G Pen: An Intelligent Designer's Playmate

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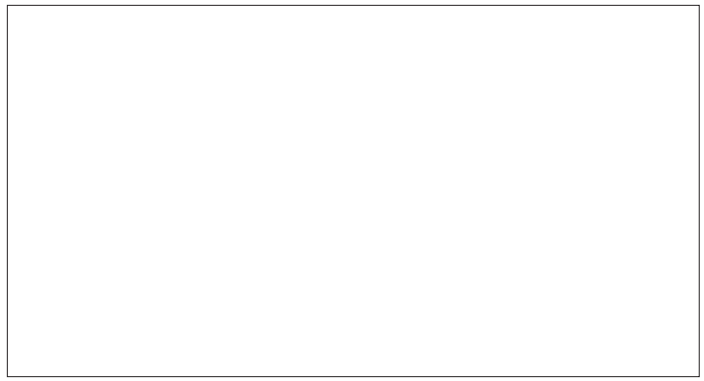
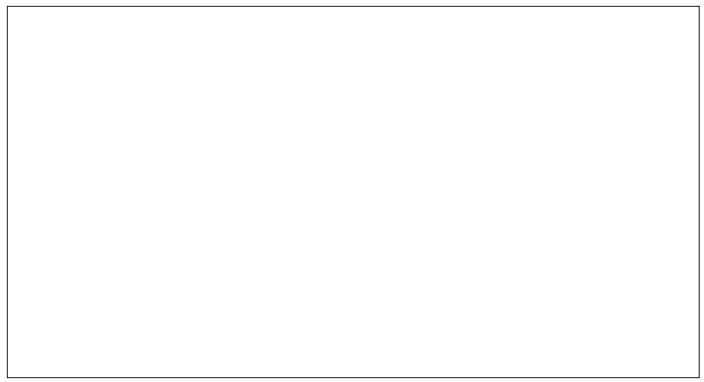
Abstract

In the field of design the pen-based system is a newly developed computer interface that provides the designer with the convenience of a pen in freehand sketches. But these pen-based systems only focus on an interface familiar to the designers and the application of the hardware and software that go with it, treating the pen only as a mouse-like input device. As pen and pad are devices for the pen-based system, the hope is that they can be endowed with more intelligent characteristics to let them interact with designer's gestures and become a creative source for the designers, while simultaneously preventing the design fixation encountered by designers during design process. This research utilizes the unintentional hand gestures made by designers, such as the designer's grip of the pen or movement involved in playing with the pen, putting it down, knocking it, twisting it or shaking it, during the thinking process or when running into a design fixation. From the interaction between the pen and the pad, certain actions may be generated to stimulate the designer's thinking process. This research uses a neural network as the main learning mechanism for the eventual development of a prototype of a pen-based drawing system that provides timely visual stimulation: a G Pen system.





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1 Introduction

In 1965 Mr. Sutherland, a computer graphic pioneer, devised the interactive drawing program called Sketchpad. Sketchpad enabled users to touch or draw directly on a cathode-ray tube image by using a light pen. However, since the 1970s when the mouse was universally adapted, this type of stylus device became relatively unpopular until the beginning of 1990, in which year pen-based systems and PDAs were introduced and marketed. Stylus devices once again became the focus of discussion, especially in the design field, due to the importance of input devices to a designer. Stacy (1996) pointed out that a good Computer Aided Conceptual Design system (CACD), should provide an environment for designers without any system limitations so that designers' ideas can flow freely. Due to the complexity of the operating interface in mouse-based CACD systems, researchers turned to designing a pen-based drawing system that would be suitable for designers in the conceptual stage (Gross 1996; Gross and Do 1996; Landay 1996; Trinder 1999; Plimmer and Apperley 2002).

Besides having such advantages as being convenient and easy to use, the pen-based system also has powerful added features: research-based features such as gestures and drawing characteristics, the application of transparent tracing paper, the simulation of the touch sensitivity of a pen, colors and the ability to edit. Given that such an application interface, which offers a natural design medium, has been tried and even found suitable in the conceptual design stage, the pen-based system, with the exception of the aforementioned intelligent assisting features, has a real chance to become something that sparks the imagination and stimulates creativity.

2 Problem and Objective

During the drawing process, designers may encounter a state of design fixation for a period (Jansson et al. 1991). It is at this time that the design media utilized can be a very important factor to a designer due to the frequent interaction or communication through the chosen design media (Schon and Wiggins 1992). The problem of design fixation can be solved if both ends in a communication process can carry out a bi-directional active or passive interaction.

