7.1 Memory Versus Computation

- Memory-based implementation
  - The action is selected by designer.
  - Agent would require large amounts of memory.
  - Designer would require foresight in anticipating appropriate reactions for all possible situations.

- Computation-based implementation
  - It will reduce the agent’s memory requirements and the burden on the designer.
  - The designer specify the computation instead of all possible situations.
  - These computations will take time

7.2 State-Space Graphs

- An example
  - Grid-space world containing 3 toy blocks (A, B, C).
  - All initially are on the floor.
  - The task is to stack blocks so that A is on top of B and B is on top of C and C is on the floor.
  - Instances of a schema
    - move(x, y) – x can be A, B, C, y can be A, B, C and floor.
  - Operators
    - move(A, C), move(A, B) …
7.2 State-Space Graphs

- Directed graph
  - A most useful structure for keeping track of the effects of several alternative sequences of actions.
  - Node
    - Representations of the individual worlds
    - Iconic or feature
  - Arc
    - Operators

- State-space graph
  - A graph representing all of the possible actions and situations
  - Any of the nodes in the graph can be taken to represent a goal situations.
7.2 State-Space Graphs

- **Plan**
  - A sequence of the operators labeling the arcs along a path to a goal.
  - Planning is searching for such a sequence.
- **Projecting**
  - The process of predicting a sequence of world states resulting from a sequence of actions.

(c) 2000 SNU CSE Artificial Intelligence Lab (SCAI) 9

7.3 Searching Explicit State Spaces

- **Search methods for explicit graphs involve** propagating markers over the nodes of the graph.
  - Label the start node with a 0.
  - Propagate successively larger integers out in waves along the arcs until an integer hits the goal.
  - Trace a path back from the goal to the start along a decreasing sequence of numbers.
- **Expansion**
  - Puts marks on all of the marked node’s unmarked neighbors.

(c) 2000 SNU CSE Artificial Intelligence Lab (SCAI) 10

7.4 Feature-Based State Spaces

- Feature-Based graphs need a way to describe how an action affects features.
  - STRIPS [Fikes & Nilsson, 1971]
    - Define an operator by 3 lists
      - Precondition list specifies those features that must have value 1 and 0 in order that the action can be applied.
      - Delete list specifies those features that will have their values changed from 1 to 0.
      - Add list specifies those features that will have their values changed from 0 to 1.
7.4 Feature-Based State Spaces

- Neural Networks
  - Train a neural network to learn to predict the value of a feature vector at time \( t \) from its value at time \( t-1 \) and the action taken at time \( t-1 \). [Jordan & Rumelhart 1992]
  - After training, the prediction network can be used to compute the feature vectors that would result from various actions.
  - Computed features in turn could be used as new inputs to the network to predict the feature vector two steps ahead, and so on.

---

7.5 Graph Notation

- A graph consists of a set of nodes.
  - A graph consists of a set of nodes.
  - Arcs connect certain pairs of nodes.
  - A directed graph
    - Arcs are directed from one member of the pair to the other.
    - Successor (child)
    - Parent
  - An undirected graph
    - Edges are undirected arcs.
    - Contain only edges.
7.5 Graph Notation

- Tree is a special case of a graph.
  - A directed tree
    - A root node has no parent.
    - Each has exactly one parent except root.
    - A leaf node has no successors.
    - Depth of any node is defined to be the depth of its parent plus 1. (The root node is of depth zero.)
  - An undirected tree
    - There is only one path along edges between any pair of nodes.

- A path of length $k$ from node $n_i$ to node $n_k$.
  - A sequence of nodes with each $n_{i+j}$ a successor of $n_i$ for $i=1, \ldots, k-1$

- Accessible
  - Exist a path from one node to other node.

- Descent, Ancestor

- Optimal path
  - Path having minimal cost between two nodes.

- A spanning tree
  - A tree including all nodes in a graph