

Research on compatibility in man-machine interface design of products

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Abstract. As a platform for information exchange between people and products, human-machine interface plays a more and more important role in human machine interaction. The compatibility of display and manipulation in human machine interface determines the ease of use to a large extent. Through the case study of HMI design for different products, this paper analyzes the spatial compatibility, the movement compatibility and the common measures to improve compatibility. Spatial compatibility refers to the correspondence of stimulus and response elements in physical layout on a display panel. Motion compatibility refers to the degree of correspondence between the motion effects generated by a controller and people's psychological expectations. It is pointed out that the common measures to improve the compatibility of human-machine interface are: shape coding, position coding, color coding, symbol coding, and taking into account human physiological characteristics and usage habits.

1. Introduction

Human machine interface (HMI) is a medium for the transmission and exchange of information between people and machines. The man-machine interface can be divided into two kinds from broad and narrow sense. The generalized man-machine interface refers to a medium or layer in the human and machine interaction process, that is, the interface. The narrow sense of man machine interface refers to the human machine interface ^[1] in computer system. In this paper, the generalized man-machine interface is discussed.

The compatibility in the man-machine interface refers to the correspondence between the product's display-controller and the person's psychological expectation, thus determining the good or bad of the compatibility of the man-machine interface of the product.

Broadly speaking, any product used by people has a human-machine interface in the process of use. The human-machine interface with good compatibility is beautiful, easy to understand, simple to operate and has a guiding function, which makes the user feel happy and enhance interest, thus improving the efficiency of use ^[2]. on the contrary, the poor man-machine interface make the user frustrated everywhere, not only the efficiency of the operation is reduced, and sometimes even lead to unpredictable serious consequences. Therefore, compatibility has become an important factor in the design of human-machine interface.

2. Compatibility overview

According to the interaction between the display and the controller in the human-machine interface, the compatibility can be divided into several categories, the most common of which are two categories: spatial compatibility and movement compatibility.



2.1. Spatial compatibility

The concept of spatial compatibility was first proposed by Fitts and Seeger^[3] in 1953. It refers to the physical layout of the stimulus and response elements on a display panel. When the relationship between stimulus and response is direct and natural, it is described as compatible; on the contrary, when its relationship is indirect and unnatural, it is described as incompatible^[4]. Specific to a product interface, the stimulus is the actual operation of the controller, and the response is the display result of the display.

A classic case study of spatial compatibility is the layout relationship between the control switch and the cooktop on the gas stove shown in Figure 1^[5]. The study found that the four different arrangements of the control switch, the reaction time and error rates are quite different, and people from different countries have different preferences for different arrangements. For example, Americans tend to choose the fourth layout, while Chinese prefer to choose the third layout^[6].

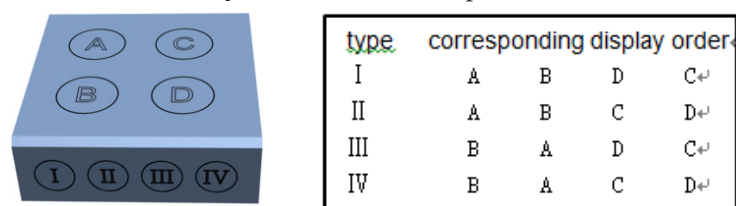
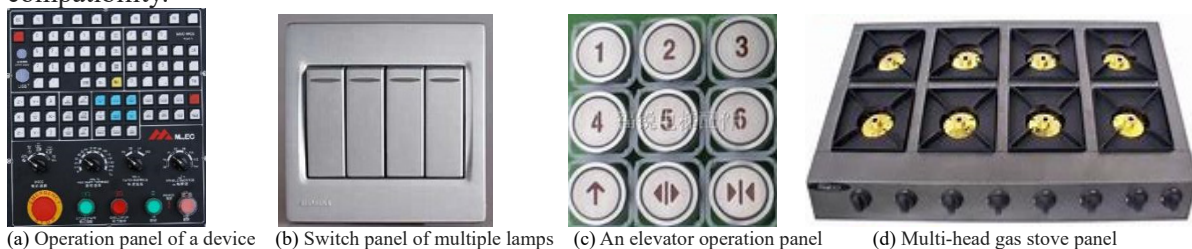


Figure 1. Example of spatial compatibility^[6]

The spatial compatibility relationship is widely existed in the product man-machine interface, such as: various cockpit control rooms such as aerospace aircraft, control room of automated factory, operation panels of various heavy equipment such as CNC machine tools. And human-machine interface of various daily life products, such as: switch between multiple switches and lamps (or fans), elevator operation panel and floor number, multi-head gas stove (4 heads, 6 heads, 8 heads), all of which reflects the importance of spatial compatibility. In such a large number of displays and manipulators, how to match them one by one, so that the user's operation is simple and clear, that is, the importance of spatial compatibility design. Figure 2 shows several examples of product space compatibility.



