



CORRELATION BETWEEN SYSTEM RESPONSE AND OPERATIONAL DIRECTION OF SLIDE SWITCH BUILT ON THE SIX PLANES OF AN OBJECT

Yongting Chen, Dengchuan Cai*, and Lanling Huang

123, University Rd., Sec. 3, Douliu, Yunlin, 640 Taiwan (R.O.C)

*caidc@yuntech.edu.tw

ABSTRACT:

With increasing variation in product designs, a switch may be fitted on any of the sides of a product. This study aims to investigate the relationship between system responses and the switching directions of a slide switch positioned on the six planes of a product. A total of 128 subjects participated in the study. The subjects were asked to operate the slide switch to turn power on, to increase volume, and to raise an object with their hands. The result showed that, on the five planes other than the bottom one, the correlations between the switching directions and the three system responses were highly consistent. On the top plane the switch was moved forward or rightward. On the left and right planes, the switch was moved forward or upward, and on the front and back planes, the switch was moved upward or rightward. However, on the bottom plane, to turn power on the switch was moved backward or rightward, whereas to increase volume or to elevate objects

the switch was moved forward or leftward. The results can be used as a reference when designing where to fit a switch on a product plane.

Keywords: compatibility, stereotype, slide switch, power on/off, volume Increase/Decrease, object up

1. INTRODUCTION

Switches are important controllers for humans to manipulate objects and have been widely used as built-in panels product surfaces. Many research studies have been conducted to address this issue (U.S. Department of Defense, 1999a, 199b, 1999c; Human Factors Society, 1988; Alan H. S. Chan A Vicki W. Y. Shum A H. W. Law I. K. Hui, 2003; Ken W.L. Chan, Alan H.S. Chan, 2005).

Most of these studies research on switches that are built on front planes or top planes. However with the number of functions of products increasing, the likelihood of a switch being built onto other planes will rise. The current study aims to investigate the typical operations human beings perform to turn power on/off, to increase/decrease volume, or to raise/lower something when the switch is positioned on any one of the six sides of a product. The results can be used as a reference when designing for switch operations.

2. METHODS

The subjects were 128 students (74 males and 54 females) studying at National Yunlin University of Science and Technology in Taiwan. Their mean age was 24.5 (SD = 24.5 years).

A slide switch was used in the study due to the popularity of slide switches and their similarity in operation style with toggle switches and rocker switches. It was fitted on a movable cubic box of 9x9x3 cm in size, so that it could be easily positioned on any one of the six planes (Figure 1). A cubic box sized 25x25x25 cm served as an experimental platform to hold the switch box during the investigation (Figure 2). The height of the switch center on the front plane from the floor was 106 cm. The height was considered the average height of workstations in general (Wang, Wang, and Lin, 2002).



Fig. 1 slide switch set on a moveable box

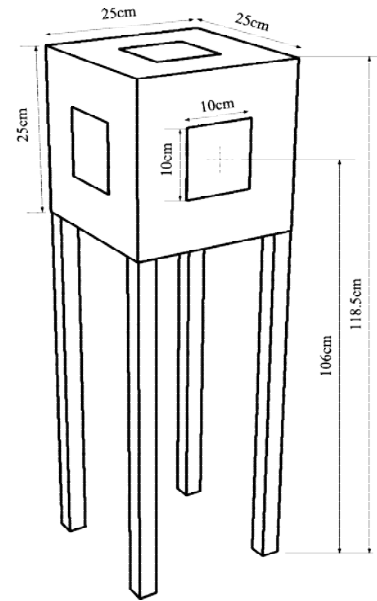


Fig. 2 the experimental platform

The six planes of the box in the study were defined as follows. Considering the way in which humans act on machines, the plane facing people was defined as the front plane and the one behind the back plane. The remaining four planes, left, right, top and bottom were defined in relation to the people facing the product (Figure 3). The operational directions of the switch were also defined in relation to the subject facing the experimental platform (Figure 4). The experimental task included three subtasks: move the switch bar 1) to turn power on/off, 2) to increase/decrease volume and 3) to raise/lower something. On each plane, the switch was positioned for either horizontal or vertical operations. The subjects were asked to use their left and right hands to operate the switch. A total of 72 (6x2x2x3) trials by each subject were conducted. The frequency percentages of the subjects' selection were calculated to indicate the intensity of the population stereotype on the directions of switch operation.

