A Preliminary Study of Current Multimedia Information Technology

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Abstract

This paper surveys more than 70 articles published in the IEEE Multimedia *journal and other journals. The survey summarizes aspects of multimedia information technology and categorizes application areas of multimedia information technology and interesting research areas related to it.*

Key Words: Multimedia, Information technology.

1. Introduction

A new field has emerged from information technology in recent years that is multimedia information technology. This field, although still relatively new, has found its position and demonstrated its power to manipulate data/information in integrated and more natural ways in many applications. The development of this integrated technology has also opened many new research fields for computer and information science.

A preliminary study was performed in the multimedia technology field. The study results are discussed with the hope of providing some useful information.

Section 2 gives an informal description of multimedia information technology. Section 3 discusses the aspects of multimedia information technology. Section 4 provides examples of the application areas of multimedia information technology. Section 5 discusses some interesting research areas of multimedia technology, and Section 6 presents conclusion remarks.

2. What is multimedia computing/technology

In defining multimedia computing/technology, we will apply the ideas of *IEEE Multimedia* editor-in-chief R. Jain [1] to our study.

An important part of human civilization has been the process of information gathering, manipulation, and application. From ancient times, our ancestors found information about food resources and used it to hunt or plant. More recently, we have found information on how to construct a Web site, build the site, and then use the information on the Web sites for many purposes. We gather, manipulate, and apply information in all aspects of our life. Information has been an important asset since the beginning of human civilization.

"Information comes to us from multiple disparate sources. We use our senses to acquire information directly from our surroundings, and we read books, listen to other people's experiences, look at pictures and maps, and watch movies." [1] In other words, we gather information from different sources; that is, information sources have the nature of multimedia.

Individual multimedia technology has existed long before this terminology became popular. Our ancestors drew pictures in their caves probably before they invented written symbols. Motion picture technology was invented in the late 19th century. However, only recently have "Technological advances... made storage and communication of image, audio, and video information possible." [1] In other words, the advance of individual multimedia manipulating technology provided the precondition for conceiving of multimedia information technology.

What is the key technology or event that characterized the birth of multimedia as a specialized field? "Processing of all these forms of information using digital technology let us bring all these disparate sources to one platform." [1] Digitization of different media forms is the key technology for the characterization.

A more direct description about multimedia information technology was made by Jain: "Multimedia computing deals with storing, communicating of information using disparate, complementary, and natural modes." [1]

"Natural modes" give a higher level of comprehension about multimedia information technology because the nature of information is multimedia. "Multimedia computing/technology involves incorporating the modes of information naturally used by humans into computing." Multimedia information technology provides a natural way to deal with information, but it is not a simple incarnation of "naturalism." Multimedia information technology incorporates many achievements in science and technology that bring human civilization to a new height.

DISCLAIMER

3. Aspects of multimedia computing/ technology

In this section, we discuss aspects of multimedia information technology. Some of these aspects are specific to the field, and some are common to all types of information technology.

Multimedia: Multimedia information technology deals with multiple representations and modes of information (e.g., text, numerical data, image, video, audio, and computer generated graphics). As a result, this technology needs different types of hardware and software.

Huge volume of data: A huge volume of data is needed for image or video information. "At a full-motion playout rate of 30 frames per second, a 30-minute video would require more than 50 Gbytes of storage." [2] This makes a crucial space demand for the multimedia system, which requires video data manipulating. At the same time, real-time delivery of a huge volume of data requires very high throughput. "For example, with QoS (Quality of Service) levels of 24-bit color, 640 x 480 resolution, and 30 frames-per-second (fps) playback, must guarantee about 200 megabites per second (Mbps) throughput for the uncompressed visual stream alone." [3]

More demanding networking capabilities: Today's information systems are likely to be connected to a network, as are multimedia information systems. This naturally puts a high demand on network capability in terms of bandwidth, transmission rate, different browsing technology, etc.

Synchronization: New synchronization mechanisms are needed for multimedia information systems. For example, the audio data stream must be synchronized with the corresponding video stream in a video playback program. Different video objects in the same scene of a virtual environment also need to be synchronized.

Different converting/compression technologies: Encoding, decoding, and/or compressing image data files are very different from encoding, decoding and compressing a text file. Moving pictures need different encoding and decoding techniques than those techniques used for still images. Audio encoding/compressing techniques will have totally different characteristics than those for video data.

