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# KINECT<sup>Wheels</sup>: Wheelchair-Accessible Motion-Based Game Interaction

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**Abstract**

The increasing popularity of full-body motion-based video games creates new challenges for game accessibility research. Many games strongly focus on able-bodied persons and require players to move around freely. To address this problem, we introduce KINECT<sup>Wheels</sup>, a toolkit that facilitates the integration of wheelchair-based game input. Our library can help game designers to integrate wheelchair input at the development stage, and it can be configured to trigger keystroke events to make off-the-shelf PC games wheelchair-accessible.

**Author Keywords**

Accessibility; games; entertainment; design.

**ACM Classification Keywords**

K.4.2 [Computers and Society]: Social Issues – Assistive technologies for people with disabilities, Handicapped persons/special needs; K.8.0 [Personal Computing]: General - Games.

**General Terms**

Design, Human Factors.

**Introduction and Research Background**

In many situations, children and teenagers using wheelchairs have access to fewer leisure activities than

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	Wheelchair Action
<i>Gesture 1</i>	Move forward
<i>Gesture 2</i>	Move backward
<i>Gesture 3</i>	Turn left
<i>Gesture 4</i>	Turn right

**Table 1.** Overview of wheelchair-based input supported by KINECT<sup>Wheels</sup>.

	Player Action
<i>Gesture 1</i>	Clap hands
<i>Gesture 2</i>	Raise left arm
<i>Gesture 3</i>	Raise right arm
<i>Gesture 4</i>	Lift legs

**Table 2.** Overview of body-based input supported by KINECT<sup>Wheels</sup>.

able-bodied persons of the same age. Video games have been a positive example of a widely accessible activity due to their sedentary nature; an individual's possibility of engaging in play is generally not affected by their ability to move around freely. Hence, children and teenagers using wheelchairs have been able to fully access video games, engaging with them on their own or competing on par with able-bodied friends.

However, the increasing popularity of motion-based game controls brings in a new focus on an individual's physical abilities. Sedentary modes of play are increasingly replaced by motion-based interaction, and research has shown that such games may yield a variety of benefits, e.g., improved health and cognitive benefits [2], [7]. This introduces new game design challenges to enable persons using wheelchairs to obtain benefits of motion-based video games [3]. Controller-based input (e.g., using the Nintendo Wii Remote or the Sony PlayStation Move controller) mainly focuses on upper-body movements, and is generally accessible to persons using wheelchairs. In contrast, camera-based systems such as the Microsoft Kinect sensor encourage full-body input and are designed with a focus on able-bodied players. As a consequence, persons using wheelchairs can no longer participate in many of these games; game mechanics frequently require players to stand and move around in the room. Microsoft has addressed this issue by integrating a seated mode that allows players to interact with the system using upper body movements only. However, alternative input schemes are only supported by few games [5], and using upper body movements only limits the range of input gestures available to players using wheelchairs.

Prior research, e.g., the GAME<sup>Wheels</sup> system, has focused on custom-designed hardware to track wheelchair input [1], [6]. Unfortunately, the complexity of the system hinders its application as a general solution to accessibility limitations of motion-based game input. To address this issue, we apply the Microsoft Kinect sensor to create a lightweight full-body motion-based game interface for persons using wheelchairs that can be applied within the home and does not require additional equipment. Our toolkit, KINECT<sup>Wheels</sup>, provides a library to facilitate the integration of wheelchair-based game input at the development stage, and it can be configured to trigger keystroke events to make off-the-shelf PC game wheelchair-accessible. The system implements traditional upper-body input for seated users, and integrates the wheelchair into the interaction process by accounting for its position and movements. Thereby, it is possible to encourage physical activity among players using wheelchairs in a novel way.

By extending the set of interaction paradigms available to players in wheelchairs rather than offering a limited subset of suitable upper-body movements, we focus on abilities of players using wheelchairs instead of adapting systems to accommodate disabilities [8]. Further exploring this approach will allow us to inform the work of game designers wishing to include accessible control schemes for camera-based game interaction, thereby helping to make full-body motion-based video games truly wheelchair-accessible.

