

## **Providing disabled persons in developing countries access to computer games through a novel gaming input device**

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**Abstract:** A novel input device is presented for use with a personal computer by persons with physical disabilities who would otherwise not be able to enjoy computer gaming. This device is simple to manufacture and low in cost. A gaming application was especially designed for this input device, requiring four participants to collaborate in order to accomplish the set task. We describe the constituent parts of this device and how colour and simple pictures were incorporated into the physical input device.

**Keywords:** tangible input device, collaboration, SlideStick, gaming, Ataxia.

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### **INTRODUCTION**

This paper's contribution is the description of an input device suitable for use by people with gross motor skill problems. The device can be manufactured at low cost.

A superficial survey of available personal computer (PC) input devices for the disabled will show that these are mostly well designed, but expensive. In developed countries where State subsidies reduce the financial burden on the disabled, this is less of a problem. However, in developing countries such subsidies either do not exist, or are minimal.

The input device we present in this paper is simple to manufacture. It is quite feasible for the local community handy-man to construct it from a variety of materials. These materials include sheets of plywood or acrylic. A modified commercial joystick, magnets, and magnetic sensors are the main components of our input device (SlideStick). The magnets and magnetic sensors are commonly used as intrusion sensors in homes and offices, making them readily-available items. Electrical contacts of the magnetic switches are wired in parallel to the joystick switches. The stick usually used when manipulating the commercial joystick can optionally be removed, resulting in an improved compact unit.

### **SYSTEM OVERVIEW**

The system consists of up to four SlideSticks (Figure 1) connected to the Universal Serial Bus (USB) ports of a PC. Gaming participants each operate one SlideStick to collaborate in accomplishing a task. A player operates only one SlideStick. A player manipulates the slider using either the hands or feet.

#### **Hardware**

A SlideStick consists of two components; these are (a) a mechanically robust slider assembly and (b) a modified joystick controller. An electrical ribbon cable connects the switches embedded inside the slider assembly to the modified joystick controller. Sensor closure events emanating from the slider assembly are made available to the software through the joystick USB interface.

##### *Mechanical components*

The frame of the slider assembly consists of a magnet sub-assembly and a number of plywood/acrylic layers. The slider assembly is approximately 100cm long, 15cm wide and 5cm high, and constructed by combining individual layers into a single unit (Figure 1). Five magnetic switches are mounted in a linear fashion onto the bottom layer. This is the base of the SlideStick. The magnetic switch contacts close as the magnetic sub-assembly moves over the sensor.

The player momentarily activates successive magnetic switches by sliding a permanent magnet across the switches. Movement of the magnet sub-assembly is physically constrained to a single linear dimension. A number of spacers separate the top and bottom layers. Within this space, the magnet sub-assembly can move freely. Yellow self-adhesive tape is attached to the magnet sub-assembly and is visible through the triangular notches of the slider assembly top layer. This provides an additional visual cue to the player of the magnetic sub-assembly's position.

#### *Electronic components*

Each of the four modified commercial joysticks contains two analogue sensors to detect X- and Y-axis movement. In addition to the analogue sensors, the joysticks also contain a "hat" switch assembly and five discreet switches spatially distributed across the joystick enclosure. Our input device only makes use of the five spatially distributed switches. The two analogue sensors and "hat" switch are not used in our design.

Our modification requires the addition of five magnetic switches in parallel to the five spatially distributed switches in the commercial joystick. This requires the partial dismantling of the joystick to trace the connections of the switches on the circuit board. Five connections, one for each switch respectively, plus an additional common connection are routed using ribbon cable from the joystick to the slider assembly.

### **Software**

#### *Overview*

We have developed a simple gaming application (Figure 3) which encourages player collaboration. The game allows the players to colour in a picture using four SlideStick controllers.

The game makes provision for four players to participate in the colouring-in process. Three players control the red, green and blue (RGB) colour mixture. The fourth player selects which part of the displayed picture should be coloured. Scrollbars on the sides of the gaming screen provide additional feedback to the players. In addition, a frame around the plying area displays the current RGB colour mixture. This is the colour that will be used to colour the selected area.

The "Painter" gaming application was written in the Visual Basic 6, service pack 5 computer programming language. "Painter" is available as open source and the compiled application is available for download (1).

#### *Colour Selection*

Three SlideSticks each respectively controls a component of the desired filling colour. This is done by moving the slider of the "Colour"-selection SlideStick to select a shade of the colour assigned to that particular SlideStick. Colour shades range from dark to light. One of five distinct colour values can be selected by each "Colour"-selection SlideStick. This allows for a total of 125 potentially distinct colours that can be used for colouring the selected areas. The individual selections are then automatically mixed by the application software to give the resultant filling colour. The mixed result is made visible by changing the colour of the rectangular border around the central painting area (Figure 3 top).

