

**DISTANCE LEARNING ACTIVE-MODEL:  
MULTIMEDIA APPLICATIONS  
IN CONTROL ENGINEERING EDUCATION**

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## **ABSTRACT**

This paper introduces practical methods that can be used to improve the level of education at community colleges and universities. Distance learning is an option that can be widely used if technically improved. Multimedia tools can help to create an active model of distance learning, however, they depend on their usability and availability. Implemented-already examples from different academic institutions have been presented and discussed. Although this paper focuses on control engineering education, the ideas are applicable to other fields.

## **KEYWORDS**

*Computer-aided control engineering, multimedia systems, multimedia applications*

# 1. INTRODUCTION

The engineering education is rapidly developed when PC came as an available tool for all students at universities. Nowadays students are working in modeling and simulation, algebraic-excersizing and models-designing, testing and reporting, and more. The easy-use tools, such as computers, help the schools to improve the teaching quality. That means teachers could give the information without difficulties, students could understand and create their own ideas, and time is saved. Using the multimedia tools, the education level in schools must be highly improved. In [6] the main origins of control engineering education have been explained including the way of teaching, the text books, software-available, and the area of research at different schools in US, Japan, and Europe. Also they described, in detail, CACE and its facilities.

References [5] and [3] offered some techniques that might be used to improve the education level and create new streams of education technology. Also, [3] described multimedia compression and multimedia networking as an introduction to multimedia object composition.<sup>(1)</sup> In [4] the architecture of a multimedia information system based on real-time application has been introduced. Also It has explained how to derive the information-bearing content-based relationship.<sup>(2)</sup> References [9], [2], [8] and [1] are worked in the multimedia area of engineering applications and their researches are clearly in the way of education improved.<sup>(3)</sup> Reference [7] widely presented the most popular software using in education and offered the useful information to use and contact.<sup>(4)</sup> Reference [6] stated, as the main opinion of their work, that “We need ‘smart’ engineers who do control; not ‘control’ engineers”. After this study case it can conclude that “By using the multimedia, the education facilities should be improved then ‘smart control engineers’ can be recognized.

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(1) For further information, *Special Issue of IEEE Spectrum*, vol.34, no.1, January 1997.

(2) For further information, *Design for Multimedia Learning*, Prentice-Hall Europe, 1997 by Tom Boyle and *Engineering A Web Site*, *IEEE Spectrum*, Vol. 33, No. 11, pp. 62–69, November 1996 by George Jankovic and Larry Black.

(3) For further information, *Special Issue of IEEE Transactions on Education*, vol.39, no.3, August 1996.

(4) For further information, *Educational Software Is Not For Children Only*, *IEEE Multimedia Magazine*, vol.2, no.1, pp.101-102, Spring 1995 by Tina Porter.

## **2. THE ORIGINS OF CONTROL ENGINEERING EDUCATION**

The origins mean the sources or the roots so that we will deal with those origins in about 10 meanings. In general the origins of education are based on two specific items; education environment and education application. The education in control engineering itemized into two masses; one deals with control theory and other deals with control software.

### **2.1 CONTROL SYSTEMS ENGINEERING**

The main subject should be divided to sub-subjects that made the control systems engineering easy to understand. Three sub-subjects are raised; control engineering in academic level, which means at universities; control engineering in practice level, which means in industry; and control engineering in laboratories, which means both academic laboratories and industry laboratories.

*A. IN ACADEMIC LEVEL:* It has been argued earlier that control engineering education must include the ideas of dynamic system, stability, feedback and compensation. Within these basic concepts, there is a wealth of details and subtopics from which the educator must select with care to compose a control curriculum. The possibilities for topics to teach are sufficiently great that if one tries to provide a global perspective, there will not likely be time to discuss the theory on which the results are based. On the other hand, if one tries to present proofs of all theoretical results, one is in danger of giving the students many mathematical details with little physical intuition or appreciation for the purposes for which the system is designed. The educational problem arises from the fact that control, more than almost any other discipline, is based on two distinct streams of thought. One stream is physical and discipline-based, because one must always be controlling some thing. The other stream is mathematics-based, because the basic concepts of stability and feedback are fundamentally abstract concepts best expressed mathematically. This duality has raised, over the years, regular complaints about the gap between theory and practice. One argument is that the theory does not solve the real problem; the other argument is that these practitioners do not understand available theory well enough to realize that using it would make a big improvement in system performance. Kheir and his colleagues in [6] showed a complaining about the gap between the left and the right horse in a wagon team. In fact,

the distinction, or the ‘gap’ is inherent in the nature of control, and both theory and experience are required to pull the load. Control education must recognize this fact from the start. Both theory and practice need to be covered, the question is how? A rather standard compromise is to assume students coming to the control course have already had simple linear systems, including Fourier and Laplace transforms. Also assumed is understanding of electric circuits and simple rigid- body dynamics. The control curriculum typically begins with one to two courses designed to present an overview of control based on linear, constant, ODE models, s-plane and Nyquist stability ideas, SISO feedback, and PID, lead-lag and pole-placement compensation. These introductory courses can then be followed by courses in linear system theory, digital control, optimal control, advanced theory of feedback, and system identification, as well as application-specific courses in such areas as autopilot design and case studies in process control. Because control design is always rooted in some real-world problem, it is especially important to include practical experience and real-world open-ended project assignments in the curriculum. As part of control education, laboratory experience is extremely important. Reference [6] offered a statement of goals for control education that might be kept in mind regardless of the specific choice of material or the structure of the course presentation. These are

- to provide the basic for a lifetime of learning to deal with ever-new control problems, and
- to establish and maintain high standards of excellence for the experience of learning the foundations/concepts of control.

*B. IN PRACTICAL LEVEL:* As technology advances, the culture of industry also evolves, and such changes impact upon industry’s needs for educated workforce. There are several aspects of this cultural shift such as; marketplace, company focus, quality, time versus money, and production. These fundamental cultural shifts within industry have filtered down to become dramatic changes for the engineers who design, develop and build industry’s products; teamwork, cultural diversity, worker expectations, and productivity. Industry wants educators to provide technical foundations that will enable engineers to remain current and competitive in an ever changing, advancing, global marketplace. Numerous industry surveys indicate that today’s college graduates are of very high quality, but they lack hands-on experience, interpersonal skills, and basic understanding and appreciation of business perspectives beyond their technical specialties. Industry wants educators to improve the practical as well as theoretical skills of

engineers. Although there are many work skills and attitudes that benefit every engineer, there are several unique talents of control system engineers. Control system is an interdisciplinary technology that uses practical aspects of many fields. The applications of control theory are likewise diverse; vehicle control, manufacturing, automation, environmental control, economic systems, medicine, resource control allocation and management systems. Control system engineers are well equipped for the new world where diverse skills are needs. Reference [6] indicate that classical control still dominates in industry, since these techniques are well tested, easy to use and generally more understandable than modern approaches. However, a continual shift toward modern techniques is expected. Industry's predictions are that the most important fields in the next century will be intelligent control, identification/estimation, learning techniques, new CAD techniques, and computers in real-time control.

*C. IN LABORATORIES:* In the beginning, we have to specify which kind of laboratory we mean. The laboratories divided to two kinds; one belongs to schools and to be as a part of educational facilities, also it might be related to industry. The other belongs to industry such as research centers and both sponsored by government. The main purpose of laboratories, in general, is to provide the connection between abstract control theory and the real world. Therefore it should give an indication of how control theory can be applied and also an indication of some of its limitations. In doing this, the laboratory experience should reinforce the concept that analytical approaches (theory and numerical) are useful in the sense that they can accurately predict what will happen.

