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Simulation of Beamline Motion Control of Shanghai Synchrotron Radiation Facility BL13U

Introduction

The Shanghai Synchrotron Radiation Facility's hard x-ray nanoprobe wire station is currently under construction, it is cannot to conduct research on online testing, however, beamline adjustment is crucial prior to conducting experiments at the wire station, this challenge can be more effectively addressed by using simulation testing instead of online testing. In order to carry out intelligent beamline adjusting research before the online station is completed, this paper designs a beamline adjusting test simulation platform based on the EPICS software. Through the software simulation of the motor control system of the above-mentioned beamline, the beamline adjusting application of intelligent control methods is realized. The test results show that the system runs well and the intelligent beamline adjusting algorithm can efficiently and automatically optimize the motors in the system. The beamline adjusting test platform based on EPICS software can be further applied to the simulation and testing of other beamlines at the Shanghai Synchrotron Radiation Facility.

Objective

Establishing a simulation testing platform to conduct research on beamline adjusting based on intelligent control technology, automating the optimization and adjustment of the beam can significantly improve the efficiency of beam adjusting. This paper constructed a simulation and testing platform for beamline stations using the Experimental Physics and Industrial Control System (EPICS) software, subsequently, the motor control system of the BL13U beamline equipment was simulated using this platform, the intelligent adjusting task was performed in the system by implementing a group-search evolutionary algorithm.

Methodology

In this paper, the automatic optimal control of the beam is realized based on the optical attitude adjustment of the part shown in Figure 1. As the controlled beamline, the motor simulation control system of BL13U is designed and implemented based on the architecture shown in Figure 2, including the OPI interface at the top layer, the Simmotor tool of IOC at the bottom layer and the BL13U motor shaft created based on Simmotor.

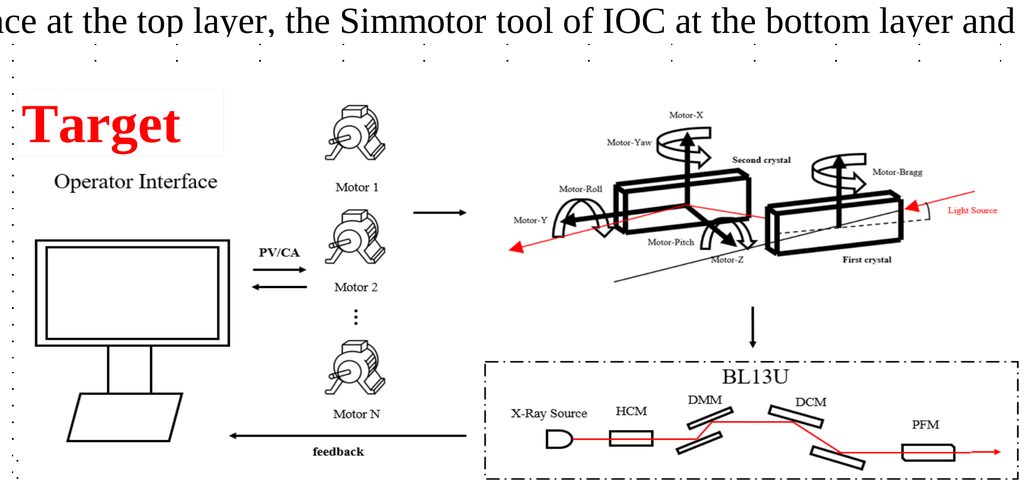


Figure 1. Beamline auto-regulation logic display

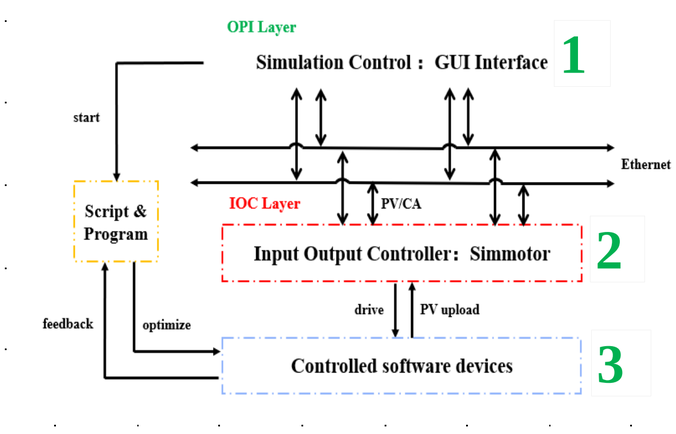


Figure 2. System software architecture

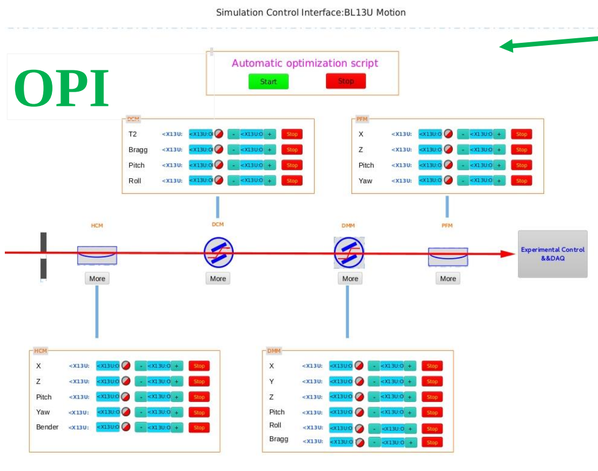


Figure 3. BL13U Simulation control interface.

