CSCI 446 – ARTIFICIAL INTELLIGENCE
EXAM 1 STUDY OUTLINE

Introduction to Artificial Intelligence

I. Definitions of Artificial Intelligence
- A. Acting Like Humans -- Turing Test
- B. Thinking Like Humans -- Cognitive Modeling
- C. Thinking Rationally -- Logicist Approach
- D. Acting Rationally -- Rational Agents

II. Foundations of Artificial Intelligence
- A. Philosophy
- B. Mathematics
- C. Psychology
- D. Computer Engineering
- E. Linguistics

III. History of Artificial Intelligence
- A. Gestation
- B. Early Enthusiasm, Great Expectations
- C. Dose of Reality
- D. Knowledge Based Systems
- E. AI Becomes and Industry
- F. Return of Neural Networks
- G. Recent Events

Intelligent Agents

I. Agents and Environments
- A. Vacuum Cleaner World Environment

II. Rationality

III. PEAS – Performance Measure, Environment, Actuators, Sensors

IV. Environment Types
- A. Observable
- B. Deterministic vs. Stochastic
- C. Episodic vs. Sequential
- D. Static vs. Dynamic
- E. Discrete vs. Continuous
- F. Single Agent vs. Multi-Agent

V. Agent Types
- A. Simple Reflex Agents
- B. Reflex Agents with State
- C. Goal-Based Agents
- D. Utility Based Agents
- E. Learning Agents

State Spaces, Uninformed Search

I. Problem Formulation
    A. Problem Types
        1. Deterministic, fully observable: Single-State Problem
        2. Non-observable: Conformant Problem
        3. Nondeterministic and/or partially observable: Contingency Problem
        4. Unknown state space: Exploration Problem
    B. Single State Problem Formulation
        1. Initial State
        2. Successor Function
        3. Goal Test
        4. Path Cost
        5. Solution
II. State Space
III. Tree Search Algorithms
    A. General Tree Search
        1. Completeness
        2. Time Complexity
        3. Space Complexity
        4. Optimality
    B. Breadth First Search
    C. Uniform Cost Search
    D. Depth First Search
    E. Depth Limited Search
    F. Iterative Deepening Search
IV. Graph Search

Heuristic Search

I. Best-First Search
    A. Heuristic Function h(n)
II. A* Search
    A. Actual Cost to Current Node g(n)
III. Heuristics
    A. Admissible Heuristic
    B. Consistency or Monotonicity
    C. Dominance
    D. Relaxed Problems

Local Search

I. Hill Climbing
    A. Gradient Ascent or Descent
    B. Local Maxima
    C. Global Maximum
II. Simulated Annealing
III. Genetic Algorithms

Constraint Satisfaction Problems (CSPs)

I. Examples
II. Backtracking Search
    A. Order of Variable Assignment
        1. Degree Heuristic
    B. Order of Value Assignment
        1. Least Constraining Value Heuristic
    C. Early Detection of Inevitable Failure
        1. Forward Checking
        2. Arc Consistency
    D. Problem Structure
III. Problem Structure and Decomposition
IV. Local Search for CSPs

Games (Adversarial Search)

I. Overview
II. Minimax (Perfect Play)
III. α–β Pruning
IV. Nondeterministic Games
    A. Chance Nodes

Logical Agents

I. Knowledge Based Agents
    A. Knowledge Base
    B. Inference Engine
    C. Separation of Knowledge and Process
II. An Example
    A. Wumpus World
III. General Logic
    A. Entailment
    B. Models
    C. Inference
IV. Propositional Logic
    A. Syntax
    B. Truth Tables
V. Equivalence, Validity, Satisfiability
VI. Inference Rules / Theorem Proving
    A. Forward Chaining
    B. Backward Chaining
    C. Resolution
        1. Conjunctive Normal Form (CNF)
        2. Conversion to CNF
        3. Resolution

First Order Logic

I. Overview
II. Syntax and Semantics
    A. Basic Elements
    B. Atomic Sentences
    C. Complex Sentences
    D. Models
    E. Universal Quantification
    F. Existential Quantification
III. Fun with Sentences
    A. Equality

Inference in First Order Logic

I. Unification
    A. Universal Instantiation
    B. Existential Instantiation
    C. Reduction to Propositional Inference
    D. Unification
II. Generalized Modus Ponens
III. Forward and Backward Chaining
    A. Forward Chaining
    B. Backward Chaining
IV. Logic Programming
V. Resolution

