COIN-O-RAMA: Designing an Interactive Exhibit for Exploring and Engaging with Coin Exhibitions

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ABSTRACT
This paper presents COIN-O-RAMA, an interactive exhibit designed for exploring and further engaging with coins in physical exhibitions. The key motivation was to create an appealing and user friendly system, augmenting and complementing the overall experience of visiting the exhibition, also offering the means for creating a personalized digital souvenir (a coin with the user's head engraved on it), working as a post-visit link to the exhibition and to related information, as well as an artifact to share with friends and the social media. In this paper the requirements and preferences upon which the creation of COIN-O-RAMA was based are presented, followed by an account of the conceptual and interaction / user interface design of the system. Subsequently, a technical description of the process followed to achieve the engraving effect used for creating the personalized digital coin is offered. Then, the results of an expert evaluation of a fully working prototype of the system are reported, comprising issues raised by the evaluators and the corresponding re-design of the system. The paper wraps up with some conclusions and pointers to future work.

CCS Concepts
• **Human-centered computing~Interaction design** • *Human-centered computing~Heuristic evaluations*

Keywords
Interactive museum exhibits; interaction design; expert evaluation; digital souvenir; image processing.

1. INTRODUCTION
In the past couple of decades, museums and public exhibition spaces worldwide have taken advantage of the abundance of low-cost, robust and readily available interactive technologies in order to provide novel, dynamic, services and added-value experiences to their visitors, moving beyond the "information kiosk" paradigm of the past (e.g., [4]; [8]; [17]; [20]). Such approaches can have a substantial impact in museum settings in various ways [8]: digital information can enrich the visual aspect of an exhibition, offering for example magnification of detail; accompanying texts can be multilingual and longer than the average caption, without taking up wall space from the exhibition; multimedia presentations can be available on demand. Additionally, as those system offer user interaction, the museum visitor is no longer a passive viewer, but an engaged participant who plays an important part in her/his own museum experience.

Coin collections constitute a particular type of museum exhibits, with unique characteristics and requirements. For example, the exhibits (i.e. coins) are small, but have considerable detail; very often, only one of their sides is visible; and, frequently, several of them share a common display case. Also, due to space limitations, very little – if any – information (e.g. a short label in 1-2 languages) is provided near each coin, or, sometimes, coins are numbered and information is presented in a nearby legend.

Presently, less than a handful of interactive systems exist which are explicitly designed for supporting and augmenting coin collections, including the *Stater 360*[2] double rotating augmented gimbal system described in [20]; the *Royal Mint multi-touchscreen system*[i] presented at the World Money Fair; the *Museum Palazzo Blu coin collection kiosk* [19]; and the *GA-SAAP* augmented-reality installation[ii] at the Coin Museum Treasury Department Thailand.

In this context, this paper presents COIN-O-RAMA an interactive exhibit commissioned by Alpha Bank as a means for exploring and further engaging with the ancient coins comprised in the "MONEY. Tangible symbols in ancient Greece" exhibition[iii], which was created as a joint collaboration between the Alpha Bank Numismatic Collection and the Museum of Cycladic Art, where it is also hosted. The exhibition presents a different side of coins, which first appeared in the late 7th century BC. During antiquity,

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[i] http://popcomms.com/case-studies/the-royal-mint-touchscreen/

[ii] https://creators.vice.com/en_us/article/78exbx/giant-coins-tell-stories-behind-thai-currency

[iii] https://www.cycladic.gr/en/page/chrima

the coin also had another use, one that is related to its iconography: it was a symbol as well as something that people could hold in their hands, it was a tangible symbol. The exhibition is structured along eight thematic units, in which 85 coins from the Alpha Bank Collection are exhibited together with 159 objects (clay vases, terracotta figurines, marble and bronze statuettes, reliefs, gold jewelry, measuring vessels, coins from closed assemblages and inscriptions) from 32 archaeological museums and collections in Greece, Italy, France and the United Kingdom, whose iconography is linked directly to each unit's content.

