Assignment 1. Due 01/31/11

Analyze the following problems and

1. Find the state space;
2. Find a solution and show search as state diagram (as it was shown in class for the "Monkey and Banana" problem — see Lecture 2),
3. Try to find a good heuristic function that would allow us to distinguish all the bad and good states of the search. Good states are those that lead to a goal state. A function should assign a numerical value to every state.

1. The Missionaries and Cannibals Problem

Three Missionaries and three cannibals find themselves on one side of a river. They have agreed that they would all like to get to the other side. But the missionaries are not sure what else the cannibals have agreed to. So the missionaries want to manage the trip across the river in such a way that the number of missionaries on either side of the river is never less the number of cannibals who are on the same. The only boat available holds only two people at a time. How can everyone get across the river without the missionaries risking being eaten?

Remark 1. Function that includes the conditions for missionaries not to get eaten only cannot serve as heuristic function. It is insufficient because it is not able to distinguish between all bad and good states. A heuristic function must include something else.

2. The Tower of Hanoi

Somewhere near Hanoi there is a monastery whose monks devote their lives to a very important task. In their courtyard are three tall posts. On these posts is a set of sixty-four disks, each with a hole in the center and each of a different radius. When the monastery was established, all of the disks were on one of the posts, each disk resting on one just larger than it. The monks' task is to move all the disks to one of the other pegs. Only one disk may be moved at a time, and all the other disks must be on one of the pegs. In addition, at no time during the process may a disk be placed on top of a smaller disk. The third peg can, of course, be used as a temporary resting place for disks. What is the quickest way for monks to accomplish their mission?

Even the best solution to this problem will take the monks a very long time. This is fortunate, since legend has it that the world will end when they have finished.

Remark 2. Analogously with Remark 1, a function that does not allow us to put disks on the peg in a wrong order is insufficient.

Introduction

Mundane Tasks

Perception
— Vision
— Speech
Natural language
— Understanding
— Generation
— Translation
Commonsense reasoning
Robot control

Formal Tasks

Games
— Backgammon
— Checkers
— Go
— Abstract Board Games
Mathematics
— Geometry
— Logic
— Integral Calculus
— Formal derivation of programs

Expert Tasks

Engineering
— Design
— Fault finding
— Manufacturing, planning
Scientific Analysis
Medical diagnosis
Financial analysis
Military Command and Control
Genome Project

Four Questions about AI

1. **What are our underlying assumptions about intelligence?**

2. **What kind of techniques will be useful for solving AI problems?**

3. **At what level of detail, if at all, are we trying to model human intelligence?**

4. **How will we know when we have succeeded in building an intelligent program?**

1. What are our underlying assumptions about intelligence?

A **physical symbol system** consists of a set of entities, called symbols, which are physical patterns that occur as components of another type of entity called an expression (or symbol structure). Thus, a symbol structure is composed of a number of instances (or tokens) of symbols related in some physical way (such as one token being next to another). At any instant of time the system will contain a collection of these symbol structures. Besides these structures, the system also contains a collection of processes that operate on expressions to produce other expressions: **processes of creation, modification, reproduction and destruction**. A physical symbol system is a machine that produces through time an evolving collection of symbol structures. Such a system exists in a world of objects wider than just these symbolic expressions themselves.

The Physical Symbol System Hypothesis. A physical symbol system has the necessary and sufficient means for general intelligent action.

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2. What kind of techniques will be useful for solving AI problems?

Use of Knowledge

- The **knowledge** captures generalizations. In other words, it is not necessary to represent separately each individual situation. Instead, situations that share important properties are grouped together. If knowledge does not have this property inordinate amounts of memory and updating will be required. So we usually call something without this property "**data**" rather than knowledge.

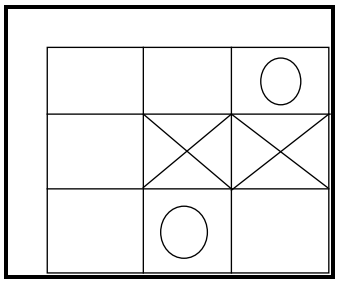
- It can be **understood** by people who must provide it. Although for many programs, the bulk of the data can be acquired automatically (for example, by taking readings from a variety of instruments), in many AI domains, most of the knowledge a program has must ultimately be provided by people in terms they understand.

- It can easily **be modified** to correct errors and to reflect changes in the world and in our world view.

- It can be used in a **great many situations** even if it is not totally accurate and complete.

- It can be used to help **overcome its own sheer bulk** by helping to narrow the range of possibilities that must usually be considered.

