The Problem: Physiological Signal to Individual Assessment

- Extraction of relevant signal features and mapping features to the states.

Approach: Computational Intelligence based Stochastic Analysis

For each of the states, we have a computational intelligence based model characterizing the physiological state of the patient.

Stochastic Fuzzy Modeling of Physiological States

- The signal of a patient $P$ with physiological state $S$ is modeled as a history-dependent probability density:

$$
\begin{align*}
\mathcal{M} : \quad & p(y_j|y_{j-1}, y_{j-2}, \ldots, y_{j-n}) \propto e^{-\frac{1}{2} \phi |y_j - FM(y_{j-1}, y_{j-2}, \ldots, y_{j-n}; \alpha)|^2} \\
p(a|m_0, A_0) &= N(a|m_0, (A_0)^{-1}) \\
p(\phi|a_0, b_0) &= \frac{1}{\Gamma(b_0)} \frac{\phi^{b_0-1}}{a_0^{b_0}} e^{-\frac{\phi}{a_0}}, \phi > 0, a_0, b_0 > 0.
\end{align*}
$$

Bayesian inference of the nonlinear fuzzy physiological state model $m$ is the first goal of the method.

Physiological State Prediction

- A discrete random variable $s$ is introduced such that the value of $s$ reflects that $s$-th physiological model might have generated the current physiological signal. That is,

  If random variable $s = 1$, then signal is generated by model $\mathcal{M}_1$

  \[ \ldots \]

  If random variable $s = C$, then signal is generated by model $\mathcal{M}_C$

- Let $\pi = [\pi_1 \cdots \pi_S]^T \in R^S$ be the vector of probabilities such that

  $$p(s = 1|\pi) = \pi_1, \ldots, p(s = C|\pi) = \pi_C$$

  where $\pi$ is generated by a Dirichlet distribution:

  $$p(\pi|c_0) = \frac{\Gamma(c_0)}{(\Gamma(\frac{c_0}{\pi_1}))^{c_0_1} \cdots (\Gamma(\frac{c_0}{\pi_S}))^{c_0_S}} \pi_1^{c_0_1 - 1} \cdots \pi_S^{c_0_S - 1}, \pi_1, \ldots, \pi_S \geq 0, \sum_{j=1}^S \pi_j = 1, c_0 > 0.$$

Stress Assessment Applications

- Stress monitoring for mobile telemedical applications.
- $N = 50$, 24-hours stress monitoring, prediction accuracy $R = 0.7729$.

Conclusions

- The intelligent fuzzy computing based biomedical signal analysis methods possess a high diagnostic efficiency and thus the physiological states of the subjects could be accurately predicted.