THE NONLINEAR DYNAMIC THEORY OF LEARNING pdf

1: Linear and non-linear learning - Ken Carroll

Learning Nonlinear Dynamic Models of certain hidden Markov models can be achieved in polynomial time (Hsu et al.,). Moreover, for lin-ear models, the posterior update rule is quite simple.

The PIs are studying a new approach to learning from data that formulates learning as a weakly chaotic nonlinear dynamical system. They show that this dynamical system, which they call? They study the abstract mathematical properties of this nonlinear mapping, such as the properties of its attractor set and the topological and metric entropy of the mapping. They then relate these to properties of learning systems. The PIs apply herding systems to a wide range of applications in machine learning. In supervised learning they show that herding suggests a natural extension to the? In unsupervised learning, herding is used to train Markov random field models from data. Herding is also extended to Hilbert spaces where it naturally leads to a deterministic sampling algorithm. Due to negative autocorrelations, this? They also apply herding to active learning problems. Herding has the potential to radically transform the way we view learning systems. It connects learning to the vast field of nonlinear dynamical systems and chaos theory. As such the impact on machine learning is significant. Scientific results will be disseminated through journal publications and conference proceedings. The PIs also introduce a new course on learning, chaos and fractals to expose students to the intriguing connections between these fields. When clicking on a Digital Object Identifier DOI number, you will be taken to an external site maintained by the publisher. Some full text articles may not yet be available without a charge during the embargo administrative interval. Some links on this page may take you to non-federal websites. Their policies may differ from this site. Van Der Maaten, Y.

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2: Dynamics of Nonlinear Systems | Electrical Engineering and Computer Science | MIT OpenCourseWare

exhibit highly nonlinear learning dynamics, and these dynamics change with increasing depth. Indeed, the training error, as a function of the network weights, is non-convex, and gradient descent dynamics on this.

If you look closely you will see the ethos of the factory: The textbooks, the curricula, the classrooms, and the schedules we follow. These are products of a 19th century factory model. To this day, the bell rings and we take our places for 45 mins of instruction in neat rows. The delivery model is that of the conveyor-belt. If the system is to work as a whole, the content has to be delivered in a very particular way: It has to be delivered in a linear format. Textbook example You can see the linear format at work in textbooks that stagger information: Almost all textbooks are designed, literally, along such lines. Let me give you an example from English language textbooks. For decades, they have traditionally begun with present tense or aspect verbs and usually with the 3rd person. He goes, and she eats, etc. From there, the books invariably proceed to simple past tense, then past continuous, and then on to the perfect aspect, and so on. This is the order in which most newcomers to English meet the language. Linear is arbitrary The striking thing about the linear approach is how arbitrary it is. The linear sequence is arbitrary. Again, this is the direct opposite of what textbook order suggests. Expediency The textbook sequence of items exists for reasons other than a natural order of learning. That is problematic, to say the least. Non-linear learning So, what is non-linear learning? On one level, non-linear learning is the way that we naturally learned for a couple of hundred thousand years. It was all very subjective and individual and not linear. In real life, children learn their mother tongue through random exposure. They make sense of the language by identifying patterns and they connect and store the patterns that work. Yet we all end up fluent in our native language. Learning in the natural environment was not linear. There is a level on which it was actually quite random. Networks, not lines If anything, non-linear learning has more to do with a network than a line. The web, like the brain, is all about links and nodes. Networks are everywhere and, as J ay Cross persuasively argues, they are changing everything, including how we learn. The last time that happened we had the Enlightenment on our hands. The problem with the a to z books on writing is that they suppress all context. Which means that each learner is forced to follow the book and jump through the same hoops, regardless of different needs. As a learner, it means that the content has nothing to do with your life, your experience, or with anything you might actually want to learn. The effect is one-size-fits-nobody. With enough skill in place to be able to make judgment calls, the learner is then encouraged to close read her own writing and find the gaps. The task then becomes to find out how acknowledged writers from Gladwell to Chekov solve his problems and learn from there. This approach subjective, connectivist , and non-linear. For more on the writing techniques go here.