2. BACKGROUND & RELATED WORK

There is an expanding body of literature related to the design of interactive exhibits. For example, Durbin [5] describes the design process and observation results of "interpretative devices" integrated within the displays of the British Galleries of the Victoria and Albert Museum, Lehn et al. [16] examine the ways in which visitors encounter and experience exhibits and how these experiences are shaped and affected by social interaction. Hope at al. [11] focus on issues of family interaction and cooperation in a technological-augmented museum. Walter [24] and Heath et al. [10] provide observation study results from the use of electronic guides and interactive exhibits respectively, and identify several problems and trade-offs between interactive media use and social interaction. Hall and Bannon [9] propose a number of heuristic design guidelines targeted to creating interactive museum exhibits for children. Knipfer et al. [14] present a framework for understanding informal learning in science exhibitions and explore the learning potential of related advanced applications. Partarakis et al [20] present a framework for implementing digital cultural heritage applications on top of Ambient Intelligence technologies supporting rich interaction and gamification, also reviewing a number of related enabling technologies.

Interactive museum exhibits can be broadly classified in four categories [8]:

- *Hybrid exhibits*: augmenting a museum artifact with graphics (e.g., [8]; [1]); or audio commentaries (e.g., [15]).
- *Side exhibits*: placed adjacent to a real exhibit, providing indirect exploration of, and interaction with, it (e.g., [8]; [12]).
- *Isolated, but linked, exhibits*: having "a conceptual affinity with the original artwork" ([15]); they are related to a real exhibit but installed in separate, dedicated, locations (e.g., [8]; [6]; [15]).
- *Stand-alone exhibits*: containing content related to an exhibition (or museum), but not directly linked to a specific artifact (e.g., [17]; [8]; [22]); often they are used to explain or demonstrate abstract concepts, scientific principles, etc., and sometimes they comprise a separate exhibition (e.g., [7]).

Currently, very few interactive exhibits exist which are explicitly designed for supporting and augmenting coin collections. For example, *360²* [20] is an interactive installation that allows to experience coins through a high resolution projection upon a metal disk that can be rotated around two axes. Visitors have the opportunity to "take into their hands" a coin at a large scale, turn it around to see both of its sides, while the system offers additional functions (description of what is presented on each side, magnifying glass, map). Additionally, on a secondary metal surface, which also supports touch, information is presented regarding the selected coin's place of origin. Both the metal disk and the secondary projection surface do not integrate any technological element as the disk's "pose" and of the user's touch on each surface are estimated using a depth camera in combination with computer vision software.

The *GA-SAAP* (which means "coin" in Thai) installation[ii] at the Coin Museum Treasury Department Thailand follows a projection mapping augmented-reality approach, also employing motion graphics, to narrate the history and evolution of Thai currency. When visitors hold circular brochures up to an installation wall featuring enlarged versions of local *bhat* coins, animated stories of Thai trade get projected onto their white surfaces.

Another two simpler related systems exist, which utilize typical touch screen technology. The Ro*yal Mint multi-touchscreen system*[i] presented at the World Money Fair, comprises six 42" touchscreens that let users interact with commemorative and circulating coins to delve deeper into finer details and explore the history of The Royal Mint; and the *Museum Palazzo Blu coin collection kiosk* [19] developed for the presentation of the coin collection of Ottavio Simoneschi, which integrates multimedia data, Reflectance Transformation Imaging (RTI) and technologies for rendering 3D content on the Web, to allow users to improve their knowledge about the coins taking advantage of the capabilities of the RTI image manipulation, including the interactive change of light direction on a coin's surface.

3. DESIGNING COIN-O-RAMA

The conceptual, interaction and experience design of the system needed to meet a number of customer requirements and preferences. More specifically the final system should:

- R1. work as a post-visit summative experience, offering additional information and interaction with the coins of the exhibition (i.e., act as an *isolated, but linked, exhibit* - see Section 2 and [8]);
- R2. reflect the thematic structure and contents of the exhibition;
- R3. present both sides of each coin and aid in viewing even the finest details;
- R4. provide minimal, but crucial information, including a map showing places of origin
- R5. support browsing of all the 85 distinct coins of the exhibition in a very brief and fast-paced session;
- R6. accommodate one active user and multiple viewers;
- R7. include a playful activity, potentially linked to some kind of digital souvenir [21], reminding visitors of their experience and stimulating word-of mouth promotion;
- R8. be "discrete", interweave and not interfere – visually, acoustically or conceptually with the rest of the exhibition;
- R9. be as slim as possible, avoiding protrusions towards the space in front of it;
- R10. fit against a 2.60m wide by 2.60 tall wall;
- R11. as a temporary exhibition, require minimum physical interventions to the installation space and be able to easily (and without any damages) relocate in another site.
- R12. be available in Greek and English, and easily accommodate more languages.