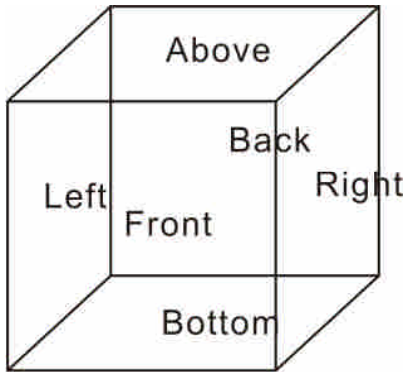


Fig. 3 the definitions of the six planes of the experimental platform

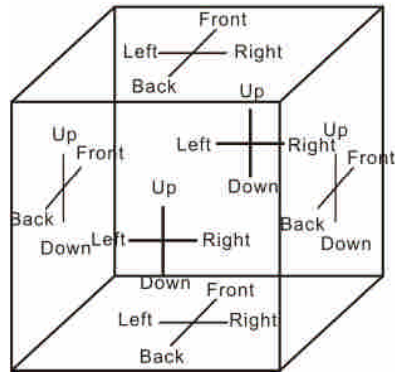


Fig. 4 the definitions of the moving directions of the switch

3. RESULTS

3.1 TO TURN POWER ON

Tables 1, 2, and 3 show respectively the percentages of switching directions selected by the subjects to turn power on using both two hands, the left hand, or the right hand. Figures 5, 6, and 7 show respectively the percentages of turning power on with both hands, the left hand, or the right hand. Figure 5 illustrates that on the top plane, to turn power on the switch was moved forward or rightward. On the bottom plane, to turn power on the switch was moved backward or rightward. On the front and back planes, to turn power on the switch was moved upward or rightward. On the left and right planes, to turn the power on the switch was moved upward or forward.

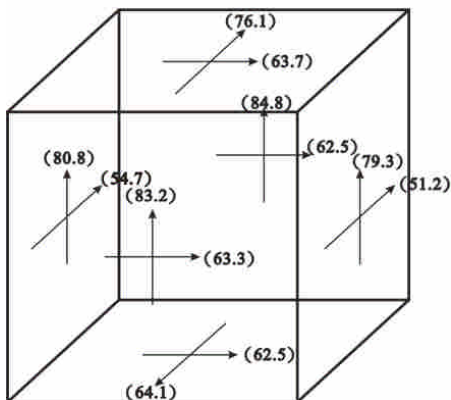


Fig. 5 the directions to turn power on by using two hands

Table 1 the percentages selected for two hands

Object's planes	Directions		To turn power on		To increase volume		To ascend object	
Top	Left	Right	36.3	<u>63.7</u>	16.4	<u>83.6</u>	21.1	<u>78.9</u>
	Front	Back	<u>76.1</u>	23.9	<u>89.8</u>	10.2	<u>89.4</u>	10.6
Bottom	Left	Right	37.5	<u>62.5</u>	21.9	<u>78.1</u>	25.8	<u>74.2</u>
	Front	Back	35.9	<u>64.1</u>	<u>60.</u>	40.0	<u>65.2</u>	34.8
Left	Front	Back	<u>54.7</u>	46.3	<u>64.0</u>	36.0	<u>73.0</u>	27.0
	Top	Down	<u>80.8</u>	19.2	<u>86.3</u>	13.7	<u>95.3</u>	4.7
Right	Front	Back	<u>51.2</u>	48.8	<u>70.3</u>	29.7	<u>73.8</u>	26.2
	Top	Down	<u>79.3</u>	20.7	<u>84.8</u>	15.2	<u>93.8</u>	6.2
Front	Left	Right	36.7	<u>63.3</u>	19.6	<u>80.4</u>	21.9	<u>78.1</u>
	Top	Down	<u>83.2</u>	16.8	<u>87.5</u>	12.5	<u>94.1</u>	5.6
Back	Left	Right	37.5	<u>62.5</u>	27.8	<u>72.2</u>	23.8	<u>76.2</u>
	Top	Down	<u>84.8</u>	15.2	<u>83.2</u>	16.8	<u>93.8</u>	6.2

