Tangible Light Interaction

*How light portrays the tangible action
of things and spaces around us*

Richard Appleby
r.s.appleby@tue.nl
Technische Universiteit Eindhoven

Kees Overbeeke
c.j.overbeeke@tue.nl
Technische Universiteit Eindhoven

Abstract. The field of tangible interaction currently studies how the user interaction with physical products can be improved through physical feedback, as a more direct experience. Here we explore this subject further with particular emphasis on the elements of visual attraction of illuminated surfaces as an early factor in the interaction process. Richard Appleby is an experienced industrial designer who has developed many consumer products where the surface definition and visual language has had a significant impact on the perceived values and tangibility of the product. These changing surface interactions should not be difficult or challenging, but intuitive and enjoyable to live with. The systems may be complex, but the way they reveal and offer their actions can heighten our awareness and sensitivity in new and unique ways. It is a question of subtlety and detail. As the surfaces we interact with have the intelligence to appreciate a much wider range of human conditions and user feedback, their response can be attuned more closely to our different senses and feelings, particularly as this leads to more subjective and sensorial types of interaction, with varying dimensions and magnitude. These surfaces change through colour and form that attract the user we coin 'tangible light interaction'. Particularly within the field of intelligent technologies, project examples show design concepts that support social interaction and remote communications in new ways.

Keywords. Tangible Light Interaction, Pre-interaction, Surfaces

Introduction

The field of tangible interaction currently studies how the user interaction with physical products can be improved through physical feedback, as a more direct experience. Here we explore this subject further with particular emphasis on the elements of visual attraction of illuminated surfaces as an early factor in the interaction process. The first author is an experienced industrial designer who has developed many consumer products where the surface definition and visual language has had a significant impact on the perceived values and tangibility of the product.

Figure 1. Pasta Maker = soft tangible surfaces, and Navigation Displays = high contrast surfaces
(product examples designed by Richard Appleby)

Early contributors to the field of tangible Interaction, particularly by Stephan Wensveen, [1], have clearly established that considerable improvements in many aspects of interaction design are attributed to the awareness of and need to 'design with' the perceptual-motor and affective skills, in addition to the more traditional cognitive processes. As Wensveen questions, " How can we design for human product interaction, so that product gets information about what we 'know' and how we 'feel' from the way we 'do' this interaction, in order to adapt to this information?"

It's all about where the 'known' information is at any given point in time, in order to provide the most sensitive interaction. If products are simply seen as tools and designed as objects then they rely on people to provide all the information during the interaction process, with no capacity for the product to interpret these given commands. There is a functional interpretation, it's just very literal and follows the instruction given from its operator. Computers and other semi-intelligent products don't work like this, they provide some feedback and reactions to our input and so we appreciate this information exchange, (and sometimes we find it irritating). Nevertheless, this change in the way products are now equipped with more adaptive and re-active capacities, signify this shift in focus to the point where the information is and subsequently, this changes our perception of products and the way we interact with them. Using the tangibility of light builds expectations of how much more products and spaces around us can contribute to our experience and interaction, simply through the information and knowledge they make tangible through action. Finally the beauty of this feedback loop between perception and interaction is manifest in the richer engagement, awareness and sensitivity to our spatial experience.

But how does light become tangible. . . .

To start with, Gibson [2], provides us with simple definition of light and surfaces. . . . ." Light comes from the sky and becomes ambient in the air. This is what makes persisting surfaces potentially visible as well as potentially tangible." . . . and then later on. . . " The surface is where most of the action is. The surface is where light is reflected or absorbed, not the interior of the substance."(p23) Within his theory of affordances, Gibson later describes surfaces as an invariant which do not change

relative to the observer's viewpoint. . . ." the affordance of something does not change as the need of the observer changes. The observer may or may not perceive or attend to the affordance, according to his needs, but the affordance, being invariant, is always there to be perceived." (P.138) With these references in mind, when designing for more intelligent environments many questions arise that are concerned with the tangibility of form, colour and surface (and their illumination to the observer), that can change the user-attraction and interaction with many different products and situations.

Also, with the introduction of intelligent technologies within our everyday spaces, we are provided with opportunities to interact in more sophisticated ways. Surfaces might be able to change their reflective qualities and tangible definition. Where materials are conceived through genetic or artificial nano-technologies, surfaces may become more variable in their colour and form. Subsequently, the surface affordances that Gibson refers to may become very much more acute in their definition and attractiveness to the user. They can change in order to attract and elicit a response from the user during the interaction experience.

