Microcomputer data acquisition and control

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Keywords: microcomputer, software, interfaces, feedback control, digital signal processing

Summary

In medicine and biology there are many tasks that involve routine well defined procedures. These tasks are ideal candidates for computerized data acquisition and control. As the performance of microcomputers rapidly increases and cost continues to go down the temptation to automate the laboratory becomes great. To the novice computer user the choices of hardware and software are overwhelming and sadly most of the computer sales persons are not at all familiar with real-time applications. If you want to bill your patients you have hundreds of packaged systems to choose from; however, if you want to do real-time data acquisition the choices are very limited and confusing. The purpose of this chapter is to provide the novice computer user with the basics needed to set up a real-time data acquisition system with the common microcomputers.

This chapter will cover the following issues necessary to establish a real-time data acquisition and control system:

1. Analysis of the research problem
   a. Definition of the problem
   b. Description of data and sampling requirements
   c. Cost/benefit analysis
2. Choice of Microcomputer hardware and software
   a. Choice of microprocessor and bus structure
   b. Choice of operating system
   c. Choice of layered software
3. Digital Data Acquisition
   a. Parallel Data Transmission
   b. Serial Data Transmission
   c. Hardware and software available
4. Analog Data Acquisition
   a. Description of amplitude and frequency characteristics of the input signals
   b. Sampling theorem
   c. Specification of the analog to digital converter

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d. Hardware and software available

e. Interface to the microcomputer

5. Microcomputer Control
   a. Analog output
   b. Digital output
   c. Closed-Loop Control

6. Microcomputer data acquisition and control in the 21st Century – What is in the future?
   a. High speed digital medical equipment networks
   b. Medical decision making and artificial intelligence

Introduction

The first electronic computer was used for data acquisition and control of artillery firing during World War II. This computer known as ENIAC (Electronic Numerical Integrator and Computer) was developed in 1946. It was the functional equivalent of today’s small handheld calculator and consisted of 18,000 vacuum tubes of 16 different types and filled most of a large room (3). In 1951 the first commercial computer (UNIVAC I) was made available and ushered in the digital computing era.

The first computer capable of real-time data acquisition was the Digital Equipment Corporation PDP-5 and PDP-8 computers introduced in 1963 and 1965. These computers were no longer solely for data processing and problem solving. They were to become the heart of the first systems that required real-time performance. (10)

The next step in the evaluation of microcomputers was the production of large-scale integrated (LSI) circuits. This contributed in the early 1970’s to Intel’s 8008 microprocessor that had the computing power and flexibility to make it suitable for real-time data acquisition and control. It was small, cheap, and consumed relatively small amounts of power. The microprocessor was rapidly implemented in a wide variety of medical equipment and has had a significant impact on medical care (3, 8, 14). Over the last five years, inexpensive microcomputer systems have been introduced for home, business and scientific use which have made it possible for many medical researchers to consider using them for real-time data acquisition and control.

The main components of a real-time microcomputer data acquisition and control system is shown in Fig. 1: a research problem; computer hardware and software; analog data acquisition; digital data acquisition; and computer control. With the ever increasing performance and decreasing cost of microcomputers the temptation to automate the laboratory becomes great. The choices of hardware and software that are available today are often overwhelming. Paradoxically most of the computer sales persons are not at all familiar with real-time applications. If you want to bill your patients you have hundreds of packaged systems to choose from; however, if you want to do real-time data acquisition the choices are very limited and confusing. The purpose of this chapter is to provide the novice computer user with the basics needed to use common microcomputers for a real-time data acquisition system.

Analysis of the research problem

Often analysis of the research problem to be solved by computer is a step that is forgotten. It is very tempting to buy computer packages which appear to be inexpensive and user friendly, advertised as ‘general systems’ for real-time data acquisition. A ‘general system’ may not meet one’s specific needs. It is critical that the needs be well defined and the intended solution be well described before one sets out to set up a microcomputer system.

The term ‘real-time’ is a very nebulous phrase. Recording body temperature ‘real-time’ may require measurements every 30 minutes. A system that successfully solves this problem may be inadequate to record and process other physiologic sig-