Research and Design of Intellectual Products for People with Visual Impairments

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Abstract. The paper mainly focuses on designing intellectual products for people with visual impairments. By analyzing physiological features, psychological characteristics and pattern of behavior of people with visual impairments and comparatively analyzing the status of current intellectual products for people with visual impairments on the market, the research designed the products based on LEGO EV3 model and proposed three functionally intellectual products design for people with three different visual impairments symptoms: automatic user tracking guide stick for the blind, traffic signals identifying guide stick for color blindness people and dim light alarm for night blindness people. The proposed products will help people with visual impairments go out freely and independently to enjoy a convenient life in the future.

1. Product demand of people with visual impairments

1.1. Physiological features of people with visual impairments

Vision, hearing, taste, touch and smell are five sensory systems from which people gain information from the outside world. These sensory systems are physiological basis of human cognition. Among them, vision is the most important sensory system no matter for human or diurnal animals. It can help us to get accurate information over a wide range and remote distance. As for people with normal vision, 90 percent of external information is obtained by the visual system. The visual system of both humans and animals generate senses by the stimulation of light, and eyes are the organ that humans use to receive and feel light.

People with visual impairments refers to people who, due to innate or acquired causes, have partial or total obstacles in the structure or function of the visual organ and after treatment they are still unable or even hard to see objects. Researches show that, due to visual obstacles, people with visual impairments rely more on touch, hearing and other sensory to make up for the missing visual system function[2]. With the help of other four sensory system, people with visual impairments can get new information from outside world which will help them to update existing memory or experience and form their own cognition of the object world. Therefore, the particularity of physiological features of people with visual impairments are the fundamental basis which guide the LEGO EV3 model design in this thesis.
1.2. Psychological characteristics of people with visual impairments

The definition of visual impairments is very broad which includes blurred vision, high hyperopia or myopia, color blindness, color weakness, night blindness, etc. In daily life, people with different symptom of visual impairments will encounter different difficulties. Because of the visual sensory deficiency, most people with visual impairments may have vague, fancy or uncertain cognition of the world, their psychological characteristics have startling similarity [2], which can be concluded into five aspects:

a. Loneliness: Because of the partial or total obstacles of vision, people with visual impairment would not like to go out. In a long period, they rely on limited methods like internet to obtain information of the world which makes them feel loneliness.

b. Dependence: People with visual impairment usually lack of abilities to take care of themselves, and their limited life experiences make them can’t bare too much stress. Therefore, when they want to complete something independently, it is easy for them to generate an avoidance mentality and a dependence on guardians.

c. Inferiority: Most people with visual impairment over care the deficiency of their physiological functions which make them doubt their own abilities and feel inferiority.

d. Lack of security: Visual system deficiency will cause many troubles for people to gain information on time, which will make them feel afraid of the environment and people around them.

e. Sensitive self-esteem: According to the survey, people with visual impairments are more sensitive than others. Because of their vulnerable position in society, they hope to get the understanding and attention of the society, but at the same time they do not want to be looked down upon by others.

2. Current status of products for people with visual impairments

There are some products for people with visual impairments on the market at present. Most of them use braille or fixed form of irregular tactility to convey message, which design is relatively lacking of intellectualization, but mainly depending on sensory system. These products such as braille household appliances, braille reading and other products are designed for users who are familiar with braille, however, for those users with visual impairments but who are not familiar with braille, it undoubtedly will become a new difficulty. For the blinds, when they rely solely on listening to locate an item, they may not be able to avoid obstacles on the road. However, if there are intelligent products which can help the blinds to predict the existence of obstacles in advance and bypass it, the blinds will be able to take care of themselves. For people with visual impairments who cannot distinguish colors properly, there are some color comparison cards that are specifically designed for their vision which can practice their ability to distinguish color. However, if intellectual products can automatically recognize color and convey message to the users, it will be more convenient for color blindness people no matter they are at home or going out. In addition, the lack of perception of different intensity of illumination is also a major problem for some of people with visual impairments. As the weather getting dark, their vision gradually become blurred. If something can remind them to turn on the lights before this, they can avoid some danger which caused by not seeing clearly. The research is to design more intelligent and convenient products to help people with visual impairments living a convenience life.

3. Research of product design

3.1. Guide stick for the blind

Some people with visual impairment will choose guide stick as their own “eyes”. If it is out of the reach, searching the stick will become a problem. To solve the problem, we make the stick find its owner by using intelligence LEGO products. If there is an unreachable distance between the user and the guide stick, by pressing the remote controller, the guide stick will lock the remote controller by infrared ray and keep forward until facing the user. During the process of achieving the function that the guide stick can find its owner automatically. We choose the infrared sensor and the collision
sensor. In the process of EV3 program, the design chooses the loop module, steering module and comparison module.

The infrared sensor of LEGO is used to lock the owner’s position.

