Means-ends Analysis

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June 5, 2026

Means-Ends Analysis (MEA) is a technique used in Artificial Intelligence for controlling search in problem solving computer programs. It is also a technique used at least since the 1950s as a creativity tool, most frequently mentioned in engineering books on design methods. Means-Ends Analysis is also a way to clarify one's thoughts when embarking on a mathematical proof.

An important aspect of intelligent behavior as studied in AI is goal-based problem solving, a framework in which the solution of a problem can be described by finding a sequence of actions that lead to a desirable goal. A goal-seeking system is supposed to be connected to its outside environment by sensory channels through which it receives information about the environment and motor channels through which it acts on the environment. (The term "afferent" is used to describe "inward" sensory flows, and "efferent" is used to describe "outward" motor commands.) In addition, the system has some means of storing in a memory information about the state of the environment (afferent information) and information about actions (efferent information). Ability to attain goals depends on building up associations, simple or complex, between particular changes in states and particular actions that will bring these changes about. Search is the process of discovery and assembly of sequences of actions that will lead from a given state to a desired state. While this strategy may be appropriate for machine learning and problem solving, it is not always suggested for humans (e.g. cognitive load theory and its implications).

How MEA works

The MEA technique is a strategy to control search in problem-solving. Given a current state and a goal state, an action is chosen which will reduce the difference between the two. The action is performed on the current state to produce a new state, and the process is recursively applied to this new state and the goal state.

Note that, in order for MEA to be effective, the goal-seeking system must have a means of associating to any kind of detectable difference those actions that are relevant to reducing that difference. It must also have means for detecting the progress it is making (the changes in the differences between the actual and the desired state), as some attempted sequences of actions may fail and, hence, some alternate sequences may be tried.

When knowledge is available concerning the importance of differences, the most important difference is selected first to further improve the average performance of MEA over other brute-force search strategies. However, even without the ordering of differences according to importance, MEA improves over other search heuristics (again in the average case) by focusing the problem solving on the actual differences between the current state and that of the goal.

Some AI systems using MEA

The MEA technique as a problem-solving strategy was first introduced in 1963 by Allen Newell and Herbert Simon in their computer problem-solving program General Problem Solver (GPS). In that implementation, the correspondence between differences and actions, also called operators, is provided a priori as knowledge in the system. (In GPS this knowledge was in the form of table of connections.)

When the action and side-effects of applying an operator are penetrable, the search may select the relevant operators by inspection of the operators and do without a table of connections. This latter case, of which the canonical example is STRIPS, an automated planning computer program, allows task-independent correlation of differences to the operators which reduce them.

Prodigy, a problem solver developed in a larger learning-assisted automated planning project started at Carnegie Mellon University by Jaime Carbonell, Steven Minton and Craig Knoblock, is another system that used MEA.

Professor Morten Lind, at Technical University of Denmark has developed a tool called multilevel flow modeling MFM. It performs means-end based diagnostic reasoning for industrial control and automation systems.