Engaging Constable: Revealing Art with New Technology

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ABSTRACT
Museums increasingly deploy new technologies to enhance visitors' experience of their exhibitions. They primarily rely on touch-screen computer systems, PDAs and digital audio-guides. Tate Britain recently employed two innovative systems in one of their major exhibitions of John Constable's work; a gestural interface and a touch-screen panel, both connected to large projection screens. This paper reports on the analysis of video-recordings and field observations of visitors' action and interaction. It explores how people interact with and around the systems, how they configure the space around the installation and how they examine and discover their properties. It suggests that designers of interfaces and installations developed for museum exhibitions face particular challenges, such as the transparency of the relationship between people's actions and the system' response, the provision of opportunities for individual and collaborative experiences and the interweaving of technological and aesthetic experiences.

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Gestural interface, Touch-screen system, Museums, Social interaction, Video Analysis, Ethnomethodology

ACM Classification Keywords
H.5 Information Interfaces and Presentation; J.5 Arts and Humanities

INTRODUCTION
Within HCI and cognate areas of research there has recently been a growing interest in developing advanced technologies designed to support people in exploring and making sense of public settings. Many of these technologies utilize computing technologies and range from conventional, touch-screen information systems through to highly complex, interactive installations. Such systems and installation have been experimented with in cities and historic sites as well as in museums and galleries. Two rather distinctive approaches have informed the development of many of these new 'interactive' resources; reflected in part by the nature of the setting where they have been tried out. In museums, for example, we have seen experiments with stand alone, 'interactive' installations that constitute exhibits in their own right [10, 12, 13, 22], and mobile and stationary systems that provide information concerning particular objects such as paintings [1, 3, 4, 6, 19]. In the main, the installations and systems have been assessed under relatively controlled conditions, often involving individuals, pairs and small groups of participants. These experiments have largely focused on the technological challenges and the opportunities offered by the systems as well as on people's ability to use them. This research has made important contributions to debates in HCI; yet it has had relatively little bearing on the development and deployment of technology in museums.

Fairly independent from these developments in HCI, museums have recently begun to deploy new technologies to attract new audiences and engage visitors in novel ways with their exhibitions. These technologies include PDAs and touch-screen systems as well as more advanced technologies like wireless networks and image recognition systems [18, 21]. These developments are to be welcomed, but have proven problematic; curators, designers and museum managers have been frustrated by the difficulties in designing interactive resources that are easily accessible to a highly diverse population, who have very different interests and commitments, who may be alone or with others, and who often devote little more than a few seconds to particular exhibits. It would seem that curators and designers may benefit from the observations and findings produced within HCI; in turn, the experience of museums in deploying advanced technologies into their exhibitions where people encounter and engage with the systems in naturalistic situations may provide useful insights for developments within HCI.

In this regard, a recent exhibition of the Landscape paintings of John Constable, at the Tate Britain, is of some interest. Tate Britain is the national gallery of British art from 1500 to the present day. It has a long-standing commitment to exploring novel techniques and technologies to enhance the engagement of its visitors with the art. Its exhibition "John Constable: The Great Landscapes" offered a unique

opportunity to develop resources that enriched people's experience of the pictures. The solutions that were developed included two interactive installations housed towards the end of the exhibition that enabled visitors to discover for themselves aspects of the technique that Constable used in a number of his major paintings. They used a gestural interface and a touch-screen system. The installations, and in particular their use by visitors, provide a unique opportunity to consider the issues and problems that arise in developing 'interactive' resources for museums, and to identify a number of sensitivities and considerations that might inform their design. The study draws on the design brief that prefigured the development of the two installations and analyses video-recordings and field observations of visitors' interaction with and around the installations. It explores how people examine and use the two installations and reveals the different local ecologies and forms of participation that emerge around them. Before turning to the data we briefly describe the two "interactive installations".

