Suggestion of High Precision Drowning Detection System Using Plural Radio Modules

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Abstract

In Japan, there are many places where people can swim, for example, sea, river, and pool. Everyone can enjoy swimming or wading in summer. However, water accidents happened about 1300 in 2014. Moreover, the victims are about 1500. Therefore, drowning detection system has developed. However, some problems is not solved, such as limitation of the place and possibility of misdetection in the existing system using smartphone.

In this study, we aimed less misdetection and without base station, and we developed drowning detection system using plural radio modules. Plural radio modules are arranged frontside, backside, leftside and rightside of head in proposal system. Therefore, proposal system can classify whether drowning or swimming, floating in water.

Further, we experimented, as a result, we showed effectiveness of proposal drowning detection system.

Keywords: Drowning, Radio communication, PSoc, ZigBee

1. Introduction

Japan is island nation and located on the eastern edge of the monsoon Asia is large precipitation amount. Therefore, Japan is rich water resources, such as sea and river. In recent years, there are many swimming facilities, such as swimming pool. In summer, many people enjoy swimming. However, it has occurred about 1300 of water accidents in 2014, and the victims are about 1500⁽¹⁾. Furthermore about half of the victims were dead or missing⁽¹⁾. Thus, water accident is dangerous. However, there is no effective way to prevent water accident. Drowning detection is approach to prevent water accident. Therefore, drowning detection system have been developed.

There is an existing research using smartphone⁽²⁾. Existing system is using communication function of the smartphone to detect drowning. Moreover, the system equips airbag. If this system detected drowning, airbag is inflated. However, this system has some disadvantages such as requirement radio waves of smartphone, and possibility of misdetection. This system cannot use at the environment of bad radio wave. Further, swimmer attach smartphone to the back of the head. Therefore, if the back of the head was submerged, smartphone cannot communicate. In other words, the system is able to misdetect drowning. We aimed the development of drowning detection system less misdetection and radio wave of smartphone is unnecessary.

2. Feature of drowning people

In this chapter, we explain the some features of drowning people. The mainly features are shown below⁽³⁾.

- Drowning people are physiologically unable to call out for help. The respiratory system was designed for breathing. Speech is the secondary, or overlaid, function. Breathing must be fulfilled, before speech occurs.
- Drowning people's mouths alternately sink below and reappear above the surface of the water. The mouths of drowning people are not above the surface of the water long enough for them to exhale, inhale, and call out for help. When the drowning people's mouths are above the surface, they exhale and inhale quickly as their mouths start to sink below the surface of the water.
- Drowning people cannot wave for help. Nature instinctively forces them to extend their arms laterally and press down on the water's surface. Pressing down on the surface of the water, permits drowning people to leverage their bodies so they can lift their mouths out

of the water to breathe.

- Throughout the Instinctive Drowning Response, drowning people cannot voluntarily control their arm movements. Physiologically, drowning people who are struggling on the surface of the water cannot stop drowning and perform voluntary movements such as waving for help, moving toward a rescuer, or reaching out for a piece of rescue equipment.
- From beginning to end of the Instinctive Drowning Response people's bodies remain upright in the water, with no evidence of a supporting kick. Unless rescued by a trained lifeguard, these drowning people can only struggle on the surface of the water from 20 to 60 seconds before submersion occurs.

Drowning is very silent as listed above. We especially focused on the last feature. When swimmer is swimming, a part of swimmer's body is out on the surface of the water. However, if swimmer is drowning, swimmer will completely submerge after struggling about 1 minute. Therefore, we can distinguish between drowning and swimming.

3. Principle

In this chapter, we explain fundamental principle to detect drowning in our proposal system.

3.1 Radio communication

Proposal method uses radio communication. Radio communication is shown in Fig.1. Radio communication is usually used on the ground, as shown in Fig.1.(a). However, if radio module was submerged, radio module cannot communicate, because radio wave is attenuated in water.

Fig.1. Radio communication

Therefore, we use radio module. Proposal system detect no radio communication to detect drowning.

3.2 Water detect circuit

Water detection circuit is shown in Fig.2. Fig.2.(a) is when the circuit does not detect water and Fig.2.(b) is when the circuit detects water. When the input terminals in Fig.2 is open, the output is "High", because transistor is turned off. However, if the input terminals was submerged, the input terminal is equivalent to the insertion of the resistance with water. Therefore, the output is "Low".

