The Experience Cylinder, an immersive interactive platform

The Sea Stallion's voyage: a case study

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Abstract—**This paper describes the development of an experimental interactive installation, a so-called "experience cylinder", intended as a travelogue and developed specifically to provide a narrative about the Viking ship Sea Stallion's voyage from Roskilde to Dublin and back. The installation provides a framework for individual experience of the Sea Stallion's voyage, where a user among the audience interacts with the installation. Interaction is mainly by position and gesture tracking and feedback is by selection and projection of objects, such as photos, videos, background images, synthesized sound and recited stories. All combine to provide an individual path of choice through a coherent story told by means of a cylindrical screen, enclosing a space providing 3D positional sound following the interacting user and exploiting data such as wind, wave and weather logs through 3D sound effects. While being intended to tell a story about a certain voyage the resulting installation has been developed as an open interactive platform suitable for story-telling/travelogue. First and foremost the platform provides an approach to easy and intuitive navigation within heterogeneous media material comprising a large number of media objects.**

Keywords - interactive installation, bodily navigation, cylindrical screen

I. INTRODUCTION AND MOTIVATION

The "experience cylinder" described in this paper is an interactive installation developed in connection with a pilot project carried out in a newly established Experience Lab at Roskilde University [1]. In collaboration with the Danish Viking Ship Museum the aim was to establish a "story-telling" platform that presents the documentation of the reconstructed Viking ship Sea Stallion's (Havhingsten) voyage from Denmark to Ireland and back in 2007-2008 and provides an individual experience of the voyage to the interacting user.

The physical surroundings comprise a continuous image on a large cylindrical screen (six meters in diameter) provided by several connected projectors, ambient positional sound provided by several speakers and precision position as well as gesture tracking using 3D cameras. The story of the voyage can be told in this environment individually to users walking around, approaching what captures their interest. The design of the cylinder allows users to obtain more details through images (photos, video, animations) and sound (video soundtracks, recitation of logbook and stories, wind and wave data reflected by artificial sound effects) that emerge as a response to movement and can be further invoked by gestures.

In its present incarnation, the focus is on presenting historical knowledge and an engaging narrative in a museum context. Our and the museum's ambition is to use recent technology for the interactive presentation of historical material in a way that does not resemble the PC-like 'kiosks' with touch screens often found in museums. The aim is to give the user of the cylinder a sense of presence and of personal exploration in the story of the Sea Stallion's voyage, as opposed to a passive experience as recipient of a predetermined narrative.

The installation comprises, however, an open platform facilitating navigation through any amount of heterogeneous media, such as video, audio, text, photography, nautical charts and weather data. We are experimenting with new embodied input models where audience movement and gestures are interpreted as expressions of interest and used to determine focus and navigation.

We are in the midst of an iterative process; first, two mockups were programmed on a standard computer using a normal screen and mouse for input. Then the full scale installation was built and the software tested. Some changes were made and the installation presented and tested at a workshop. The next stage includes more extensive and formalized user testing, more data to be displayed, and in time different data sets.

II. THE EXPERIENCE CYLINDER

The experience cylinder, a section of which is shown in Fig. 1, consists of a 6 meter diameter projection screen. Participants enter this 360 degree other-worldly immersive experience by sliding past a section of curtain, the curtain serving both as the projection screen and as the visible boundary to the technologically enhanced reality within the cylinder, where normal physical laws are supplemented with sensors allowing control of the surroundings just by moving about.

