

Artificial Intelligence Applications to Fire Management¹

Don J. Latham²

Abstract: Artificial intelligence could be used in Forest Service fire management and land-use planning to a larger degree than is now done. Robots, for example, could be programmed to monitor for fire and insect activity, to keep track of wildlife, and to do elementary thinking about the environment. Catching up with the fast-changing technology is imperative.

Just what is artificial intelligence (AI), and what could it possibly do for (or to) fire science and management? Before getting into uses that, as we shall see, will be manifold and pervasive, let us examine some of the characteristics and definitions of artificial intelligence.

Many potential or actual users of AI will insist that the term is an oxymoron, that is, anything artificial cannot be intelligent, and vice versa. There is a simple operational definition that gets us around this difficulty: the Turing test, named after its inventor, Allan Turing. If you are communicating with someone or something, and you can't tell whether the someone or something is human or machine, then it is intelligent. This test is simple, yet

effective. We can expand this test just a little to include more behavior than communication, and we have a pretty good working definition of artificial intelligence along these lines: if it walks like a duck, quacks like a duck, and looks like a duck, then it's probably a duck.

I don't think there is any question that man can replicate his thinking processes in machinery and use machinery to expand those processes. We've already done this. We will build machinery that thinks to match the job to be done. Imagine coming to work one morning and turning on your desktop thinking machine, only to have it announce that it was calling in sick. It would probably really be fishing. So, we'd probably want our desktop machines to be rather subservient. On the other hand, suppose we send a machine to explore the surface of Jupiter. We would want this machine to have a great deal of intelligence, including the capability of refusing to carry out a self-destructive action (see Asimov's laws of robotics).

Where are we now in the realm of AI? Currently, the field is broken into several overlapping categories. The most common divisions are: environmental sensing (vision, hearing), including pattern matching and recognition of things; computer learning and analysis; "natural" language and linguistics; and reasoning, or knowledge-based systems ("expert systems"). Does this sound familiar? It should, because it is just what people do: input data from through their senses (or from internal sources such as a dream), filter and think about the data, apply known processes and remembered data to the result, and act on the result (fig. 1, 2). Some of our actions are

¹Presented at the Symposium on Wildland Fire 2000, April 27-30, 1987, South Lake Tahoe, California.

²Research Meteorologist, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Missoula, Montana.

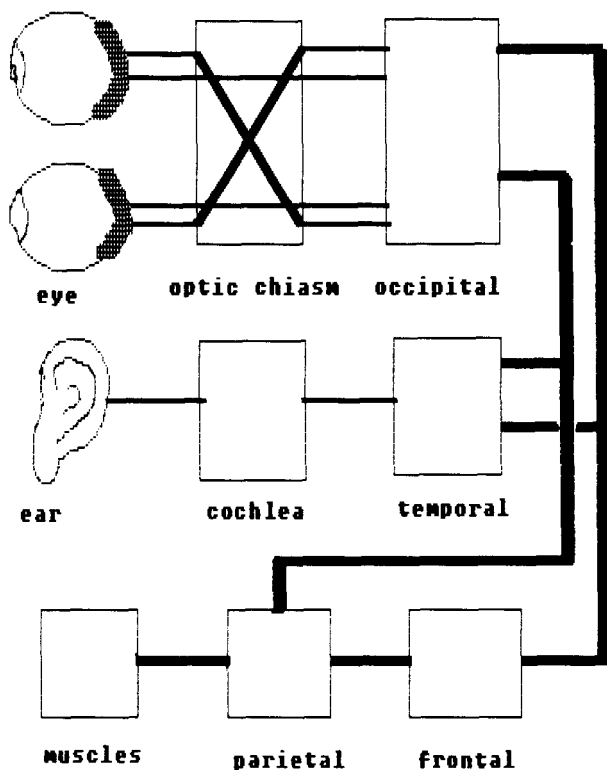


Figure 1--A simple-minded mind.

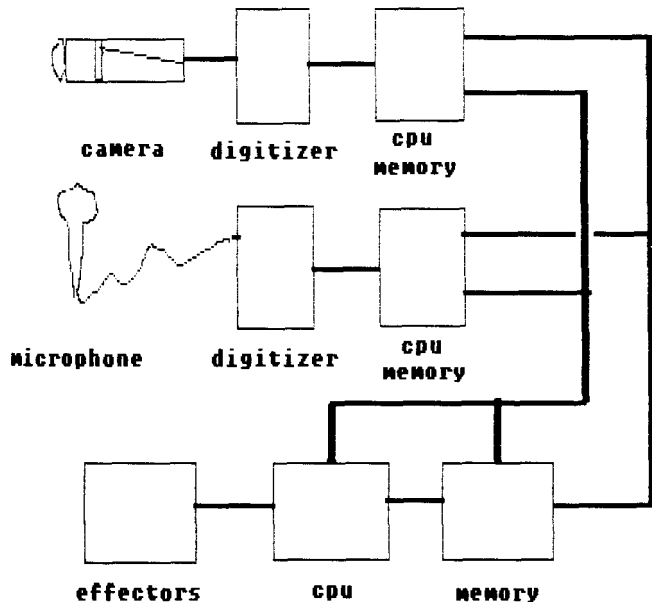


Figure 2--An artificial simple mind.

"hard-wired" like reflexes, some are "background" or meta-programs like driving a car, and some call for much active thought like reading this paper (I hope).

Each of these divisions of AI is in its embryonic stage. Every step forward seems to generate more questions than answers. Robotics, for example, a sort of melding of these arbitrary divisions of AI, is moving fast. Both military and commercial interests want robots to work for them: robots don't talk back, they obey orders, are dispensable, and cannot sue you. At present, however, robots are limited in capability. A robot van has successfully negotiated a road, on its own, at about 3 mi/h. Remotely piloted helicopters are being developed to recognize tanks using infrared scanners and knowledge-based systems. Does that sound like something desirable for fire application?

