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GAUSSIAN PROCESS WITH HYPERPARAMETERS OPTIMIZATION USING LBFGS ALGORITHM: A CASE STUDY WITH 5G NEW RADIO THROUGHPUT DATA

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Gaussian Process Regression (GPR) is a fast and powerful non-parametric regression method for data mining and machine learning. The Bayesian optimization method, which has remained one of the standard methods of optimizing the GPR, usually leads to poor parameter tuning and code start problems. In this paper, we proposed and leveraged the accurate and robust gradient-based limited-memory Broyden–Fletcher–Goldfarb–Shanno (LBFGS) algorithm to surmount the aforementioned Bayesian optimization tuning method. We have applied the proposed GPR-LBFS tuning algorithm to mine and predict a set of throughput data that were acquired over 5G New radio networks. We show by engaging the Root Mean Square Error (RMSE) and Correlation coefficient (R) statistics, that the proposed GPR-LBFS tuning algorithm provides the best hyperparameter tuning results, and also attains the best throughput data prediction accuracies at different measurements points and spatial domains.

Introduction and Problem Statement. For effective model selection and application of any machine learning method during data mining processes, its hyperparameters tuning algorithm plays a decisive role [1]. Particularly, tuning the hyperparameters of Gaussian Process Regression (GPR) based machine learning and predictive modelling method can be exhaustive and cumbersome if the data is relatively large [2-4]. The Bayesian optimization method, which has remained one of the standard methods of optimizing the GPR, usually leads to poor parameter tuning and code start problems [2].

In this paper, we proposed and leveraged the accurate and robust gradient-based limited-memory Broyden–Fletcher–Goldfarb–Shanno (LBFGS) algorithm to surmount the aforementioned Bayesian optimization tuning method. We have applied the proposed GPR-LBFS tuning algorithm to mine and predict five different sets of throughput data that were acquired over 5G New radio networks. We show by engaging the Root Mean Square Error (RMSE) and Correlation coefficient Indicators, that the proposed GPR-LBFS tuning algorithm provides the best hyperparameter tuning results, and also attains the best throughput data prediction accuracies at different spatial domains.

Methodology. A novel stepwise framework is engaged in this paper to tune the GPR model hyperparameters for effective throughput data predictive mining. The first step concentrates on real-time throughput data acquisition. The second step focuses on GPR model description and its hypermeter identification. The next step is GPR-based hyperparameter tuning with the LBFGS algorithm and application to mining and predicting the acquired throughput data.

The LBFGS Algorithm. The LBFGS algorithm [2, 5], is a strong and resourceful gradient-based optimization algorithm that has the capacity to solve diverse large-scale data mining problems, mostly within the sphere of artificial network applications. The LBFGS is an improved version of the BFGS method and its memory requirements are about (12+2m) N where N and m indicate the model space size and BFGS updates number. LBFGS achieves its adaptive optimization by employing inverse Hessian matrix approximation via iterative processes to pilot its line search over variable space.

Results. The graphs in Figures 1 and 2 display the extrapolative learning and prediction accuracies using the proposed GPR–LBFGS in comparison with the standard BOP method. We can infer from the figures the proposed GPR–LBFGS technique achieved 0.38 RMSE accuracy in throughput data prediction. In contrast, the standard GPR-BOP and GPR with hyperparameter tuning achieved 90.20 and 288.42 RMSE accuracies.

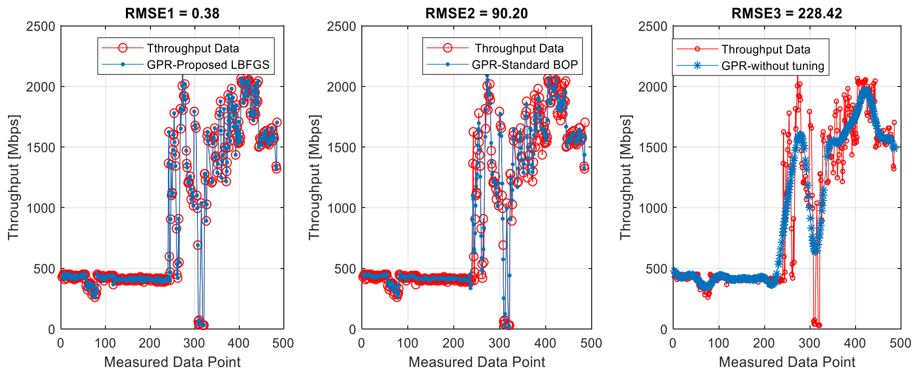

Figure 1. Measured Throughput Data and RMSE prediction performance with Proposed LBFGS and BOP

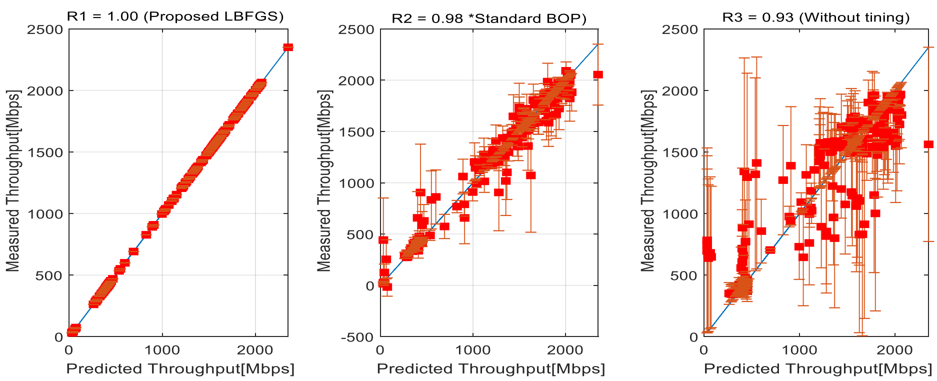

Figure 2. Measured Throughput Data and correlation coefficient prediction performance with Proposed LBFGS and BOP

Conclusions. The LBFGS algorithm has been successfully proposed and applied with the GPR to analysis and predict real-time throughput data sets. The datasets were collected from 5G-New Radio networks. Moreover, we show by means of the RMSE and Correlation coefficient, R Indicators, that the proposed GPR-LBFS tuning algorithm provides the best hyperparameter tuning results, and also attains the best throughput data prediction accuracies at different spatial domains.

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