CArVATAR – A novel remote control for toy cars

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ABSTRACT

We describe a novel controller for a remote controlled (R/C) car. The controller is a small car-shaped toy which is used for controlling the larger toy car. In this avatar-inspired relationship between controller and controlled, operations performed on the small car are implemented by the larger car. The cArVATAR addresses limitations of the traditional R/C, and is proposed as an alternative allowing younger children to use R/C toys. Details of the prototype and observations from an exploratory study performed with five children aged 6 to 7 are presented, and possible applications to other products and domains are discussed.

Author Keywords

cArVATAR; Remote Control; Tangible Interfaces; Mimicry

ACM Classification Keywords

I.2.9 Robotics: Operator Interfaces
H.5.2 User Interfaces: User-Centered Design

INTRODUCTION

In the early years of life, children play in elaborate ways with objects: examining them and manipulating them directly [1]. As their knowledge grows, they give these objects symbolic properties: a toy car turns from an object to bang on a table to something that is moved on the floor while making engine sounds [2].

When first attempting to use a remote-controlled vehicle, children need to adopt new abstraction of play. They need to discover and master the relationship between the controller and the controlled in order to achieve a rewarding play experience. The division between cause and effect, as well as the sensory-motor skills required for control, are challenging. For some, this is a joyful process of mastery; for others, a frustrating one.

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TRADITIONAL CONTROLLER CHALLENGES

There are three main types of traditional remote controllers for toy vehicles. The simplest controller has four buttons for forward, backward, left and right functions. The more advanced controller has two sticks, one for forward and backward control, the other for orientation control (turning the wheels). A third controller type, specific to toy cars, has a circular knob for orientation control and a trigger button for forwards and backwards control. Focusing on the two-stick controller, since it is the most commonly used for R/C cars, we identify a number of challenges for beginner users:

1. **Functional separation:** the controlled car is a single object, able to move only to one direction at a time; however, the controller has two sticks, suggesting two separate functions. Users need to process these two dimensions simultaneously in order to control the car.
2. **Mapping:** while forwards and backwards movements of one stick map quite directly to movement of the controlled car, the second stick works differently! It moves right and left, but does not cause the car to move unless the other stick is being used.
3. **Relativity:** driving and turning are relative to the car's orientation: when the car front is facing the child, pushing the forward/backwards stick upwards (forward) causes the vehicle to approach the child, and pushing the left/right stick to the right makes the vehicle turn to the child's left. This relative control scheme requires children to adopt a non-egocentric point of view.
4. **Fine motor skill:** the sticks require fine motor skills, especially in controllers where the measure of stick movement translates to the speed or turn radius of the controlled car. Also, gaining full control requires coordination between the hands.

ALTERNATIVE CONTROL METHODS

Recent research has looked into alternative control methods in which the relationship between controller and controlled is made more direct.

Dang and Andre [3] compared the traditional remote controller with a gestural control method: both hands turn an imaginary steering wheel left or right, and push it forward or pull backward to drive forward and back. The article describes the users' difficulty in orientation, due to the relative nature of the controls: the user's forward direction often differs from that of the car.

Various projects have explored control interfaces that employ repetition of a series of motions [4,5,6]. In these projects, however, there is a sharp distinction between a “recording” phase and an “execution” phase. The concept of mimicry was explored by Guo et al [7], who compared two control techniques for robots: the first was based on toys which were of physical resemblance to the controlled robots; the second was graphical representations of the robots presented on a touched screen. The robot was controlled by setting a new position and orientation to its matching controller (toy or graphical representation) on the screen, thus initiating an autonomous motion of the robot to its new position. Most users strongly preferred the tangible interface to the touch surface.

In our project, we employ an object of physical and functional resemblance to the controlled object: a car avatar, or cArVATAR. Through it we explore the use of mimicry in real-time control, addressing the disadvantages of traditional controllers, especially for younger children. We aim for an easier point of entry to the interaction, and for a high level of play value.

THE CARVATAR

The cArVATAR is a small plastic toy car with two pairs of hinged wheels that roll forward and backwards but do not rotate to the sides. The cArVATAR controls an off-the-shelf R/C car with four-wheel drive. The cArVATAR is similar to the controlled car in having a car’s prototypical form, and is thus a good model of the controlled car. However, it differs in scale and in the central affordance of non-turning wheels. The partial resemblance between controller and controlled allows the implementation of different control schemes.

For this exploratory study we implemented a simple control scheme for cArVATAR, keeping a high degree of similarity between the traditional controller and the cArVATAR functions. The control functions are:

- Forward and backward movement: rotation of the controller wheels is translated to motor force of the controlled car. The faster the controller wheels are rotated, the car accelerates more and stops accelerating at higher speeds.
- Orientation: changing the controller orientation while the car is in motion causes the controlled car to make the same change in angle.