A control laboratory should illustrate many aspects of control engineering, i.e. modeling, identification, simulation, analysis, design and implementation. A good laboratory experiment should demonstrate important theoretical ideas

- reflect important real-life problems
- give visual and acoustic sensation
- have a suitable timescale
- be non-hazardous
- be inexpensive
- be easy to understand and use.

There are many typical laboratories such as; mechatronics, which is based on position and velocity control, process control, which is based on level and temperature control, manufacturing system, which is based on control system and logic and sequencing, and autonomous vehicle, which is based on remote control.

## **2.2 COMPUTER-AIDED CONTROL ENGINEERING (CACE)**

Computer-aided engineering tools are an important aspect of teaching, since they make it possible to significantly increase the personal efficiency in problem solving. They also make it possible to deal with realistic problems, which contribute to making teaching more interesting and more realistic. A control laboratory should have software for computer-aided control engineering. This includes numerical linear algebra, computer algebra, and data analysis and report writing. There should also be tools for modeling, system identification and control system design simulation.

*A. CACE ENVIRONMENT:* An essential feature for successful CACE software is a smart technical computing environment architecture where a user can interact with the computer and build his or her applications in a convenient way. At the kernel of CACE software is normally a collection of callable mathematical, scientific and engineering functions for delivering high-performance numerical computation required in control applications. It should also have an open architecture that easily allows a user to modify existing functions as well as add his or her own. A partial list of the available CACE software includes MATLAB, MATRIXx, ACSL, Control-C and Program CC. Of the above software, MATLAB appears to be the most popular among academic institutions. The software is a general- purpose high-performance numerical computation engine with over 500 callable kernel functions to support numerical and graphics applications across a wide range of disciplines. Its functionality is extended by toolboxes for signal processing, system identification, optimization, control, robust control, analysis and synthesis, neural network, symbolic math, image processing, statistics, etc. Its open architecture allows a third party to create his or her own toolbox where necessary. Simulink is an advanced modeling and simulation feature of MATLAB that allows a user to build block diagrams of dynamic systems through interactive GUI and icon manipulation. Simulink has over 200 built-in

block types of simple and complex subsystem icons, and allows a user to add personal custom blocks using the MATLAB language and toolboxes. Control toolbox is a basic collection of MATLAB functions that perform block diagram manipulation, system analysis and design based on classical and modern control methodologies. It covers Laplace-transform, frequency domain and state- space methods in the continuous-time and discrete-time domains rather extensively. Some of the control design and analysis tools include root locus, Bode diagram, Nyquist plots, Nichols chart, pole placements, linear quadratic optimal control and estimators, etc.

*B. ROLE OF SOFTWARE IN EDUCATION:* MATLAB assignments to students may consist of simulation analysis of system stability, effect of parameter variation, evaluation of feedback control system, transient and steady-state analysis, frequency response analysis, etc. Laboratories should be designed to challenge students to correlate observations from the simulation with the theory presented in the class. With a few lessons on the basic necessary commands and using the on-line help for the CACE software, students can progress on their own through the tutorials that accompany the software and the examples given in the class. Control applications for illustrating and exposing students to different aspects of control theory are only limited by the imagination of the instructors, scope of course and time factor. Personal computers are a learning aid or catalyst to students, whether one realizes it or not. The problems posed by laboratory assignments occupy their ability to solve control engineering problems and demonstrate them using the CACE software. The motivation and determination to succeed often find students working persistently on the computer, and learning more and more about the subject in their own time. Students usually rediscover the theory thought and discover the strong link between theory and application. The shortfalls for relying heavily on CACE software are the potential ignorance of hidden numerical computation that powers the software, CACE software's users may not need to know the details of a numerical integration algorithm as long as the software has a smart routine with variable integration step size; the deficiency of realizing the limitation of the actual physical system being modeled and simulated, a main reason for this shortfall is that control engineering curricula tend to simplify representations of systems using generic behavioral type of representation rather than physical component type representation; and the lack of practical hands-on experience in dealing with actual physical control system, a control system project requires them to pull together much of their previously acquired engineering knowledge,

including system theory, computer programming, electronics, mechanics, sensors and instrumentation, to successfully complete the control application. More importantly, the hands-on laboratory experience is the reckoning where control engineering students learn to appreciate the difference between the perfect world of CACE simulation and the imperfect world of reality.

*C. TRENDS IN CACE: Computer-aided engineering (CAE) software for modeling and simulation of physical components.* CAE software for capturing detailed models of physical components has recently been developed in the field of electrical, electronics, mechanical, thermal pneumatic and hydraulics systems, with minimal consultation with the field of control. One such software that is widely used in the industry is the Saber Simulation Software (a product of Analogy), which uses the concept of component templates for various-engineering parts. For example, its library consists of comprehensive sets of templates for off-the- shelf electronic parts (transistors, ICs etc.), generic mechanical components (motors, gears, mass, spring, dampers etc.), electrical circuits (cables, thermal properties etc.) and others. The software allows a user to construct the component diagram for a control application using the templates of the tentative physical component. The simulation can be used to evaluate the suitability and statistical tolerance of the components for the proposed design. The use of such physical (object) oriented model line and simulation should be an excellent and natural extension for many control engineering curricula. *Animated visualization of dynamic system motion.* Visualization often confirms the more abstract or hidden information that would otherwise be missed or misinterpreted. Animation is often the most natural form of visualization for simulating the motion of a physical system. Reference [6] shows that students' conceptual understanding of the simulation results and control concepts can be significantly enhanced by having them interact with real-time simulation and animation software. High-performance and high-speed interactive video graphics technology is available today, and it will only be a matter of time before the technology is utilized more extensively in CACE.

*Real-time code generation and controller hardware.* Implementation of a real-time controller normally requires skillful hardware design and software programming, as well as careful project scheduling and management. This is the reason why certain pieces of CACE software, such as Matlab/Simulink's Real-Time Workshop and Matrixx/SystemBuild's AutoCode-100, now support automatic generation of real-time code for implementing dynamic function of the system

or subsystem block developed in the simulation diagram. Such real-time software and hardware CACE support, which offer a quick mechanism to transfer theoretical simulation into actual implementation, is an excellent tool for introducing students to the world of computer-controlled systems.

### **3. THE AVAILABLE TOOLS OF MULTIMEDIA**

Multimedia systems combine a variety of information sources, such as voice, graphics, animation, images, audio, and full-motion video, into a wide range of applications. The big picture shows multimedia as the merging of three industries: computing, communication, and broadcasting. Research and development efforts in multimedia computing fall into two groups. One group centers its efforts on the stand-alone multimedia workstation and associated software systems and tools, such as music composition, computer-aided learning, and interactive video. The other combines multimedia computing with distributed systems. This offers even greater promise. Potential new applications based on distributed multimedia systems include multimedia information systems, collaboration and conferencing systems, on-demand multimedia services, and distance learning.

