EXHIBIT 6

Microcomputer-Based Expert Systems

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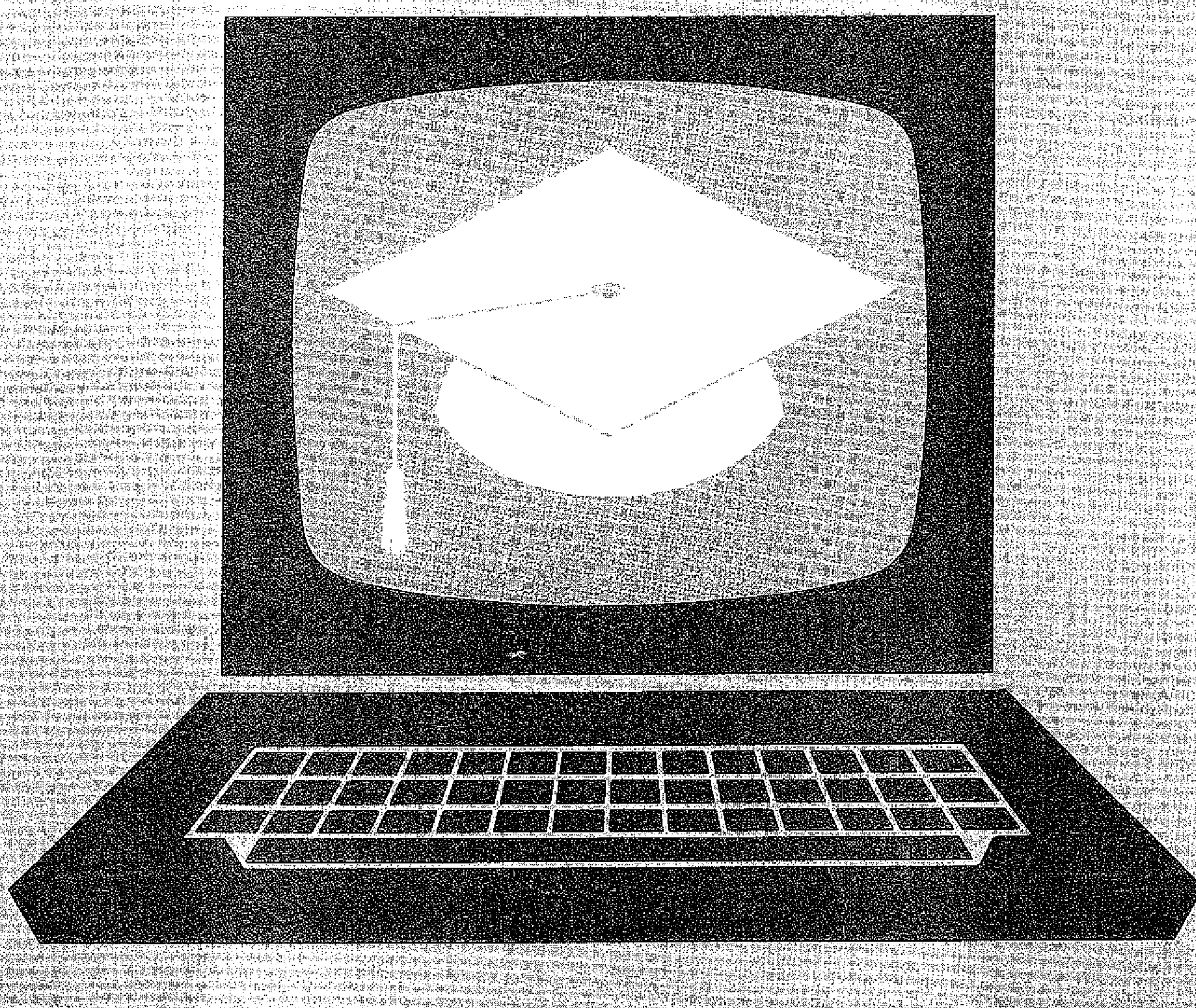

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Part I
Introduction

THE area of microcomputer-based expert systems is one of the fastest evolving components of the computer industry. Currently, the growth rate for this area, in terms of percentage increase per year, far exceeds the rate for microcomputers in general, as well as the rate of increase for the overall artificial intelligence industry. At the beginning of this decade, microcomputer-based expert systems were virtually nonexistent; by the end of the eighties, expert system tools will be in common use both in the office and at home.

