TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Single module identification - full MISO with direct and indirect method

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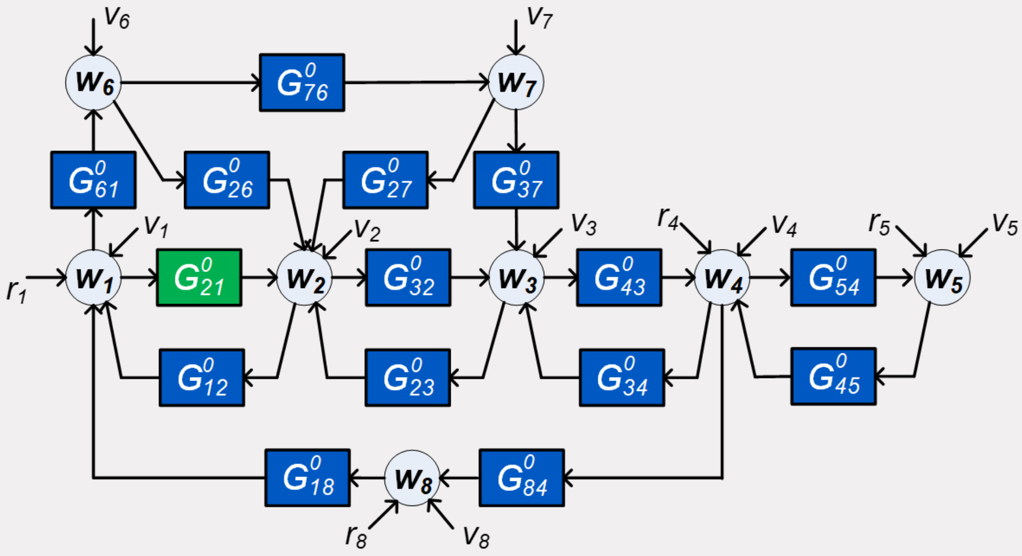
Single module identification



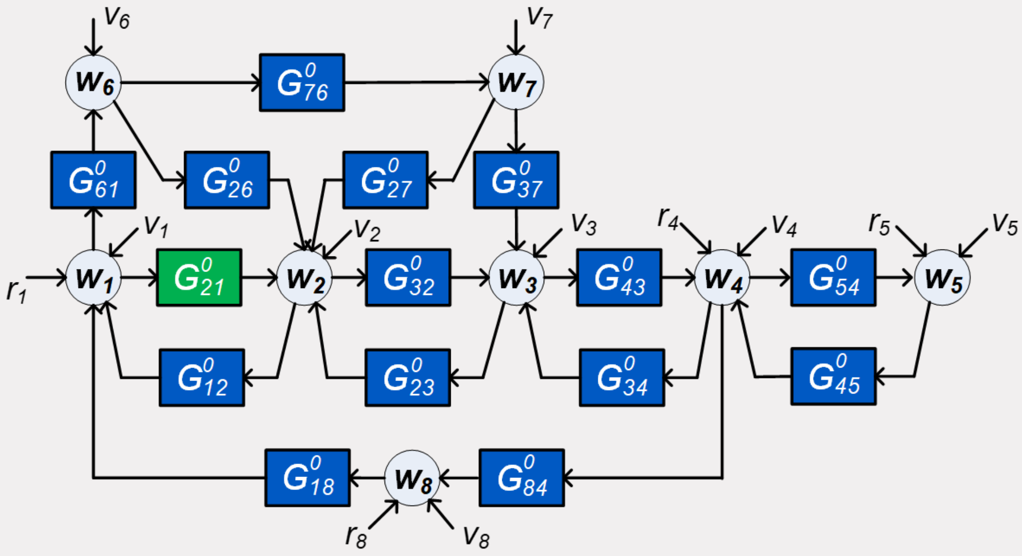
The problem:

For a network with known topology:

Identify G^0_{21} on the basis of selected measured signals (w, r)

Preference for "local" measurements and limited excitation

Single module identification



Option:

Identify the full MIMO network:

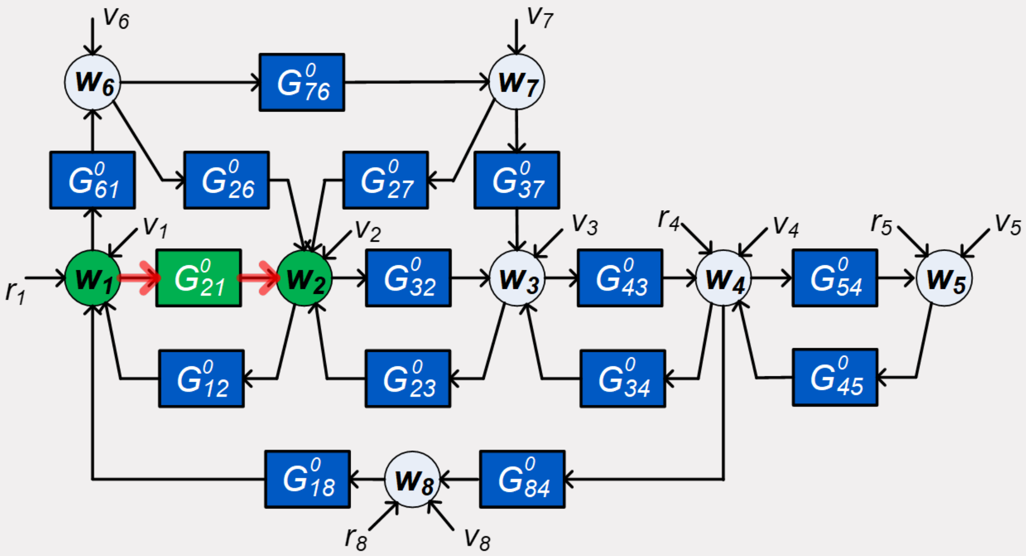
$$\begin{aligned} w &= (I - G^0)^{-1}[R^0 r + H^0 v] \\ &= T_{wr} r + T_{we} e \end{aligned}$$

