Robust Bayesian Optimization for Electronic Devices Design

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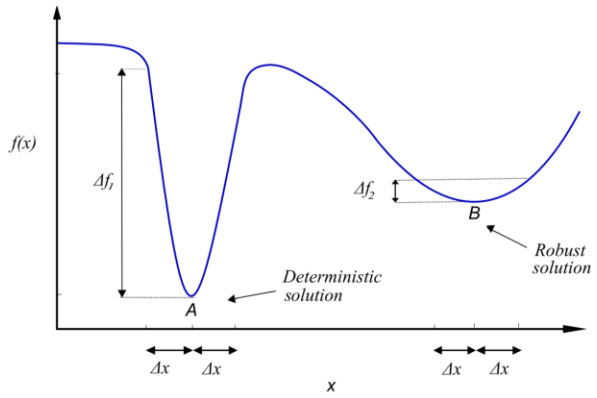
Reference: D. De Witte, J. Qing, I. Couckuyt, T. Dhaene, D. Vande Ginste, D. Spina, "A Robust Bayesian Optimization Framework for Microwave Circuit Design under Uncertainty", Electronics, 11(14), 2267, 2022

Objective Description

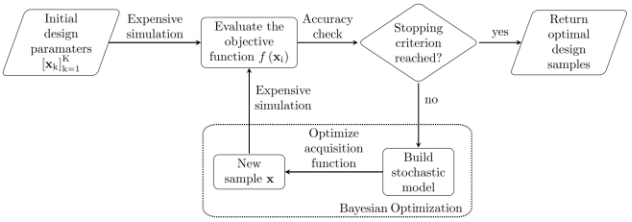
Defining a new optimization framework including uncertainty effects ➔ Robust designs



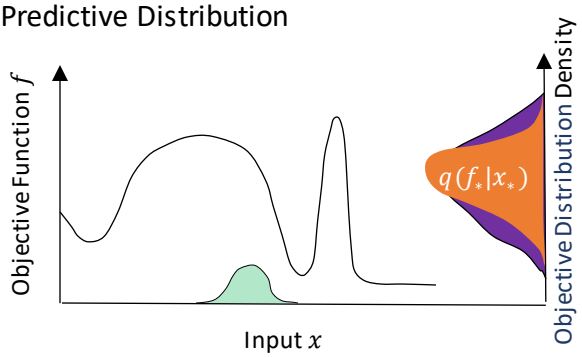
Example: find the minimum of this function that it is robust against *input uncertainties*

Methodology

Robust Bayesian Optimization (RBO)



1. Moment Matching of Marginalized Predictive Distribution



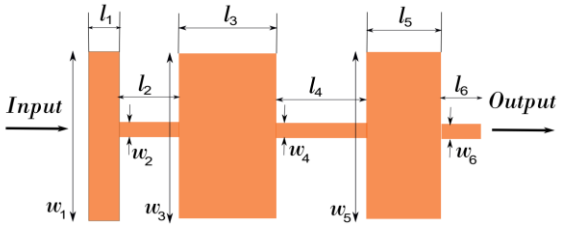
2. Robust Expected Improvement

$$\alpha_{\mathrm{sEI},n}(\mathbf{x}_\star) = \mathbb{E}_{p(\mathbf{z}|\mathbf{x}_\star,\Sigma)}[\alpha_{\mathrm{EI},n}(\mathbf{z})]$$
$$= \int_{-\infty}^{y_{min}} (y_{min} - f_\star)\left[\int_{\mathbb{R}^D} p(f_\star|\mathbf{z},\mathcal{D}_n)p(\mathbf{z}|\mathbf{x},\Sigma)\,\mathrm{d}\mathbf{z}\right]\mathrm{d}f_\star$$

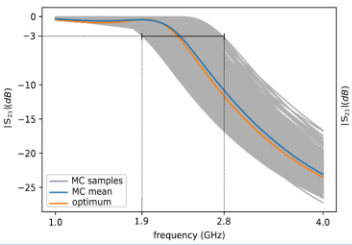
Example: Microstrip Lowpass Filter Design

Design parameters:

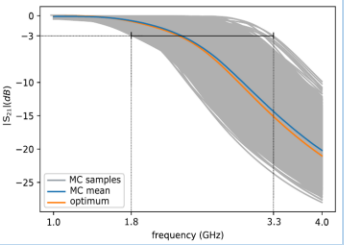
- $l_{1,6} \in [1, 5]$mm, $l_{4,8} \in [1, 5]$mm, $l_{2,3} \in [6.5, 10.5]$mm
- Gaussian uncertainty, diagonal covariance matrix: $(0.62^2, 1.22^2, 1.72^2, 1.72^2, 1.22^2, 0.62^2)\text{mm}^2$
- Objective: $f_c(\mathbf{x}) = |f_c - 2.4|$



RBO



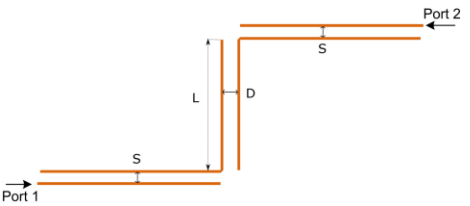
Standard BO



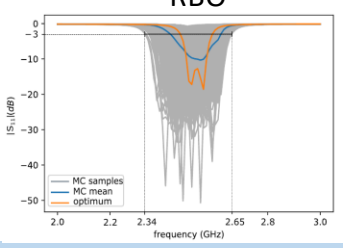
Example: Zigzag Bandpass Filter Design

Design parameters:

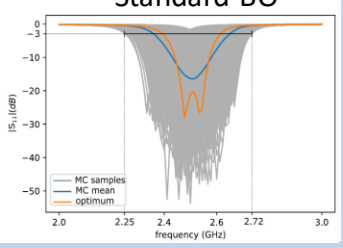
- D ∈ [0.2, 2]mm, L ∈ [16, 20]mm, S ∈ [0.1, 1]mm
- Gaussian uncertainty, diagonal covariance matrix: $(0.06^2, 0.9^2, 0.03^2)\text{mm}^2$
- Objective: $f(\mathbf{x}) = |f_L - 2.4| + |f_H - 2.6|$



RBO



Standard BO



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