AMBIENT TECHNOLOGY FOR museums

an investigation into **applying** the **benefits** of many modern **technologies** to **enhance** the **museum** goers' **experience**

RESEARCH PRACTICE REPORT

M. Toby Harris April 2000 MA Product Design BIAD UCE

Research Practice

AMBIENT TECHNOLOGY FOR museums

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Abstract: A report documenting the main research phase for the Master of Arts project 'Ambient Technology for Museums', spanning from the identification of contexts to development of initial product concepts. Three research threads are explored, broadly concerning style (what aesthetic possibilities are there in applying 'ambient'?), substance (what technologies can be made tangible?) and situation (what is implied by 'museums'?). From this two research propositions are concluded, defining the design philosophy of 'ambient technology' and a system proposal for development in the design practice phase subsequent to this report.

10th April 2000

M. Toby Harris | MA Product Design | Birmingham Institute of Art & Design | UCE

Primer

'Ambient Technology for Museums' is an investigation into applying the benefits of many modern technologies to enhance the museum-goers' experience. This report forms the bulk of the project's research phase.

The term 'ambient technology' is used to describe the application of technology in a non-imposing and ubiquitous fashion, such that it's benefits come readily and naturally to the user without detracting from their otherwise normal activities. The project seeks to apply this principle to the experience of visiting museums, prompted by previous personal investigation which concluded that there was considerable potential in the application of modern technologies to aid the perception of exhibits.

Figure One
Organisations involved with this project: Birmingham Institute of Art & Design (above), a faculty of the University of Central England (below)

UCE
University
of
Central England
in
Birmingham

Report Objectives

This report should:

- ? Identify the contexts of the subject area
- ? Investigate the issues, problems and opportunities within the area
- ? Address the direction and conduct of the subsequent design practice unit
- ? Provide design hypothesises and initial design proposals

Contextual Position

This project is orientated towards producing a system that will realise museum-related research in a system suitable for reaching the public. This sets up a number of contexts:

Infomatics[1] and Museums

Museums' changing role in society

Public attitudes to technology

Implementation within museum spaces

In effect, this means combining the advantages of the present museum experience with the increased scope for interpretation and interaction offered by virtual[2] interpretations of museums. This fits with current governmental policy[3], which promotes museums as centres of lifelong learning with the implication of educational experience serving many different needs and users. Museums are also increasingly competing with leisure industries and are embracing technology as a facet of this. For the system to be successful it will first have to be entirely realistic in its use of technology, and accommodate the concerns of both public use and museum staff.

Take the visceral thrill of the physical museum, left, with the dynamic power of the virtual museum, right, and develop as MA project…

Figure Two: The essence of the project

[1] Informatics: The interdisciplinary study of information content, representation, technology and applications and the methods and strategies by which information is used in organisations, networks, cultures and societies.

[2] Where virtual implies information and communication technology (ICT) based

[3] Refer to Situation Research / Museum Purpose

Contents

AMBIENT TECHNOLOGY FOR museums
EXPLORATORY RESEARCH

The starting points for research are suggested by the title:

- ? Ambient – leading to design philosophy
- ? Technology – leading to product & system research
- ? Museums – leading to product and system requirements

From this the following driving questions were generated, broadly resolved to style, substance and situation.

- ? What aesthetic possibilities are there in applying ‘ambient’?
- ? What technologies can be made tangible?
- ? What is implied by ‘for museums’?

The ensuing exploratory research is mapped out overleaf.

Style Research

A review guided by the question *what aesthetic possibilities are there in applying 'ambient'?*

Ambience, Electronics and Aesthetics

Ambient technology could imply the paint surrounding us on walls or biros distributed around our environments. However, as proposed in this project there is a sense of a functionally unified ambience, and so it is reasonable to say that this will be achieved through electronics. Another implication of electronics is that aesthetics is used in a generic sense, extending beyond visual qualities to a more holistic appreciation. As a first step this discourse will dismiss computers, and instead investigate how electronics and computing can be used to aesthetic advantage.

Aesthetic Failure of Computers

While the concept of a computer is diametrically opposed to that ambient technology, they are discussed here to provide relief against the similar technologies that will form the project. Computers are multipurpose devices that stand alone from the human world, demanding total operation from their user; the ambience aim of this project seeks to bring a unified system of technologies to integrate with humans in their world. Another, cruder, perspective is people just don't like computers. While many regard them in awe as tools, in terms of enabling functionality (which extends to those who like them for game playing), who actually enjoys the relationship generated with 'one person and one computer in uneasy symbiosis, staring at each other across

the desktop without really inhabiting each other's worlds'?[4] If a machine is designed to be able to do everything, compromises will have to be made. If this machine was also a computer and so translates all tasks to a virtual domain, then there will be further confusions between the human operators' knowledge of how the world works and the virtual world of the machine. The result is an inevitable aesthetic failure, as any attempts at aesthetic influence – applying some form of beauty through the system - are by their nature tailored and cannot be applied universally with success.

Ambient technology offers a pathway forward from this situation, by taking computing out of the computer and applying it as a design tool in a greater system of functions, products, environments, all empowering humans on our terms.

Approaches to Electronic Products

Electronic products quickly developed far beyond simple implementations as calculators and suchlike, to a level today where a product system such as implied by the brief proposed in this project seems not at all far-fetched. However, there has not been a parallel development of aesthetic potential, the minimal work in the field resulting in highbrow philosophy rather than design theory development[5]. The consensus of these works and the critical starting point for

Figure Three
The Apple Lisa, the world's first 'user friendly' computer (1982) according to the Computer Museum of America. But what is user friendliness? It is not pure interactivity, which "would require the machine to talk back and challenge users to think and react. The machine wouldn't just smile back 'stupidly' like the Apple Mac always has.
[Rogers, R. Extract from *Flirting with the Ghost in the Machine*, in *Technological Landscapes*]

[4] Weiser, *Whole House*, p2

[5] eg, Maurzio Morgantini, *Man confronted by the third technical generation* in Design Discourse, Victor Margolin (ed)

approaching electronic products, is that electronic products extend our minds rather than musculature.

Pioneers of realising the design potential of this field, the Computer Related Design department at the Royal College of Art have developed a framework for analysing electronic products, believing that electronic products operate on three levels[6]:

Concept	What does the product do, who is it for, what is its aim, what is the context of its use?
Representation	How will the system be represented to users? What kind of explicit or implicit model are we planting in their mind that will enable them to understand and use it?
Experience	The third level is that of appearance and experience: what are its physical qualities, what colour is it, how much text is on the screen, how does it feel? And then, what are its social, aesthetic and cultural qualities? What associations does it suggest or evoke?

Further to this, research conducted for a CRD PhD thesis ultimately concerned with broadening the consideration of electronic products throughout the electromagnetic spectrum – of which light, and so its visual qualities, is just a part – has in doing so brought many important new approaches to bear. This seminal work, published as Hertzian Tales[7], suggests that 'the most difficult challenges for designers of electronic objects now lie not in technical and semiotic

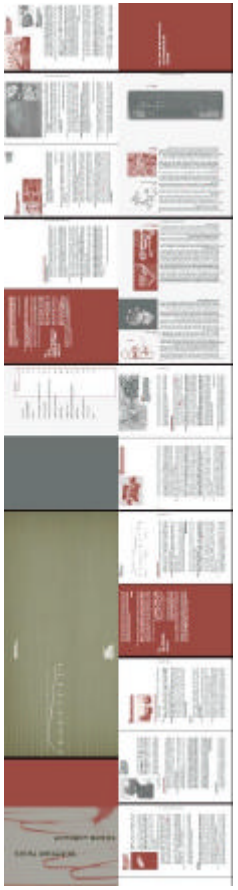

Figure Four
Hertzian Tales: an overview

[6] http://www.crd.rca.ac.uk/crdcourse/ (Available April 2000)

[7] Dunne, A (1999) *Hertzian Tales*. RCA CRD Research Publications. ISBN 1 874175 27 6

functionality, where optimal levels of performance are already attainable, but in the realms of metaphysics, poetry and aesthetics, where little research has been carried out.'[8] A précis of two of the fundamental premises of the book follow below:

Aesthetics of Use – With the plethora of stylistically similar electronic products in everyday use, such as VCRs and mobile phones, it is clear that there is a difference in aesthetics beyond the static perception. There is, therefore, a time based aesthetics or rather an aesthetics of interaction. Aesthetics of use extends this insight further, with the interaction method 'engaging with the cultural context with which the technology is used' [p27].

Post Optimal Objects – We live in age where mass-market products often represent the best in their field[9], and most electronic/computing design centres on mapping the virtual aspect to our existing preconceptions[10]. Factors such as these lead to primarily functional products that do not engage with us, but moreover are conceptually limited. Post Optimal Objects seek to offer qualities beyond function and beauty, such that their use provokes a more reflective relationship, enlightening beyond the initial purpose.

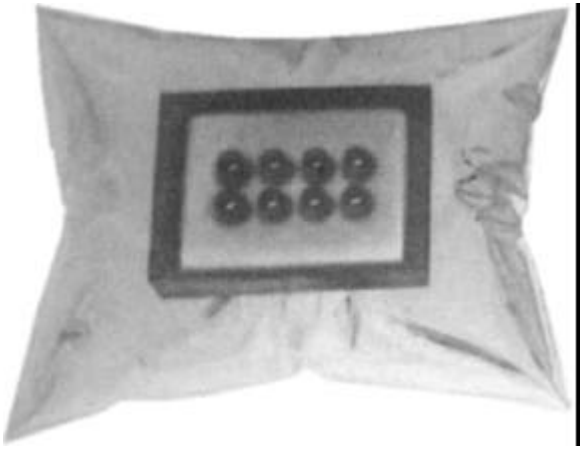

Figure Five
'Pillow Talk' by Anthony Dunne. An inflatable pillow with strangely glowing brick inside that reflects the state of the radio-wave world. A taxi using their CB radio outside will give a certain effect, as will the neighbours babycom another… A post optimal object, as its use poetically illustrates an idea beyond its material implementation: the existance of another dimension all around us – the invisible world of radiowaves.

[8] Dunne, *Hertzian Tales*, p28

[9] Dormer, P. (1990), *The Meanings of Modern Design*

[10] Dunne, *Hertzian Tales*, p31-35

This ambient technology project is indebted to this work and its ideas extend far beyond the limited examples allowed in the space of this report.

Approaches to Electronic Omnipresence

Whereas electricity was merely integrated into our built environment, electronics are becoming omnipresent throughout our lived space. At a basic technological level, the battery untied electronics from the wall, and now with digital technologies and wireless communication the potential for integration is immense[11].

It can be seen that this is highly relevant to ambient technology, and also a good time to differentiate between ambient technology and electronic influenced architecture and interior design: these concern only a technological ambience generated by the environment, and do not relate to a system of products co-existing within. From this perspective, the aesthetics of ubiquitous computing is the key topic and so is discussed here rather than the architectural approaches to ambience[12].

Ubiquitous computing (UC) is where there are many computers co-existing with each user (and each other), such that the computers ultimately become ubiquitously embedded computing. The concept of UC is derived from analysis of the trends of computing – first the mainframe age

Figure Six
Architectural and interior design approaches to electronic ambience do, however, suit pictures whereas UC does not. Shown here is a new London cyberlounge, as featured in appendix one.

[11] Digital technologies all speak the same language - 0s and 1s – and wireless communications not only remove a direct link but some types pass through virtually any physical barrier (eg Radio-Frequency devices).

(many people to one computer) to the PC age (one to one) then extrapolation of the UC age follows (one to many). The current development of the internet only reinforces this, bringing widespread distributed personal computing which goes some distance to bridging the transition to the UC age. However, this means that current research is very much from a purely technological perspective – driven by the engineering possibilities. As such this offers very little interest in terms of aesthetic development or potential.