THE "INTERACTIVE INSTALLATIONS"

"John Constable: The Great Landscapes" was displayed at Tate Britain from June 1 to August 28, 2006. It was the first occasion to see Constable's six-foot landscape paintings together. They include such famous works as "The Hay Wain" (1820-1), "Hadleigh Castle" (1829) and "A View on the Stour Near Dedham" (1822). Alongside the 'six-footers' the exhibition provided access to the preliminary full-scale compositional sketches that Constable produced when planning the exhibition pictures. The display of the finished exhibition paintings besides the preliminary sketches allows visitors to obtain an understanding of Constable's working practice and techniques.

The curator responsible for the interpretation of the exhibition was interested in deploying two "interactive installations capable of engaging visitors, supporting curatorial themes, complementing the space and surviving months of heavy usage" (Design Brief). He invited design companies to tender for the development of "interactive interpretation" resources that would allow visitors to see the changes the artist made between the sketches and the final picture and to understand the "physical techniques used to create and scale the work" (Design Brief). Any developments would have to preserve the integrity and aesthetics of the pictures themselves, to enhance rather than undermine the objects. He suggested an X-Ray Examination and a Drawing Activity. After a successful tender the London-based design company AllofUs developed the installations that were deployed in the final room of the exhibition.

The X-Ray Examination is a life-size projection of Constable's sketch of "Salisbury Cathedral from the Meadows" (1831). The projection can be video-mixed with the X-ray of the painting to analyze the artist's *pentimenti* (the underlying images beneath overpainted alterations)" (Design Brief). It is connected to a conventional Pentium PC and a basic black and white CCTV camera located underneath the projection screen (Figure 1). As the camera captures people's movement in front of the projection bespoke software translates people's movements into changes in the picture. The curator hopes the X-Ray Examination "allows for exciting and intuitive exploration of the changes that Constable made in the sketch" (Design Brief) (Figure 1).

Figure 1: X-Ray Examination

Figure 2: Drawing Activity

The "Drawing Activity" aims to reveal how "the artist would lay a grid of threads across his sketches for the purpose of accurately transferring the image to the finished painting" (Design Brief). The installation consists of a large projection of Constable's painting "A View on the Stour Near Dedham" and a table showing a pencil sketch and a slightly larger oil painting of the same scene by Constable; the oil painting being placed under a touch-sensitive glass-panel. These sketches provided the artist with the basis for his full-scale work (Figure 2). By touching various sections of the glass-panel, parts of the painting become visible on the projection screen in front; bespoke software on a Pentium PC translating the user's actions on the glass-panel into images appearing on the projection.

Both installations are designed to be used by the general public in a setting populated by multiple people. They are meant to "foster an understanding amongst visitors: both those using the interactives and – importantly – those merely witnessing their use" (Design Brief). This study explores the ways in which people engage with the two installations and

examines the forms of participation that arise in their immediate locale.

ENGAGING CONSTABLE

Both installations were a great success with visitors to the exhibition. Due to its display in the final room all visitors to The Great Landscapes walked by the two installations and at least glanced at them. For this study we undertook intensive data collection over five days at Tate Britain. Data collection involved field observation and video-based studies in the exhibition. Data were collected with two conventional, stationary cameras set up in a corner of the exhibition to avoid people being drawn to it; to capture people's talk microphones were placed underneath the projection screen of the X-Ray Examination and behind the small table with the touch-sensitive surface. While the recordings were undertaken the researcher observed visitors and made field notes. The video-based and observational data were augmented by interviews with the curator responsible for the deployment of the installations. We also examined written documentation of the installation like the design brief and the labels describing the installations printed on the gallery wall. Our body of video-data contains numerous fragments involving approximately 100 visitors, including individuals, couples, pairs and groups, adults of all age groups and children who used the installations and spent considerable time examining the opportunities for participation and discovery they offered; even more visitors explored the installations by "witnessing" the actions of others.

