

FURTHER READING

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- Held, Gilbert. *The Complete Modern Reference*. New York: Wiley, 1991; 3rd ed., 1997.

—Margarita Esponda

Heuristic

Heuristic (pronounced “hyu-RIS-tik”), which derives from the Greek *heuriskein*, means “to discover” and refers to problem solving using a rule of thumb rather than a preestablished formula. Heuristics outlines “learning by trying” without necessarily having an organized hypothesis or way of showing that the results prove or disprove the hypothesis (i.e., trial-by-error learning).

The analysis of heuristic problem solving dates back to the Hungarian mathematician George Pólya (1887–1985). His 1945 book *How to Solve It* taught students how to approach mathematical problems; the book offers advice, such as, “If you cannot solve a problem, then there is an easier problem you cannot solve: find it.” Pólya devised four steps for problem solving:

1. Understanding the problem (recognizing what is being asked for)
2. Devising a plan (responding to what is asked for)
3. Carrying out the plan (developing the result of the response)
4. Looking back (checking; what does the result tell me?)

His book is still a success, has sold over 1 million copies, and has been translated into 17 languages.

Pólya’s idea of heuristics greatly influenced **artificial intelligence** (AI). In AI, many problems can be formulated as search problems. For example, a chess program may search for the most promising move given the current configuration of the chess board. The program may represent every possible configuration of the board as *states* in a *search space* and assess each state with an evaluation function. Obviously, such a search space is very large, in fact, too large to be searched completely. Therefore, heuristics are widely used as rules of thumb to discover solutions in the search space.

A typical heuristic search method is *hill climbing*. The states in the search space are classified by an evaluation function and we are looking for a state where the function reaches a maximum. With hill climbing, we start the search at a random position and move to the most promising neighbor state (i.e., the one with the highest value of the evaluation function). In many cases, this heuristic leads quickly to the goal state; but it may get stuck in local minima, where it cannot improve. Here, a more sophisticated heuristic search method known as *simulated annealing* can be used. Now, we do not blindly move to the best neighbor state, but with a certain probability we continue the search in another direction. To avoid a degeneration of the approach to random search, the probability to start somewhere else decreases the longer we search. When tuned properly, and for certain problems, simulated annealing can lead rapidly to the goal state.

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—Michael Schroeder

Hewlett-Packard

Hewlett-Packard (HP) is one of the largest computer companies and the largest producer of scientific electronic instruments. The Palo Alto-based company had net revenue of U.S.\$42.4 billion and net income of U.S.\$3.1 billion in fiscal year 1999. The company has more than 86,000 employees worldwide. The vast majority of its revenue came from the sale of computer products, with the rest coming from the sale of test and measurement systems, medical electronic equipment, chemical analysis devices, and semiconductors.

Long before **Silicon Valley** was a household name, the legend of computer companies being founded in garages began with the success story of Hewlett-Packard. Two Stanford graduates, **William Hewlett** (1913–2001) and **David Packard** (1912–96), founded a partnership on 1 January 1939. Some time before, they

had started working in a garage in Palo Alto, California, with an initial capital of U.S.\$538. The name of the new company was decided democratically—by a coin toss.

The first products offered by HP were electronic instruments for laboratories. Later, HP began selling test and measurement equipment to be used in a variety of fields. The introduction of the **transistor** in the 1950s spurred the growth of electronic companies, which were able to ride a downward cost spiral that continues until this day. HP was no exception: It developed rapidly and made its first public stock offering in 1957. It also began to internationalize its business by establishing offices and manufacturing facilities in Europe.

In 1966, HP introduced its first computer, the HP 2116A, which was used as a controller for other kinds of equipment. The company also entered the emerging field of desktop calculators in 1968 with the HP 9100A; HP introduced the HP-35, the first handheld scientific calculator, in 1972. Although other handheld calculators were being offered at the time, they were limited to the four basic arithmetical operations. The HP-35 could compute trigonometric functions, logarithms, and exponentials. It made the once-ubiquitous **slide rule** obsolete; meanwhile, the initial high price of the calculators made them a status symbol among engineers. The HP-35 was tremendously popular; more than 300,000 units were sold in just three years. Many engineers still active at the turn of the century have fond memories of their first handheld scientific calculators; the official **Apple Computer** story states that **Steve Jobs** (1955–) got part of the initial capital for the company by selling his HP calculator.

In the 1980s, HP started offering both personal and **minicomputers**, going head to head against the minicomputers sold by **Digital Equipment Corporation**. However, HP is now better known in the computer world for its successful family of ink jet and laser **printers**, which went on the market in the mid-1980s. Thereafter, HP concentrated its efforts in this line of products and diverse lines of handheld computers.

In the second half of the 1990s, **Intel** and HP reached a historic agreement to merge their microprocessor lines: the HP Precision Architecture and the **Pentium** family of processors. The result, the IA-64 microprocessor, may well become the new standard for desktop computing.

The new computing engine will process 64-bit words and will be compatible with older Pentium software. It will be, in fact, two computers in one.

FURTHER READING

Packard, David. *The HP Way: How Bill Hewlett and I Built Our Company*. New York: Harper Business, 1996.

—Raúl Rojas

Hewlett, William and David Packard

U.S. Engineers and Entrepreneurs
1913–2001 and 1912–96

William Hewlett and David Packard founded the first major electronic instruments company; it helped form the backbone of what was to become **Silicon Valley** in California. The company they started in a garage went on to become one of the largest information technology companies in the world. Their legendary story has been an inspiration to many of the subsequent companies founded in Silicon Valley.

Hewlett and Packard were both exceptional electronics engineers who met in the early 1930s as undergraduates studying under Fred Terman (1900–82) at Stanford University. As a graduate student, Hewlett developed a resistance-tuned oscillator. This audio device, which helped to cut the cost of measuring equipment by about 75 percent, became the basis of Hewlett's initial partnership with Packard. The two engineering classmates became friends and formed a partnership known as **Hewlett-Packard** (HP) in 1939. The company's first product was a resistance-capacitance audio oscillator based on Hewlett's design. The capital used to start the company was U.S.\$538 and HP's initial location was a small garage in Palo Alto, provided by Packard and his wife Lucile, which has since been preserved as a California State Historical Landmark. By 1940 the partners needed larger premises and rented part of a small building on Page Mill Road near Stanford University, employing their first staff to help in the production of instruments. The first important contract was the provision of audio oscillators for the groundbreaking Walt Disney animated film *Fantasia*.