#### **3.1 TECHNICAL DEMANDS**

A multimedia system can store audio and video information and use it later in an application such as training, or transmit it live in real time. Live audio and video can be interactive, such as multimedia conferencing, or non interactive, as in TV broadcasting. Similarly, stored still images can be used in an interactive mode (browsing and retrieval) or in a non interactive mode (slide show). The complexity of multimedia applications stresses all the components of a computer system. Multimedia requires great processing power to implement software codecs, multimedia file systems, and corresponding file formats. The architecture must provide high bus bandwidth and efficient I/O. A multimedia operating system should support new data types, real-time scheduling, and fast-interrupt processing. Storage and memory requirements include very high capacity, fast access times, and high transfer rates. New networks and protocols are necessary to

provide the high bandwidth, low latency, and low jitter required for multimedia. We also need new object oriented, user-friendly software development tools, as well as tools for retrieval and data management important for large, heterogeneous, networked and distributed multimedia systems. Researchers are working within established computer areas to transform existing technologies, or develop new technologies, for multimedia. This research involves fast processors, high-speed networks, large-capacity storage devices, new algorithms and data structures, video and audio compression algorithms, graphics system, human-computer interfaces, real-time operating systems, object-oriented programming, information storage and retrieval, hypertext and hypermedia, languages for scripting, parallel processing methods, and complex architectures for distributed systems. Compression techniques clearly play a crucial role in digital multimedia applications. Audio, image, and video signals produce a vast amount of data. Reference [3] illustrates the mass storage requirements for various media types. Present multimedia systems require data compression for three reasons: the large storage requirements of multimedia data, relatively slow storage devices that cannot play multimedia data (specifically video) in real time, and network bandwidth that does not allow real-time video data transmission. Figure 1 illustrates storage requirements for a multimedia application consisting of various media types, compressing the images by a ratio of 15:1 and the video by factors of 30:1 and 200:1. The total storage requirement for this application becomes a little over 2 Gbytes, much more feasible than 225.5 Gbytes uncompressed. The compression techniques can be classified into lossless and loss approaches. Lossless techniques can recover the original representation perfectly. Loss techniques recover the presentation with some loss of accuracy. The loss techniques provide higher compression ratios, though, and therefore are applied more often in image and video compression than lossless techniques. The loss techniques can be divided into prediction-, frequency-, and importance-based techniques. Predictive techniques (such as ADPCM) predict subsequent values by observing previous values. Frequency-oriented techniques apply the discrete cosine transform (DCT), related to fast Fourier transform. Importance-oriented techniques use other characteristics of images as the basis for compression; for example, the DVI - technique employs color look up tables and data filtering. Hybrid compression techniques combine several approaches, such as DCT and vector quantization or differential pulse code modulation. Various groups have established standards for digital multimedia compression based on the existing JPEG, MPEG, and px64 standards.

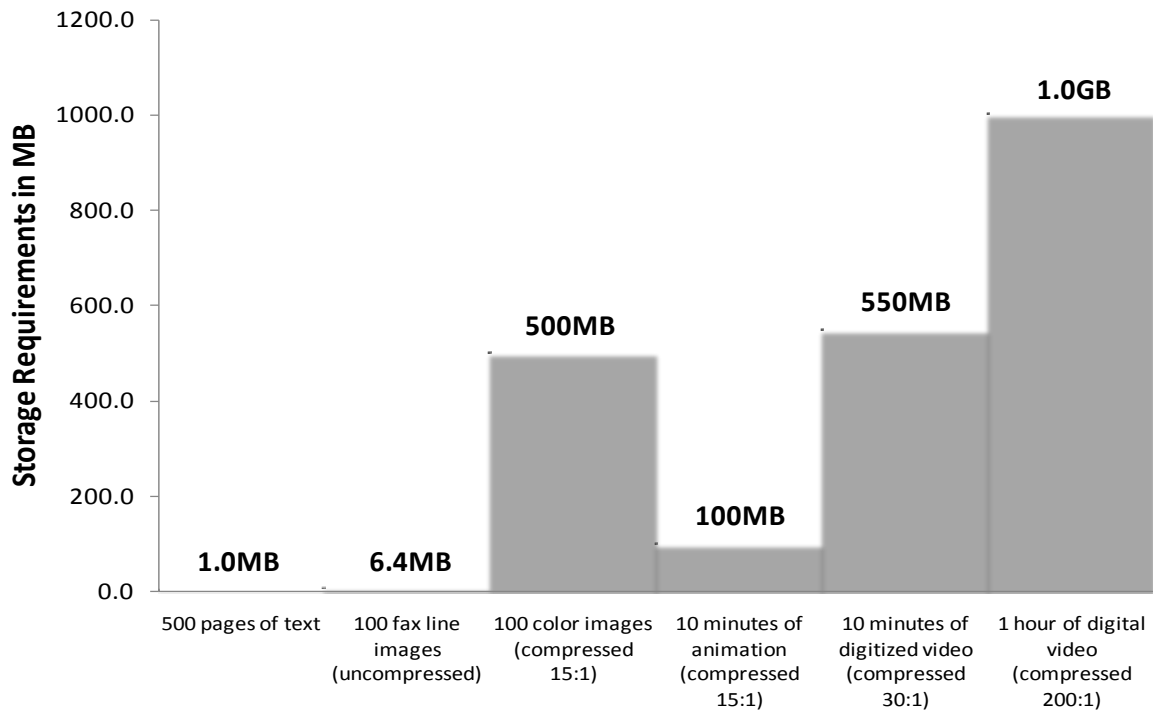


Figure 1: Storage requirements for a typical multimedia application with compressed images and video [3]

Reference [5] explains that the idea of hypermedia is to offer the user the possibility of flexibly combining information from different sources, and focusing on some specific detail he is interested in. In principle, hypermedia facilitates free association, progressing from an idea to another without predestinated fixed paths. This kind of an approach is especially suitable for studying new things. Traditionally, hypermedia applications are implemented as hypertext, where combination and manipulation of information is based on text search. This results in the efficiency problem, because all information that might be relevant in that application environment must be stored in the system beforehand, as the user's actual needs and his flow of thoughts cannot be predicted. Also in the field of control engineering, there are plenty of small scale educational programs that are based on the 'hypertechniques'. Usually, the programs are realized using the *de facto* standard development tools available in the Macintosh or PC Windows environments. The resulting products are then also very similar regardless of the application field, the contents is based on information that is stored mainly in text form. Rather than reading a book, the student scans the text on the computer screen. It is questionable whether the computing capacity is used optimally this way.

### 3.2 MULTIMEDIA NETWORKING

Many applications, such as video mail, video conferencing, and collaborative work systems, require networked multimedia. In these applications, the multimedia objects are stored at a server and played back at the clients' sites. Such applications might require broadcasting multimedia data to various remote locations or accessing large depositories of multimedia sources. Traditional LAN environments, in which data sources are locally available, cannot support access to remote multimedia data sources for a number of reasons. Reference [3] contrasts traditional data transfer and multimedia transfer. Multimedia networks require a very high transfer rate or bandwidth, even when the data is compressed. For example, an MPEG-1 session requires a bandwidth of about 1.5 Mbps. MPEG-2 through-4 will take 4 to 10 Mbps, while the projected required bandwidth for HDTV is 5 to 20 Mbps. Besides being high, the transfer rate must also be predictable. Traditional networks are used to provide error-free transmission. However, most multimedia applications can tolerate errors in transmission due to corruption or packet loss without retransmission or correction. In some cases, to meet real-time delivery requirements or to achieve synchronization, some packets are even discarded. As a result, we can apply lightweight transmission protocols to multimedia networks. These protocols cannot accept retransmission, since that might introduce unacceptable delays. Multimedia networks must provide the low latency required for interactive operation. Since multimedia data must be synchronized when it arrives at the destination site, networks should provide synchronized transmission with low jitter. In multimedia networks, most communications are multipoint, as opposed to traditional point-to-point communication. For example, conferences involving more than two participants need to distribute information in different media to each participant. Conference networks use multicasting and bridging distribution methods. Multicasting replicates a single input signal and delivers it to multiple destinations. Bridging combines multiple input signals into one or more output signals, which it then delivers to the participants. Traditional networks do not suit multimedia. Ethernet provides only 10 Mbps, its access time is not bounded, and its latency and jitter are unpredictable. Token-ring networks provide 16 Mbps and are deterministic; from this point of view, they can handle multimedia. However, the predictable worst-case access latency can be very high.

