Symbolic AI and SOAR

- Symbolic AI is the art of making machines do things that would require intelligence if done by a human, such as playing chess, speaking English, or diagnosing an illness.
- Sloman (1986) gives a broader view : "AI is a very general investigation of the nature of intelligence and the principles and mechanisms required for understanding or replicating it."
- This view exhibits both the engineering side of AI and its cognitive science side. Both SOAR and the first AI debate are intimately concerned with each side..

Production Systems

- Introduced in 1943 by Post, production systems were first employed to model intelligence by Newell [2] and Simon (1972). Since then, they've played a major role in several symbolic AI systems, including SOAR.
- Production Systems also provide the theoretical foundations of rule-based expert systems (Buchanan and Shortliffe 1984).

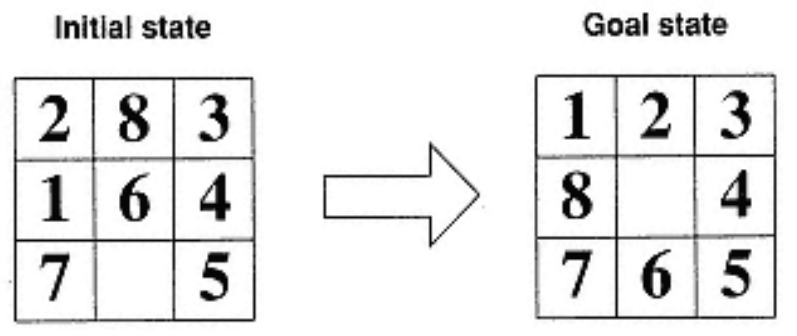
Production Systems

- A *production system* is a special kind of discrete dynamical system that consists of three components. One is the *global database*, which comprises the data of the system. Another is the set of *production rules*, the operations of the system that take it from state to state. Finally, the *control structure* acts as the executive of the production system, determining which production rule will fire next.

  - A *dynamical system* consists of a set S, called its state set, and a transition function, M, that maps S into itself. [3] If we think of the system's changing in discrete steps—a *discrete* dynamical system[4]—then M specifies for each state s in S its next state, M(s).

Production Systems : Example
8 Puzzle Problem

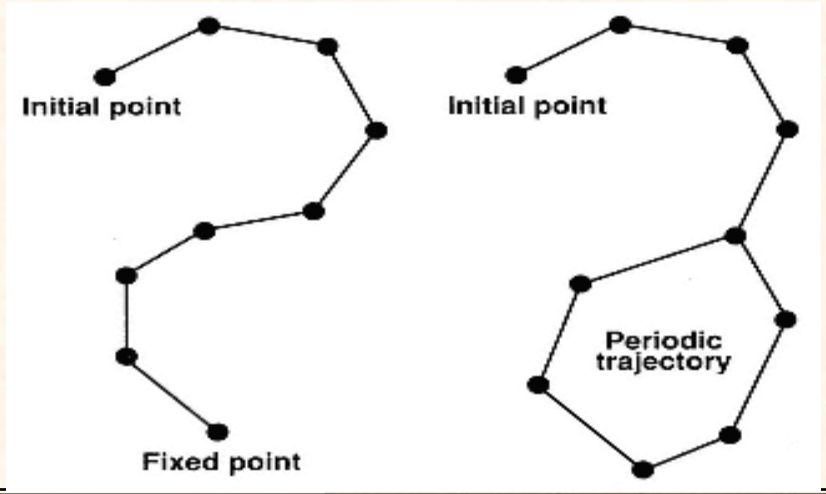
The eight puzzle (adapted from Laird et al. 1987)



The *state space* of a system is the set of all possible current states, that is, the set of all the states the system could possibly assume. The state space of the eight puzzle consists of all possible arrangements of the eight small squares within the large one.

Trajectories (8 puzzle)

- Starting with some initial state s_0, as in the eight puzzle, the series of states through which the system steps before arriving at a goal state is called the *trajectory* of s_0. A trajectory need not lead to a *fixed point*, such as a goal state, which is always mapped by T to itself. It may be *periodic*, visiting each of several states in turn over and over again:



Three components of a Production System

- The global database is sometimes referred to as working memory, short-term memory, or the fact list. It's the system's representation of the current state of its world. In other words, the global database at a specific time can be thought of as a point in state space. The state space of a production system is the set of all possible global databases
- Production rules, often simply called *productions*, are condition/action rules: whenever a certain condition is satisfied, then a specified action is performed or may be performed.

  WHENEVER (condition) IS SATISFIED,

  PERFORM (action).