A designer's gesture in a pen-based system expresses his/her intentions. The most common situation will be when a designer puts down the pen as he/she is tired of drawing at the moment. This gesture represents the state of design fixation. Other gestures, like playing with the pen, are also common occurrences in a design process. From this, we derive that a pen is not only an input device; it is also a "playmate" to a designer. Therefore, other than providing multi-functional features and extensive memory capacity, a pen-based system should also be equipped with intelligent interactive mechanisms to provide designers with creative or imaginative visual stimuli. This research focuses mainly on how to make the interactive relationship between a designer and design media more interesting. Solutions for the question of how to provide a designer with appropriate visual stimuli should be found in order to solve the problem of design fixation. The objective of this research is to devise a prototype of a pen-based sketching system, or G Pen, that is able to provide timely visual stimuli. This system utilizes the Neural Network (Coyne and Newton 1990; Haykin 1999) as the main learning mechanism (Figure1).

3 Previous Works

3.1 Development of computers' User Interface

The computer's user interface (UI) has been modified and invented to fulfill the demands of different fields, such as mouse-ware and light pen devices development in the early periods. Nowadays, due to advanced technology, various devices have been developed. These can be categorized as:

1. General input devices: mouse-like devices (mouse, wheel mouse, trackball, etc); keyboards (QWERTY, Dvorak, Maltron, chording keyboard); pen-based devices (pressure sensitive, tablet computer, palm-top).

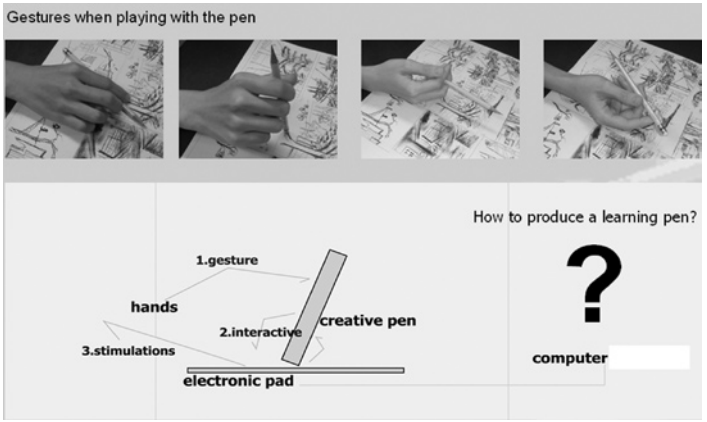

Figure 1. System concept

2. 3D input devices: mainly gesture-based like electromagnetic tracker, acoustic-inertial trackers, optical trackers, gloves and motion capture.
3. Output devices: divide into two parts-Classification-Stereo & Degree of immersion, such as desktop (vector display, CRT, LCD); semi-immersive desktop (rear projected, typically in stereo); immersive (CAVE, stereo shutter glasses).

The development of these devices attempts to be more useable and interactive to the users, especially in correlation to the human behavior or human gestures.

3.2 User Interface in Design Field

During the design conceptual stage, the designer gives a tangible form to the inner thought process via the design media. The design media therefore must be something that the designer is accustomed to using. The speed with which they operate must also be unencumbered by complex commands. Since 1990, many researchers labored hard to find suitable interfaces for designers to draw with. Gross, Landay, Trinder and other researchers all proposed pen-based systems as a suitable interface which can overcome the cumbersome movement required to operate a mouse. With the pen-based system hand drawing or handwriting replaces keyboard entries while gestures replace the keys and buttons on a physical device.

The pen-based system is suitable as a drawing interface, because pen-and-paper is thoroughly familiar to the designers, and the pen-based system is derivative of the pen-and-paper. Other than to serve as a natural input interface, it can also couple the system's functions with more functions like gesture-based, transparency, adaptability of the pen and knowledge based systems to form a total intelligent design-assisting system.

3.3 Development of pen-based system

The pen-based system has improved the CAD operating interface to enable designers to complete the whole course of design in a computer environment. Currently developed pen-based systems can be classified into three categories:

1. Projection drafting systems that combine physical pen-and-paper to aid in group communications (Wellner 1993; Moran and Chiu 1995).
2. Systems that translate two-dimensional sketches into three-dimensional models (Igarashi 1999; Schweikardt and Gross 2000; Do 2001).
3. Systems that function mainly as graphic recognition engines for sketches (Landay 1996; Gross & Do 1996; Plimmer & Apperley 2002).