The analysis employs a combination of qualitative social scientific methods, including methods that have frequently been used within CSCW and workplace studies and recently have become increasingly important in HCI [9, 20]. It draws on video-based field studies, ethnographies of conduct and interaction, in the Constable exhibition to consider how visitors explore and make sense of the two installations. In particular, it focuses on how people engage with the systems, how people's engagement arises in social interaction with others, and how different spatial arrangements and forms of participation emerge at the systems. It is based on an analytic and methodological framework developed in sociology, namely Ethnomethodology [7] and Conversation Analysis [17]. This framework draws attention to the social and sequential organization of people's vocal, bodily and material action and interaction. It helps to reveal how objects and artifacts as well as tools and technologies gain their sense and significance in and through the interaction amongst participants [9].

Video-recordings offer certain advantages over more conventional qualitative data. They provide resources through which we can capture (versions of) conduct and interaction and subject them to detailed, repeated scrutiny, using slow motion facilities and the like. They help to reveal the fine details of conduct and interaction that cannot be uncovered through observations or interviews, yet form the foundation to how people see and experience objects and artifacts in museums. Despite their advantages, video-recordings are not without their problems. Critics of the methodology have raised particular concerns about the reliability of the data and people's reaction to the camera. In this regard, however, one may argue that video-recordings are less obtrusive than field observation and reduce the reactivity of observational methods [14, 15].

The study has arisen as part of a program of research in which we explore how people examine and make sense of museums in and through their interaction with others. These data support our understanding of how visitors' experience of paintings may be affected by their use of innovative interpretation technologies [11]. In this paper, we primarily focus on the X-Ray Examination and refer to the Drawing Activity to highlight some interesting issues that these two distinct interfaces raise when being deployed in a museum.

Impromptu Interaction

The success of the X-Ray Examination primarily arises from the intuitive form of engagement facilitated by the gestural interface. Changes to the picture on the projection are triggered by movements within range of the interface. For example, in one case a woman, we call her Mary, approaches the large projection showing a life-size picture of the sketch of "A View on the Stour Near Dedham". As she comes close to the projection parts of the picture change from color to black and white. She moves closer to the image and inspects it in more detail. She notices a green bush by the riverbank turning into a black and white figure sitting by the river. Having discovered this distinct difference between the color picture and the black and white image she retrospectively searches for the cause of this change in the picture. She moves back and forth to explore whether her bodily movement is connected to the changes in her immediate environment. She repeatedly sees the bush turning into a figure and back into a bush and infers that the projection responds to her actions. Thus, only after having triggered changes to her environment Mary discovers the functionality of the system. She sees that her movement is the first part of a two-part sequence of user-action, system-response through which the installation is operated. She has been turned into a user by the system that registers her movement.

Figure 3: Mary (in grey jacket) inspects the X-Ray Examination with others

While Mary inspects the picture other people arrive behind her. They walk into the gallery looking at the projection. They notice the woman's body movement and the changes in the picture. As the woman goes to the center of the space in front of the projection the middle of the picture turns black and white; when a moment later she stretches her arm up in the air parts at the top of the picture change color. By observing the relationship between the woman's movement and the changing picture they may notice that the woman interacts with the installation. They discover the functionality of the installation by observing the action of another visitor they have no personal relationship with (Figure 3).

In many cases, people who have observed the interaction of others for a while move closer to the projection to interact with it themselves. In one instance, a man arrives at the installation that is currently examined by a woman. The woman stands to the right of the projection. As the man moves in he stands to the left and notices the projection in front changing color. He then notices another part of the projection changing color corresponding to the woman's body movement; she has stretched her arm up in the air. A moment later, he stretches his arm up in the air and then to the side, thus exploring various sections of the picture in his reach. The actions through which he examines the installation imitate and build on those of the woman to his right. Her actions provide him with resources to inspect areas of the picture that otherwise he would not have noticed.