By back-tracking to when the enabling technologies of UC were undeveloped but the future could be seen, some interesting research can be found. A 1991 Scientific American article entitled 'The computer for the 21st century' has very little to do with 'computers' and instead is a cutting synthesis of technological development, human psychology and our relationship with the tools we create for our existence. UC is introduced, and early developments discussed, in context of a human centred world. From the developed viewpoint there is significant aesthetic potential, the thrust of which was introduced in a 1996 paper: 'The Coming Age of Calm Technology' by Mark Weiser and John Seely Brown. The pertinence of 'calm' can be seen through taking virtually any symptom of the 'information age': for example, it is a universal experience of our times to see people desperately scrabbling for their ringing phone as the whole room scowls (or smirks) at the intrusion. The key is to both inform and encalm, 'meeting two human needs not usually met

[12] Refer to 'Beyond the final frontier' in appendix 1 for a journalistic account of such matters.

together[13]. The aesthetic potential lies in actually supplying more information in such a way that people actually need to attune to it less (this can perhaps be considered equivalent to the aims of this project). The authors propose that this is achieved in a similar manner as why one feels comfortable at home - we are encalmed because we are in a sense subconsciously attuned to the rich information space provided by our environment. They suggest that calm design will cater for this periphery perception and allow the desired aspect to become and lose the central focus easily – calm technology therefore empowers our periphery, simultaneously providing more information and providing us with a sense of calm.

Style Synthesis

The aesthetic possibilities of 'ambient technology' can be seen as vast, and a field in its infancy. There are a few general observations to make:

- we are beginning to see beyond the computer as an ideal and end in itself
- electronic products are 4 dimensional, being equal in their attachment to 3D form as time
- electronics can become ubiquitous in a non-imposing manner

[13] Weiser & Brown, *The Coming Age of Calm Technology,* 16th paragraph

The main conclusion to be made is that getting the aesthetics right, which is critical to the design philosophy of ambient technology as described in the primer section, will be much more biased towards the concepts, systems and operations implemented rather than the physical form. This will require significant work to equal the refining techniques developed through conventional modelling processes. The problems in this field are more enigmatic, for example: 'As we enter an age of smart technology – a time when technologies learn user behaviours and preferences and act more and more in accordance with previous patterns of use – alienation more likely will derive from technology making you conform not to the designer's envisioned user but to your old self.'[14]

Due to the novel issues raised by this field, an essential extension to this research will be discussion with representatives of the RCA computer related design department. To this end, this project is due to be discussed with the author of Hertzian Tales, Dr Anthony Dunne, prior to the 'Design Practice' stage.

[14] Rogers, *Technological Landscapes*, p68

Substance Research

A review guided by the exploratory question *what technologies can be made tangible?*

Distributed and Mobile Computing Concepts

It is clear that any system aiming to integrate technology in a manner stated in the brief will have to have some form of computing foundation. Therefore this important issue was investigated in depth in the previous research report for the 'Research Methods' unit. This was chosen in lieu of existing 'technology in museums' research so as not to bias the projects development at such an early stage.

Analysis of Previous Report

The choice lies between ubiquitous computing and context aware mobile computing. Effectively the former is adding computing to the environment and the latter adding computing to the person. Adding technology to the environment instead of adding technology to each visitor would seem logical as it is permanent installation rather than an ongoing process. However, the constraint of the sanctity of the fabric of the museum coupled with the immense infrastructure cost likely to be involved suggest that a realistic museum-wide system will add technology to each person. This also implies the system will be widely applicable beyond museum contexts and could operate relatively simply, through physical hyperspace: effectively turning an environment into a physical version of a web page, where approaching significant areas/objects - hotspots – implicitly

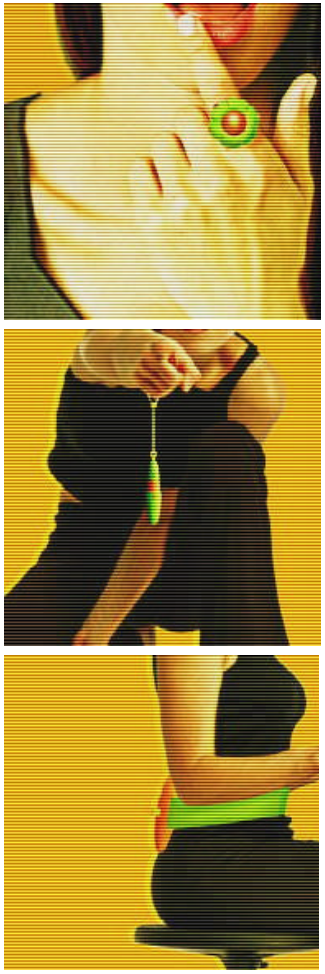

Figure Seven
Next-generation wearable computing from MIT and IDEO. Top: Interface ring, with buttons as petals and inertial sensor. Middle: 'Message Wand' combination of one-line text display and 'digital ink' pen. Bottom: Small backpack containing CPU and related hardware. All accessories operate through RF so there are no wires. Available: www.media.mit.edu/wearables/mit-ideo/index.html

requests related information (becoming the equivalent of clicking on a hypertext link). Further research into the ways of adding technology to the user and technologies to realise physical hyperspace was conducted, encompassing:

- ? wearable computing – quite a realistic proposition nowadays
- ? active badges – core conceptual technology for physical hyperspace
- ? wireless communication – vital component of active badge systems

'Augmented Reality' was investigated as a field in its own right, as the ultimate way of recombining the physical and virtual worlds, producing a synthesis of the two rather than the juxtaposition inherent in discrete displays.

Figure Eight
More wearable computing, this time from a fashion show.

Existing Research

This section reviews some key existing research projects investigating technology in museums.

Augmented Art Gallery[15]

A good introduction to the field of technologically enhanced museums is the Augmented Art Gallery (AAG), part of the author's undergraduate work. It was conceived as the demonstrative application of an investigation into 'Augmented Reality Through Projected Displays', and - albeit tangentially to this title - it provides some excellent founding insights into the benefits of applying technology to the museum experience. The two key enhancements are:

Potential for explanation and understanding through the principle of augmenting the physical exhibit with spatially aligned virtual media, as developed through figures 9,10 and 11. This example works by projecting light onto a dark image: the top image is the physical exhibit, the middle a projection onto it, which combine to give a new dynamic display type featuring the actual work.

The ability to automatically tailor the experience to the user, selecting appropriate content from a database. This is shown through figures 11-15.

The project also simply implimented the concept of physical hyperspace, demonstrating both the suitability of the concept in a museum context and the practicable nature of the technology.

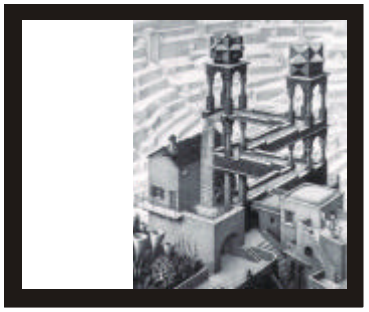

Figure 9: Actual exhibit, an Escher work also with white space as text/visual narrative.

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Figure 10: The projected image, white lights up the exhibit, black hides the exhibit.

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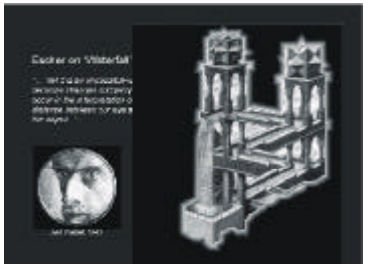

Figure 11: The simulated result, forming a new dynamic display based around light and original works.

While the AAG's implimentation of projecting light onto artworks is obviously flawed in the case of artworks due to their delicate nature, the benefits of the *concept* of augmentation can be seen through examples such as giving the ability for the narrative to reference some brush strokes and they be somehow highlighted or the imposibilities of Escher's buildings being explained by animated wireframe models superimposed on his laboured realism, cutting through his illusion. In fig 11 the narrative is concerned with the actual building, so through augmenting the picture only the building is shown.

Tailoring the content to the user is fast becoming a modern must (as in mass customisation) and the benefits can be seen simplistically as in the AAG example which can contain three different narratives, allowing an English, French or Japanese versions, or kid/adult/academic pitched narratives. This technology can be extended to be ever more ingenious so that, for example, the system can cross-reference between works it knows you have already seen[16].

The other benefit of starting with the AAG, is that these concepts were put to user trial experiment. Comparison was made between the AAG experience and an equivalent paper based (conventional) guide. The results were quite conclusive, and result in five key benefits of such a *conceptually* enhanced museum experience (with illustrative quotes from the user trial debrief):

Figure 12: Database entry screen showing different texts for different user profiles

Figure 13: A screen for users to select their characteristics for appropriate content.

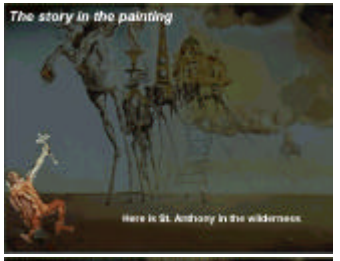

Figure 14: A simulated slide highlighting a character with a kid appropriate narrative

Figure 15: The same slide with an academic appropriate narrative

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[15] Harris (1999), *Augmented Reality Through Projected Displays*

[16] As developed in the ILEX project: http://cirrus.dai.ed.ac.uk:8000/ilex/index.htm

1. The projected display keeps the viewer's focus on the artwork. "If you get a handout, you look at the handout not the painting, and I wouldn't want to look at a painting holding a handout. With a projector the words are by where you want to look, you're not flicking between them."

2. The projected display is more appealing and more fun than the paper booklet. "You can play with it, much more fun...People are drawn to it, moving things."

3. The projected display has a clearer presentation of complex ideas. "Animation build up, going at your own pace to figure it out takes you with it instead of presenting the conclusion."

4. The projected display forces deeper consideration of the concepts presented. "I'm used to scanning text whatever but the projector draws to everything, the details."

5. The projected display forces wider appreciation of concepts. "With the paper guide the main thing you pay attention to is the water, but because the AAG can highlight bits it draws your attention much more than a text mention...Wasn't fully aware of bits until highlighted."

6. Paper gives more control. "Paper more flexible as back and forwards, and you know what's coming; with the projector version we didn't know whether it would be an animation or a new slide."

The conventional guide only bettered the AAG on grounds of control, which was very basically implemented in the AAG – whereas a book has instant information navigation - flipping/thumbing through pages, scanning, non-linear access - the AAG only had a next step button.

IMPS[17]

The Interactive Media Presentation Study (IMPS) and this project both share their roots with the Augmented Art Gallery project and, though conducted independently, have a loose association of mutually beneficial research directions. Sharing not dissimilar briefs, IMPS is primarily technology driven research 'to produce numerous low-fidelity concept demonstrators' while this project seeks to address a more holistic conceptualism to the problem coupled with the industrial design concern of or real world implementation.

Atypical of much technological development, and through credit to an user centred design process, the results of the IMPS project form an integrated museum system as in addition to the various prototype implementations of the concept of physical hyperspace in an art gallery.

Before discussing the IMPS system, it should be noted that the project was in its concluding stages when this report was written. This analysis is therefore based upon a preview demonstration and consultation with team members prior to their final conclusions.

The IMPS system consists of visitors logging in and out on entry and exit, and using one of the various prototypes described overleaf as a tour guide through the gallery. The system logs the user's activities such that customer care can be offered beyond the museum with custom web page generation pertaining to the users visit and gallery usage statistics are collated for analysis by the curators. These two seemingly peripheral factors were deemed very important by museum staff invited in evaluation of the system by museum staff.

