The Development and Research of Wearable Water Life-Saving Products

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Abstract. As recent years have witnessed the increase in people's safety awareness in water activities and the rapid development of wearable devices, the combination of water life-saving equipment and wearable devices has represented the general trend. Therefore, in this paper, the development status of water life-saving equipment is analyzed, the influence of wearable devices on the development of water life-saving equipment is discussed, and the design thoughts and methods of wearable water life-saving products are researched so as to advance the research and development of water life-saving equipment, thus guaranteeing users a safer and more convenient experience.

Keywords: Water Rescue · Wearable Device · Life-saving Products

1 Introduction

In such a society where increasingly stricter requirements are set for water safety, people, while engaging in relevant water activities, have also proposed new requirements for life-saving equipment that can guarantee life safety. With the development of network technology, intelligent wearable devices have long penetrated from the professional field to daily life. However, water life-saving equipment, at present, is dominated by traditional life-saving equipment. And there seems to be inadequate research on intelligent water life-saving equipment that can be quickly implemented when drowning, making it pressing to research more about water life-saving equipment based on intelligent wearable technology. This paper starts from the current status of life-saving equipment, analyzes the existing problems, introduces wearable intelligent water life-saving equipment, and innovates in design thoughts and methods to better ensure the safety of those drowning in water activities.

2 The Development Status of Water Life-Saving Equipment

The term "life-saving equipment and devices", the standard term of the International Convention for the Safety of Life at Sea (SOLAS), refers to the general term for the special equipment that enables the safe and quick evacuation of the personnel and the maintenance of life when the ship is in distress [1]. Water life-saving equipment can be

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mainly divided into individual life-saving equipment and collective life-saving equipment, mainly used in fisheries, water transport industry, water operations, water sports and other water activities, as well as customs anti-smuggling, military and other special industries and departments [2]. And the life-saving equipment mentioned in this paper falls into individual life-saving equipment.

2.1 Research and Development for the Needs of Different Groups

The functions of individual life-saving equipment differ in different water environments and different needs of water activities. And individual life-saving equipment can be broadly divided into two types, namely civil life-saving equipment and military equipment.

(i) Civil Life-saving Equipment
Civil life-saving equipment includes not only marine life-saving equipment, operational life-saving equipment and other professional life-saving equipment but also sports life-saving equipment, children's life-saving equipment and other individual life-saving equipment. Professional life-saving equipment is generally used for water rescue or water operations. Mainly stored on board, it features a small size, easy storage, quick wearing, and other characteristics. As users tend to face a wider range of water with complex water situations, professional life-saving equipment, compared to individual ones, necessitates a greater buoyancy and certain warmth retention property. While individual life-saving equipment applies to personal protection and life-saving equipment in water activities. In addition to basic buoyancy, it emphasizes the suitability of life-saving equipment to give users more activity space, reducing discomfort.

(ii) Military Life-Saving Equipment
Modern water life-saving equipment can be traced back to World War II when the British took the lead in developing naval inflatable life-saving equipment in 1952 to protect the military and improve combat capability. To date, military life-saving equipment has been developed in the sea, land, and air forces with functions and structures continuously refined. Given its high requirements on buoyancy to carry weapons, military life-saving equipment often adopts fire-retardant materials and focuses more on rescue performance than civil life-saving equipment. For example, the MK-1 vest life-saving equipment on the U.S. Navy Submarine boasts a scientific buoyancy distribution design and self-righting function [3], thus keeping the user's head above the water even if he is unconscious. Besides, it uses blended fabric combining 88% flame retardant cotton and 12% high-strength nylon and is equipped with a complete emergency alarm component such as fluorescent distress lights and distress signal lights.

2.2 The Basic Buoyancy as the Main Life-Saving Function

Although diversified functions and equipment, including heat generation and insulation, GPS positioning, and beeping alarm, have been added to the existing drowning rescue equipment, the basic buoyancy that maintains the user's head above the water still remains the main life-saving function. There are three main ways to provide buoyancy, the first is

to obtain buoyancy by inflating the airtight airbag, which sets high sealing requirements and requires durable and unbreakable material for the airbag; the second is to make use of the inherent buoyancy of the material itself to make life-saving equipment. This type of material, such as silk cotton and polyfoam, can be easily produced into prefabricated units with high suitability, which applies to the life-saving vest. But its large volume makes it inconvenient to be stored; the third lies in the combination of inflatable and buoyant materials, which is commonly seen in military life-saving equipment. With the main source of buoyancy provided by buoyant materials and supplemental buoyancy from airbags, the user can keep the physical strength from depleting, saving enough strength for rescue.