The stick is located the position by receiving the infrared ray produced by remote control, then it adjusts the angle of guide stick until the distance between the stick and its owner is less than the setting value. It will stop in front of the owner. During the process of going forward, the design avoids the obstacle by using the collision sensor. While the returned value is true, it will turn right 90 degrees and keep going towards the owner to achieve the function of obstacle avoidance. (Figure 1)

3.2. Guide stick for color blindness people

Among the people with visual impairment, the color blindness symptom takes a large part. The research should take it into consideration, especially when they are going out, it always arises the security problem that they can’t tell the traffic lights. During the process of achieving the function to help the color blindness tell the traffic lights, color sensor and the infrared sensor are chosen. In the process of EV3 program, the loop module, comparison module and steering module are chosen. The color sensor has color mode, reflected illumination mode and environmental illumination mode. The infrared sensor has close range mode, control mode, near beacon mode and guided beacon mode. The design will detect the recognized color by using the color mode.

During the process of going forward, the product avoids the obstacle by using the infrared sensor. While setting at the close range mode, it can measure the distance between the sensor and the obstacles. The measurement uses 0%-100% instead of centimeter or feet. If the measurement is lower than the setting value, the procedure to avoid obstacles will be triggered. (Figure 2)

3.3. Annunciator for night blindness people

Night blindness is a kind of the visual impairment. Its symptom appears under different intensity of lights or the symptoms of things cannot be seen clearly. Due to lack of vitamin A and lesions of the body, they may get short-term night blindness or acquired night blindness. Facing with the night blindness people, the recommended signal will be sent before the environmental illumination lower than the setting value to avoid the problem of inconvenient movement of night blind patients under the dark light condition. The color sensor and the collision sensor are chosen, and set the color sensor into
environmental illumination mode to sense the outside illumination, at the same time, avoiding the obstacle in low illumination environment. In the process of EV3 program, the loop module, comparison module and steering module are chosen. Under testing environment, the road are set that illumination from strong to weak with some unknown obstacle. Before testing, the range of thresholds at which the color sensor senses illumination are measured, and make it the variable under control. If the illumination higher than the setting value, the sound will play. After the sounds plays, it will stop for a second and keep going. If the collision sensor is touched during the journey, it will be turned to the left to avoid obstacles. If the illumination remains the same value, it will repeat continuously, and the ring is set to ring for no more than 30 minutes, and the program will terminate automatically.(Figure 3)

4. Product prototype based on LEGO EV3

4.1. Automatic user tracking guide stick for the blind
The prototype for this direction design is shown in Figure 4. The modules used in this design are: infrared sensor, EV3 programming module, collision sensor, motor module, infrared tele-controller.

Set the infrared sensor of EV3 in the beacon working mode, and the button of the infrared tele-controller keeps pressing (continuous signal is sent). Using the "guided beacon" mode to achieve the function of advancing toward the target, the infrared sensor can receive the signal from the infrared tele-controller and identify the position of the beacon and then proceed to the position of the beacon. The guide stick advance until the adjacent beacon value of the infrared sensor is less than 10\%, and it will stop when less than 10\%. The collision sensor is used to avoid obstacles. The guide stick will turn right 90 degrees when the return value of the collision sensor is true, then continue to identify the position of beacon. (Figure 5)

![Figure 4. Design product structure of automatic user tracking guide stick for the blind](image1)

![Figure 5. The function of obstacle avoidance.](image2)

4.2. Traffic signals identifying guide stick for color blindness people
The prototype for this direction design is shown in Figure 6. The modules used in this design are infrared sensor, motor module, EV3 programming module, and color sensor.

Setting the EV3 color sensor to color mode and the infrared sensor to close distance mode, then the color sensor will recognize the color and the guide stick continue to advance when the color turns to green, else the guide stick will stop. The robot will turn right 90 degrees in advance about 10 cm, and then turn left 90 degrees. When the measurement result of the infrared sensor is less than 50\%. (Figure 7, Figure 8)
4.3. Dim light alarm for night blindness people

The prototype for this direction design is shown in Figure 9. The modules used in this design are: color sensor, and two EV3 programming module, collision sensor, and motor module.

Setting the color sensor of EV3 in ambient light mode, the module repeats ringing to prompt when the light intensity under the threshold, then the waiting block pauses the program, the ringing is repeated and the actuator is pressed.

5. Conclusion

People with visual impairments are vulnerable groups in society. The pain points of such groups have caused public’s concern and need to be solved urgently. The pertinence and humanization of intelligent product design for people with visual impairments is the fundamental condition for helping them to back to society independently, and help them to recover self-esteem and self-confidence. Based on the current situation of intelligent product design for people with visual impairments, the research found that the design function of existing products is vague during the research process, and it is not advisable to make one product serve all visually impaired people. It can be concluded that only by paying close attention to the different pain points of people with different symptoms and visual
impairments, and designing for different pain points, the smart products can serve such groups better. The LEGO EV3 model used in this design can help designers realize the expected functions and synthesize the product prototypes for function testing quickly. In addition, the modular programming form also reduces the burden on the design team. As a matter of fact, the Sensors based on the LEGO EV3 model still have some limitations. So they are just designed to provide some design ideas for intelligent product design innovation for visually impaired people. There still has a long way to go for in-depth design research and perfect product application.

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