New ways of interaction: Multimedia information technology introduced new ways of human-machine/human-human interaction. Participating in the interaction is not only through graphical user interface (GUI) components; in many cases, the entire system is designed and implemented specifically for interaction. Examples of these types of systems are the virtual reality (VR) systems, or virtual environment (VE) systems, etc.

System and system modeling: System modeling is a common aspect of all information systems and even of other systems (such as manufacturing systems). However, multimedia information systems require different types of system modeling because of their specific characteristics.

Information and information modeling: Information/ data modeling is a common aspect of information technology, but multimedia information/data modeling needs to be extended to include its special multimedia aspects.

Interoperability: Interoperability means cooperation through distributed, networked computer systems that share data and technology across paths, equipment, and services -- a common aspect of many information systems. However, the synchronization mechanism and communication protocol needed to support interoperability of multimedia capabilities need to be enhanced or extended.

Global information exchanging and cooperation: Multimedia information technology opens a larger opportunity for global information exchange and cooperation. Multimedia information technology allows easier understanding among people from different cultural backgrounds. However, this also creates challenges to put the development of this technology into a global picture.

4. Application areas of multimedia technology

Applications of multimedia information technology can be found in most areas of modern life. This section categorizes these application areas based on only those areas published in *IEEE Multimedia* journals.

Education

Application of multimedia technology in education ranges from software to system. Educational software includes software for children, such as games and stories, and for the general population, such as history, science, and health care[4]. Distance learning systems [5, 6] use video conferencing and other multimedia technologies to provide distanced, real-time teaching and learning. Special-purpose systems are also designed, such as systems to help hearing-impaired children to acquire various communication skills simultaneously: sign language, speech, fingerspelling, lip reading, reading, and writing [7]. There are network-compatible multimedia medical training materials [8] and new electronic conference proceedings [9] utilizing not only agenda and paper text and graphics on CDs but also presentation slides, video, and audio records.

Science -- research and practices

Virtual reality technology has been used for scientific and engineering research. Argonne's CAVE (Cave Automatic Virtual Environment), one of four such sophisticated virtual reality systems, gives scientists the ability to correct design problems, and modify experiments before committing to a final procedure [79]. Multimedia technology is applied to visualize neuronal activity in the brain [10], to share radiological image databases [13], and to support cooperative medicine [15]. A Multimedia home-healthcare support system utilizing artificial intelligence (AI) technology is developed for the domain of childhood leukemia [14]. A multimedia system was also developed to preserve traditional medical knowledge by recording oral traditions disseminating healing practice [76]. Interactive multimedia technology is applied to sophisticated geographical information systems (GIS) [12] and to ecological applications and general purpose spatial information systems (SIS) [16]. There is a multimedia system created as platform for "multiloguing" that serves as a forum for discussion and social intercourse among multiple ethnographers [11].

Industry/manufacturing

A Web-based multimedia system for microelectronics (integrated circuit) fabrication training has been developed to cover diverse series of physical and chemical processes including oxidation, photolithography, diffusion, metallization, etching, and ion implantation [17]. This example has a dual purpose, that of educational application. The industrial process controlling has many uses for multimedia, from incorporating diverse imaging sensors to visualizing, monitoring, and controlling time-critical processes. Study has been done on general requirements and technological components of industrial control systems, and implementation of the study, Mercuri, can be used for precision-coating applications [18].

Communication

The editor-in-chief of *IEEE Multimedia* envisioned a future communication conception called Telepresence [19]. Telepresence allows a person be virtually present at a remote place and to participate in an event, for example, a meeting. The merger of virtual reality television, 3D technology, and networking will make this conception a near-term way of communicating. At present, e-mail is an important means of communication among people with access to a computer network. Conventional e-mail contains only text data/information. What about implementing multimedia e-mail, which has undergone research and even standards [20].

Commerce

Commerce on the Internet is not news any more, as many instances of commerce can be found on the Internet [21]. However, research and development can improve the existing commerce. A study on the objectives of electronic advertising and the consumption model for electronic ads has been done [22]. With well-defined objectives and a driving consumption model, electronic advertising is to be implemented in a "new look."

Office automation

Video conferencing has become more and more popular for interoffice communication. Videoconferencing incorporates many aspects of multimedia technology, including video, audio, and networking [5]. Besides video conferencing, multimedia technology can be used for supporting flexible working and/or CSCW (computer supported cooperative work) practice. "Flexible working lets employees perform tasks with computers no matter where, when, or how they work." [23] Interactive virtual office systems are created for social communication and collaboration such as, "Oxygen" [24]. "Users log into Oxygen and appear in their personal 'room', a two-dimensional graphical space with a photorealistic background image. From there they can travel to other people's spaces or to shared rooms. Wherever they go, their icon, usually an image of their face, appears along with the faces of other visitors."

