Interfaces to Digital Collections of African Art

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ABSTRACT
This paper describes some of the issues in creating a digital collection of African art. We start by investigating the problems of uncertainty in the data relating to this art and propose a database model to cope with this uncertainty. We then investigate interfaces to query such a collection and discuss how best to display the results of the query in a virtual gallery.

Keywords
On-line galleries, Human-Computer Interaction

INTRODUCTION
Africa is a continent rich in culture. Within the Department of Computer Science at the University of Cape Town (UCT) is the CAMA (Contemporary African Music and Art Archive) project[6], whose aim is to digitally capture as much contemporary African culture as possible. To this end CAMA has installed computers and digital video equipment at seven key sites throughout Africa (Mozambique, Ethiopia, Sudan, Kenya, Ghana, Senegal, Mali and South Africa). Having captured this material, there still remain the problems of storing and providing access to it. This paper examines the problems of designing interfaces to access this material, but looks at the storage issues and nature of the data as these also place considerable constraints on the interface design.

ON-LINE GALLERIES
On-line galleries have been around since the earliest days of the World-Wide Web. In fact, one of the first Web sites to impress Tim Berners-Lee (the inventor of the Web) was a virtual gallery containing some of the Vatican's art work[3]. This was driven via a simple museum metaphor, with visitors first choosing a wing, then a corridor and eventually a room.

This type of structuring in a gallery is appropriate for European art work where it is usual to know the date, location and maker of each object. Furthermore, the study of Western art is so established that it is also possible to categorize artifacts by school or style (e.g. pre-Raphelite, post-modern etc.) Within an African context, however, it is more usual to know very little about the period or origin of a piece of art. Also, the study of African art is not yet at a point where widely recognized classifications exist to allow us to create a museum around themes in the same way that is possible with Western art. This uncertainty in classification and data has, as we shall demonstrate, huge implications on the design of on-line collections of African artifacts.

STORING DATA
Of the seven sites in the CAMA project, South Africa serves as the central distribution node. In other words, all the sites send new digitized material to UCT for central

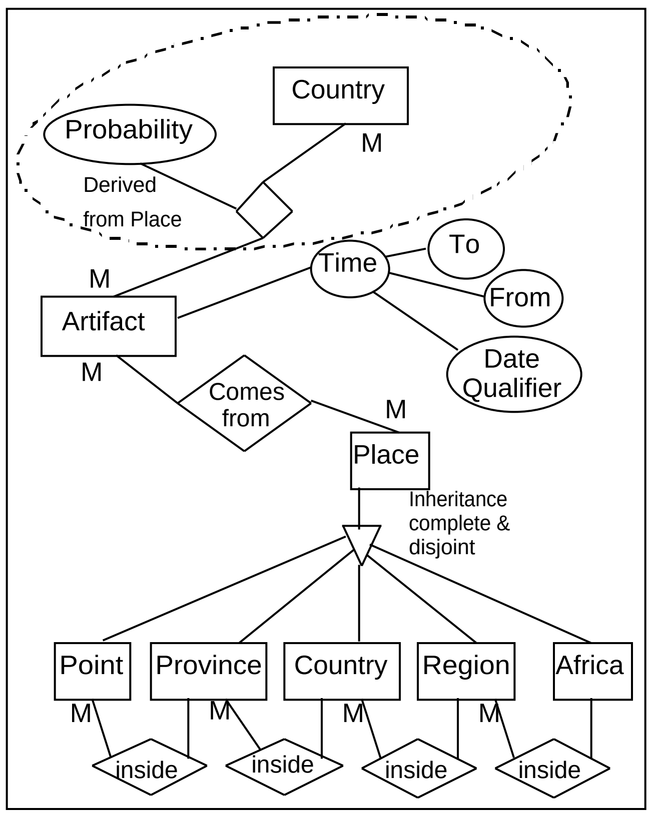

Figure 1. Extended E-R Diagram of Data Model for Storing Uncertainty

archiving. It was necessary, therefore, to create a central database which would allow artifacts to be stored and catalogued in a way that preserved as much meta-information as possible. To that end we developed a data model which took into account some of the unique attributes of cataloguing African artifacts.

