Test Count Reduction Algorithm for Determining the Optimal Phase in Wireless Power Transfer using Bayesian Optimization

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Various ways of finding the optimal phase and amplitude of RF Wireless Power Transfer (RF-WPT) have been studied. Several studies are focused on finding optimal values when the channel information of the systems is assumed to be known. But in real applications, Rx locations are unknown. So, it is important to find the optimal values without prior information about the channel. In this case, the optimum excitation condition was usually found by using the feedback information of the received power. However, it takes quite long time to determine the optimal phase and amplitude since the control variables are too many. This abstract suggests the method of reducing the time for determining the optimal phase and amplitude of WPT system by using Bayesian Optimization with the information of the received signal power sent back by the receiver.

WPT system consisting of M×M Transmitter arrays and N×N Receiver arrays is assumed. Each antenna of Transmitter array has phase shifters that can control phase ranges from 0 to 2π by P-bit digital signals. To reduce the complexity of finding the Transmitter phase matrix, the decomposition of the phase matrix by the weighted sum of orthogonal basis matrices was shown to be effective [1]. Hadamard matrix is commonly used for orthogonal basis matrix sets. Order n ($n \in I$) Hadamard matrix satisfies the following:

$$H_n {H_n}^T = nI_n \tag{1}$$

If two different $M \times M$ Hadamard matrices $i, j (i \neq j)$ is satisfies $\langle H_i, H_j \rangle = 0$ (Frobenius inner product), the two matrices are orthogonal. This can derive the objective phase matrix into the weighted sum of orthogonal basis (2).

$$\varphi_{tx} = \sum_{i=1}^{M^2} \alpha_i H_i \tag{2}$$

Bayesian Optimization is then used to reduce the number of phase selections. Fig. 1 shows the common progress of Bayesian Optimization. This can be used in this WPT system to reduce the attempt of testing by selecting the candidate x cleverly instead of testing all the x values in Fig. 1. The same method can be applied to reduce the count of test to find the optimal phase matrix instead of searching all phase values of [0, 2π].

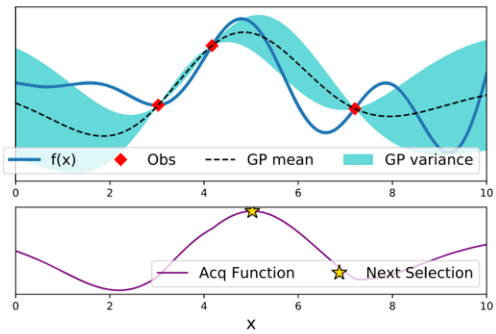

Figure 1. Basic operation example of Bayesian optimization using Gaussian Process [2].

References

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