2.3 Waiting Passively for Rescue as the Main Life-Saving Mode

Although the development of water life-saving equipment has been divided according to the needs of different groups, the protection of the lives of those drowning still depends on traditional rescue methods, such as the above-mentioned airbag-type life-saving equipment that requires advanced inflation or life-saving equipment made of buoyant materials. Traditional life-saving equipment includes neither the warning function before drowning nor the automatic rescue when drowning. It proves difficult to detect a drowning accident and can only wait for rescue from drowning, failing to protect the safety of the drowning. In addition, the relatively large volume of traditional life-saving equipment results in poor suitability and issues ranging from inconvenience in water activities to poor experience affect users' motivation, which in turn invariably increases the probability of drowning accidents. In conclusion, traditional life-saving equipment can no longer meet people's needs.

3 The Influence of Wearable Devices on Water Life-Saving Products

Wearable devices, microelectronic ones that can be placed directly on the skin or combined with textile products, detect, process, and transmit information about the human body or the surrounding environment through the integrated use of sensors, intelligent interaction, data processing platforms, mobile Internet and other technologies [4, 5]. With the continuous development of wearable technology comes the wide application of wearable devices in medical devices, sports and health, emergency rescue, special operations and other fields, providing a variety of possibilities to ensure human safety. From the existing sensing technology and data processing and analysis technology, wearable devices mainly influence water life-saving products in three directions, namely prediction and warning, behavior assessment and alarm rescue.

3.1 The Improvement in the Performance of Drowning Prevention Prediction

Drowning accidents are generally unexpected events. And traditional life-saving equipment only has passive rescue functions after drowning, but does not have predictive functions before drowning, which will miss the best rescue time. At present, wearable

Fig. 1. Water Life-Saving Equipment PLOOTA. (Boat, 2018, source: http://gd.zhidao.189.cn/ckb/kd/20180627/1121_348403.html;TNSESSIONID_CKBEXT=m0AXSFNHK5uxhPEm1V3lIlS4FDyzhPQAWHuwaZnB6W6TKxS-pcaD!795095438?city=mz)

devices use physiological sensors to detect human physiological parameters, such as ECG, EEG, EMG and other bioelectric activity changes, which can assess the user's physical condition; environmental sensors can monitor the environment to give predictive warning before drowning. The collar-shaped life-saving equipment PLOOTA is taken as an example. Whenever the device identifies the water environment when drowning, the life-saving device will be automatically triggered to eject two airbags on both sides of the collar, bringing the drowning out of the water (Fig. 1).

3.2 The Enhancement in the Performance of Drowning Self-help

Usually inexperienced, the drowning tends to be panic. The body's instinctive consciousness and physiological reaction will then make the muscles tense and struggle, and the lack of oxygen will influence accurate judgment, thus accelerating death or hurting rescuers. All of these make it especially important to enhance the self-help ability of the drowning. And the mechanical sensors in wearable devices can measure the movement of the human body. Currently, research on human movement posture through sensors has become a trend. Liu Yongqing et al. calculated the acceleration characteristics of different swimming postures through experimental testing and analysis by fixing acceleration sensors on wrists and ankles [6]. The dynamics of human behavior when struggling in the water during drowning differs greatly from the dynamics of normal swimming. Through the identification and analysis of swimming posture, arm stroke and other movement behavior, drowning can be found in time to trigger the life-saving airbag to obtain self-help.

3.3 The Advancement in the Performance of Others' Rescue

In traditional drowning rescue detection where lifeguards in the pool or onshore observe and protect the safety of those engaged in water activities, swimming drowning casualties still dominate the cause of death among young people. When a drowning accident occurs, the drowning fails to call for help. As it is difficult for others to detect the drowning's physical state and behavioral performance, the rescue cannot be carried out quickly. For example, iSwimband wearable drowning intelligent alarm equipment can be connected

Fig. 2. iSwimband Drowning Prevention Equipment for Children (Information small value, 2014, source: https://post.smzdm.com/p/axn5p09/)

to cell phones via Bluetooth. When the user is underwater for more than the safety time or the device is submerged underwater, an alarm will be immediately issued to call for help (Fig. 2).

4 The Design Thoughts and Methods of Wearable Water Life-Saving Products

It can be found through the above analysis that wearable water life-saving products implement rescue not just depending on the pure physical materials but integrating intelligent wearable equipment of sensors and other technologies in a way to better protect the lives of users. Therefore, the design thoughts and methods of wearable water life-saving products also vary from the traditional life-saving equipment.