(a) Operation panel of a device (b) Switch panel of multiple lamps (c) An elevator operation panel (d) Multi-head gas stove panel

Figure 2. Spatial compatibility application of product human-machine interface

2.2. Movement compatibility

The research of movement compatibility began in 1947^[7]. It refers to the degree of correspondence between the effect of operation of a controller and people's psychological expectations^[8]. As shown in Figure 3^[9], when the manipulator is a handle, if pulls it up to the right (or rotates it clockwise when the manipulator is a knob), and its corresponding display pointer moves up to the right, so that the manipulation display relation is compatible, otherwise it is not compatible.

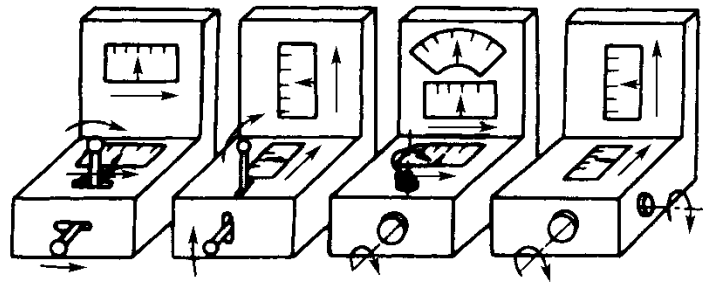


Figure 3. Example of movement compatibility

The relationship of movement compatibility is also widely existed in the man-machine interface of the product, such as the relationship between the fan switch and the wind speed, the relationship between the window switch button (or the handle) and the lifting of the window glass, and the relationship between the game machine remote control and the game scene, as shown in figure 4. In the display and controller associated with the above, how the control result of the controller is embodied in the display, whether it meets the user's psychological expectation, is the main point of the research on the compatibility of the movement.

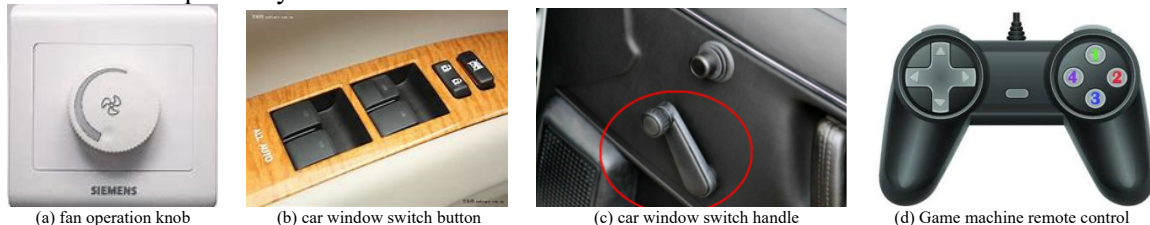


Figure 4. Movement compatibility application of product human-machine interface

In daily production and life, there are a lot of human machine interfaces which are not compatible whether in space or in movement, such as the operation panel shown in Figure 3 (a). There is no clear correspondence between the manipulator and the display. In actual operation, it is unavoidable that the operation reaction time is longer, the error increases, and it will even lead to the cause of a production accident. And as shown in Figure 4 (a), when the electric fan operation knob is rotated clockwise, its wind speed is smaller, which does not conform to the psychological expectations of the people, obviously will bring a lot of trouble to the operation of people. As a result, the compatibility of the human-machine interface has a great influence on the operating efficiency and error rate of the man-machine system, so it is very important to improve the compatibility of the human-machine interface.

3. Measures to improve the compatibility of man-machine interface design

3.1. Manipulator coding

A manipulator is a device that transfers human information to a machine for adjusting or changing the state of the machine. In the complex operation of a variety of manipulators, proper coding of manipulators is an effective way to improve system efficiency and reduce error rate^[9]. Commonly used coding methods are shape coding, position coding, color coding and symbol encoding.

3.1.1. Shape coding

Shape coding means that the manipulator with different functions has its own shape features, and there is a logical connection between its shape and function, so that the operator's visual and tactile recognition can be easily identified. As shown in Figure 5 (a), there are many buttons on a remote controller. For the sake of distinction, different buttons have different shapes for their different functions.

3.1.2. Position coding

Positional coding refers to the use of different location to distinguish the manipulator. If the design is reasonable, the operator can operate without paying attention to the object of operation. For example, the accelerator and brakes of a car and all kinds of keys on the computer keyboard are coded according to location, as shown in Figure 5 (b).

3.1.3. Color coding

Color coding refers to the use of different colors to distinguish the manipulator. Because color coding depends on vision, it has certain requirements for daylight and operator's visual ability, and the color category should not be excessive. If color coding is combined with other coding methods, the effect is better. As shown in Figure 5 (c), it is a part of a NC machine operation panel, which adopts the combination of color coding and shape coding.