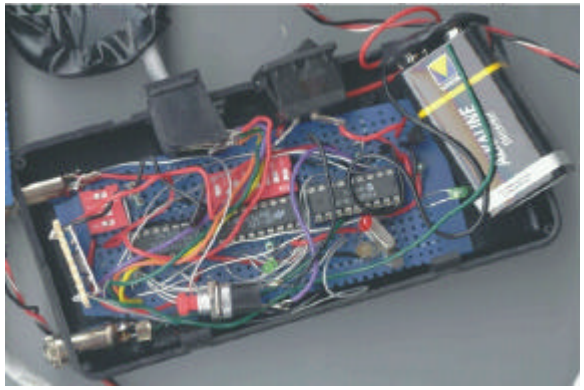

Figure 16:
Part of the IMPS prototype hardware, showing raw technological development

[17] IMPS development website: http://www.sorrellp.demon.co.uk/index2.htm

1 . Projection onto exhibit	
Produces a display formed on the original exhibit by means of superimposing a projected image. As in AAG. Media: Visual AR (high definition and accurate registration)	+ Superb at highlighting areas of interest + Concentrates visitor purely on exhibit - Single user monopolises whole exhibit - Not suitable for light sensitive exhibits

Figure 17
Projector mounted in ceiling creates dynamic display on exhibit

2 . Terminal	
Effectively a touch-screen PC mounted adjacent to the exhibit. Media: Visual (high definition)	+ Exhibit unaffected + Powerful software & interaction capability - Single user monopolises terminal

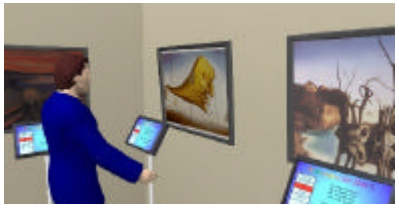

Figure 18
Terminal in front of each work, still personalised at it responds to the badge worn by visitor in all the systems

3 . Head Mounted Display	
One eye has miniature display producing a virtual image in the perceived foreground. Can highlight areas of exhibit when correctly aligned. Media: Visual AR (low definition and poor registration), Aural.	+ Exhibit unaffected + Concentrates visitor purely on exhibit - Significant readjustment per user - Alignment involves many problems

Figure 19
Video screen mounted in front of one eye keeps the augmented reality presentation personal

4 . Personal Digital Assistant	
Users carry PDA mounted with terminal style software. Present models have limited multimedia capabilities. Media: Primarily text based	+ Unobtrusive + Exhibit unaffected - Small display limits visual interest

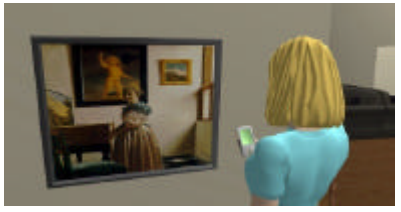

Figure 20
PDA as electronic guidebook

HyperAudio[18]

Essentially technological research with a museum demonstrative example, HyperAudio is a thorough realisation of possibilities of adaptive hypermedia and physical hyperspace. Adaptive hypermedia is a further development of ability to customise hypermedia presentations as demonstrated in the AAG and IMPS.

The hardware is analogous to the IMPS PDA implementation, with IR tags attached to exhibits and the user carrying a PDA with headphones. However, the difference lies in the sophistication – the adaptiveness – of the software:

> *'the HyperAudio system adapts information presentations (in the context of a Museum of Natural Science) to (i) each single user, (ii) who is performing a certain task, (iii) in a physical context. Each of these three facets influences in a different way and to a different degree the process of dynamically building presentations. HyperAudio capabilities will be exemplified by comparing different sequences of interactions, pointing out how these turn into different selections of content, language style and linguistic features. Moreover, for each interaction context it will be shown how further exploration steps in the visit are proposed to the visitor (as displayed links or as explicit suggestions), and how a coherent discourse is dynamically maintained as main support to a personal path of visit.'*

Figure 21
The Hyperaudio Equipment.
Clockwise from top left: IR transmitter to tag hotspots, Headphones with front facing IR receiver, PDA (an Apple Newton) and the PDA's stylus.

[18] http://luke.acm.org/sigchi/chi2000/call/categories/demosamples/hyperaudio-script.html, http://ecate.itc.it:1024/projects/hyperaudio/index.htm

While the level of adaptiveness of the hypermedia presentations is very advanced, there is also a shift in focus of delivery: the narrative is deployed as spoken word. This is very important from a museum and cultural perspective: as essentially viewing museum exhibits is a visual activity then using aural delivery for information does not directly compete with the appreciation of the exhibit and culturally we often have a certain comfort with spoken story-telling. The PDA's screen then only becomes a useful extra – as a sophisticated control pad.

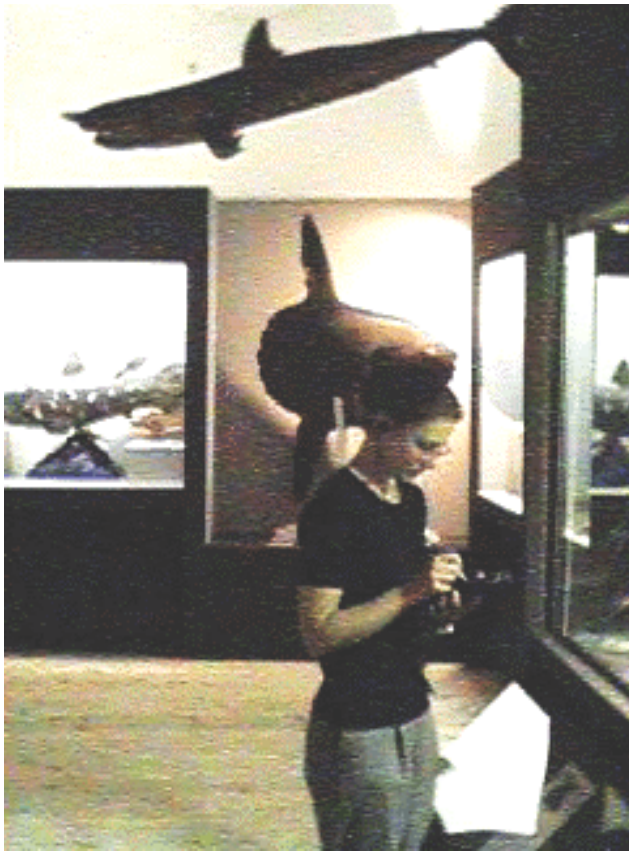

Figure 22
Using HyperAudio in a museum space

MIT ICHIM Submission[19]

One of the leading technology institutions in the world, MIT, submitted a paper to the key source for the field of this project, ICHIM, with a rationale similar to this project: to see what 'technological intervention' could be beneficially applied in a museum context. The result, 'Technologies and methods for interactive exhibit design: from wireless object and body tracking to wearable computers' is compelling material.

Their conclusions-as-systems which 'contribute to engage the public and enrich its experience during the museum visit' are:

- Information overlay in smart rooms

  (adding technology to the museum space)

- Spatialised Interactive Narrative with smart clothes

  (adding technology to the visitor)

The first is an exploration of how modern presentation technologies can be used to the best of their potential, giving a slight science-fiction feel. As such, the system was very well received and its impressive implementation is shown in figures 23 and 24. The other system is an application of an existing development within MIT, which is a wearable 3D world-wide-web browser that

Figure 23
'Unbuilt Ruins' by MIT

Figure 24
A close up of the central interactive table

[19] http://vismod.www.media.mit.edu/people/flavia/Papers/ichim99.pdf

displays webpages, and their linking structure, as a cityscape. By linking this spatial arrangement of webpages to the museum environment through physical hyperspace, they constructed a novel interpretation of the personalised hypermedia system already discussed throughout this section.

RCA CRD Museum Showcase[20]

Conceived as a demonstration of the novel approaches taken by MA Computer Related Design students at the Royal College of Art, a simple brief of 'controlling information flow' was typically laterally applied in a museum context. were developed for a museum context. Some of the examples are described below:

- Navigation

  Various gallery maps with the added dimension of somehow showing congestion, one shows an appropriate intensity of white noise (ie crackle to fuzz to snow), another has water tanks with level as number of people and bubbles as volume.

- Pavlov's Box

  Through lighting and sound control, the gallery environment guides your journey by darkening the tone of the generated ambience as you stray from its pre-programmed path.

Figure 25
Two different 'navigation' gallery maps

[20] Students' portfolios (year of 97-99) available from http://www.crd.rca.ac.uk/crdcourse/index.htm

? Beam me up Scotty

Visitors are given a torch which, through fixed projectors and a user profile stored in the torch, when pointed at 'hotspots' around an exhibit projects an explanation of that part onto it, pitched at the visitor's level.

? 3'20

Through a database of different interpretations of content, audio-visual displays respond to your interests declared through loading data 'blocks', generating personalised presentations.

? Displace

If the safe capacity of a room is exceeded, a soft orange cube responds by inflating until the excess people co-operate and leave before being simply forced out.

Figure 26 Beam me up Scotty exhibit. Note the interpretive power of the bottom left projection, akin to X-ray vision.

Analysis of Museum Systems

The systems reviewed have been analysed from two perspectives:

? The benefits they bring, and what exactly contributes to this

? Their potential for installation in existing museum spaces

The MIT project shows the benefit of this approach, and draws some important conclusions for the field and this project. The adding-technology-to-the-museum example, merging exhibit and exhibition space, has immense advantages and is a true implementation of ambient technology.

They conclude: 'Through information overlay it is possible to compress in the limited space of the museum a larger portion of material relevant to the exhibit and to the public. The interactivity of the setup, in addition to the projections, stimulates people to explore and construct meaning out of the displayed artwork.'[21] However, it is a stated aim of this project that the proposed system must be suitable for implementation in existing galleries. From this perspective the system's infrastructural implementation becomes flawed, upon which the concept of information overlay relies (at least at a high enough quality to become an exhibit in its own right). The AAG, IMPS projection and 'Beam me up Scotty' all rely on major infrastructure changes around each exhibit, and are similarly flawed for a museum wide implementation. Their unique concept of spatially aligned information – the augmented reality aspect – is definitely a significant advance over traditional media, but the only way this has been practicably implemented is with fixed projectors which also bring the issue of monopolisation of, and in certain types of exhibit light damage to, exhibits. The 'terminal' version of the IMPS system is an infrastructure implementation, but on a scale that is applicable for retrofitting to museums. While it does have advantages over the conventional touchscreen systems already up and running in various museums, in that it transparently responds to the user's profile, it does not meet the ambient technology philosophy in any way.

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[21] Technologies and Methods for Interactive Exhibit Design, p9

‘Beam me up Scotty’ shows the power of a well executed industrial design analogy: sharing seemingly identical technology to the AAG, its use of a pseudo-torch to illuminate the exhibit with information ties in nicely with this projects aim of introducing technology ‘such that its benefits come readily and naturally to the user without detracting from their otherwise normal activities’. Another nice idea incorporated in a RCA prototype is that of assembling a digital user profile with some form of building blocks: physical icons.

The IMPS head mounted display can be discounted on practical terms, the factors being cost, adjustment and delicacy. It does, however, go someway to solving the monopolisation and light damage problems of projected augmented reality, as the augmentation is done on the receiving end, ie. personally, allowing the exhibit to remain unaffected for others (whether using technology or not – another advantage).

Enhancing the museum experience through personal technology seems the way forward from most of the disadvantages so far proposed, but will be harder to align with the design philosophy of the project. The IMPS PDA, then, seems the best implementation of the IMPS prototypes but is too overtly a computer-based guide, imposing on the cultural experience of a museum visit. HyperAudio, using similar hardware addresses this issue: becoming primarily a walkman-evolution, a story teller with minimal computer interaction, relying on much input implied by the users behaviour. The only museum space disruption is a small ‘black box’ placed adjacent to each exhibit and the performance to cost ratio is favourable. However, it is the narration as main

form of information delivery that is the most persuasive factor, the importance of which becomes apparent only when experiencing a collection of these prototypes: while the appeal of multimedia is undoubted, when it becomes ubiquitous throughout the museum visit it ultimately gets in the way: the reason the public are visiting the museum in the first place is to see the exhibits up close, first hand.

An ideal hybrid system would therefore:

- Be personal rather that infrastructural (like PDA + HyperAudio)
- Be personalised in its delivery (like most of them)
- Be narrative driven (like HyperAudio)
- Incorporate AR to complement the narrative (like AAG + Beam me up Scotty)
- Be operated by implied input (like HyperAudio)
- Make use of its physicalness in its overt input (like 3'20)

Existing Parallels

A wider review of technologies made tangible, drawing from examples which have little to do with a museum context but share analogous features to the museum brief, has been underway for some time now but is proving problematic to condense into a form required for this report.

The main search strategy has been the examination of every issue of a techno-culture magazine since January 1999 to the completion of the project. This has been chosen so as not to allow any gaps in researching the techno-culture of recent times, which will encompass existing parallels. 'Wired' magazine has been chosen for this as the leader in its field. Parallel searches have also been made through on-line British newspaper archives.

A seminal newspaper article which provides a comprehensive review of the vast field of future of design and technology is included in appendix one, and goes someway to illustrate the futility of an analysis of existing technologies for cultural ends: within reason specific technologies are now irrelevant to the conceptual design process. More accurately, the unrealised potential of current technologies – as computing, telecommunications, digital media converge with material design – is so immense that designers can increasingly operate in 'blue-sky' mode and then examine the means to achieve the idea.

