Near drowning detection system based on swimmer's physiological information analysis

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Identifying a person facing drowning accident remains challenging even for experienced lifeguards, especially among non-swimmers who tend to be silent when they face such a situation (1).

With the recent advancement in electronic and material science, wearable biomedical devices are emerging. Two wearable drowning detection systems have already been commercialized: 1) SenTAG (2) is a wrist band based system which triggers an alarm when the swimmer is motionless for twenty seconds; 2) WAHOOO (3) a head band based system which sends alarms if the swimmer spends a long period under water. However, these systems are not considering advanced physiological features of the swimmer in near drowning situation leading to a delay triggering alarm. Besides, a video based drowning detection system can be another alternative (4), but it mainly suffers from occlusion problems when the pool is crowded.

In this work we aim at designing a swimming cap that detects near drowning situation as early as possible by analyzing the swimmer's physiological states. Surveys on wearable computing (5) have shown that the user is demanding regarding the device design and comfort. A design based on a swimming cap is convenient since most public swimming pools require swimmers to wear one. Panic reaction has been observed among persons facing near drowning situation (1). It results in a sudden increase of autonomous nervous activity leading to a rise of the heart rate. However, such a feature does not necessarily imply that the person is in danger, as it could result from swimming activity. Additionally, we make use of the observation that a person near drowning tends to have a vertical body posture while struggling at the same location to ensure that the swimmer is in danger (1).

The heart rate activity can be analyzed from ECG or PPG signals. However, we have tried to use piezofilm polymer sensor which is particularly thin, light-weight and flexible so that it can be sandwiched between the layers of a swimming cap at the level of the superficial temporal artery. For the body posture estimation, the vertical position can be detected using an accelerometer or gyroscope. The information will be processed in the cap and an alarm will be triggered if an abnormal behavior is detected. Primary laboratory experiments with the piezofilm sensor have been conducted and have shown that the measured heart activity signal suffers especially from electromagnetic, baseline wander and motion noises. We applied a method we previously developed, Weight Factor Mode (WFM) (6), based on EEMD(7), and were successful in removing the first two types of noises. In the future, we consider using motion information measured from accelerometer to reduce the motion noise and designing a prototype of the system to be tested in the swimming pool.

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