

Digital Signal Processing for Speech Communication and Prevention of Decompression Sickness during Deep-Sea Diving

October, 1994

Takayoshi Nakai

This paper describes two issues, which are very important for deep-sea diving.

The first issue is dedicated for helium speech unscrambling. To avoid the decompression sickness, a man breathes hyperbaric helium-air at more than several tens meter depth. Speech spoken in it is called "helium speech". It is difficult to hear the helium speech. In this paper, actual helium speech signals are analyzed. From the result, a new algorithm is proposed, which is capable of non-linear conversion of formant frequencies using line spectrum pairs, a kind of linear predictive (LP) method. A real time helium speech unscrambler is implemented, and evaluated. The articulation score of original speech at 300 meter depth is about 10% and that of unscrambled speech is improved about 70%. Furthermore, this algorithm has been improved and a robust system against noise was implemented using high speed digital signal processors.

The second issue is a description of system to detect the gas bubbles generated in diver's blood during decompression process. Rapid decompression generates gas bubbles in the body and causes decompression sickness. Therefore, to assure the safety in submergence, it is necessary to detect the gas bubbles at lower grade. A conventional method for bubble detection is to project ultrasound into the pulmonary artery and listen for Doppler shifted sound in the reflected sound. In this paper, a new algorithm based on LP analysis is proposed and a quasi real time automatic detection system is implemented. The performance of the bubble detection system by the algorithm are almost identical with those by expert bubble detectors.

In summary, this paper gives a solution for the difficulties in speech communication and diagnosis of decompression sickness of divers.