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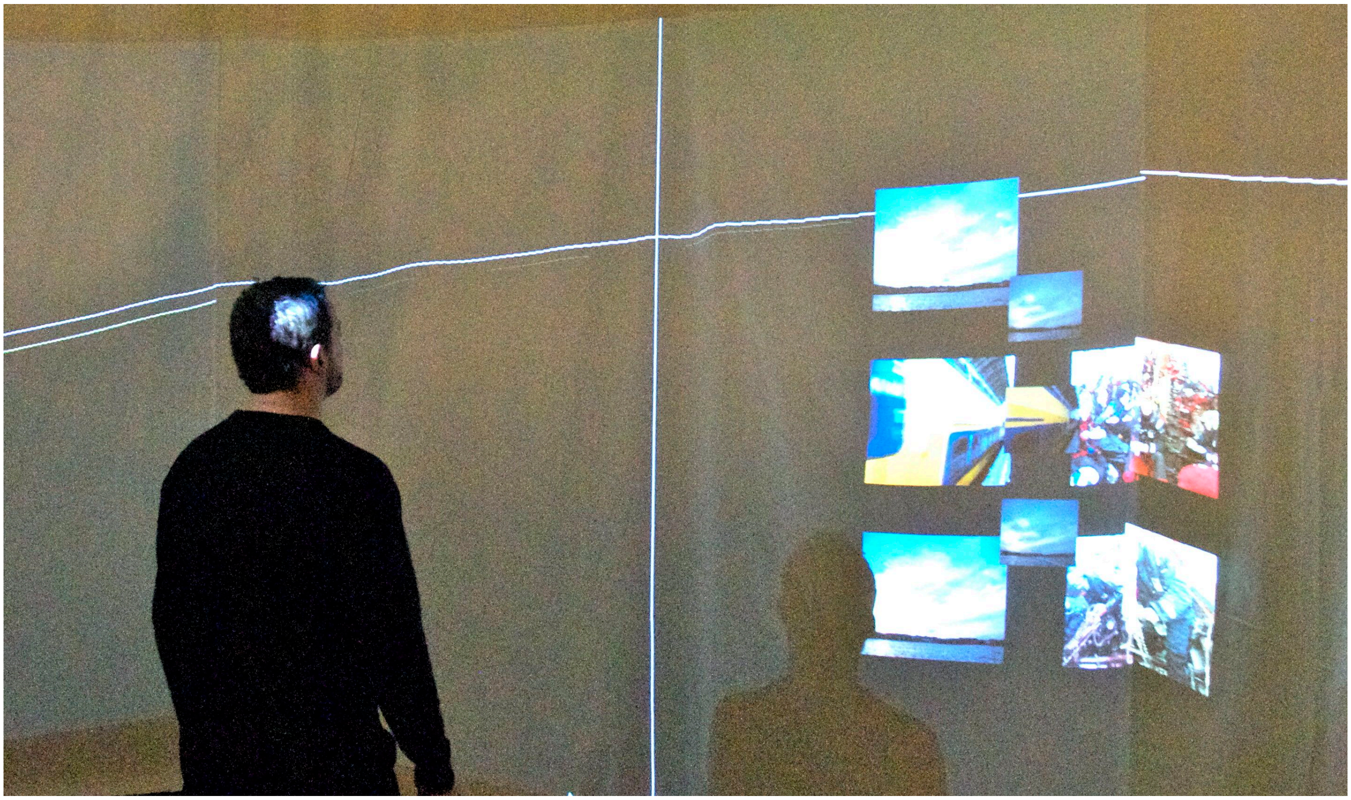

Figure 1. The experience cylinder.

Media are displayed all around the inside wall of the cylinder, reminiscent of pictures hanging on the wall at a gallery. The initial state is one of rest, all media about the same size, no video or sound playing, only a calm sea as background visual and ambient sound. When the participant signifies interest by moving towards a cluster of media, those media are fluidly expanded, more details and more media objects appear and video or sound clips can be activated. The participant can thus by merely moving around navigate a very large media collection and zoom in upon any particular single element, without use of any traditional computer UI elements and metaphors such as windows, cursors or mice.

A. System design

A required property of the design was from the beginning the ability to navigate through the trip following the route with a possibility to walk or jump to certain sections of interest to immerse into more detail. So a simple first solution was to draw a map of the route on the floor according to the geo-coordinates of the track, a particular point representing geographical as well as temporal location in the narrative as illustrated in Fig. 2, and to support navigation by walking this map.

While such a design would have fulfilled the main purpose of presenting the Sea Stallion's voyage, we moved away from this as we felt it would not function optimally as an engaging installation, being very predictable and lacking the ability to inspire participants "by surprise" – and thereby stimulating participants to experiment with the interaction in a playful manner.

