



# Children's use of mouse-based interfaces to control virtual travel

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## ABSTRACT

Children's performances using three different mouse interfaces to control point-of-view (POV) navigation in a prototype of a CD-ROM based "virtual forest" were assessed. Results indicate that while children readily understood POV movement and were able to use all three interfaces successfully, each interface was less than optimal for different reasons. An assessment of the strengths and weaknesses of each interface in light of the intended usage scenario was conducted, and the least problematic of the three was selected for the system.

## KEYWORDS

Children; interface; virtual travel

## INTRODUCTION

IBM Corporation and Children's Television Workshop have developed "Woods Visit" (WV), a CD-ROM based, interactive multimedia forest environment. WV is designed to provide first grade children with a virtual 'nature walk,' during which they search for animals and plants along forest trails. The 'nature walk' design metaphor, and the desire to simulate the exploration of a forest environment as realistically as possible, led to the decision to adopt a point-of-view (POV) interface for the system. Digitized video footage, produced by a camera moving along forest trails, was used as the core of

the system. The goal was to create a virtual environment in which the user appears to be actually walking through the forest, searching for animals in their different habitats.

What is the appropriate user interface for such a design? The range of possible options was restricted by two important factors. First, the input devices specified for WV were restricted to the standard mouse and keyboard combination. Second, the anticipated usage scenario was defined as a classroom, with groups of up to four first grade children using the system with minimal adult supervision.

Given that the children's major activity using WV was going to be selecting onscreen locations where they thought animals might be located, the mouse was selected as the best hardware device for WV. The most effective way to use the mouse to control the POV movement through the forest trails, however, was not clear. Several possible mouse-based interfaces were suggested. The present paper reports the results of a study comparing children's use of three possible mouse-based POV movement interfaces in a prototype of the WV system. The goal of the study was to assess children's performance using a POV-based prototype with each interface, to determine which interface method (or methods) seemed most appropriate for the intended user audience and usage scenario.

## THE WALK IN THE WOODS PROTOTYPE

The environment used in the WV prototype was filmed in a park in Northern New Jersey. It was comprised of a series of six short trails, connected to one another at three distinct junctions. The trails were filmed such that users could "walk" along the trail in either direction, starting from either end.

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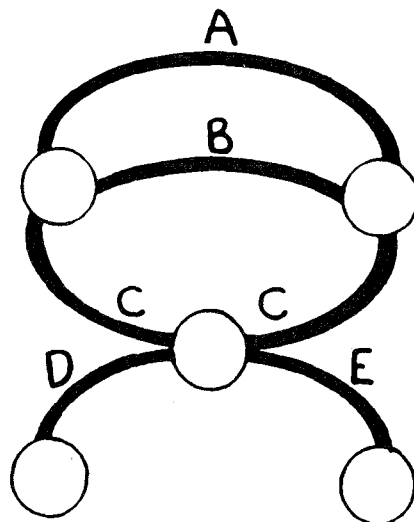


Figure 1: Map of the trails in the WV forest prototype.

Junctions were filmed as 360-degree rotations, in both clockwise and counter-clockwise directions, with each trail option clearly visible at distinct points in the rotations. At each junction, it was possible to choose to either turn around and return up the trail just taken, or choose a new trail to traverse. The trails were connected as shown in Figure 1. Trails A, B, and C always led to another trail from their choice points, while trails D and E terminated at the ends, forcing users to turn around and return the way they came.

Realistic stuffed animals were placed approximately midway along each route in a slightly obscured location, such as beneath a tree or by a rock. These were meant to simulate the animals and locations that would be part of the interactive video in the actual product.

#### Movement in the forest

There were two levels of interaction. The first was movement on the forest trails. This consisted of "walking" along the trails, and choosing new trails to travel on at the junctions. Movement for all three interfaces tested was based on an iconic system. Stopped on the trail, the users were always presented with two icons: a rectangle with the word BACK printed in it, and an up arrow. The forward movement initiated by the up arrow differed depending on the interface used:

*Click go/click stop (CGCS).* On the trail, when the user moved the cursor to the up arrow and clicked, this caused the arrow and the BACK icon to disappear, and forward movement commenced. Movement continued without pause until the user pressed the mouse button again, causing the movement icons to reappear, with the cursor on the up arrow.

*Hold and go (HG).* On the trail, the user moved the cursor to the up arrow and held down the mouse button. This caused the arrow and the BACK icon to disappear, and forward movement commenced. As long as the button was depressed, forward movement was engaged. If the user released the button, movement stopped and the up arrow and the BACK icon reappeared, with the cursor on the up arrow.