For the 1st category, Digital Desk proposed by Wellner (1993) integrates the physical table and the projection of the computer to constitute the table as a digitized workstation. The 2nd category enables the translation from two-dimensional sketches into three-dimensional models. Igarashi (1996) had developed the Teddy system which is generally used in the industrial field. As an example of the 3rd category's system, Gross (1996) proposed a graphic recognition system—Electric Cocktail Napkin for the architecture field in order to be used in the conceptual design stage.

In addition to these software developments, pen-based systems attempt to explore the input interface. For example, Nabeshima (1995) developed a memo pen which integrate some components to a pen such as lenses, a CCD, a stress sensor, a micro computer, a memory and a battery to enable recording naturally the process of writing (figure 2). Furthermore, Hennessy (1992) proposed a drawing tool in the industrial field called IDEATOR which is constituted by the LCD tablet and various functional electronic pens (figure 3). These pen-based systems extend the current pen-and-paper's characteristics; especially attach more computational function to it.

3.4 Method

This input and output device of the G Pen system is no longer a simple input/output device; rather, it is now a mechanism to interact with the designer. It is designed mainly on the designer's unintentional gestures, such as putting the pen down, touching and knocking with the pen, and twirling and shaking the pen (Figure 4), and the interaction between the pen and pad to produce stimulating visual feedbacks.

This research proposed a preliminary prototype of the system. Due to the differing gestures of the different designers, the G pen system needs a learning mechanism to recognize these gestures. The manipulation of the G pen system is divided into two stages (Figure 5):

1. External tracking process—to detect various gestures as the input data for the second stage.
2. Internal training system—utilizing the Neural Network for learning and training in the recognition of the different gestures, and then reacting into the proper assigned feedback actions.

The system operational procedures are as the following:

1. Tracking:

Two light points (point A and point B) are installed on each end of the pen as trackers. After continuously filming the designer's gestures when drawing, coordinates of the light points are marked in a 7x7 grid. The purpose of tracking is to detect various gestures.

As Figure 6 shows, different gestures can be detected from the key frame of the continuous film as it records the track of the light point trackers (A & B): when putting down the pen, it is static and idle, hence we can obtain the coordinates of A and B (AX1,AY1)(BX2,BY2); while knocking with the pen is a continuous action, and the track is vertical, so we can derive the coordinates of A(AX1,AY1)(AX2,AY2) or B (BX1,BY1)(BX2,BY2); shaking the pen has two different gestures, shaking with one end of the pen and both ends of the pen. Both of these tracks are curved; nevertheless it can be differentiated by the amount of the