These changing surface interactions should not be difficult or challenging, but intuitive and enjoyable to live with. The systems may be complex, but the way they reveal and offer their actions can heighten our awareness and sensitivity in new and unique ways. It is a question of subtlety and detail. As the surfaces we interact with have the intelligence to appreciate a much wider range of human conditions and user feedback, their response can be attuned more closely to our different senses and feelings, particularly as this leads to more subjective and sensorial types of interaction, with varying dimensions and magnitude. This surfaces change through colour and form that attract the user we coin 'light tangible interaction'.

Cues and tangible responses.

Through our knowledge of construction and needs of high volume consumer markets, our built environment and physical products are traditionally designed in a way that facilitates the manufacturing process. The configuration and arrangements of these constructed artefacts have visual cues which are more to do with their 'history of making', rather than embodied design values for user interaction.

Now we can design specific 'cues and responses' which are more closely related to our human interaction at that moment, rather than design values that are centred around the object's construction. There will simply be various states of interaction – such as active or passive, collaborative or autonomous, and so on, where the character and resemblance of objects and the surrounding context depends on the type of human interaction. If we are concerned with physical elements and a physical space where we are designing for adaptive changes which happen frequently, then materials and dimensions used for designing and creating these environments need to maintain a simple geometric framework or 'design system' which can then contain interactive zones (functions and media) which may be highly complex. Such was the design exploration from the 'Light Story' project, by Guus Baggermans,[3], an Industrial Design Master Student at Eindhoven University (TU/e). He developed the product concept "Newsflash".

This project topic was about how people review news stories in the paper and other media. Since these stories are publicized 24/7, they are much more available to read in your free time, (rather than necessarily on the way to work or when the newspapers are available). Also, because this information is updated on worldwide databases (internet) with different interpretations appearing in many different papers across many continents, then comparisons between different opinions and political interpretation are easy to see. The project studied how light itself can become more physically tangible and how it can be influenced by the visual attraction and gestural movement when people are browsing or reading the newspaper stories. Projected light is deliberately chosen to deliver the image to the reading pane because it simulates the experience of a more typical reading situation. The light and dark parts of the image are reflected from the surface of the reading pane rather than being electronically emitted from a PDA type screen based product. The challenge was to form a more sensitive balance between the visual attraction and hand movement, to guide how the text flows across the 'reading plane'. In this way, the turning page action is replaced with a connected visual and gestural action.