*Slide and go (SG).* On the trail, the user moved the cursor to the up arrow and clicked, causing the up arrow and the BACK icon to disappear. However, movement only commenced when the mouse was moved forward on the table. When the user slid the mouse forward, the movement on the trail moved forward, and when the user stopped the mouse the movement on the trail stopped. Sliding the mouse in any other direction had no effect. The icons did not reappear until the user clicked the mouse button again, causing them to reappear with the cursor on the up arrow.

In all interfaces, the cursor was not visible on the screen during movement on the trails.

The BACK icon and the junctions functioned in the same manner in all conditions. Clicking on the BACK icon simply moved the POV backward on the trail approximately sixty frames. At each junction, movement stopped and the children were presented with the BACK icon and three arrows: Left and right arrows for examining other possible routes, and an up arrow that would initiate movement onto the currently selected trail head, if clicked. Clicking on the left or right arrow caused the icons to disappear, and rotated the viewpoint along the 360-degree circle to the next trail head. At each trail head, rotation stopped and the icons reappeared.

#### Finding animals

The second level of interaction concerned selection of the animals on the trails. When movement on the trail was stopped, the cursor reappeared and could be moved around the screen in the conventional manner. 'Hotspots,' or click-sensitive areas, were placed on



the animals in each of the frames of video in which they were visible. Clicking on an animal resulted in a speech reward (e.g. "You found a rabbit!"). The animals remained visible and could be clicked on again.

Pilot testing revealed that children had some difficulty locating the stuffed animals in the pixellated images presented by the interactive video. To make the animals easier to locate on the trail, the sound of a dog barking was added to the trails. The dog barking commenced at the frames where the animals first came into view, and persisted until the last frame in which the animal was visible was displayed. The dog bark proved to be very effective for alerting children to the presence of animals in the scene (see below).

## METHOD

### Subjects

Ninety-four children (49 first graders and 45 second graders) participated in the present study. Most children were tested in same-sex pairs, and approximately equal numbers of boys and girls were tested in each condition.

### Procedure

Children worked in pairs, and took turns using the mouse. In all conditions, children were told, "What you are going to do today is try to find animals that are hiding in the forest. To help you find the animals, there is a little dog walking in the forest with you, and he will bark when he sees an animal. When you find an animal, you have to stop walking and touch the animal with the pointer and press the button." Interface-specific instructions on movement followed.

## RESULTS

### Success of the virtual point of view

Before examining the differences between the three interfaces, it is worthwhile to consider the findings regarding children's understanding of and use of the virtual travel that POV navigation provides. The first major observation is that the children readily appreciated and acted on the metaphor that they were walking down a forest trail. Evidence for this came from several sources. The first is the result of a fortuitous accident: The cameraman's shadow appears at several points in WV as the trails are being traversed. A notable 66% of the children commented verbally on this, with statements such as "Look! It's our shadow!", or "Hey! It's me!" These sorts of comments reflect the children's willingness to treat the DVI as

a powerful kind of pretend situation, and place themselves in the scene where the action is occurring. The second finding supporting the success of the idea that the children believe, or are willing to pretend, that they are "traveling" in the WV is the observation that some of the children actually moved the mouse to match curves and winding portions of the trails as they moved. While the percentage of children who did this is small, the manner in which they did it was often striking: several children actually "leaned into" curves, or expressed fear about "crashing" into trees, and would steer the mouse in a move designed to avoid them. Finally, the metaphor was so powerful that it actually led some children to try to exceed the bounds of the current prototype. They frequently asked if they could walk off the trail to find animals, believing they could literally walk around in the WV forest just as you would in a real forest environment. Other children ducked to avoid branches that struck the camera during filming. One girl actually stopped walking and just sat on the trail; when asked why she wasn't moving, she said she was "just waiting, to see what animals will come."

The ability to project themselves into the virtual environment provided by WV raises potential problems as well, however. First, as they do in their own informal wanderings, the children did not show any tendency to be systematic in their travel patterns. Only 22% of children in the entire sample examined all their options at a junction before choosing a direction; and those who did so typically did it only once, not at each junction they encountered. The children also did not attend to clues, such as landmarks, about where they had traveled during the session, and very few were able to recognize where they had been in the forest earlier in the session. The children's ability to recognize a trail they had previously traveled was determined by asking them, at a junctions where they were confronted with a trail head they had already chosen earlier, if they recognized it or if they knew which animal lay down that trail. Only 13% of the sample were able to do this.

