psychoIR: Relevance Prediction

WP3, Probabilistic modeling for multi-source fusion (Task 3.2)

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MindSee Kickoff Meeting
Berlin, Oct 28-29, 2013

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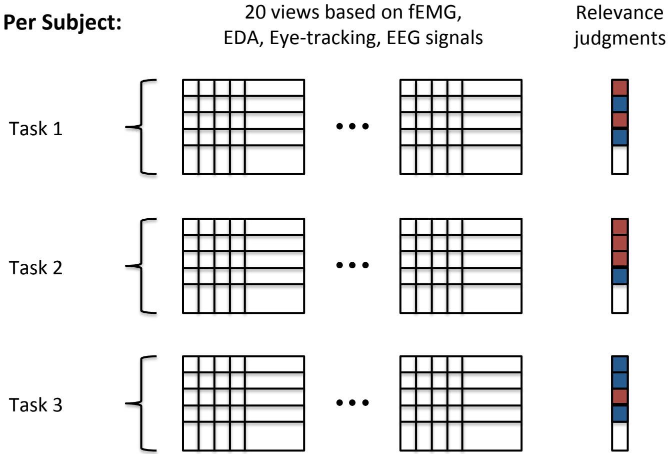
HELSINKI INSTITUTE FOR INFORMATION TECHNOLOGY

Setup


Per Subject:
20 views based on fEMG, EDA, Eye-tracking, EEG signals
Relevance judgments
Task 1
Task 2
Task 3

Research questions

1. Can we predict relevance from physiological signals?

2. What is the predictive power of different physiological signals?
3. What features of a physiological signal are important?

4. Is the relevance prediction task-dependent?
5. Is the relevance prediction subject-dependent?

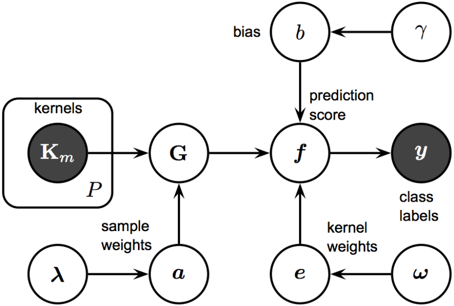
Multiple kernel learning

Compute a kernel for each view and use, e.g., a weighted sum of the P kernels $\{\mathbf{k}_m : \mathcal{X} \times \mathcal{X} \to \mathbb{R}\}_{m=1}^{P}$:

$$f(\mathbf{x}_*) = \alpha^t \left(\sum_{i=1}^{P} e_m \mathbf{k}_{m,*} \right) + b$$

where $\mathbf{x}_*$ is an unseen sample, is the vector of kernel weights, $\mathbf{k}_{m,*} = [k_m(\mathbf{x}_1, \mathbf{x}_*), \ldots, k_m(\mathbf{x}_N, \mathbf{x}_*)]^t$, α is the vector of sample weights, b is the bias, and $\{\mathbf{x}_i \in \mathcal{X}\}_{i=1}^{N}$ are the training samples.