3: Dynamical systems theory - Wikipedia

What is linear learning? Some aspects of our educational system reflect its machine-age origins. If you look closely you will see the ethos of the factory: The textbooks, the curricula, the classrooms, and the schedules we follow.

Is the Alpha model a linear model? Its output, the plot of its behavior over time Figure 1 above is not a straight line. No, what makes a dynamic system nonlinear Not whether its behavior is nonlinear. And y is a nonlinear function of x if x is multiplied by another non-constant variable or by itself that is, raised to some power. We illustrate nonlinear systems using The Logistic Difference Equation, or Logistic Map, though simple, displays the major chaotic concepts. Growth model We start, generally, with a model of growth. If r is larger than one, x gets larger with successive iterations If r is less than one, x diminishes. In the "Alice" example at the beginning, r is. So years 2, 3, 4, 5, Our population is growing exponentially. By year 25 we have over a quarter million. Limited Growth model - Logistic Map. The Logistic Map prevents unlimited growth by inhibiting growth whenever it achieves a high level. This is achieved with an additional term, [1 - x n]. The growth measure x is also rescaled so that the maximum value x can achieve is transformed to 1. So if the maximum size is 25 million, say, x is expressed as a proportion of that maximum. Limited growth Verhulst model. We have to iterate this function to see how it will behave Along the way we see very different results, revealing and introducing major features of a chaotic system. The same fates awaits any starting value. So long as r is less than 1, x goes toward 0. This illustrates a one-point attractor. Now, regardless, of the starting value, we have non-zero one-point attractors. We have a two-point attractor. Four-point attractor Another bifurcation. So, what is an attractor? Whatever the system "settles down to". Here is a very important concept from nonlinear dynamics: A system eventually "settles down". Bifurcation Diagram So, again, what is a bifurcation? A bifucation is a period-doubling, a change from an N-point attractor to a 2N-point attractor, which occurs when the control parameter is changed. A Bifurcation Diagram is a visual summary of the succession of period-doubling produced as r increases. The next figure shows the bifurcation diagram of the logistic map, r along the x-axis. For each value of r the system is first allowed to settle down and then the successive values of x are plotted for a few hundred iterations. Bifurcation Diagram r between 0 and 4 We see that for r less than one, all the points are plotted at zero. Zero is the one point attractor for r less than one. However, the system is not chaotic for all values of r greater than 3. Bifurcation Diagram r between 3. In fact, between 3. A small change in r can make a stable system chaotic, and vice versa.

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4: Functionally defined Nonlinear Dynamic Models Â« Machine Learning (Theory)

Learning Nonlinear Dynamic Models from Non-sequenced Data 2 Learning linear dynamical systems from non-sequenced data (Huang & Schneider,) ï¬•rst proposed and stud-.