Data Modeling

If we are to successfully catalogue digital representations of artifacts in some form of database, then it is important to know where and when the artifact originated from. With African artifacts this information is not always certain. Furthermore, the uncertainty itself is of a nature not found in artifacts from, say, Europe. Usually uncertain information is fuzzy in nature, meaning that there is some form of normal distribution of certainty: an artifact may date from 1650 to 1700, but most likely it dates from 1675. For African artifacts we have encountered as part of the CAMA project, the date can be given as "19th Century" and it is as equally likely to have originated in 1800 as 1899! This kind of uncertainty is known as probabilistic uncertainty (for more on the distinction between fuzzy and probabalistic uncertainty, see Fisher[7] and Burrough[4]).

Besides the issue of date uncertainty, there is also the issue of geographic uncertainty. For example, there are artifacts in European museums which are simply labeled as "from Africa" – the artifact could be from anywhere in the entire continent. When designing the database, however, our overall guiding principle was to store as much detail as was available. Later, this could be aggregated to less detail, as required. A simplified version of the Entity Relationship diagram for the data model is given in Figure 1.

Each artifact has a time associated with it. The date qualifier is a textual description of the time, whereas the from and to fields denote time as integers. In this way, we store the time as a range, where the range indicates the minimal time period in which the origin is known to fall. We call this the range of uncertainty. For example, the date of an artifact could be: "18th Dynasty, Amarna period". This means that we do not know the precise year of origin, but we know that it originated at some time in that period. In order to do comparative queries on the time attribute, it has to be expressed numerically, so the from and to fields associated with this period would be –1352 and –1345, respectively, while the date qualifier would contain the original string. When the date is precise (i.e., known to within a year), the from and to fields store the same date. For example: an artwork which was made in 1985 would have 1985 stored in both fields.

Each artifact could come from a number of places, where place is either a point, a province, a country, a region or Africa as a whole. Place, in this context, refers to the origin of the artifact rather than where it is currently kept. For example, an artifact originally from Ethiopia could currently be held in the British Museum, London. Where it comes from is a more important attribute for relative querying than where it is currently being kept.

The relationships between these sub-places are also stored. For instance, a point, Tada Village, falls into a province, Kwara State, which falls into the country Nigeria, which falls into the region, West Africa, which falls into Africa. In this way, if the place of an artifact is Tada Village, a query on West Africa would also return this artifact.

Some artifacts originate from a number of places (usually because the original location is uncertain). For example, an artifact could come from Ghana/Ivory Coast. For these cases, we calculate and store a probability for the artifact and each country concerned. The probability of an item falling into a country is a function of the number of countries which that item could possibly fall within.

Populating the database

For most media types, it is obvious how they may be captured digitally using relatively inexpensive digital cameras, camcorders and audio recorders. Each of the seven sites was therefore equipped with a Macintosh G4 and a digital video camera. One problem, however, is the digitization of three dimensional sculpture. Several systems exist, but none seem suited to the African environment. The most of expensive of these are laser scanners which give very accurate and detailed scans of three dimensional artifacts, but they are delicate and prohibitively expensive. An alternative solution would be to use professional turn-tables and digital cameras, such as [1]. These, however, are built to deal with light objects and are not substantial enough to cope with heavy stone sculptures. In the end we had to develop our own turn-table, based on the very smooth, accurate and strong rear axle of a car. The resulting system can be seen in Figure 2.

Figure 2 – A turntable made from old car parts

RETRIEVING DATA

The majority of our work has been in providing an interface to the digital artifacts held in the CAMA collection. The work has two main areas of focus: querying and display.

