論文の内容の要旨

# Early Drowning Context Awareness Using Werable Sensors
（ウェアラブルセンサを用いた早期溺れ検知）

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Drowning is among the main causes of accidental death in the world. Several of these incidents occur in sea or swimming pool with the presence of professional lifeguards. Drowning is often described as fast and silent death. In fact, in many cases victims are not able to call for help or even attract the attention of the bathers swimming next to them. The victim main occupation at that instances is to get a last breath once he reach the surface of water before getting submerged again. Observation among several victims who faced near drowning incidents has shown that they have particular physiological patterns in early drowning stage called Instinctive Drowning Response (IDR). In which, victims tend to get panicked and struggle vertically at the same location with up and down motion. We took profit of such an observation, to propose to use the recently available wearable MEMS sensors to detect automatically such a particular pattern. As it is difficult to get information from real drowning incidents, we asked professional lifeguards to infer near drowning pattern. We attach motion and pressure sensors at both the chest and head level of the lifeguards. The measured data shows a particular pattern from the head level pressure sensor and the chest level pressure sensors, accelerometer and gyroscope. We used neural network to train and test the possibility to detect such a pattern automatically. We were able to detect near drowning pattern with twenty-second time window from the head level pressure sensor and with twelve-second-time window from the chest level pressure and motion sensor data. In addition, victims who face drowning incident tend to get in panic situation, which is usually associated with high heart rate activity. So we investigated

the possibility to use Piezofilm sensor to monitor the heart activity of the swimmer. Piezofilm sensors are particularly lightweight and flexible so they can be attached to the swimming cap at the level of head's superficial temporal artery to monitor the swimmer heart activity. Our experimentation on Piezofilm sensor shows that the signal suffers from noises particularly in motion situation. Our pre-experimentation on Emipirical Mode Decomposition (EMD) signal processing method has shown encouraging results in processing the signal in both motion and motionless situations. So we decided to investigate further more the performance of this method in non-motion situation, as it is easier to evaluate its performance. Our experimentation on EEMD has shown that it suffers from adaptively issue called mode mixing. So we proposed a new method, which we called Weight Factor Mode (WFM) to reduce this effect. The method has been tested in both Piezofilm data which we measured from our laboratory's subjects and ECG benchmarking databases. We succeed to obtain a good performance in reducing mode-mixing effect. As the system we are proposing is based principally on an inferred data, it is difficult to ensure its performance. So we proposed another system based on counting the amount of time the swimmer spent underwater, which can be used in the case the previous early drowning detection system fails. The lapse time underwater is measured based on pressure sensor attached at the swimmer's head level. So the system automatically distinguishes if the swimmer's head is submerged underwater or not. In addition the system can detect if the swimmer become motionless while underwater using accelerometer information. We made a prototype of this system using android smartphone. We have also developed a waist airbag that can be automatically triggered if a drowning pattern is detected. Finally, in order to ensure a higher layer of safety, we proposed a cloud service, which can track the user's head position while swimming and automatically trigger an alert if an incident occurs with information about the bather location. The proposed service can also be operated as a stand-alone system and this by using a new proposed cloud pulling method. In addition to the swimmer location the system can send periodically information about the swimmer's head depth, motion as well as mobile network signal and battery strength. The information is sent then to the cloud using mobile network to detect if any abnormal behavior is detected. We believe that a combination of these different proposed wearable drowning prevention solutions which we call it Hakim Drowning Prevention System can reduce considerably drowning incidents.