### Interface Differences

#### Analysis

All results reported below were submitted to a 3 (interface type) x 2 (gender of pair) ANOVA. Nonsignificant effects are not reported.



### ***Movement control***

Movement along the forest trails was meant to be interrupted only when the child wished to search for an animal, or click on one they had found. However, children in all conditions accidentally stopped moving during use, either by accidentally clicking the mouse button (CGCS and SG), or releasing pressure on the button in the HG condition. Results indicate that there was a significant difference among conditions for this problem,  $F(2, 82) = 14.61$ ,  $p < .0001$ . The HG condition produced many more accidental stops per session than the other two conditions ( $M = 4.29$  vs.  $M = 0.97$  for CGCS and  $M = 1.68$  for HG). This result appears to be due to children's inability to maintain consistent pressure on the mouse button for extended periods of time. Twenty-one percent of the children in the HG condition resorted to using both hands to press on the button to keep up pressure, and another 25% picked up the mouse and held it, squeezing tightly on the button as they did so. In addition, 21% of all the children using the HG interface either verbally expressed fatigue or indicated it nonverbally, by shaking their hands at the wrist or pausing to flex their index finger when opportunities arose.

Accidentally terminating movement on the trail gave rise to an additional difficulty: the cursor would often move off the arrow icon, and had to be repositioned for movement to resume. There was a significant difference among the conditions for this problem,  $F(2, 82) = 13.33$ ,  $p < .0001$ , and an effect for gender as well,  $F(1, 82) = 3.87$ ,  $p < .05$ . The condition effect indicates that the HG and SG conditions produced this problem at 4 times the rate of the CGCS condition ( $M = 2.00$  for HG and  $M = 2.21$  for SG vs.  $M = 0.50$  for CGCS). In the HG condition, changes in finger pressure occurred when children tried to change the position of the finger pressing the button, a change that often moved the mouse on the table as well. In the SG condition, the mouse was actually moving when the button was accidentally clicked, so the cursor moved because the mouse was in motion when trail movement was ended and the cursor returned to the screen. For CGCS, this was not the case. Since the mouse was stationary during use, the chance of moving it off the arrow icon when accidentally clicking the button was greatly reduced.

The gender effect is due to the fact that boys tend to move the cursor off the arrow when accidentally stopping more often than girls ( $M = 1.70$  vs.  $M = 1.18$  for girls), a finding most likely attributable to the generally higher activity level of boys, who were

more likely to be moving or fidgeting with the mouse than were the girls.

### ***Search strategies***

The dog bark signaling the presence of an animal was very effective as a design feature for alerting children to begin searching the video for the presence of animals. Children adopted one of two strategies for locating animals on the trails. The first strategy was the most common: Children simply continued movement until they spotted the animal, and then stopped and clicked on the animal. Given that the animals were hard to identify, this strategy was often not successful. Children frequently had to back up and move down the trail several times to find the animal. Another strategy, much more successful in terms of finding animals on the first try, was to "creep up" on the animal. This strategy took the form of a repetitive cycle of stopping movement, visually scanning for the target animal, very briefly resuming movement to advance the POV a few frames, and then stopping again, for more searching.

The frequency of the use of the creeping strategy differed among the three interface conditions. For CGCS and HG, creeping means moving slowly along the trail via a series of button presses. In CGCS, this is accomplished by repeatedly clicking the mouse button twice, once to move and then once again to stop quickly, creating a series of short movements along the trail. In HG, the method is similar: repeatedly holding down the button in brief bursts produced the same effect. The SG interface, however, supports this search method much more naturally: Children just slid the mouse in small increments, producing incremental advances on the trail. A comparison of the three interfaces confirms that children utilize the three interfaces differently; children "creep up" on animals significantly more often when using the SG interface,  $F(2, 82) = 4.26$ ,  $p < .02$ ,  $M = 43\%$  of animals selected per session for SG, but  $M = 8\%$  for CGCS and  $M = 14\%$  for HG.

An unexpected problem with the SG interface arose during children's use of the creeping strategy, however: Children would press the button on the mouse to stop their movement while continuing to slide the mouse forward. Typically, while sliding the mouse forward, they would spot the animal and hit the button to stop movement on the trail. This was an appropriate performance, given that pressing the button did end trail movement and return the cursor to the screen. Unfortunately, movement often



continued briefly prior to stopping, and the children overshot the animal. Often, the button press did not appear to register at all: for 39% of the children using the creeping strategy in the SG condition, if the button was pressed during movement it did not result in an exit from the movement mode.

