

Nature-Inspired Computing

Introduction to Course Topics

Dr. Şima Uyar

September 2006

Contents of Course

1 Introduction

- Nature-Inspired Computing
- Optimization and Decision Support Techniques

2 NIC Approaches

- Evolutionary Algorithms
- Swarm Intelligence
- Others

3 Evaluation Techniques

- Benchmarks and Testing
- Evaluation Criteria
- Output Analysis

4 References on Topic

- Books
- Journals and Major Conferences
- Web Sites

Contents of Course

1 Introduction

- Nature-Inspired Computing
- Optimization and Decision Support Techniques

2 NIC Approaches

- Evolutionary Algorithms
- Swarm Intelligence
- Others

3 Evaluation Techniques

- Benchmarks and Testing
- Evaluation Criteria
- Output Analysis

4 References on Topic

- Books
- Journals and Major Conferences
- Web Sites

Synonyms to NIC

- Nature-Inspired Computing
- Natural Computing
- Biologically-Inspired Computing
- Bio-Inspired Computing
- ...

What is NIC?

Definition

computing approaches

- inspired from nature
- constructed by using biological materials
- modeled on natural processes

Which Techniques?

- artificial neural networks (ANN)
- evolutionary algorithms (EA)
- swarm intelligence (SI)
 - ant colony optimization (ACO)
 - particle swarm optimization (PSO)
- artificial immune systems (AIS)
- cellular automata
- artificial life (ALife)
- DNA computing
- quantum computing
- ...

Contents of Course

1 Introduction

- Nature-Inspired Computing
- Optimization and Decision Support Techniques

2 NIC Approaches

- Evolutionary Algorithms
- Swarm Intelligence
- Others

3 Evaluation Techniques

- Benchmarks and Testing
- Evaluation Criteria
- Output Analysis

4 References on Topic

- Books
- Journals and Major Conferences
- Web Sites

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 **NIC Approaches**
 - **Evolutionary Algorithms**
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

What are EAs?

Definition

group of search and optimization techniques

- based on
 - Mendelian genetics
 - Darwinian theory of evolution
- which are
 - heuristic
 - stochastic
 - population-based

Which Techniques?

- genetic algorithms
- genetic programming
- evolutionary strategies
- differential evolution
- grammatical evolution
- memetic algorithms (evolutionary algorithms hybrid with e.g. hillclimbing)

Application Areas

- optimization
 - function / combinatorial
 - discrete / continuous
 - free / constraint / constrained
- scheduling
- design
- learning and prediction
- automated program development
- multi-criteria decision making
- evolvable hardware
- software / hardware testing
- embedded systems
- ...

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 **NIC Approaches**
 - Evolutionary Algorithms
 - **Swarm Intelligence**
 - Others
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

What is SI?

Definition

algorithms or distributed problem solving devices inspired by the collective behavior of social insect colonies and other animal societies [Bonabeau, Dorigo, Theraulaz, 1999]

Which Techniques?

- Ant Colony Optimization
- Particle Swarm Optimization

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 **NIC Approaches**
 - Evolutionary Algorithms
 - Swarm Intelligence
 - **Others**
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

- Artificial Immune Systems
- DNA Computing
- Artificial Life

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques**
 - Benchmarks and Testing**
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Benchmarks and Testing

- existing benchmark functions
- standard test problems
- existing data sets
 - real-world data
 - artificial data
- research on new benchmarking tools
- research on new artificial data generators

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques**
 - Benchmarks and Testing
 - Evaluation Criteria**
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Evaluation Criteria

- existing evaluation criteria to analyze different aspects of techniques
- research on new criteria

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques**
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis**
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Output Analysis

- NIC techniques are stochastic
→ statistical output analysis required

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Contents of Course

- 1 Introduction
 - Nature-Inspired Computing
 - Optimization and Decision Support Techniques
- 2 NIC Approaches
 - Evolutionary Algorithms
 - Swarm Intelligence
 - Others
- 3 Evaluation Techniques
 - Benchmarks and Testing
 - Evaluation Criteria
 - Output Analysis
- 4 References on Topic
 - Books
 - Journals and Major Conferences
 - Web Sites

Grading

- Midterm exam: 30%
- Term project: 30% (survey, program, presentation)
- Final Exam: 40%