Near Drowning Pattern Detection Using Neural Network and Pressure Information Measured at Swimmer's Head Level

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Abstract
It is difficult for a person who cannot swim to call for help while he face a drowning incident. This make from drowning incidents very dangerous as it can occur silently. In this research we consider the use of wearable sensors to identify victims at early drowning stage. For this we attached a pressure sensor logging unit at the head level of a professional lifeguard, then we asked him to imitate near drowning pattern. We process the obtained dataset with neural networks at 20 second time window. The trained neural network succeed to classify the near drowning and normal swimming pattern.

1. INTRODUCTION
Drowning is the second cause of death among children under 12 in United States [1]. Few wearable drowning alert systems are commercialized [2,3]. These systems consider mainly the time lapse spent by the swimmer underwater without taking in consideration the behavioral changes of the victim at early drowning stage, called also near drowning situation. Besides, video based drowning detection systems can be another alternative [4]. However it is difficult to extend its application to the sea.

In this research we aim to create a system helping detecting victims at early drowning stage basing on information measured from wearable pressure sensor attached at the swimmer head level. For this we make use of the observations made by Frank Pia [5] who noticed a particular behavior among persons facing near drowning situation. As we are not able to get measurement from real drowning incidents. We asked a professional life guard to imitate near drowning pattern. We use then supervised neural networks method for learning the system to classify automatically normal swimming and near drowning patterns.

2. EXPERIMENTAL SETTING
In near drowning situation, victims get panicked and tend to have a vertical body posture while struggling at the same location [5]. In order to analyze this pattern, we attached a pressure sensing unit at a professional lifeguard's head back level and we asked him to infers near drowning victims Fig.1 . We used then two video camera to record the swimmer behavior inside and outside water for data indexing.

Figure 1. Lifeguard imitating near drowning pattern

The lifeguard is then asked to follow the following scenario:

- Swim for 30 second in place.
- Conduct free style swimming for 3 minutes.
- Infer drowning pattern for 40 second.

3. DATA ANALYSIS
3.1 Measured Raw Data:
The analysis of the measured raw data shows that a particular pressure pattern can be observed in near drowning situation Fig.2. This pattern is marked mainly by a large low frequency pressure fluctuation compared to the pattern measured in normal swimming situation Fig.3 and Fig.4.

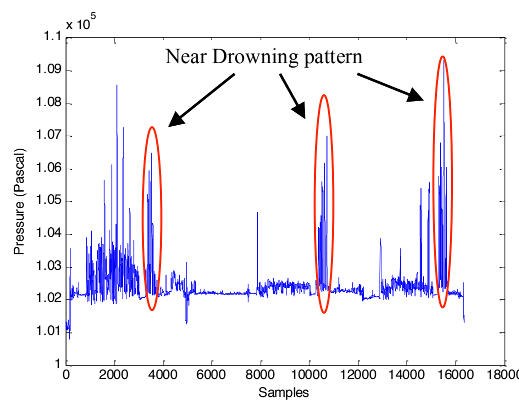

Figure 2. Measured pressure information in three data set

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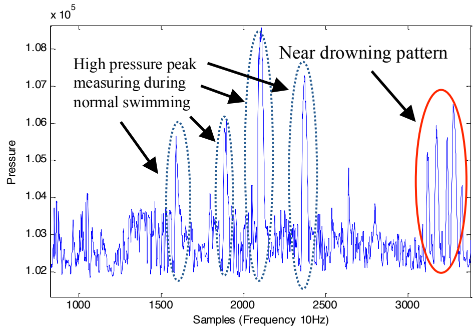

Figure 3. Measured pressure information in one data set

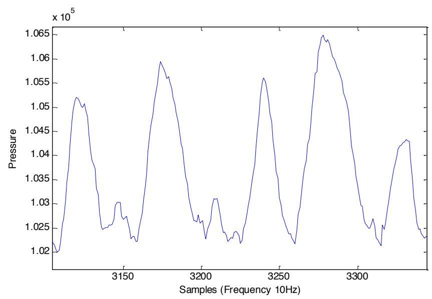

Figure 4. Measured pressure in near drowning scenario

3.2 Neural Network Training

We train neural network by supplying it with the logged dataset . For this we use two layers of feed-foreword neural network, with sigmoid hidden and output neurons Fig.5.
By selecting a time window of 20 second, we can split the entire dataset into 160 vectors. With 149 vectors corresponding to normal swimming situation and 11 vectors for near drowning situation. We use then Neural Network Pattern Recognition Tool Box in Matlab.

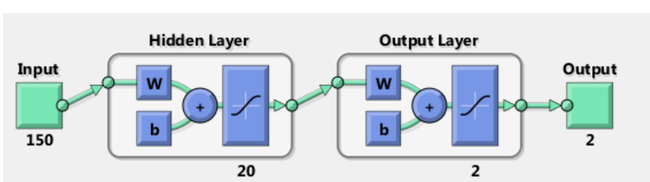

Figure 5. Used neural architecture

We dedicate 70% of the data (112 samples) for training, and 15% (24 samples) for each validation and testing stages. The data is divided then randomly between the three different stages.

4. RESULTS AND DISCUSSION

The system succeed in classifying all the input vectors into near drowning and drowning classes as described in the confusion matrix in Fig.6. However, we have to consider that this high accuracy does not mean necessarily that the trained neural network will be able to achieve such a high performance with new data . So more training data set from new subjects is required to evaluate the classification performance of the system

Figure 6. Neural networks confusion matrix

Nevertheless, ensuring the real performance in real near drowning incidents detection will be difficult as no real training data is available.
We notice also during the periods where the subject is swimming with head underwater some high pressures peaks Fig.3. In fact, during the experimentation the subject did not follows any particular swimming style.
So we are not sure if a classification problem might appears in the case the subject followed continuously a particular swimming pattern in which his head is submerged periodically under water. This scenario is unlikely to occurs among the main target user of our system who should have a limited swimming ability.

5. CONCLUSION AND FUTURE WORK

The ultimate goal of this research is to create a system helping detecting victims facing near drowning situation as early as possible. For this we asked a professional lifeguard to mimic victims facing near drowning situation while wearing wearable pressure sensing unit attached at the head level. We use then the collected data set to train a neural network and test its performance in classifying normal swimming and near drowning patterns. The trained neural network was able to achieve 100% success rate in both validation and test stages. However a larger dataset with different subjects is required for better training and evaluation of the system performance.

6. REFERENCE

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