Having discussed and compared several solutions for navigation input, including a variation of simplifying projections of the track image, we finally agreed on an alternative that also implicated a model interactive framework as a whole – a circular projection as a metaphor for the route track enclosing the interior disk as a navigation space, as illustrated in Fig. 3. The obvious addition to this was a cylindrical projection screen leading to the basic design of the experience cylinder.

Thus in this setting the circular extent represents the track as well as a timeline for the voyage. Media are organized on the screen corresponding to temporal placement in the duration of the voyage. The ship's departure from Roskilde is at "0 degrees", the middle of the voyage, landfall in Dublin, is at "180 degrees" and arrival at home port of Roskilde again is at "360 degrees". This arrangement seemed intuitively graspable by most participants – seeing the floor of the circular space as a large clock face laid flat, where further clockwise corresponds to 'later'.

The experience starts in the middle of the circular area. The entire journey is visualized divided into an appropriate number of pieces shown on a corresponding number of equal sized circular segments on the canvas as indicated in Fig. 3. By turning around in the middle, one can assess the entire trip. Immersion into more detail of a whatever part of the trip that captures ones interest can be done simply by moving in the direction of this part.

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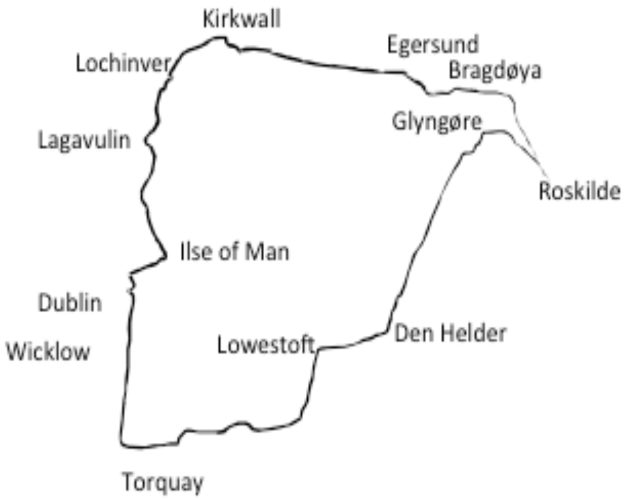

Figure 2. Geo-coordinates of the track.

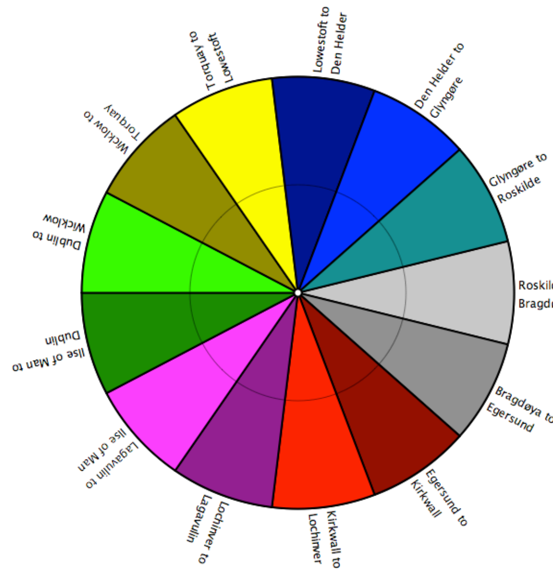

Figure 3. A circular projection enclosing a navigation space.

This causes the map to be "re-projected" so that the segment in focus grows and other segments shrink. This magnification is progressive - the distance from the center determines the degree of magnification. Fig. 4 shows an example of a projection based on the indicated position on the disk – the user has moved towards the "Den Helder – Glyngøre" segment to study this in more detail. When the distance to the center exceeds the appropriate limit (here the half-radius) then segment division will be frozen allowing the viewer to walk around inside the corresponding pie to study details of part of the trip in focus without being disturbed by further re-projections. By moving back towards the center and continuing in another direction, a new part of the trip can be investigated. Or by going in circles around the center, the whole journey can be traversed in more or less detail depending on the viewer's distance to the center.