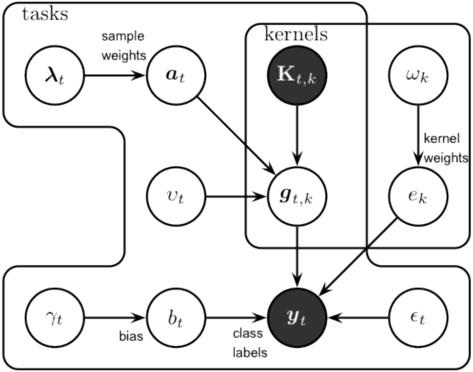
Bayesian Multiview MKL



$$
\begin{aligned}
\lambda_i &\sim \mathcal{G}(\lambda_i; \alpha_\lambda, \beta_\lambda) && \forall i \\
a_i | \lambda_i &\sim \mathcal{N}(a_i; 0, \lambda_i^{-1}) && \forall i \\
g_i^m | \boldsymbol{a}, \boldsymbol{k}_{m,i} &\sim \mathcal{N}(g_i^m; \boldsymbol{a}^\top \boldsymbol{k}_{m,i}, 1) && \forall (m,i) \\
\gamma &\sim \mathcal{G}(\gamma; \alpha_\gamma, \beta_\gamma) && \\
b | \gamma &\sim \mathcal{N}(b; 0, \gamma^{-1}) && \\
\omega_m &\sim \mathcal{G}(\omega_m; \alpha_\omega, \beta_\omega) && \forall m \\
e_m | \omega_m &\sim \mathcal{N}(e_m; 0, \omega_m^{-1}) && \forall m \\
f_i | b, \boldsymbol{e}, \boldsymbol{g}_i &\sim \mathcal{N}(f_i; \boldsymbol{e}^\top \boldsymbol{g}_i + b, 1) && \forall i \\
y_i | f_i &\sim \delta(f_i y_i > \nu) && \forall i
\end{aligned}
$$

Gönen (2012): Novel kernel combination formulation with a fully conjugate probabilistic model, which leads to a very efficient variational approximation.

Bayesian Multitask/Multiview MKL



$$\lambda_{t,i} \sim \mathcal{G}(\lambda_{t,i};\ \alpha_\lambda, \beta_\lambda) \quad \forall(t,i)$$
$$a_{t,i}|\lambda_{t,i} \sim \mathcal{N}(a_{t,i};\ 0, \lambda_{t,i}^{-1}) \quad \forall(t,i)$$
$$\upsilon_t \sim \mathcal{G}(\upsilon_t;\ \alpha_\upsilon, \beta_\upsilon) \quad \forall t$$
$$g_{t,k}|a_t, K_{t,k}, \upsilon_t \sim \mathcal{N}(g_{t,k};\ K_{t,k}a_t, \upsilon_t^{-1}I) \quad \forall(t,k)$$
$$\gamma_t \sim \mathcal{G}(\gamma_t;\ \alpha_\gamma, \beta_\gamma) \quad \forall t$$
$$b_t|\gamma_t \sim \mathcal{N}(b_t;\ 0, \gamma_t^{-1}) \quad \forall t$$
$$\omega_k \sim \mathcal{G}(\omega_k;\ \alpha_\omega, \beta_\omega) \quad \forall k$$
$$e_k|\omega_k \sim \mathcal{N}(e_k;\ 0, \omega_k^{-1}) \quad \forall k$$
$$\varepsilon_t \sim \mathcal{G}(\varepsilon_t;\ \alpha_\varepsilon, \beta_\varepsilon) \quad \forall t$$
$$y_t|b_t, e, G_t, \varepsilon_t \sim \mathcal{N}\left(y_t;\ \sum_{k=1}^{K} e_k g_{t,k} + b_t 1, \varepsilon_t^{-1} I\right)$$

TeamFIN (2013): Extension to tasks with shared kernel weights; TeamFIN won "The NCI-DREAM Drug Sensitivity Prediction Challenge".

Selected references:

Mehmet Gönen. Bayesian efficient multiple kernel learning. In *Proceedings of the 29th International Conference on Machine Learning*, 2012. URL `http://users.ics.aalto.fi/gonen/icml12.php`.

TeamFIN. Bayesian multitask multiple kernel learning. Members of HIIT (Helsinki Institute for Information Technology) and FIMM (Institute for Molecular Medicine Finland): Elisabeth Georgii and Mehmet Gönen and Muhammad Ammad-ud-din and Petteri Hintsanen and Suleiman A Khan and John-Patrick Mpindi and Olli Kallioniemi and Antti Honkela and Tero Aittokallio and Krister Wennerberg and Samuel Kaski, 2013.

More information, including papers and code, at:

`http://research.ics.aalto.fi/mi/`