Computer-Assisted Cardiac Nuclear Medicine

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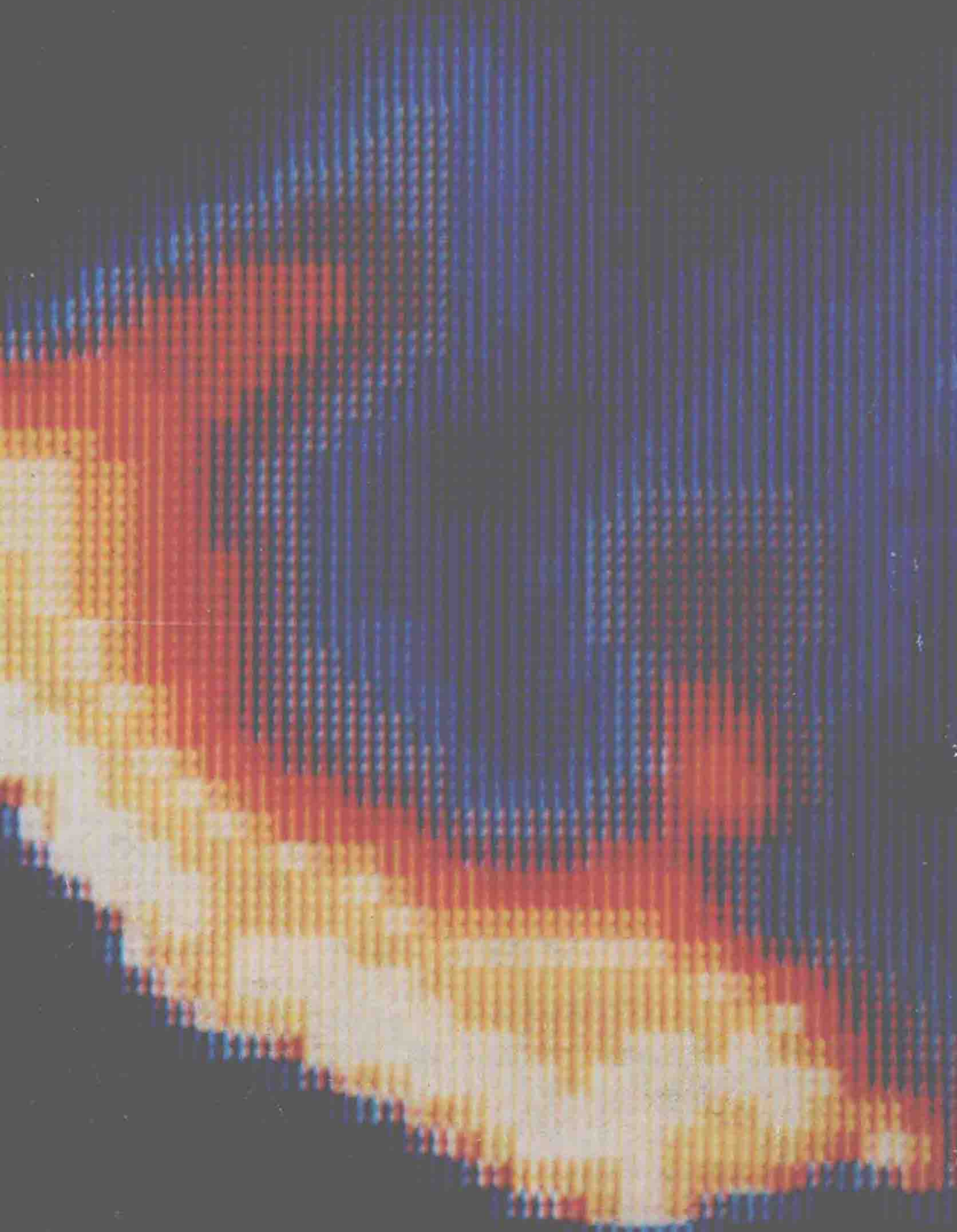

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RADIOLOGY OF THE URINARY SYSTEM