An inherent feature of the cArVATAR interaction is that it requires a surface on which to move. This can be the floor, an elevated surface like a table, and even body parts like an arm.

Interesting limitations arise regarding the mapping of motion from the controller car to the controlled car. The main issues are:

- Slow forwards and backwards movements of the cArVATAR can be faithfully mapped to the controlled car. However, due to limitations in the acceleration of the controlled car, very fast gestures of the cArVATAR controller create shorter and slower movements.
- In the simple plastic car model of the cArVATAR, orientation can be changed by simply lifting and turning the whole toy car; however in the controlled car - as in all cars - orientation can be changed only while driving, and the turn radius is limited by the car wheels’ degree of rotation.

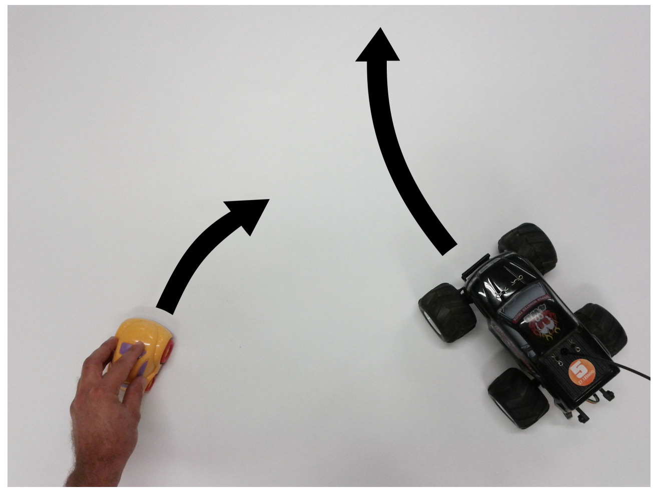

Figure 1: The cArVATAR controller and the controlled car, with motion trajectories

Expected advantages and challenges of cArVATAR

We expect cArVATAR to simplify learning and increase playfulness in controlling the car.

The main expected advantages are:

1. **Unity of control:** all functions of the controlled car are performed with a single object and gesture, removing the need for cognitive coordination between two functions.
2. **Simpler mapping:** high physical resemblance - and partial affordance resemblance - to the controlled car should enable the children grasp the functional mapping faster.
3. **Flexible orientation:** the problem of differing points of view of the controlled car and user can be easily alleviated by turning the toy car controller so that it heads in the same direction as the controlled car. In this way, drive and turn gesture directions become mapped naturally.
4. **Gross motor control:** the cArVATAR works with more gross motor skills (large gestures of the arm and shoulder) than fine ones, which fits well with younger children’s capabilities.

Technical Implementation

The toy car used for the cArVATAR controller was fitted with an Arduino board, an XBee transceiver for communication with the controlled car, a rotary encoder used for sensing the rotation of the wheels and a compass module for sensing the controller's absolute orientation.

The controlled car's electronics were hacked and programmed with an Arduino board. The car was equipped with a 9 degrees of freedom sensor for sensing orientation, a rotary encoder for allowing tight control over the speed and rotation of the wheels and an XBee transducer.

PLAY SESSIONS

We conducted play session with cArVATAR in which a single child used a traditional remote, and then the cArVATAR, to control the same toy car. We chose to include the traditional controller to have an impression of children's abilities with it; however, we focus on the children's use of the cArVATAR and point to significant differences from the traditional remote when relevant. Because all children reported at least partial familiarity with the traditional remote, we chose to present it first in all sessions, followed by the novel cArVATAR.

The sessions were conducted in an empty room measuring 4 by 7 meters. Five children, aged 6-7 (3 boys, 2 girls) took part in this exploratory study. Each session, which lasted 20 minutes, consisted of the following four parts:

1. Traditional controller: A quick demonstration followed by free play
2. Traditional controller: play challenges
3. cArVATAR: A quick demonstration followed by free play
4. cArVATAR: play challenges

The play challenges were:

1. Drive slowly on the straight line marked on the floor (controlled car facing forward)
2. Drive backwards on the straight line marked on the floor (controlled car facing backwards, towards the child)
3. Drive along the tight arc marked on the floor (controlled car on the beginning of arc, facing forward)
4. Drive along the tight arc (controlled car at the end of arc, facing backwards)
5. As in challenge 3, this time along the loose arc
6. As in challenge 4, this time along the loose arc
7. Drive to a tower of blocks and knock it over

At the start of each challenge the child stood at the starting point of the curves, with the car placed before them.

Observations

We first present observations related to the basic driving functions performed in the challenges; we then present additional observations related to play value.

Driving forward and backward

All children were able to immediately start using the cArVATAR and to perform the basic forwards and backwards driving gestures simply and directly. There was no hesitation or confusion in these functions, and they were performed with the simplicity and spontaneity of playing with a toy car.