Entertainment

Multimedia technology plays a center role in entertainment. All forms of entertainment use multimedia, including TV, movies, and live performance in theaters and opera houses. Modern multimedia information technology provides new ways to create and deliver entertainment services. Video on demand delivers video programs to users homes through either network [25] or cable line [26]. Producing movies is expensive because large costs accrue when scenes are created. Multimedia information technology provides cost-reduction methods to create movies and/or TV/video programs. Virtual studio or digital studio is one of the solutions [27,28]. There has been study on the "cinema of the future", proposing a system architecture for distributing movies and live video electronically over broadband digital network to future cinemas and for playing back the digital films there [29].

Government

Intelligent transportation system (ITS): The Federal Highway Administration (FHWA) and many state agencies such as the Illinois Department of Transportation (IDOT), Georgia Department of Transportation (GDOT) have initiated ITS developments [30]. Foreign countries such as Japan also have these type of initiatives [31].

Multimedia document systems: Hypermedia and multimedia technology have found extensive application for building document database and retrieval systems. For example, Argonne National Laboratory has built the Facility Profile Information Management System (FPIMS) [81] for the U.S. Department of Energy (DOE) for storing environment, safety and health related DOE documents and the Human Radiation Experiment (HREX) document system, etc.

Video arraignment: Multimedia information technology has also been applied in our judiciary system [5].

Gun shot location system (GLS): GLS helps the police dispatcher locate gun shots through distributed sensors and a central display system [32]. Another geographic information system is used by the Department of Housing and Urban Development and the National Institute of Justice. This system monitors 911 calls to determine how space and environmental facts affect crime [32].

International computer-supported cooperative work

A system to allow multipoint, multimedia, transcontinental computer-supported collaborative work (CSCW) has been developed [33]. This system supports real-time multimedia communication that incorporates video teleconferencing facilities, CSCW and multimedia document storage, editing, and exchange through hybrid network connections.

Other international activities related to multimedia may give readers a global view of development in this field.

The Commission of the European Communities (EC) plays a important role in multimedia and telecommunications development in Europe [34]. The current round of EC research and technological development (RTD) programs will provide $16 billion from 1994 through 1998. Projects fall into 15 key areas, from information technology to socioeconomic research. A new EC Multimedia Task Force will specialize in multimedia research.

The National Infobahn (or information superhighway) efforts are being undertaken in many Asian countries and

regions, such as Singapore, Hong Kong, Malaysia, China, India, south Korea, and Taiwan, and in Australia [35]. "The state of Infobahn in Asia very much reflects the existing economic stratification" according to Sharma [35].

5. Research areas of interest to multimedia information technology

In this section, we discuss some interesting research areas in the multimedia information technology field and give examples for each area. Because of the space limitations and the type of the survey, each area is summarized briefly by pointing out its position and/or characteristics.

New hardware technologies

Hardware development is the material base for the development of multimedia technology. High-speed, multiprocessor CPUs provide the key technology for processing huge volumes of data which is crucial for multimedia data processing. In the early 1980s, image processing tasks could only be performed on supercomputers; much smaller workstations were used then for this type of task. The new generation of home PCs can now perform this task. The speed of the development of high-capacity data storage, such as optical disks, recordable CD-ROMs, and high-density hard disks has not yielded to the speed of the development of the CPUs. Other new peripherals, like high-resolution, high-speed, large-screen color monitors, printers, and scanners; new networking hardware, like high-speed modems, cable modems; and new accessory boards like sound boards, video boards, computer/TV converting boards are blooming like spring flowers.

Hardware advances rely heavily on the development of many scientific disciplines such as physics, chemistry, material science, electronics, etc. At same time, computer/information science plays an important role. Many areas of hardware development are done by computer or information scientists, for example, research on algorithms to improve disk access speed [36], and an analytical model for obtaining the cost of storing video files and solutions to reduce the cost [37]. Here, the term "hardware" carries a broader meaning than just "peripheral systems."