Querying

Our query system had to be designed to cope with uncertain data – uncertain both in time and space. We believe that the interface we created to access this collection is novel in the way that it supports users querying this uncertain data.

Our initial idea was to use a map to drive the interface to the system. Items were plotted as a point in the map at some random location which fell within the given locational uncertainty for the item. Several alternative algorithms were used to generate this location – circular and square grids with random offsets and pure random positioning. However, formative usability tests showed that users inferred that the plotted point was an exact location – the mental models users constructed of how accurate maps were in the real world caused a cognitive

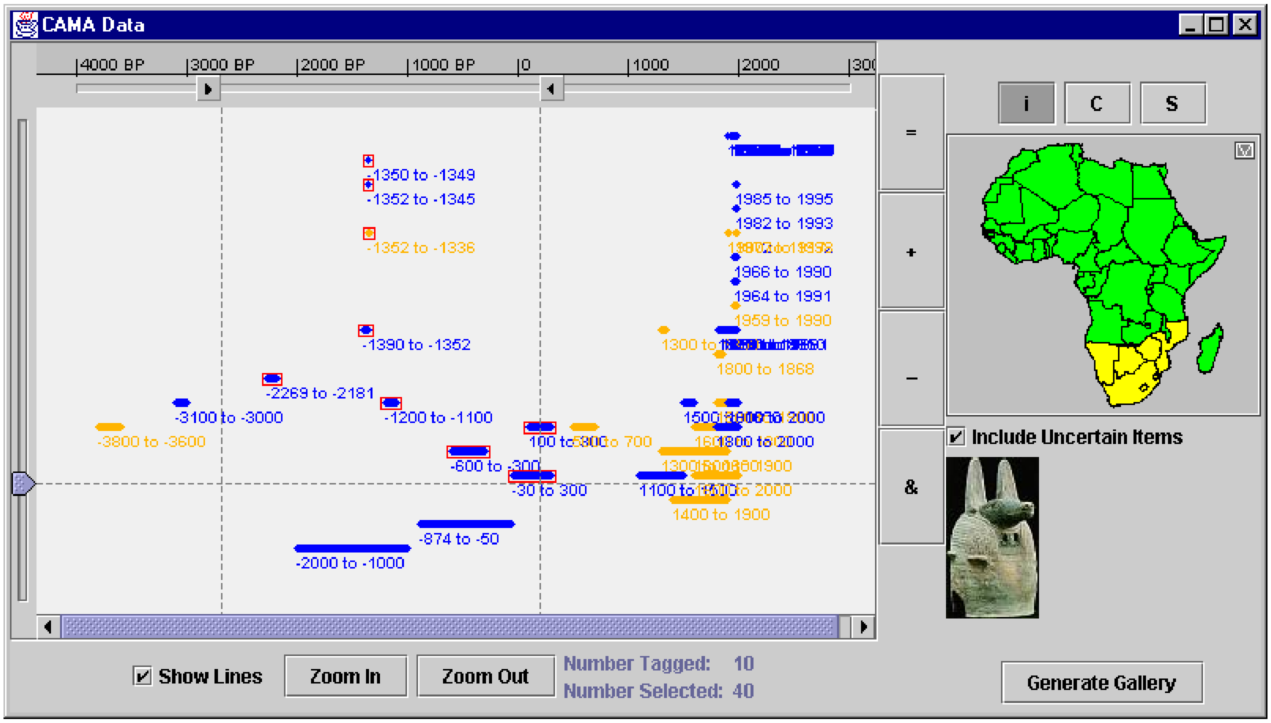

Figure 3 – Query interface based on a time line.

dissonance when looking at the maps generated by our system. Users became confused and gave complaints as to why there were no more items found at known population centres. Clearly an alternative solution was required.