### **3.3 MULTIMEDIA SYSTEMS**

The defining characteristic of multimedia systems is the incorporation of continuous media such as voice, video, and animation. Distributed multimedia systems require continuous data transfer over relatively long periods of time (for example, play out of a video stream from a remote camera), media synchronization, very large storage, and special indexing and retrieval techniques adapted to multimedia data types. The sidebar lists a number of acronyms relevant to multimedia systems. Advances in several technologies are making multimedia systems technically and economically feasible. These advances include powerful work stations, high-capacity storage devices, high-speed networks, advances in image and video processing (such as animation and graphics), advances in audio processing (such as music synthesis and sound effects), speech processing (speaker recognition and text-to-speech conversion), and advanced still, video, audio, and speech compression algorithms. A multimedia system consists of three key elements: multimedia hardware, operating system and graphical user interface, and multimedia software development and delivery tools (referred to as authoring tools).

### **3.4 MULTIMEDIA INFORMATION SYSTEM**

A student peruses a multimedia database on the history of Rome. It contains textual information, images, videos, and audios of various buildings and people of historical interest. She applies a filtering operation based on her interest in information pertaining to Julius Caesar. This removes any entities that have no direct or indirect reference to the entity Julius Caesar. She then browses the resulting subset of information. For example, one browsing path might take her from an image of Julius Caesar in front of a particular building to an image showing the architectural details of that building to a video about the main architect of that building. After browsing, the student has a better idea of the information she really wants. She then issues another filtering operation. This results in a still smaller subset, which she again explores by browsing [4]. This scenario indicates the possible interactions with multimedia information systems we can expect in the not too distant future-if not already available. Assume the dream of information superhighways is fulfilled, and each house now wired for cable TV has the added bandwidth needed for interactive multimedia. Then the multimedia database of the scenario could exist on a

server at the local library, with each client residing on a high- definition computer/TV combination sitting in a family’s home. I expect that research in digital libraries now under way will provide the techniques needed to manage and distribute these large amounts of multisource multimedia information. Figure 2 shows a generic architecture for a multimedia information system. There are three repositories of information: a standard alphanumeric database, a multimedia object database, and a feature database. These three repositories are shown separately because they are logically independent of each other. Any implementation of this generic architecture, however, may place these repositories in a single database.

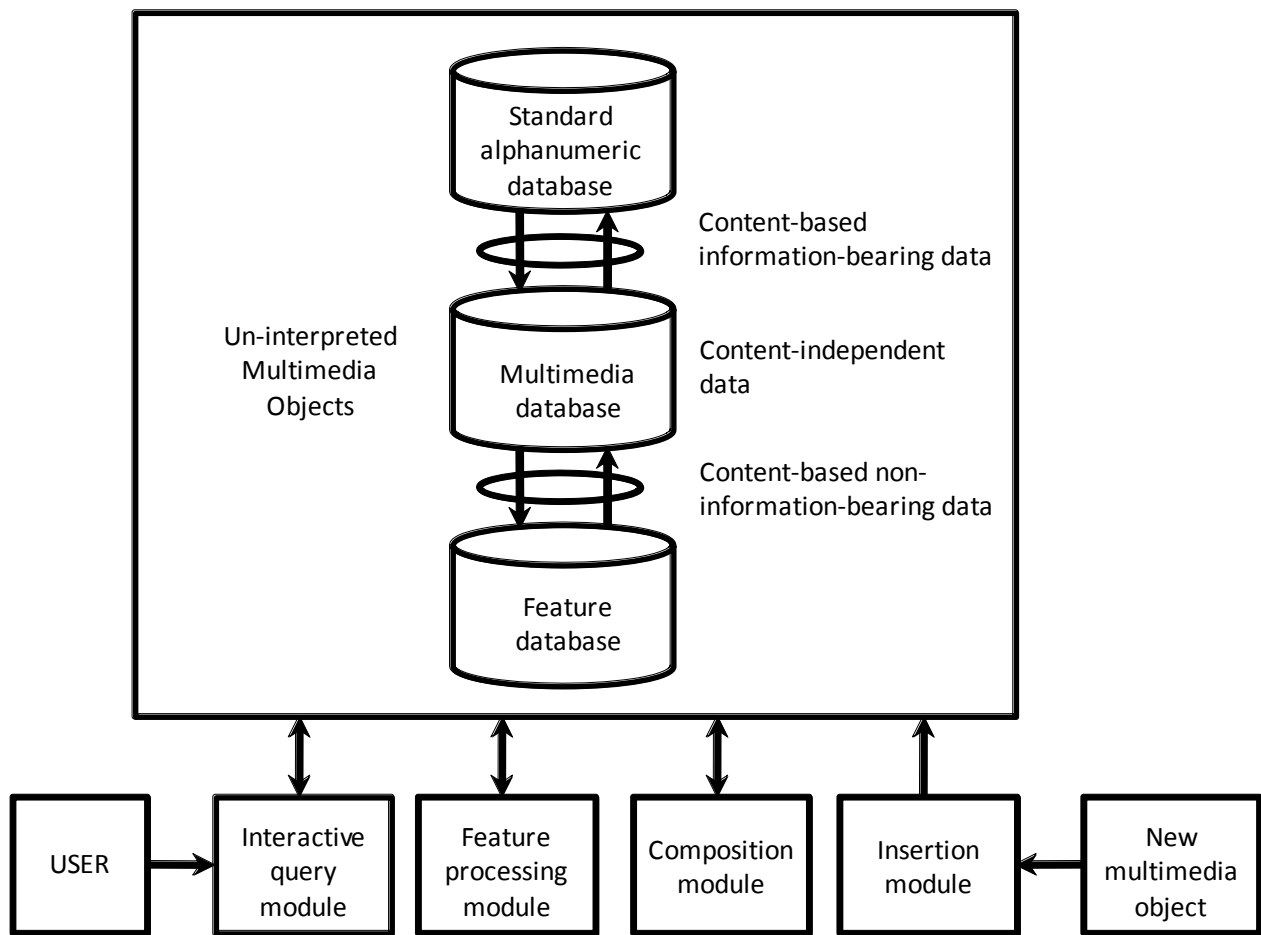


Figure 2: A generic architecture for a multimedia information system [4]

The standard alphanumeric database holds information concerning non- multimedia real world application objects. The multimedia object database contains the un-interpreted multimedia

objects, as well as multimedia-related content independent information. The feature database contains features extracted by the feature processing module and used for content-based retrieval. A composition module allows for the combination of component multimedia objects into a new multimedia object. Insertion of new multimedia objects is done using the insertion module. Note, however, that multimedia information systems are generally insertion- and query-intensive, not update-intensive. Content-based information-bearing data are represented by relationships between the standard alphanumeric database and the multimedia object database. Content-based non-information-bearing data are represented by relationships between the feature database and the multimedia object database. By navigating between the standard, multimedia-object, and feature databases, a user can process quite complex content-based queries.