System configuration and software system modeling

System configuration and resource allocation: For large distributed client-server systems, system configuration is no longer an easy task. How to configure hardware and software components is a research topic that needs much attention and effort. A study on cost-based program allocation for distributed multimedia-on-demand systems has been conducted [38] "to place the various movies in an economically efficient way at the system's various video servers." Another more general example is the "Three-Tier Computer Architecture" adopted by Forte, an international software company. This architecture divides distributed client-server systems, including hardware and software, into three partitioned parts or tiers, namely GUI, application business logic, and data access functions. To apply this seemingly simple partition to a specific system design, much careful study is needed.

System component modeling and system behavior modeling: System components are the static nature of the system, and the behavior of the system is the dynamic nature of the system. Modeling of these two characteristics of a software system is normally done at the same time. Many modeling languages such as Visual Language [39] and UML (Unified Modeling Language) by Rational Software [80] try to define both system components and system behavior by letting users model both multimedia objects and corresponding operations. Some of the modeling formality requires use of grammar type of syntax, such as Video Algebra [40]. Some models use mathematical formulas [41]. Mathematical modeling can provide a more accurate quantitative way to model the system behavior in many cases.

Temporal/schedule modeling plays a central role in behavior modeling. A playback scenario and SORT (scenario object rendering time) graph were used to model the scheduling of a video-audio playback system [42]. A methodology using extended Petri Nets to model the scheduling and synchronization behavior of a distributed multimedia information system was proposed [43].

Agents can be used for modeling the general behavior of any information system, including multimedia information systems. An agent is one type of software component that can be characterized as one or all of the following: (1) operates autonomously, interacting with other agents -- including humans -- through communications; (2) reactively adapts to changes in an environment; and (3) proactively exhibits goal-directed behavior [23]. How to make an agent more intelligent continues to be a general research topic in computer/information science.

The finite state machine, although an old concept in computer science, is still a good way to model software with a deterministic nature. Multiple finite state machines were used to model the behavior of a multimedia system for interactive television (ITV) applications [44].

New operating system: Some of the researchers proposed new operating system to accommodate the special aspects of multimedia information systems, with emphasis on scheduling [45].

Information modeling

Information modeling can be part of system components modeling. However, many researchers devote separate efforts to model information. The most well-known effort of this kind is object-oriented information modeling. From another point of view, system behavior can also be considered as certain type of information. Therefore, many of the methodologies used to model systems can also be used as information modeling methods independent of system considerations. For example, the spatial and temporal logic representation in visual programming [41] can be used for more general purposes.

Multimedia databases

Multimedia database research is an extended area of general database research. This area can also overlap substantially with system and information modeling research. Multimedia information technology requires more challenging research so that its multimedia nature is included.

Video and audio data/information indexing techniques are challenging research topics involving difficult areas such as speech recognition and/or video classification [46].

Comparison of text data with image data for querying or retrieval of multimedia objects is difficult. Supportive information needs to be provided in some way. In [47], a "knowledge-assisted context-based" retrieval approach was proposed by providing "domain knowledge," which describes how the system views the target multimedia data for context-based retrieval.

Information structuring or organization in multimedia databases is also a relatively new topic. In [47], the object-oriented data model MORE (multiple objects relationship) schema was used to organize the data. This schema considers two kinds of hierarchy to manage the relationships among classes: class hierarchy and aggregation hierarchy.

Some research on modeling hypermedia databases has been done. The Dexter model [48] organizes a hypermedia database into three layers: storage layer, which contains a network of nodes and links; within-component layer, which contains the content/structure inside the node; and run-time layer, which contains the presentation of the hypertext (or hypermedia). The Dexter model emphasizes the storage layer but does not specify the structure inside the within-component layer. The Amsterdam hypermedia model [49] extended the Dexter model by adding time and contents to the Dexter model.

Taxonomy is a important part of any information modeling/structuring. A taxonomy based on media type and media expression has been proposed [50]. There are three categories under media expression: elaboration, representation, and abstraction.

New networking technologies

The current multimedia applications demand at least 1.4 Mbps per direction even for compressed video data. There are other more demanding requirements for networks by multimedia applications such as transmission delay, multipoint communication, reliability, etc. Stuttgen [51] did an evaluation on the requirements of multimedia application to network technologies. Some results from this study are listed below.

Ethernet: Because of the lack of delay guarantees, Ethernet is not a good network for distributed multimedia. However, it provides enough bandwidth for a few streams plus a multicast function, which makes it suitable for experimental setups with a limited number of stations.

