

The image shows a spiral-bound notebook with a light brown, textured cover. The spiral binding is on the left side. The text is centered on the cover.

# Artificial Intelligence

Multi-Agent Systems,  
Applications of Intelligent Agents  
and Agent R&D Roadmap

## Lecture 2b

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# Content: MAS, Applications & Research Roadmap of IA



- ☞ Quick Review on Lecture 1
- ☞ Six AI Textbooks and Related Chapters
- ☞ Multi-Agent Systems in a Nutshell
- ☞ Case Study: “Multi-Agent Collaboration with Strategic Positioning, Roles and Responsibilities”.
- ☞ Class Activity 1: A paper on “Applications of Intelligent Agents” - Guided Reading.
- ☞ Class Activity 2: A paper on “A Roadmap of Agent Research and Development” - Guided Reading.
- ☞ What’s in Store for Lecture 3

# Quick Review on Lecture 2



## 📄 Intelligent Agents

- Three laws of robotics (*iop*)
- What is an Agent
- How Agents should Act
- Rational behaviour depends on knowledge
- Structure of an I. Agent (*a+p*)
- Examples of Agents and their PAGE description
- Five Major Agent Types (*trsgu*)
- Shopping Example Activities
- Agent Environments (*adesc*)
- An Agent Portfolio

📄 Class Activity 1: To write the PAGE description for Robocup

📄 Class Activity 2: To write the characteristics of of the environment of Robocup domain.

📄 Class Activity 3: A paper on Intelligent Agent - Reading.

# AI Textbooks and Related Chapters



(1) **Artificial Intelligence: A Modern Approach** by Stuart Russell and Peter Norvig

## AI

- Introduction
- Intelligent Agents

## Problem Solving

- Searching
- Informed Search Methods
- Game Playing

## Knowledge and Reasoning

- First order logic
- Building a Knowledge base
- Inference in first order logic
- Logical reasoning systems

## Acting logically

- Planning
- Practical planning
- Planning and Action

## Uncertain Knowledge and Reasoning

## Learning

## Communicating, perceiving and acting

- Agents that communicate
- Practical Natural Language Processing
- Perception
- Robotics

## Conclusion

- Philosophical foundations
- AI: Present and future

# AI Textbooks and Related Chapters

(2) **Artificial Intelligence and the Design of Expert Systems** by George F. Luger and William A. Stubblefield



## AI: History and Applications

## AI as representation and search

- Predicate calculus
- Structures and strategies for state space search
- Control and implementation of state space search
- Heuristic search

## Language for problem solving

- An introduction to Prolog
- LISP

## Representation for Knowledge-based systems

- Rule-based expert systems
- Knowledge representation
- Natural language
- Automated reasoning

## Advanced AI programming techniques

- Advanced representation in Prolog
- Advanced LISP programming techniques for AI
- Advanced topics in AI problem solving

# AI Textbooks and Related Chapters

## (3) Essentials of Artificial Intelligence by Matt Ginsberg



### Introduction and Overview

### Knowledge representation: Other techniques

### Search

- Blind Search
- Heuristic Search
- Adversary Search

- Assumption-Based Truth Maintenance
- Nonmonotonic reasoning
- Probability
- Frames and Semantic Nets

### Knowledge representation: Logic

- Predicate logic
- First order logic

### AI Systems

- Planning
- Learning
- Vision
- Natural Language
- Expert Systems

# AI Textbooks and Related Chapters

(4) **Artificial Intelligence (2nd Ed)** by Elaine Rich and Kevin Knight



📖 Problems, Problem Spaces and Search

📖 Heuristic Search Techniques

📖 Knowledge representation

- Issues
- Predicate Logic
- Rules
- Symbolic reasoning under uncertainty
- Statistical reasoning
- Weak slot-and-filler structures (Semantic Nets, Frames)
- Strong slot-and-filler structures (Conceptual dependency, scripts, CYC)

📖 Advanced Topics

- Game playing
- Planning
- Understanding
- Natural Language Processing
- Parallel and Distributed AI
- Learning
- Connectionist models
- Common sense
- Expert Systems
- Perception and Action

# AI Textbooks and Related Chapters

(5) Artificial Intelligence: Principles and applications by Masoud Yazdani



## Principles of AI

## POPLOG, LISP

## Applications

- Computer processing of Natural Language
- Computer speech synthesis and recognition
- Computer vision
- AI and robotics
- Expert Systems

## Frontiers

- Machine Learning
- Memory models of man and machine

## Implications

- Why AI needs and empirical foundation
- Breaking out of the Chinese room
- Social implications of AI



