A review of the book "Optimal control and forecasting of complex dynamical systems" by Ilya Grigorenko, World Scientific, Hackensack, NJ, 2006.

The book describes some applications of optimal control and numerical optimization in quantum physics. The first three and the last chapters are introductory. Chapter 1 is a short survey on calculus of variations and optimal control theory, with a focus on the Euler-Lagrange equations and similar necessary first-order conditions for optimality of a control law. Chapter 2 mentions briefly some global optimization techniques to solve locally nonconvex problems with multiple extremas. Most of the emphasis is on genetic algorithms, and applications in quantum physics are described, such as finding the ground state wave functions of interacting particles. Chapter 3 is a short historical survey on chaotic dynamical systems. The author's preference goes to the Lorenz attractor (one of the simplest continuous-time nonlinear systems showing chaotic behavior), and its generalization to fractional derivatives. Finally, forecasting techniques (identification and filtering) are mentioned in the closing chapter 6.

Central chapters 4 and 5 are the technical core of the book. They describe extensively some applications of optimal control techniques to nanoscale quantum systems. Technological achievements now allow ultrashort laser pulses inducing chemical reactions. Pulse sequences with given optimal shape and phase can be designed to induce desired atomic wave packet dynamics, exploiting various interference effects. Generally, the underlying control problems amount to solving coupled nonlinear partial differential equations, for which numerical solutions can be devised sometimes. In Chapter 4, the author focuses however mostly on simplifying the problem settings so that analytical solutions can be derived. For example, for some quantum problems an explicit Euler-Lagrange ordinary differential equation can be obtained for the optimal control field. Using genetic algorithms, the author also shows how the decoherence process, induced by uncontrolled interactions with the environment, affects the optimal control field. In Chapter 5, applications to quantum computing are described, and it is shown that optimal control can be used to decrease significantly the number of errors due to quantum decoherence, hence improving the performance of basic quantum logical operations.

The book is clearly organized around the main chapters 4 and 5, where most of the concepts described in the introductory chapters 1,2,3 are used in the context of optimal control of quantum systems. The author's contribution to the field is assessed by several publications in key technical journals of physics (2000-2005) and I see these chapters as a collection of some of these results. If I enjoyed reading chapters 1,2,3 which can be viewed as informal introductive technical and historical surveys, I believe that chapters 4,5 are far too technical and too dense for a reader with no previous exposure to quantum systems control (like this reviewer).

In addition to this considerable material on quantum systems optimal control, the application of genetic algorithms for few-body quantum mechanics eigenproblems (in chapter 2) and the extension to fractional derivatives of the Lorenz attractor (in chapter 3) can be viewed as original results of independent interest, with mostly remote connection with the results of chapters 4 and 5. Similarly, the description of forecasting techniques in chapter 6 could be removed without harming too much the self-containment and consistency of the book.

In summary, the book describes a collection of strong technical results on quantum systems optimal control (chapters 4 and 5) but the accompanying introductory material (chapters 1, 2, 3 and 6), if interesting on its own, seems to be of little help to a reader who is not already familiar with the latest developments in quantum physics.

Didier Henrion, Prague, July 2007.