Analyzing Human Behaviors in an Interactive Art Installation

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Abstract. Arithmetik Garden is an interactive art installation designed to perform arithmetic operations by using the body. Analysis of data collected during its exhibitions shows that viewers behave differently than optimal solutions generated by computer. There is also an indication that viewer's emotional changes can be detected by monitoring interactions.

Keywords: Interaction, behavior, emotion.

1 Introduction

Arithmetik Garden is an interactive art installation designed to provide the viewer with an experience of performing arithmetic operations by using the body. The viewer feels as if he or she became a number that is transformed when it goes through gates. There are eight gates in the installation, including the entrance gate, the exit gate marked with $= 73$, and arithmetic gates of $+5$, $+8$, $\times 3$, $\times 7$, -4, and $\div 2$. The viewer picks up a card at the entrance and hangs it around the neck. An initial number -8, -1, 2, 4, 5, 7, 8, 36, 87, or 91 is printed on the surface of each card.

Fig. 1. Arithmetik Garden

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Starting from the initial number, the viewer tries to make the number equal to 73 by going through the arithmetic gates. For instance, if the viewer starts with 2 and goes through the $\times 7$ gate, the current number will become $2 \times 7 = 14$. One can walk along a path such as

$$2 \overset{\times 7}{\rightarrow} 14 \overset{+8}{\rightarrow} 22 \overset{\div 2}{\rightarrow} 11 \overset{\times 7}{\rightarrow} 77 \overset{-4}{\rightarrow} 73$$

to arrive at the goal number 73, where

$$\mathrm{A} \overset{\mathrm{op}}{\rightarrow} \mathrm{B}$$

means that the current number A becomes B by going through the gate op. The $\div 2$ gate works only with even numbers. If the viewer becomes uncertain about the current number, he or she can go to the equation monitor to see the current number and the path walked so far.

Fig. 2. Cards with initial numbers

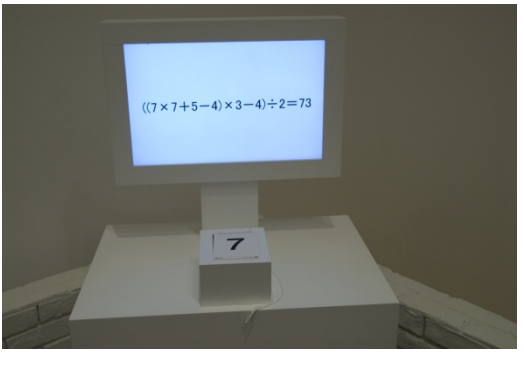

Fig. 3. Equation monitor

The viewer can successfully leave the exit gate if the current number becomes 73. Outside the exit gate, an equation of the path is printed on a piece of paper such as

$$(2 \times 7 + 8) \div 2 \times 7 - 4 = 73 .$$

The state transition diagram mounted on the wall shows all paths leading to 73 (Figure 5). The viewer can reflect on the experience by tracing the path in the diagram, while discovering other possible paths.

Arithmetik Garden was created in 2007 and first exhibited at Mori Art Museum, followed by the second exhibition at NTT Inter-Communication Center [ICC] in 2008, both in Tokyo, Japan. Over the two exhibitions, a total of 72,000 visitors experienced Arithmetik Garden. Some visitors reflected on their experience such that they were getting close to the goal but at some point they got lost. Other visitors mentioned to the enlightening moment in which they found a path to the goal. Such changes are of interest for interaction design because they make the experience engaging. We analyzed event logs and video recording to know how visitors walked in Arithmetik Garden and when their behaviors changed. In the rest of this paper, we discuss the methods and results of analysis.

2 Installation

Arithmetik Garden employs RFID technology. When the viewer goes through a gate, an RFID sensor inside the gate reads the tag embedded in the card. Each event of passing through a gate is sent to the server and stored in the database. The server maintains the current number and the path of each viewer.

The underlying mechanism of this installation is hidden from the user. People walk through gates without being bothered by menus and buttons. In fact, they do not touch anything from the entrance to the exit, because all sensing is done wirelessly.

