Complementary Filters Shaping Using $\mathcal{H}_\infty$ Synthesis

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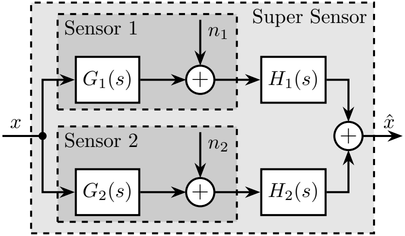
Motivation - Sensor Fusion Architecture



$$\hat{x} = \left(G_1 H_1 + G_2 H_2\right) x + H_1 n_1 + H_2 n_2$$

Complementary Property

$$H_1(s) + H_2(s) = 1$$

Let's first consider **Perfectly Known Sensor Dynamics**:

$$G_1(s) = G_2(s) = 1 \Longrightarrow \boxed{\hat{x} = x + H_1 n_1 + H_2 n_2}$$

We need a synthesis method of complementary filter that allows to **shape the norm of the generated filters**.

Shaping of Complementary Filters using $\mathcal{H}_\infty$ synthesis

Design Objective

$$H_1(s) + H_2(s) = 1$$

$$|H_1(j\omega)| \leq \frac{1}{|W_1(j\omega)|} \quad \forall\omega$$

$$|H_2(j\omega)| \leq \frac{1}{|W_2(j\omega)|} \quad \forall\omega$$

$\mathcal{H}_\infty$ Synthesis

Find $H_2(s)$ such that:

$$\left\| \begin{matrix} [1 - H_2(s)]\, W_1(s) \\ H_2(s) W_2(s) \end{matrix} \right\|_\infty \leq 1$$

$$H_1(s) \triangleq 1 - H_2(s)$$

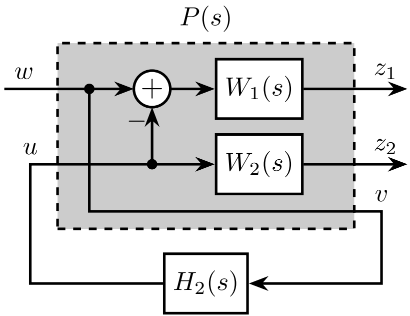


Figure: $\mathcal{H}_\infty$ Architecture used for the shaping of complementary filters

Results - $\mathcal{H}_\infty$ Synthesis of Complementary filters

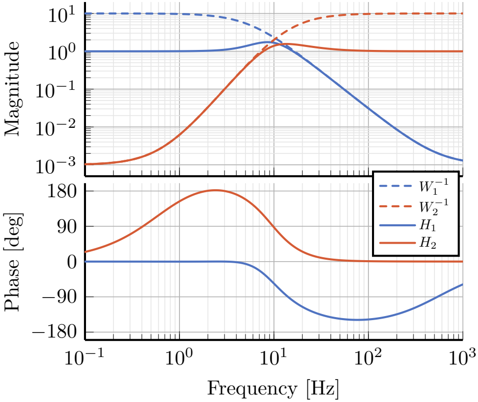


Figure: Frequency response of the weighting functions and complementary filters obtained using $\mathcal{H}_\infty$ synthesis

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