3.1.4. Symbol coding

Symbolic coding refers to the use of symbols marked on the manipulators to distinguish the manipulators. Usually, when the number of manipulators is large and other coding methods are difficult to distinguish, appropriate symbols or characters can be marked on the manipulators to increase the resolution effect. For example, the keys on the computer keyboard have corresponding symbols on each button. As shown in Figure 5 (d), the fan control knob, which identifies the corresponding characters and symbols, is clear at a glance and is not easy to make mistakes.

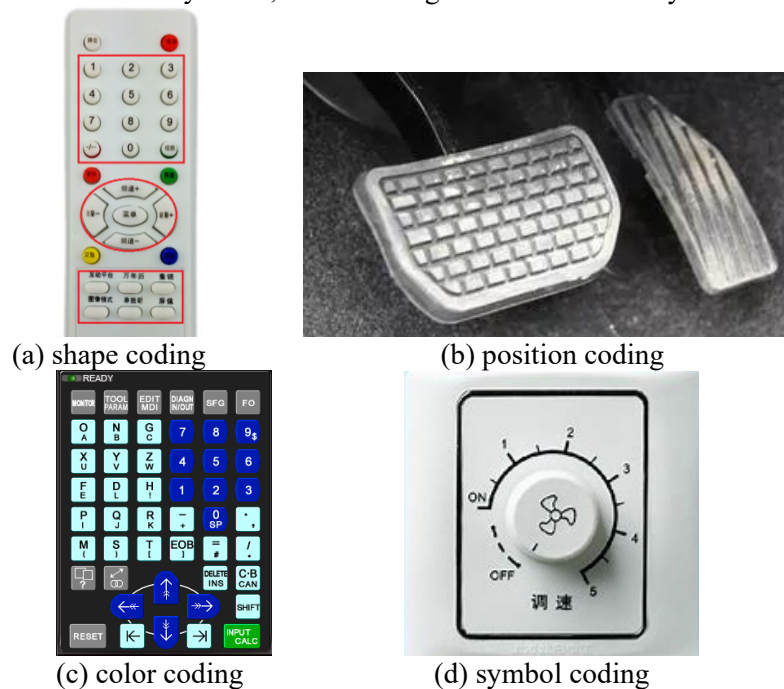


Figure 5. Manipulator coding

3.2. Consider the physiological characteristics and use habits of people

According to the principle of movement compatibility above, when the knob is operated clockwise, the corresponding display value should be increased accordingly. This principle can be applied to most man-machine interface designs. But there are exceptions, such as the gas cooker knob shown in Figure 6. When the knob is operated counterclockwise, the fire will increase, and the fire reaches maximum when the clockwise rotation is 90 degrees. After 90 degrees, the fire decreases with the increase of the knob degree.

The reason is that this design mainly takes into account the physiological characteristics and habits of human beings. Because about 90% of the people are right hand, that is, the right hand is used, so

most users use the right hand when they operate the gas cooker knob. When the knob is counterclockwise with the right hand, the hand is flanking^[9], while the flanking deviation is more in line with human physiological characteristics and usage habits. Therefore, considering human physiological characteristics and habits is a very important principle in the consistency design of display and manipulation of human-machine interface.

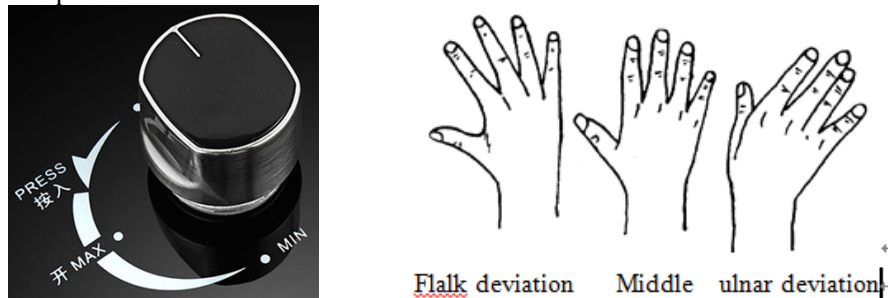


Figure 6. Consider the human physiological characteristics and usage habits

4. Conclusion

As a bridge between people and products, human-machine interface plays a more and more important role in human computer interaction. The compatibility of display and manipulation in human-machine interface largely reflects the degree of humanization of products and determines the ease of use of products. The user interface with good compatibility can get feedback from psychological anticipation in the process of operation, so the accuracy of operation will be improved and the error rate will be reduced, and vice versa. Spatial compatibility and movement compatibility are widely existed in product man-machine interface. Examples of poor design are everywhere, which brings great confusion to user operation. Therefore, in the design of human machine interface, it is very necessary and important to follow some principles and measures. Only in this way can a good product interface be designed and a better user experience will be brought.

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