# AI Textbooks and Related Chapters

(6) **Artificial Intelligence (2nd Ed)** by Patrick Henry Winston



1. Exploiting natural constraints    5. Knowledge representation

2. Search

6. Natural Language Processing

3. Rule-based systems

7. Computer Vision

4. Logic and theorem proving    8. Machine Learning

# Multi-Agent Systems

- Agent-to-agent communication
- Cooperation and collaboration
- Team and coalition formation
- Information sharing among the team
- Joint beliefs, goals and plans - Beliefs, Desires and Intent

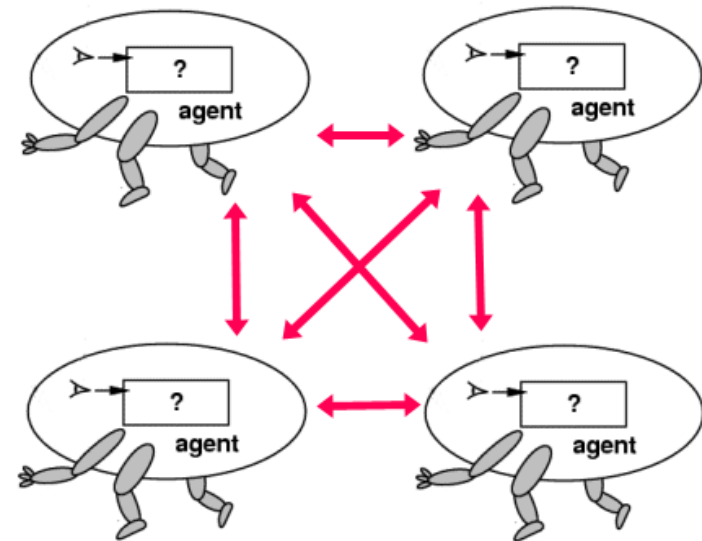


Figure 3.1 A simple 4 agents MAS.

## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [1/8]

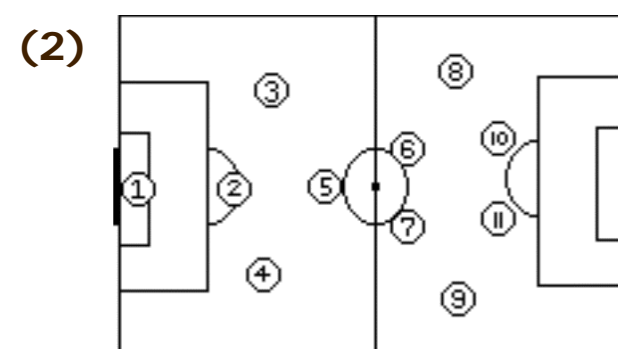
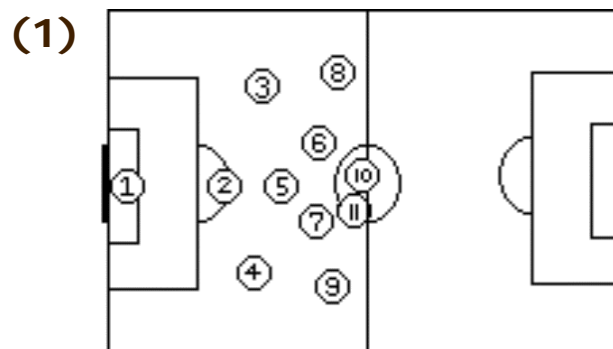


- Our approach to the first RoboCup Pacific Rim Series (PRS) competition prioritise on the research aspect of Robocup over development work.
- We explored (1) multi-agent collaboration with strategical positioning, roles and responsibilities and (2) virtual global vision agents (3) Knowledge discovery agents.
- Development work on (2) & (3) remains in the lab due to time-constraints.

## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [2/8]



- Each agent has a strategical position that defines its default position and movement range inside the soccer field.
- Two categories of positioning: (1) Initial and (2) Gameplay



## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [3/8]



- 📄 **Goal-keeper:** Positions in goal-mouth, prevents ball from going past, and distributes ball to team mates.
- 📄 **Defender:** Positions in front of our penalty area, tackles for ball, and passes ball to midfielders. Wing-backs will in-charge of kick-ins in their own half.
- 📄 **Midfielder:** Feeds forwards with ball and goes for the ball. Wingers will in-charge of corner-kicks and kick-ins in the opposing half.
- 📄 **Forward:** Hard-press opposing defense for ball, strikes ball at goal.

## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [4/8]



In a nutshell, we attempt to

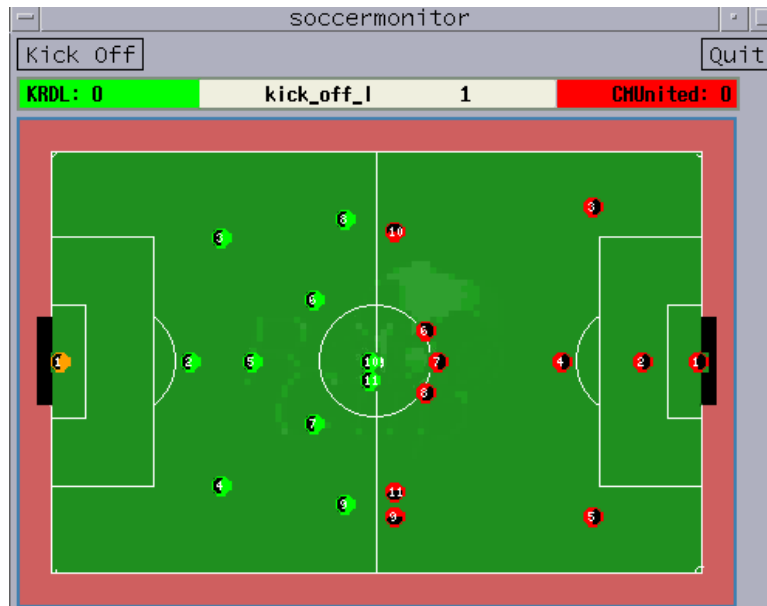
- 📄 Formulate a dynamic global map of the field by integrating vision senses of the distributed agents in the field.
- 📄 The use of this information to best play the game, balancing team stamina, team workload and team.

## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [5/8]

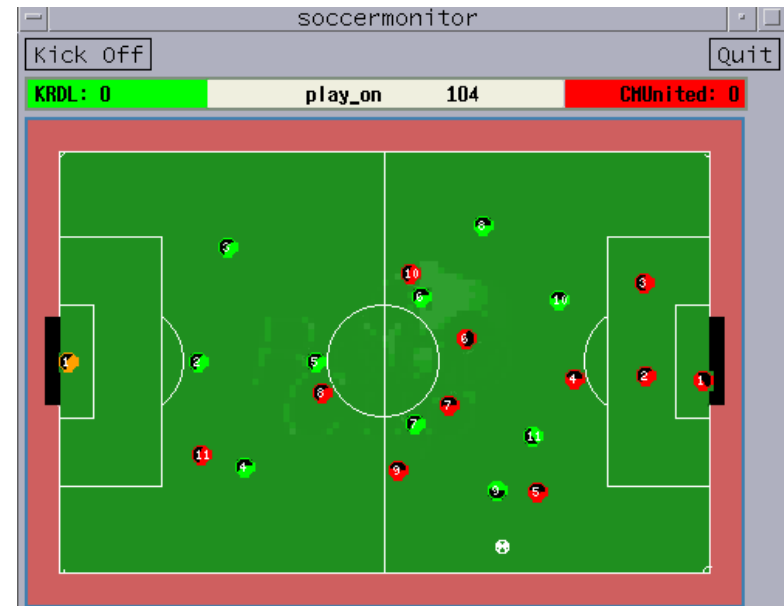


In short, we do **data** (numeric) and **text mining** using the rich and generous broadcast of the **auditory and possibly visual information** from the **opposing team** through the soccer server.

# Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [6/8]



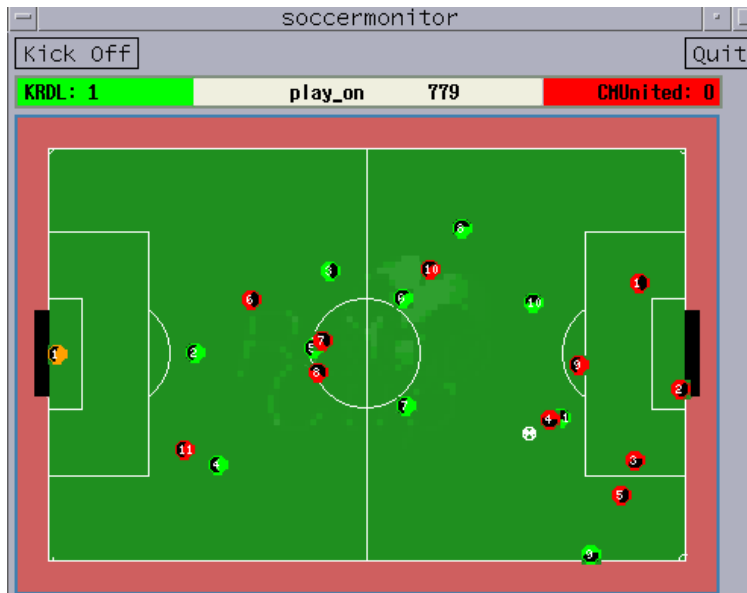
S1. Initial Position (T-1)



