

Discussion

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Extensions - Discussion

- **Including sensor noise** ^[1]
 - Errors-in-variables problems can be more easily handled in a network setting
- **Distributed estimation (MISO models)** ^[2]
 - Communication constraints between different agents
 - Recursive (distributed) estimator converges to global optimizer (more slowly)
- **Experiment design** ^{[3]-[6]} **and variance issues**
 - design of least costly experiments

[1] Dankers et al., Automatica, 2015.

[2] Steentjes et al., IFAC-NECSYS, 2018.

[3] Gevers and Bazanella, CDC 2015.

[4] Morelli, Bombois et al., ECC 2019;

[5] Bombois et al., Automatica, 2018;

[6] Bombois et al., Automatica, 2023;

Extensions - Discussion

- **Full network identification in partial measurement/excitation case**
[1]-[4] partly concerning acyclic networks.
- **Data-driven distributed control** [5]
- **Relating single module identifiability conditions to identification methods**
- **Model validation and diagnostics** [6]

[1] A. Bazanella et al., CDC 2019.

[2] E. Mapurunga et al., IFAC 2021, CDC 2022, TAC 2024.

[3] A. Legat and Hendricks, CDC 2020.

[4] X. Cheng et al., TAC 2023.

[5] T. Steentjes et al, CDC 2020, ECC 2021, SYSID 2021, CDC 2021.

[6] Y. Shi et al., SYSID 2024.

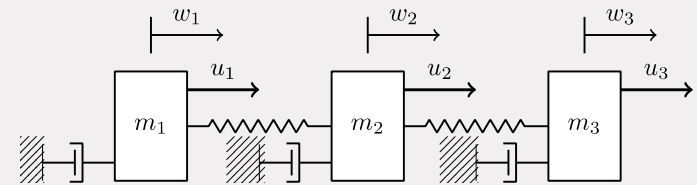
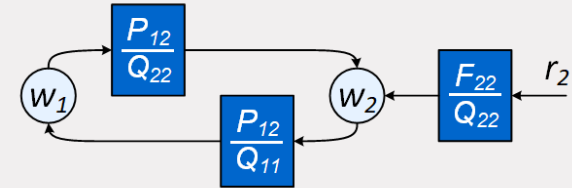
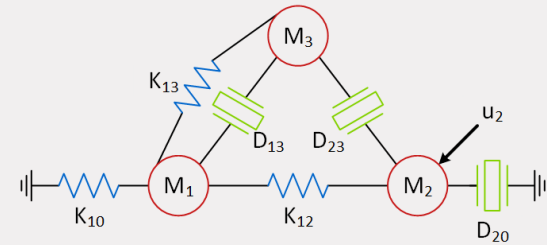
Extensions - Discussion

- **Physical networks**

Do not have a prior input-output structure

Difference of node signals drives the interaction:
diffusive coupling

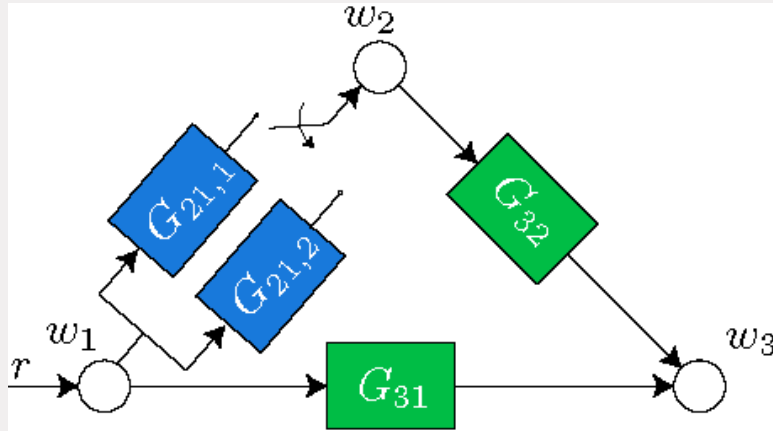
Nodes are bilaterally coupled with symmetry properties in the transfer functions



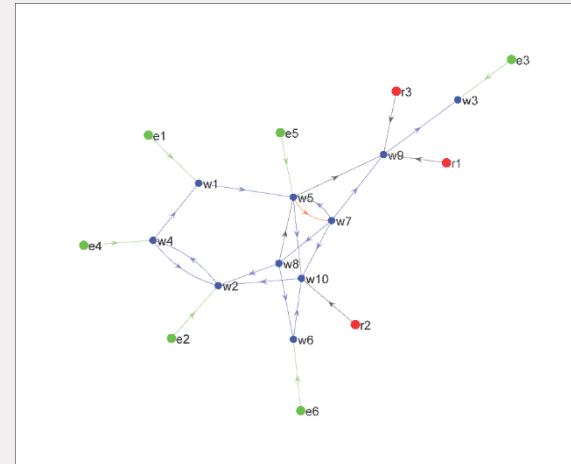
- Framework is fit for representing **cyber-physical systems** (combining physical bi-directional links, and cyber uni-directional links).