Tic-Tac-Toe

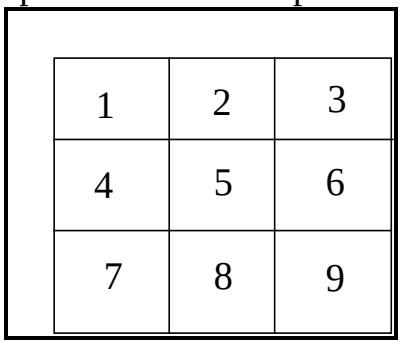


Program 1

Idea: Store all possible positions with respective best moves.

Data Structures:

Board A nine-element vector representing the board, where the element of the vector correspond to the board position as follows:



An element contains the value 0 if the corresponding square is blank, 1 if it is filled with an X, or 2 if it is filled with an O.

Movetable A large vector of 19,683 elements (3^9), each element of which is a nine-element vector. The contents of this vector are chosen specifically to allow the algorithm to work.

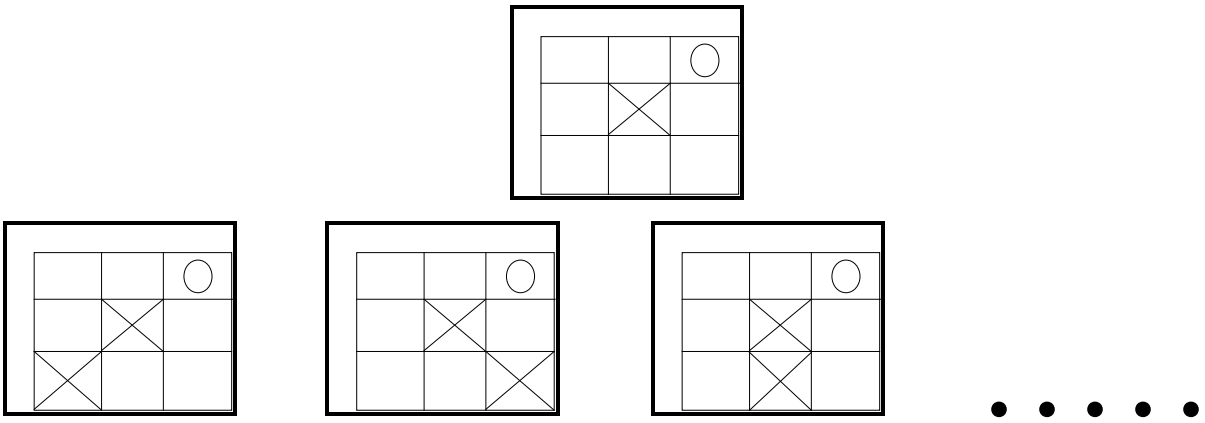
The Algorithm

To make a move, do the following:

1. View the vector Board as a ternary (base three) number. Convert it to a decimal number.
2. Use the number computed in step 1 as an index into Movetable and access the vector stored there.
3. The vector selected in step 2 represents the way the board will look after the move that should be made. So set Board to that vector.

Program 3 (Program 2 is in the textbook)

Idea: Search for the best move.



BoardPosition A structure containing a nine-element vector representing the board, a list of board positions that can result from the next move, and a number (rating) representing an estimate of how likely the board position is to lead for the player to move.

The algorithm To decide on the next move, look ahead at the board positions that result from each possible move. Decide which position is best (as described below), make the move that leads to that position, and assign the rating of that best move to the current position.

To decide which of a set of board positions is best, do the following for each of them:

1. See if it is a win. If so, call it the best by giving it the highest possible rating.
2. Otherwise, consider all the moves the opponent could make next. See which of them is worst for us (by recursively calling this procedure). Assume the opponent will make that move. Whatever rating that move has, assign it to the node we are considering.
3. The best node is then the one with the highest rating.

This algorithm will look ahead at various sequences of moves in order to find a sequence that leads to a win. It attempts to maximize the likelihood of winning, while assuming that the opponent will try to minimize that likelihood. This algorithm is called the minimax procedure, and we will discuss it in the future.

Question-Answering Programs

Consider a statement

Russia massed troops on the Czech border.

Then either of the following question-answering dialogues might occur (and in fact did occur with the POLITICS program {Carbonell, 1980).

Dialogue 1

Q: Why did Russia do this?
A: Because Russia thought that it could take political control of Czechoslovakia by sending troops.
Q: What should the United States do?
A: The United States should intervene militarily.

Dialogue 2

Q: Why did Russia do this?
A: Because Russia wanted to increase its political influence over Czechoslovakia.
Q: What should the United States do?
A: The United States should denounce the Russian Action in the United Nations.