Examples include the mathematical models that describe the swinging of a clock pendulum, the flow of water in a pipe, and the number of fish each spring in a lake. A dynamical system has a state determined by a collection of real numbers , or more generally by a set of points in an appropriate state space. Small changes in the state of the system correspond to small changes in the numbers. The numbers are also the coordinates of a geometrical spaceâ€"a manifold. The evolution rule of the dynamical system is a fixed rule that describes what future states follow from the current state. The rule may be deterministic for a given time interval only one future state follows from the current state or stochastic the evolution of the state is subject to random shocks. Dynamicism[edit] Dynamicism , also termed the dynamic hypothesis or the dynamic hypothesis in cognitive science or dynamic cognition, is a new approach in cognitive science exemplified by the work of philosopher Tim van Gelder. It argues that differential equations are more suited to modelling cognition than more traditional computer models. Nonlinear system In mathematics , a nonlinear system is a system that is not linear â€"i. A nonhomogeneous system, which is linear apart from the presence of a function of the independent variables , is nonlinear according to a strict definition, but such systems are usually studied alongside linear systems, because they can be transformed to a linear system as long as a particular solution is known. Arithmetic dynamics[edit] Arithmetic dynamics is a field that emerged in the s that amalgamates two areas of mathematics, dynamical systems and number theory. Classically, discrete dynamics refers to the study of the iteration of self-maps of the complex plane or real line. Chaos theory[edit] Chaos theory describes the behavior of certain dynamical systems â€" that is, systems whose state evolves with time â€" that may exhibit dynamics that are highly sensitive to initial conditions popularly referred to as the butterfly effect. As a result of this sensitivity, which manifests itself as an exponential growth of perturbations in the initial conditions, the behavior of chaotic systems appears random. This happens even though these systems are deterministic , meaning that their future dynamics are fully defined by their initial conditions, with no random elements involved. This behavior is known as deterministic chaos, or simply chaos. Complex systems[edit] Complex systems is a scientific field that studies the common properties of systems considered complex in nature , society , and science. The key problems of such systems are difficulties with their formal modeling and simulation. From such perspective, in different research contexts complex systems are defined on the base of their different attributes. The study of complex systems is bringing new vitality to many areas of science where a more typical reductionist strategy has fallen short. Complex systems is therefore often used as a broad term encompassing a research approach to problems in many diverse disciplines including neurosciences , social sciences , meteorology , chemistry , physics , computer science , psychology , artificial life , evolutionary computation , economics , earthquake prediction, molecular biology and inquiries into the nature of living cells themselves. Control theory[edit] Control theory is an interdisciplinary branch of engineering and mathematics , that deals with influencing the behavior of dynamical systems. Ergodic theory[edit] Ergodic theory is a branch of mathematics that studies dynamical systems with an invariant measure and related problems. Its initial development was motivated by problems of statistical physics. Functional analysis[edit] Functional analysis is the branch of mathematics , and specifically of analysis , concerned with the study of vector spaces and operators acting upon them. It has its historical roots in the study of functional spaces , in particular transformations of functions , such as the Fourier transform , as well as in the study of differential and integral equations. This usage of the word functional goes back to the calculus of variations , implying a function whose argument is a function. Its use in general has been attributed to mathematician and physicist Vito Volterra and its founding is largely attributed to mathematician Stefan Banach. Graph dynamical systems[edit] The concept of graph dynamical systems GDS can be used to capture a wide range of processes taking place on graphs or networks. A major theme in the mathematical and computational analysis of graph dynamical systems is to relate their structural properties e. Projected dynamical systems[edit

] Projected dynamical systems is a mathematical theory investigating the behaviour of dynamical systems where solutions are restricted to a constraint set. The discipline shares connections to and applications with both the static world of optimization and equilibrium problems and the dynamical world of ordinary differential equations. A projected dynamical system is given by the flow to the projected differential equation. Symbolic dynamics[edit] Symbolic dynamics is the practice of modelling a topological or smooth dynamical system by a discrete space consisting of infinite sequences of abstract symbols, each of which corresponds to a state of the system, with the dynamics evolution given by the shift operator. System dynamics[edit] System dynamics is an approach to understanding the behaviour of systems over time. It deals with internal feedback loops and time delays that affect the behaviour and state of the entire system. These elements help describe how even seemingly simple systems display baffling nonlinearity. Topological dynamics[edit] Topological dynamics is a branch of the theory of dynamical systems in which qualitative, asymptotic properties of dynamical systems are studied from the viewpoint of general topology. In biomechanics[edit] In sports biomechanics , dynamical systems theory has emerged in the movement sciences as a viable framework for modeling athletic performance. From a dynamical systems perspective, the human movement system is a highly intricate network of co-dependent sub-systems e. In dynamical systems theory, movement patterns emerge through generic processes of self-organization found in physical and biological systems. In cognitive science[edit] Dynamical system theory has been applied in the field of neuroscience and cognitive development , especially in the neo-Piagetian theories of cognitive development. It is the belief that cognitive development is best represented by physical theories rather than theories based on syntax and AI. It also believed that differential equations are the most appropriate tool for modeling human behavior. In other words, dynamicists argue that psychology should be or is the description via differential equations of the cognitions and behaviors of an agent under certain environmental and internal pressures. The language of chaos theory is also frequently adopted. This is the phase transition of cognitive development. Self-organization the spontaneous creation of coherent forms sets in as activity levels link to each other. Newly formed macroscopic and microscopic structures support each other, speeding up the process. These links form the structure of a new state of order in the mind through a process called scalloping the repeated building up and collapsing of complex performance. This new, novel state is progressive, discrete, idiosyncratic and unpredictable. Dynamic approach to second language development The application of Dynamic Systems Theory to study second language acquisition is attributed to Diane Larsen-Freeman who published an article in in which she claimed that second language acquisition should be viewed as a developmental process which includes language attrition as well as language acquisition.