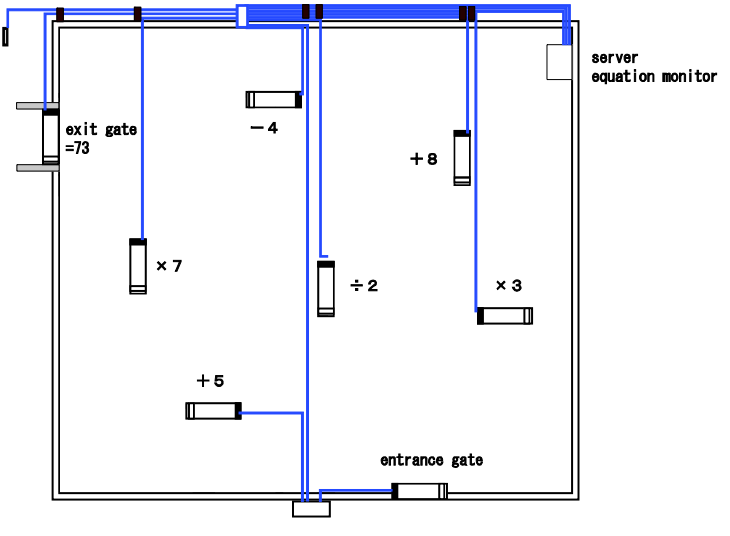

Fig. 4. System layout

Fig. 5. State diagram

3 Human Behaviors

3.1 Intuitive Decision

During the exhibitions of Arithmetik Garden, we collected paths walked by viewers. Each record consists of an initial number and a sequence of arithmetic operations with timestamps. The records are represented in an XML format after exported from the SQL database. Once represented in XML, we can use XQuery and XSLT for data analysis. They are convenient to look for patterns in a large amount of data [1].

By comparing paths taken by viewers against the shortest paths calculated by computer, we discovered gaps between human decisions and logical optimality. For instance, if the current number is 10, there are two shortest paths to the goal;

$$10 \xrightarrow{+5} 15 \xrightarrow{-4} 11 \xrightarrow{\times 7} 77 \xrightarrow{-4} 73 \text{ and } 10 \xrightarrow{-4} 6 \xrightarrow{+5} 11 \xrightarrow{\times 7} 77 \xrightarrow{-4} 73.$$

But among 6,259 cases in which the current number became 10, the largest number of people (2,694) chose the ×7 gate as the next (Fig.6). In fact, going to the ×7 gate takes the viewer away from the goal from distance 4 to distance 6. Here, distance d of a number N to the goal 73 is defined as the minimum number of steps needed to go to 73. Number 10 is of distance 4 to the goal because the two shortest paths to 73 shown above contain 4 steps.

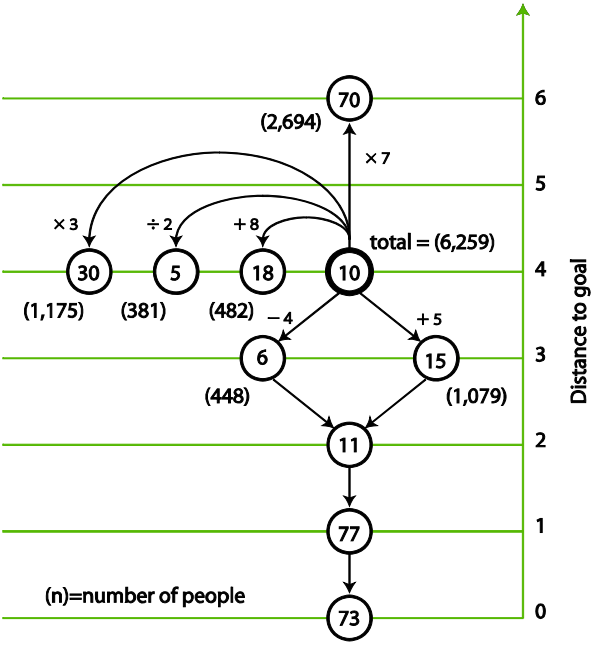

Fig. 6. Selections from 10

We suppose that the $\times 7$ gate appears to be most promising for the viewer whose current number is 10, as $10 \times 7 = 70$ is numerically close to 73. It seems that people have chosen this gate by intuition. Table 1 shows average time spent to choose the next gate after the current number became 10. It took 15.5 seconds in average to decide to go through $\times 7$, which was one of the two transitions that took the shortest time. This fact suggests that people intuitively chose the $\times 7$ gate because the resulting number was close to 73.