#### *Area Selection and Colour Application*

The pictures in the painting application are composed of circles and rectangles. The user operating the "Object"-selection SlideStick sequentially selects a circle or rectangle for painting. The slider on the screen (Figure 3 top) moves in unison with the "Object"-selection SlideStick. Moving this slider either sequentially selects the object to be painted, or initiates the painting action using the current selected colour combination. The rate at which the sequential selection takes place depends on the slider position. The rate is adjustable between very fast, fast, slow, and very slow. The selected object flashes in the current selected paint colour. To apply the selected colour, the slider is moved to the "Paint" position on the extreme left of the SlideStick.

### **METHOD**

The SlideSticks and gaming application were tested with the assistance of residents of a home for intellectually and physically handicapped adults (2). Four persons were identified as testees; all over 50 years of age and having had no prior computer exposure. The testees' intellectual ages at the time of

testing ranged from 7 to 10 years. One of the testees is a Cerebral Palsy case with moderate Ataxia – she is also wheelchair-bound. The other three testees do not have any serious physical disabilities.

To improve the system's affordance (3), we made some adjustments to the SlideSticks before testing with this group.

The first adjustment was the use of coloured paper cut-outs in shades of blue, green, and red respectively. These were attached to the top surfaces of the three "Colour"-selection SlideSticks. Five cut-outs of each colour were placed on the respective SlideStick. The darkest shade cut-out was placed on the extreme left and the lighter shades sequentially to the right. These correspond with the shades shown in the application on the computer screen (Figure 3 top).

The second adjustment was the addition of printed grey-scale pictures to the "Selection" slider. On the extreme left of the slider we pasted a picture of a paintbrush. This indicates that a paint action will take place when the slider is in that position. In the remaining four positions, a picture of an animal or an object was attached. These were placed sequentially in order of the speed each could attain in real life situations. They are: a tortoise, an elephant, a motor car, and an aeroplane. The tortoise represented slow changes, the elephant represented faster changes, the motor car represented even faster changes, and the aeroplane represented the fastest changes. These correspond to the actions depicted in Figure 3 (bottom). We also modified the "Paint" application by replacing the wording "Stop" (Figure 3 (bottom)) with "Very Slow".

## **RESULTS**

Previous formal tests of the SlideSticks, using the custom-developed educational BodyPingPong gaming application, have been done with able-bodied children (4). Informal tests with disabled children, using the same BodyPingPong gaming application, have shown promising results.

Current testing was executed with the aid of mentally handicapped adults. Interaction with the testees was verbal, no written questionnaires were used, and neither did we make written notes while interacting with the testees. In our discussions with the occupational therapist associated with the mentally handicapped testees, we were told that the testees tended to want to please adults and this therefore influenced how the testees responded to our questions (5). This was indeed evident when we asked them what problems they had experienced with the test system during the week when have had unrestricted access to it. Collectively they denied that they had experienced any problems or that any system improvements were required. However, one testee later spontaneously mentioned to us, and in the presence of the other testees, that they all needed more time to master the system. We did not get any other unsolicited feedback from the testees.

## **DISCUSSION**

We have presented an alternative input device which is suitable for use by people with certain disabilities. The input device can be manufactured by adapting commercial gaming joysticks. The required adaptation is simple and can be accomplished by an able-bodied person with limited technical experience. The high-volume at which commercial joysticks are manufactured, and the subsequent relatively low cost compared to other custom-built aids, makes this device a viable alternative to commercial aids.

By virtue of its large range of movement and low resolution, the SlideStick controller may be an ideal input device for people with fine motor control challenges. Our tests indicate that the input device can be manipulated by either the player's hand or the foot, making it potentially useful to people with physical disabilities.

We have developed this input device and the associated software as a concept demonstrator. The custom-developed gaming software still lacks in several areas and future versions of the software will have the capability to use suitable bitmaps of the user's own choice as well as the ability to print and save coloured images.

SlideStick was developed with the specific purpose of testing the viability of a low-cost, community-manufactured input device, together with custom-developed software, for use by people in developing countries. As such the SlideStick emulates the sequential pressing of five buttons on a joystick and no other

joystick functionality. SlideStick in its current form is not meant as a replacement for a commercial joystick but rather offers an alternative input mechanism for custom-designed applications.

Informal evaluations of SlideStick with the custom-developed gaming application indicate that the emulation of the joystick's "hat" switch would result in a better system. This option would open up other possibilities with existing commercial games – such as changing the player's point-of-view and movement in a game.