**Figure 2.** Newsflash project by Guus Baggermans

The physical product was comprised of a book system, which opened to provide a two-page surface, with a laser projector positioned as a 'reading light' to project text based images onto the book surfaces. Incorporated within these surfaces, sensors were embedded and tuned to recognize proximal hand movements. The projector resourced the text from the internet, based on the direct interaction movements of the reader, which are sensed and transmitted to the projector light by Bluetooth connectivity. Holographic projector technology with infinite focus is used in order to maintain a sharp image across variable contoured surfaces of the book.
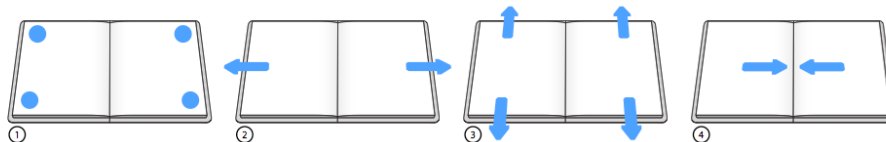
Figure 3. These illustrations show the four stages of interaction. (1) Four headlines are displayed and the reader can move his hand over the desired topic to select a more detailed story. Then within the selected category, two new stories appear, resourced from the web search. (2) By moving the hand from the centre of the page outwards to the edge, then this story is pushed off the edge of the page. (3) If the hands are moved either upwards or downwards, then this action discards the story and replaces it with another story in the same topic. (4) Finally, if two hands are brought towards the centre of the book, then this signifies closing and returns the page view to (1) the four headlines again.
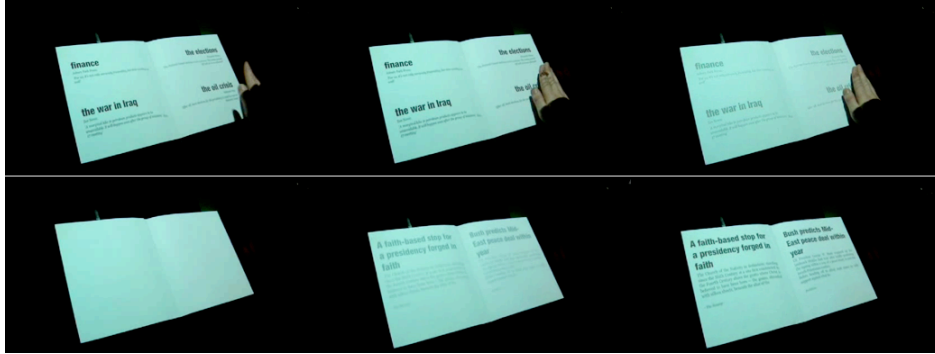
Figure 4. Four headlines are displayed and the reader can move his hand over the desired topic to select a more detailed story. Then within the selected category, two new stories appear, resourced from the web search.
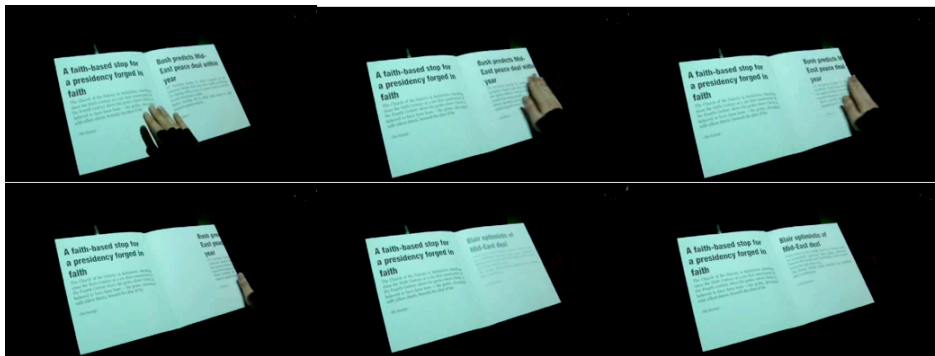
Figure 5. Rather than considering the pure efficiency of the technology, this project links the human movement and feeling to the searching and reviewing gestures. The light projection provides the atmospheric tangibility with all the shadows and other influences of ambient light that contribute to the reading moment. The user's movement shapes the portrayal of stories. It only happens at human speed, however fast or slow that might be. Sample users were invited to inspect and play with the working prototype to provide some early qualitative feedback on the interactive design, readability, and browsing experience.

More tangible presence and proximity

With many interactive experiences such as those found in modern communication technologies, the form of interaction greatly determines the kind of experience a person feels. With simple voice telecommunications there were clear differences in the social protocols between business conversations and more casual 'gossip'. Business calls are generally functional in nature and once the questions have been answered, then the call ends. With more sociable conversations the objectives are different. It is not so important what the conversation is about, but pleasure is gained from simply talking to someone you know. Vodaphone identified in their consumer research that the network usage for these 'social' conversations was much higher, for each person, than the time spent on more direct functional calls. This research also indicates user preferences of

difference technology products (wired versus wireless) because of the perceived reliability of the product makes a difference to the consistency and emotional feeling communicated between people. *(It is not a pleasant experience to be exchanging intimate comments in areas with intermittent bandwidth)*

Now with increased use of posted (email) and real time messaging, the 'presence' of the person you are communicating with becomes more abstract. It is more difficult to imagine where your friend is answering from, or what their situation is, are they at work or home, etc., exemplified by the telephone table interaction project entitled, 'ratphone' from Ab Rogers [4]. There are things that can be deduced in real time voice conversations but are somewhat disguised and missing from messaging and email services, more contextual information is missing. Also common in longer voice calls is that people multi-task. They are able to have longer conversations provided they can continue with other tasks in their daily routine, but this is a problem with communications services that require keyboard input. All of these issues steer towards questions about communicating 'context' and 'presence' between callers as an important factor that supports the interaction experience. (remote sociable interaction)

These notions are further supported by David Frohlich [5], which provides a survey that contrasts domestic calls with workplace conversations, and identifies different aspects and recommendations for further research in this field.