Based on the above an interactive exhibit was conceptualized (Figures 1, 2 & 3) comprising two linked interactive areas:

1. A 42'' touch screen (right hand-side of the picture) used for browsing the coin collection and retrieving information about each coin (R6 - active user).
2. Two round metallic surfaces of 60cm diameter (named the "Virtual coin") used for projecting enlarged versions of both

sides of a coin, also supporting multi-touch interaction (R6 – multiple viewers).

Figure 1. COIN-O-RAMA preliminary conceptual sketch.

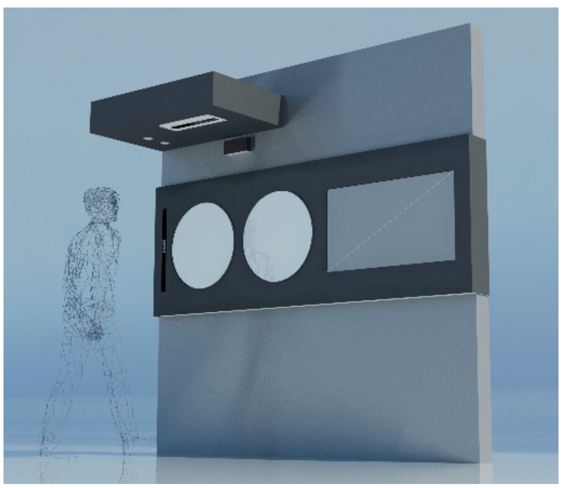

Figure 2. Pre-production 3D rendering of COIN-O-RAMA physical installation.

Figure 3.
Installation at the Museum of Cycladic Art.
(Photo by Paris Tavitian ©, Museum of Cycladic Art 2017)

The concept for the playful activity was to provide visitors the option to engrave their own head on a "blanked" coin of the collection and send the resulting image via e-mail. The interaction for this activity was envisaged to take place in the area of the Virtual Coin also employing a web camera embedded to the leftmost area of the installation, as well as some spot lights to ensure appropriate lighting in the moderately lit spaces of the exhibition.

The final installation is very slim and clear-cut, with no protrusions and of the same dark colors as the physical exhibits (R8, R9), it is 2.60m wide and 2.60 tall, requires just some minimal fastening against the back wall (for safety reasons) and is very easy to dismantle and relocate (R11).

3.1. Interaction Design

The main user interface of the system is presented on the 42'' touch screen. When the system is idle, the touch screen shows the "Home Screen" (Figure 4) which includes a top view of the exhibition space also illustrating the theme covered in each space and a short descriptive text about the exhibition (related requirements R1 & R2). Users are offered 3 options:

a) Select a theme, to see the corresponding coins (R5).
b) Create their personalized (digital) coin (R7).
c) Change the language (R12).

When the home page is visible, a rotating coin is projected on the left side of the Virtual Coin (every time the coin flips side, a different coin appears) and the exhibition's poster on the right side.

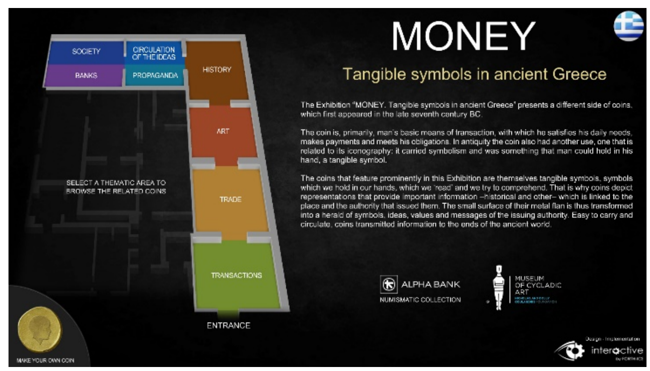

Figure 4. COIN-O-RAMA Home Screen.

3.1.1 Theme selection

When a theme is selected, a screen appears displaying all the coins available in the corresponding exhibition space along with a short description, including some further explanation about the theme (Figure 5). The visible side of all coins in this screen is the same as that of the exhibited real coins (R2). When this screen is visible, the contents of the Virtual Coin are the same as in the case of the Home Screen.