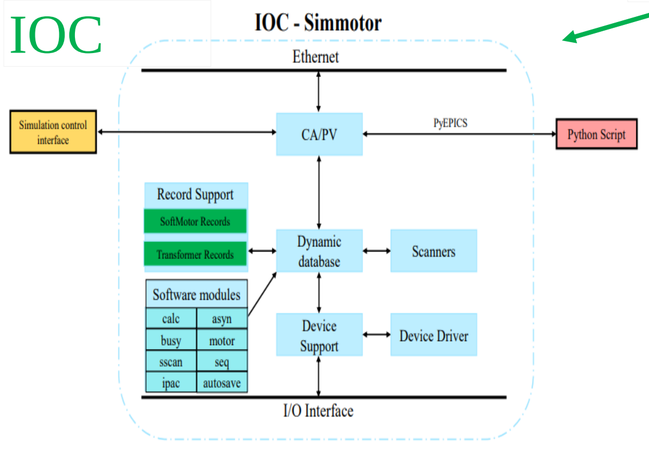


Figure 4. IOC tool composition structure..

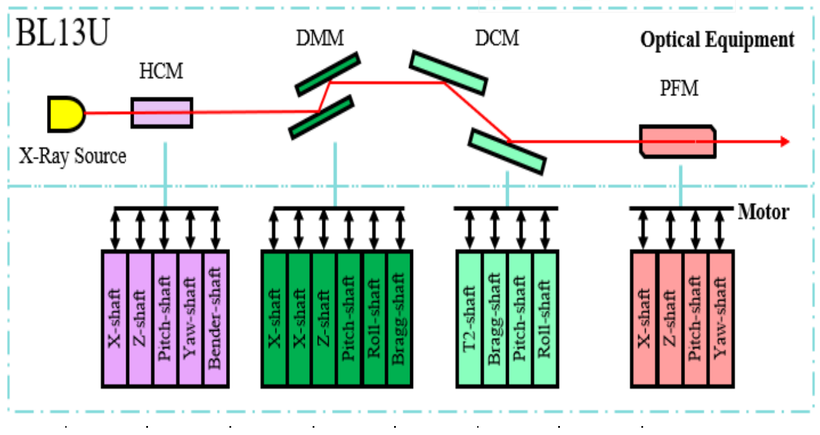
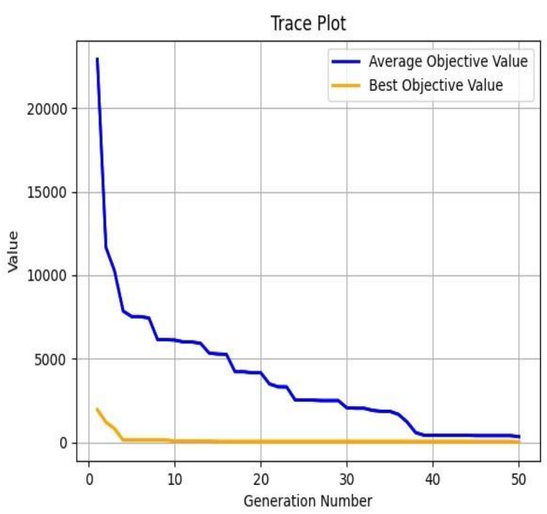
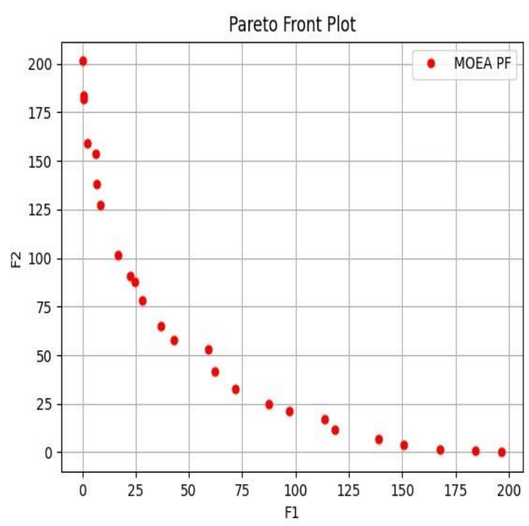


Figure 5. BL13U software motor shaft.

Result & Conclusion



(a) DE



(b) NSGA-II

Automatic optimization programs based on single-objective differential evolution (DE) and multi-objective NSGA-IIalgorithms were developed, and launched from the BL13U motor control simulation interface. Figure (a) shows the optimization results of the differential evolution algorithm, which had a population size of 10, a maximum optimization count of 50, and used Rastrigin function as feedback criteria. The blue line in the figure represents the relationship between the average optimization value of the entire population and the number of optimizations, while the yellow line represents the relationship between the optimization value of the best individual in the population and the number of optimization times. From Figure (a), it can be seen that the automatic optimization program continuously optimizes motor positions within finite generations until they reach the optimal target value. Figure (b) shows the optimization results of the NSGA-II algorithm, which had a population size of 25, a maximum optimization count of 50, and used BNH function as feedback criteria. From Figure (b), it can be seen that the automatic optimization program can optimize software motors and obtain the optimal solution set composed of many optimal solutions.

Using this beamline adjusting simulation platform, the motor control system of the Shanghai Synchrotron Radiation Facility hard X-ray nanoprobe wire station was successfully simulated, and the simulation control interface of BL13U and software motors were designed to simulate the BL13U motor control system. The reliability of the system's functions was verified by introducing an intelligent control method based on automatic optimization. Compared to manual online beamline adjusting, this study provides a foundation for researchers to conduct efficient offline testing research.