Our informal tests with mentally handicapped adults indicate that the interface device should be simplified, perhaps only using two input positions instead of the current five positions.

Formal tests are needed with the mentally- and physically disabled communities to properly evaluate the value which this input device can provide to these target groups.

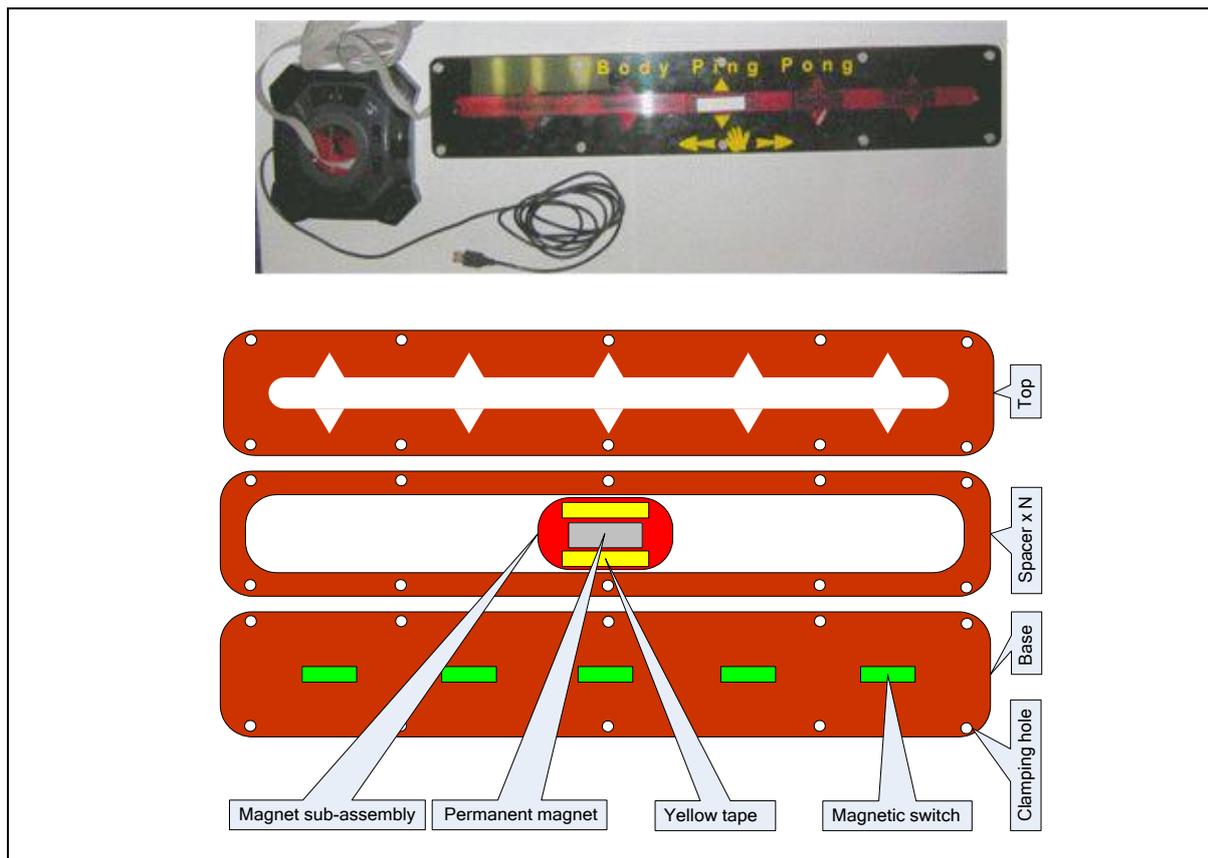
#### ACKNOWLEDGEMENT

This research was sponsored by the South African Department of Science and Technology.