3.1.2 Coin selection

When a specific coin is selected, the selected coin pops-up, starts to move towards the left-hand-side of the screen while also enlarging. Eventually, (due to the fact that the projection area of the Virtual Coin overlaps with this screen) the coin seems to "break out" of the screen and move over the Virtual Coin (on the side it corresponds). When it has landed, a copy of it flips over to the other projection surface.

Figure 5. Viewing all coins related to a specific theme.

Figure 6. Information about a specific coin.

Figure 7. Map showing the area of origin of a coin.

When this animation is over, the touch screen interface changes focusing on both sides of the selected coin (R3). Over them, the place of origin, the value and the time period are shown, and below each side a separate brief description (R4). At the bottom of the screen, some additional information about the place of origin is provided along with a mini-map (Figure 6) illustrating the corresponding geographical position place (R4).

If the mini-map is selected, it scales up to fit the whole screen so that more details are visible to the viewer (Figure 7).

3.1.3 Creating a personalized (digital) coin

A playful activity was integrated to the system (R7), having a two-fold role:

a) Engaging children and getting them more interested in the topic of coins and the issues related to them (also in the context of the museum's educational programs).

b) Let visitors create a personalized digital souvenir which will remind them of their visit, but also will offer links to additional related information and resources.

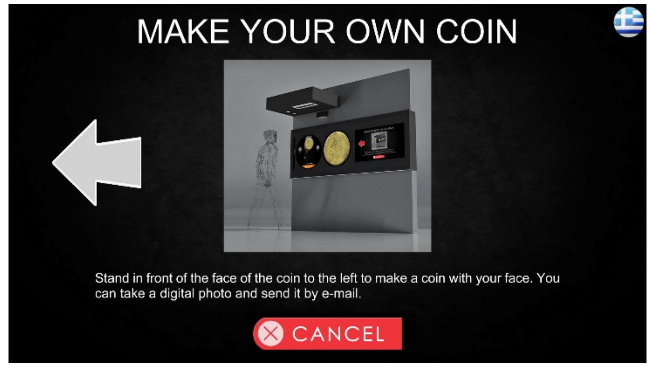

Figure 8. Help screen for coin creation.

Figure 9. User interface for creating a personalized coin (projected over the 2 surfaces of the Virtual Coin).

This activity is about creating an image of a coin with the user's head engraved on it (for technical details about how this is achieved, see Section 4) and can be activated by the corresponding button of the Home Screen. In this case, (inter)action takes place in the Virtual Coin side of the exhibit. The touch screen offers some help (Figure 8) and the option to terminate the activity. When this mode is active, two spot lights embedded in the top side of the exhibit are turned on, in order to ensure the best possible aesthetic results.

The user interface is very minimalistic and simple. On the left surface of the Virtual Coin (Figure 9 - left) live feed from the camera is shown (in portrait format). A blank coin is overlaid on it, upon which the underlying camera image is "engraved" in real time using image processing effects, while an enlarged version of it appears on the right surface of the Virtual Coin (Figure 9 - right). The coin can be dragged up and down, thus effectively clipping different parts of the camera image, in order to accommodate users of different height (from young children to adults). Users can capture a snapshot of the coin by pressing a corresponding button, or select an alternative type of coin through two buttons (previous/next). When a snapshot is taken, the touch screen provides a virtual keyboard for typing in the user's email along with a send and a cancel button (see Figure 10), while the left surface of the Virtual Coin provides related instructions (Figure 11).

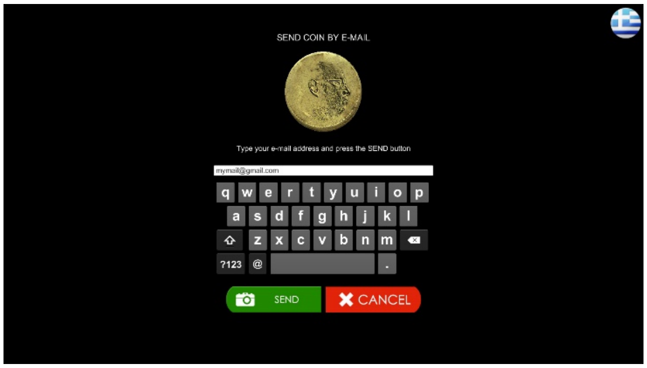

Figure 10. User interface for sending the personalized coin via e-mail (on the touch screen).

