Motion Simulation Techniques for Game Controllers

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1 Introduction

The simulation of real life motion and interaction with an abstract controller is a continual challenge facing video game developers. This challenge involves mapping joystick motion and button pressing into realistic motion so convincingly that the user becomes unaware of the controller. By reducing awareness of the controller mechanism, the player is allowed to concentrate primarily on playing the game rather than fighting with the controller.

There seem to be several methods of effectively using a video game controller as an interaction intermediary, which bear striking similarities to Hutchins' ideas on direct manipulation interfaces [1]. Hutchins suggests that direct manipulation may be achieved by semantic and articulatory directness, inter-referential input and output, a responsive system, and an unobtrusive interface. Video game interaction techniques seem to follow these principles well in order to create direct manipulation. Rapid feedback from the television screen allows the player to see the effects of his actions, a comfortable controller encourages extended hours of gaming, and multiple buttons are provided to allow semantic and articulatory directness. All of these factors contribute to effective controller to video game world mapping.

The controller-world mapping must be natural so that the player may instinctively execute complex interactions to meet his goals. One of the most important interactions in a video game is the ability to move around in the virtual world fluently. This ability is provided by giving the player constant awareness of the game character's direction and orientation without distraction from the controller. The use of direct manipulation and mapping hand motions into an imaginary video game world was studied using the generic PlayStation 2 (PS2) controller and the game "Grand Theft Auto 3" (GTA3). The controller consists of one directional pad, two joysticks, and a variety of buttons (Fig. 1) that may be used to perform actions in the game. The game required players to control both motion by foot and motion by car, while performing other actions such as fighting or stealing. The objective of this study is to analyze how well direct manipulation techniques have been employed to provide fluent motion control and an enjoyable gaming experience.

2 Motion of Character

The character in GTA3 is able to move at variable speeds, rotate his field of vision in full 3D, and perform high level interactions with the environment. Translational motion is performed

Figure 1: Photo of PlayStation 2 controller

through the use of the analog joystick controller where a forward press causes the character to move forward. A press in the other directions first changes the character's orientation relative to the camera, then moves the character forward. Direct manipulation is achieved in this situation because the joystick motions match directions with the character direction.

This motion technique tends to fix the camera viewpoint as the player moves the character, allowing the player to better see the character's response to joystick motion. The view of the camera may also be aligned to the character's line of sight by pressing a button, which places the player in first person view after the orientation has been determined. By emphasizing character direction over line of sight, the player is able to take the output orientation of the character and translate that into an input corrective action in the form of rapid feedback.

The character is also able to move at different velocities by varying the displacement of the joystick in the direction of interest. If the player decides the character should walk, the joystick is pressed forward forward slightly. If the player should jog, the joystick is pressed forward to maximum extent. While jogging, the player may elect to run by rapidly pressing the "x" button. As the player's thumb gets tired, the player will hit the run button at longer intervals, simulating the exhaustion of the character. Furthermore, by forcing the use of cognitive resources in pressing the run button, the player becomes less capable of adjusting to changes in the environment that may have been easy to spot while walking. The sensitivity of the joystick and the additional run button build a metaphor that by exerting more effort on the joystick, the character exerts more effort towards translational motion. This metaphor is intuitive because the psychological variable here is physical effort, and the game controls are mapped directly to it. The result is an easy to understand, lifelike way of interacting with the controller.

A tradeoff made by controlling both jogging and walking speed with the same joystick is to exchange precision for a range of speeds. By varying the intensity of the joystick press,

the player can control approximately how much speed he wants, but he also needs to remember how far to move the controller to do so. Sometimes, the player may push the joystick too far and cause the character to jog where the intent was to cause the character to walk. Alternatively, if the player were presented with separate buttons for walking and jogging, there would be no need to worry about moving at an undesired speed. With the alternate method, however, the disadvantage then becomes a limited set of character speed.

A full range of motion in adjusting the character's perspective is also provided to enhance the player's sense of location. By moving the second joystick, the player can tilt or pan the camera from the location of the character's head. The pan is achieved by left and right motions on the joystick, while the tilt is adjusted by the up and down, similar to what one would do if holding a camera in viewing a scene. By providing the additional degree of freedom, the illusion of having moved through a three dimensional space is created and the player's awareness of current character location and orientation is supported.

3 Motion of Car

Both the video game and real life car motion have the same psychological variables of speed and direction, and contain the same inputs of turning rate and acceleration. However, the physical variables, the game controller and the car driver's seat, have clear differences. These differences seem to have been overcome by changing the controls for foot motion directly into the controls for car motion. This immediately forces the player to think in terms of driving a car rather than moving a person and calls different psychological variables into the cognitive space.

To create a transition of control, vehicle motion in the game is controlled by the same set of controls as character motion. The analog joystick changes from character orientation to car orientation, and the "x" button changes from controlling running into the car accelerator. The player is automatically switched over to the appropriate control mode upon entry into the vehicle, similar to how people change their thinking process when driving a vehicle in real life. This transition encourages the player to draw from existing knowledge of vehicle control and apply those same principles of turn rate and acceleration towards the video game. Much as in an actual car, the severity of the turn or acceleration is determined by how much effort is placed into them. By receiving rapid updates from the screen, the player may quickly make intensity adjustments the same way observing the surroundings would help familiarize a driver to a different car.

While the semantic distance may have been reduced by matching the psychological variables, the articulatory distance prevents the player from getting the exact same feeling of driving a car. Many players seem to have difficulty controlling the car at high velocities because of a tendency to over-accelerate and to turn too sharply. The over-acceleration is caused by a tendency to press the "x" button all the way down, which may be due to controller's lack of force-feedback. This problem is compounded by the awkward process of mapping the linear motion of the joystick into rotational motion of a steering column. A real life turning motion consists of a rotation, hold, and counter-rotation, which is difficult to duplicate on the video game

controller. The result is that the player to may not be able to articulate the exact turning rates needed although the controls are fully capable of doing so.

Other visual and audio cues contribute to the illusion of driving an actual vehicle by providing realistic feedback. Inertial effects, such as the car fish-tailing or skidding on pavement, further reinforce the illusion of driving a car by simulating familiar real world physics. Additionally, the car driving experience is made more realistic by pressing the joystick to emit a honk, or by being yelled at by other drivers were included as well.

4 Conclusion

Direct manipulation techniques were used effectively in the PS2 controller and GTA3. By tying real-life motions to the input, video game players are presented with a closely mapped virtual motion to match their psychological intent. The parallel between character effort and button sensitivity helps the player develop a model that correlates his psychological variables with the game characters physical motion. This provides both a sense of direct manipulation and a relatively intuitive set of controls that players can familiarize with to learn the interface quickly. In addition, by simulating real life motions on the game controller, such as rapidly pressing the run button when running, the player feels more immersed within the context of the game. By implementing these techniques in GTA3, effective interaction between the player and the character is achieved.

However, a few trade-offs in the use of real-life mapping techniques are noticeable and disrupt the fluidity of game flow. The degrees of freedom presented by the range of joystick motion and the use of an additional run button may prove disorienting to the first-time player. The complexity is increased by the awkward use of a joystick to simulate the rotation of a steering wheel. This sacrifices directness of simulation and does not add to the overall presentation. However, the interface design is significantly simplified and the player benefits economically. Although some aspects may be improved upon, the interaction techniques were generally effective and are commonly used in many 3D games.

References

[1] Edwin L. Hutchins, James D. Hollan, and Donald A. Norman. Direct manipulation interfaces. *Human-Computer Interaction*, 1:311–338, 1985.