Extensions - Discussion

- Switching modules can provide excitation



Adding a switching module from w_5 to w_7 creates generic identifiability of the network

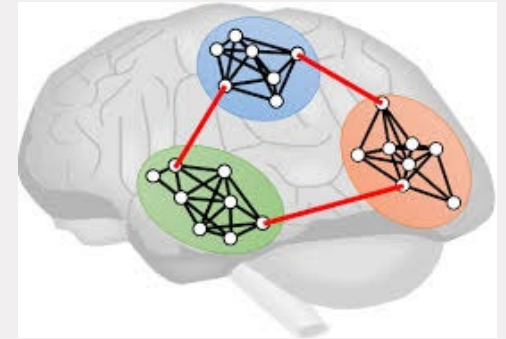


Extensions - Topology identification

- Topology resulting from full dynamic model
- Alternative: non-parametric models (Wiener filters ^[1]) or kernel-based approaches ^{[2][3]}
- modeling module dynamics by Gaussian processes, kernel with 2 parameters for each dynamic module
- Optimizing likelihood of the data as function of parameters and topology:

$$p(\{w(t)\}_{t=1}^N | \theta, \mathcal{G})$$

- Forward-backward search over topologies + empirical Bayes (EM) for parameters



[1] Materassi & Innocenti, TAC 2010.

[2] Chiuso & Pillonetto, Automatica, 2012.

[3] Shi, Bottegal, PVdH, ECC 2019

Neurodynamic effect of listening to Mozart music

Identifying changes in network connections in the brain, after intensely listening for one week

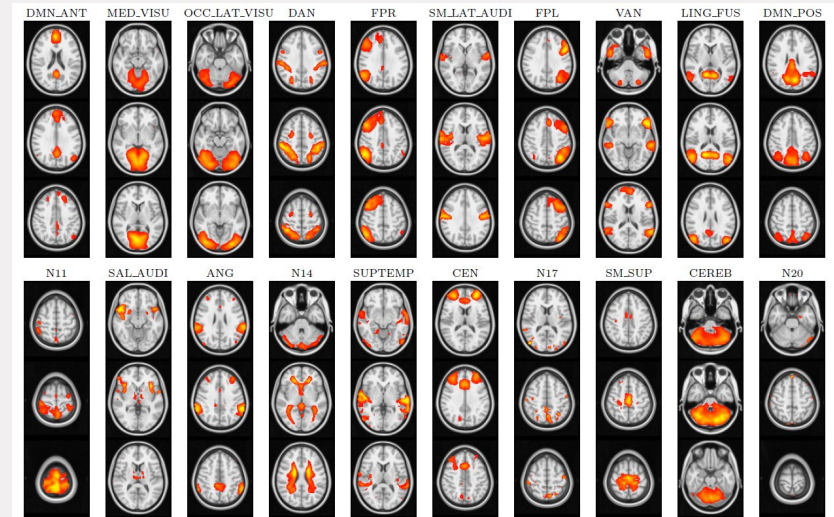
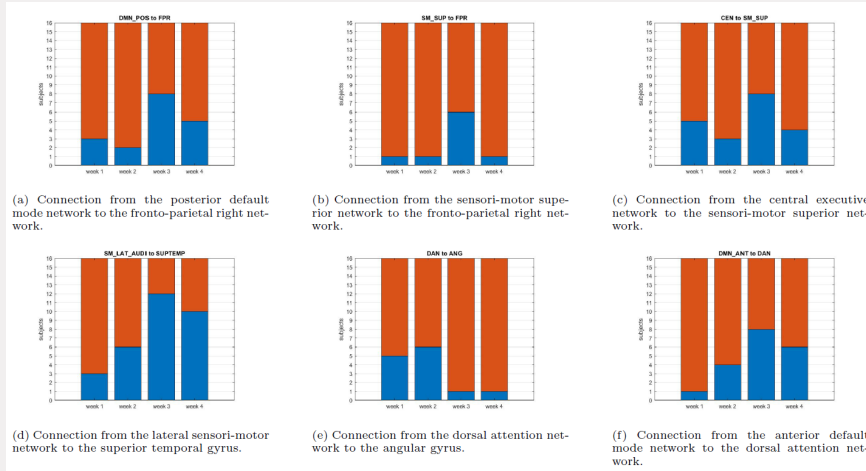
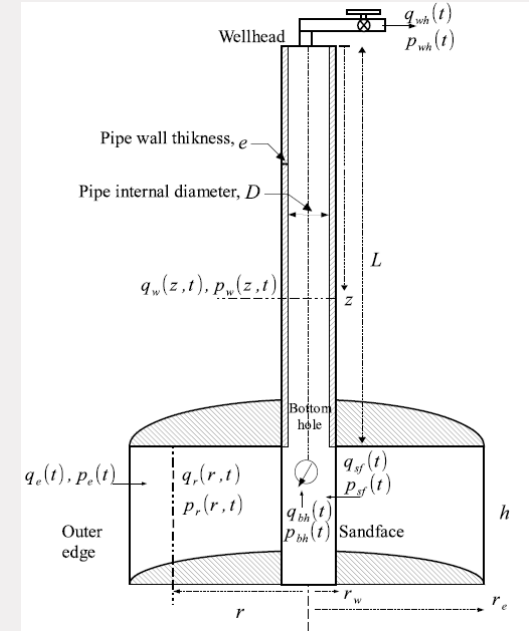
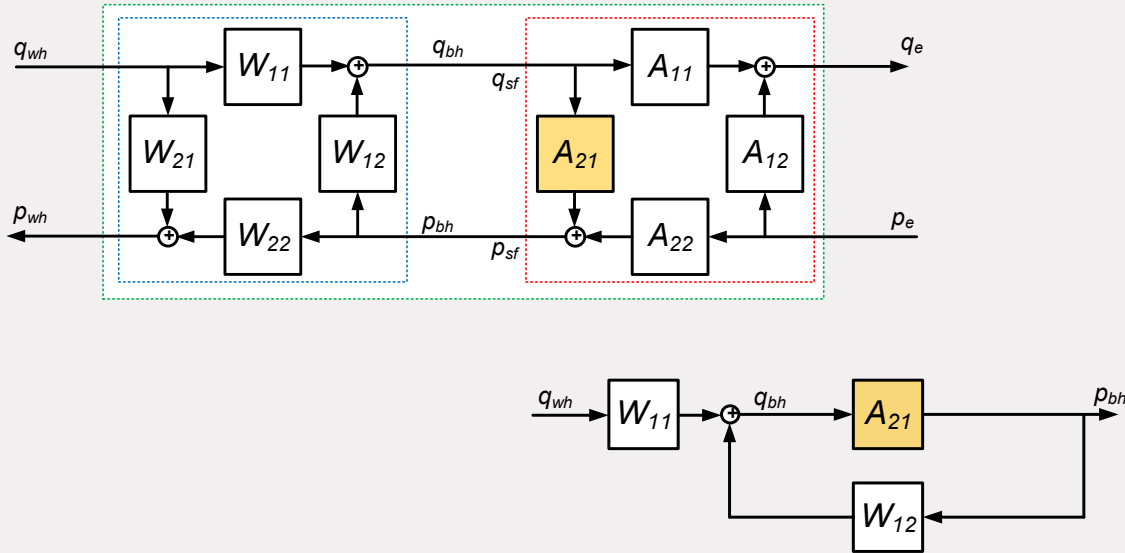