Analogous Products

In terms of existing products, rather than investigating the rather limited commercial products concerned with the enhancing the museum experience, it was deemed more pertinent to examine some characteristics that a future-looking system might have to address. To this end, the project brief suggests the replacement of the conventional, paper based, guidebook. While there are direct technological equivalents, for example a PDA could be loaded with equivalent visual information, the paper version has some very sophisticated characteristics which are not so easily transferred. The issue of information navigation is very well addressed in a paper guidebook, in that it is very easy to search and get an overview just by variations on the theme of flicking the pages (this does not follow for more conventional documents). Therefore handheld products containing controls were analysed, from the perspective of the minimalism yet capability of controls. Products analysed were drawn from domestic appliance remote controls, universal remote controls, PDAs, computer mice, walkman remote controls and computer monitors[22].

From the analysed products, a number of control 'species' were identified and in addition to their control potential there was an important further aspect discovered concerning whether the user was focused on the control or the operation was abstract from the user's focus. However, when

Figure 27
A portable minidisc player's remote (actually wired) control. The transport controls on the end are single function 'buttons' just as any other remote control, but their pleasing design elevates the product.

Figure 28
Computer mice are an incredibly powerful, yet minimal, control.

[22] While not handheld they are minimal and excellent in their diversity of implementation.

considered in terms of the aims of the project, all controls were somehow inappropriate – perhaps lacking a certain human association, being too close to the technology they control.

Beyond this, it was concluded that controls can be pleasing to use, and the following characteristics may contribute to this:

? Attractive as physical entities

? Intuitive in function

? Engaging, perhaps affable or rewarding, in use

But most of all, creativity and good design rather than sophistication of control technique was the consistent factor through the products deemed commendable.

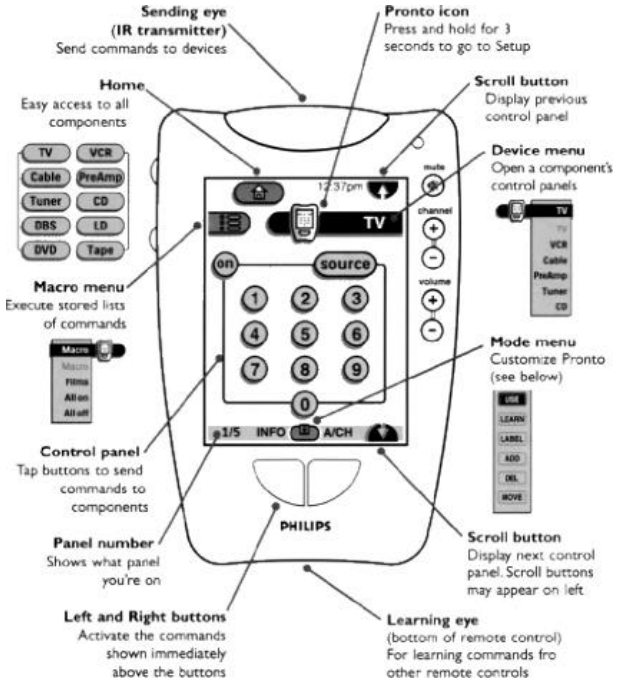

Figure 1
Universal remote controls are now resembling PDAs with sophisticted graphical user interfaces and touchscreens

Substance Synthesis

The analysis of the substance strand of review has effectively been conducted throughout the section, leaving – appropriately enough – just an overview conclusion with little to do with the actual technologies or their tangible implementation.

While technical progress will always be ongoing, it seems reasonable to say we are entering a new phase in our relationship with technology, where the individual technologies will become increasingly immaterial with their cultural – or human centred – adoption becoming the driving factor. An example culled from the newspaper article 'Forward Thinking' included in appendix two states:

> *Boxes, it seems, are on their way out across the board. 'Computers have to stop being black boxes and pay more attention to who we are and what we want to do,' say Chris Pacione and Chris Kasabach, of the visionary design house Sandbox Advanced Development. They are thinking not only of the curves and colour overload of the iMac computer, but of something more radical.*
>
> *A few years back, they were asked by Intel to come up with their vision of the computer in 10 years' time. One of their solutions was Digital Ink - a computer in the shape of a pen. They see no reason why hi-tech devices shouldn't come in the form of everyday objects. 'All projects are cubes, because all the components, such as the chips and circuit boards, are cubes,' says Sandbox's CEO, Astro Teller. 'Yet objects can take any form. We are no longer limited by technology.'*

Situation Research

A review guided by the question *what is implied by 'for museums'?*

Museum Purpose

> *Museum: Building devoted to learning and the arts (regarded as a home of the muses). Building for exhibition of objects of art or science (first applied to "Mr Ashmole's museum at Oxford").*
>
> *The Oxford dictionary of English Etymology*

Named after the goddesses of memory, Museums since Mr Ashmole's museum of 1706 have existed to preserve and conserve the artefacts and knowledge that best represent the notion of a society's collective memory. More recently in the late nineties there have been a plethora of reports realigning this aim to fit within modern society, specifically addressing issues of lifelong learning, public outreach and the 'digital age'[23]. This has been easiest to interpret through developing Internet applications, resulting at the present as an established extension to the physical museum. Now the emphasis is shifting to a more holistic approach, including a blurring of traditional divisions, adoption of technology and more proactive public outreach. This was outlined in the first communication of the new governmental 'Museums, Libraries and Archives Commission'. In an introductory speech to Museum professionals, the chairman stated

"Those of us involved in managing cultural activities such as museums must fundamentally change what we do and the way we do it, if we are to remain relevant to politicians - and to the millions of ordinary people who not only directly or indirectly fund us but are our customers - if we don't, we risk turning into a cultural version of Marks and Spencer - symbols of once great institutions that have failed to move with the times and are suffering as a result."[24] *There is, then, a huge present imperative to morph the role of the museum, deploying the contents throughout local communities and aligning the actual museum experience towards the world of leisure industries.*

Museum Users

While there are certain demographics that reflect any given museum's audience, the renewed intention is for access and enjoyment for all. While further research will be required for detailed development of any system, at this stage and in light of the changing role of museums it is fair to say that museum users will be representative of the whole population, if not the whole population itself.

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[23] Eg. *A Netful of Jewels: New Museums in the Learning Age* (1999) National Museum Directors' Conference, *A Common Wealth: Museums and Learning in the UK* (1998)Department of National Heritage

[24] Matthew Evans, 18/1/2000, speaking at the annual Association of Independent Museums lecture

Museum Operators

Museum operators, from Government policy makers through to exhibit curators, have a diverse and often contradictory brief to meet – the wider notions of preserving and presenting are often at odds with each other. This research stage has not addressed the detail of their role, being based as a conceptual overview. Instead, this will follow hopefully through regular contact with museum professionals as one of the most important factors in the design practice phase.

Interpretation

For museums, displaying exhibits is only half of the equation: for the exhibit to be meaningful its relevance has to be portrayed. This issue is interpretation, turning a certain dusty pottery shard into an heirloom from another civilisation, and further interpretation can use this to provide insight into this civilisation.

‘One of the main challenges that exhibit designers are faced with is that to give life to the objects on display by telling their story within the context determined by the other objects in the exhibit. Traditional storytelling aids for museums have been panels and labels with text placed along the visitors' path. Yet the majority of visitors express uneasiness with written information. Usually time

spent reading labels interrupts the pace of the experience and requires a shift of attention from observing and contemplating to reading and understanding[25]

[25] Klein, L. (1986) *Exhibits: Planning and Design*, pp70-71

Virtual Potential

The virtual potential of museums, ie creating information and communication technology based interpretations of museums, has become so established that it is no longer a museuology or policy issue, but unequivocally reflected by the public: the National Gallery website received 21million hits in 1999[26]), to name one example of many.

The field has been subject to much research, and subject to 'the unimaginable having a determined way of appearing at a rapid pace in high technology'[27], is a surprisingly mature field. The key text in this field presents four main opportunities:

- *Overcoming the confines of space that enable museums to display only a limited number of exhibits and a small sample of their collections at any one time.*
- *Overcoming the geographical or logistical obstacles that hinder people from visiting the physical sites of museums.*
- *Forging more direct links with educational curricula by making museums a resource that students can visit from their classrooms*
- *Presenting subject-matter and integrating diverse media in new and interactive ways to enhance the learning process.*

The Wired Museum, 'Conclusion: Towards a meta-museum', p272

Figure 30 Screenshots from a world wide web interpretation of Birmingham Museums and Art Gallery's Pre-Raphaelite collection.

[26] *Dust of fusty image, museums told*, The Guardian Newspaper, 19/1/2000

[27] *The Wired Museum*, p32

While there is a great breadth and history to this field, the ‘killer-app’ is that of the internet and world-wide-web pages:

‘The internet has been the basis of a quiet revolution that has been sweeping through our museums and galleries over the last few years… [‘A Netful of Jewels’ report] shows how the new technologies allow educational access to our collections in ways that were unimaginable even a decade ago:

• The 24 hour museum. This has been created as a popular gateway to museum and gallery websites. It makes collections of our museums available as an on-line educational resource around the clock. It received 1.5m hits in its first month of operation. Eventually, users will be able to prepare for their museum visit and do an "electronic follow-up" afterwards from their own armchair.

• Scran - the Scottish Cultural Resources Access Network. This is a £15m project that uses multimedia and web technology to create "Scotland's digital heart". Users can access hundreds of thousands of images, sound and movie clips relating to Scottish museums, galleries, libraries, archives and historic buildings. Virtual resource packs have also been made available for schools and libraries in Scotland, and web users everywhere. More than a thousand schools already subscribe’

David Puttnam, ‘Antiquity at the touch of a finger’, The Guardian Newspaper, 16/6/99

Situation Synthesis

Developing the dominant museum environment is a field ripe with potential due a combination of fruition of technologies and a sense of timeliness with present policy trends. While various

attempts have been made to develop the museum experience this has mostly resulted in web based catalogues operating outside of the museum itself. This has numerous advantages, but they rarely are engaging or stimulating beyond the scope of searching for specific information. 'Presenting large bodies of information in the form of an electronic catalogue, usually does not stimulate learning or curiosity.'[28] Developing the actual museum experience is a less developed field, with much opportunity for combining the proven advantages of virtual media with the museum environment and exhibits. The key issue is interpretation, which - as demonstrated elsewhere - technology is apt to enhance. With conventional means, it could be concluded that 'a visit to a museum demands a certain amount of effort, knowledge, concentration, and guidance, for the public to leave with a consistent and connected view of the material presented'[29].

Museum exhibits, and often the environments themselves, are very precious which leads to many problems of implementation. It can be seen why web-based technologies have been so widely adopted, giving many advantages of the virtual museum while requiring minimal investment in equipment and leaves the museum itself untouched. Essentially, there is huge opportunity for the combination into one experience of the two museum paradigms – real and virtual – while maintaining their proven advantages and museological grounding.

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[28] *Technologies and Methods for Interactive Exhibit Design*, p1

[29] *Technologies and Methods for Interactive Exhibit Design*, p2

A good illustration of the issues, problems and opportunities of the museology aspect of this project is found in a journalistic article about a recent museum development:

"…visitors are greeted with well-designed walkways, in-formation points, balconies and cafe furniture. It is subtle, though the architecture and planning, although quite special, play second fiddle to the exhibits. And of these, criticism can and perhaps should be made. I see no ships in the Neptune Court; it relies too much on clever artworks and "experiences" when it might show us ships and shippy things.

If museums and galleries move away from the curating of objects, they will slowly become redundant as new technologies allow us to enjoy exhibits in the privacy of our own homes. Visitors will brave [the journey] to see ships not to soak up redundant "experiences".

This is a warning bell worth sounding. The South Bank Centre could easily fall into the same trap, decking out buildings and spaces between them with arty gizmos, electronic frippery, excess visitor information and "orientation", when what people really come for is music, art, atmosphere and the chance to escape from their claustrophobic, backstabbing offices. "

Jonathan Glancey, 'The ship of things to come', The Guardian Newspaper, 31/5/99

AMBIENT TECHNOLOGY FOR museums RESEARCH PROPOSITIONS

The convergence of research and conclusions drawn are represented in the two essays as research propositions forming this chapter:

- ? Ambient Technology: Calm design with electronic omnipresence.
- ? The Museum System: A design proposal as research conclusion.

The convergence of research to these essay-proposals is mapped out overleaf.