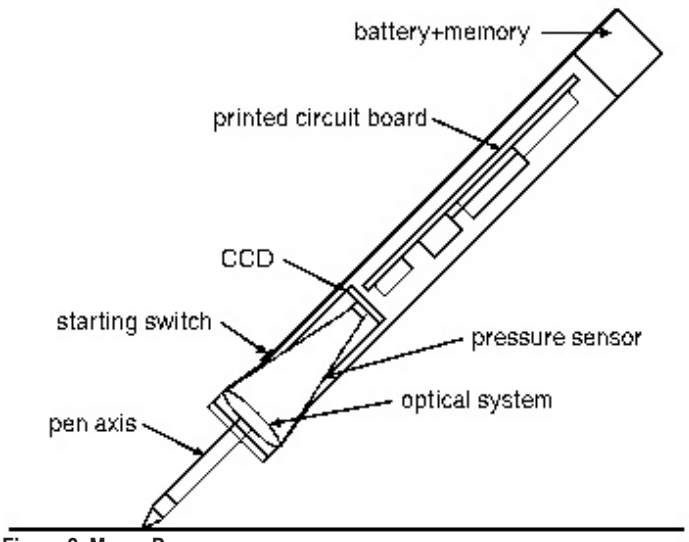

Figure 2. Memo Pen

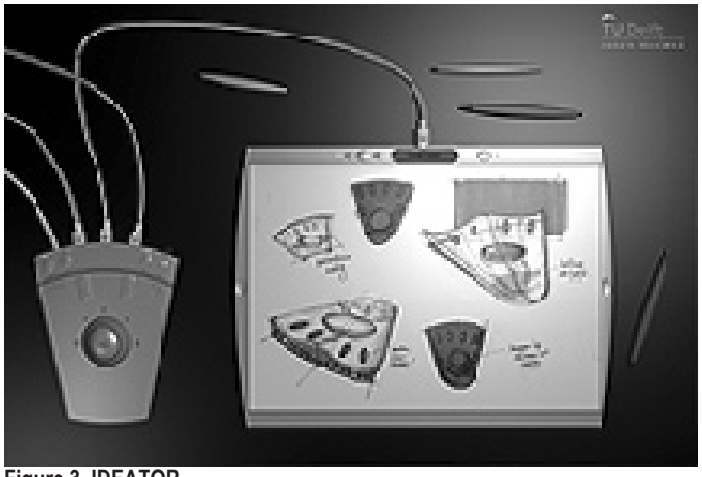

Figure 3. IDEATOR

light point trackers, one point or two points. Lastly, twirling the pen has a horizontal track, and obtains the two trackers (A & B) coordinates (AX1,AY1)(AX2,AY2) (BX1,BY1)(BX2,BY2). All these coordinate values will conduct input data for the next training stage.

2. Training:
The neural network is utilized as the training and learning mechanism. The coordinates data derived from tracking is used as object-oriented input data for the neural network system, and assigned feedback actions are used as the output data (Figure 8).

• Input data: In addition to the data of the coordinates data from the tracking phase, it incorporates another two attributes to constitute the input data for the neural network system: 1. The amount of the light point trackers. 2. The track figures of the key frames, such as: point A, point B, vertical track, horizontal track and curve track.
• Output data: Various feedback actions are used for the output data, such as idle, edit, zooming, and image display and rotate (Table 1). However, so far the operating system now is using some symbols to represent these actions (Figure 7).

Table 1: Feedback actions

	Gestures	Feedback action
1.	Put down the pen	IDLE
2.	Knocking	Edit
3.	Shaking (single light point)	Zooming
4.	Shaking (two light points)	Image display
5.	Twirling	Rotate

• Training data: Draw 20 different sets of gesture coordinates from the films to be used as neural network training data (4 sets of data each from the 5 gestures data, Figure 9). Then configure the neural network software system with 63 input data, 49 output data, and two 25 hidden layers [63-25-25-49] (Figure 10). These 20 sets of data proceeds the training process until the value of training error is less than 0.01, which is called “well train.” Use this “well train” network to test the input data, finally it obtains an exact assigned output data.
• Testing data: After the above stated training data is well trained, draw another 20 sets of coordinates from the film as testing data (Figure 11). This testing data will be tested by the “well train” network to confirm that the outcome is exactly true.

3.5 Results

After the neural network is well trained and tests have been done with the testing data, derived results are stated in figure 12 and 13. Although the output data of the fourth and fifth groups are not as intact as the previous three, they can still be easily identified. Due to the fact that this research is still in progress, the system uses the symbols to represent the outcome feedback actions instead of reacting to the proper actions by the display device. However, from the derived results of the network, it can prove that the utilized neural network as the learning mechanism is feasible. Therefore, we conclude that the prototype may have the opportunity to be developed into a better interactive pen-based system for design purposes. This system does not have the difficulties in using the interface, and the neural network learning mechanism learns and trains to adapt to different gestures of different designers. Therefore, it will become a new design media equipped with intelligent creativity assistance.

