The building is the program

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Abstract. We present interaction with a physical building as a hypothetical example of peripheral interaction. The state of the building's windows provides input to an algorithm which produces abstract art as the result of the interaction. This paper assumes the principles of autotopography and Gestalt when considering the use of physical objects for peripheral interaction and computer program definition. By including the Internet of Things in the discussion on peripheral interaction, the latter is no longer constrained to geographically co-located stimuli and responses.

Keywords: internet of things, computer program, peripheral interaction.

1 Introduction

Individuals often modify their environment towards self-determined objectives. For example, a person might turn on a desk lamp or open a window. These examples of individualistic actions are peripheral to the ultimate objectives of reading a book or breathing fresh air. Not only are these actions peripheral, but they are also executed at the periphery of an individual's attention.

The result of an action may be instantaneous (a lit lamp) or gradual (fresher air). A delay may therefore exist between an action and its outcome. Also, an action may manifest itself remotely. An example of an action with both delayed and remote results is when a window is opened at one end of a long passage to allow air in all interconnected offices to be refreshed.

An individual action may affect multiple persons. Conversely, the actions of multiple persons may affect an individual. Therefore, one-to-many and many-to-one relations between actions and results are possible.

In the lamp and window scenarios it would be quite feasible to enhance these physical devices with computational abilities and have them interact with each other when manipulated. Such human-initiated action-reaction, which incorporates computationally enhanced physical devices, is generically called Tangible Interaction (TI) (Baskinger & Gross 2010). However, because the interaction is no longer generic but at the periphery of an individual's attention, it is called Peripheral Interaction (PI).

The Internet of Things (IoT) is an internet-supported action-reaction phenomenon that connects geographically dispersed sensors, computational devices, and actuators. The geographically dispersed sensing and acting dimension of PI can be enhanced by exploiting the IoT to make the relationship between multiple actions and multiple reactions even more multifaceted. The almost unlimited geographic distances which IoT affords to PI can only be fully realised if Hornecker's space-centered view of TI (Hornecker & Buur 2006) is applied to PI. We call TI which includes both PI and IoT, space-centered peripheral interaction (SPI).

In this paper we explore SPI by considering an individual's hypothetical peripheral interaction with a physical building. Here, the building is computationally enhanced and receives input from its windows, and reacts by producing abstract two-dimensional art.

This paper approaches SPI from the theoretic standpoints of autotopography and Gestalt. Section two provides the theoretical perspective to our approach. Section three discusses, with examples, objects and their relationships. In section four we consider the potential relationship between objects and computer programs. Section five concludes.

2 Autotopography and Gestalt School of Thought

Autotopography (**auto=one's own** (from the Greek *auto*), and **topography=place** (from the Greek *topo*)) is the behaviour a person exhibits by adjusting the physical environment to "*…construct a sense of themselves*", through arranging physical objects to create "*a physical map of memory, history and belief.*" According to Hoven, external memory is a subset of distributed cognition, and one of the functions served by external memory is to reduce memory load by facilitating memory recollection (van den Hoven 2004).

Petrelli (Petrelli et al. 2008) studied, amongst others, (1) what types of objects persons used for autotopography, (2) the way in which these objects were used, and (3) what made these objects suitable for this purpose. These studies revealed that the appearance of the physical objects was not always important, but rather the "time or emotion" it represented.

As far as the use of generic objects to recall memory is concerned, Hoven states that these are not ideal for this purpose because they all look the same. Hoven continues by suggesting that personal objects would be better served for this purpose "*…because the mental model is created by the user herself and not imposed by the system.*" Yet Hoven states that a single object can have different meanings to different persons. It thus seems plausible that a generic object could be used to recall memory if the person has emotion attached to the object.

The Gestalt theory of perception states that sensations are not perceived in isolation, but are "*…assembled into perceptual experiences… called a Gestalt*" (Kasschau 2003, p224). According to the Gestalt school of thought, the brain constructs perceptions from sensations based on the principles of proximity, continuity, similarity, simplicity, and closure (Kasschau 2003, p224).

3 Objects and Their Relationship

We consider computer programming with the premise that the spatial relationship between a set of objects carries information for the person who has placed and oriented the objects.