To be successful, our final metaphor would need to explicitly show uncertainty. A map is a two-dimensional object and would require plotting in the third dimension to show uncertainty. One prototype we explored had items floating above the map – the further the item was from the map, the more uncertain its location. This prototype raised more problems than it solved, however – not least among these being that objects still had to float above some spuriously exact location.

A better approach was found in driving the interface around a time-line metaphor. Time is a one-dimensional attribute, and it is relatively easy then to use the second dimension to display uncertainty information. In our prototype shown in Figure 3, we can represent the uncertainty explicitly as a distance from the time line. It is relatively easy to compare relative amounts of uncertainty by comparing the length of the time line for each individual artefact. It is also easy to spot prolific periods, (or periods for which much data was collected) as these will exist as vertical clusters: e.g. the 1350BP period in Figure 3.

The time line, as presented in Figure 3, permits querying in a variety of ways:

By period: using the sliders on the time line, a period of interest can be selected. Items which, due to uncertain date information, straddle either slider boundary are, by default, included in the selection (after all, the artefact could have occurred within the period of interest). It is also possible to use the uncertainty slider on the left edge of the display. This allows the user to select increasingly certain items by moving the slider closer to the time line. Uncertain items may be displayed, or ignored, on the map by using the check box beneath the map.

Individually: by clicking on the item in the time line, a image of that item is retrieved and its country (or countries) of origin are highlighted on the political map.

Besides being a display mechanism, the map can also be used to specify queries. (This idea is known as “equal opportunity” and was first proposed by Thimbleby[15]. It allows users to refine queries, just as with the Query-by-Example techniques described by Zloof[17].) The map query works in one of three ways:

Information: Using the ‘i’ button, users can click on an individual country to find information about that country.

Country query: Using the ‘C’ button, users can click on an individual country to limit the results of their query to items only from that country.

Region query: Using the ‘S’ button the user can drag a rectangle over the map to select a number of countries.

Besides the map and the time line, the system includes a full set of Boolean operators based on Mirel’s work [11] (the ‘+’ ‘=’ ‘-’ ‘&’ buttons to the left of the map in Figure 3). Using these operators it is possible to specify intersections, additions and subtractions of a query’s results from the set of currently tagged items. This solution was chosen over that of Jones[8,9], whose system of Venn-