Ambient Technology

Humane design of electronic omnipresence

The term 'ambient technology' was conceived for this project to describe 'the application of technology in a non-imposing and ubiquitous fashion, such that it's benefits come readily and naturally to the user without detracting from their otherwise normal activities'. This essay will develop this premise into practical advice for designing ambient technology.

The crucial starting point is to identify how people perceive the technologies that surround them, and examine why the relationships duly built can sometimes be stressful and imposing, yet sometimes serene and even pleasurable. Various thinkers[30] have proposed that there is a dichotomy in how we perceive the world: we either have to interpret what we perceive or there is already an automatic, learnt, interpreter in place ('affordance', after Gibson[31], is probably the most widespread term for this interpretation). This premise can be used to develop the concept of two conscious 'areas' of perception: the centre where whatever we are focused on resides, and the periphery where whatever we are *attuned to without attending to explicitly* resides[32].

This notion of periphery can be used to address the two challenges proposed in the ambient technology definition: making ubiquitous technology non-imposing, dealt with next, and making the benefits of the technology come readily and naturally, dealt with after.

By designing for the periphery much information can be digested without detracting from the user's otherwise normal activity, ie their focus, the centre. This makes the technology non-imposing, if coupled with design that allows the ability for the information source to switch easily between the periphery and centre (and back) when the information becomes relevant and needs attention. Another advantage of designing for the periphery is that it can act as a radar to the immanent future, detecting signs that something is about to happen so that when it does we are

[30] Computer scientist, economist, and Nobelist Herb Simon calls this phenomenon "compiling"; philosopher Michael Polanyi calls it the "tacit dimension"; psychologist TK Gibson calls it "visual invariants"; philosophers Georg Gadamer and Martin Heidegger call it "the horizon" and the "ready-to-hand" ... from Weiser, *The Computer for the 21st Century*

[31] Gibson, J. (1979) The Ecological Approach to Visual Perception.

[32] Brown, J.S. and Duguid, P. Keeping It Simple: Investigating Resources in the Periphery *Solving the Software Puzzle*. Ed. T. Winograd, Stanford University.

prepared for it (even if we don't realise we are). A similar argument applies for the near past.

For the benefits of ambient technology to come readily and easily it is first necessary to clarify the problem: consider that as people using technology for our own ends, the internal workings are irrelevant to the benefits. They certainly are related in the material world, but from a psychological view, or just user centred functionalism, there is no connection. Therefore, the problem of harnessing the benefits is essentially an input/output problem. The challenge then is to design the technology so it takes our wishes and delivers the results back, or more pertinently *communicates*, using human techniques. We communicate both explicitly and implicitly, then so should ambient technology. Implicit techniques will also be useful to engage the periphery, allowing a direct understanding without interpretation. Designs should therefore use speech recognition and synthesis, gestural commands… whatever people would use in the context of the technologies' use - this will be the key to harnessing the benefits of the technology naturally.

To illustrate these points with a common product of electronic omnipresence and rarely humane design, consider the mobile phone. One of the main problems of mobile phones is that of the ringer – to the user it is often quite a shock when it goes off and can often be socially undesirable. When close to loudspeakers, the signal between phone and tower often interferes and so can often be subtly heard. This can be comforting as it gives one a chance to prepare for the actual ringing almost without realising it. Likewise some phones vibrate, which the periphery is attuned to, so that when it does start there is a progression of peripheral recognition, a switch to the centre and a conscious decision to answer it or not, and if not it falls back to the periphery with ease, to the point where you suddenly realise that the caller has rung off – giving pre and post attentive perception. A recent MA project within the BIAD school of product design developed a gesturally operated mobile phone, which shows how consideration of the human angle can radically transform an established product. It mounted the phone in a scarf, turned on when picked up and adjusted to the context of its use: drawing it tight around your head assumes privacy and so reduces the volume, and so on. The challenge of this project is to develop these ideas into the conceptual stage, such that Kenneth Grange's 'small pleasures' of mechanical objects become 'quiet pleasures' of electronic products.

The Museum System

A system proposal as research conclusion

The straight response to the brief, this proposal forms a conceptual outline of an ideal (as concluded from the exploratory research) museum system. In the consequent design practice unit the design philosophies and dissemination ideas discussed in this section – co-evoved with this conclusion - can be applied to develop the system into one suitable for real-world implementation, and hopefully one involving many quiet pleasures in use.

The system proposed is based around adding technology to the visitor, effectively providing them with a tool equivalent to a personal curator-cum-tour-guide. There are two sides to the system, this tool – the Visitors' Product (VP) – and the Museum Integration Infrastructure (MII).

The Visitors' Product has a primary function of a personal adaptive-hypermedia presentation device for enhanced understanding and enjoyment of the museum, operated by tacit and implied input synthesised with knowledge of it's position, the user, it's history of use by that user, and a virtual museum database. It has secondary functions of a navigator device and note-taker.

The Museum Integration Infrastructure supports the VPs' operation through the museum environment, accommodates off-line functions, adds follow-up material, and incorporates the VP into the greater museum visit experience.

Together, they expand the user experience beyond the museum through custom follow-up material based upon knowledge of the user's visit and provide the museum operators with invaluable museum usage information.

The Visitors' Product will feature:

- ? 'Looking Glass' – a novel realisation of augmented reality consisting of a transparent display used to guide user to correct registration (framing up the exhibit) and to augment exhibits with spatially aligned visual information
- ? Headphones – to provide aural narrative guide
- ? CPU & related hardware – containing database, context of use interpreter and adaptive hypermedia engine
- ? Sensors – hotspot determining and for gestural input
- ? Controls – explicit input for whatever is undesirable to be gestural
- ? Physical icon receptor – to provide initialising user profile

The Museum Integration Infrastructure will feature:

? Distributed autonomous transmitter tags – to mark hotspots

? Docking station – charging and information exchange

? Server computer – link to www server and virtual museum database design software

? Physical icons – different forms reflecting various broad user profiles, chosen on entry

This generic system will operate as such: A visitor will enter the museum, and be presented with a display of physical icons representing predefined user profiles, such as 'English speaking academic'. Having chosen one they will combine it with the VP they also receive. This initialises the adaptive hypermedia system in the VP to a certain degree of personalisation. The visitor then proceeds into the exhibit space whereupon an audio commentary starts through the headphones. As the visitor enters an invisible 'hotspot' around an exhibit, the narrative changes to be specific to that exhibit. Whenever the narrative makes reference to a physical feature, the looking glass is used to identify the feature and visually annotate the narrative: looking through the looking glass display effectively superimposes graphics onto the exhibit, with correct alignment by the visitor. The technologically updated looking glass itself does the majority of this by virtue of its size, and accurate alignment is achieved through a framing display consisting of a silhouette mask. The VP adapts the narrative's content and presentation as per the HyperAudio research[33], ie. through consideration of the user's responses to its presentation so far and inferences obtained by the user's movements through the exhibit space against information about the exhibits themselves. Upon leaving the exhibit space, the VP is handed back and docked onto its recharge bay where the history of the user's visit is also uploaded onto a conventional computer (and any updates to the virtual museum model downloaded). The visitor is then given the option of follow-up material customised through the knowledge of the visitor's history, which could be in the form of a web page or hardcopy. The visitor history information can logged for analysis without any legal or moral implications, as there are no personal details, just knowledge of the stereotype the visitors identified themselves as on entry.

[33] Included as appendix two

museums

AMBIENT TECHNOLOGY FOR

APPLICATION

This section addresses the direction and conduct of the subsequent unit, design practice. It states a brief, considers the time constraints, and provides an initial concept as catalyst for the design process.

Design Practice Brief

? Develop the stated Museum System beyond the present functional conceptualism

This will involve consideration of the stated Ambient Technology design philosophy coupled with targeted, practical, research as required.

? Realise this system into a set of product designs

This will co-evolve with the later stages of the system development.

? Facilitate public and professional appraisal of the designed system

This will require some means of disseminating the sense of the solution suitable for public use and professional scrutiny

Tasks + Plan

	May	June	July	August	September
Course Critical Dates	11th Definitive Design Brief	29th Detailed Design Proposals		17th Design Practice Report	11th Exhibition
Project Critical Dates	5th IMPS presentation				
Project Specific Tasks	Resolve 'Tomorrows World' possibility Create Web-Page Establish museum links	Complete use-of-media essay	Devise+Conduct Appraisal		
Personal Commitments		*8th, 23-26th VideoScreen Work*			

A detailed plan of project development will form a initial task of the design practice unit.

Initial Concept – Visitor's Product

Development Beyond Museum Specification

The specification stated as a research conclusion addresses the ambient technology brief in its system architecture, but further application of this design philosophy can be applied in the individual products. This section is a first attempt at such application, addressing only the major component of the museum system – the Visitors' Product (VP), which will form the bulk of the design practice unit.

Operational development has been through consideration of the possibilities of gestural input, as developed in the following fictional narratives. Material form development has been through consideration of how the VP could 'fit' a visitor, rather than its sculpted shape. Four examples are shown overleaf. Technologically, these narratives and forms are possible, the features being either analogous in features to those in various museum systems investigated or incorporating known commercial products (such as 3D tracking for positioning and movement tracking of the looking glass around exhibits). The only untested aspect is the looking glass display, which will require investigation into display technologies and ergonomic issues.

Fictional Narratives of Use

"As I enter a gallery room, my headphones start telling me a short story of the rooms theme. As I've got the executive model, it's pretty highbrow – though it's changed to a more terse treatment after realising that I kept on advancing through the narrative. You do this and more by treating the looking glass like some update of a magic wand; a flick to the right advancing the narrative, holding it flat bringing up a floor plan - between you and me, while I had a room to myself these actions got quite theatrical! I even hardly realised that when you use it to examine an exhibit's detail, the narration seamlessly alters to that topic.

"Fair 'nuff, holding the viewer thing to the statues' balls didn't start a discussion on the Romans' sex lives, but its pretty cool that it works on most stuff. S'pose this could be 'cos me and my mates, we got the kiddie cover on ours, so its like all covered in this squidgy foam. Even if its pretty tame in what it tells you, we've had a laff with the primary school story telling its used. We can't wait to get to the school network room and check out the webpage it'll have generated for us… I bet its going to be all kiddie stylee, but our comments – what we've recorded against each bloody Roman – wot it'll bring back up definitely aren't going to be!"

I am amazed by the transparency of the technology, I believe it's a whole new paradigm in computer interfaces – well there's got to be a computer in there somewhere. The audio narrative is excellent: simple and unfussy, leaving you to concentrate on the actual exhibit, and the spyglass quite revolutionary. The ability to annotate the narrative with visual references, simply by framing the silhouette presented on the glass is a very powerful tool, and sometimes the diagrams it superimposes onto the exhibits can almost be like having X-ray vision!

Form and Fit Concept Sketches

Fat Boy

An oversized looking glass containing all hardware. It might be too heavy to use over the duration of a museum visit, as it will have to be held, raised to eye level whenever required and articulated around for gestural input

Fan

The blue-sky model. An oriental fan with flexible display in place of paper. It would be carried folded up as a neat bar and flicked open whenever the visual aspect is needed.

Stone

A ‘stone’ central unit containing battery, CPU and related hardware with a consequentially light looking glass. The otherwise featureless stone could be pocketed or held.

Sash

Similar principle to the stone, but fitting the person as a worn garment: a sash with hardware distributed throughout, being flat-mounted and semi-flexible.

Appendix One – Journalistic Articles

Ambient Aesthetic Newspaper Article

Beyond the final frontier

At last someone has opened an internet cafe that's not just for geeks. The design of Nutopia, says Jonathan Glancey, is as innovative as the technology it offers up on its sleek, streamlined terminals

Ever since Stanley Kubrick released his magisterial 2001: A Space Odyssey, people have dreamed of inhabiting the film's supercool interiors. That was in 1968, when Nasa's own living spaces were about as glamorous as an electrician's workshop, but the movie sets still look good. They have influenced generations of designers from Tom Dixon and Marc Newson to Grant Mitchell, the New Zealander who has just put his stamp on London's newest internet cafe, the ethereally good-looking Nutopia.

Mitchell and his associates make the link explicit - the new cafe is, they say, "challenging the imagination of its competitors with interiors that steal from Kubrick's masterpiece". It also "aims to provide a space where technology meets creativity in an environment designed to appeal to a style-conscious clientele". That claim, loosely translated, means that a group of talented young computer and design buffs have created the first convincing "cybercafe", a space that aims to match the dream of computer technology.