3.1 In Physical Space

A physical artefact can be considered an ‘object’ or a ‘thing’, depending on its context. When an artefact is considered in isolation from its surroundings, the artefact is classified as a ‘thing’ but when it is considered in context with its surroundings it is classified as an ‘object’ (Latour 2004, p233). Objects ‘gather’ meaning because of their relation to other ‘things’ (Boradkar 2010).

3.2 In Print

The lines, colours, and curves of a drawing are at times interesting to some in that these two-dimensional prints contain a story (Suda 2010). This is also called “visualisation” of data and has become the subject of study for some. It has also been suggested by some that a “language of charts and graphs” exists (Suda 2010). The purpose of the visualisation graphs and charts is to convey the complicated messages contained in a data set to the observer in a simple way. Suda compares the graphs that tell a story to the reader to the story is carried by text, for example in a novel, or the story conveyed to the observer with a cartoon or painting. Examples are respectively that of a painting, a plan for an electrical circuit, and a building plan for a dwelling. These are interpreted by the observer. Depending on the observer’s training and cultural background, the three examples will each convey some message to the observer. The nature of the message could range from being of no interest or value, to one of instruction/informative, to philosophical. The message can be both subjective and objective at the same moment in time, depending on the observer and the circumstance it which it is being observed. For example, the painting shown here could elicit a philosophical discussion amongst the group of artists viewing it at the Musée du Louvre in Paris. However, for a young electronic engineer it may have very little value, simply representing something a renowned person created long ago. The converse could be stated about the electrical diagram when viewed by the young engineer and the group of artists; it has little value to the artists, but to the engineer it represents a very specific assembly of physical objects that can transform an electrical signal.

Dondis (Dondis 1973, p17) explains that “*when we see…it is a multidimensional process…*”, that is, we see so many things at the same time and “*imposing…compositional forces*” on what we are seeing. We are thus not looking at an image as one would read a manuscript line by line, but taking notice of the complete image all at once and deriving the “*compositional forces*” therein. Dondis states that visual literacy is acquired through training and learning, and this explains why an electrical engineer, artist, and architect would identify with ease respectively a electrical circuit diagram, the message in a painting, and the designed function of a building.

3.3 In Art

The previous subsection considered patterns created by engineers, for engineers. Here, we consider patterns created by artists.

Artists sometimes personify art; objects depicted in a pencil drawing on paper has been described as "*a carafe with mugs as bodyguards...*" (Clement & Kamena 2000). This supports our thinking that to the observer it seems that there exists a relationship between objects. In the example of Clements, there exists a relationship between the carafe and mugs. The relationship is that of a master and those whose function it is to protect the master. Here the carafe is the master, and the mugs are the bodyguards. Next we consider how this relationship may be made clear by adding another dimension to the relationship: the dimension of forces. **Fig. 1** depicts Clement's description of the bodyguards as a force diagram. In the diagram, the red objects 'guard' the yellow object from approaches by the blue objects. 'Force lines' emanating from the red and blue objects indicate the direction on strength these 'forces'. The length of the force line is proportional to the magnitude of the force. The solid force lines are repelling forces, and the dashed force lines represent the force propelling the object in the direction of the arrow. The solid line linking objects indicate the bodyguard/master relationship.

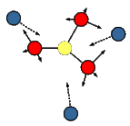

Fig. 1. 'Bodyguards' (red) repel 'invaders' (blue). Inspired by Clement (Clement & Kamena 2000).

Fig. 2. James Stirling. New State Gallery, Germany (Fichner-Rathus 2012, p28)

4 A relationship between Objects and Computer Programs

Art on canvas, and engineering drawings, may also include straight lines and geometrical symbols.

Our research considers the extension of the two-dimensional relationship between art, engineering, and computer programs to the possible three dimensional correspondences between art, engineering, and computer programs.

The vertical lines in Stirling's New State Gallery architecture (**Fig. 2**) may remind one of the sequential and uninterrupted execution of instructions in a computer program. The multiple vertical lines may represent multiple simultaneous streams of code being executed in a computer program, commonly known in the field of computer science as parallel execution of multiple program threads.

