Popular Science

Knowing your location is important for many applications, for example for wireless sensor networks, emergency rescue services, civil defense and in transportation. Suppose that a room is equipped with several microphones (or sensors), and one person is making a sound while moving around in the room. Can one find the microphone and sound source positions as well as reconstruct the room geometry? This is a problem studied in this thesis and the answer is “Yes”. In the first part of the thesis, a system for microphone self-localization based on ambient sound without any assumptions on the 3D locations of the microphones and sound sources has been developed. The results show that the system works well when there is one dominant sound source. For such a setup the resulting accuracy is in the range of few millimeters. To estimate the source positions, we need to know the time that sound reached the microphone through direct path. But the sound also bounces off walls, ceilings, floor and every other surface in the room before reaching the microphone. Thus the microphone not only receives the so called direct sound waves, but also the indirect or reverberant sound. Presence of several reflective planes in a room makes the problem difficult to handle. Another difficulty lies in the background noise which is captured by the microphone during the sound recording. In addition, in the thesis we also consider the problem when two microphones are fixed on a rigid rack. This is important because these days more and more smart phones comes with two or three microphones. By putting such microphones in a room and play a sound while moving around, one can find sources position. For such a constellation, particularly the minimal problems (i.e. minimal number of microphones and sources needed to solve the problem) have been analyzed. We have identified the number of solutions and have produced efficient non-iterative solvers for these problems.

Preterm birth is among the top causes of death in infants worldwide. Nowadays increasing numbers of extremely preterm infants are surviving, however they are at greater risk for short and long term complications. Another signal processing problem considered in the thesis is to analysis electroencephalogram (EEG) activity burst patterns for predict outcome in preterm infants (fetus born between 23-30 weeks’ gestational age) by using feature extraction and machine learning techniques. For this purpose, a pilot datasets from 15 extremely preterm born infants have been studied. Good and bad outcome were defined as neurodevelopmental impairment according to psychological testing and neurological examination at two years’ age. The results showed 80% of precision on test set. However, because of the limited data set, it is not possible to draw solid conclusion about the exact predictability of our method.

Surveillance of fetal condition during labor is made using cardiotocography (CTG). While there are impressive achievements in modern obstetric care, there is still room for improving automatic bed-side CTG-interpretation for finding early sign of danger. The fetal heart rate is determined by ultrasound, and the uterine contraction (toco) is measured by a pressure transducer. These numbers are represented on a time scale, producing a graphical representation. Considerable expertise is required to interpret whether the fetal response to the uterine contractions is adequate, or fetal response shows sign of fetal exhaustion or asphyxia. In this work we aim to automatic detect suspicious patterns in short intervals by finding the correlation between fetal heart rate patterns and toco patterns. Our proposed method has shown some predictive power. However, further research is needed to improve the results for this important problem.