Table 2 the percentages selected for left hand

Object's planes	Directions		To turn power on		To increase volume		To ascend object	
Top	Left	Right	<u>58.6</u>	41.4	29.7	<u>70.3</u>	30.5	<u>69.5</u>
	Front	Back	<u>72.7</u>	27.3	<u>86.7</u>	13.3	<u>89.8</u>	10.2
Bottom	Left	Right	<u>52.3</u>	47.7	33.6	<u>66.4</u>	34.4	<u>65.6</u>
	Front	Back	35.9	<u>64.1</u>	<u>58.6</u>	41.4	<u>67.2</u>	32.8
Left	Front	Back	<u>53.9</u>	46.1	<u>61.7</u>	38.3	<u>70.3</u>	29.7
	Top	Down	<u>78.1</u>	21.9	<u>86.7</u>	13.3	<u>94.5</u>	5.5
Right	Front	Back	47.7	<u>52.3</u>	<u>66.4</u>	33.6	<u>71.9</u>	28.1
	Top	Down	<u>82.8</u>	17.2	<u>86.7</u>	13.3	<u>94.5</u>	5.5
Front	Left	Right	<u>54.7</u>	45.3	34.4	<u>65.6</u>	35.9	<u>64.1</u>
	Top	Down	<u>83.6</u>	16.4	<u>85.9</u>	14.1	<u>93.8</u>	6.3
Back	Left	Right	<u>58.6</u>	41.4	40.6	<u>59.4</u>	30.5	<u>69.5</u>
	Top	Down	<u>83.6</u>	16.4	<u>82.8</u>	17.2	<u>93.8</u>	6.3

Table 3 the percentages selected for right hand

Object's planes	Directions		To turn power on		To increase volume		To ascend object	
Top	Left	Right	14.1	<u>85.9</u>	3.1	<u>96.9</u>	11.7	<u>88.3</u>
	Front	Back	<u>79.7</u>	20.3	<u>93.0</u>	7.0	<u>89.1</u>	10.9
Bottom	Left	Right	22.7	<u>77.3</u>	10.2	<u>89.8</u>	17.2	<u>82.8</u>
	Front	Back	35.9	<u>64.1</u>	<u>59.4</u>	40.6	<u>63.3</u>	36.7
Left	Front	Back	<u>55.5</u>	44.5	<u>66.4</u>	33.6	<u>75.8</u>	24.2
	Top	Down	<u>83.6</u>	16.4	<u>85.9</u>	14.1	<u>96.1</u>	3.9
Right	Front	Back	<u>54.7</u>	45.3	<u>74.2</u>	25.8	<u>75.8</u>	24.2
	Top	Down	<u>75.8</u>	24.2	<u>82.8</u>	17.2	<u>93.0</u>	7.0
Front	Left	Right	18.8	<u>81.3</u>	4.7	<u>95.3</u>	8.6	<u>91.4</u>
	Top	Down	<u>82.8</u>	17.2	<u>89.1</u>	10.9	<u>94.5</u>	5.5
Back	Left	Right	16.4	<u>83.6</u>	14.8	<u>85.2</u>	17.2	<u>82.8</u>
	Top	Down	<u>85.9</u>	14.1	<u>83.6</u>	16.4	<u>93.8</u>	6.3