The length of an arm span was not sufficient for performing the long drive of Play Challenge 1 with the cArVATAR. In this case, the children tended to move their body to the place where their hand had reached, in order to push the car from there onward. They did not spontaneously employ the option of lifting the controller and placing it back next to them (somewhat similarly to a computer mouse at the edge of the mousepad). In this aspect cArVATAR differs significantly from the traditional controller, in which long drives do not require added effort, creating a different play pattern.

Moving precisely along the drawn line was challenging with the cArVATAR. Small unintentional changes of orientation were implemented by the controlled car, causing it to steer away from the line. In this case the traditional remote's separation of control functions makes forwards and backwards driving more precise.

Turning

In the free play session with cArVATAR, all children performed gestures composed of both straight driving and turning. In this free movement scenario, there was no gap of understanding of the basic mapping between gesture and outcome, regardless if driving straight or turning. This is different from the traditional controller, in which the basic mapping between the two sticks was not inherently clear to the children, and they tended to break their driving movements into separate forward driving and turns.

Play challenges 3,4, 5 and 6 required making a turn directly from a stationary position. Here most children tried, at first, to turn the stationary controller to the desired orientation and then drive it straight forward, rather than turning the controller while driving it forward. When they discovered this did not work, they learned to turn the controller while it is moving.

Opposing view positions

As previously described, situations in which the car is facing a different direction than the child make control more difficult, requiring the child to mentally rotate her viewpoint to that of the car, or to move to a position where the viewpoints are aligned.

All children spontaneously discovered the option of turning the cArVATAR controller to the same heading as the controlled car. They used this solution often in Challenges 4, 6 and 7. It seems to be a natural and successful solution to the complexity of relative direction control.

Reaching a target

Challenge 7 was designed to require the combination of the different skills described above, and to provide a goal that is more gratifying and playful in nature.

While this challenge was difficult with both controllers, the level of success was lower with cArVATAR than with the traditional remote. We attribute this to two issues: the problem of straying aside due to small unintentional orientation changes, and a technical problem that caused a deviation from the path while driving backwards.

When using the cArVATAR, children were markedly more expressive than with the traditional controller. This was especially apparent in this challenge, and most pronounced in the final gesture of knocking over the block tower: the gesture was not only that of guiding the car forward, but moving foreword with a force and a gesture of enthusiasm, as if actually knocking over the tower.

Play value

Children reacted with surprise and delight when the relationship between cArVATAR and the controlled car was demonstrated to them. They were eager to try it. During the free play session, they explored the relationship, enjoyed performing large and expressive gestures such as large arcs and other round gestures like the figure 8.

The similarity between controller and controlled prompted the children to create physical contact between the two cars: three of them pushed the controlled car with the controller, making it 'escape'. One child placed the small car on the large car, trying to make it move in that configuration.

CONCLUSIONS AND FUTURE WORK

Our observations were exploratory in nature, but point to significant potential in this novel control model. The direct mapping, especially in the forward and backwards motion, was clearly an 'easy way in' to this relationship between controller and controlled, and points to cArVATAR as a model that enables young children a faster introduction into using remote controlled toys. The playful nature of the controller makes it a promising source of enjoyment.

Improving a number of implementation issues can increase the precision of cArVATAR. We plan to filter small orientation changes, informed by the attributes of the involuntary movements seen in this study, to facilitate more precise straight driving gestures.

For improving turning gestures, we plan to try an “absolute” control scheme for the next cArVATAR version. In this scheme, changing the orientation of the controller will be implemented by the controlled car as a series of short and tight arcs for aligning its orientation to the absolute orientation of the controller.

cArVATAR can be viewed as a new controller category altogether, or as a transitional model for smaller children on their way to the traditional controller. After this study, we view it more as a new category of its own. Each controller affords different play scenarios and promotes different kinds of skills. The traditional controller develops sensory-motor coordination and fine motor skills through its two sticks. Children play with it standing up, and can move large distances. cArVATAR is used mostly in a sitting or crouching posture, in a smaller area, with more potential contacts between the controller and controlled car and more expressivity in the control gestures. We plan to explore these new play opportunities through implementation improvements and further studies with children.

While mimicry is not a new concept – it has been used, e.g. in the context of robotic teleoperation - cArVATAR shows the potential of this type of interaction for young children. The simplicity of the mimicry mental model may be even more advantageous in more complex interactions of this type: for example, R/C toys with additional degrees of freedom, such as a bulldozer or excavator, in which the child can control the blade or bucket directly by moving it!

As the use of robots within the home environment grows wider, the avatar-inspired relationship of controller to controlled can be considered an interesting alternative for users and tasks where a simple entry level is more important than high levels of expertise. Furthermore, this model may be relevant to simple household objects that are out of reach, such as controlling the direction of the air conditioning vents or the speed of a ceiling fan.

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