Thus the interaction results in feedback in the form of a modified screen division and an adapted presentation of media objects. Each point on the circle represents a position on the trip (a time slot). Each pie represents a piece of the trip and the period for which this was completed. The selection of media objects adapts such that more objects and more details are presented on large pies and less details are shown on small.

Media objects are as mentioned presented by projection on the cylindrical screen and by means of the 3D positional sound. Objects that appear and float as projections on the segments of the screen include segment titles, photos, videos, stories (shown as titled icons) such as fragments from the log or tales on themes such as seasickness. Video and story objects involve sound and occupy time spans and therefore activation and deactivation options for each of these are needed in the interaction. These media objects can be activated by arm pointing gestures (or by approaching close enough) and deactivated by moving away or activating other objects.

Obviously the zooming functionality explained above in itself will enable set-ups with a significant amount of media objects (the Sea Stallion voyage has about 25000 photos). However, to improve support of huge amounts we are experimenting with ways to include 3D rendering of 2D media with objects positioned at different depths in a 3D space projected on the screen. Thereby a new means and purpose of interaction arise: a user can look behind an object covering another by moving to the side. This 3D-rendering is illustrated in Fig. 5. The challenge here is to intuitively combine the basic zooming feedback with 3D perspective behavior.

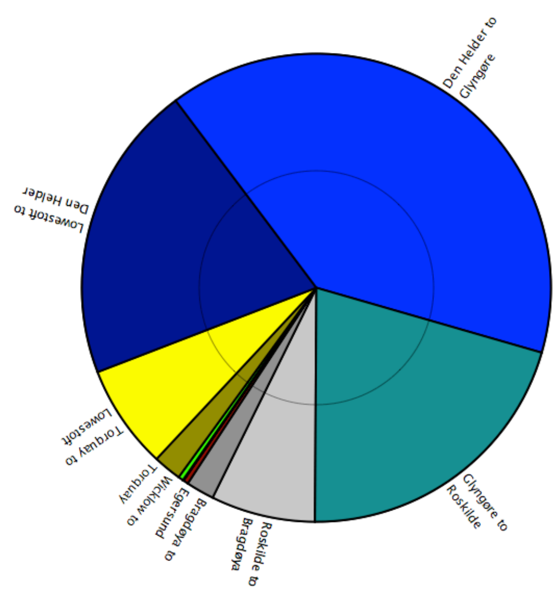

Figure 4. Interacting by walking – moving towards a section of interest.

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In addition to the primary objects mentioned above the installation also incorporates a seascape animation by means of a visual as well as auditory background to provide the visitors with a feeling of being on a ship at sea. The background visual rendering exploits the 360 degree sea level "horizon" animating waves as well as rolling of the ship. The visual horizon is accompanied by a synthesized background sound imitating wind and rolling waves.

This seascape animation can also be used to exploit data from the voyage. A significant amount of detailed data about waves and weather conditions logged on geo-positions is used to reflect the weather conditions and intensity of the waves at the time and position of the media currently being focused on.

III. IMPLEMENTATION

A. Tracking

Tracking the participants is accomplished with a Microsoft Kinect® 3D webcam and computer vision algorithms. The Kinect sensor functions by projecting a special pattern with an IR (infrared) laser, which enables the IR camera to calculate the distance to all objects in the field of view by measuring distortion of the known pattern. The Kinect delivers distance data in the form of a greyscale value for each pixel. Until recently, tracking individuals would have required IR floodlighting the whole area and applying background subtraction, frame differencing and finally blob detection to images captured by an IR security camera. The Kinect now makes it far easier to recognise a person, simply using blob detection.

The system is programmed to lock onto the participant in the center of the circle and follow this individual until she leaves the field of view. This means any number of people can be in the installation at one time, without confusing the system, the interaction or each other. The only challenge with the Kinect is engineering a large enough field of view, as it (being a consumer device) does not support interchangeable lenses. The easiest is to have a high ceiling, or, failing that, to stitch together multiple images in software.