  If the empty square isn't next to the left edge of the board,

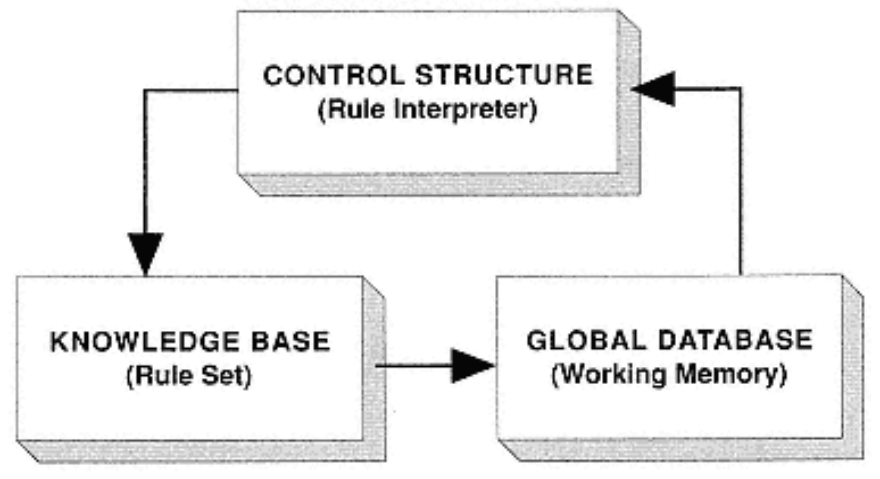
  move it to the left

  Note that something like pattern matching is required to tell whether the condition is satisfied

Three components of a Production System….

- Production rules can be thought of collectively as the long-term memory of the production system, that is, what the system knows: its knowledge base. This is the declarative view. From a procedural view, production rules are operators. As a collection, they constitute what the system can do.
- The control structure, which performs the selection process in the PRODUCTION SYSTEM procedure. The control structure picks out the production rule to be fired next.
- The selection is done through various heuristic search strategies. Search is required because typically not enough is known to point directly to the ideal rule. The search is heuristic in the sense that it's likely, but not guaranteed, to find the best choice. Nilsson (1980) describes several production system control strategies with such colorful terms as irrevocable, backtracking, graph-search and hill-climbing.

Production System: A Symbolic one?



- While the human user of a production system may think of its global database as representing something in the outside world, to the production system its global database *is* its own internal world.

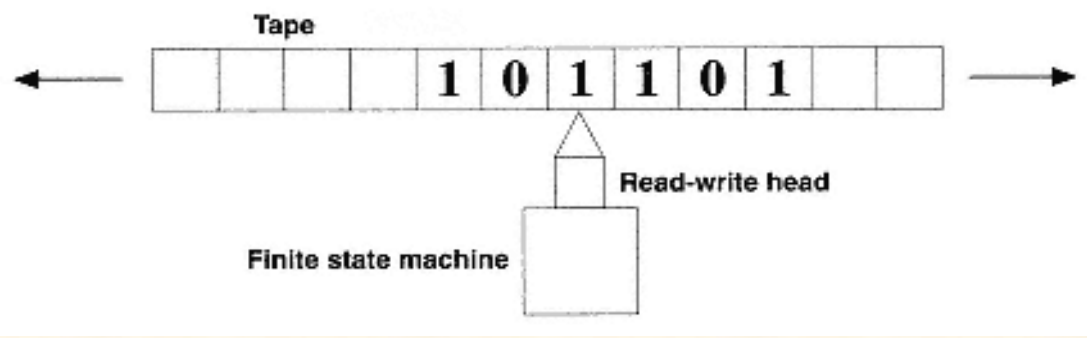
Production System: A Symbolic one?

- The control structure perceives this internal world in some unspecified way and then acts on it via the production rules.
- For it to be of use to us, some human must provide the initial global database and interpret the final global database.
- Relative to the outside world, a production system is purely a syntactic device manipulating symbols without regard to their meaning. Its relations to the outside world, its meanings, its semantics, must be provided by a human.

The issue of connecting mechanisms of mind to the outside world is important

What problems can a Production System solve?

- A production systems can control, solve, or compute anything a computer can, no more and no less.
- It was later shown that any computation on a Turing machine could be emulated by a production system and vice versa.



- Hence, Researchers in symbolic AI use production systems to model cognitive processes.

Parallel Production Systems

- The production systems where more than one production rule can fire simultaneously.
- Shared memory machines seem ideal for implementing parallel production systems. Common memory holds the global database; all facts are stored in memory. A few processors would be devoted to controlling input to the system and output from it. Each production rule, or a small set of them, is implemented by its own processor.
- Note that no central executive rules here. Such a parallel production system is strictly a local operation. Each demon looks only to its own condition. No one has a global view, much less global authority.
- There is a conflict resolution device, but its powers are quite limited