Figure 4. Gestures

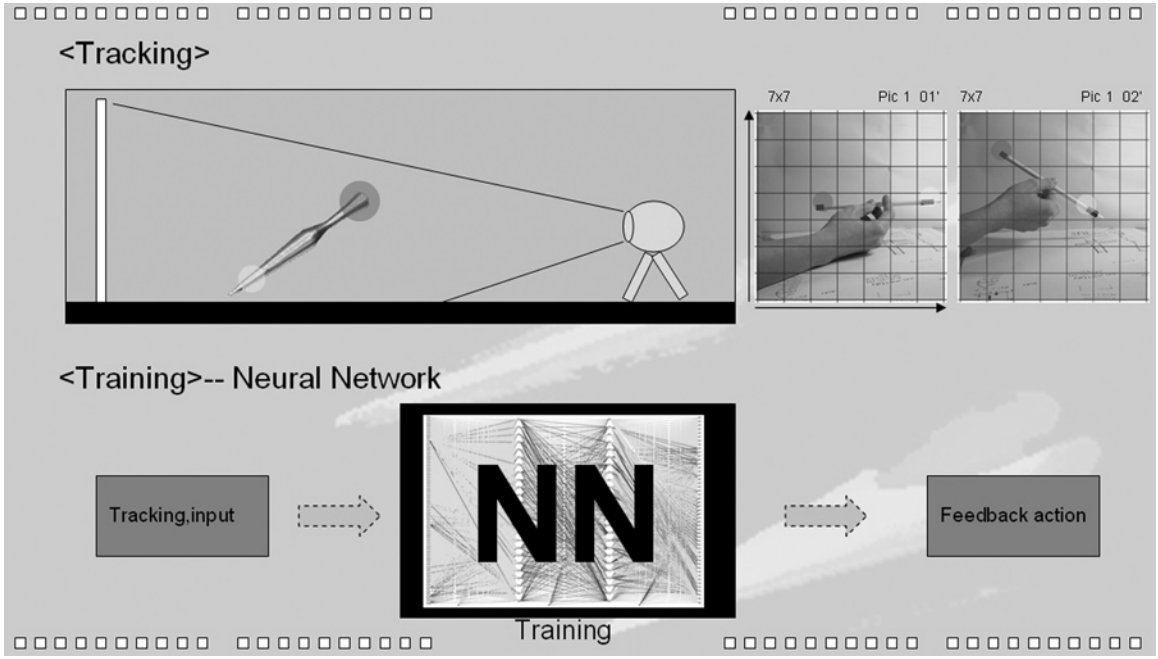

Figure 5. Mechanism

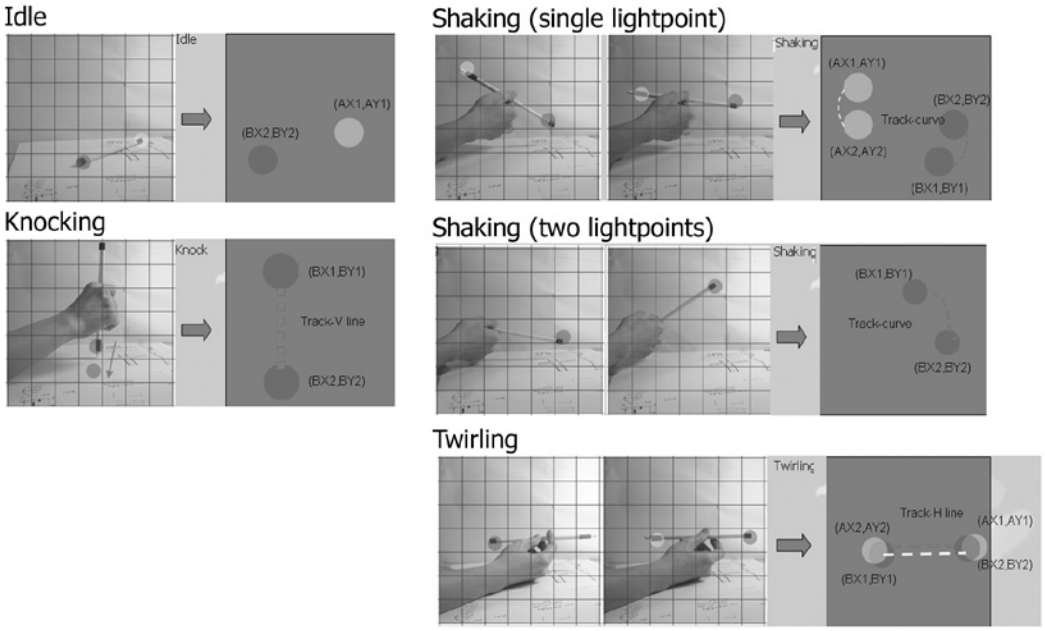

Figure 6. Tracking

3.6 Significant and Future Studies

The G pen system proposed by research is an interactive design media, destined to provide designers' with visual stimuli and solve the design fixation encountered by designers while drawing. It can encourage designers to think of a new idea or experience some unexpected discoveries. Meanwhile, designers will become accustomed to it naturally as it is a pen input device which is convenient to most people. Further more it can become a good design "playmate" to the designers and can be used by them in general.

For future studies, it is hoped that this prototype of the system can enhance its learning and training mechanism in order to provide designers with the ability to set the feedback actions or different gestures more freely. Moreover, the feedback actions must be revised so that they provide a good interaction between designers and their drawings instead of influencing the design process.