B. Software architecture

The installation is programmed in OpenFrameworks [10], an open source C++ toolkit for creative coding. OpenFrameworks provides easy access to multiple libraries we require (OpenGl, Quicktime and freeType among others) and can run on Mac, Windows and Linux.

The sound is created and controlled in MaxMSP [8]. The positioning of sounds etc. is controlled by MAX, which receives commands from OpenFrameworks via UDP, enabling the work to be distributed to several computers.

The visualization is written to a virtual buffer in OpenFrameworks, offering the possibility of distributing work across several computers and in the future supporting projector overlap with alpha blend for a more seamless display, higher light intensity and easier adjustment.

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Figure 5. 3D display of media objects.

The seascape background rendering is based on Virtual Choreographer [5] for the interaction (message capture and interpretation) and on OpenGL for the geometrical rendering. The output frame can be captured in a Frame Buffer Object and distributed over different viewports to cope with the distribution of the graphical rendering over 3 GPUs.

C. Physical construction

For the physical construction of the installation we utilised rapid prototyping principles to quickly get to a testable stage. We were interested in using as many standard off-the-shelf elements as possible both to keep costs down and to increase flexibility, but did have to custom produce certain elements.

The construction is illustrated in Fig. 6 and 7. The 6 projectors (an Acer widescreen 4000 ANSI lumen model selected for its good price/resolution/light output ratio) are driven by one Mac Pro computer with 8 cores and 2 graphics cards, via 2 Matrox Triple Head 2 Go, which split the computer's 2 DVI outputs to 6 VGA outputs (VGA being selected as it is easier to run long cables).

A 7 channel surround sound system consisting of Prodipe monitor speakers mounted at head height, supplemented by 4 subwoofers, is driven by an 8 channel M-audio Firewire sound card connected to the Mac Pro.

The projection screen is standard cheap unbleached cotton cloth.

We had to custom weld a modular circular lighting rig of 50mm standard tubing to carry the circular projection screen and the projectors. After trying out different commercially available projector mounts, we found it easiest and cheapest to produce our own, CNC milling them out of 12mm plywood. The whole rig is suspended on 3 chain hoists enabling it to be raised and lowered for easier adjustment.

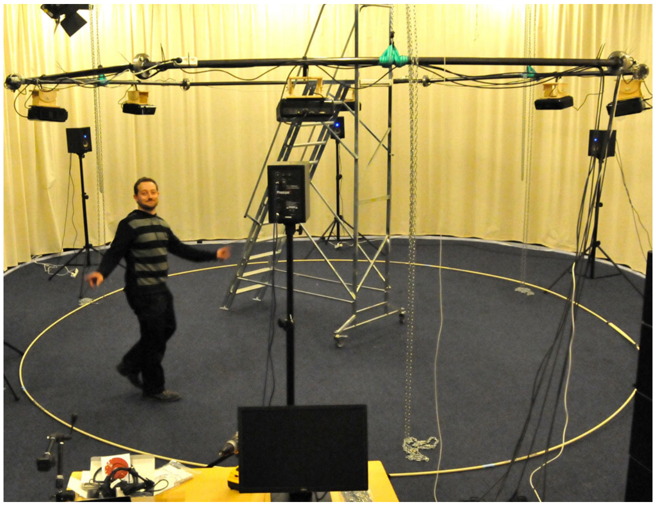

Figure 6. Construction of the experience cylinder.

D. Media and narrative

The material made available by the Viking Ship Museum for the project involves mainly the two parts of the journey:Wicklow to Torquay and Den Helder to Glyngøre. The material includes photos, video, position, weather and wave data recorded at locations along the route. In addition we have had access to selections of texts, including log books and descriptions related to a theme and stories written by crew members.

All photos and video footage taken by photographer Werner Karrasch from the Viking Ship Museum. These are unique and impressive recordings that are ideally suited to "dramatize" the tour. Much of the footage is taken from a dinghy that followed the Sea Stallion at a distance and managed to give a very vivid impression of movements on the high seas.

The installation does not include any direct display of text apart from simple words and titles for parts of the trip. However, the installation includes functionality for playback of audio clips, and texts such as logs and stories related to certain themes, which are recited and included as clips.