The discovery of the functionality of the installation arises as people act and interact in the range of the gestural interface. They do not choose to become a user of the system but they "run into" the system and thus become users. It may be worthwhile to briefly consider people's interaction with the Drawing Activity displayed only a few meters from the X-Ray Examination to bring to light the important difference between using a gestural interface and small touch-sensitive interface. As with conventional touch-screen systems the size and location as well as the physical character of the interaction define where the user stands and how s/he operates the interface. Consider the following case where a woman arrives at the table. She glances at the small oil sketch laid out on the table underneath the touch-sensitive glass-surface. A moment later, she touches the glass and looks up where the projection shows a brush stroke corresponding to where she touched the glass-surface (Figure 4a).

A moment later, she again looks down, touches the glass surface and then glances to the projection to discover the effect of her action on the picture in front (Figure 4b). Her use of the system is characterized by two part sequences of user-action and system response. The woman has become a user of the system by touching the glass surface and engaging in the drawing activity. Her discovery of the functionality of the exhibit and of Constable's technique systematically arises in and through the sequential organization of her interaction with the system (Figure 4b).

Figure 4a: Jenny looking at Projection of Drawing Activity

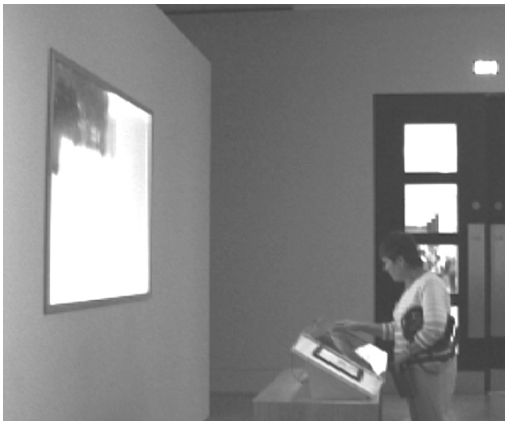

Figure 4b: Jenny looking at sketch under glass-panel

Other people arriving near the installation notice the changing image on the projection and the woman standing at the table poking the glass surface and looking up at the screen in front. They see a relationship between the projection and the woman's actions and consider her to be the user of the installation. Whilst they are standing near the woman their participation in her activity is limited to witnessing and maybe commenting on the events.

The analysis reveals fundamental differences in the ways in which people interact with the X-Ray Examination and the Drawing Activity. The gestural interface's sensitivity to movement turns everybody who moves into its range into a user. The discovery of being a user may occasion sequences of interaction with the system to examine its functionality and the opportunities it offers. In comparison, to become a user of the Drawing Activity visitors are required to touch the glass-panel and see the effects of their action on the projection. Their interaction with the system may occasion other people to stand near by, observe the action and maybe become users themselves later. The different ways in which the two installations facilitate people's use of them have an impact on the distinction between "user" and "witnesses", highlighted in the Design Brief. Whilst the Drawing Activity differentiates the user and her/his witnesses based on their hands-on interaction with the system, at the X-Ray Examination visitors may be turned into users, often without knowing there was a system to interact with.

Configuring Spaces

The Constable exhibition was generally very busy. People came with companions and explored the exhibition together while others were in the same gallery. Our observations show that people's experience of the installation is fundamentally affected by the presence of others. The position of others influences where people who arrive in the room view it. For example, when people enter the room they often see the X-Ray Examination that other people view while standing a few meters away from the screen. They move closer towards the projection and stop where they can view it without obstructing others' line of sight. As more and more people arrive at the exhibit they gradually form a semi-circular arrangement that allows all of them to view the events in front.