Mitchell, 35, came to England from Auckland 15 years ago. He studied the piano from the age of five, but trained as a graphic designer before emigrating. He liked the idea of setting up some sort of work and meeting place where anyone could drop by, and was disappointed by the internet cafes that sprang up across Britain in the 90s. There was a mismatch, he thought, between what computers could do in terms of imagery, and the look and feel of internet cafes and offices that revolved around computers.

So Mitchell teamed up with George Philippakos (Nutopia's IT director) and Toula Philippakou (its operations manager) to create a corner of the capital in which those willing to pay £5 an hour can disappear into a computer-generated virtual world while inhabiting a workplace that is itself about as close to cyberspace as you can hope to find.

The Nutopia concept will doubtless be copied, but Mitchell and gang intend to keep several steps ahead of their rivals. What they have between them is that all too rare mix of passion, energy, imagination and technical know-how. "It's about imagining what we could do and could be," says Mitchell. "The name Nutopia comes from a statement made by John Lennon and Yoko Ono in 1973. We announce, they said, the birth of a conceptual country, Nutopia. It has no land, no boundaries or passports, only people". And this, more or less, is what Mitchell and co have set out to achieve in Covent Garden - a space

where boundaries dissolve and it can be hard to tell what is real and what is unreal.

Karl Marx, after a few glasses of claret, might have liked working in Nutopia, for here, like nowhere else in London, all that's solid really does appear to melt into the air. By mixing old and new technologies - film projectors, slides, computer-generated imagery - Nutopia escapes the unthinking attachment to the new that distorts so much current thinking.

Low lighting levels, fish tanks, wires and cables hushed away are just some of the elements that help to make Nutopia such an airy and relaxing space to be in and work in. These, and the continually changing installations of furniture, fittings and artworks chosen by Mitchell and co. On display until the beginning of April are a light-emitting polycarbonate sofa by Ansel Thompson; a kinetic light sculpture made of three skipping ropes and a "chromastrobic" light by Paul Friedlander; and wall-mounted light panels by Jason Bruges that change as you move across or in front of them. These are inspired designs that connect the pop art world of the 60s with that of the 2000s and the promise of cyberspace.

The question that emerges and morphs in the brain after a mind-expanding visit to Nutopia is this: why, given the ability of computer programs to generate fantastic visions, are architects and designers incapable of realising such digital dreams in real space?

It's true that without computer modelling we would never have seen such brave and inventive buildings as Frank Gehry's Guggenheim Museum in Bilbao or Renzo Piano's Kansai International Airport. And yet, inside, neither building offers a breakaway sense of space. This is for one necessary reason: they are required to perform tasks - the display of artworks of many periods, the mass movement of people - that more fantastic configurations might only confuse. Except in the smoke-and-mirror games played in spaces like Nutopia, the cyberdream can so far only be seen on computer screens and in books.

Hybrid Space, a new book by Peter Zellner, a US architect who studied with Rem Koolhaas at Harvard, looks at the work of a dozen architectural practices worldwide. All are attempting to connect the real world with the virtual world, to exploit the computer's ability to create unexpected new forms through digital animation and complex algorithms, even to crossbreed biology and technology (very much a 60s dream; try not to think of Roger Dean's album covers for Yes). "Their researches," says Zellner, "are triggering a phase-shift in our perception and comprehension of space, materiality and time at the start of the new millennium."

Maybe. This is, of course, millennial and thus messianic thinking, although no less valuable for that. Many of the weird and wonderful spaces shown in the book are as unattainable, given existing building materials and technology, as the speed of light is for a spaceship, even the wonderful machines that moved so gracefully through 2001. That said, it is also true that Ludwig Mies van der Rohe, the great Prussian modernist, designed two remarkable glass skyscrapers between 1919 and 1921. These were to set the tone of many

of the best office buildings of the 20th century, but at the time Mies conjured them, they were impossible to realise.

The mere fact that Zellner's architects are thinking about cyberspace is important. Architecture need not come to a full stop with bricks and mortar, steel and glass or even polycarbonates and neoprene. At the moment, however, we will have to make do with subtly theatrical spaces like Nutopia. This gives us the feel of what we might yet achieve as computer design comes of age and we begin to see how we might create buildings and interiors as ethereal and happily uncertain as a magic-lantern show. Or Mitchell's favourite interior, the Louis-XV-meets-supertech hotel room somewhere deep in hyperspace where Dr David Bowman, hero of 2001, arrives during the last reel of Kubrick's masterly exploration of future space.

The Guardian Newspaper, 28/2/2000

Future of Design and Technology Newspaper Article

Forward Thinking

Cars that phone home, walls that move and fabrics that make us run faster: technology is about to change the way we live. As London focuses on innovation, with the opening of 100% Design and London Fashion Week, we offer a glimpse into the future...

Ian Philips

Imagine this. You tell your curtains to close, and they do so. Your washing machine orders parts for itself when it breaks down. And the walls of your sitting room can move back and forth. Sound like a bad acid trip? Well, if you believe Neil Spiller, a senior lecturer in architecture at University College London, these innovations could soon be coming to a home near you.

According to Spiller, the author of a book called Digital Dreams: Architecture And New Alchemic Technologies: 'We're at the most interesting point for architecture in the last 100 years. With computing power doubling every 14 months at no extra cost, we can start to sew it into the surface of buildings to create "interactive-response architecture".'

The possibilities are endless: doors that open with the help of a retinal scanner rather than a key; lamps controlled by robotic arms, so they follow you around; and furniture made of latex and 'muscle wire', which changes shape to hug the body of each new user.

Similarly mind-blowing notions of the home of the future are on show until 5 October at New York's Museum of Modern Art, in an exhibition called The Un-Private House. It includes a conceptual project devised last year by the Manhattan practice Hariri & Hariri. In the Digital House, interior and exterior walls are made of liquid-crystal-display (LCD) blocks,

which can offer a range of functions to enhance daily living. Information about cooking, for instance, can be shown above the kitchen worksurface, while the bedrooms are equipped with devices that allow sleepers to record and replay their dreams.

Another of the projects exhibited - Frank Lupo and Daniel Rowen's Lipschutz/Jones Apartment - has actually been built. The couple who own it are both Wall Street traders, and in order for them to keep up with stock-market movements around the world, there are computer screens throughout the flat. There's one next to the bathroom mirror, which can be consulted while you are shaving. There's also one by the bed, which no doubt means that Lipschutz and Jones can synchronise their love-making to the ups and downs of the FTSE 100.

For many, being reminded of work when you are brushing your teeth seems like the ultimate nightmare. While most of us won't be eager for an LCD screen to be installed in the shower, William Russell, of the London architectural practice Adjaye & Russell, is sure that within a few years, mainframe computers for houses are going to become as common as televisions. 'They will operate everything in the home,' he predicts. 'They are very expensive now, but for top-level jobs, they're what clients are asking for.'

What seems certain is that, increasingly, the objects within our homes will interact with each other. 'Design nowadays is more about creating experiences than it is about objects,' affirms Tucker Viemeister, head of the industrial-design division at Razorfish in New York. He is talking about things such as your car phoning your house to let it know you're on your way home, or your coffee maker being linked to an electronic calendar so it knows not to make an espresso for you if you're away on holiday. These things, he says, could be with us in the next three years.

The technology used to create such wonderfully wacky 'experiences' is called Wireless Application Protocol, or WAP. 'WAP,' Viemeister is convinced, 'will bring about bigger changes than the Internet.'

Others are not so sure. 'People have a healthy resistance to gadgets,' insists architecture's Mr Minimalism, John Pawson. 'I don't think the home will be full of them,' agrees London-based architect, Pierre d'Avoine, who recently won the Concept House 1999 competition for his vision of the terraced house of the future. 'There will be invisible technology. Environments will keep their ordinary facades, but technology will be built in.'

Even a techie like Kevin Warwick, professor of cybernetics at Reading University, is not certain what the public is ready to accept. He has developed a robotic security guard for the home, but asks, 'Do people want things moving around their house at night?'

At Philips in the Netherlands, enormous research is being carried out to find out exactly which innovations would be welcome. 'The process now is validating what is acceptable on the marketplace,' says the company's design director, Stefano Marzano. 'How far are consumers ready to embrace hyper-intelligence? What kind of intelligence do we want objects to have?'

Listen to Daniel Libeskind, the Berlin-based architect behind The Spiral, the celebrated extension for London's Victoria & Albert museum, and he'll tell you that fascination with technology and gimmicks is on its way out. 'Technology should not be an end in itself, but a means to an end,' he says. 'People will just lose interest in technology if it overshadows the human and imaginative space of architecture and desire. People don't want to live in the experimental world of technicians, but in a place that deeply concerns the stability of the human being.'

He is convinced, though, that technology will change the shape of buildings. 'Frank Gehry is only just scratching the surface,' he says, referring to the American architect's amorphous Guggenheim Museum in Bilbao. The technique used by Gehry came from the aircraft industry, and consists of a robotic arm tracing the form of a hand-made model and then relaying the information to a computer. It allows buildings of almost any shape to be made, and Pierre d'Avoine, for one, believes that 'exotic' forms will soon be more widely adopted for private homes. 'There will be an openness for something other than box houses,' he says.

Boxes, it seems, are on their way out across the board. 'Computers have to stop being black boxes and pay more attention to who we are and what we want to do,' say Chris Pacione and Chris Kasabach, of the visionary design house Sandbox Advanced Development. They are thinking not only of the curves and colour overload of the iMac computer, but of something more radical.

A few years back, they were asked by Intel to come up with their vision of the computer in 10 years' time. One of their solutions was Digital Ink - a computer in the shape of a pen. They see no reason why hi-tech devices shouldn't come in the form of everyday objects. 'All projects are cubes, because all the components, such as the chips and circuit boards, are cubes,' says Sandbox's CEO, Astro Teller. 'Yet objects can take any form. We are no longer limited by technology.'

At Philips, Stefano Marzano is also keen to combat the dehumanising nature of hi-tech objects, and talks about devices for the future that are 'intelligent, but also caring. Vases could contain not only water and flowers, but also software,' he suggests. He also imagines a hi-fi system in the form of ceramic pots, and television remote controls integrated into the arms of sofas.

IDEO Product Development in London has designed a computer in the form of a plant and a printer disguised as a drawer. They have also come up with the Kiss Communicator, which allows you to blow a kiss to your beloved, even at a distance of thousands of kilometres. Sensors in the handheld device pick up your kiss, transform it into a colour pattern and transmit it electronically to your partner's device. As it lights up, your partner knows you are thinking about them. 'It's very playful,' says IDEO's Matt Marsh. 'It's about taking the technologies and working out ways we can delight people.'

Integrating technology into haute couture is the goal of French designer Olivier Lapidus. For years, he has been working with research laboratories to present a new innovation at

each season's catwalk show. In the past, these have included fabrics made of flowers and plants, as well as dresses incorporating solar panels and wearable computers. 'Innovation will be incredibly important for fashion in the next 10 years,' he predicts. 'Styles will be dictated by technological breakthroughs.'

In the media lab of the Massachusetts Institue of Technology (MIT), researchers are working on a whole range of mind-boggling 'wearables'. So far, they have managed to make keyboards from conductive fibres that can be put through the wash, developed a lapel pin that doubles as a camera and microphone, and come up with wearable electronic navigation aids, which are currently being tested by the US Army. In the future, they imagine tourists wearing them to find their way in a city.

Meanwhile, Sandbox Advanced Development has created an offshoot called Bodymedia, which is working on ultra-chic and wearable health monitors. 'Our aim is to become the Swatch of health monitoring,' says Astro Teller. The goal, it appears, is to bring a bit of hip to health-related devices. What looks like a sports top, for example, actually has a mini-computer and sensors built in, which can monitor everything from your respiration and heartbeat to your skin temperature. Through a two-way pager, it sends signals to the Internet, which can then be accessed by your doctor to check whether you're in fine fettle. The company also plans to make stylish rings that can tell you whether you're stressed, and to turn the hearing aid into a covetable fashion item. What's next? The designer colostomy bag?