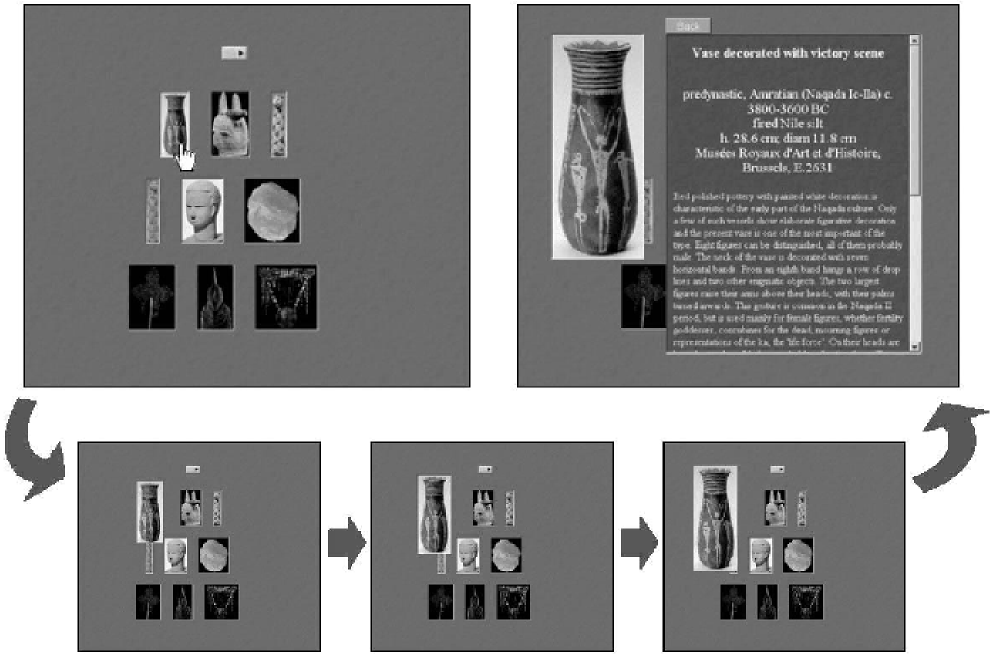

Figure 4 – The user starts by selecting an item (top left), the item then grows in size until the final screen (top right) where the image is at full size and a text description appears beside it.

diagrams had some limitation, such as an inability to select the universal set.

In this way we provide the user with a scalable, dynamic and powerful query environment.

Displaying

Having queried the information, the problem then remains of how to display the information in an appropriate way. (The user can generate a gallery, populated with their choice by clicking the "Generate Gallery" from the query interface). We have examined a number of different display techniques with varying success.

We were keen to explore the effect that different gallery layouts would have on visitors' enjoyment, interest, ability to explore and ability to learn about the artifacts.

Our first gallery was a simple, HTML based, collection of Web pages and images. As shown in Figure 4, the user is presented with a variety of images. Once an image is selected, the image enlarges and the accompanying text appears beside it. This smooth transition was chosen to help aid navigation and avoid confusion from abrupt changes in context[14].

Besides creating a Web based interface, we wanted to exploit the power of virtual reality to provide a better context for the contents of the collection – after all, real world galleries are three dimensional. The work of Muller[12] suggests that, for the average user, hardware is now good enough in terms of cost and speed for applications such as virtual galleries. By using virtual reality, we are also able to exploit work in gallery design, such as Badre[2], who stress the importance of making the gallery ecologically rich. As the gallery is virtual-reality, we were able to carry over ideas of [10] from the design of physical galleries in the real world.

To that end, we built two separate virtual environments to display the work.

The first of these environments was based around an African village metaphor, where huts were generated to contain the art works (see Figures 5 and 6). Here, users could wander from hut to hut or move rapidly to different locations by clicking on the overview map. Here, rather than teleport the users, a rapid animation of their movement was shown to preserve a sense of location. Navigation is a vital element for improving the usability of three-dimensional virtual environments. Studies such as [14] have shown that a mouse is particularly poor at controlling movement in a virtual environment. To improve navigation within the virtual environment, users were provided with an overview map which displayed their current location and orientation. Furthermore, objects on the map were 'clickable' – the user could click on the object to navigate directly to it.

The second virtual gallery was based on using Great Zimbabwe as a backdrop for the selected artwork (see Figure 8). The aim of this gallery was to provide a more unstructured but richer environment than the previous metaphor. Unlike the huts, which had artwork hung regularly in a regular space, the Great Zimbabwe gallery had artwork hung at irregular intervals in an irregular space. Again, the user was provided with a map, which was clickable, just as in the village hut environment (see Figure 7). Due to the irregular nature of the Great Zimbabwe environment, a second map was provided which shows the arrangement of the art works closest to the visitor.

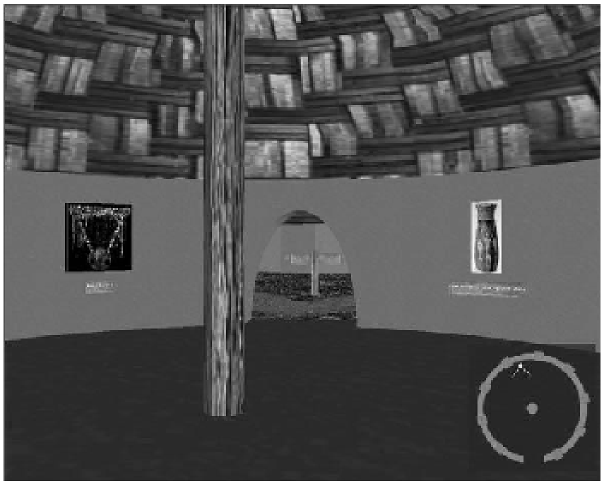

Figure 5 – Inside a gallery hut. The hut is perfectly circular with artifacts shown at regular intervals around the walls. The map in the bottom right shows a map of the room and the current view orientation of the user. By clicking on the map, the user can move around the gallery.