The rapid evolution of this area has been catalyzed by three factors: (i) advances in expert systems technology; (ii) advances in microprocessor technology; and (iii) proliferation of microcomputers. The role of each of these factors is examined in the following.

Advances in Expert Systems Technology

The honor of being known as the first expert system is usually given to the DENDRAL system developed at Stanford University in the early seventies [6]. Around the same time, researchers at the Massachusetts Institute of Technology were developing the MACSYMA system [7]. These systems permitted inferences to be drawn in specific areas—the DENDRAL system focused on molecular structures and the MACSYMA system concentrated on algebraic areas.

An important component of all expert systems is their corpus of knowledge. This knowledge is frequently expressed in terms of facts and rules. For example:

FACT: PROFESSIONAL SOCIETIES PUBLISH EDUCATIONAL BOOKS.

RULE: IF A BOOK HAS BEEN PUBLISHED BY A PROFESSIONAL SOCIETY, AND THE PROFESSIONAL SOCIETY IS IEEE, THEN THE BOOK HAS BEEN PUBLISHED IN NEW YORK.

Contemporary expert systems are organized to hold problem-domain knowledge separate from problem-solution knowledge. The former is termed the "knowledge base," while the latter is called the "inference engine." In both MACSYMA and DENDRAL, the focus was primarily on the inference engine. Such systems are usually classified as first-generation systems. Second-generation systems distinguish between the knowledge base and the inference engine. Most currently available expert systems fall under this category. Research continues on the development of a third generation of systems with more sophisticated knowledge-restructuring and inference-drawing capabilities than their predecessors [1].

Among the different methods available today to structure a knowledge base, the rule-based approach and the frame-based approach are most commonly used. In a rule-based representation, knowledge is organized in the form of IF–THEN rules, while a frame-based system uses a hierarchical organization based on frames. At the top level of the hierarchy, the object represents a "class" or a "parent"; below it, there are "slots" representing attributes that describe the main object. These slots in turn contain additional slots or frames.

The inference engine is responsible for deciding which rules should be executed, using either a forward-chaining approach or a backward-chaining approach, and when. In the forward-chaining approach, one starts with a given set of evidence and invokes all the production rules in a sequence until all conclusions have been drawn. In the backward-chaining approach, one starts by making an assumption about the goal, and then works backward to see if any known fact or rule has been violated. If so, the assumption is incorrect. If not, the assumption can indeed be true. Additional information may be needed to select one definite conclusion.

Concepts in the areas of knowledge acquisition, knowledge representation, inference mechanisms, and heuristic programming have been studied and refined by researchers during the last three decades. In the mid-fifties, there was a utopian dream of using nascent computer technology to develop systems that would mimic human intelligence. During the next three decades, it became clear that since the computer functions very differently from the human mind, the latter is not the best paradigm for designing new generations of computers. The current thought is that while computer systems are far inferior to human beings in dealing with unforeseen problems, these systems can be infused with extensive expertise in narrow domains to match, and even outperform, human experts. Examples include programs for playing chess and software for locating hidden materials.

The harbingers of today's expert systems served two major functions. First, they helped to develop new techniques and methodologies for dealing with knowledge, as opposed to simple data. Second, the early systems helped to reduce expectations. Gradually, a consensus emerged in favor of dealing effectively with small areas of expertise rather than coming up with superficial solutions for larger scenarios. This emphasis on smaller domains and the advent of better tools and techniques led to increased popularity of expert systems.

So far, we have focused on the field of expert systems. (This field is discussed in greater depth in [1].) However, even with all the advances in expert systems, the field of low-cost systems would have remained a distant reality had the microprocessor not been invented in the early seventies. We now turn our attention to advances in the field of microprocessors.

Advances in Microprocessor Technology

The term "microprocessor" was first used in 1972. However, the distinction of being the first "computer on a