Figure 5: Semi-circular Arrangement at X-Ray Examination

People standing at some distance from the projection rarely move sufficiently to trigger noticeable changes to the picture. They often stay within the semi-circular arrangement and view the picture for half a minute or so before some of them begin to leave disbanding the semi-circular arrangement (Figure 5). The departure of some viewers allows the remaining visitors to move closer to the projection without interfering with other people's viewing of it. For example, in one case, a semi-circle is dissolved allowing Mary and John to approach the projection and inspect the picture in more detail. They stand close by the projection and examine its features. After a few moments other people arrive behind them in the room. They stop to either side and behind the couple and view the projection that in response to Mary and John's actions changes its look. Thus, the space around the installation is reconfigured; the people who have just arrived at the installation forming a semicircle around the installation including the couple interacting with it. They see the projection in the light of the couple's actions in front of it (Figure 6).

Figure 6: Mary and John observed by others

When having observed the performance of others for a while some of those "witnessing" the users' interaction with the installation step closer to the installation. As they move into the range of the gestural interface parts of the image on the projection change and they themselves become users of the exhibit. They begin to move backwards and forwards and to either side, wave with their arms and brochures, thus playfully exploring the installation.

The gestural interface provides for flexible spatial configurations within which people can examine and make sense of the installation in interaction with others. It allows them to ongoingly configure how they and others use the space in front of the projection. For example, in one moment they can stand in a semi-circular arrangement and view the projection whilst a few moments later they form small groups of two or three people who examine the installation together. This flexibility in the ways in which people can use and configure the space at the installation is facilitated by the range of the interface and the size of the projection.

The Drawing Activity allows for different forms of spatial organization in which visitors participate in the activity. The small touch-sensitive interface prioritizes individual users over collaborative modes of engagement. Yet, while a visitor interacts with the installation other people gather nearby monitoring her/his actions and observing the events on the projection; they witness the user's actions and the events on the projection. Those witnessing the actions and events are often comprised of companions and strangers. They can be differentiated by their spatial orientation to the user and their participation in the activity.

Figure 7: Spatial Arrangement at Drawing Activity

For example, while Pete interacts with the system his partner Jenny stands close-by observing how brush strokes appear on the projection in response to Pete's actions on the table. Where Jenny stands she can see the specific areas her partner selects on the table and relate them to the brush strokes appearing on the projection in front. Strangers arriving at the installation occupied by Pete and Jenny stand further back observing the actions by the table an the events on the projection (Figure 7). Their participation in the activities is largely limited to watching them. They read the text printed on the wall and then move closer to the table to have a better view of the user's actions. Yet, their engagement with the installation remains limited to monitoring and observing the events. They often leave the exhibition when they have seen the relationship between the user's actions and the projection without waiting for a turn at the installation.

Probing the Installations

When people have found out the functionality of the X-Ray Examination they often further examine the exhibit by moving forward and back or by waving with their arms. Thus, they gradually discover differences between the finished sketch of the painting and the black and white X-Ray picture. In many cases, people notice the difference between the sketch and the X-Ray when a companion's or another person's movement reveal a striking feature in the X-Ray that is not visible in the sketch. For example, after having viewed the projection with her mother for some time a girl makes a step forward triggering a visible change to the projection. She stands still for a few moments and looks at the picture when her mother points out a figure sitting by the riverbank. The girl looks to the projection and then again steps forward causing other parts of the projection to change. Having discovered the effects their actions have on the projection the mother encourages her daughter to jointly move in front of the projection to examine the picture (Figure 8).

Figure 8: Mother and Daughter examining Installation

The range of the gestural interface enables multiple users to interact with the system at the same time. As more and more people arrive at the installation many people try to examine the projection simultaneously. The space in front of the projection fills up with people. Consequently, it becomes ever more difficult to differentiate whose actions affect the picture in front. Indeed, people themselves find it increasingly difficult to identify the effects their actions have on the projection. Our observations show that when the space in front of the projection is populated by a large number of people some of them often produce elaborate actions to apply changes to the images on the projection. They stretch out their limbs, use brochures and paper cards to enhance the reach and affect their body movements have on the projection. By embellishing their actions people create private experiences of the installation in a very public environment (Figure 9).