Such was the design exploration from the 'Follow me phone' project, by Joris Zaalberg, [6], an Industrial Design Master Student at Eindhoven University (TU/e). This project explores how light tangible interaction can replace forms of more physical manipulation of hand held phone products. By including a more multi-sensorial approach in the design process for social interaction, we are able to provide considerable freedom and preference in how people enjoy more continuous conversations. He developed product concepts for a multi-node domestic phone system that referenced the speaker's proximity within the immediate physical context and communicated that in real time to the respondent. Further research explores how we understand social voice conversations, how we perceive different forms of space, intimate space, personal space, social space and how that influences our notion of 'presence', between callers. Another important aspect of this project was changing the time dimension. Zaalberg observed that when people talk to each other in everyday situations, they do not start and stop conversations in a formal way. Rather they 'drift' in and out of a continuous sequence of conversations, where others join and leave at different times, but the main conversation continues. Conversely, normal telephone conversations have well established protocols of 'opening the call' and 'closure', which interrupt the general flow of any longer social interaction.

Subsequently the concept emerged as an 'open' conversation space (on 24/7), which determined the different aspects of human proximity and presence, with light tangible interaction embodied within the distributed nodal system. This meant that users can drift from room to room and simply adjust their interaction according to proximity to the speaking node. This distance and movement is made tangible through the colour, intensity and size, of light rings that surround the voice node. This is seen by the remote caller to register their presence and availability to talk. Obviously this can support multiple users where many people can freely join and leave the conversation, without interruption, and each can see the presence and proximity of other callers.

The technology is based on a network of a few nodes positioned in a domestic setting (perhaps one per room), and using a simplified version of short range radio

frequency that senses the variance in received signal strength, thus determining the distance (proximity) between slave and master devices. This had the technical sensitivity at low range (close distance) and the advantage of relatively low power consumption for this kind of computing process.
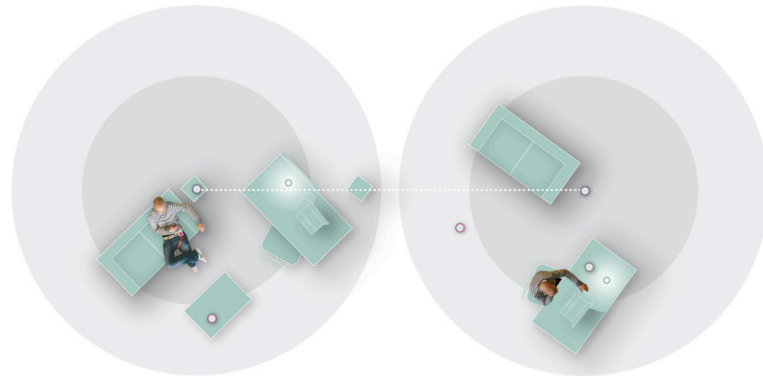
Figure 6. Distributed network of phones in domestic environment
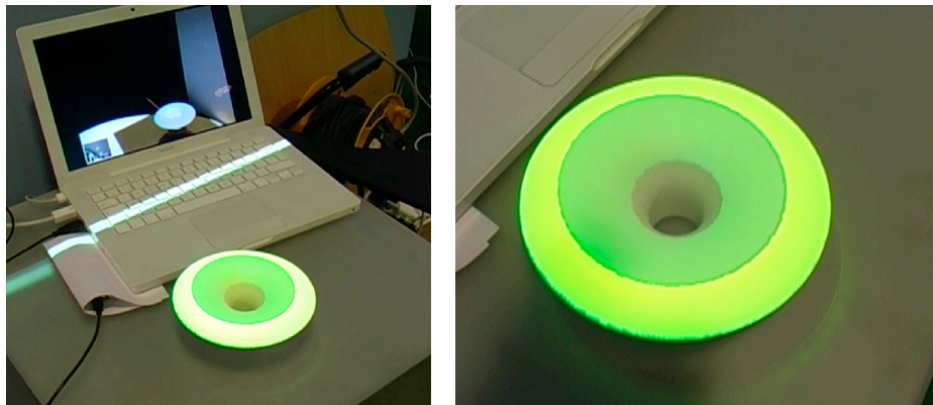
Figure 7. These pictures show a prototype set up where in the background you see one phone is in a remote environment being recorded on video and displayed on the computer screen. In the foreground is a similar phone connected directly. As people move closer or further away from the phones their proximity is registered and changes the visual response from the phone system nodes.
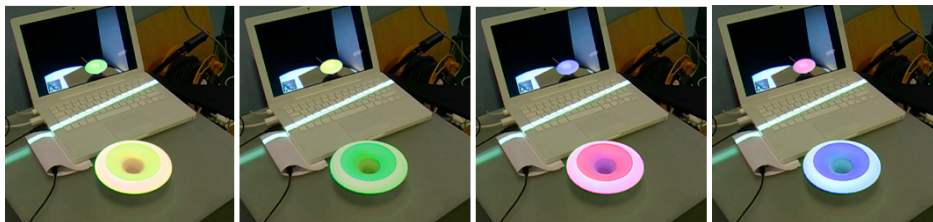
Figure 8. These four simulated images show how the visual indications (colour differences) can change according to the user proximity at both places.