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RENAL MICROVASCULAR DISEASE

Holman & Parker
COMPUTER-ASSISTED CARDIAC NUCLEAR MEDICINE

D'Orsi
CARCINOMA OF THE BREAST

Ring & McLean
INTERVENTIONAL RADIOLOGY

TO DALE AND JANE, WHOSE PATIENCE AND ENCOURAGEMENT MADE THIS BOOK POSSIBLE

Preface

Nuclear medicine began more than 50 years ago, when Blumgart and Weiss, using radiotracers to measure the velocity of human blood flow, demonstrated that radioactive materials could be used to monitor physiologic events. Despite these pioneering achievements, diagnostic nuclear imaging lay dormant for many years due to the limitations of available instrumentation and radiotracers. Nuclear imaging procedures began in earnest with the development of the sodium iodide scintillation detector in the 1950s. The development of the Anger scintillation camera and the introduction of short-lived radiopharmaceuticals made nuclear medicine an important clinical specialty. The latest generation of computers provides us with an unprecedented degree of miniaturization, rapid data transfer rates, and remarkably massive data storage capabilities. These technological achievements have made the rapid advances in cardiac nuclear medicine – that subspecialty of nuclear medicine dealing with cardiac performance and myocardial perfusion and metabolism – possible.

Cardiac nuclear medicine is more dependent on the computer than are other areas of nuclear imaging; in fact, the computer is indispensable to cardiac imaging. It is in this specialty that the computer has become an integral part of the nuclear medicine clinical unit and the cardiac nuclear medicine laboratory, not only in major medical centers but in most community hospitals as well.

Computer science has received very little attention in the curriculum of professionals who will be performing cardiac nuclear medicine; for the most part, it is only superficially discussed in the nuclear medicine literature. This is ironic, since a thorough knowledge of instrumentation is considered a fundamental prerequisite of the nuclear medicine physician. Similarly, the nuclear medicine technologist is usually well versed in all aspects of nuclear medicine instrumentation except the computer.

Yet the use of the computer in cardiac nuclear medicine is unlike that in business or hospital administration. In those areas, the role of the computer operator is generally less interactive, less imaginative. In cardiac nuclear medicine, the computer operator is asked to perform highly interactive chores using programs which are frequently experimental, even when supplied by commercial vendors. The operator, whether a physician, technologist, or physicist, must understand the limitations of the computer and the software far more than in any other computer use. The operator must have a full understanding of the computer system. It is easy to get accustomed to operating the computer at a very superficial level, failing to take advantage of its full potential. In a field as sophisticated and innovative as cardiac nuclear medicine, this is a serious mistake.

This textbook attempts to provide the computer user with an understanding of computer hardware, software, and special techniques in cardiac nuclear medicine so that he or she can (1) make intelligent decisions about the computer system that will be purchased; (2) have sufficient knowledge of the computer system to keep abreast of innovations in computer technology; (3) write programs to provide techniques which are not provided by the commercial vendor (or at least to be able to talk to a programmer with an understanding of the limitations and capabilities of the system); and (4) determine the library of special techniques which should be available for routine and special applications in nuclear cardiology.

This book is divided into four parts. In Part I, we provide an introduction to basic computer terminology, to numbers, and to logic. Numbers and logic are fundamental to the development of computer architecture and to data manipulation using assembly language programs. The principles outlined in Chapter 2 (Logic) are also important in understanding the basic fundamentals of programming in general. This material may be reasonably familiar to you, in which case you may wish to go directly to Part II, which covers the hardware considerations of the computer system. For the most part, the information is general in nature, but cardiac nuclear medicine applications are discussed, particularly in Chapters 5 through 8 (dealing with mass storage devices, displays, interfaces, and instrumentation).

Part III, on software, provides the reader with the basic concepts of programming; it concentrates on Basic and outlines the principles of Fortran, two high-level programming languages. We recommend that Basic be learned initially by the reader who has no background in computer languages. The reader who is serious about computer programming should then concentrate on Fortran, which is considerably faster than Basic – an important consideration for many cardiac nuclear medicine applications. The serious programmer should also realize that he or she will want to turn very soon even from Fortran to a structured programming language such as Pascal or Ada. But here one must wait for the nuclear medicine computer industry to catch up with more advanced software, and for the time being it is probably necessary to rely on Basic and Fortran. Part III ends with chapters on file structure and operating systems, essential ingredients to an understanding of the way data is handled and categorized by the computer.