4.1 Design Thoughts

(i) To Meet the Psychological Needs of Users
Water life-saving equipment, unlike general life-saving products, should consider the great sense of tension and helplessness generated during drowning. While the general wearable devices focus more on the technological maturity and stability of electronic components, prone to ignore the appearance and form design. Therefore, the psychological needs of users should also be satisfied after meeting the basic physiological needs of safety and health, playing a calming and stabilizing role. It is thus necessary for designers to analyze users' feelings, emotions, perceptions and other aspects, concretize the psychological needs into the design elements of wearable water life-saving products, and also improve and optimize the overall requirements and details so as to maximize the protection and rescue function of water life-saving products.

(ii) To Transform Human-Computer Interaction
Life-saving equipment should be convenient and rapid in use without any obstruction generated between the structure and way to wear, which highlights the human-computer interaction. Traditional life-saving equipment basically depends on a physical operation

to open the life-saving device, a way not good enough to meet the fast and convenient requirements of the interaction process. Wearable devices should satisfy the two characteristics of intelligence and comfort, intelligence that does not require a deliberate operation to meet the user's needs. Therefore, designers need to center on users, research the relationship between humans, products, and the environment in light of the functional characteristics and morphological characteristics of wearable water life-saving products, analyze the factors that can affect human-computer interaction, change the traditional human-computer interaction, break the traditional single interaction mode, establish multimodal interaction, and seek to reach an interaction solution with high operational efficiency that matches the natural way of interaction between wearable water life-saving products and users.

(iii) To Design a Safe and Suitable Structure

Large in size and heavy in weight, traditional life-saving equipment cannot be easily stored and can even hinder normal underwater activities. Besides, the unreasonable buoyancy distribution will endanger the life safety of users. The physiological data obtained from the sensors placed in different positions are also different, and wearable products, restricted by electronic components, have the problem of an obvious sense of weight and constraint when worn. Therefore, wearable water life-saving products should fit in the body structure and meet the user's requirements for free underwater movement. And a scientific buoyancy distribution structure can ensure that the user's head will keep above the water when drowning. It can be concluded that the enhancement in suitability can maintain the user and product in a comfortable and harmonious state so that the efficient and safe use of water lifesaving products can be guaranteed.

4.2 Design Methods

(i) Consideration of Body Movement Underwater

When at rest, the sizes and dimensions of each body part are relatively stable; while in action, the data of each body aspect will change accordingly. Therefore, it is imperative to, in addition to grasping the basic body size, analyze and research the movement range, frequency and amplitude of each body part when in underwater movement and grasp the amount of change in human movement from the ergonomic point of view, thus ensuring the suitability structural design of wearable water lifesaving products. At the same time, the human behavior characteristics when drowning should be mastered and the posture in water be controlled through the analysis of buoyancy distribution position in order to obtain the safest and most reasonable structure design and to ensure the safety of those drowning.

(ii) Analysis of the Water Environment

In underwater activities, wearable life-saving equipment, as an extension of the human body, should grasp the interaction among people, products and the environment. In addition to providing basic floating functions, wearable life-saving equipment sets different function requirements in different water environments. For example, in seawater and other cold water where people will die due to rapid loss of body temperature, the

function of warmth insulation should be applied to the life-saving equipment; while in swimming pools or water parks and other freshwater environments, the function of rapid rescue should be emphasized to provide sound and light alarm and other devices.

(iii) Selection and Application of Materials

Drowning prevention life-saving products provide buoyancy support to guarantee life savings based on human activities in a water environment. At present, airbags and polyfoam still dominate the main source of buoyancy, but buoyant materials are bound to become lightweight, comfortable, and efficient with the emergence of new materials. Wearable devices with built-in electronic components require a waterproof and sealed cover material to meet the demand for safe use of products underwater. The combination of wearable devices and water lifesaving products is not simply a superposition of functions, but an integration of functions based on materials, while meeting a certain degree of skin-friendliness and suitability.

5 Conclusion

In summary, although water lifesaving products are gradually upgrading to smart technologies, wearable technology-based life-saving products still remain in the initial stage with many problems to be solved. With the continuous development of sensor technology, information technology and new materials, wearable water life-saving products will become more targeted, obtain more accurate data, and penetrate from the professional field to daily life, playing an important role in improving life quality and protecting lives. At the same time, the design and research of water life-saving products based on wearable devices also require integration with the technology of other professional fields. Only by constantly eliminating technical barriers to truly serve users will a more profound impact be exerted on the field of water rescue.

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