and recover $\hat{G}_{21}$ from the estimated model.

Consequence:

- Computational complexity
- High demand on excitation and sensing of signals

Single module identification

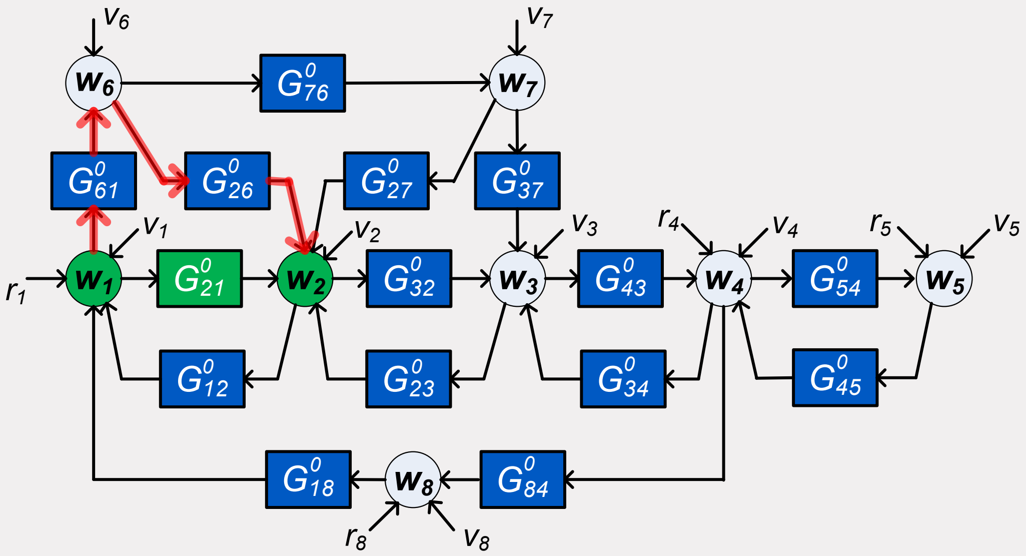


Naïve local approaches:

- identify based on w_2 and w_1 ; or
- identify based on $T_{w_2 r_1} T_{w_1 r_1}^{-1}$

do not work,
e.g. because of parallel paths

Single module identification



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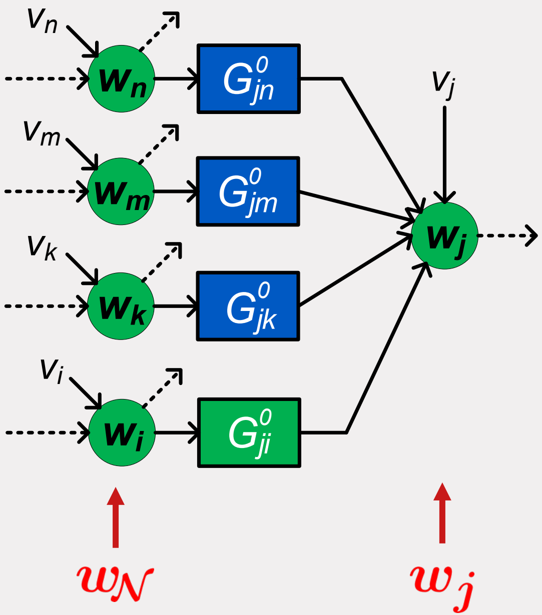
do not work,
e.g. because of parallel paths

The "observed" transfer function between w_1 and w_2 is not necessarily G_{21}^0.

