clice de Toledo Sanjar Mazzilli. 2015. Reflexões acerca das técnicas de construção de imagens táteis

encontradas em museus e possíveis caminhos7º Congresso Internacional de Design da Informação, 2, 2, 332-341.

40. Timm Rosburg. 2008. Tactile ground surface indicators in public places. *Human Haptic Perception: Basics and Applications*, 491-499.

41. Kari Salo, Vallo Zinin, Merja Bauters, and Tommi Mikkonen. 2017. Modular Audio Story Platform for Museums. *Proceedings of the 22nd International Conference on Intelligent User Interfaces Companion*, 113-116.

42. Carmen Santoro, Fabio Paternò, Giulia Ricci, Barbara Leporini. 2007. A multimodal mobile museum guide for all. *Mobile Interaction with the Real World (MIRW 2007)*, 21-25.

43. Constantine Stephanidis, Gavriel Salvendy. 1998. Toward an information society for all: An international research and development agenda. *International Journal of Human-Computer Interaction,* 10, 2, 107-134.

44. Ben Shneiderman. 2000. Universal usability. *Communications of the ACM*, 43, 5, 84-91.

45. Klaus R. Scherer. 2005. What are emotions? And how can they be measured? *Social science information*, 44, 4, 695-729.

46. Lucinda Bittencourt Thesbita. 2014. *Mapa tátil como recurso de acessibilidade à cidade: um estudo de caso na estação do metrô Santa Cruz da cidade de São Paulo* (Dissertação de mestrado, Universidade de São Paulo).

47. Evan Thompson, Mog Stapleton. 2009. Making sense of sense-making: Reflections on enactive and extended mind theories. *Topoi*, 28, 1, 23-30.

48. Simon Ungar, Mark Blades, Christopher Spencer. 1993. The role of tactile maps in mobility training. *British Journal of Visual Impairment*, 11, 2, 59-61.

49. Francisco J. Varela, Eleanor Rosch and Evan Thompson. 1991. *The embodied mind. Cognitive Science and Human Experience*.

50. Silvia Elena Ventorini, Maria Isabel Castreghini de Freitas, Antonio José dos Santos Borges, Diogo Fugio Takano. 2006. Cartografia tátil e Mapavox: uma alternativa para a construção de maquetes táteis. *Revista Ciência em Extensão*, 2 (Suplemento), p.28-29.

51. Scooter Willis, Sumi Helal, 2005. RFID information grid for blind navigation and wayfinding. *Proceedings of the 9th IEEE International Symposium on Wearable Computers*, 34-37.

52. Terry Winograd, Fernando Flores. 1986. *Understanding computers and cognition: A new foundation for design*. Intellect Books.

53. Frederico Zonca. Inventor. Graphic representaion sign. 2001. *Patente europeia EP 1283512* A1, 8 de agosto.

54. Stuart Card, Thomas P. Moran, Allen Newell. 1983. *The psychology of human-computer interaction*.