Figure 9. The experiments

Experiments were conducted to test a variety of aspects of this prototype where users followed a scripted conversation. Whilst this research is not completed, we can draw some provisional; conclusions from the observations taken during the experiments. The original research question was concerned with: does an 'always on/visual proximity cues' phone system facilitate social interaction over distance'? Early findings showed: Always on audio looks like a very promising tool for social interaction over distance. People who talk a lot benefit from the voice and visual light interaction of this system, whereas quiet people tended to use the visual presence indication more frequently. The tests also indicate that the users find it easy to experience the system in their peripheral awareness and only address it when they wish to.

Light Tangible Interaction - In Space.

Designing for spatial interaction requires a more 'immersive' approach to the design process. This has been explored in many different ways already. . . design in context, designing movement, senses design. Spaces don't change to such a great extent. However the interventions of light, sound, movement and other media can radically change the 'feeling' and 'awareness' of the space around us and change the way we perform and move within a space. We are interested to explore these more adaptive elements that make the spaces more tangible and intuitive. These can be very direct and functional objects moving, or more ambient media that is more seductive and gradually changing. Our perceptual awareness and interactions within a space

change according to the viewing position and depending on the type of ambient information provided. So, to what extent do your senses pick up the contextual media and how does this influence your interaction within the space? There are many meanings hidden in the background of the space and lighting of our environment. How is the spatial information delivered and presented? How can it be created and performed within the spaces we occupy, how can it intervene and change space. This is a more phenomenological approach to designing that appreciates conscious experiences and sensations that are immediate and peculiar to each person and place. Maurice Merleau-Ponty [7].

With recent intelligent technologies and various types of sensing tools we can develop 'adaptive spaces' which can do several things. They can sense the presence and movement of people and objects and change some elements to be more tuned to our perceptions. Or they can work the other way round and reverse and augment what we currently perceive as being 'normal' in our everyday environment. This can subvert our relational senses as a form of surreal and disorientating effect. This spectrum is a kind of dimension of adaptation, where the outcome of the created effects are directly relative to the senses of the individual person or object that is experiencing the change. There are many possible aspects and interpretations.

These surreal and imaginary scenarios may be quite theatrical. The tuning of contextual information can enhance the quality of experience, where ambient signals and reflections heighten or reduce awareness. The interconnection of different visual fields relative to each other and the observer, can propose a more directional 'teasing and seducing' approach, thus producing a more personable and persuasive context . Overbeeke, C.J., Wensveen, S.A.G. (2003) [8]. To explore this further, we conducted a short workshop for the ID Master students in the Faculty of Industrial Design, Eindhoven University. We also made comparisons to other design research work from Mathew Emmett [9] and Peter Dalsgaard [10].

Taking these explorations a step further, within such adaptations of light, sound or other media is the idea that they serve as 'monitors' of our perception (awareness signals) These effects influence our feelings creating attraction towards or distraction away from the source. In this way it helps us to measure these dimensions as relative values with our immediate environment in physical terms of distance, proximity, temperature, resonance, etc. So our senses 'monitor' our perception of effects around us. We watch how different media are rendered and presented and feel how this affects our emotional state. In this way we can estimate these proximal dimensions as a more intuitive reference. So instinctively, we are attracted towards sources of illumination, and brightness that allow things to reflect and be perceived in greater detail.