In this way, we can detect water. Proposal system can detect drowning by combining the wireless communication modules and water detect circuit.

4. System organization

4.1 Overview of proposal system

Proposal system is composed transmitter unit and receiver unit. Transmitter unit is attached such as a swimming cap or goggles, and receiver unit is had by lifeguard or parents. The block diagram of the entire system is shown in Fig.3. Transmitter unit is composed detection part, control part, and communication part. Receiver unit is composed communication part, control part, and notification part.

Fig.2. Water detect circuit

Fig.3. The block diagram of entire system

The process of detection phase are as flows;

- (1) Transmitter unit communicates periodically to a receiver.
- (2) The communication data transmitter sends includes information whether swimmer is in water or on land.
- (3) Receiver unit indicates reception data.
- (4) If the communication stopped definite period of time, is called communication permissible time, a receiver unit judges whether swimmer is drowning or not from the data received just before.
- (5) Receiver unit judges to drown if swimmer is in water. Receiver unit judges to be far away if swimmer is on land. Receiver unit call other people's attention with display a different message.

4.2 Transmitter unit

The detailed block diagram of transmitter unit is shown in Fig.4. Detection part is composed of plural water detect circuits. Further, communication part of transmitter unit is composed of plural radio modules. Control part is microcomputer. Plural radio modules and water detect circuits are shown in Fig.5.

Submerged pattern is shown in Fig.5. Fig.5.(a) is considered likely to swimming, floating, and drowning. Similarly, Fig.5.(b) is considered likely to swimming, floating, and drowning too. Fig.5.(c) is considered likely to swimming and floating. Finally, Fig.5.(d) is considered likely to drowning and diving.

Fig.5.(a), (b), and (d) is likely to drowning. However, as mentioned in the chapter 2, drowning people can only struggle on the surface of the water from 20 to 60 seconds before submersion occurs. Therefore, Fig.5.(d) is higher

Fig.4. Detail block diagram of transmitter unit

Fig.5. Submerged pattern

possibility of drowning than Fig.5.(a) and (b). For this reason, Fig.5.(d), detection part and communication part is completely submerged, is drowning pattern. However, Fig.5.(d) is considered likely to diving. People can dive, in other words, people has ability to swim to some extent. In addition, there are individual differences in activity time in water. Therefore, proposed system is a specification that can be arbitrarily set the communication permissible time by the user.

4.3 Receiver unit

The detailed block diagram of receiver unit is shown in

Fig.6. Detail block diagram of receiver unit

Fig.6. Communication part of receiver unit is composed of a radio modules, is different from transmitter unit. Control part is microcomputer, and notification part is LCD module. As mentioned in section 4.1, receiver unit judges to drown if swimmer is in water. Receiver unit judges to be far away if swimmer is on land. Moreover, receiver unit call other people's attention with display a different message.

5. Experiment

In this study, we experimented whether proposal method can detect drowning or not. In addition to that, we experimented whether proposal method can classify danger different from drowning or not.

We carried out demonstration of the principle on the breadboard in this experiment. We made radio modules watertight simply by putting in the waterproof bag.

We experimented under the follows situations;

- The number of water detect circuits 4
- The number of radio modules 4

Electronic components of our proposal system are as follows;

- Microcomputer : PSoC CY8C29466-24PXI
- LCD : SC1602ASB-XA-GS-F01
- Radio module : Xbee XB24-Z7WIT-004

In experiment, we confirmed all submerged pattern of radio module. The pattern is 16 pattern. As a result, receiver judged one pattern is drowning, the pattern is all radio modules completely submerged. Furthermore, receiver unit judged the others is not drowning. In addition proposal system could classify 16 pattern as drowning or not from the data received just before.

Therefore, we showed effectiveness of proposal drowning detection system.

6. Conclusions

In this study, we have developed drowning detection

system, less misdetection and unnecessary of base station, by using plural radio modules. However, it is difficult for the proposal system to classify diving and drowning. Moreover, proposal system cannot detect drowning of early stage. Furthermore, the proposed system used the AC adapter as the power supply method, because the output current is large.

In future, we aim development of drowning detection system is able to classify diving and drowning, by using motion sensor. In addition we aim development of the method to detect drowning of early stage. Moreover, we must use the battery as the power supply method for practical use.

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