Single module identification – Full MISO situation

Full MISO situation:

Measure output $w_j = w_2$ of target module and all in-neighbors $w_{\mathcal{N}}$ of w_j

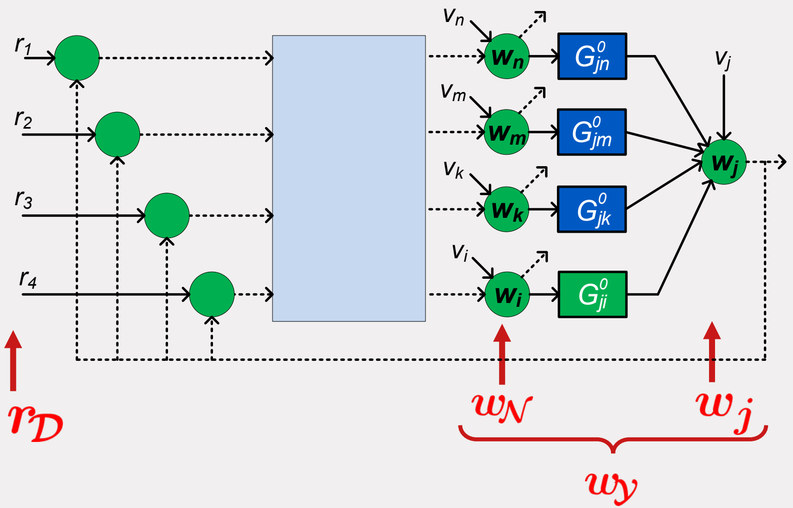


Multi-input single-output identification problem

to be addressed by a closed-loop identification method

(direct or indirect method)

Indirect methods



MISO identification problem

- Select output w_j and all its in-neighbors $w_\mathcal{N}$ as predictor output; $r_\mathcal{D}$ as predictor input
- Estimate $\bar{T}_{\mathcal{N}r}$ and $\bar{T}_{jr}$ consistently, and determine:

$$\hat{G}_{j\mathcal{N}} = \hat{T}_{jr}\hat{T}_{\mathcal{N}r}^{-1}$$ [1]

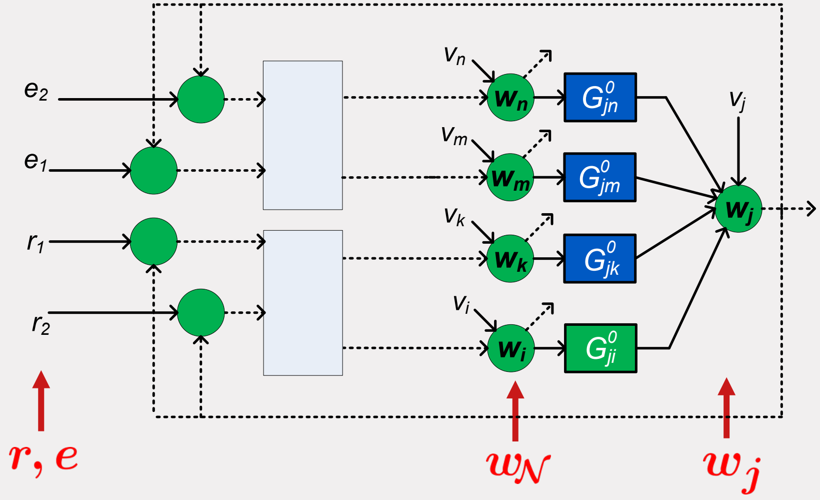
- or through IV or two-stage method[2]
- freedom in location of r-signals (e.g. directly on $w_\mathcal{N}$)

Condition for consistency of $\hat{G}_{ji}$:

- $G^0 \in \mathcal{G}$, no noise model required
- $r_\mathcal{D}$ persistently exciting, $\Phi_{r_\mathcal{D}}(\omega) > 0$, at a sufficient number of ω
- Typically, $dim(r_\mathcal{D}) \geq dim(w_\mathcal{N})$

[1] Gevers et al., SYSID 2018; Hendrickx et al, TAC 2019; Bazanella et al., CDC 2019
[2] VdHof et al., Automatica 2013; Dankers et al., Automatica 2015

Direct method



$$\varepsilon(t,\theta) = \bar{H}(q,\theta)^{-1}[w_{\mathcal{Y}}(t) - \bar{G}(q,\theta)w_{\mathcal{N}}(t)]$$

- Estimate transfer $w_{\mathcal{N}} \rightarrow w_j$ and model the disturbance process on the output.
- provided there is enough excitation, through external signals r and e

Conditions for consistency of $\hat{G}_{ji}$:

- $\mathcal{S} \in \mathcal{M}$
- $\Phi_v(\omega)$ is diagonal
- Every loop around w_j has a delay
- $\Phi_\kappa(\omega) > 0$ with $\kappa(t) = \begin{bmatrix} w_j(t) \\ w_{\mathcal{N}}(t) \end{bmatrix}$ (1)

+ Excitation through both r and e signals
+ Consistency + minimum variance (ML)

[1] VdHof et al., Automatica 2013;
[2] VdHof and Ramaswamy, CDC 2020;
[3] Bombois et al., Automatica, 2023

(1) assuming $r_j = 0$

Summary full MISO case – direct and indirect method

- All local nodes are measured — To be relaxed later on
- Closed-loop identification concepts (direct / indirect) can be used

Indirect method:

- No noise models required
- More ``expensive'' experiments

Direct method:

- Noise models required
- Minimum variance results
- Requires a diagonal noise spectrum — To be relaxed later on

Both methods: non-convex algorithms are poorly scalable to large dimensions