Presently, the most useful AI technology is the expert system. These computer programs (to put them in their place) use knowledge bases. composed of facts and rules, interpreters of the facts and rules called inference engines, input and output routines, and explanation routines (fig. 3). Most of these programs follow long and sometimes tortuous reasoning chains to a conclusion. They are good at this, whereas

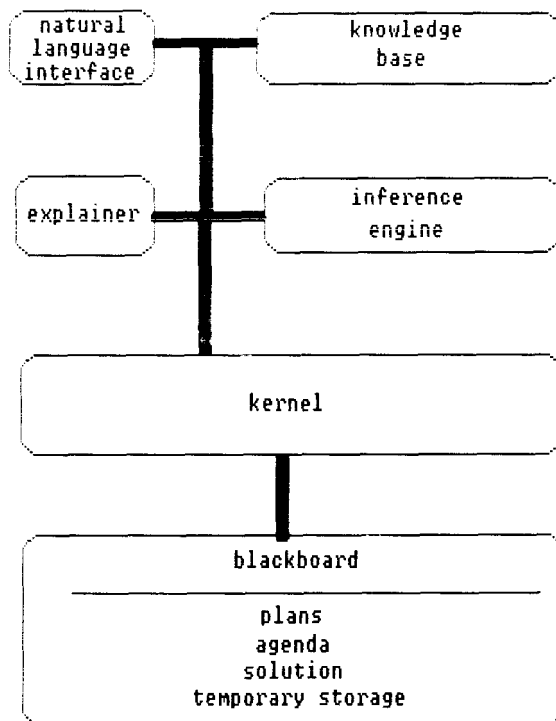


Figure 3--A contemporary expert system.

people are not; it is not a survival characteristic. A person engaging in long reasoning chains when threatened by a saber-tooth tiger probably would get eaten.

An expert at something has created a domain of knowledge about the something. Within that domain, the expert has formed heuristics, or rules-of-thumb, to guide activities. If the expert can--with the aid of a knowledge engineer, or without--codify his or her knowledge, an expert system can be constructed to mimic the behavior of the expert in the domain. The codification and the knowledge base that results are knowledge representation, one of the major problems in expert systems. This process is, of course, putting the expert's knowledge into machine-understandable format.

Why not just teach the machine to accept the knowledge and codify it, thus replacing the knowledge engineer with a program? Attempts to do just that are ongoing. It is one of the current hot topics in artificial intelligence.

Of course, the program, unlike the expert, is not able to extend the knowledge base in other than an elementary deductive way. Once we have started the program and it has deduced all the consequences of the knowledge it has in its knowledge base, it stops. We have not told the program how to extend its knowledge. The machine's extension of its knowledge is, as you might expect, one aspect of machine learning. The program has to know not only how to learn or store data, but also how to form and test new hypotheses about new input. To do that, the program has to know how to think about thinking, and so on.

If our understanding of how to build effective machines is so infantile, then what good, in a practical sense, are the simple programs that are available to us? Right now, we can computerize any repetitive process or any closed operation for which a knowledge representation can be found. We can also generate programs that add facts within the representation to their knowledge bases, and reason using those new facts. We can construct intelligent databases and inventory systems. If we had started work 5 years ago, in a serious way, we could right now be using:

- an expert system that is the Forest Service Manual on Fire Management
- a semi-automated land-use planning system
- an elementary reasoning fire dispatch system

- prescribed burning plans that learn
- interactive, self-correcting, geographic information systems

Many of these would have been available this year or during the next couple of years on cheap mass storage and running on advanced workstations, large desktop computers. We are, then, at least 5 years behind.

If we rush to catch up, how far could we get by the year 2000? We could be testing or have:

- the first crude robots for forest use
- completely automated fire dispatch machinery that would be able to use the forest robots as smokechasers
- interactive teaching tools

A robot for a forest or rangeland would be programmed to roam a given geographic area, monitoring for fire and insect activity, keeping track of wildlife, and the like. It could be programmed to do elementary thinking about its environment and would call for help if needed. Of course, it knows where it is by satellite navigation, presently available.

Fire dispatch machinery such as I describe is already beginning to be used, except for the robotics, in Ontario and Quebec. The package and concept were developed by Peter Kourtz at Petawawa. The machine dispatcher keeps track of fuels by satellite, rainfall by radar, and weather and lightning occurrence by land-based sensors. It is at present dependent on human input, but will become more and more intelligent as time goes on.

Do such machines and programs replace people? Yes, of course. They replace people who are doing mundane, repetitive tasks, tasks that almost all people dislike and perform poorly. Machines and programs free people to do what they do better than machines--think creatively and with common sense. The machinery must be looked at as a tool, as an extension of the mind and body. Look--did the bulldozer replace the Pulaski? Sure, for some uses, but each still has its place.

Aside from cost, which is a matter of commitment to a course of action, the things that hold us back from implementation of this or other new technology are simple human inertia, a reluctance to change, and a management system firmly rooted in the 19th century.

Resistance to change, however, is a survival trait. New things must be tested to assess their value. What I am doing is proposing that application of new technology is more than just developing a better way of finding and putting out a fire, or even better planning tools. It now includes change in a chain of command with information and policy implementation passing through many layers, to a system two or three layers deep and with far more automated information passing. We are seeing the bare

beginnings of this with the Forest Service-wide computer system. It is starting as an aid within the old management structure, but will sooner or later enable a far more efficient structure, releasing managers from much of the paper shuffling necessary for passing information through a vertical structure. We will move from turf to meta-turf. And artificial intelligence programming techniques will be helping us all the way.