Fuzzy Logic

I. Membership Functions
II. Linguistic Variables
III. Fuzzy Set Operations
IV. Fuzzy Inference
    A. Fuzzification
    B. Rule Inference
    C. Rule Composition
    D. Defuzzification

Planning

I. Search vs. Planning
    A. Actions, States, Goals, Plans
    B. Situational Calculus
II. STRIPS Operators
    A. Initial and Final States
    B. Operators
        1. Action
        2. Preconditions
        3. Effects (Postconditions)
III. Partial-Order Planning

IV. The Real World
    A. When Things go Wrong
        1. Incomplete Information
        2. Incorrect Information
        3. Qualification Problem
V. Conditional Planning
VI. Monitoring and Replanning

Uncertainty
I. Uncertainty
    A. Sources of Uncertainty
    B. Methods for Handling Uncertainty
II. Probability
    A. Terms
        1. Sample Space
        2. Event
        3. Random Variables
        4. Propositions
III. Syntax and Semantics
    A. Prior Probability
    B. Joint Probability
    C. Conditional Probability
IV. Inference
    A. Enumeration
        1. Normalization
V. Independence
    A. Absolute
    B. Conditional
VI. Bayes' Rule

Bayesian Networks
I. Syntax
    A. Nodes
    B. Directed Arcs
    C. Conditional Probabilities
II. Semantics
    A. Global and Local
    B. Constructing a Bayes Net
III. Inference
    A. Enumeration

Rational Decisions
I. Rational Preferences
II. Utility
    A. Assessment of Human Utility
III. Decision Networks

A. Decision Node
B. Chance Node
C. Utility Node

IV. Dominance
A. Strict Dominance
B. Stochastic Dominance

V. Value of Information

Machine Learning

I. Learning Agents
A. Architecture
B. Learning Element
C. Supervised/Unsupervised Learning

II. Inductive Learning
A. Approximate f(x) with h(x)
B. Overfitting
C. Generalization
D. Structural Representations
1. Decision Trees
2. Rules
3. Numeric
E. Algorithms
1. Decision Trees – Information Theory / Entropy
2. Rules – Instance Covering
3. Artificial Neural Networks
a. Multilayer Perceptron
1. Feed Forward
2. Backpropagation
b. Kohonen Net
4. Case Based Learning
5. Clustering

III. Genetic Algorithms
A. Encoding / Representation
B. Evaluation / Fitness Function
C. Development Process
D. Genetic Operators
1. Selection / Reproduction
2. Crossover
3. Mutation

III. Measuring Performance
A. Learning Curve
B. Training Set / Test Set (and Validation Set)
C. Estimating the Error (Confidence)
D. Comparing Models

Philosophical and Ethical Issues

I. Weak AI
II. Strong AI
III. Ethics

Neuroevolution

I. What are Neuroevolutionary Algorithms
II. Why Should I Care?
III. Where are they Used?
IV. How to Build One
    A. Encoding
        1. Direct Encoding
        2. Indirect Encoding
    B. Tuning

Swarm Intelligence

I. What is Swarm Intelligence?
    A. Stigmergy
II. Swarms in Nature
    A. Reynolds Rules
        1. Cohesion
        2. Alignment
        3. Separation
III. Ant Colony Optimization
IV. Particle Swarm Optimization
    A. Reynolds Rules Plus:
        1. Attraction to a target
        2. Fitness function

Artificial Neural Networks

I. History
II. Model
    A. Parameters
        1. Pattern of connections between layers
        2. Learning rule
        3. Activation function
III. Training
    A. Backpropagation
    B. Mean Squared Error (MSE)
    C. Error surface
IV. Applications

Support Vector Machines

I. What are Support Vector Machines?
II. SVM Uses
III. History
IV. SVM Concept
    A. Maximum Margin Hyperplane
    B. Creating Linearly Separable Problems Using the Kernel Trick
    C. Nonparametric, but Store only Support Vector Cases
V. Practical Guide to SVMs

Genetic Algorithms

I. What are Genetic Algorithms?
II. History
III. Methodology
    A. Selection
    B. Crossover
        1. One point
        2. Two point
        3. Cut and splice
    C. Mutation
    D. New Generation