Figure 11. User interface for sending the personalized coin via e-mail (on the Virtual Coin).

3.1.4 Providing user help

When the system is idle help is provided to the users through an animated hand that moves over interactive parts of the screen and simulating the act of touching accompanied with a highlight effect (see Figure 12).

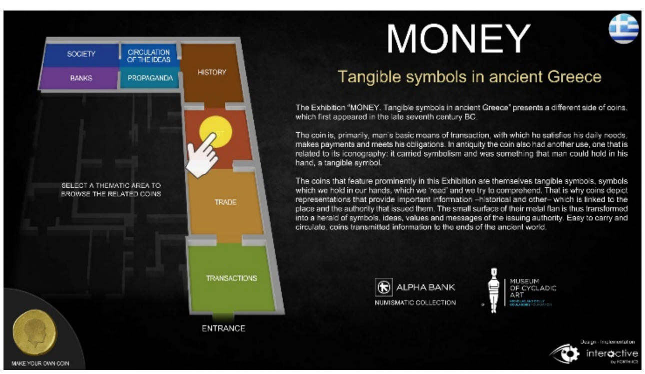

Figure 12. Example of providing animated help.

4. COIN PERSONALIZATION

Coin personalization employs an “engraving” image processing effect that is applied upon a facial image of the user. This effect intonates dominant facial features and lighting emulation, to realistically simulate the appearance of an anaglyph structure on a coin with the user’s face.

Two images are provided as input. The first is image *C* of a coin, upon which the user’s face will be displayed. The second is the image of the user’s face against a dark homogeneous background. This image is already cropped to envelope the user’s head. Upon provision this image is converted into grayscale *G*, its values in [0, 1]. The output is image *B*, a modification of *C*, where the coin is “engraved” with the user’s face.

Image processing modifies the region within *C* where the face will be rendered. It is separated into three steps. The first constructs weighting mask *M*, which pivots blending of facial characteristics upon the coin image. The second processes *G* to create image *F*, which contains the “carved” facial abstraction of the user’s face. The last blends images *F* and *C*, using weighting mask *M*. These steps are formulated below and their results are illustrated in Figure 13.

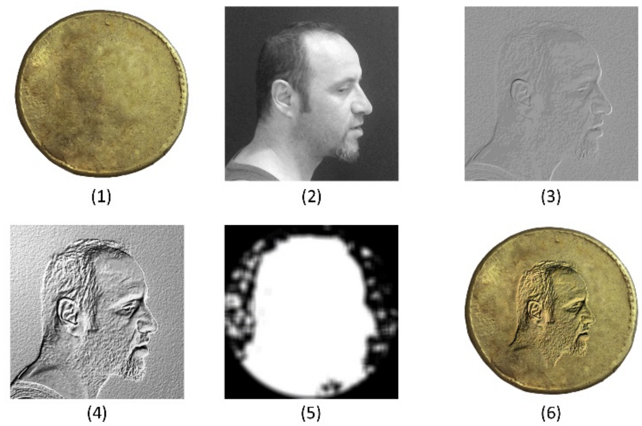

Figure 13. (1) Coin image *C*. (2) Greyscale image *G*. (3) Emboss image *E*. (4) Intermediate result, image *F*, containing the engraving effect *F*. (5) Weighting mask *M*. (6) Result image *B* that blends *C* and *F*, according to *M*.

4.1. Weighting mask M

M is a mask on *F* and its purpose is dual. First, non-zero pixels distinguish face from background in *F*. Second, (non-zero) pixel values provide weights that modulate the blending with *C*, of the corresponding pixels in *F*.

Image *L* is the result of the convolution of *G* with a Laplacian kernel. Image M_p, an intermediate result, is formed as:

$$M_p(i,j) = \begin{cases} 1, \text{ if } L(i,j) > t \text{ OR } G(i,j) > \tau)) \\ 0, \text{ otherwise} \end{cases}$$

where, *i*, *j* are pixel coordinates, while τ and *t* are thresholds on *L* and *G* respectively. Threshold τ conservatively subtracts the dark background from the image. Threshold *t* adds structurally rich head regions in the mask that may contain very dark pixels (i.e. hair, eyes), and consequently may have escaped the filtering with threshold τ.