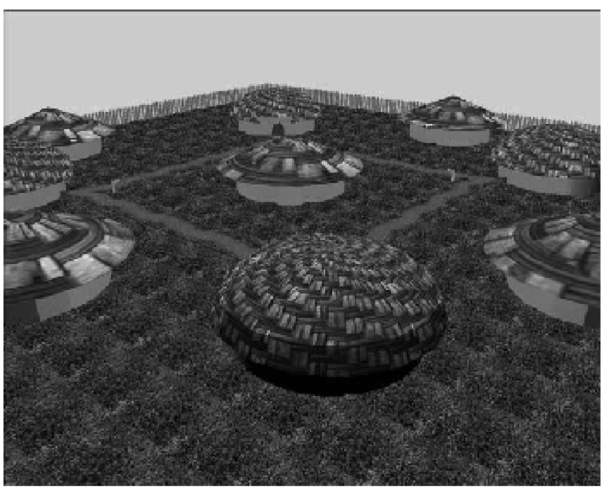

Figure 6 – A bird's eye view of the African village. Each hut contains a collection of images.

Figure 7 – Inside a Great Zimbabwe corridor. Here the environment is irregular and art hung at irregular intervals. The gallery is split in sub-galleries. This time the left-most of the two maps in the lower right is the navigation for this particular sub-gallery, again showing locations of art and view of user. The map to the right of that shows all the different sub-galleries in the environment. Again, clicking on a map will move the user around a gallery.

Figure 8 – Outside view of the Great Zimbabwe scene

Evaluation

Due to the changing requirements of the CAMA project, we have not been able to conduct extensive user tests with the query interface. To date, we have only conducted formative studies which influenced our design away from the geographically based interface to the current time-line interface. We have, however, tested the functionality of the query interface as shown in the example below.

Query: *Find all items which occur in the period 1000BP to 1000 in Southern Africa, including uncertain items* (i.e. items that could occur in the given time and place).

On the visual interface the user would do the following:

1. Tag items to the given range by using the time controls.
2. Add this to the selection by using the replace (=) button.
3. Tag the items within this selection that occur in Southern Africa, but using the region query tool on the map.
4. Intersect these two sets using the intersect (&) button.

The equivalent in SQL would look like this:

```
Select Catalogue
From Artworks, Artwork_Country_Link
Where (Artworks.CatalogueID = Artwork_Country_Link.ArtworkID)
And (year2 >= -1000 and year1 <= 1000)
And placeID in
        (Select Place
        from Place
        where type = country
        and inside = “Southern Africa”)
```

Novice users cannot be expected to express queries using such complex syntax. The use of dynamic queries, extended to handle uncertain data, with the possibility of fully combining queries, means that users can do all their querying visually.

Gallery evaluation

Unlike the query interface, we have conducted extensive user testing with the different galleries. Thirty six participants took part in our experiments. All participants were familiar with browsing the Web and were randomly allocated to one of three groups. Each group was only shown one of the interfaces, to counteract the effect noticed by Pierce[13], where subjects tried to give the answer they felt the researchers wanted to hear – in our case, we were worried that by showing subjects two-dimensional and three-dimensional galleries, they would feel that we wanted them to prefer the three-dimensional environment.

Quantitative data was collected using logging software built in to the gallery code. Qualitative assessment was conducted using a questionnaire designed to determine:

- Enjoyment
- Interest in Artwork
- Encouragement to Explore
- Usefulness in Learning
- Amount of Distraction generated by the environment.