Weather and wave data are presented by combining synthesized wave, wind and rain sound and artificial sea level animation as background images. Currently sound modeling as well as background animation is developed, but this is not coupled to the data. Some work has yet to be done on data preparation and modelling.

IV. CONCLUSION, PERSPECTIVES AND FURTHER WORK

A. Evaluation and Related Work

The main result and contribution of the project is to create a physically interactive environment - the experience cylinder - in which precise tracking of body movements results in immediate responses in the visual and audio display of media items on the cylinder's screen and speakers. The cylinder has been applied to an experiment in which the items displayed relate to the voyage of the reconstructed 11th century Viking ship Sea Stallion from Denmark to Ireland and back. Initial evaluation in two workshops with about 25 participants each gave valuable user feedback and suggestions for further work. Firstly, experience shows that the cylinder gives the user a sense of control and engagement in that the display reacts smoothly and coherently to personal movements. Secondly, the cylinder can “tell a story" even though the user can in principle move freely in the space, the physical arrangement of the media items providing a certain narrative timeline structure. The cylinder has a domain-independent architecture, in that the media content relating to the Sea Stallion is independent of the tracking and display control, and thus the cylinder could be adapted for other applications.

The ideas behind the experience cylinder evolve from earlier concepts such as “physically interactive environments” [9], [11], “immersive virtual environments” [13], and “tangible interfaces" [12], originate in Kruger’s seminal ideas dating back to the 1980s on computer-controlled interactive spaces [7]. Our system uses low-cost and easily available technology, as do other recent systems such as the CryVe system [6]. However, the system described here differs from other typical virtual and mixed-reality systems in that it aims to allow a user to navigate using physical movements though a mass of heterogenous but interrelated media, rather than place the user in some specific virtual spaces.

Numerous examples appear in the literature of the development of interactive environments for the general purpose of communication, in areas such as advertising, entertainment, story-telling and dissemination of cultural assets; see for example [2], [4], [11]. One of the main motivations for such developments seems to be that physically interactive environments are perceived to offer the user a greater sense of presence and immersion, allowing the user to engage more actively with the content of the communication than is the case with traditional media. This is particularly so when interaction involves substantial physical body movements and gestures; Falk and Dierking [3] argue that the human sense of self is closely bound to physical interaction and that this is vital when considering individuals’ learning experience in the museum context. Our experiment shares the same general motivations, and exploits newly available affordable 3D camera technology for precise body tracking, allowing refined physical interaction such that small movements provide immediate and precise visual and audio feedback. We conjecture that the new concept of “tangible” computing is not necessarily related to tangible objects alone, but that new technology enables spatial interfaces which allow us to leverage humans’ well developed spatial reasoning abilities in UI and invent new metaphors for engagement.

The concept of narrative is vital to the experience cylinder. In the case of the Sea Stallion's voyage, the physical structure of the circular screen in itself imposes a narrative structure corresponding to the route from Roskilde to Dublin and back, even though the user can "follow" the