Finally, Gaussian blur is applied upon M_p resulting in image *M*, in [0, 1], that smoothly blends *F* with *C*.

4.2. Face image F

Image *F* contains the result of the engraving effect. Initially, image *E* is created by convolving *G* with a smooth emboss kernel. The convolution result is contrast-enhanced by sequential application of methods [13] and [23] to form image *S*. The resultant image *F* is formed by applying a lighting emulation filter on image *S*. To emulate the appearance of an engraved face, lighting emulation is performed per pixel using the Blinn-Phong reflection model [2] and bump mapping [3], Bump mapping uses gradient direction vectors, obtained from *G* using the Sobel operator.

4.3. Blending the face and coin images

Blending of *C* with *F* is determined by weighting mask *M* and provides image *B* as the result.

Initially *M* and *F* are scaled to fit into a predefined rectangular Region of Interest (ROI) within the coin image. This region is the rectangle where image *F* will be located with appropriate weights for each pixel, after blending with *C*. Let image point (O_x, O_y) be the top-left origin of the ROI, *w* its width in columns and *h* its height in rows.

Images *C* and *F* are converted to HSV. Image *B* is initialized as a copy of *C* with the exception of the *Value* channel within the ROI; blending takes place only in the ROI of this channel. The *Hue* and *Saturation* channels are identical with the ones in image *C*. Within the ROI, the *Value* pixels are determined as:

$$V_B\,(i+O_y, j+O_x) = w_1 * V_F(i, j) \;+\; w_2 * V_C\,(i+O_y, j+O_x)$$

where *i* is in [1,*w*], *j* is in [1,*h*], and V_B, V_F, V_C denote the *Value* channels in HSV of *B*, *F*, and *C*, respectively. Weights w_1 and w_2 are set as $w_1 = M(i\,, j)$ and $w_2 = 1 - w_1$.

Intuitively, blending creates an image that retains the chromaticity of the coin image, but modulates its brightness by changing only its *Value* channel. In essence, brightness is copied from the facial regions of *F* where *M* has high values. Conversely, at background regions the coin image is copied. The smoothing of *M* safeguards a smooth transition between facial and background values. Retaining coin chromaticity simulates the appearance of the same material by which the coin is made, while modulation of its brightness simulates the appearance of an anaglyph structure on the coin surface.

Finally, *B* with its *Value* channel now updated within the ROI is converted back to RGB, comprising the output.

5. EVALUATION

The creation process of COIN-O-RAMA followed an iterative approach where in all steps, starting from the preliminary concepts and sketches all the way to the final interactive exhibit, formative evaluation sessions where held, both with experts and representative end-users. When a first, fully functional, prototype was available, a formal expert-based evaluation was conducted with five interaction design / usability experts with great experience in similar interactive systems, who had no involvement at all in any phase of the creation of COIN-O-RAMA and had not seen any part of it before.

The method used was heuristic evaluation [18], a well-known and widely-used method which evaluates the system against a set of ten design principles (Table 1). The method facilitates the identification of usability and interaction issues that real users might have with the system, before its actual use. To this end, the experts were first given a short introduction on the purpose of the system and its context of use and were then asked to interact with it like they would if they came across it in a museum type of environment. The experts were asked to verbalize their thoughts as they interacted with the system and any violations that they observed. The evaluation moderator took extensive notes on everything that was said during each evaluation session. At the end of the evaluation process, all the comments were aggregated in one document and each identified problem was rated by the evaluators for its severity, using a scale ranging from 0 to 4 with 4 being 'most severe'.

Table 1: The 10 heuristics principles (Nielsen, 1994)

Heuristic principles
H1. Visibility of system status
H2. Match between system and the real world
H3. User control and freedom
H4. Consistency and standards
H5. Error prevention
H6. Recognition rather than recall
H7. Flexibility and efficiency of use
H8. Aesthetic and minimalist design
H9. Help users recognize, diagnose, and recover from errors
H10. Help and documentation

5.1. Expert Evaluation Results

All the experts were able to easily and directly identify the main functions of the system. They located all the interactive elements and navigated through the various coin galleries inside each room, selected coins to read more information, located the *Make your own coin* button and went through the process of engraving their face on the coin of their choice and sending it to their email address without encountering any major problems. All experts expressed that the overall user experience is positive and that the system is engaging and entertaining at the same time. Some issues (numbered as I1, I2, etc.) raised by the evaluators and corresponding actions / comments (preceded by a ▸ symbol) are provided below:

I1. An issue that was brought by all evaluators, was that one of the rooms named "*Coin and society*" didn't behave like the rest of the rooms, as it didn't include any interactive elements, i.e. it didn't have any coins to select, and thus it was suggested that this category be removed altogether (Heuristic H4 - average severity rating 3).