Figure 9: Woman waving with Arm

The embellishment allows them to distinguish their actions on the projection from those of others. At the same time, they become noticeable as users of the installation because their actions are highly visible for others and can often be related to events on the projection. Thus, actions undertaken to produce a private experience become a critical resource for others to make sense of the installation. Yet, when the exhibition is very busy people often have difficulties to disambiguate the effects their actions have on the picture from the effects of other people's actions, even when they

design them in an embellished way. The interface does not discriminate or prioritize between actions of particular people (Figure 10).

Figure 10: Man waving with Brochure

Our analysis of the video-recordings and observations reveal that the users' of the installation are often accompanied by companions who monitor, comment on and pose questions regarding the changes that become visible on the projection. When with others a user may design her/his actions to enable the observers to make interesting discoveries. For example, when a man notices a figure by the riverbank that becomes visible in the X-Ray when moving his arm in front of the projection he repeats his arm movement a few times to draw his companions' attention to it. The man's actions are also visible to other people who have gathered around the installation. They learn about the functionality of the exhibit and about the differences between the finished sketch and the X-Ray image by virtue of the users' actions.

The flexibility of use and spatial arrangement that we observed at the X-Ray Examination stands in some contrast to the rigidity of use and spatial organization facilitated by the Drawing Activity. Our observations show that the small touch-screen interface provides for differential access to the installation. The principal user interacts with the system by virtue of pre-structured two part sequences of user-action, system response and so on. Her/his experience of the installation is direct, immediate and thus first-hand.

Companions often stand close by the user, monitor her/his actions and are sometimes drawn in by the user who voices comments and questions. They are not passive observers but in interaction with the user create a shared experience of the installation. For example, when a user notices differences between the small oil sketch and the projection, "oh quite different there", her companion joins in the inspection of the exhibit. She confirms that there are distinct differences in the oil sketch and the painting, "mhm quite different there". Her discovery of the differences between the two works stimulates the search for further differences which a moment later are found in the depiction of the horses and the cathedral itself. Talk arising at the installation is closely coordinated with the two part sequences of user-action, system response. It often occurs when the user has revealed a distinct feature of the painting. For example, when a woman reveals a couple of dogs in the bottom left corner of the painting a discussion with her friend arises about Constable's liking of dogs; or in another case, when a man fills the entire projection by moving his hand across the panel his companions notice the systematic relationship between the grid laid over the small oil sketch and the life-size painting. Once the user completes his interaction with the installation he and his companions leave the exhibition, often without the latter having used the exhibit themselves. The companions have had a second-hand experience that is shaped by the observation of the user's actions and their talk and interaction with him.

Strangers stand further back or to the left of the user where they can read the text on the wall, see the projection and monitor the user's actions. Their participation is largely limited to watching the events. Their remote position allows strangers limited access to the user's actions on the table. They experience the installation second-hand and have only few opportunities for participation in the users' actions. They may be able to see the user's action but have only limited visibility of the small oil painting and the grid laid over it. Hence, their understanding of the installation is impoverished by the private character of the user's activity facilitated by the small touch-sensitive interface. The public display of the effects of the user's actions on the projection provides them with only a partial understanding of the Drawing Activity. After having read the text they may move closer to the table to have a better view of the user's actions. Yet, their engagement with the installation remains limited to monitoring and observing the events. They often leave the exhibition when they have seen the relationship between the user's actions and the events on the projection without interacting with the installation themselves.

DISCUSSION AND IMPLICATIONS

The installations deployed as part of the Constable exhibition have been very popular with visitors and have withstood heavy usage over the course of eight weeks. Study of the two installations provides an understanding of how the general public encounters and deals with technologies they have not seen and used before; at least not in the same circumstances. In our data people rarely examined the installations in isolation; they arrived at and used the systems in interaction with companions and in the presence of other people who happened to be there at the same time. In some ways the installations meet the requirements given in the design brief to provide opportunities for participation for users and their witnesses. Yet, this study highlights that participation with the installations is more complex than captured by the simple distinction between 'users' and 'witnesses'.