An example of this from the workshop is a design proposal for waiting areas within 'sHertogenbosch Railway station, created by Annegien Bruins Slot, [11]. Seasonal changes mean that some areas of the station are well lit during the summer months, whereas during the colder seasons they remain dark and rather uninviting. During rush hour there are sufficient people to provide a safe atmosphere, however in the times between or late in the evening, people hurry by, avoiding personal contact and are often frightened by the prospect of standing alone. Simple 'hotspots' of light were suggested, automatically activated by individual's presence on the platform, which provides a warm cocoon of light, appearing from above and below, to surround and protect the waiting person.
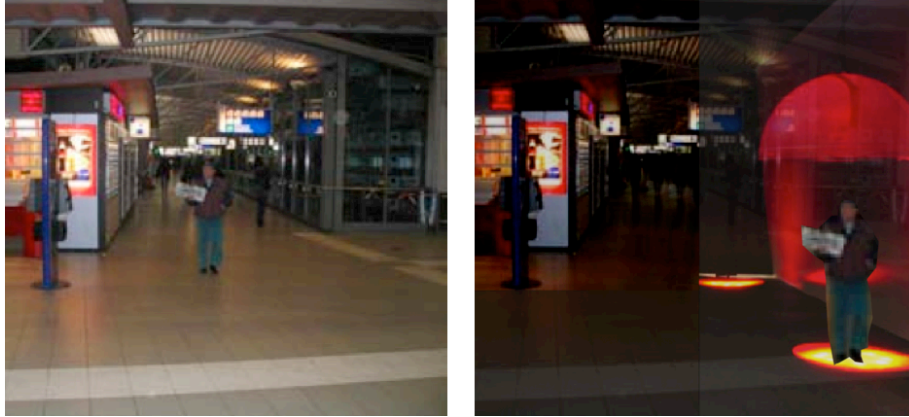
Figure 10. 'Railway Station Hotspots' by day and by night.

At a more precise level, objects with high contrast and high reflectance such as jewelry and precious metals, high contrast screen displays, black/white text, etc., all induce high levels of attraction. These things are very clearly seen and accurately perceived, where the media levels describe the physical attributes and boundaries of objects and contextual effects very clearly. On the other hand, when experiencing situations of low media sensitivity, our perception is blurred and diffused. There is nothing to sense and measure from. In this situation designed interventions for interaction can be introduced to heighten our perceptual focus and ability to measure our relative position. Arguably, within these examples there are known environments where the physical dimensions are evident and realized through frequent visits. In terms of how our awareness alerts our actions relative to our emotional feelings, this known physical information has a fairly low level of importance compared to more direct intervention of user specific media and light which has a much higher emotional effect and magnitude.

How tangible light experiences can contribute to the pre-attentive awareness of subsequent interactions.

Within the recent film 'Minority Report', Spielberg [12], the 'Pre-cognitives' were three characters portrayed as special people who could anticipate and see into the future. They were employed by the national crime agency in order to see and intercept crimes before they were committed. It isn't quite as simple as that but this is an aspiration that we all imagine would be interesting to happen. The term precognition from the Latin definition of 'prior cognitio' refers to a situation of 'getting to know' where there is a form of extra sensory perception that is required to perceive information about things before they are about to happen. This effect is rather paranormal, clairvoyant, and scientifically difficult to argue.

However, our explorations and experiments that involve 'tangible light' are about real time events that are a prelude to human interaction with objects and situations. It refers to the earlier part of the human interactive sequence that is often assumed or ignored. Early perceptions are formed about the objects that are seen, which contribute

to the expectations and actions we subsequently perform. These early perceptions 'before the interaction' are quite clearly evident and can be observed in everyday scenarios. This phenomenon is about the quality and type of subsequent interaction. It is an information collecting and selection process for the preparation of the action. These early perceptions we coin 'pre-interactive'. Importantly, some are quite direct and intuitive, elicited during the performance of action. But there are also things observed that are relative or can be associated to other situations. The latter are concerned with more abstract perceptions like visual language, semantics, and other associative concepts. I have tried to distinguish the differences:

• Pre-Interaction is everything that immediately precedes a human interaction with other objects or media, where the purpose and values of the interaction are introduced, indicated by the pre-interactive state of the observer.
• Semantics is a definition of meaning that is achieved through the deliberate use of icons, symbols, or other indices that is relative to the observer in that particular situation. Some would argue that everything we create has some semiotic dimension or effect, simply through the process of being created or built. It is away of relating other known experiences and forms within the newly designed object (or interaction) that makes it more understandable. It conveys the meaning in several ways simultaneously. More abstract semantics can form a 'visual language' of particular objects and spaces.
• Gibson's 'affordance' of an object is a phenomenon that pre-interaction includes. In the sense that yes, affordances are visual signals that indicate the subsequent potential action and information available (and user orientation). Pre-interaction however, is a more deliberately designed experience, rather than an ecological definition, made up from both direct perception and more abstract observations.