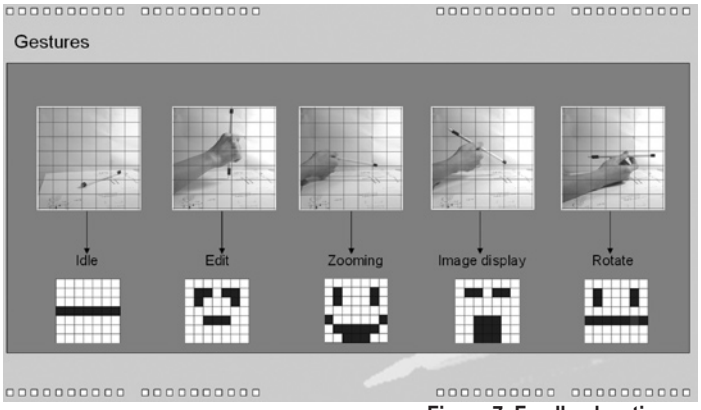

Figure 7. Feedback actions

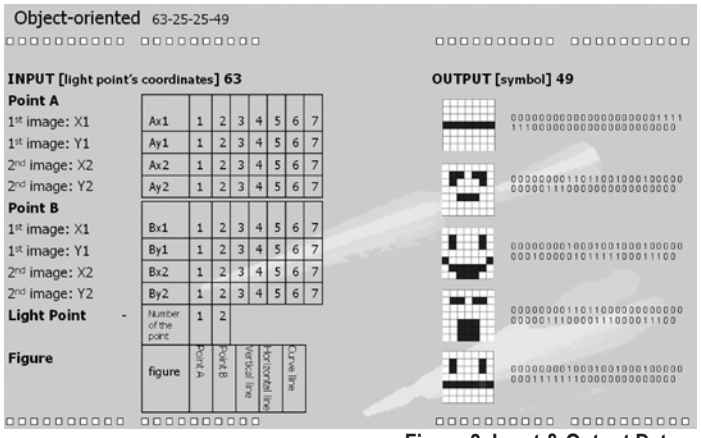

Figure 8. Input & Output Data

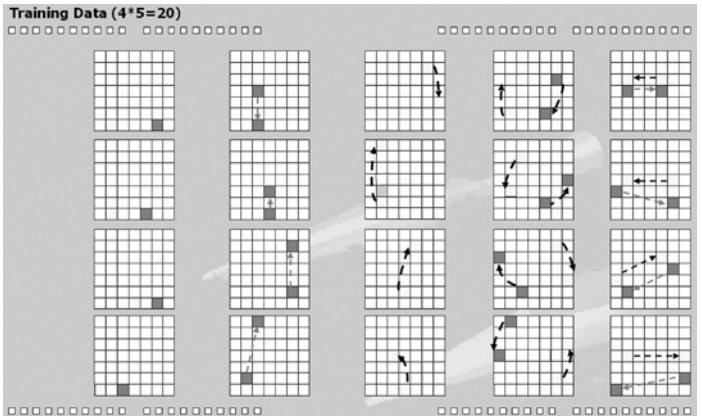

Figure 9. Training Data

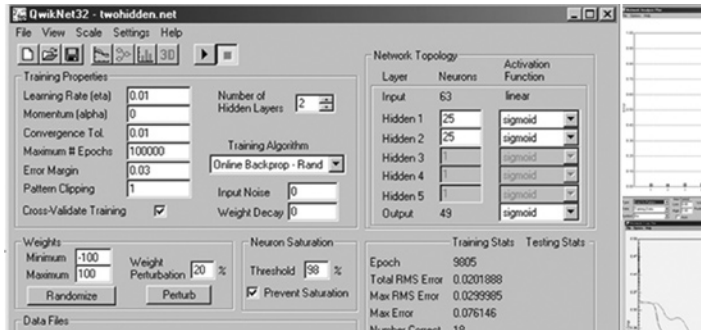

Figure 10. Training

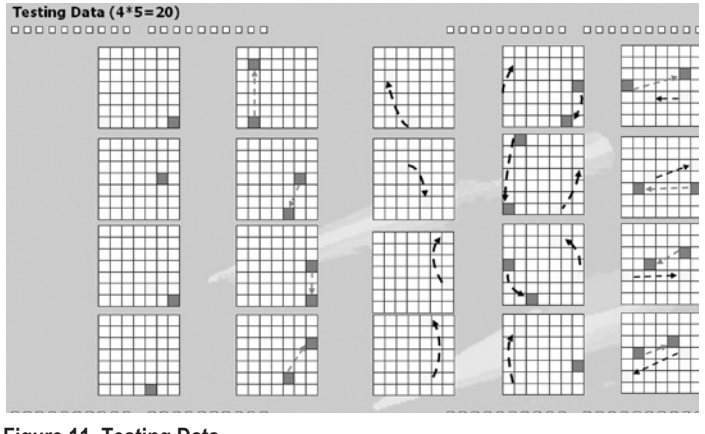

Figure 11. Testing Data

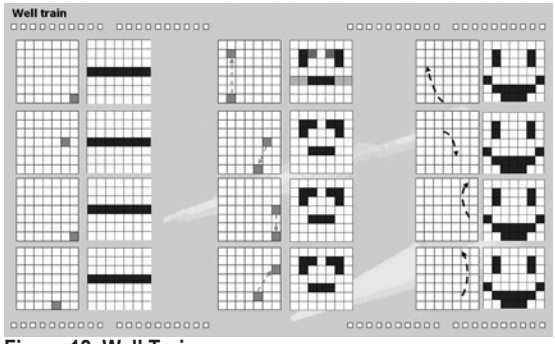

Figure 12. Well Train

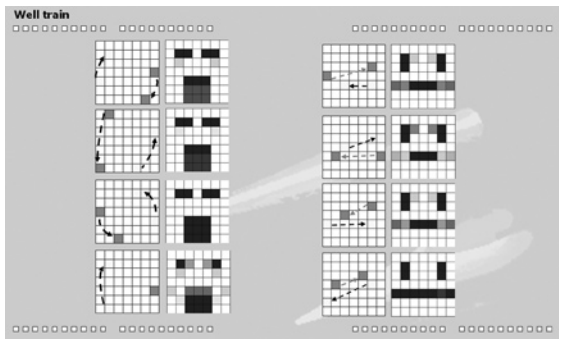

Figure 13. Well Train

References

Coyne, R. D. and S. Newton, (1990). Design reasoning by association. *Environment and planningB: Planning and design*. 17: 39-56.
Do, E. Y.-L. (2001). VR Sketchpad. *CAAD FUTURES.* Eindhoven. 161-172.

Gross, M. D. (1996). The Electronic Cocktail Napkin - a computational environment for working with design diagrams. *Design studies*. 17(1): 53-69.

Gross, M. D. and E.Do. (1996). Ambiguous Intensions: A Paper-like interface for creative design. *Proceedings of ACM conference on user interface software technology.*

Haykin, S. (1999). *Neural networks: A comprehensive foundation:* Prentice Hall.

Hennessey, J. M. (1992). The IDEATE project: Exploring computer enhancements for conceptualising. Edited by T.White and A Tzonis, *Automation based creative design.* Elsevier, Amsterdam.

