RETRIEVING LOST SPACE WITH TANGIBLE AUGMENTED REALITY

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Abstract. Tangible Augmented Reality can be an innovative way for designers to understand the spatial conception. Due to the high integration of tactile and vision, this realm allows users to gain a better understanding how to retrieve ‘lost space’ in an urban context. By using a variety of visualisation methods, such as wireframe and transparencies, hidden or other ways unperceivable (lost) space is made available. With the aid of Tangible Augmented Reality designers are subsequently able to evaluate the design context and its solution more holistically. This paper argues that the retrieval of lost space enhances the design communication.

Keywords. Tangible augmented reality; tangible user interface; augmented reality.

1. Lost Space

Before explaining how space in Augmented Reality (AR) can be lost, it is better to understand the meaning of ‘space’. Space can be defined as the unlimited or incalculably great three-dimensional (3D) realm or expense in which all material objects are located and all events occur (http://dictionary.reference.com/browse/space, Dec 2008). In various circumstances, space can represent different meaning, such as the room in three dimensions: the space occupied by a body or surface, the gap to be filled in a document, etc.

Space has caught much attention in urban design processes (Seichter and Schnabel, 2005). The usual process of urban design looks at the space to be filled with buildings, streets and squares as isolated objects within a landscape. Typically this process causes the designer to make decisions about growth patterns based on the two dimensional (2D) land-use plans or statistical data,
without really considering 3D relationships between buildings and spaces and often without a deep understanding of human behaviour within that space. However, an urban context can be understood as an exterior volume with properties of shape and scale and with connections to other spaces. In reality, it is difficult for designers to image the space between the individual objects because that space is void which is impossible to be seen. Obviously most time that space become lost since it seems impossible to be defined clearly. Lost space can be regarded as the leftover unstructured landscape at the base of high-rise towers to the unused sunken plaza away from the flow of pedestrian (Trancik, 1986). Lost spaces are also considered like the residual areas between districts and loosely composed commercial strips that emerge without anyone realizing it (Trancik, 1986).

Such a gap could disrupt the overall continuity of the city form. In order to develop public spaces that are vibrant and economically sustainable the designer needs an understanding of the space that is experienced in by users of the urban space in a one-to-one scale. The current tools seem do not provide enough information for designers to understand the urban development master plans with for example effective pedestrian movement and spatial change. It is essential for architects and engineers to work alongside and develop strategic ideas based on the updated change.

2. Needs

There are two kinds of form perceptions: visual forms are usually perceived by means of our eyes, and haptic forms which we perceive by means of our hands or some other part of the body. Tangible Augmented Reality (TAR) is a high integration of visual and haptic forms which beyond what Computer Aided Design (CAD) tools offer. Although CAD tools are inevitable means for expressing and simulating innovative ideas and concepts, whereby traditional processes are being replaced by mixed realities and 3D CAD systems in making sketches, study models, control drawings, mock-ups, etc. (Schnabel, 2009). As information unit of design tools has been transformed from “paper-based” to “computer-supported/generated”, designers’ performance has been greatly improved; most design tasks are now impossible without CAD tools.

However, vision is always regarded as the most noble of the senses (Pallasmaa, 2005), and education philosophy has likewise understood architecture primarily in terms of vision, emphasising the construction of the 3D visual images in space. A visual form is always supposed as a figure against a background (Hesselgren, 1975). An example can be demonstrated from Robin’s classical figure-and-ground (see Figure1a). Usually people first perceive
a white vase against a background, but all of a sudden, the understanding changes and we see two black faces looking at each other and they are perceived as figures against a white background. On the other hand, if you reverse all the black and white to paint a black vase on a white ground (see Figure 1b), one considers all the black as “figure” and all the white as that which it represents the background, which lies behind the figure and stretches out on both sides with no definite form. If one tries fixing the figure in our minds we will notice that at the bottom the base extend out on both sides and above it a number of convexities also project on to the white ground. But if one considers the white as figure and the black as ground, for instance, an empty space in the figure opening into a black space, immediately one sees something quite different. The vase disappears and instead two faces in profile appear (Rasmussen, 1987). In other words, the white becomes the convexities projecting out onto the black ground and forming nose, lip and chin. This simple example underlines that in most cases the attention has always been caught by the filled space. Although people can shift their perception at will from one to the other, alternately seeing vase and faces. But each time there must be an absolute changing in perception. It is not ease to see both vase and faces at the first moment.