Comparing Fig. 6 and 7, it was found: For vertical (up-down) switching by using either the left or the right hand the switch was moved upward on any of the six planes. For left-right switching, with the left hand the switch was moved leftward, and for left-right switching with the right hand the switch was moved rightward. For switch front-back switching, on the top and bottom planes the direction was the same, on the top plane the switch was pushed forward, while on the bottom plane the switch was pulled backward regardless of whether the left or right hand was used. However on the left and right planes, to turn power on using the right hand the switch was pushed forward, but on the left plane to turn power on using the left the switch hand was pushed forward, and on the right plane, to turn power on using the left hand the switch was pulled backward.

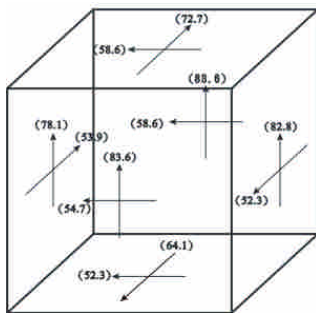


Fig. 6 the directions to turn power on by using the left hand

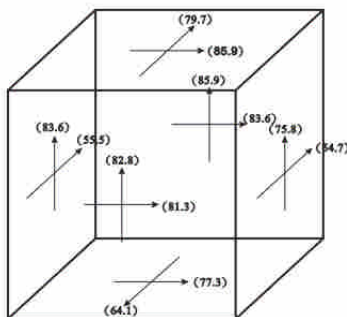


Fig. 7 the directions to turn power on by using the right hand

3.2 TO MAKE VOLUME INCREASED

The results on switching direction to increase volume are shown in Tables 1, 2, and 3. Figures 8, 9, and 10 show respectively the percentages switching directions to increase volume by using both hands, the left hand, or the right hand. The three figures show that the switching directions to increase volume are consistent regardless of whether the left hand or the right hand was used to operate the switch.

On the top and bottom planes, to increase volume the switch was moved forward or rightward. On the front and back planes, to increase volume the switch was moved upward or rightward, and on the left and right planes, the switch was moved upward or forward. In general, for vertical switching, to increase volume the switch was moved upward. For left-right switching, to increase volume the switch was moved rightward, and for front-back switching, the switch was moved forward.