Igarashi, T., S.Matsuoka, and H.Tanaka, (1999). Teddy: A sketching interface for 3D freeform design. *ACM SIGGRAPH*. Annual Conference on Computer Graphics. 409-416.

Jansson, G, D. and S.Smith, (1991). Design Fixation. *Design studies* 12(1): 3-11.

Landay, J. A. (1996). SILK: Sketching Interfaces Like Krazy. *Human factors in Computing. CHI96*.

Moran, T. P. and P.Chiu, (1995). Implicit Structures for Pen-Based System within a Freedom Interaction Paradigm*. Proceeding CHI'95*.

Nabeshima, S.,Yamamoto,K.Agusa,T.Taguch (1995) MEMO-PEN: a new input device.*CHI'95 Conference Companion* 1995: 256-257.

Plimmer, B. E., and M. Apperley. (2002). Computer-aided sketching to capture preliminary design. *Australian user interface conference* (AUIC2002).

Schon, D. A. and G.Wiggins (1992). Kinds of seeing and their structures in designing. *Design studies,*13: 135-156.

Schweikardt, E. and M. D. Gross, (2000). Digital clay:deriving digital models from freehand sketches. *Automation in construction* 9: 107-115.

Trinder, M. (1999). The computer's role in sketch design: A transparent sketching medium. *Proceedings of CAADfutures'99*.

Wellner, P. (1993). Interacting with paper on the DigitalDesk. *Communications of the ACM*. 87-96.