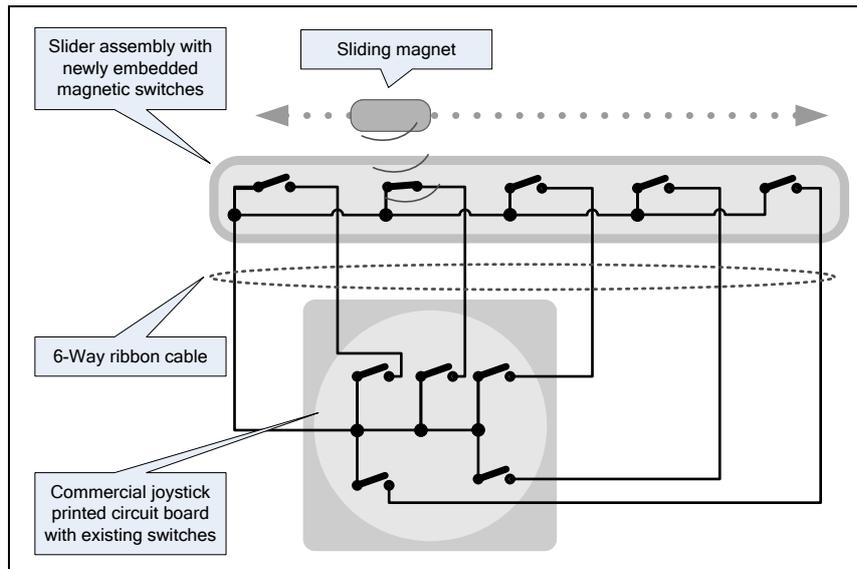
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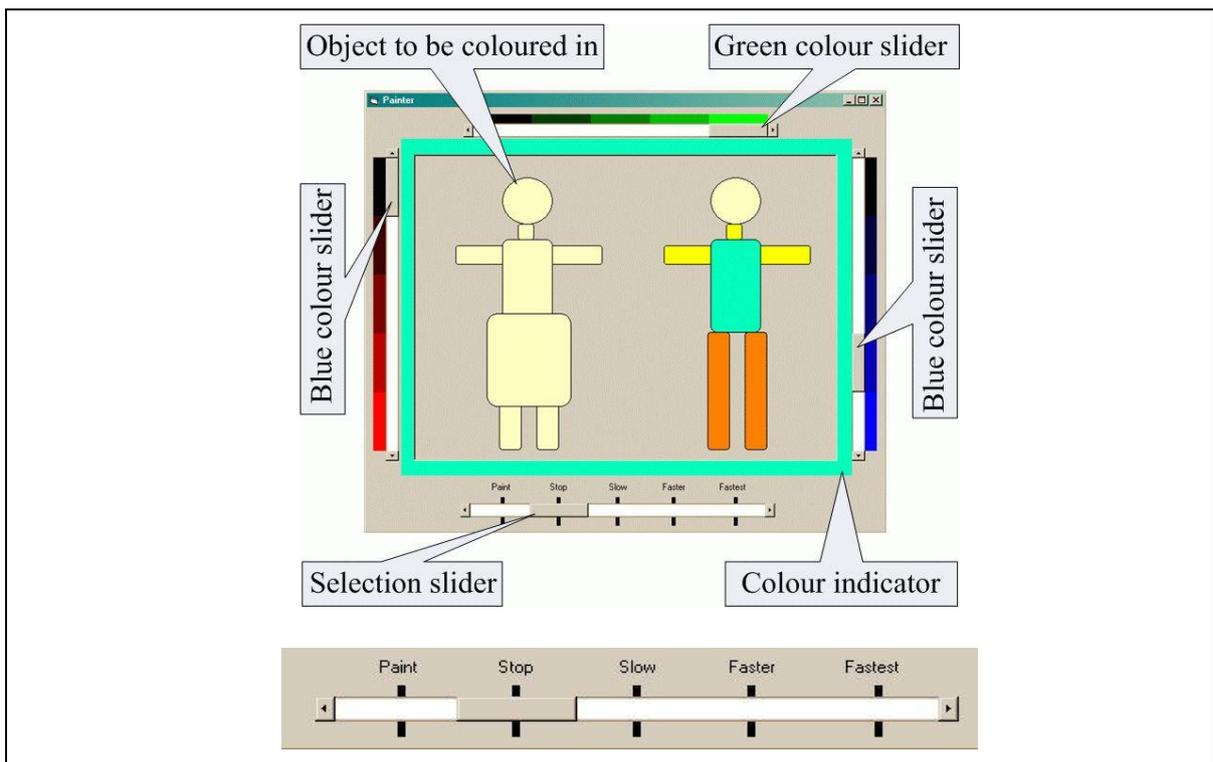
#### FIGURES



**Figure 1.** *top:* The SlideStick tangible input device consisting of: (left) the modified joystick controller and (right) the slider assembly. *bottom:* Engineering diagram of the SlideStick slider assembly. Lateral slider movement is possible, closing the fixed magnetic switches as it passes.



**Figure 2.** SlideStick electrical diagram showing the added switches.



**Figure 3.** *top:* The gaming application which was designed especially for use with the SlideSticks. Four players have to collaborate in order to successfully complete the task of colouring in the picture. *bottom:* An enlarged view of the selection slider which located at the bottom of the gaming application display.