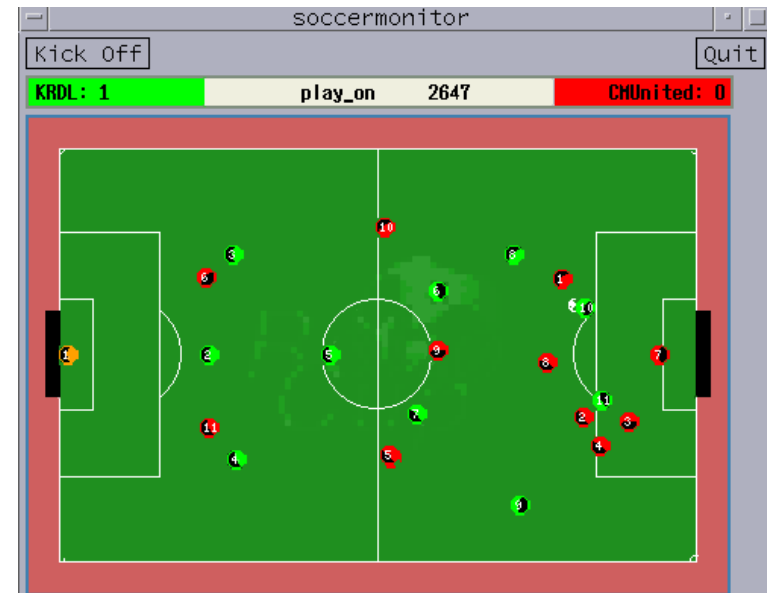
S2. Game Play Position (T-104)



# Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [7/8]



S3. During Game Play (T-779)



S4. During Game Play (T-2647)

## Case Study: “Multi-Agent Collaboration with Strategical Positioning, Roles and Responsibilities” [8/8]



- 📄 Our debut participation in the Robocup simulation league focus on the strategic positioning, roles and responsibilities of multiple agents.
- 📄 We hope to implement our ideas on (1) virtual global vision agents and (2) knowledge discovery agents in the future Robocup conferences.

# Class Activity 1: A paper on “Applications of Intelligent Agents” - Guided Reading.



## 1.1 Introduction

## 1.2 Agent Application Domain

### Characteristics

1.2.1 Solving New Types of Problems

1.2.2 Improving the Efficiency of Software Development

1.2.3 The Limitation of Agent Solutions

## 1.3 Agent Application Domains

1.3.1 Industrial Applications

- Process Control, Manufacturing, Air Traffic Control

1.3.2 Commercial Applications

- Information Management, Electronic Commerce, Business Process Mgt

1.3.3 Medical Application

- Patient Monitoring, Health Care

1.3.4 Entertainment

- Games, WTetris, Interactive Theater and Cinema

## 1.4 The Agent Development Bottleneck

1.4.1 Requirements Specification

1.4.2 System Design

1.4.3 System Implementation

1.4.4 System Testing, Debugging, and Verifications

## 1.5 The Structure of this Book

1.5.1 Introductory Chapters

1.5.2 Vision Chapters

1.5.3 Systems and Their Applications

# Class Activity 2: A paper on “A Roadmap of Agent Research and Development” - Guided Reading.



## 1. Introduction

## 2. Autonomous Agents

2.1 History

2.2 Issues and Future Directions

## 3. Multi-Agent Systems

3.1 History

3.2 Cooperative Multi-Agent Interactions

3.3 Self-Interested Multi-Agent Interactions

3.4 Issues and Future Directions

## 4. Applications

4.1 Key Domains and Exemplar Systems

4.2 Future Directions

## 5. Concluding Remarks

# What's in Store for Lecture 3-5



Formulation of search problems

Uninformed (blind) Search Algorithms

Informed (heuristic) Search Algorithms

Game Playing

Students' Mini Research Presentation by Group A

Class Activity 1: One paper on Search Strategies - Reading

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**End of Lecture 2b**

Good Night.