Part IV turns to specific cardiac nuclear medicine applications. Chapter

14 provides an introduction to the cardiac nuclear medicine techniques themselves so that the reader understands precisely what the applications are, why they are used, and when they are used. The next three chapters describe the nuclear medicine computer system; Chapter 15 concentrates on data collection techniques, Chapter 16 deals with data analysis, and Chapter 17 discusses system requirements, a topic which is particularly important for the potential customer. In Chapter 18, the special cardiac nuclear medicine techniques that are used to perform the tests described in Chapter 14 are described in detail. In Chapter 19, a very important application of the computer in nuclear imaging, tomography, is described as a separate topic. Tomography will play an important role in the future development of cardiac nuclear medicine, and the role of the computer for data analysis and processing is a critical one.

Before proceeding with Chapter 1, check over the glossary to make sure you are familiar with the terms used by computer and nuclear imaging specialists.

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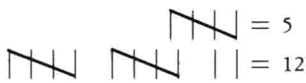
I

Introduction

1 Numbers

TYPES OF NUMBER SYSTEMS

Number systems were developed to enable us to keep track of quantities and to add to or subtract from these quantities. The first number system that was developed was a base-5 system (built around units of 5): the familiar tally marks first used by cavemen and still used today.



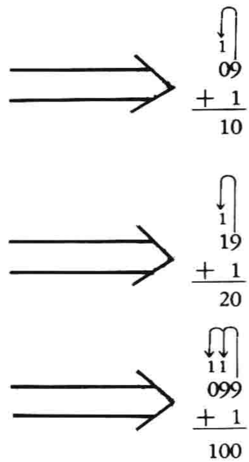
Number systems built around units of 10 probably originated with the early Egyptians and were derived from counting on the fingers. In some warmer climates, where shoes were not a climatic necessity, the toes as well as the fingers could be used for counting, and base-20 systems were developed. The Babylonians developed a base-60 number system that was adaptable to division; however, it was difficult to learn since there were 60 symbols to memorize. A truly positional decimal system originated in India and provided us with a powerful tool which has been responsible in many ways for the rapid scientific advances of the past several centuries.

Our decimal number system contains the ten symbols 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. We will examine some of the characteristics of the decimal system because they are fundamental to an understanding of any positional number system, including binary and octal (which we will discuss later), and because the decimal system is so familiar to us that its operation will be easily understood.

Counting in decimal proceeds from 0 to 9 (Table 1-1), when we run out of symbols. There are no additional one-digit symbols available to represent the next highest number, so we go from 9 to 10. But let us see what happened as we made that jump. The first column from the right (the units column) initially contained 9; now it contains 0. In other words, we have started over from the beginning in that column. The digit 1 of our number 10 is carried to the next column to the left, called the tens column. If we again count from 0 to 9 in the units column, we can again carry 1 to the tens column ($1 + 1 = 2$), resulting in the number 20 (see Table 1-1). Counting continues in this fashion until we reach the number 99. To find the next number, 9 in the units column is replaced with 0 and 1 is carried to the tens column. But we have run out of symbols in the tens column ($9 + 1$), so we replace the digit with 0 and carry the 1 into the column to the left of the tens column (the hundreds column), giving us the number 100 (see Table 1-1).

TABLE 1-1. Counting in the Decimal System

0
1
2
3
⋮
9
10
11
12
⋮
19
20
⋮
98
99
100
⋮



The operations that we have carried out here seem trivial in the decimal number system because they are so familiar to us. Since we use this system many times every day, we no longer need to think about how it works. The same operations are carried out in the binary and octal number systems except that the number of symbols is different.

We have described the operation of a *positional* number system. Some of the earliest number systems, such as the system of tally marks discussed earlier, were not positional. The Romans developed a system in which a number was represented by the total configuration of its symbols: for example, X represented 10, XI represented 11, and XII represented 12. In this system, the *relative* position of a symbol can change the value of the number (IX does not represent the same number as XI), but it is not a truly positional number system. There is no such thing as a units column or tens column in this type of number system. There is no rule for extending the number system; when we get to a number we cannot represent, we must invent a new symbol (L, C, D, M, . . .). As a result, this type of system was most useful for record keeping but was extremely cumbersome for arithmetic calculations.

In a positional number system, there is not only a unique value for each symbol but also a unique value for the position of the symbol within the