Cellular Automata: Simulations Using Matlab

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Abstract—This paper presents a series of implementations of cellular automata rules using the Matlab programming environment. A cellular automaton is a decentralized computing model providing an excellent platform for performing complex computations with the help of only local information. Matlab is a numerical interactive computing environment and a high-level language with users coming from various backgrounds of engineering, science, and economics that enables performing computationally intensive tasks faster than with traditional programming languages (such as C, C++, and Fortran. Our objective has been to investigate and exploit the potential of Matlab, which is simple mathematical programming environment that does not require specific programming skills, regarding the understanding and the efficient simulation of complex patterns, arising in nature and across several scientific fields, captured by simple cellular automata structures. We have implemented several cellular automata rules from the recent literature; herein we present indicative cases of practical interest: the forest fire probabilistic rule, the sand pile rule, the ant rule, the traffic jam rule as well as the well-known "Game of Life". Our work indicates that Matlab is indeed an appropriate environment for developing simulations for cellular automata models.

Keywords-cellular automata; simulations; Matlab.

I. CELLULAR AUTOMATA

A cellular automaton (CA) is an idealization of a physical system in which space and time are discrete and the physical quantities take only a finite set of values. Informally, a cellular automaton is a lattice of cells, each of which may be in a predetermined number of discrete states (a formal definition can be found in [7]). A neighborhood relation is defined over this lattice, indicating for each cell which cells are considered to be its neighbors during state updates. Time is also discrete; in each time step, every cell updates its state using a transition rule that takes as input the states of all cells in its neighborhood (which usually includes the cell itself). All cells in the cellular automaton are synchronously updated. At time t = 0 the initial state of the cellular automaton must be defined; then repeated synchronous application of the transition function to all cells in the lattice will lead to the deterministic evolution of the cellular automaton over time. Many variations of this basic model exist. CA can be of arbitrary dimension, although one-dimensional and two-dimensional CA have received special attention in the literature. CA can be infinite or finite. Finite CA can have periodic boundaries (e.g., the opposite ends of a one-dimensional finite CA are joined together so the whole forms a ring). Updates can be synchronous or asynchronous. Transition rules can be deterministic or stochastic. Many other variations exist; those mentioned above are some of the most typical ones.

The concept of cellular automata was initiated in the early 1950's by John Von Neumann and Stan Ulam [18]. Von Neumann was interested in their use for modelling self-reproduction and showed that a CA can be universal. He devised a CA, each cell of which has a state space of 29 states, and showed that it can execute any computable operation. However, Von Neumann rules, due to their complexity, were never implemented on a computer. Von Neumann's research raised a dichotomy in CA research. On one hand, it was proven that a decentralized machine can be designed to simulate any arbitrary function. On the other hand, this machine (CA) can become as complex as the function it is intended to simulate.

Cellular automata have received extensive academic study into their fundamental characteristics and capabilities and have been applied successfully to the modelling of natural phenomena and complex systems [1], [3], [4], [13], [17], [24], [23]. Based on the theoretical concept of universality, researchers have tried to develop simpler and more practical architectures of CA that can be used to model widely divergent application areas. In the 1970, the mathematician John Conway proposed the (now famous) Game of Life [10], which received widespread interest among researchers. Since the beginning of the 80's, Stephen Wolfram has studied in much detail a family of simple one-dimensional cellular automata rules (known as Wolfram rules [24]) and has showed that even these simplest rules are capable of emulating complex behavior. Other applications include, but are not limited to, theoretical biology [2], game theory [19], and non-equilibrium thermodynamics [15].

The rest of the paper is structured as follows: Section II includes a brief description of Matlab as well as main reasons that motivated us for using it in our simulations. Simulations are presented in Section III. Section IV includes conclusions and plans for future work on cellular automata simulations using Matlab.

Cellular Automata Simulations Using Matlab

Lingjun Ying

Cellular Automata Simulations Using Matlab:

Digital Human Modeling: Applications in Health, Safety, Ergonomics and Risk Management Vincent G. Duffy,2016-07-04 This book constitutes the refereed proceedings of the 7th International Conference on Digital Human Modelling Applications in Health Safety Ergonomics and Risk Management DHM 2016 held as part of the 18th International Conference on Human Computer Interaction HCII 2016 held in Toronto ON Canada in July 2016 and received a total of 4354 submissions of which 1287 papers were accepted for publication after a careful reviewing process These papers address the latest research and development efforts and highlight the human aspects of design and use of computing systems The papers accepted for presentation thoroughly cover the entire field of human computer interaction addressing major advances in knowledge and effective use of computers in a variety of application areas This volume contains papers addressing the following major topics anthropometry ergonomics design and comfort physiology and anatomy models motion prediction and recognition quality and safety in healthcare design for health work design and support modeling human behavior and cognition *Intelligent Systems* Cornelius T. Leondes,2018-10-08 Intelligent systems or artificial intelligence technologies are playing an increasing role in areas ranging from medicine to the major manufacturing industries to financial markets The consequences of flawed artificial intelligence systems are equally wide ranging and can be seen for example in the programmed trading driven stock market crash of October 19 1987 Intelligent Systems Technology and Applications Six Volume Set connects theory with proven practical applications to provide broad multidisciplinary coverage in a single resource In these volumes international experts present case study examples of successful practical techniques and solutions for diverse applications ranging from robotic systems to speech and signal processing database management and manufacturing *Future Information Technology, Application, and Service* James (Jong Hyuk) Park,Victor C.M. Leung,Cho-Li Wang,Taeshik Shon,2012-06-05 This book is proceedings of the 7th FTRA International Conference on Future Information Technology FutureTech 2012 The topics of FutureTech 2012 cover the current hot topics satisfying the world wide ever changing needs The FutureTech 2012 is intended to foster the dissemination of state of the art research in all future IT areas including their models services and novel applications associated with their utilization The FutureTech 2012 will provide an opportunity for academic and industry professionals to discuss the latest issues and progress in this area In addition the conference will publish high quality papers which are closely related to the various theories modeling and practical applications in many types of future technology The main scope of FutureTech 2012 is as follows Hybrid Information Technology Cloud and Cluster Computing Ubiquitous Networks and Wireless Communications Multimedia Convergence Intelligent and Pervasive Applications Security and Trust Computing IT Management and Service Bioinformatics and Bio Inspired Computing Database and Data Mining Knowledge System and Intelligent Agent Human centric Computing and Social Networks The FutureTech is a major forum for scientists engineers and practitioners

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models of equipment service and control The authors suggest applying numerical methods for analysis of super large failure trees having large amount of multiple vertices The methods allow finding minimal sections and reducing the amount of time necessary for such calculations The Bayesians theory is applied under conditions of uncertainty The methods of finding robust parameter estimates for the most commonly used classes of a priori distribution functions are suggested As an alternative approach to stochastic methods the authors propose the algorithums of critical stats estimation for the reactor s active zone that utilise the theory of fuzzy logic   *Proceedings of the ... IEEE Conference on Nanotechnology* ,2004

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