ISDN (Integrated Services Digital Network): ISDN can be bundled to provide up to 2 Mbps bandwidth. It is currently the only available choice for interactive wide-area multimedia communications aside from leased line services. The lack of multicast services restricts ISDN to point-to-point rather than distribution or multiparty conferencing environments.

ATM (asynchronous transfer mode) **technology**: According to many researchers ATM is the next logical step in network evolution. An ATM network based on twisted pair (UTP-3) cabling can provide 25 to 51 Mbps bandwidth. It can also provide less than 10 ms transmission delay and multicast functions to meet the network demand of multimedia applications.

Many ATM-related researches and implementations have been done along with other multimedia information technologies. Some studies incorporate ATM network connections to allow effective delivery of the network's high bandwidth to the processing, controlling, and/or storage subsystems in different applications [52,53,55]. Some studies proposed a detailed model (e.g. QoS Broker [54]) to manage QoS in ATM network connection.

Other researches related to networks include gateways between the implementations of different standards [56].

Standardization

Data formatting: Many standards related to data formatting, coding/decoding, and compressing have emerged for multimedia information technology. The International Organization for Standardization (ISO) has three groups working on creating coding/decoding standards for multimedia data stream. The Joint Photographic Experts Group (JPEG) defines compression algorithms/or codec methods for still images. The Moving Picture Experts Group (MPEG) defines the compression and interchange format for motion pictures, including audio [57]. Other works include the International Communications Union's (ITU) H.261, Intel's Digital Video Interactive (DIV) [51], and ISO/ITU's Abstract Syntax Notation One (ASN.1) [58].

Information modeling: Information encoding standards define the interrelationships between different pieces of multimedia presentation and, in some cases the logical structure of the multimedia information/data. The Multimedia Hypermedia Experts Group (MHEG) of ISO has been working on the standard to define system-independent encoding of the structure information used for storing, exchanging, and executing multimedia presentations [57]. An earlier standard created by another subcommittee of ISO - SGML (standard generalized mark-up language) - defined a general or abstract syntax for multimedia, mainly for hypertext, logical and layout structure. The Hypertext mark-up language (HTML) used on the Web is one of the reference concrete syntaxes of SGML.

System modeling: Some standards are for modeling multimedia systems. The standards mentioned above such as MHEG and SGML (and its concrete forms) can also be used for modeling certain features of a system, but they may not be able to capture all the dynamic features of a multimedia system. New standards being created for modeling systems include dynamic features. HyTime is "a standard neutral markup language for representing hypertext, multimedia, hypermedia, and time-based documents in terms of their logical structure by extending SGML." [59, 60] Documents represented in HyTime conform fully to the ISO standard SGML. An emerging standard for multimedia presentation called Premo originates from the object model [61]. Premo emphasizes the ability of objects to be active, primarily to meet the need for synchronization in multimedia environments. Research has also being conducted for "an open architecture for digital communication systems" that emphasizes adaptability to evolving standards, reprogramming, modular upgrading, etc. [62].

Scripting language: Scripting language standardizes the framework for implementation of multimedia applications. The same group responsible for SGML and Hytime is developing the standard multimedia/hypermedia scripting language (SMSL). SMSL is a standardized mechanism for

embedding scripts in SGML hyper-documents. MHEG II has considered the use a reference script language for example decodings [63].

Network standard: IEEE standard 802.9 for multimedia in a local area network is a physical layer standard that incorporates an ISDN phone system with LAN-based Ethernet for mixed data transmission. [64].

Videoconferencing standards: Videoconferencing standards have emerged, such as ITU's H.320, T.120, H.323, and H.324 [5].

Media data/information converting technologies

Speech recognition and audio classification: Speech recognition and audio classification are challenging research topics because a rather simple perceptual characteristic could correspond to very diversified acoustic parameters. They also include the topic of natural language recognition. Researches on audio classification, searching, and retrieving have been done. One study [65] proposed an approach using a classification engine and a class knowledge base. The classification engine reduces sounds to perceptual and acoustical features. Features of classes learned by the classification engine are stored in knowledge base for future comparison/reference. The study on videoconference indexing [46] proposed paradigms for indexing videoconferences and implementation system architecture.

Compared with audio classification and speech recognition, speech synthesis could be considered easier if one does not care about the richness or character of the output pronunciation. Many applications use synthesized speech [66].

Motion analysis in digital video: Video classification and motion analysis in digital video recognize objects or movement of objects in image and video data stream. This research area presents difficulties similar to those presented by voice recognition research. One object can have thousands of pixels with different characters (e.g., color or intensity), and the same type of pixels can appear in completely different objects. Research activity has been done by using the MPEG video encoding scheme to analyze motion in digital video [10].