### **3.5 DESIGNING MULTIMEDIA SYSTEMS**

Multimedia information system design is in its infancy, with no agreement on how to proceed. Clearly, data model design, query processing, browsing support, and multimedia composition and presentation are important. Not too coincidentally, these happen to be the topics in which most research in the area has concentrated. In [4], content-based keys are used to derive new information-bearing content-based relationships between multimedia objects and real-world application entities.

## **4. MULTIMEDIA APPLICATIONS IN ENGINEERING EDUCATION**

### **4.1 STANFORD MULTIMEDIA NETWORK**

Reference [9] described the proposed system on distributed server architecture. Figure 3 shows a general overview of the system. Besides the communications networking infrastructure, the system consists of three basic components: capture stations, video servers, and playback stations.

In addition, the system contains a database of information on courses, lectures, arid servers, plus the software needed to automate its operation. Capture stations digitize and compress analog video signals in real time and transmit the compressed video to the central server for storage and

distribution to other servers. A capture station is an off-the-shelf personal computer equipped with

- a video digitization and compression component (MPEG),
- network interface hardware connecting it to the central server,
- user interface software for initiating and terminating a capture operation, and
- Software for streaming video data to the central server.

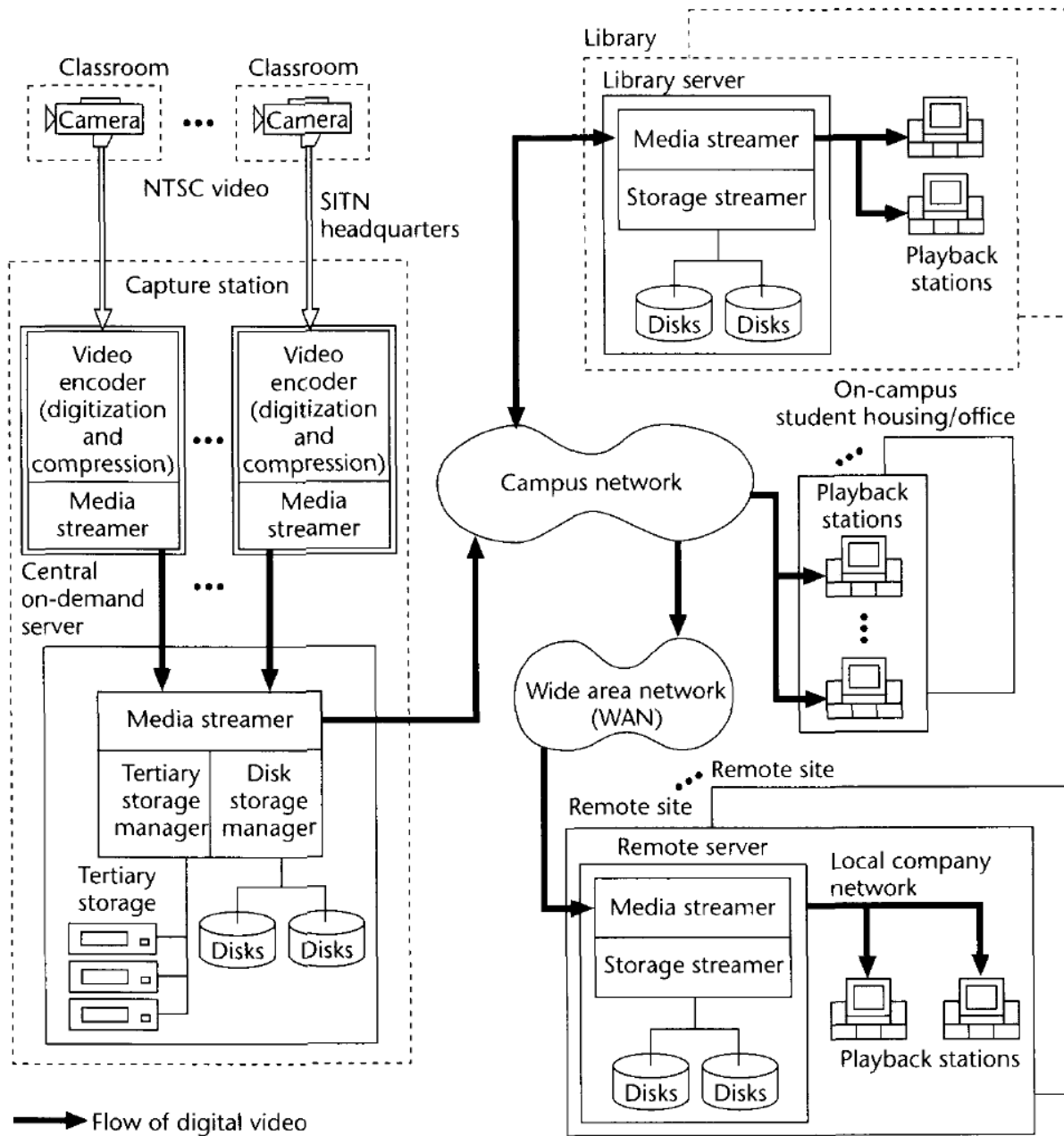


Figure 3: System overview of the Stanford Multimedia Instructional Network 'capture stations'

(From *Distance Learning with Digital Video* by F.A. Tobagi, *IEEE Multimedia Magazine*)

We chose MPEG for its quality compression, the fact that it's a standard and low-cost decoding technology.

*Video servers:* The video servers required for the system are also off-the-shelf computer systems (PCs or work stations) equipped with

- storage systems, such as an array of magnetic disks and/or tape cartridge libraries,
- network interface hardware connecting them to the same network as the one to which capture stations or playback stations are connected,
- software for managing the storage of compressed video, and
- software for streaming incoming video from capture stations and outgoing video to playback stations.

We distinguish two types of video servers by their roles in the system: the central server and satellite servers. Playback stations Playback stations are used to view the proceedings of lectures, either live or on-demand after they have been stored on a server. A playback station consists of a personal computer system equipped with a pair of speakers or headphones, a video decompression component (hardware or software), network interface hardware connecting it to the network, and software for controlling the playback operation.

## **4.2 TELE-TEACHING SYSTEM IN UNIVERSITY OF L'AQUILA**

Over distance classes (tele-classes) can be held either in an office or in an actual classroom, filled with local students. The basic structure, Fig. 4a, for tele-teaching activities should include two monitors, for fixed and moving images, respectively; two cameras, one for fixed images and placed on an Overhead Projector (OP), the other for moving images and located in the corresponding monitor structure; a Dedicated Personal Computer (DPC) Platform with related software; a graphic tablet; an audio system for voice functions. In Fig. 4b, the possible connection between a teaching classroom (teacher, equipments and local students) and a single remote classroom (remote students and, eventually, a tutor) is shown. A Multi-conference Unit (MCU) is otherwise required, if the tele-class is desired between the teaching classroom and a number of remote classrooms (multipoint system). As tele-teaching differs from multiconference due to the lack of star connections among remote classrooms, a simplified and external-to-the-network MCU could be adopted for tele-teaching purposes.