Health-related issues are clearly on the minds of manufacturers at the forefront of textile development. 'Smart' fabrics that protect against harmful ultraviolet rays are already available, while others are marketed as 'anti-bacterial' and 'anti-stress'. 'Stress is static electricity which builds up in the muscles,' says Thomas van Cauwenberghe, from the Belgian fabric manufacturer Sofinal. 'Anti-static yarn such as carbon fibre is incorporated into materials, takes out the static in your body and helps you relax.' Sofinal has also developed a remarkable 'auto-regenerating fabric'. You can make a hole of up to 1 sq cm in it and then repair it by simply rubbing.

Other textile manufacturers are concentrating on developing fabrics that keep body temperature constant, whatever the weather. Schoeller Textiles in Switzerland has come up with ComforTemp - a material in which there are microcapsules that absorb your energy if you are too hot, and store it. 'When you are too cold, they release the energy and heat you up,' explains the company's vice-president Christine Jenny.

A similar temperature-regulating fabric called 'ceramic polyester' has been developed by fashion designer François Girbaud. He is currently developing textiles that allow you to introduce substances, such as beauty products, to act on the skin. They will be made of hollow fibres, into which you can insert the desired liquids. The same principle has already been used by the MIT media lab to develop fabrics that change colour. 'You have hollow fibres with electronic ink in them,'

explains MIT professor Alex Pentland. 'When you apply small charges to the fibres, the ink changes colour.'

Guillaume Tiberghien, from Paulbonte Technical Yarns in northern France, imagines fibres that will act as artificial muscles, even further into the future. 'They will contract or elongate at the same time as your own muscles and provide you with extra strength,' he says. No doubt they will prove particularly popular with 21st-century Tour de France cyclists!

The development of wild and wacky materials, however, is not a domain exclusive to the fabrics industry. Daniel Mason, of London screen printers Artomatic, has started to work with 'plastic paper', a futuristic, white polyester film. The Australians have started printing money on it. However, despite his dalliance with polymers, Mason believes 'people will go away from plastics in the next five years'. John Pawson agrees: 'The more technology there is, the more people will need to find a refuge from it. More people will value materials such as stone, wood and water.'

Ecological considerations will inevitably influence design in the near future. 'Architects will have to move towards non-technical solutions which don't consume energy,' predicts Daniel Libeskind. Architect Pierre d'Avoine believes that buildings of the future will be heavily insulated with organic products, such as shredded newspaper and sheep's wool, and that the majority of houses in 20 years will be fitted with photovoltaic panels, which convert solar energy into electricity. John Pawson believes that sound pollution will increasingly become an issue. 'There will be more emphasis on places to escape to - quiet places in public spaces. I think technology will also gradually make machines quieter,' he says. Anyone for a silent pneumatic drill?

Sound is just one of the things on the mind of Geoff Crook, who runs the Sensory Design Research Laboratory at Central St Martins, in London. For him, the future of design should be multi-sensory. 'As human beings, we have at least five senses,' he says. 'However, contemporary design is generally just visual. Everywhere you look, even in architecture, there is a lack of tactility, audio design and aroma.'

He plans to remedy this by having different smells piped into homes, doorknobs made out of new tactile, sensuous materials, and sounds we like automatically played as soon as we arrive home. Crook also believes that companies could market their identity through other means than image. One of his students, for example, has worked with Tesco to produce its own brand smell.

Crook himself has developed a sensory-led concept to replace aisles in supermarkets. It consists of snaking glass walkways with water flowing underneath. On either side are tiered plastic display mounds that emit the smells of the produce on them when touched.

Whatever the future of supermarkets, the future of homes is sure to be about versatility and flexibility as both a reaction to the increasing speed of change in our lives and the collapse of the nuclear family. Adjaye & Russell is currently working on a versatile building in Brick Lane, east London, in which the ground floor and basement can either be a

photographic studio, a separate apartment or part of the whole house.

In the architect Rem Koolhaas's much-lauded Maison à Bordeaux, sliding screens fitted into ceiling tracks can be shifted and artwork displayed on them to change the look of the space. As for John Pawson, he predicts that more sophisticated ways of plumbing will allow water to be delivered to every part of the house and thus blur the distinction between different rooms. 'We'll have water in our living rooms and bathrooms that are places to spend time in.'

A number of exhibitions in the UK this week give a further insight into the homes of the future. At the 100% Design exhibition at Earl's Court (23-26 September), Jam Design and Communications have collaborated with Whirlpool and Corian to present a vision of the kitchen of the future. It includes a versatile refrigerator, in which various sections can be closed down.

'Most people go shopping once a week,' explains Jam's Jamie Anley. 'So, by the end of the week, there's almost nothing left in the fridge and you're uselessly consuming energy to cool down empty spaces.' In the future, he envisages food being delivered to houses the way mail is, and deposited into a chute that will lead directly into the refrigerator. He also confidently predicts that 'light bulbs will be obsolete in three years' time' - to be replaced by light-emitting diodes and luminescent panels: 'Lighting will all be integrated, and you won't need any wires.'

Whether or not we do away with Edison's invention by that time, lighting possibilities will certainly increase in the next decade. At the cutting-edge Designers Block show at Bishopsgate Goodsyard in Brick Lane this week (23-26 September), the German company Kombinart will present a lamp whose light source is an LCD screen. In the future, John Pawson imagines plaster walls that can take an electrical charge to make them glow.

For the Homes For The Future expo in Glasgow (until 24 October), Habitat's Tom Dixon came up with large, colourful lights that can be joined together to act as room dividers. Versatility is clearly a major preoccupation of furniture designers. For the Glasgow show, Ron Arad has created inflatable seats that can be transformed into different shapes by vacuuming, and One Foot Taller has come up with a lounge chair that can be expanded into a sofa of variable sizes.

At 100% Design, young designer Fiona Davidson will present 'Room Project 1', a system of six pieces of furniture which fit together into a box shape. The function of each piece is deliberately blurred. You could either sit on them or put things down on them. You can also create different shapes by slotting together various pieces. 'It makes the user think,' declares Davidson. 'You become more aware of the space you're creating when you move these things around.'

Renny Ramakers, co-founder of the ultra hip Dutch cooperative Droog Design, predicts there will be a greater interaction between users and objects in the next few years. 'There may be products which are not finished, for example, and which the user has to complete,' she says. 'Thus, the products will become part of the user's identity.'

Already, motorists can change the colour of their Smart cars with adjustable panels, and customisation of products is becoming increasingly available with every day. The North Carolina non-profit research lab TC2 has developed a complex version of an inkjet printer using a dye that won't stain or fade, which will allow people to custom-print their clothes. It also invented the 3D body scanner that has been installed in a new Levi's store in San Francisco. The machine takes your body measurements in a matter of seconds. They are then sent to the factory, and within a couple of weeks, you have your own tailor-made jeans.

Ramakers foresees a backlash to globalisation, with designers reanalysing their own regional identity. 'Everything is now looking the same. There are the same shops in New York and London,' she laments. 'I think designers will start placing much more importance on regional qualities and traditions.' She also believes there will be renewed creativity, and certainly more choice.

'We're on the verge of the century of eclectism,' says French designer André Putman. 'With minimalism, we have banished any deviation, anything amusing. Design has become a sort of dictatorship, in which people choose objects simply out of snobbism. My greatest hope is that people will understand that a house can only be beautiful when it resembles themselves. For me, there is going to be a renewal of charm.'

Putman's scenario seems plausible, but who knows how design will really develop in the next 10 years? As John Pawson says, 'The design of the future is like sharks. The only thing we know about them is that they are unpredictable.'

The Guardian Newspaper, 19/9/99

Appendix Two – Adaptive Hypermedia Technology (HyperAudio Research)

Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia,
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Content Adaptation for Audio-based Hypertexts in Physical Environments

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Find a postscript version here (gzipped, 56k)

Abstract:

The most important new issue emerging when allowing the fruition of a hypermedia repository of information while the user is moving in a physical space is the fact that information is presented in different situational contexts. Also, an additional perceptual dimension comes into play, providing stimuli, attention grasping and feedback. Emphasis should be put on *integrating* the perceptual experience with helpful information, *without competing* with the original exhibit items for visitor's attention.
In this paper we shall discuss some of the critical issues about content adaptation emerging in physical hypernavigation, presenting the approach adopted in the HyperAudio project.

keywords: content adaptation, physical hypernavigation

Introduction: navigating a physical hyperspace

New hardware technology allows the fruition of virtual repositories of information while enjoying the physical space: for example, kiosks or portable devices may allow the access to a portion of a virtual information space relevant for the object in front of the visitor.

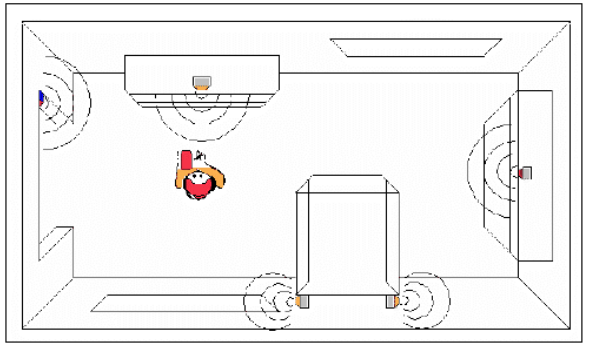

Figure 1: A visitor exploring an augmented room in a museum. (full size, 8k)

Figure 1 suggests one possible scenario of this kind, where visitors of a museum or an exhibition may enjoy a personalized tour through the interaction with the physical space augmented with an overlapped synchronized informational hyperspace (we will call this interaction context a *physical hypernavigation*). Each visitor is equipped with a palmtop

computer endowed with headphones, on which an infrared receiver is mounted. Each meaningful physical location has a small (power-autonomous) infrared emitter, sending a code that uniquely identifies it.

Exploiting the infrared signals, the system is able to identify when the visitor reaches a certain physical location and can activate a relevant portion of the information repository loaded on the palmtop. Meaningful information are selected and organized to be played as audio messages or displayed on the palmtop screen. Adaptive and dynamic hypertext technology can be exploited to tailor a presentation according to the visitor interests, the actual context of the visit and so on.

We are currently investigating the features of this scenario inside the HyperAudio project [Not *et al.* 1997], a project IRST is developing in collaboration with the Civic Museum of Natural Sciences in Rovereto (Italy). The results gained inside HyperAudio will contribute to more advanced research efforts towards a richer interaction scenario, to be explored jointly with other partners inside the HIPS European project.

Navigating in a physical hyperspace is quite different from browsing an electronic book or a traditional (even adaptive) hypermedia running on a stationary console. The cognitive problems that may arise when a person is moving in a virtual information space (e.g., being lost in the hyperspace or the cognitive overload, [Conklin1987]) are different from those of a person moving in a real space, since an additional perceptual dimension comes into play, providing stimuli, attention grasping and feedback.

In this paper we shall discuss some of the critical issues about content adaptation emerging in physical hypernavigation. We shall particularly focus our discussion on the museum environment, which introduces additional stimulating challenges for effective content adaptivity.

Content Adaptation in a physical hypernavigation

The problem of adapting content for (cultural) information presentations in physical hypernavigation shares many features with the problem of producing adaptive and dynamic hypermedia for virtual museums (e.g. [Mellish *et al.* 1997]) or dynamic encyclopedias (e.g. [Milosavljevic *et al.* 1996]), as confirmed by many psychological studies made on museum visitors. For example: information should be stated in terms the visitor can understand (adaptation to expertise/knowledge level) and should help the visitor connect the new information to what he already knows ([Hood1993]); information should include references to visitor's interests ([Serrell1996]); content should be provided in a form that best stimulates learning on the part of the hearer ([Serrell1996]).

However, content adaptation in a physical environment poses some original problems which are related to the fact that the visitor is experiencing a ``real'' situation: moving in a real environment, looking for concrete objects to observe, and receiving perceptual orientation feedback. The peculiarity of inserting a hypertextual structure onto a physical space generates new ways of navigating information:

- moving around the physical space, approaching the various cases, the visitor implicitly "clicks" on meaningful points of the hypertext (the system is able to track the visitor's position by means of sensors);

- as in solely information spaces, the visitor may explore the sub-network of the hypertext nodes related to the physical object he is standing in front of; in addition he can proceed with the exploration within the physical dimension:
- after getting information about the object, the visitor may decide to move in a direction that was explicitly or implicitly suggested by the message (for example because a comparative description was heard that introduces a new interesting and related object). But the visitor may also decide to suddenly change the suggested tour thread. Physical hints may attract his interest more than the proposed hypertextual links: he may be distracted by interesting objects close by or he may have personal intuitions about semantic relations between objects that make him stray from the undertaken path. The system can try to cope with movements that drop out from the hypertextual structure applying techniques coming from the area of dialogue modeling: for example, tracking topic shifting or modifying its assumptions on the user's preferences.