So how do things become 'pre-interactive' Where more contextual information can be sensitive to human presence, movements, sounds, then this provides information which enable 'action possibilities' that determine and 'tune' the experience. Again, it is a sensitizing process where the more attractive the interaction the closer the sensitivity can be. With this in mind, further hypothetical project studies are evolving that review the material 'person to product' relationships and propose more layered and abstracted ways interact with material and projected media. The next paragraph introduces future projects that explore this research topic further.

Tangible light to communicate remote context

Many different types of media available today are able to support social communications in many different ways, particularly remotely. The direct, voice to voice conversation as it has evolved only provides a limited 'experience' value in terms of appreciating the wider emotional senses and feelings of users communicating with each other. The time spent in social communication has become more abstract. Many different services are now available that provide posted media as a background presence to support relationships – email, msn, facebook, etc. More economic travel services have led to need to support long distance relationships, particularly within a business environment. Communicating contextual information and media is seen as a key element of the communication of more social and emotional feelings, within everyday environments.

The 'Context Communicator Prototype' spatial design system is a hypothetical concept to explore these theories. The objective is to provide the 'point of view' of a remote person to another, transmitting different types of recorded media in real time. The important factor here is the positioning and selection of the communicated media and presentation to the receiver. These aspects can illustrate the actions, senses and feelings of one person to another, as a direct contextual link. You see what they see, and hear what they hear. This is seen as directly opposite to the picture postcard, or the holiday video that has a deliberately manufactured effect. This intends to capture more random but real experiences without edition, thus portraying the true experiences from one to another person. This will be much more interesting than a normal voice calls on current telephones or mobiles. It communicates your physical point of view (your seeing position and perspective) and articulates this image within the receiver's environment. It will communicate what the other person is looking at, both objects and contextual information in answer to the question – 'where are you?' and 'what does it feel like?' Deliberately only images and sounds sent at predetermined intervals (or indeed triggered by the caller) could provide rich information about the immediate surroundings and events to a distant friend. There can be many different abstractions that provide different interaction possibilities, from direct and literal information (media) in real time to adaptive and abstract media, with time dependencies. The spatial interpretation also has many variable parameters, which can be explored according to how the user interaction intervenes as a component of the communication. Because of the difficulty in seeing the complete 360 degree context at the same time, the captured data can only provide cues and suggestions of context and movement. This has "suggestive" and impressionistic" advantages. As individual elements they are quite random and abstract, but when reviewed collectively, these aspects can illustrate the actions, senses and feelings of one person to another, as a direct contextual link. Below is an example of context sample images to provide the feelings and impressions of being in the same location. The position as a 'viewpoint' is communicated through the height, position, movement, and angle of view. – Walking by the waterfall in the sun. .

Figure 11. Context views, walking by the waterfall in the sun.