The *Drawing Activity* illustrates the opportunities of interfaces that prioritize the individual user over social and collaborative forms of engagement. This kind of single-user interface fosters social situations characterized by a particular spatial organization that differentiates between the user and her/his witnesses and further discriminates those witnessing the actions at the installation. Some studies argue that the differential access and the layered forms of participation undermine the emergence of social and collaborative

experiences of exhibits. In drawing on the design brief this investigation shows that the curator and designers anticipated the differential access to, participation with and experience of the installation. Yet, it reveals that knowledge about the complex and differentiated forms of participation at touch-screen interfaces could provide useful resources to further enhance the experience of those around the exhibit; for example, by making visible how through their actions the user transposes the small oil sketch onto the large projection.

The *X-Ray Examination* sheds light on the opportunities of computer technology for designers and curators to create new forms of engagement with artworks. The gestural interface facilitates simultaneous multi-party participation; people engage in impromptu interaction with the installation, sometimes without noticing it; they figure out their "participation status" [8] in the activity by exploring the relationship between their actions and the system's response.

We would like to suggest that these findings bear upon recent debates in HCI concerning the development and deployment of sensor-based technologies and also the distinctive demands of designing for 'spectators'.

There have been a number of recent papers to identify challenges and obstacles to the successful development of readily usable sensor-based technologies [2, 5]. In particular they have highlighted some of the problems that machine inference of human states may have for users and the difficulties users may face in deciding whether and how they are engaging a device. However these problems are derived from assumptions about *individual* users encountering technologies in isolation. These challenges are significantly complicated, and new problems emerge, when the aim is to support interaction in public settings, where there are multiple co-present participants in range of the sensors. In these more public arenas, it is not just a question of whether the system is responding, but who is the system responding to? Maybe more fundamentally the ways in which users discover functionality are not tied to individual exploration of technologies, but rather to explorations of technologies and the activities of people who surround them.

With the *X-Ray Examination* the range of the interface facilitates the flexible configuration of the space in front of the projection allowing simultaneous multi-party participation. People can interact with the installation in various locations, create personal experiences for themselves and share them with others. However, when a large number of people occupy the space in front of the projection it becomes increasingly difficult for them to differentiate the effects each other's actions have on the picture. Detailed knowledge about the ways in which people use the space in front of the installation may be a useful resource for designers to provide visitors with facilities that allow them to disambiguate their actions from those of others.

This leads on to the recent interest in the ways in which technologies may be configured for spectators and how spectators should experience another's interaction with a computer. To explore this concern Reeves et al. develop a taxonomy that rests on a categorization of systems "according to the extent to which a performer's manipulations of an interface and their resulting effects are hidden, partially revealed, fully revealed or even amplified for spectators" [16: 741]. In essence, they reflect on how private or public the use and effects of systems are.

However there are notable limitations of this taxonomy when we consider its relationship to our analysis of the *X-ray Examination*. The visibility of manipulations by a user (or in their terms, a performer) is not readily categorised as it is not static. As individuals explore an exhibit the manipulations of the system by others can begin as 'hidden' but then can become 'revealed'. Indeed once the exaggerated gestural conduct of a participant is *recognised as* constituting manipulations of the exhibit, there can be a very quick shift from hidden to amplified. Furthermore as we are considering a multi-party public setting, manipulations can be 'hidden' for one spectator but 'revealed' or even 'amplified' for another depending on their knowledge and experience of the exhibit, and on their emerging sensitivity to the conduct of others in relation to the exhibit. Moreover, people can work to hide or reveal manipulations or even effects of technologies (consider the act of turning a mobile phone display to show others).

Thus these properties do not rest in the technology alone. They cannot be straightforwardly *designed in*. Rather they reside in the complex and contingent configuration of the socio-technical assembly of people and technologies.