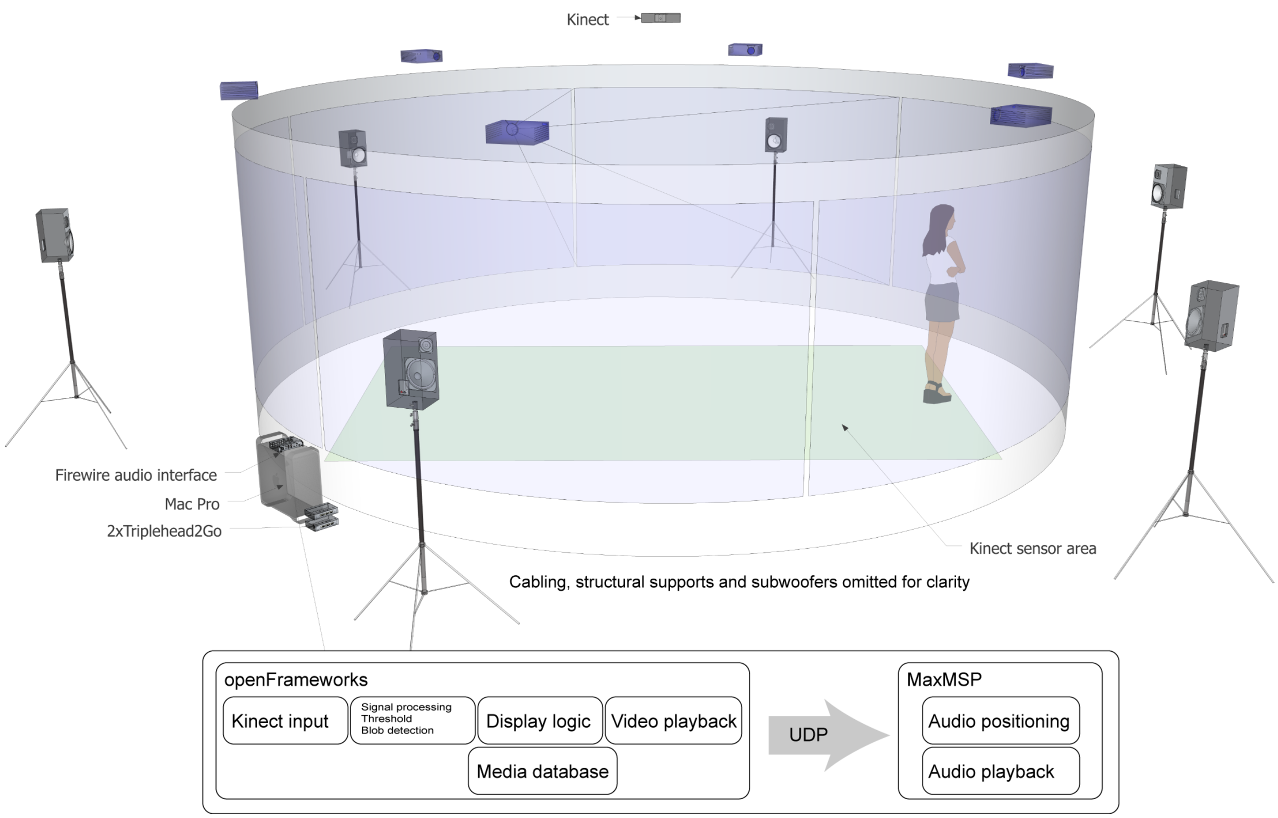

Figure 7. Diagram showing layout and main hardware and software components.

narrative in any desired order by moving around in the space. By contrast, the temporal order, size and arrangement in which media items appear on the screen can be controlled by the designer, allowing local storylines to be imposed within the overall structure. These aspects are the subject of continuing experiment and evaluation in the experience cylinder. The concept of "narrative spaces" is further explored by Sparacino [14], who offers promising narrative models, merging ideas from artificial intelligence such as probabilistic interaction models with physically interactive environments.

B. *Future Work*

Preliminary experiments and demonstrations confirmed that the cylinder has considerable potential to deliver an immersive, engaging experience that can be personalized and that the platform can combine knowledge transfer and story-telling with the feeling of being present on the journey. At the same time, the experience cylinder showed clearly the need for much further research in both technical and communicative dimensions. Firstly, the platform itself can be improved by technical refinements and extensions, including the addition of more 3D sensors covering the area with greater precision; this will also contribute to extensions allowing gesture tracking and tracking several users simultaneously. The quality of the projection and rendering can be improved with, for example, back projection, while alpha blending allows transparency effects and a more seamless display. Secondly, the narrative elements and structure will undergo further investigation, experiment and evaluation. Questions that arise include how to provide better visual and audio orientation points that maintain the narrative structure, and how context such as the user's previous route or prior knowledge could influence the interaction. Thirdly, the Sea Stallion voyage generated a huge amount of data, which motivates the integration of techniques for intelligent searching, for example based on an ontology relating to the voyage and its historical background. The intention is that the user can explore a chosen theme within the huge amount of available media, such as for example life on board the ship, shipbuilding methods or Viking history.

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