This is just one discussion of what the architecture might represent if it were to be interpreted as the logic for a computer program. It would be for the designer of the physical language to define the meaning of the physical artefact.

4.1 A relationship between Architecture and Computer Programs

We now consider how architecture could be interpreted as a computer program.

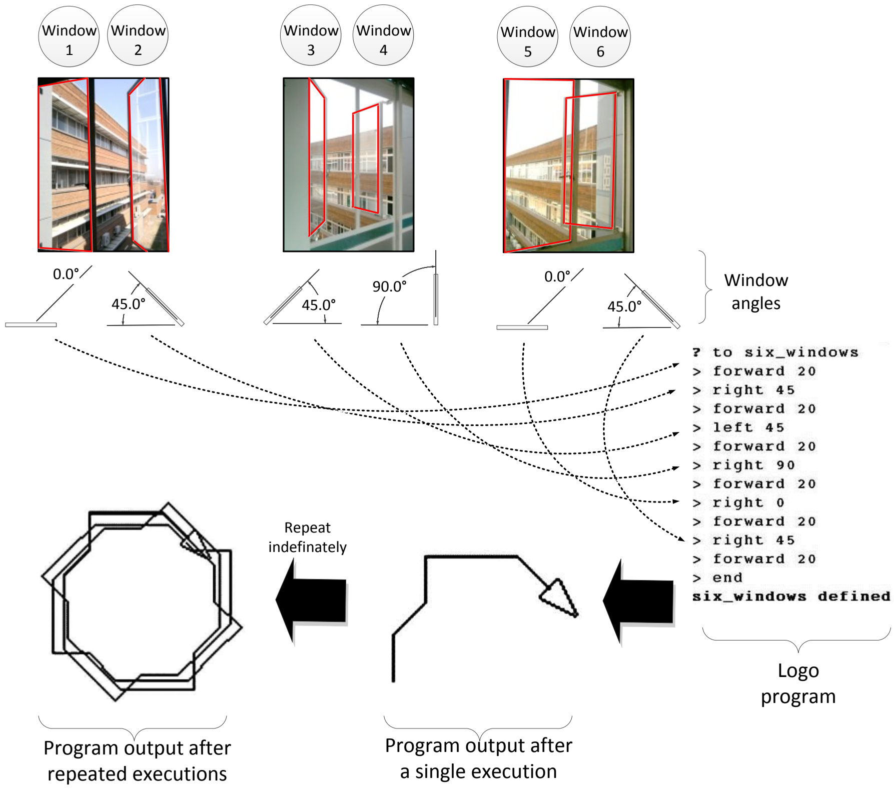

Fig. 3. Window positions translate to Logo program parameters.

Consider an array of windows (**Fig. 3**, top) and assume that the state of each window can be interpreted as a computer program instruction. Using this approach we anticipate that an office complex could be regarded as a computer program. We illustrate this concept using indoor photographs of windows along a passage linking two sections of an office complex. In this example some of the windows are fixed and others can be opened. The angle to which a particular window is opened is determined by the user and can vary between zero degrees and 90 degrees. Let's make the assumption that this angle represents the angle a Logo turtle (Abelson & diSessa 1980) turns and each turn is followed by 20 units of forward motion.

We use the following mapping: if the window opens to the left as per the user's point of view, the Logo turtle will turn to the left. The converse is also true. We do not yet have a means to instruct the Logo turtle to move forward or backward. To add this ability to our bag of instructions, let us agree that the turtle moves a fixed amount forward immediately after a turn instruction has been executed. As we do not have a mechanism to state how much the Logo turtle should move forwards, let's make this an arbitrary constant of, say, 20 units. The angle and direction which the Logo turtle rotates can simply be the same angle and direction in which the window has been opened. We further assume the Logo pen is always down. **Fig. 3**, bottom left, is the result.

5 Conclusion

We have explained why peripheral interaction can be considered to be a special case of tangible interaction, and how the inclusion of the Internet of Things enhances the spatial quality of interaction. Spatial Peripheral Interaction (SPI) was used to describe the resultant interaction form. The potential of SPI was illustrated by means of a hypothetical computationally enhanced physical building which produces abstract art in response to the status of its windows.

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