We depend on the surrounding context as a definition of the physical and material dimensions, according to how well or how occluded the immediate surroundings are. This is how we read our surroundings and explore location specific information. The surface geometry and materials also change how images may reflect the sense of location and experience and to what extent the visual detail can be perceived on the same plane or separate surfaces.
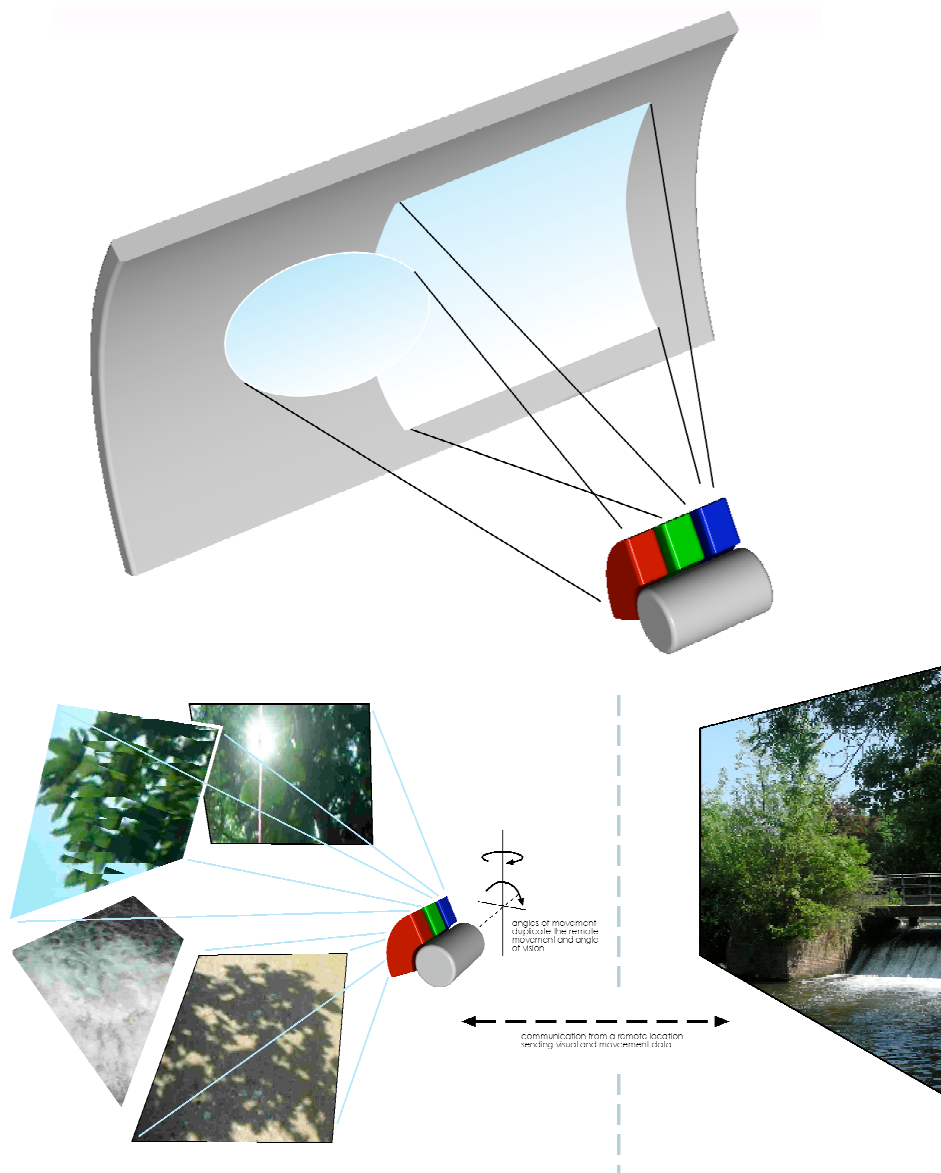
Figure 12. Basic projection system connected to remote location

The physical aspect is also important. Ecologically we exist within a mixture of direct and ambient light, both daylight and artificial light behaves as a multiple source depending on the environment around us. In this respect screen displays on many technology products are too literal. They have a consistent back-light which is not particularly context sensitive and trying to create the right ambient lighting without glare or reflection is difficult for many products. However, projected images on the other hand, behave in a similar way to other lighting systems (both direct and ambient), where they are able to contribute to the general atmosphere – affording the observer

visual dimensions from the physical and material surroundings. Smaller LED and laser technologies enable a much higher colour resolution, video image display, with a long focal range. Surfaces and object planes at different distances and angles can always maintain a clear image definition. The visual images are abstracted from the normal technology format in order to portray a more direct 'feeling' of the environment they are being retrieved. The impression of the remote location becomes more immediate and purposeful and thus a more direct and realistic 'shared experience'.

To summarize, we have discussed the way surface definition and lighting reflection can influence our tangible perception and interaction with objects and environments around us. There are examples of projects that show cues and responses that are informed through tangible light. There are also examples of how these design concepts can integrate theories of presence and proximity as tangible light for communication. Then aspects of spatial context are discussed to explore feelings and awareness within larger scale locations and how lighting surfaces and effects provide a relative and tangible visual field. Finally, I note three supporting observations which contribute to these thoughts and ideas as; 'pre-interaction', 'semantics', and Gibson's [2] 'affordances' before concluding with a hypothetical concept of the 'context communicator' as a next step for this study. I believe that the research and development of these theories and concepts will provide a platform to explore many different aspects of how media supports communication of feelings and actions more directly and sensitively. Subsequently, indicating how this can remotely support the social and emotional aspects of relationships over distance.

Acknowledgement:

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