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ThinkFinity Grant

Informatics and Natural Computation: Progress Report

Francis T. Marchese
Seidenberg School
8/9/2009

Introduction

The purpose of this grant is to develop an interdisciplinary course in Informatics and Natural Computation that would service undergraduate computer, natural, and physical science majors. Informatics is the science of information, the practice of information processing, and the engineering of information systems. Informatics studies the structure, algorithms, behavior, and interactions of *natural* and artificial systems that store, process, access and communicate information. *Natural* computing refers to a collection of disciplines that unite nature with computing in three distinct ways:

1. Nature serves as a source of inspiration for the development of computational tools or systems that are used for solving complex problems.
2. Computers are used as a means of synthesizing the structural patterns and behaviors of natural phenomena.
3. Natural materials such as those molecules found in nature (e.g. DNA) or those designed by humans (e.g. nanotechnology) are employed as the computers.

The logical intersection point between natural computing and the sciences is in the field of bioinformatics, a growing interdisciplinary scientific area aimed at analyzing, interpreting, and managing information from biological data, sequences, and structures. By employing natural computing methods, it is possible to solve bioinformatics problems in classification, clustering, feature selection, data visualization, and data mining.

Project Specifications

There are three parts to this project:

1. Develop an upper-level undergraduate interdisciplinary course in Informatics and Natural Computation.
2. Develop a set of experiences in the planning, executing, writing up, and critical evaluation of research in informatics and natural computation.
3. Develop a research agenda that may be integrated into the course. Specifically, design a set of evolving research projects that students may work on as part of the course and may be extended beyond the course.

Timeline and Progress to Date

The project has been placed on the following schedule:

Summer 2009	Select topics for course and assemble an initial bibliography
Fall 2009	Develop initial set of lectures
Spring and Summer 2010	Refine lectures, create exercises and experiments, and assemble an initial research perspective.
Spring 2011	Offer course.

The schedule has been met for summer 2009. An initial topics list and bibliography are attached. Richard Schlesinger has been contacted, as per the grant review committee's request, and the attached document will be used for discussions about the course and refinements in its content and structure.

My current schedule has spring 2011 as the time period for the first course offering. The reason this is so is that I have scheduled an interdisciplinary course entitled Visual Thinking for fall 2010 that is being developed and co-taught with Professor Jillian Mcdonald of the Department of Fine Arts. This course is new as well, and will be offered in fall 2010 for the first time.

Informatics and Natural Computation: Topic List

F.T. Marchese
8/9/2009

INTRODUCTION

Philosophy of Natural Computing
General Concepts

COMPUTING INSPIRED BY NATURE

Evolutionary Computing

Scope of Evolutionary Computing
Problem Solving as a Search Task
Hill Climbing and Simulated Annealing
Evolutionary Biology
Evolutionary Computing
From Evolutionary Biology to Computing

Neurocomputing

Scope of Neurocomputing
The Nervous System
Artificial Neural Networks (ANN)
Typical ANNS and Learning Algorithms
From Natural to Artificial Neural Networks

Swarm Intelligence

Ant Colonies
Swarm Robotics
Social Adaptation of Knowledge

Immunocomputing

Scope of Artificial Immune Systems
The Immune System
Artificial Immune Systems
Artificial Immune Networks
From Natural to Artificial Immune Systems

COMPUTER SIMULATION AND EMULATION OF NATURAL PHENOMENA

Fractal Geometry of Nature

Cellular Automata
L-Systems
Iterated Function Systems
Fractional Brownian motion
Particle Systems
Evolving the Geometry of Nature
From Natural to Fractal Geometry

Artificial Life
Scope of Artificial Life
Concepts and Features of Artificial Life Systems
Examples of Artificial Life Projects
From Artificial Life to Life-As-We-Know-It

COMPUTING WITH NATURAL MATERIALS

DNA Computing
Scope of DNA Computing
Basic Concepts from Molecular Biology
Formal Models: A Brief Description
Universal DNA Computers
From Classical to DNA Computing

Quantum Computing
Scope of Quantum Computing
Basic Concepts from Quantum Theory
Principles from Quantum Mechanics
Quantum Information
Universal Quantum Computers
Quantum Algorithms
Physical Realizations of Quantum Computers
From Classical to Quantum Computing

THE FUTURE
New Prospects
The Growth of Natural Computing
Some Lessons from Natural Computing
Artificial Intelligence and Natural Computing

Informatics and Natural Computation: Bibliography

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