▸ Since this room is also part of the exhibition and it was asked for the specific content to be included in the system there was no option of removing or changing.

I2. The text displayed under a selected coin was found to be too dense, long, and very wide, making it difficult to read from a close range (Heuristic H7/H8- average severity rating 2.3). Users have to step back to be able to read it and then step forward to continue interacting with the system.

▸ The text size was reduced to legible from a shorter distance.

I3. One expert expressed the concern that novice users may not understand that the screen is interactive and suggested adding some sort of explanatory animation during idle time.

- An animated hand showcasing indicative interaction options is playing when the system is idle or when the user encounters a screen for the first time and delays interacting with it (see Figure 12).

I4. A potential ergonomic concern that was brought up by four of the experts was that some elements on the touch screen (e.g., back arrow, top coin row, etc.) might be hard to reach for very young children or people in wheelchairs (Heuristic H7 – average severity rating 3.4).

- The height of the screen was lowered. Depending on *in situ* observations of actual system use, if deemed needed, some interaction elements (e.g., back arrow) will be relocated.

I5. All five experts also remarked that the *Make your own coin* button was not obvious regarding the functionality it entailed, because the coin had a silver/gray color that made it look like being disabled and also had a question mark which made it look like a help button (Heuristic H1/H2- average severity rating 2.4).

- In the final version of the system the button was replaced (see Figure 4) with one bearing a golden coin and no question mark.

I6. In the *Make your own coin* help screen, the Close button cancels the entire process instead of just closing the window as suggested by the label. One evaluator read the instructions and pressed the Close button before proceeding to make a coin, cancelling the process without realizing it (Heuristic H2/H4- average severity rating 2.4).

- The button was renamed to *Cancel* (see Figure 8).

I7. In the *Make your own coin* UI, two of the experts did not realize that the position of the coin frame is adjustable to the height of the user by dragging it up and down (Heuristic H7- average severity rating 2.2).

- Brief instructions were added to this screen (see Figure 9).

I8. Three experts suggested that the camera should mirror the user's movements and face on the screen for easier placement adjustment (Heuristic H7- average severity rating 2.5).

- The suggestion was adopted.

I9. There was also discussion about the side-to-side physical setup of the two interaction areas, noting that the information text is physically disassociated from the larger coin view, making the user move from side to side between the two views to get the whole experience.

- The rationale of the side-to-side design was to accommodate larger audiences (i.e. a group of people watching the larger scale projection, while a presenter / guide is navigating through the coin menu). However, the concern of the evaluators that this setup may not be practical for single person use will be examined in the in-situ evaluation.

6. CONCLUSION & FUTURE WORK

This paper has presented COIN-O-RAMA an interactive exhibit for presenting and engaging with coin collections. The key motivation was to create an appealing and user friendly system, augmenting and complementing the overall experience of visiting the physical exhibition also offering the means for creating a personalized digital souvenir, working as a post-visit link to the exhibition and to related information, as well as an artifact to share with friends and the social media.

The final installation accomplishes to meet all 12 customer requirements and, according to findings from expert evaluation sessions (and the related improvements described in the previous section), achieves to reach a satisfactory level of usability and user experience. Also, according to statistics and feedback received from the use of the installed system, the implemented playful activity (i.e., *Make your own coin*) is very successful and popular, (with more than 900 personalized coins / e-mails per month), thus, effectively also achieving its intended design goals.

Future work includes running an extensive *in-situ* user experience study for evaluating the system under real conditions with a large number of diverse real users and identifying opportunities for potential improvements and extensions, but also in order to get a deeper understanding of the expectations, needs and ideas of different user groups with regards to interactive museum exhibits. Additionally, we are currently experimenting with the option of turning the digital personalized coin into a physical artifact using alternative 3D printing technologies and parameters, in order to assess the feasibility, viability, production quality and time, cost and desirability of such an option in a museum setting.

7. ACKNOWLEDGMENTS

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