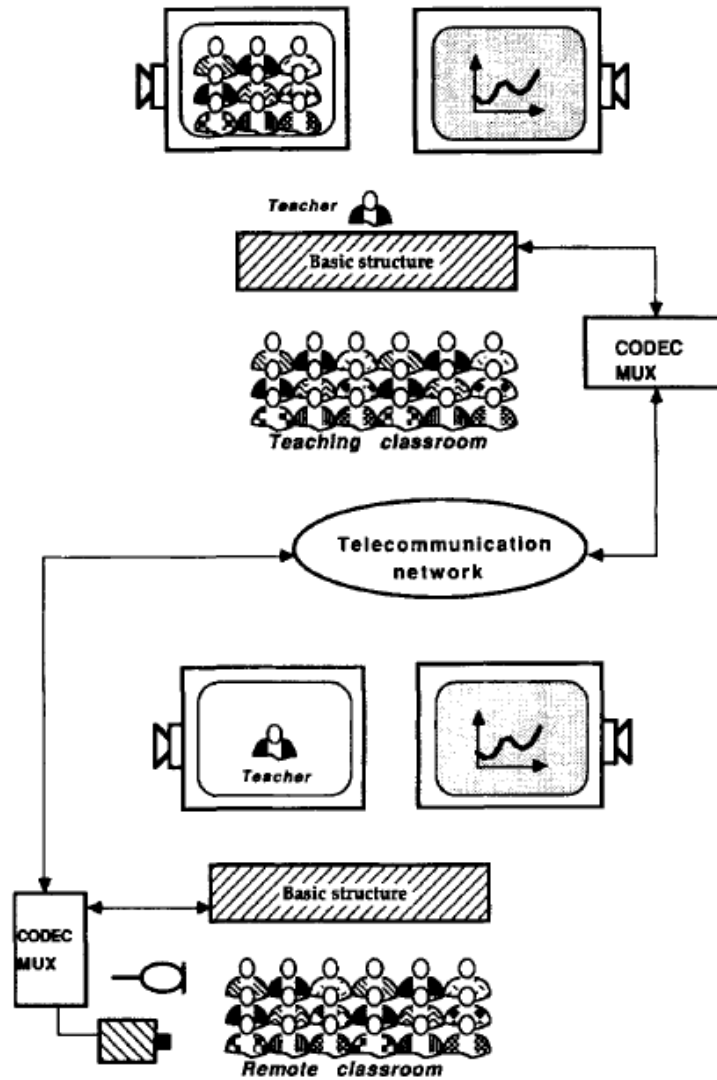


Figure 4: Office equipment for tele-teaching, or tele-conference (a);  
connection structure between two classes (b)

*(From Procedures and Classroom Architectures for the Development of Tele-Teaching Activities by E. Chiricozz, F. Mancini, G. Paladin, and M. Ruggieri, IEEE Transactions on Education)*

The tele-class procedure is similar to that of a conventional class, taught by means of an overhead projector and a set of previously prepared transparencies. In the conventional class, the teacher makes comments on the projected material, eventually overlies real-time notes and utilizes new transparencies to write, draw and develop mathematical expressions. In the case of tele-classes, drawings and pictures are generally stored in the local image bank and transmitted to the remote

one in advance. During tele-classes, the teacher can use the graphic tablet as an overhead projector. Images can be, then, recalled simultaneously in all the classrooms, by means of a proper command on the tablet, and notes can be overlaid on the images. Finally, writing is allowed over an image-free screen. Obviously, tele-writing and tele-commands are transmitted in real time. The teacher can also utilize images not previously transmitted to the remote banks and, thus, only available in the local one. In this case, image transmission time is related to the channel capacity. However, a starting visualization of the image takes place very quickly, allowing teachers comment to start soon, while the final image definition is reached progressively. Students can make questions or comments from any classroom by using the same audio-graphical tools as the teacher. The large similarity existing between a conventional and an over-distance class is more formal than substantial. In fact, the physical separation between teacher and remote students imposes a dramatic innovation in both the teaching approach as well as in the type and the quality of the material to be used as graphical support. The latter should make an optimum use of the equipment graphic potentialities as well as capture students attention properly. The additional presence of local students, beside the remote ones, has also to be considered in assessing the teaching methodology.

#### **4.3 DISTANCE-LEARNING SYSTEM IN CONTROL LABORATORY AT OREGON STATE UNIVERSITY**

Second Best to Being There (SBBT) is a network application, developed at Oregon State University, combining new and existing software and hardware to provide remote laboratory users the opportunity to conduct experiments in a local laboratory. For SBBT, the Internet provides the communication infrastructure between students and the experiments.

The experiment part of SBBT is basically unchanged from what it would be conventionally. Common experiments in laboratory are x-y positioning tables, robot arms, dc motor control and magnetic suspension systems. Criteria to consider when selecting an experiment for remote use fall into three categories: economics, logistics, and presentability. If substantial time, human, or financial resources have been dedicated to design and to build an experiment, it is a worthy candidate to make available to students via SBBT. The cost of replicating an experiment at other sites should be compared to the effort and expense of installing

SBBT, keeping in mind that most SBBT costs occur only once, while experiment replication costs scale. To share expensive or unique equipments, it makes sense to use SBBT.

The logistical considerations include:

1. remote power control;
2. safety for people and property in the laboratory;
3. ability to run without human intervention;
4. a stable start state; and
5. at least one reset position, which may be the same as the start state.

The importance of finding the proper solution to each of these concerns should not be underestimated. At each stage, from design to implementation, all the planned procedures for use and all interfaces should be reviewed. These evaluations serve not only to verify understanding, but also to provide informal training. Regardless of the type of system the controller runs on (e.g., personal computer, real-time operating system on a workstation, DSP board, or embedded controller), the ability to download the experimental control code from the remote site is mandatory. SBBT must present the results of an experiment to the remote student. If video equipment is available, consider what visual information the experiment will offer to the remote user. From watching the experiment, will the student get a good grasp of the overall behavior? For a robot experiment this is obvious. In the case of a dc motor, perhaps alterations, such as notches on the rotor, will give additional information. In general, any experiment that has movement is a candidate. Another presentability criterion, mostly for demonstration purposes, is whether the equipment is unique or interesting to watch.

*A. HARDWARE CONFIGURATION* : The basic control engineering experiment consists of the controller and the system being controlled. To make the experiment accessible to a remote student, another level of equipment control was introduced, consisting of a Motor Control Interface (MCI) and UNIX workstation, see Figure 5. The MCI provides remote power control and enables the implementation of safety features. The workstation supports network video and audio and connects the controller and the MCI to the Internet. Our hardware configuration enables overall connectivity and comprehensive safety features.

**B. MOTOR CONTROL INTERFACE (MCI):** The custom-built IVICI handles all of the safety features through basic power access. The MCI receives orders from the workstation using a separate line (RS232/R5485) from that used by the student for controller implementation. It transmits on/off directives to the experiment's power supplies. The robot motor powers on/off functions are used by normal start and stop, by the panic stop button, by the safety mats, and by the system heartbeat. The PC power on/off is used to reboot the PC when it hangs up. Because the MCI provides the ability to turn the equipment on and off, the MCI makes it possible to have the robot available 24 h a day.

**C. WORKSTATION TO PC COMMUNICATIONS:** Dependable communications between the workstation and PC are essential. All the source code and data communications occur via this link. The communication is implemented through a full-duplex RS232 serial connection. Tasks are performed by shell scripts on the workstation and corresponding batch files on the PC. By implementing these directives at the operating system level, we gained flexibility and portability. These communications are transparent to the user, who can observe the effect of his or her controller by video and audio feedback and data returned from the PC.

