Online detection of physiological fetal distress pattern during birth

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This proposal is derived from our studies on changes of fetal brain electrical activity (electroenkephalogram, EEG) and heart rate (FHR) which we recorded during simulated labour in fetal sheep model of human pregnancy and fetal development.

The goal is to develop mathematical models allowing online detection of physiological patterns alarming of incipient fetal distress in clinical conditions of labour.

There are two major aspects of the problem:

1. A pattern of time correlated changes in EEG and FHR is now known to occur during conditions of deteriorated blood supply to the fetus as it may occur during labour. This pattern is an early predictor of immanent severe drop in fetal pH. Fetal pH under 7.00 (severe acidemia) is associated with increased risk of brain injury and sustained neurological deficits. In obstetrical care, an urgent need exists for technologies allowing the detection of such severe acidemia in fetus. We describe the phenomenon in detail in Frasch et al (2011).

Question 1: Can we create a mathematical model of this phenomenon robust enough to be capable of capturing the onset of the pattern **online** despite varying EEG/FHR signal characteristics?

2. Certain properties of FHR variability (FHRV, higher order fluctuations in FHR on millisecond time scale) can also be used for early detection of the onset of severe acidemia.

FHRV can be calculated in different signal property domains (linear, nonlinear, time and frequency or both). Different measures of FHRV are known to reflect somewhat different aspects of underlying physiological activities and probably carry a predictive value variable in time. A group of FHRV measures is likely to provide a higher positive predictive value of fetal acidemia than one particular FHRV measure alone. Please see also Frasch (2011).

Question 2: Can we develop a mathematical model to allow us to 1) identify the FHRV measures that would perform best together to detect the pathophysiological mechanism of incipient acidemia and 2) incorporate such FHRV measures into the model that captures the correlated changes in EEG and FHR?

In a broader sense, we hope that such approach would help create a novel paradigm for context-specific generation of mathematical models for online detection of complex physiological patterns. Ideally, this new paradigm should go beyond a purely statistical or data mining framework. For example, can we build a model that incorporates physiological mechanisms into a standard data mining approach?

In order to facilitate the discussion and modeling building exercise, relevant data will be provided for workshop participants.

References:

1. M.G. Frasch, A.E. Keen, R. Gagnon, M.G. Ross, B.S. Richardson (2011), Monitoring Fetal Electrocortical Activity during Labour for Predicting Worsening Acidemia: A Prospective Study in the Ovine Fetus Near Term. PLoS One

2. M.G. Frasch (2011), Monitoring of fetal heart rate variability, J. Critical Care, 26(3), p. e24. (doi:10.1016/j.jcrc.2011.02.033)