Three Important AI Techniques

— **Search**
Provides a way of solving problems for which no more direct approach is available as well as a framework into which any direct techniques that are available can be embedded.

— **Use of knowledge**
Provides a way of solving complex problems by exploiting the structures of the objects that are involved.

— **Abstraction**
Provides a way of separating important ones that would otherwise overwhelm any process.

3. At what level of detail, if at all, are we trying to model human intelligence?

1. To **test psychological theories** of human performance. One example of a program that was written for this reason is PARRY [Colby, 1975], which exploited a model oh human paranoid behavior to simulate the conversational behavior of a paranoid person. The model was good enough that when several psychologists were given the opportunity to converse with the program via a terminal, they diagnosed its behavior as paranoid.

2. To **enable computers to understand human reasoning**. For example, for a computer to be able to read a newspaper story and then answer a question, such as "Why did the terrorists kill hostages?" its program must be able to simulate the reasoning processes of people.

3. To **enable people to understand computer reasoning**. In many circumstances, people are reluctant to rely on the output of a computer unless they can understand how the machine arrived at its result. If the computer's reasoning process is similar to that of people, then producing an acceptable explanation is much easier.

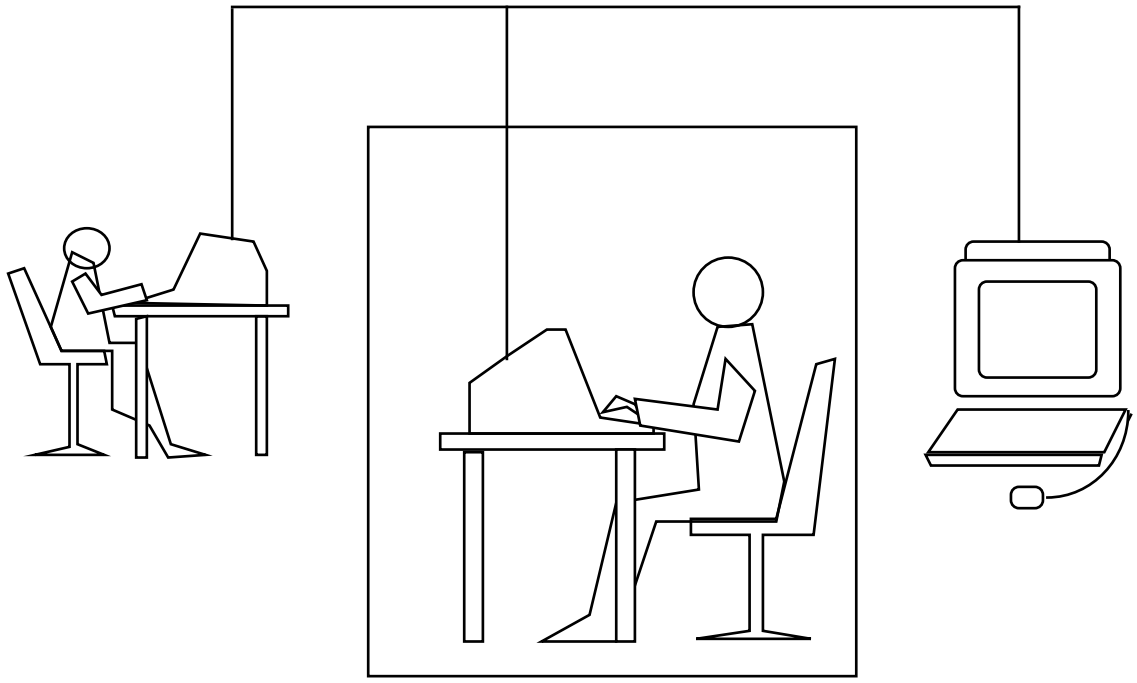
4. To exploit **what knowledge we can glean from people**. Since people are the best-known performers of most of the tasks with which we are dealing, it makes a lot of sense to look to them for clues as how to proceed.

4. How will we know when we have succeeded in building an intelligent program?

Criteria for Success

Chess programs, DENDRAL, R1, G2

The Turing Test



Interrogator: In the first line of your sonnet, which reads "Shall I compare thee to a summer's day," would not "a spring day" do as well or better?

A: It wouldn't scan.

Interrogator: How about "a winter's day." That would scan all right.

A: Yes, but nobody wants to be compared to a winter's day.

Interrogator: Would you say Mr. Pickwick reminded you of Christmas?

A: In a way.

Interrogator: Yet Christmas is a winter's day, and I do not think Mr. Pickwick would mind the comparison.

A: I don't think you're serious. By a winter's day one means a typical winter's day, rather than a special one like Christmas.