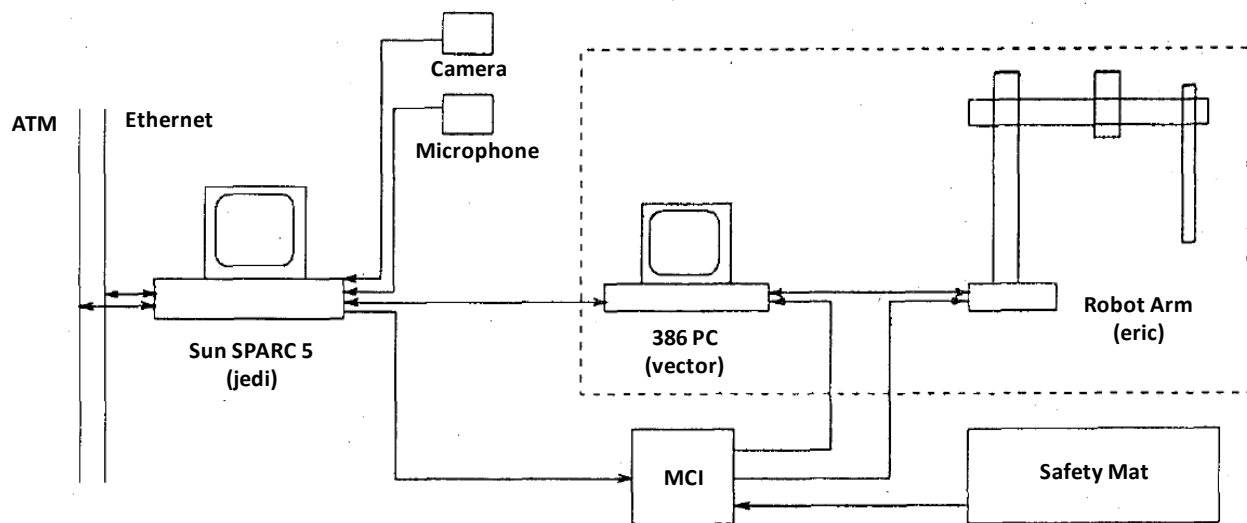


Figure 5: SBBT hardware configuration

(From *Distance Learning Applied to Control Engineering Laboratories* by B. Aktan, C.A. Bohus, L.A. Crawl and M.H. Shor, *IEEE Transactions on Education*)

#### 4.4 POWER SYSTEMS CONTROL USING MULTIMEDIA IN UNIVERSITY OF MAINE

The project will develop a multimedia, PC-based, hydroelectric power generation system simulator to interface, via real-time data acquisition and control, to programmable logic controllers. The goal of the multimedia presentation is to augment junior-level electrical power systems labs with simulation-based exercises that ‘connect’ the lab to the real world.

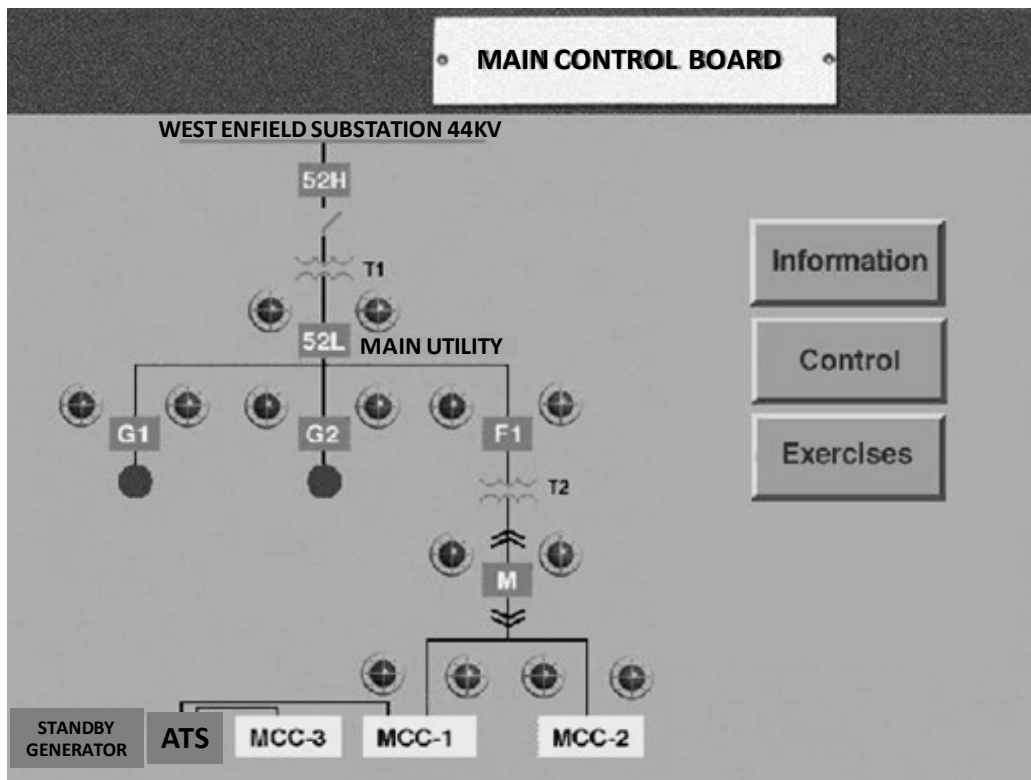


Figure 6: The power plant on-line diagram

*(From The Making of Multimedia Power Systems Control and Simulation Labware  
by J.B. Patton and P. Jayanetti, IEEE Transactions on Education)*

The simulator models the control and operation of the West Enfield hydro-generating power station. The model is sufficiently detailed to illustrate the fundamental concepts of the junior-level power system lab course, but not so detailed as to overwhelm the student. Each plant subsystem of interest is represented as a simulation module that is interconnected either to other simulation modules or physical devices via a data acquisition board. Where possible, an interface

is made to physical devices. In particular, programmable logic controllers can be programmed separately by students and interfaced to the power system simulator in much the same way they are interfaced to the real world plant, see Fig. 6.

The heart of the model is a dual synchronous generator representation written in Java. The output terminals of the synchronous machines contain three-phase voltage and current information that is fed to the metering and protective relays. The relay outputs are interfaced to the data acquisition system and fed to the laboratory PLC's. Manual or PLCoperated generator field and governor controls determine the machines' behavior. A synchronizing switch enables manual synchronization. The wye-grounded/delta power transformer is connected between the main bus and the equivalent system. The equivalent system represents an infinite bus behind the system impedance and draws or supplies real and reactive power based on the synchronous machine field and governor controls.

## **5. CONCLUSION**

The conclusion can be divided into two parts that are very important in the way of improving the level of education. First part deals with the tools that could use in that way and second part deals with the possible areas of research. The usability and the availability of tools **MUST** be taken into account.

### **5.1 EDUCATIONAL SOFTWARE**

The following software packages are available in most of universities and used by students. The educational software has been divided into two subjects; algebraic software and simulation software. Also the courses and textbooks, on discs, using multimedia are included.