Furthermore (and as acknowledged in [16]) the distinction between 'user' and 'witness', or 'spectator' and 'performer', is not straightforward. Through moving through the space people often become users of the exhibit without knowing it – furthermore they can move from unwitting users to knowing performers. Thus we can start to see how the private and the public, and indeed the individual and the collaborative, use and understanding of the system are deeply enmeshed, are highly variable across the group at any one time and are dynamically configured from moment to moment.

As we have noted elsewhere "Recognising and designing for … variable and highly contingent forms of participation with an artefact, or assembly of artefacts, raises different and potentially more complex challenges than traditionally associated with the design of computer interfaces" [12]. However we believe that these findings point towards a series of questions and issues that designers may use in addressing challenges of deploying novel gesture-based interfaces in museums, galleries and similar public places. These questions include the following:

Combining unobtrusiveness and transparency

The managers and curators of art museums often shy away from the deployment of technology in their exhibitions

because they are afraid it may affect people's experience of the artworks. Sensor-based technology may provide a way forward in this respect because it can be unobtrusive. This needs to be complemented by a transparency of the relationship between actions and system response;

- *How can people be more smoothly introduced to the use of installations and their part within the exhibition?* When visitors come near the *X-Ray Examination* they are often turned into users, sometimes without them noticing it and leaving this part of the exhibition without having seen its relationship to its central theme.

- *How can the system's responses be designed to more readily reflect the different forms of participation arising in its locale?*
  People may participate in different ways with the system; they may point and gesture, wave with their hands or use paper cards, or they may stand by the side and monitor the actions of others. The *X-Ray Examination* does not differentiate between these different actions but response relatively crudely to all events in range of the camera interface.

Providing for personal and collaborative experience
People often come with others to museums and explore and examine exhibits in the presence of companions and others. They may engage with the system individually, examine it in collaboration with others, or participate in other people's examination of the system.

- *How can systems be best designed to discriminate between people in range of the system?* The *X-Ray Examination* does not discriminate between those willingly interacting with the system and those standing by the user to observe the events; some people come in range of the interface merely to discuss the projection with another whilst others move into the space to change parts of the picture.

- *How can system be best designed to respond to fluctuating numbers of people?* The *X-Ray Examination* responds to the movement of all those in its range rendering the image on the projection useless when the entire space in front is occupied. The *Drawing Activity* accommodates multiple people, yet provides them with differential access and experiences of the installation.

Interweaving aesthetic and technological experiences
Art museums tend to physically separate the display of the artworks from technologically enhanced information and interpretation resources. They often create interactive galleries where people can engage with novel information resources but fairly recently also deploy new touch-screen and mobile devices near exhibits. Yet, these novel devices have been criticized for overwhelming people's experience of the authentic objects. The latent properties of ubiquitous and sensor-based technologies may allow curators to enhance people's experience of the artworks in new ways;

- *How can systems be designed to establish clearer links between interactives and the orginal artworks?* Both, the *Drawing Activity* and the *X-Ray Examination* are displayed in a room remote from the original artwork they refer to. Only very few visitors returned from the installation into the main exhibition to view Constable's paintings. It would be worth considering how to better support connections between the two.

This paper can only raise some of the challenges for designers of "interactive installations" in museums and galleries. However it also points to the opportunities afforded at the intersection of HCI and the museum world. We believe that this intersection provides extremely fertile ground to explore the ways in which advanced technologies are encountered and used under the real-world demands of public settings. Museums and galleries are increasingly adopting a range of very novel interaction technologies to engage visitors and that have to meet the demands of heavy and varied use. Thus it provides opportunities for HCI to learn from the *in situ* use of advanced technologies and to re-consider the assumptions on which new systems are developed. It also points to opportunities for curators and designers to use methods from HCI (including ethnographic and video-based studies) to evaluate these technologies and to develop clearer understandings of the social organization of visitor conduct and interaction in their exhibitions; understandings that could develop new ways to enhance visitors' engagement with and appreciation of artworks.

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