Figure 3: Spatial maps of the 20 active brain networks found through the ICA decomposition. Each image consists of 3 relevant horizontal slices of the brain, where the spatial map is indicated by the red color scale.

Discussion - Applications

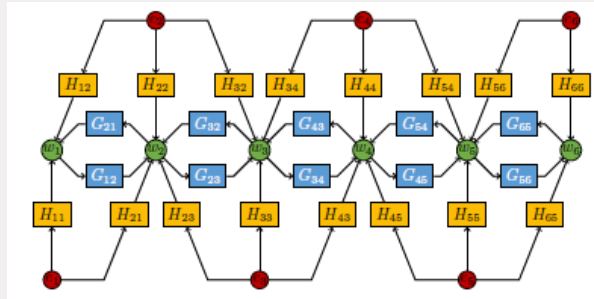
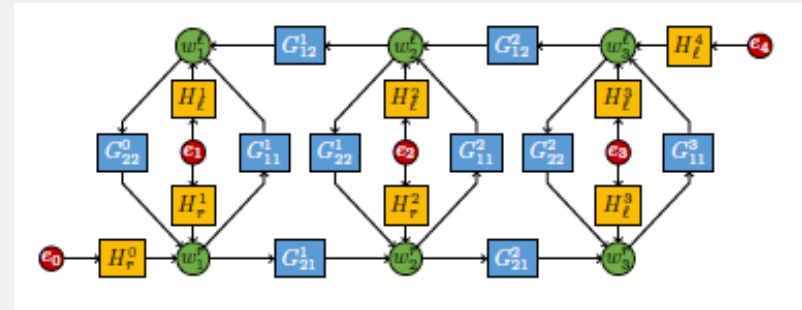
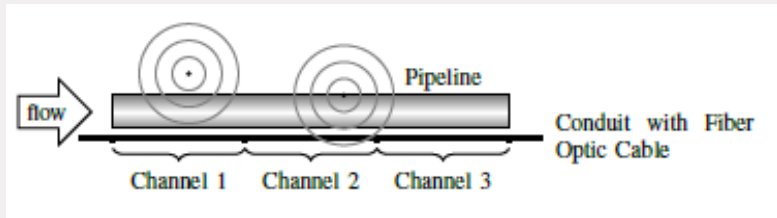
Underground reservoir identification using generalized wellbore data



M. Mansoori, P.M.J. Van den Hof, J.D. Jansen and D. Rashtchian (2015). Pressure transient analysis of bottomhole pressure and rate measurements using system-identification techniques. *SPE Journal*, Vol. 20, no. 5, pp. 1005-1027.

Discussion - Applications

Pipeline monitoring using acoustic measurements and network system identification^[1]



[1] A. Dankers, D. Westwick, E. Jalilian, submitted 2021.

Thank you !

Dynamic network identification

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