Results

Enjoyment: The African village was rated as the most enjoyable environment. This is most likely due to the interactivity of the virtual environment, coupled with its ease of navigation (the regular structure allows it to be more easily navigated than the Great Zimbabwe scene).

Interest in Artwork: was found to be the same for all three environments.

Encouragement to Explore: The African village was seen as the most encouraging to explore. We were surprised by this as the Great Zimbabwe scene provided a richer environment. Again, we attribute this result to the regularity of the African village reducing the cognitive load on novice visitors.

Tool for learning: Users reported no significant difference between the environments. However, using the logs recorded by the computer, we discovered that visitors spent 30% longer reading artifact information in the two-dimensional environment than in either of the two three-dimensional environments. This could be due to the strong association with the Web as a means of discovering information – if users had encountered virtual environments before, it would most likely be in the context of a game.

Distraction by environment: Users rated all environments identically, but the results from the exploration questions would lead us to conclude that navigating the Great Zimbabwe scene was distracting.

Museum design conclusion

From these results we can draw two main conclusions for gallery developers

(1) Users enjoy interacting with three-dimensional environments, provided they are supported with comprehensive navigation support. However, a navigationally-poor three-dimensional environment can be worse than a two-dimensional environment.

(2) For educational purposes, two-dimensional galleries could be preferable.

DISTRIBUTION

Currently we have a prototype database set up in Cape Town to hold the digitised artifacts being sent to CAMA from the other six regional centres. However, one of the goals of CAMA is to “Reflect Africa back to Africa”[6] – to allow Africans in other countries to see what else is happening on the continent. It is therefore necessary to design some form of distributed database.

Were this project being conducted in Europe or the USA, a potential solution would be to set up an on-line central database, where each site could submit data that would become instantly available to all other parties. However, the telecommunications infrastructure in Africa is such that a synchronous solution is not possible. Although all the institutions partaking in this project have land-based telephone access, and some form of Internet access, CAMA’s experiences show that these services are unreliable. Some countries’ exchanges are so overloaded that even voice communication is impossible, so most Internet access is sporadic and at a low speed (typically 9600 baud). We may safely conclude that using the Internet to send multi-media content across the continent is not, for now, a viable option.

Instead, we have opted to publish collections from the central database onto CD-ROM. Although not a perfect solution, it allows us to distribute interesting collections in a way that is compatible with current infrastructure. It is hoped that with the advent of satellite communications, we may be able to create a truly interactive art resource for Africa.

FUTURE WORK

We have succeeded in building a system which allows users to store, query and display digitized versions of African artifacts. These systems work, despite uncertainty in the data relating to the date and location from which an artifact originated. Whilst we have tested the query system from a functionality perspective, and conducted user testing with early prototypes, we still need to conduct user tests with the new interface. This we intend to do within the next few months.

In a wider perspective, we believe that there is a lot more work to be done within the field of creating interfaces to uncertain data. Our application has introduced us to time and location uncertainty, but there exist many other types of uncertainty which could be addressed – for example uncertainty about the creator of the artifact. We believe this is a fertile area for study.

CONCLUSIONS

Storing and retrieving digitized African art introduces complications not found in systems designed for Western art. Time and location uncertainty, coupled with a lack of standard classification categories, mean that new interfaces need to be developed if we are to make African artifacts accessible to an on-line audience. We have built a system which stores uncertain data and have built a novel interface which allows this data to be queried effectively, despite the uncertainty. We have also investigated how the output of these queries can be used to populate two-dimensional and three dimensional galleries. We discovered that two-dimensional galleries may be better for educational purposes and three-dimensional galleries need extensive navigational support if they are to be enjoyed by users.

ACKNOWLEDGMENTS

We would like to thank the NRF for a staff development grant which supported one of the authors in this work. We would also like to thank CAMA for providing the artifacts and information for the development of the system.

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