NEW CERN PROTON SYNCHROTRON BEAM OPTIMIZATION TOOL

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Abstract: This paper describes a new software tool recently developed at CERN called "New CPS Beam Optimizer". This application allows the automatic optimization of beam properties using a statistical method, which has been modified to suit the purposes. Tuning beams is laborious and time-consuming, therefore, to gain operational efficiency, this new method to perform an intelligent automatic scan was implemented. The programming language allowed the creation of a very useful and reliable application, respecting a very simple logic composed with a model, a view (GUI) part and a controller part. The application has been developed using the Matlab tool. These two charts display the evolution of the optimization process while scanning devices: the top chart shows acquisition data from the selected observables (or their ratio). Another type of measurements to test more intensively the robustness and efficiency of the algorithm was performed to maximize the transmission of the injected intensity in PSB from the Linac2.

ACCELERATOR, BEAM TUNING, PARAMETERS, FUNCTION

CERN accelerator complex is a succession of machines that accelerate particles to increasingly higher energies. Beam tuning is the process where operators change accelerating beam parameters in order to maximize or minimize beam observables. Tuning different parameters in one or more detectors can be compared to a numerical analysis where optimization is devoted to the study of the theory and methods to search the smallest or largest value of a function.

When the problem is looking for minimum or maximum of a function, most of the known algorithms are based on the concept of the derivative and on the gradient information. In general it is not always possible to have an analytical expression of the function (which is abstract), direct search methods are effective heuristics in deterministic applications especially when derivatives are unavailable and they have been targeted as primary choice for the development of our new tool.

In the group of direct-search methods, the most popular one is called Nelder-Mead algorithm. The algorithm uses a regular simplex, which is a polytope in n-dimensional space with n + 1 vertices, each of which is connected to all other vertices (e.g. a triangle in 2D, a tetrahedron in 3D). In order to perform an optimization, the algorithm begins with the function's values on a set of n + 1 points in the parameter space of n variables (simplex S) and it moves across the surface to be analyzed in the direction of steepest ascent (for maximization) or steepest descent (for minimization) by replacing the worst vertex in the simplex with a "mirror image" across the face formed by the remaining vertices. The algorithm, while running, can change in five different ways during an iteration.

Some modifications with respect to the original method have been adopted. The first important one was to add constraints with upper and lower bounds for all beam parameters x_i (0 ≤ x_i ≤ 1). This is an essential condition due to HN limits in the different devices (imposed by the power supplies' working range) and to SW limits given by different possible stable space-time profiles. As output limits, both operational efficiency and...