This reveals that we do not conceive the two diagrams as complementing each other. Ordinarily convex forms are seen as figure, concave as ground. The outline here being a curvy line it is possible to see either black or white convexities, as you choose. But most 2D motives that are carried out in two colours force the observer to see one of the colours as figure and the other as ground. In Figure 2a, the designer used different colours to represent different functions with various definitions of space. The image provides users to test design options prior to project start, identifying potential opportunities and risks in advance. Sometimes designers use dark colours such as the black to
represent the background within the city (see Figure 2b). This figure shows how accessible every transport facility is from each part of the street network. These figures are used to illustrate an integral part of the consulting solutions such as pedestrian movements, public transport accessibility, land use, etc. It is obvious that people would not understand the illustration unless equipped with specified knowledge. Even if they do have the qualified knowledge, they may still have to keep track the meaning of different colour while making any design decision, which is a heavy cognitive load to designers and users.

Another shortcoming may be that the information presented is based on 2D diagrams. However, a design scenario is often more complex than it could be depicted in 2D diagrams. Architects are dealing with 3D space. Nowadays, designers are using computer simulations, renderings and other information as their core of their design, yet this base is often only the result of small scalar environment that obits elements that are perceivable in the physical environment.

As the design environment transforms from physical world to virtual world, designers are faced with emerging intangibility problems. As realistic as it can be, the rendering results on monitors cannot provide realistic tactile feelings of design models as can foam models or other physical prototypes.

3. Proposed Methods

TAR can enable designers to learn how to retrieve the lost space as described above. High integration of representations from visual and haptic stimulus is a unique feature of TAR systems, which exposes learners to multi-channels from the concreteness and sensory directness. The proposed TAR-based training
system consists of video-imaging, computer vision/graphics and knowledge-based components. The learner can see the urban space from the video image. This image is also the source for the computer to detect, and track physical objects and then merge this image with additional graphical information for the final process. During the design procedure, tracking is used to detect and track objects, whereby the position of each object is reported continuously to the system. All virtual objects obtained from the computational process present wire-frames and images showing the object’s orientation. That allows boundaries of different objects be viewed within the wire-frame visualisation. When the designer makes changes of configuration, the corresponding feedback can be viewed at the screen. The wire-frame guides the designer to the destination of picked object, whereby the space between different objects can be viewed in relationship to the properties of shape and scale with its connections to other spaces. Additionally, with direct feeling through physical materials from tangible interfaces, perceptual and motor responses are complemented to have an enhanced spatial competence.

Billinghurst (2007) has categorized four types of AR-display: first, there are browsing interfaces which are used to receive information; second, 3D AR interfaces which are comparable with conventional interface transferring 2D to 3D; third, the Tangible Interfaces (see Figure 3) which use the object to produce operating interaction and combine AR with real environmental space. This category of interfaces allows users to manipulate objects freely with cognition of each individual operator. And fourth, TAR uses the projection system to augment virtual objects on the interface to enable real-time interaction. Figure 4 illustrates a TAR used with a computer game.

![Figure 3: Tangible Interfaces (Ishii et al, 2004)](image-url)
TAR allows reflecting on different void spaces. For example, when a designer tries to decide which type of contour for the buildings to use, it may seem that such a decision would not actually affect the movements of the streets, etc. Figure 5 and Figure 6 present two different outdoor spaces. The spaces between buildings and streets are highlighted with a red line. Yet once these void spaces are highlighted, the designs are distinguished differently. Therefore, these spaces can be perceived by designers since the wire-frame will outline these spaces. This helps designers to achieve better understanding of different options by highlighting invisible spaces.
4. Tangible Augmented Reality System

There are three levels of functions of the TAR-system: distance, 2D area and 3D volume. The initial interpretation for an urban area can be provided with the raw data for the distances of the spaces between different objects. For example, a 2D map can be projected to the screen using graphical interface. The raw data could be pre entered into the TAR program. Physical objects are then arranged and positioned in the initial plan. When a designer starts to observe the relationships between buildings, streets, rear-gardens, etc., distances and measurements can be visualized and presented according to the specific relationship between objects. Hereby the designers are presented with instant feedback and relevant results in ‘real scale’ of the given scenario. Users then can interact with the physical objects as they would do with a physical model in a conventional design studio. These and additional data are immediately projected to the corresponding location within the AR-system.

The second level deals with data/information based on area. Users modify the size of buildings or other objects in order to fit guidelines or regulations while at the same time the designer can decide maintaining the information received from the earlier step.

The third level considers space within its 3D representations. Users can study a particular scenario in their design and choose between different methods to display solid and void, which reveals another set of information.
5. Conclusion

This research integrates the TAR into digitized technology. Mainly this research intends to enhance the interaction of Tangible User Interfaces (TUI) and AR systems to define the void space in urban design activities. The aim of using TAR is to evoke new instructional technology into design learning during a design activity. This allows designers to interact with the space, which can effectively transmit information to user with the immediate feedback from the change of design decision. Therefore the starting point is to utilize the digitized interface operation application. According to the form of designers' behaviour it is known that there is desire and requirement on the perception of the design. This research applies TAR technology to solve this part of the problem to understand how to use the space more efficiently and ecologically.

References