Table 1. Number of people and average time for transitions from 10

gate	transition	number	time (sec)
$\times 7$	$10 \overset{\times 7}{\rightarrow} 70$	2,694	15.50
$\times 3$	$10 \overset{\times 3}{\rightarrow} 30$	1,175	17.18
$+5$	$10 \overset{+5}{\rightarrow} 15$	1,079	15.14
$+8$	$10 \overset{+8}{\rightarrow} 18$	482	24.45
-4	$10 \overset{-4}{\rightarrow} 6$	448	21.48
$\div 2$	$10 \overset{\div 2}{\rightarrow} 5$	381	21.28
total		6,259	17.22

3.2 Sticking to a Pattern

Sometimes people are occupied in an immediate goal and do not look for alternatives. For instance, 65 is only one step away to the goal. One can make the number 73 by going through the $+8$ gate. Of a total 8,097 cases in which the current number was 65, 6,646 people went to 73. However, 1,123 people went through the $+5$ gate instead, such that;

$$65 \overset{+5}{\rightarrow} 70.$$

It means that in 14% of the total 8,097 cases, people missed the goal. Among the 1,123 people, 552 (49% of 1,123) came from the $+5$ gate as in;

$$60 \overset{+5}{\rightarrow} 65 \overset{+5}{\rightarrow} 70.$$

Moreover, 234 people (21% of 1,123) went through the +5 gate three times in a row such as;

$$60 \overset{+5}{\rightarrow} 65 \overset{+5}{\rightarrow} 70 \overset{+5}{\rightarrow} 75.$$

Fig. 7 illustrates these transitions. The pattern of repeating to go through the +5 gate can be explained that people stick to a simple pattern of adding 5 to the current number. Once people started to follow this pattern, they tend to forget about looking for alternatives.

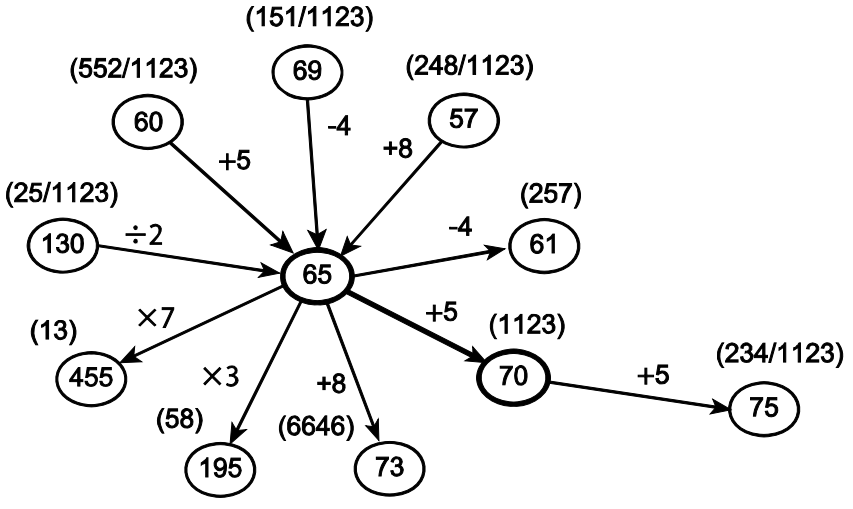

Fig. 7. Sticking to a pattern of adding 5

3.3 Emotion

Before the exhibition of the Arithmetik Garden, we did a public testing at university. We videotaped 340 people to analyze how they behave in the installation. By watching video, we found that people started to run near the end of the path since they became certain about how to make the goal. Some visitors were clearly seen an emotional change on the face [2].

It is also found in data that the intervals from a gate to the next became shorter near the end of path. We located such changes of intervals in data and reviewed the video of that moment. The video recording indicated that people were indeed delighted at knowing how to reach the goal. We believe that by monitoring data we can detect emotional changes It may be useful for making interactive systems respond to emotional changes of people [3].

Although initial numbers are 4 to 6 steps away from the goal, people spend 8 to 12 steps in average to reach the goal. We assume that people need to understand the situation and the task by exploring the space. Once the idea of embodiment of transformation becomes clear, they can start concentrating on calculation. If it is true, we may be able to detect another type of emotional change from exploration to concentration by watching the tendency of selecting gates.

4 Conclusions

We found that event data collected during exhibitions were extremely useful to study human behaviors in Arithmetik Garden. The data indicate that paths taken by humans were different from computer-generated optimal solutions. People tend to prefer to a seemingly promising path such as

$$10 \overset{\times 7}{\rightarrow} 70$$

over the shortest paths to the goal.

The fact that people in average spent only a short duration of time on the transition to 70 indicates that this selection was made intuitively. Another finding is that people stick an immediate goal. While increasing the current number to 73 by going through the +5 gate multiple times, people tend to miss a solution such as

$$60 \overset{+5}{\rightarrow} 65 \overset{\times 8}{\rightarrow} 73.$$

It was also found that people started to run when they became certain about the way to the goal. Such a change can be detected by monitoring intervals between gates. Monitoring the user behavior will be useful to design interactive systems that respond to user's emotional changes.

Future research includes applying data analysis techniques developed in this study to other interactive art installations for better understanding of human behaviors.

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