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5: Dynamical system - Wikipedia

Learning a sports skill is a complex process in which practitioners are challenged to cater for individual differences. The main purpose of this study was to explore the effectiveness of a Nonlinear Pedagogy approach for learning a sports skill. Twenty-four year-old females participated in a 4.

Overview[edit] The concept of a dynamical system has its origins in Newtonian mechanics. There, as in other natural sciences and engineering disciplines, the evolution rule of dynamical systems is an implicit relation that gives the state of the system for only a short time into the future. The relation is either a differential equation , difference equation or other time scale. To determine the state for all future times requires iterating the relation many timesâ€"each advancing time a small step. The iteration procedure is referred to as solving the system or integrating the system. If the system can be solved, given an initial point it is possible to determine all its future positions, a collection of points known as a trajectory or orbit. Before the advent of computers , finding an orbit required sophisticated mathematical techniques and could be accomplished only for a small class of dynamical systems. Numerical methods implemented on electronic computing machines have simplified the task of determining the orbits of a dynamical system. For simple dynamical systems, knowing the trajectory is often sufficient, but most dynamical systems are too complicated to be understood in terms of individual trajectories. The difficulties arise because: The systems studied may only be known approximatelyâ€"the parameters of the system may not be known precisely or terms may be missing from the equations. The approximations used bring into question the validity or relevance of numerical solutions. To address these questions several notions of stability have been introduced in the study of dynamical systems, such as Lyapunov stability or structural stability. The stability of the dynamical system implies that there is a class of models or initial conditions for which the trajectories would be equivalent. The operation for comparing orbits to establish their equivalence changes with the different notions of stability. The type of trajectory may be more important than one particular trajectory. Some trajectories may be periodic, whereas others may wander through many different states of the system. Applications often require enumerating these classes or maintaining the system within one class. Classifying all possible trajectories has led to the qualitative study of dynamical systems, that is, properties that do not change under coordinate changes. Linear dynamical systems and systems that have two numbers describing a state are examples of dynamical systems where the possible classes of orbits are understood. The behavior of trajectories as a function of a parameter may be what is needed for an application. As a parameter is varied, the dynamical systems may have bifurcation points where the qualitative behavior of the dynamical system changes. For example, it may go from having only periodic motions to apparently erratic behavior, as in the transition to turbulence of a fluid. The trajectories of the system may appear erratic, as if random. In these cases it may be necessary to compute averages using one very long trajectory or many different trajectories. The averages are well defined for ergodic systems and a more detailed understanding has been worked out for hyperbolic systems. Understanding the probabilistic aspects of dynamical systems has helped establish the foundations of statistical mechanics and of chaos. In them, he successfully applied the results of their research to the problem of the motion of three bodies and studied in detail the behavior of solutions frequency, stability, asymptotic, and so on. Aleksandr Lyapunov developed many important approximation methods. His methods, which he developed in , make it possible to define the stability of sets of ordinary differential equations. He created the modern theory of the stability of a dynamic system. Combining insights from physics on the ergodic hypothesis with measure theory , this theorem solved, at least in principle, a fundamental problem of statistical mechanics. The ergodic theorem has also had repercussions for dynamics. Stephen Smale made significant advances as well. His first contribution is the Smale horseshoe that jumpstarted significant research in dynamical systems. He also outlined a research program carried out by many others. The notion of smoothness changes with applications and the type of manifold. When T is taken to be the reals, the dynamical system is called a flow ; and if T is restricted to the non-negative reals, then the dynamical system is a semi-flow. When T is taken to be the integers, it is a cascade or a map; and the restriction to the non-negative integers is a semi-cascade.

6: SCTPLS Basic Workshop

The idea will be to cast various methods of nonlinear dynamic analysis into a unified machine learning framework based on optimisation; preliminary work showing that normal form analysis is accommodated by the proposed framework has been presented in.

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