### The KINECT<sup>Wheels</sup> System

KINECT<sup>Wheels</sup> is a toolkit that facilitates the integration of wheelchair-based game input at the development stage, and it can be configured to trigger keystroke events to make existing games wheelchair-accessible.



**Figure 1.** A player interacts with KINECT<sup>Wheels</sup>.

### System Architecture

The KINECT<sup>Wheels</sup> system is a software library written in C# based on the Microsoft Kinect SDK. It allows developers to easily and quickly add interactivity to their programs. The system provides the data from the official Microsoft Kinect SDK, as well as extra gestures that help take advantage of the movements that a wheelchair can make. Data available from the Kinect SDK contain all the joint positions of the skeleton and the raw image data (colour and depth). The new gestures the KINECT<sup>Wheels</sup> system provides include the direction the wheelchair is pointing, a gesture for clapping hands, and a gesture to determine quick movements to the left and right sides as well as the front and the back. The direction of the wheelchair is given as a two-dimensional vector. This vector is calculated using the two shoulder joints. The clap detection uses the three-dimensional distance between the hands. The distance is calculated once the hands are raised above the shoulders. The KINECT<sup>Wheels</sup> system also contains classes to easily and conveniently threshold data from the system.

Once a gesture is recognized, any action can be performed including sending keystrokes to the operating system so that any program, including Flash, OpenGL, and XNA games can be controlled using gestures from the Kinect sensor.

### Motion-Based Player Input

The KINECT<sup>Wheels</sup> system supports two types of motion-based player input. First, the toolkit implements a set of predefined body-based gestures that can be carried out while using a wheelchair (Table 2). Second, we implement common wheelchair-based actions (Table 1). Our system offers the possibility of processing

wheelchair-based input in two different ways. Actions can either be turned into continuous game input (e.g., if the player moves forward, a continuous action of her in-game representation is triggered, such as a car moving forward) or discrete game input (e.g., if the player moves forward a single in-game action is triggered, such as the in-game representation jumping up). Thereby, the toolkit adapts to different game concepts and can be applied to different game genres.

### Case Study: XNA Racing Game

In order to assess whether KINECT<sup>Wheels</sup> can be used for game input, we combined the toolkit with an XNA racing game that allowed us to test basic interaction paradigms (Figure 1). In the game, players control their car using wheelchair movements (Table 1). Common procedures were mapped onto wheelchair movements in the following way: To speed up, the player has to move the wheelchair towards the camera. To slow down, the player has to move away from the camera. In order to steer to the left or right in the game, the player has to turn the wheelchair to the corresponding direction.

The results of preliminary user tests show that players can control the car using wheelchair input and that players enjoy the interaction process. In the context of our case study, we plan to explore issues related to the fine tuning of player input (e.g., sensitivity) and balancing (e.g., to allow for competition between players using keyboard and mouse input and players using wheelchairs).

### Conclusion and Future Work

KINECT<sup>Wheels</sup> can help make motion-based video games wheelchair-accessible by assisting designers wishing to

integrate wheelchair-accessible input into motion-based video games using the Kinect sensor, and by allowing end-users to configure keystroke events that allow them to map wheelchair-based gestures onto off-the-shelf PC games.

There are a number of limitations and open research questions related to the approach presented in this paper. The current version of the toolkit only works with PC games, and many motion-based video games are released on console platforms. Additionally, it only covers a limited breadth of input gestures. Adapting the toolkit to accommodate complex in-game actions, e.g., sequential input that requires a combination of different gestures, or the combination of chair-based and body-based input, could help address this issue. Finally, future work should focus on the creation of custom-designed games. Such games could include game mechanics that are well suited for wheelchair-based input, particularly focusing on the design of exergames to encourage physical activity among children and teenagers using wheelchairs.

Our work can help designers to build upon the abilities of players using wheelchairs rather than making limited subsets of existing motion-based interaction paradigms accessible. Because of the increasing popularity of motion-based video games, it is important to encourage the inclusion of wheelchair-accessible control schemes to allow children and teenagers using wheelchairs to participate in play and obtain the full benefits of motion-based video games.

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