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the critical dynamics of neural networks have been studied most extensively in the context of a model proposed by bak, tang and wiesenfeld (bak, tang and wiesenfeld, 1988) called the btw model. in their model, a sandpile is constructed from an initial set of particles and the dynamics of the sandpile is studied by adding particles to the sandpile, or removing particles from the sandpile, and measuring how the sandpile evolves. the btw model is scale free because the rate of avalanche growth and the distribution of avalanche sizes are power law functions of the size of the avalanche [3]. the btw model, and the scaling exponents which describe the avalanche growth and size distribution, are fully characterised by a single, critical parameter, the sandpile density, d. the btw model has been shown to describe the dynamics of both natural and man-made avalanches in a variety of different contexts, including the propagation of forest fires, rainstorms and earthquakes. a variant of the btw model can be used to study the dynamics of structural instabilities in two and three dimensions, which have been proposed as candidates for the mechanism by which information is stored in the brain [4]. one form of criticality can be found in natural processes such as natural or human-made avalanches, as opposed to man-made avalanches. nature provides no constraints on the form of the initial perturbation, and as a result, the initial perturbation is usually distributed randomly and the characteristics of the perturbation are not well defined. the characteristics of natural avalanches are well defined. in nature, we are always dealing with the extreme case of a perturbation of maximum size that may evolve as a power law in time, or the extreme case of a perturbation of minimum size that may evolve as a power law in time. a self-organized critical system can be thought of as a system which has a critical, power law distribution of perturbations that lead to a critical, power law distribution of avalanches. a critical, self-organized system is typically scale free, so the growth of avalanches in a critical, self-organized system will be a power law. this power law growth is not easy to study because in order to detect the power law behaviour, one must look at a very large number of avalanches. this is because avalanches of all sizes will tend to follow a power law distribution, and as the system approaches criticality, avalanches are large. in order to study the dynamics of criticality, one must study avalanches of all sizes, and that is what this book does. one of the main aims of this book is to help readers understand how to derive the power law behaviour of the btw model and the scaling exponents associated with the btw model in the presence of constraints on the initial perturbation and in the presence of constraints on the dynamic growth of the perturbation. the book includes the derivation of the scaling exponents of the btw model and the derivation of the scaling exponents in a wide variety of other systems. the book also includes the derivation of the scaling exponents in the presence of constraints on the initial perturbation, and the derivation of the scaling exponents in the presence of constraints on the dynamic growth of the perturbation. the book contains the derivation of the scaling exponents in the presence of constraints on the initial perturbation, and the derivation of the scaling exponents in the presence of constraints on the dynamic growth of the perturbation.

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book won the 2009 american society for engineering education award for outstanding books from the society for engineering education and the american society of engineering education for outstanding achievement in engineering education, and it was listed for its first title as a "notable engineering book" by the most engineering problems are impossible to solve directly, so that the solution must be encoded in a model and then revealed from the problem statement. in the 1960s this process was formalized and gave rise to a new domain called model-based design. a key component of model-based design is the machine learning paradigm. in this report we make the case that approaches based on machine learning and neural networks are intrinsically model-based in nature. but we also show that there are several ways in which the problems inherent in model-based design are avoided and the domain of machine learning extended. firstly, in model-based design the model is explicit. in contrast, in machine learning the learning algorithm is implicit. secondly, model-based design is represented by mathematics whereas machine learning is expressed in code and an algorithm. similarities between human cognition and machine learning have been pointed out since the 1940s (minsky & papert, 1991) and the idea of a learning machine was first proposed in the 1960s (hayes & hayes, 1968). unlike early machine learning which was based on data fitting, modern machine learning has become increasingly concerned with issues such as learning, generalization and explanation (schölkopf & müller, 2001). for example, "reinforcement" learning has been applied to problems in artificial neural networks with highly abstract learning algorithms. 5ec8ef588b