Learning the Nonlinear Dynamics of Cyberlearning

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Summary. The aim of this paper is to present a method to model the dynamics of a distance interactive learning process, so that the navigation through a course is achieved by optimal control techniques and the learner becomes proficient in the material in the least time possible, given his attitude, learning style, basic knowledge and propensities for study. A nonlinear dynamical system representation of the learning process, permits to enact optimal adaptive controls of the process at the general level, by defining a system which is controllable, observable and reachable in a technical sense, determined through a simultaneous estimation and optimization algorithm, which assures a correct representation.

1 Introduction

Learning is a dynamic process dependent on the quality of the teaching, the method and the instruments available. In Ancient Times, teaching was principally argumentative, in the form of a discussion, known as the Socratic method. As writing instruments were costly and not easily accessible, learning relied on memorization and teaching on Oratory. The same method lasted well into the era of printing and cheap paper (for instance, it is not known whether Galileo Galilei used the Socratic style in his major works to make his presentation didactic or to offend Pope Bonifacius VIII [11]). Eventually, the process was integrated with formal lectures and a blackboard. Many innovations have been tried, such as the Harvard case method, overhead projectors, teaching machines and projective teaching methods. In the ensuing discussion, none of the alternatives have been shown to be superior [1], because essentially, the underlying dynamic learning process is unobservable, in a technical sense, (given the history of the process, one can not determine the initial state of the process).

The process of e-Learning, that is interactive distance learning will depend on the quality of the teaching process, the method and the instruments used [21]. As such it defines a dynamic process which is affected by synergy [4].
Evidence suggests that learning is highly nonlinear with substantial lags and the learning dynamics form irreversible processes. Thus nonlinear dynamical modelling seems to be an appropriate representation of e-Learning knowledge acquisition process, since a linear dynamical system would be a too simple process [5].

A number of difficulties preclude identification and control by traditional methods for general nonlinear systems [12], so to avoid biases and suboptimization a simultaneous estimation and optimization method must be applied [9] [10].

The aim of this paper is to formulate a nonlinear dynamic system implementation of distance interactive learning through computer techniques (e-Learning), such that the underlying process is observable, identifiable, controllable and reachable, in a well defined technical sense. Further the system must satisfy the statistical properties for a maximum likelihood estimate. Adaptive optimal control trajectories will be formulated to guide the succession of learning frames to be studied.

The outline of the paper is the following. In the next section, the experimental set up to define an e-Learning optimal control process is described and the various aspects are examined. In the third section, the mathematical dynamic learning system is formalized and relevant mathematical properties indicated. In section four the implementation aspects of two cybercourses are discussed present on the World-Wide Web.

2 Knowledge Acquisition by e-Learning Dynamics

Distance Education is the delivery of education courses from one location to students at other locations [14], while Cyberschools are the institutions that deliver these courses, Cyberlearning is the process by which content is designed, transmitted and acquired.

The effect of Distance Education, depends on the content of what is taught and method by which it is imparted. Students have differing learning styles to acquire Knowledge, which depend on [1]:

- the method of exposition [13] :
  - a formal axiomatic or deductive exposition of the material,
  - an informal presentation, followed by its formalization,
  - an intuitive and illustrative development of the material,
- the structure of the presentation [21] :
  - a linear structure, as in a book,
  - a guided tree structure with a limited capacity of selection,
  - an adaptive feedback mechanism in a tree like decision network.
- the interaction policy envisaged [6] :
  - no interaction allowed,
  - periodical question periods,