*A. COMPUTER-ACCELERATED ALGEBRA:* Finding symbolic solutions to a wide variety of math problems is the terrain of computer algebra programs, which tirelessly perform long-winded mathematical manipulations and nearly always obtain the correct answer. For some years now, as engineering educators came to realize the usefulness of these programs, students have been

exploring engineering concepts, deriving formulas, and visualizing results to an extent that was formerly impractical. Several high-end computer algebra programs, including Mathematica, Maple, and Macsyma, have risen to the top. All these products have similar mathematical talents, such as the ability to solve algebraic and differential equations and to evaluate integrals. Moreover, they each have sophisticated graphing abilities and elaborate programming languages. One of the most welcome additions to these packages is a notebook-style interface that lets users combine equations, text, and graphics in a single interactive document. For educational purposes, instructors can use such interfaces to create interactive notebook tutorials on any topic. The notebook interface also encourages teachers at different universities to share problem sets and tutorials by compiling courseware libraries on the Internet. One of the dominant packages, Mathematica (from Wolfram Research Inc., Champaign, Ill.), has developed a plethora of resources for the academic market. At last count, over 60 textbooks had been written on its use in various areas of mathematics and engineering. Most of these books center on calculus and linear algebra; only a select few have been written specifically for engineers, and these were published quite recently. The scarcity of good engineering-related textbooks in print is one reason these programs are not yet widespread in engineering departments. Another program popular in the computer algebra marketplace is Maple, from Waterloo Maple Inc., Waterloo, Ont, Canada. It, too, is entrenched at many universities. It was the first computer algebra program available for personal computers and is currently in its fourth release. But such packages as Maple are quite sophisticated and as a consequence their learning curve differs little from the curve for conventional programming languages. Instructors should bear in mind that considerable work and planning is necessary to prevent students from becoming overwhelmed. Of the three computer algebra programs under discussion, Macsyma has had the least exposure in university level engineering departments. This is a bit surprising, for Macsyma, sold by Macsyma Inc., Arlington, Mass., is the first computer algebra program ever developed (1970), as well as the most mature of the three products. The recent development of PDEase, a finite- element-based solver for partial differential equations, has made Macsyma perhaps the most versatile mathematical program of all. Matlab, whose name derives from 'matrix laboratory', is the clear leader. It offers hundreds of built-in numerical functions and focused toolboxes in such areas as fuzzy logic, wavelet analysis, symbolic math, partial differential equations, and nonlinear control. No wonder it has inspired almost 150 college textbooks and is used in nearly every engineering school in the

United States, where it often replaces traditional programming languages. Instructors who want their students up and running quickly may opt for the more user-friendly MathCad, from MathSoft Inc., Cambridge, Mass. MathCad has integrated what many people regard as the most intuitive user- interface of any general mathematics program. Described by MathSoft as a ‘mathematical scratch pad’, this interface allows users to perform calculations, place graphs, and add text anywhere on screen; there is essentially no learning curve, so students start to perform practical Calculations in a matter of hours. Numerical integration, for instance, simply involves selecting the integral sign, typing in the equation, and getting the result. Although not nearly as efficient or as powerful as Matlab, MathCad still has plenty of punch for most calculations. Since the MathCad 6.0 version it has incorporated some unique features, notably, built-in electronic-mail capabilities and a World Wide Web browser. The most recent version nowadays is MathCad 15.0. Users are able to send or import MathCad worksheets through the Internet to and from other users around the globe.

*B. PROGRAMMING WITH PICTURES:* Two distinct classes of graphical software have evolved, simulation and modeling programs, on the one hand, and more general packages used primarily for data acquisition and instrument control, on the other. Notable simulation and modeling programs include Simulink (The MathWorks), VisSim (Visual Solutions Inc., Westford, Mass.) and System View (Elanix Inc., Westlake Village, Calif.) Popular data acquisition packages include LabView (National Instruments Corp., Austin, Texas) and HIPVee (Hewlett-Packard Co. Loveland, Cob.). LabView, one of the first graphical programming products, has found a place in dozens of engineering schools across the United States. Originally intended only for data acquisition and instrument control, Lab- View has evolved into a more general programming language commonly used for simulations and analysis as well. Maple has incorporated a reduced version of its symbolic kernel in both MathCad and Matlab. A relatively new product, Scientific Workplace (TCI Software Research Las Cruces, N.M.) has combined Maple with a Tex-based word processor, permitting students to perform calculations, create graphs, and include text to produce truly professional-looking documents. Mathematica has incorporated the capabilities of other applications by using what it calls Mathlink, which connects the Mathematica kernel to a number of different programs Matlab, Xrmath, Microsoft Word, Microsoft Excel, Visual Basic, Spyglass, and LabView. By availing themselves of Math- link for Matlab for instance, users can

freely mix Matlab and Mathematica commands in a single program, thereby combining symbolic and numerical strength. Many Mathematica Mathlinks, including the one for Matlab and LabView, are available over the Internet at no charge.

*C. COURSES AND TEXTBOOKS:* Although electronic textbooks are now used primarily as supplements to conventional textbooks, computers are not always available in places where students like to study, their interactive style has some distinct advantages. For example, they can give hints to someone who gets stuck, as well as suggest alternative solutions. Students can also use them as electronic reference manuals, to search quickly for examples on specific topics or to locate equations or material constants.

MathCad currently leads the league in the number of electronic textbooks utilizing its software, more than 50 interactive titles. Several classical engineering textbooks have been converted into MathCad-based electronic versions. Selected engineering titles from the Schaum's Outline Series include Electric Circuits Feedback and Control Systems, Electromagnetics, and Thermodynamics. Other engineering classics, such as Roark's Formulas for Stress and Strain and the Standard Handbook of Engineering Calculations (both published by McGraw-Hill, New York City) have also been recast into digital form. Maple recently announced a partnership with the CRC Press Inc., publishers of the well-known CRC Handbook series. Together, they hope to produce a complete series of interactive technical reference tools that exploit Maple's mathematical engine. Such classic CRC Handbooks as Standard Mathematical Tables and Formulae, Chemistry and Physics and Electrical Engineering will soon be obtainable in electronic versions. MathSource, the Web site of Wolfram Research (Mathematica's vendor), holds one of the most extensive libraries of educational course ware, submitted by Wolfram staffers and others. Located at <http://www.wri.com/mathsource.html>, MathSource contains a large collection of Mathematica packages notebooks and course ware, all of which are downloadable free of charge using the file transfer protocol (FTP). It even includes search tools for locating course ware by subject area, author's name, and organization. Much time and effort can be saved by exploring this site before developing one's own Mathematica course ware. As has already been seen, MathSoft has made one of the largest commitments to interfacing its product with the Internet by integrating a Web browser in the newest version of MathCad. MathSoft maintains its own extensive Web site at <http://www.mathsoft.com>. The MathWorks, too, maintains an

electronic library of user-contributed software and graphics tools in its case for Matlab and Simulink, at <http://www.mathworks.com>. The site has hundreds of demonstrations, tutorials, and utilities quite useful to engineering educators. Another site from The Math Works, <http://education.mathworks.com>, provides links to educators concerning anything from curricula to teaching techniques. The Internet addresses for other software products mentioned here are <http://www.maplesoft.com> and <http://www.macsyma.com> for Maple and Macsyma, and for LabView, <http://www.natinst.com>.

## 5.2 FUTURE TRENDS

After this study it could point out some of the research areas dealing with control engineering education using multimedia. Some of them created during my previous study when it recognized that the ability to create ideas, to approve theories, to construct models, and to improve the level of thoughts depend on the education facilities at schools. The research for developing the new methods of education is competitive area that really reflects the research strength and the level of education at school, and then reflects the education level in the whole society. In [6] pointed out some future trends control education coming from their experience

- more real-world laboratory experiments with novel applications;
- increased reliance on computer-aided control engineering (CACE);
- broader education of control engineers and more emphasis on interdisciplinary teamwork activities;
- closer ties between industry and academia. particularly with regard to continuing education;
- continued novelty in how textbooks in control engineering blend theory and applications for a computer-based instructional environment;
- more discussion among educators on the pedagogical aspects of teaching controls;
- continued sophistication in the laboratory (computer visualization, interactive and virtual) environment as technology advances rapidly;
- more programs expected to present newly developed concepts of control in the form of specialized courses.

In respect to the above, it is important to mention that the multimedia applications are the main future streams to improve the education level and educator capability.

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