When assembling information presentations the system should take into account the prominence of the situational context, *integrating* the perceptual experience with helpful information, *without competing* with the original exhibit items for visitor's attention:

- The system should provide information to help direct visitor's attention to and stimulate interest in the objects ([Bitgood and Patterson1993], [Boisvert and Slez1994]). This means that messages offered to the user should directly refer to what the user is seeing (also exploiting appropriate linguistic forms, e.g. deictic references as ``this object'' or ``the object on your left'') and should help the user to identify the object described (and its importance) among the others displayed.
- The information should be preferably conveyed via audio messages, allowing the user to freely concentrate on the concrete objects.
- The system should not overwhelm users with information ([Finn1985]), though providing opportunities for the interested visitor to easily find new and more detailed information on a subject ([Serrell1996]). Although this issue is relevant for presentation systems in general, it becomes crucial when the user is physically moving through museum rooms and standing in front of exhibits. In fact, physical tiredness might appreciably affect user's attitude toward long commentaries, as well as his satisfaction and learning.
- The system should integrate information with directions that help the user orient himself in the physical space (e.g. how to reach an interesting object, a friend, the exit, ...) and decide where to go next.
- The system should adapt its behaviour according to a user model dynamically updated interpreting either the user explicit interaction (clicking on the palmtop screen) and his movements.

It may be argued that nowadays virtual reality technology allows the realization of virtual museums in which visitors navigate in a synthesized 3-D environment. Many of the issues above are relevant to this scenario too. However, the human computer interaction in augmented space is still substantially different at least for the presence of physical fatigue associated to movement.

Two dimensions of content adaptation: the user and the situation

In traditional adaptive hypermedia (either running on a stand alone computing station or accessed from a stationary console through the WWW) the most important adaptation factor considered is the user. The interaction context is quite constrained, with the user sit in front of the screen on which the system interface is displayed and with the following possible modalities to interact with the system: clicking on hyperlinks; typesetting information requests; gesturing (if suitable devices are available, e.g. a touch screen).

The most important new issue emerging when allowing the fruition of a hypermedia repository of information while the user is moving in a physical space is the fact that information is presented in different situational contexts. The main factors determining the situational context are (i) the user position and movements (whether he is in front of an object or whether he is simply walking around a room); (ii) the structure of the surrounding physical space; (iii) whether other people are examining the same item or not; (iv) whether the user came alone or not. Even though mobile computing nowadays allows to access hypermedia while the user is moving in the physical space (as in the case of a visitor walking around a museum and browsing on his palmtop computer the museum's web pages), existing systems do not offer real dynamic adaptation with respect to the situational context.

A system effectively supporting physical hypernavigation should integrate the individual, dynamic modeling of the user (his knowledge, interests, goals, integrated with abilities, attitudes and preferences) with a general model of the environment, of user's movements and user's social context.

Importance of audio modality

In a traditional hypermedia, where the user is typically expected to browse around and *read* written information, though enriched with images and sounds, the system can hardly be sure that the user has really read (let alone assimilated [Mellish and O'Donnell1998]) the message. Permanence time associated to hypertext pages is usually not significant, unless some additional feedback is exploited (e.g. mouse moves).

When the audio output modality is available, combined with a position locating system tracking the user movements in the physical space, more information can be inferred about how the user is receiving the messages. For example, if the user is standing in front of the object currently described by the system and does not explicitly stop the presentation or does not move, the system could guess a high assimilation score.

But even if audio output could be a plus, we must be careful not to waste the positive aspects of this resource. In fact, if message content is not properly adapted to the audio modality the risk occurs of introducing an additional disorientation effect or dissatisfaction in the user. This

phenomenon is more evident here than in traditional hypermedia because the user can not skip uninteresting or unsuitably tailored information as easily as in a hypertext.

HyperAudio Presentation Composer

In HyperAudio, information presentations are built by the system and are provided to the visitor whenever he reaches meaningful locations or when he explicitly asks for information. Each *presentation* is a structure containing (i) a sequence of audio files which will be played through the headphones, (ii) a set of relevant concepts worth of further elaborations which will be depicted on the display as clickable buttons, and possibly (iii) images related to the object or concept described and a properly oriented map displaying the visitor's current position.

The audio presentations are built concatenating precanned audio files selected from the informational space. In HyperAudio, the informational space is designed so that its contents and its structure can be used in an adaptive way. The information unit is the *macronode* (see fig. 2). Each macronode includes a network of audio files, a list of pointers to other relevant macronodes (including the particular rhetorical relations between them), the type of text (e.g., general introduction, detailed description, ...), a pointer to the relevant semantic concept in the ontology, and possibly a link to a physical location for which the message would be pertinent.

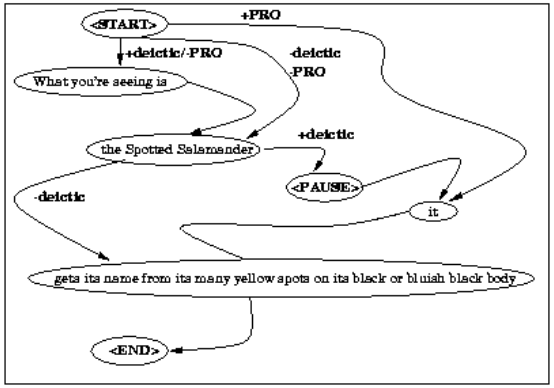

Figure 2: Sketch of macronode network (full size ,5k)

More than one macronode can be selected to build the actual presentation. A macronode is atomic with respect to its content but it can have some optional parts that are selected only in some particular discourse contexts. For example, the macronode audio file network in figure 3 can be instantiated in the following messages:

- when the feature `deictic` is selected (i.e. when the visitor is in front of the object being described): *What you're seeing is the Spotted Salamander <PAUSE> it gets its name from its many yellow spots on its black or bluish black body*;
- when the feature `deictic` is deselected: *The Spotted Salamander gets its name from its many yellow spots on its black or bluish black body*;

- when the feature PRO is selected (i.e. when the message has to be joined to another one with the same topic): *It gets its name from its many yellow spots on its black or bluish black body*.

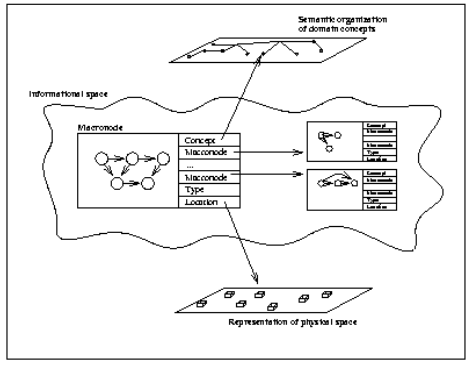

Figure 3: The audio files network for the Spotted Salamander macronode (in the figure, each circle in the network represents an audio file or a command to the audio player). (full size, 3k)

An audio file network encodes lexical variations of the same message (that means that whatever instantiation you choose, the content of the text is the same). The task of instantiating a network performs in a simplified way some of the choices typically performed by the tactical component of an automatic natural language generator.

An important piece of information included in the macronode is the type of the message stored in the audio file network. Borrowing from [Serrell1996], we have defined the following message types occurring in the museum setting:

- **introductory labels**: descriptions of exhibition goal and extent; they have to be slow enough to help the visitor get used to audio modality and must contain invitation to look on the screen to request further information and exploit the maps;
- **section labels**: descriptions of rationale behind subgrouping of objects (including area descriptions or overviews and historic/social background); they can be played also while the visitor is moving;
- **captions**: object descriptions; they should contain visual, concrete information and make use of deictic language;
- **follow-up information to captions**: information related to objects (for example, general descriptions, anecdotes or similar); they are meant to elaborate information in caption messages;
- **way-finding and orientation messages**: directions for reaching a physical location; they should make use of orientation hints (it is important a correct assumption on user position).

The type describes the purpose of the message and it is exploited in the decision process aimed at building communicatively effective presentations (as discussed below).

Another important information contained in a macronode is the set of macronodes semantically related to the current one. For each related macronode the kind of connecting relation is also indicated. At present, we are using a limited set of relations to capture the ways in which **follow-up information to caption** add information to a **caption** message: among

others we consider `elaboration-general` for general new information, `elaboration-part` for part-whole descriptions (it is useful in natural science domains), `elaboration-legend` for legends, anecdotes, and so on.

How an adapted presentation is assembled

Each time the system has to describe a concept, it collects all the macronodes which refer to that concept and exploits a set of heuristics to decide what macronodes have to be discarded, what have to be played as the current audio presentation (and in what order) and what will be realized as textual anchors on the screen. Some of the heuristics are similar to those used by other adaptive systems, exploiting the user knowledge model (for example to select comparisons to already known concepts or introducing explanations for unfamiliar terms), the user interest model (to stress user preferred topics), discourse history (both to not select macronodes already presented and to introduce references to already seen objects)[Mellish and O'Donnell1998].

Other heuristics are more specific for the task of hypernavigation in physical space. For example, adaptation to the physical situation (discussed in section 2.1) can be addressed by:

- (i) selecting the feature `deictic` whenever possible (in particular, for **captions** and **follow-up to captions** but also for **section labels** in order to enrich presentations with references to the physical environment);
- (ii) for **section label** presentation: adding **orientation messages** to highlight interesting spots nearby (exploiting the user interest model [Sarini and Strapparava1998], and a model of the physical environment to compute distances between interesting objects);

Of course, the visual part of the presentation is exploited as well: in our current implementation, **introductory labels** and **section labels** have associated a map which is displayed on the screen and is always maintained oriented consistently with the user's current orientation, and **way-finding messages** are played on demand.

In order to maximize the communicative efficacy of the presentations, we have implemented a set of heuristics that constrain the ordering and the type of messages that are concatenated in a single audio presentation. For example,

- in front of an object, only one **caption** can be selected for an audio presentation, and it can be followed by one or more **follow-up to captions** with the same associated concept (selecting the feature PRO);
- when entering a new room or exposition area, only one **section label** can be selected, and it can be followed by **captions** and **follow-up to captions** preferably with the same associated concept (selecting the feature PRO); if needed the presentation can end with a **way-finding and orientation message**;

- if **way-finding and orientation message** is the primary communicative goal of the presentation, it should not be followed by any other message.

The length of audio presentations should be carefully constrained: presentations based on **captions** should be short (relying on the visual anchors on the screen if the visitor needs more information), presentations based on **section labels** can be longer. **Way-finding and orientation messages** should be very short when associated with other messages while can be longer when they represent the primary goal of the presentation.

Conclusion

Even though we focussed our discussion on the museum setting, many of the critical issues discussed in this paper about content adaptation beyond the traditional stationary hypermedia setting do apply to any physical hypernavigation setting (e.g. being guided in tourist/cultural sites, in airports or in complex buildings).

We are currently designing a set of experiments with real users both in a laboratory setting and in the Civic Museum in Rovereto in order to test the validity of the proposed heuristics as well as the user acceptability of HyperAudio.

We wish to acknowledge the contribution of the other members of the HyperAudio team (Gregorio Convertino, Daniela Petrelli, Marcello Sarini, Oliviero Stock and Carlo Strapparava) to the discussion of the ideas presented in this paper. In particular, many thanks to Marcello Sarini and Carlo Strapparava for useful comments and suggestions on previous versions of this paper. Valuable input was also provided by the discussions with the other members of the HIPS consortium.

Key Texts

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Harris, M. (1999)	*Augmented Reality for Projected Displays,* [BEng Dissertation]. Dept. of Manufacturing & Mechanical Engineering, University of Birmingham.

Key WWW Gateways

ICHIM	Useful for an overview of technology in museum research papers	http://www.archimuse.com
HyperAudio	The homepage linking to all research papers developed for this significant technology	http://ecate.itc.it:1024/projects/hyperaudio
RCA CRD	The homepage linking to research and MA course information in 'Compute Related Design'	http://www.cdr.rca.ac.uk
BIAD Museums Project	A central resource for museum related projects conducted, like this, at BIAD.	http://www.biad.uce.ac.uk/research/museums

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