#### *Cooperative use*

WV was designed with the assumption that the normal use scenario always involved more than one child using the system. In the present study, children took turns using the mouse; however, the pairs of children frequently collaborated when using the system. The inactive partners assisted in searching for the animal being hunted at least once in 71% of the pairs tested. Even when not actively participating in the search, the inactive partners attempted to influence the active children's performance. In 79% of the pairs, the inactive children suggested to the active child where to turn, to back up, etc. at least once.

The inactive partner's behavior was not always beneficial. Attempts to control the mouse, despite explicit turn-taking guidelines, were observed as well. Inactive children were scored for their attempts to use the mouse when it was not their turn. Results indicate that there is a significant difference among the conditions, such that CGCS gives rise to much more competition than either of the other interfaces,  $F(2,82) = 5.27$ ,  $p < .007$ ,  $M = 1.50$  incidents per session for CGCS, but  $M = 0.36$  for HG and  $M = 0.57$  for SG. The competition for control of the mouse in the CGCS condition is directly related to a behavior only seen in this condition: 63% of the children removed their hand from the mouse and left it untended on the tabletop during movement on the trail. This was a natural thing for children to do in this condition, since once the button was clicked, no further performance was required until an animal was detected. However, the untended mouse invited the inactive child to attempt to use it, causing competition for mouse control to occur as the two children struggled for possession. Removing one's hand from the mouse was correlated with the inactive child trying to take control of the mouse in the CGCS condition,  $r = .40$ ,  $p < .02$ .

#### **CONCLUSIONS**

The present results indicate that a POV interface design can be an effective design for multimedia experiences for young children. The children in the

current study responded intuitively to the 'nature walk' metaphor of the WV, and the design had a high level of appeal. Children understood the activity they were being asked to perform, and their comments and actual behavior indicate that they could execute it without difficulty. These results are similar to those reported for older children using the Palenque Project videodisc, where POV travel is used to navigate ancient Mayan ruins [1].

In addition, the usage scenario appeared to be successful as well. Children spontaneously cooperated with one another, a finding previously observed for pairs of children using computer software [2]. The only qualification to this result is the tendency of a minority of children to compete for control of the mouse, a behavior apparently related to properties of the different interfaces tested (see below).

Choosing among the three mouse-based interfaces for controlling POV movement requires evaluating the relative importance of various factors for the overall design scheme and usage scenario. Only the HG interface, which presented children with the unacceptable physical demand of too much finger pressure, can be eliminated outright as an unacceptable design.

The choice between the two remaining interfaces is less clearcut. The present results show CGCS and SG to have relative strengths and weaknesses. SG seems to support the spontaneous use of an effective search strategy ("creeping") for finding animals. However, the strategy itself apparently gives rise to a problematic device usage style, where children click while the mouse is still moving, and the click fails to register. In addition, children accidentally disrupted movement on the trail at substantially higher levels with this interface than with CGCS.

The CGCS interface did not support creeping as a search strategy. But it did demonstrate the lowest level of accidental disruption of trail movement among the three interfaces, as well as the lowest incidence of accidentally moving the cursor off of the movement icon, when disruption of trail movement did occur. The only serious problem with the CGCS interface is that the child users show an unfortunate tendency to remove their hand from the mouse, inviting competition for mouse control.

Which interface is best? Of the three, CGCS has the least severe problems associated with it. Improving on its deficiencies, however, raises issues of implementation rather than design. Since creeping is not



spontaneously adopted by children using this interface, the creeping search strategy can, for example, be modeled for children when WV is introduced to them.

Similarly, competition for the mouse is a management issue in the usage scenario, rather than an issue related to the interface design in any strict way. The frequency of competitive incidents reported, given the length of each session, is high only when compared to the other interfaces tested. It is probably sufficient to alert teachers, or other adults who will be working with children using this technology, to the potential for competition the mouse represents. Management of the competition can be left up to them.

In closing, the present study demonstrates that for young children, POV navigation has high appeal and is easy to comprehend - even if they are somewhat careless in paying attention to where they travel. The comparison of the three possible interfaces, in addition, underscores the importance of empirically evaluating the useability of potential interfaces in situations that not only simulate their intended use, but reflect as much as possible their intended usage scenario. The results obtained for the three interfaces provided critical data that informed the decision on which interface method to adopt. More frequent use of these kinds of studies in the development of educational technologies could substantially improve the quality of interactive products for school use in the future.

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