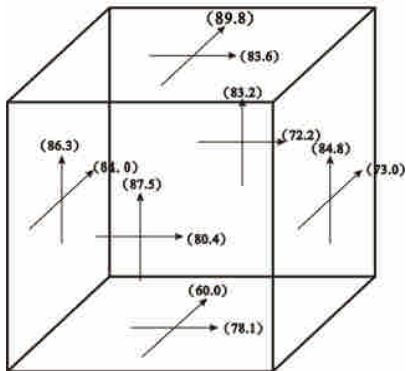


Fig. 8 the directions to increase volume by using both hands

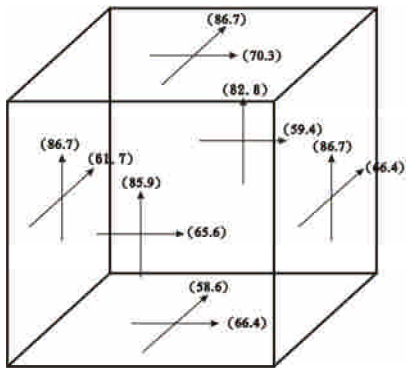


Fig. 9 the directions to increase volume by using the left hand

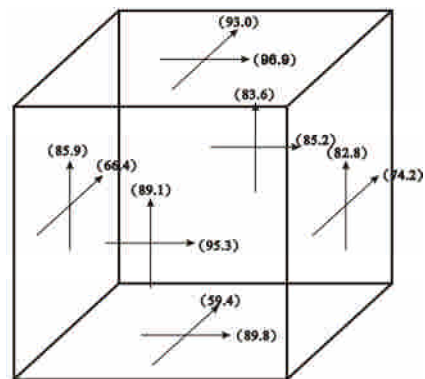


Fig. 10 the directions to increase volume by using the right hand

3.3 TO RAISE OBJECT

The results on switching direction to raise object with both hands, the left hand, or the right hand are show respectively in Tables 1, 2, and 3. Figures 11, 12, and 13 show respectively the percentages of switching directions on horizontal and vertical planes when using both hands, the left hand, or the right hand to raise object. The three figures show that the switching directions to raise object, whether by using the left hand, the right hand or both hands, were very similar.

Similar to the results on switching to increase volume, on the top and bottom planes, to raise object the switch was moved forward or rightward. On the front and back planes, to raise object the switch was moved upward or rightward, and on the left and right planes, the switch was moved upward or forward. Totally, for vertical switching, to raise object the switch was moved upward. For left-right switching, to raise object the switch was moved rightward, and for front-back switching, to raise object the switch was moved forward.

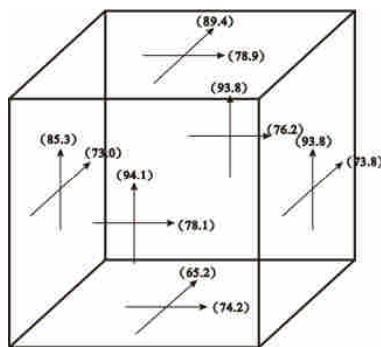


Fig. 11 the directions to raise object by using both hands

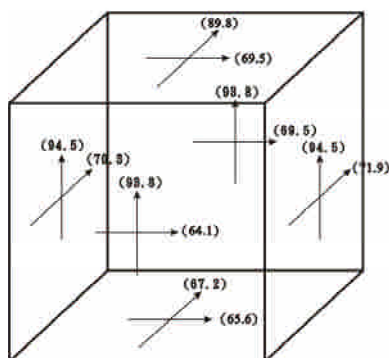


Fig. 12 the directions to raise object by using the left hand

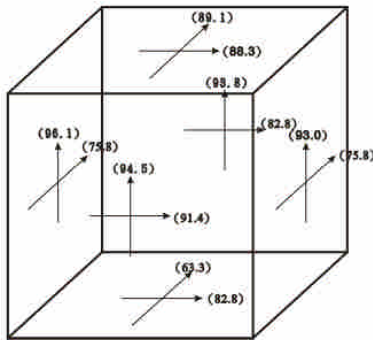


Fig. 13 the directions to raise object by using the right hand

4. CONCLUSIONS AND SUGGESTIONS

Three tasks: to turn power on, to increase volume, and to raise object were performed in the study. Several conclusions can be drawn, as follows:

1) to turn power on: for vertical switching to turn power on the switch was moved upward. For left-right switching using the left hand the switch was moved leftward, and for left-right switching using the right hand the switch was moved rightward. For front-back switching, on the top plane the switch was pushed forward, while on the bottom plane the switch was pulled backward regardless of whether the left or the right hand was used. However on the left and right planes, the switch was pushed forward when using the right hand, but when using the left hand, the switch on the left plane was pushed forward and on the right plane the switch was pulled backward.

2) to increase volume: In general, for vertical switching, to increase volume the switch was moved upward. For left-right switching, the switch was moved rightward, and for front-back switching, was moved forward.

3) to raise object: overall, for vertical switching, to raise object the switch was moved upward. For left-right switching, the switch was moved rightward, and for front-back switching, the switch was moved forward.

4) from the results discussed above, it was found that to turn power on the switching direction when using the left hand was consistent with operate the switching direction when using the right hand. However for increasing volume and raising object the switching directions were very similar. This may be related to culture difference and learning effects (in the one-light tow-switch setting, the on and off directions were not fixed).

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