The many facets of Natural Computing

Lila Kari and Grzerog Rozemberg

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General Subject

Natural computing introduction for Computer Scientists

Specific Subjects

Describes fields in which the natural phenomena is abstracted to solve human problems. Where these methods can be implemented. And looks to understand understand biology as information processing.

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New areas: - Swarm intelligence

- Artificial immune systems
- Artificial life
- Membrane computing
- Amorphous computing

What we know about computation can change by taking a look at nature information processing.

Key points

Neural Netorks

Three important features of neural networks are: function of each neuron, the topology of the network, the learning algorithm to change the weights

Backward propagation[k]

Evolutionary Algorithms

Evolutionary algorithms gained momentum on 60ties. Good for real valued, discrete and mixed types of parameters.

Genethic Algorithms

Genetic algorithms use strings to represent the genetic material.

Good for real-valued parameters, combinatorial tasks.

Swarm Algorithms

The velocity of the particle in a swarm algorithm depends on it's previous velocity (inertia). There's a good balance between global best and local best.

Applied on unsupervised learning, game learning, scheduling and planning applications, and design applications.

Ant algorithms have been used to solve combinatorial optimizations defined over discrete search spaces.

Artificial Immune systems

Artificial immune systems uses learning, memory, associative retrieval to solve recognition and classification problems. Often called second brain.

Parts of the immune system: innate (non-specific) and adaptive (acquired).

Used in computer virus detection, anomaly detection, fault diagnosis, pattern recognition, machine learning, bioinformatics, optimizations, robotics and control.

Artificial Life

Artificial systems try to imitate the whole "living organism". Lindenmayer systems (L-systems) 1968, are the first research in artificial life. Used in model plant growth and development and modeling the morphology of other organisms.

Evolving virtual blocks creatures (36), selected for their ability to swim.

Membrane Computing

Membrane computing studies the compartmentalized internal structures effected by membranes. Uses include computer graphics, public-key encryption, approximation and sorting algorithms, linguistics.

Amorphous Computing

Amorphous programming has been used as a computing paradigm. The goal is to engineer specific different types of hardware. There's only local communication.

Hamiltoninan path problem == "caixeiro viajante" was solved by dna strands using "amorphous" concepts.

20 variables instance of the 3 satisfiability problem we're already solved through use of DNA manipulation.

Quantum computing

Feynman first suggested a quantum computer in 1982. A qubit can hold 0 or 1 or a quantum superposition of these. A quantum computer operates by manipulating those qubits with quantum logic gates.

144km experiment of quantum criptography on Cannary islands

Shors quantum algorithms quantum teleportation transports quantum states (not energy or matter) to an arbitrary location.

Quantum algorithms where shown to have a quadratic time advantage when compared to classical algorithms by Grovers.

Biological Systems

Systems biology focus on the interactions between biological networks. Has focused on DNA, RNA, proteins, lipids, carbohydrates and their building blocks.

khon maps are a step forward in the creation of a programming language to describe biology. These maps are a graphical notation of molecular interactions. The mantra of synthetic biology is that one can understand only what one can build.

In 1960 Jacob and Monad discovered mathematical logic in gene regulation.

People already generated the synthetic genome of a virus in 14 days by synthesized short DNA strands.

The ciliates micro and macro nuclei combination for self assembly is another promissory field.

Conclusion

Zuse and Fredkin in 1960 says that information is more fundamental than matter or energy.

Thanks