Encoding, decoding, compressing: Some of the standards discussed above define the format and/or algorithms to implement the codec process. The codec processes can be implemented as software-only or hardware-assisted. "Hardware-assisted codecs provide substantially better image quality and better coding and playback performance compared to software-only video codecs." [67] There is some research on converting methods between different formats [2] for special needs. Some discussed the theory behind the MPEG/audio compression algorithms [77].

Methodologies, frameworks, and paradigms

There has been much discussion within the research community about methodologies, frameworks, and paradigms for software engineering and information system development since large-scale software engineering is a very complex and challenging process. Adopting and understanding a unified methodology/framework/paradigm by all the participating engineers are the keys to cost-efficiency, reliability, and reusability. This is more serious for distributed multimedia (DMM) application development.

The approach proposed in [68] aims for an encompassing framework of tools and services unified by a common paradigm such as "distributed object-oriented programming" for DMM applications.

Presentation issue

It seems that all the issues related to multimedia can be seen as a presentation or human/machine interface issue. However, there still are some issues directly related to how to present multimedia material, such as color, dimension, background, character size and font, etc. Some research has been done in this area [69].

Optimization of resources allocation and evaluation of system performance

QoS is a broadly adopted term. According to [70], "quality of service represents the set of those quantitative and qualitative characteristics of a distributed multimedia system necessary to achieve the required functionality of a application." The QoS of a given system is expressed as a set of parameter-value pairs. QoS parameters can be categorized as performance-oriented, format-oriented, synchronization-oriented, cost-orient, or user-oriented. QoS is not only the measurement of system performance. In a more broad meaning, it defines the functionality set to achieve these performance measures for a system.

Some QoS parameters can have a trade-off relationship with system resources. QoS management plays an important roll in multimedia information systems. Many researches have been done related to this area. Some proposed specific QoS management system or component [3,54]. Some proposed mapping QoS parameters between different layers [54] and/or building QoS assurance into scripting language [44].

Information and/or system security/intellectual property rights

The security of information and system is an important and sometimes hard-to-tackle problem for both multimedia and text/numeric-only systems. There may be some special areas for multimedia only. For example, how do you encrypt an image? On the other hand, multimedia may also provide some special solutions with regard to information security or copyright issues [71].

Interactive multiuser virtual environment

Virtual environment, virtual reality, and virtual participation can be seen as application areas of multimedia information technology. They also open up some specific research topics since some sophisticated human-machine-human interaction issues are associated with these areas. Many researches have been done in these areas. Some proposed generic platform to support multimedia interaction [78]. Some studied issues associated with implementing VE/VR systems [24,72].

Application modeling

Application modeling models application information, so it can be included in the information modeling category. However, information modeling as mentioned above models general or abstract forms of information. Application modeling deals with a specific application domain. Application modeling takes a more concrete form. In many cases it requires extensive knowledge about that specific application field. The consumption model for consumer-driven advertising in [21] is an example. This research focused on developing an efficient and well-targeted consumption/ advertising model and proposed suitable technologies for implementing the mode.

6. Remarks

We have provided a survey of multimedia information technology and discussed the special aspects of this technology. We also pointed out the more general aspects associated with information technology. We categorized applications of multimedia information technology. We discussed a list of research areas associated with multimedia technology. The study is mainly based on the *IEEE Multimedia* journal. The study helps us to understand this newly developed field. We hope that this study will give readers an overview of current multimedia technology.

Some excerpts offer important advice and/or predictions about multimedia information technology [19,73,74,75]. Because of space limitations, we do not cite the paragraphs here but encourage readers to refer to the original articles.

We feel that multimedia information technology as a special field is still relatively new, and it will take more time and effort by researchers to identify the most essential and important issues in this field. More general rules and/or theorems need to be developed to characterize this field. Since this field utilizes the research results of many different fields of science and technology, the issues that synthesize concrete and abstract forms might be of special interest to researchers.

Information technology is bringing human civilization into a new era. Multimedia information technology is taking a central role on the information technology stage. Multimedia information technology is an area that encompasses myriad of changes, an area full of predictions and promises for the national and global information infrastructure, and an area that promises vast opportunity.

The work discussed in this paper was partially supported by the U. S. Department of Energy under contract W-31-109-Eng-38.

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