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# Principles of MULTIMEDIA 2e

*Principles of Multimedia, 2e* essentially discusses about characteristics, representation, compression, storage (file format) and processing tools for understanding and utilization of various multimedia components, like text, image, graphics, audio, video, animation. This edition additionally focuses on programming concepts using which practical tasks and tutorials related to media processing and presentations, can be carried out by the reader to gain a deeper understanding of the underlying theoretical concepts.

## Key Features :

- ❖ Introduction to topics on image processing, audio processing, and video processing along with numerous MATLAB coding examples for performing related tasks
- ❖ Studies on concepts related to 2D and 3D graphics and animation including splines, polynomials, transformations, projection, modeling, surface mapping, light, camera and rendering
- ❖ Overview of lossless and lossy compression techniques with emphasis on JPEG and MPEG standards
- ❖ Discussions on hardware and OS supports for multimedia including optical storage technologies, transmission standards, real-time protocols and playback architectures
- ❖ Focus on research issues in the fields of multimedia database, content-based storage and retrieval, pattern recognition and computer vision
- ❖ Information on text formats and standards, multimedia document architecture, interchange formats, IPR, digital copyrights, digital library and multimedia archives
- ❖ Exploration of Web-enabled multimedia content creation, hypermedia design and Web programming languages like HTML, Dynamic HTML, CSS, JavaScript, XML, SMIL, SVG and VRML
- ❖ Guidelines and case studies for multimedia application development and authoring

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# Principles of MULTIMEDIA

RANJAN PAREKH



# Principles of Multimedia

## Second Edition

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School of Education Technology  
Jadavpur University  
Kolkata, India*



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# Contents

<i>Preface</i>	<i>xiii</i>
<i>Abbreviations</i>	<i>xx</i>
<b>1. Multimedia—An Overview</b>	<b>1</b>
1.1 Introduction	1
1.2 Multimedia Presentation and Production	1
1.3 Characteristics of a Multimedia Presentation	2
1.4 Hardware and Software Requirements	5
1.5 Uses of Multimedia	6
1.6 Analog and Digital Representations	8
1.7 Digitization	12
1.8 Nyquist's Sampling Theorem	14
1.9 Quantization Error	16
1.10 Visual Display Systems	17
<i>Review Questions</i>	36
<b>2. Text</b>	<b>39</b>
2.1 Introduction	39
2.2 Types of Text	39
2.3 Unicode Standard	43
2.4 Font	45
2.5 Insertion of Text	47
2.6 Text Compression	48
2.7 Text File Formats	49
<i>Review Questions</i>	53
<b>3. Image</b>	<b>55</b>
3.1 Introduction	55
3.2 Image Data Representation	55
3.3 Image Acquisition	57
3.4 Image Processing	64
3.5 Binary Image Processing	77
3.6 Grayscale Image Processing	82
3.7 Color Image Processing	99

3.8	Image Output on Monitors	128
3.9	Image Output on Printers	134
3.10	Image File Formats	137
3.11	Image-Processing Software	139
	<i>Review Questions</i>	153

## 4. Graphics

155

4.1	Introduction	155
4.2	Advantages of Graphics	155
4.3	Uses of Graphics	156
4.4	Components of a Graphics System	157
4.5	2D Coordinate Systems	157
4.6	2D Transformations	158
4.7	Line-Drawing Algorithms	160
4.8	Circle-Drawing Algorithms	162
4.9	Filling Algorithms	163
4.10	Clipping Algorithms	163
4.11	2D Modeling	165
4.12	Curves and Splines	166
4.13	Splines as Polynomials	168
4.14	Linear Splines	172
4.15	Quadratic Splines	174
4.16	Cubic Splines	176
4.17	Hermite Splines	180
4.18	Catmull–Rom Splines	182
4.19	Cardinal Splines	184
4.20	Bezier Splines	186
4.21	B- Splines	190
4.22	Spline Conversions	198
4.23	Plotter	199
4.24	3D Graphics	200
4.25	3D Transformations	203
4.26	Projection	211
4.27	3D Modeling	217
4.28	3D Surface Characteristics and Lights	221
4.29	Graphics File Formats	226
4.30	Fractals	227
4.31	QuadTree	229
4.32	Graphics Software	232
	<i>Review Questions</i>	246

<b>5. Audio</b>	<b>248</b>
5.1 Introduction	248
5.2 Acoustics	248
5.3 Sound Waves	249
5.4 Types and Properties of Sounds	251
5.5 Psycho-Acoustics	258
5.6 Components of an Audio Systems	261
5.7 Digital Audio	267
5.8 Synthesizers	269
5.9 Musical Instrument Digital Interface (MIDI)	270
5.10 Digital Audio Processing	276
5.11 Speech	301
5.12 Sound Card	311
5.13 Audio Transmission	314
5.14 Audio File Formats	317
5.15 Surround Sound Systems	324
5.16 Digital Audio Broadcasting	329
5.17 Audio-Processing Software	332
Review Questions	338
<b>6. Video</b>	<b>340</b>
6.1 Introduction	340
6.2 Motion Video	340
6.3 Analog Video Camera	341
6.4 Analog Video Signal Representation	344
6.5 Television Systems	353
6.6 Video Color Spaces	355
6.7 Digital Video	358
6.8 Digital Video Processing	375
6.9 Video Recording and Storage Formats	380
6.10 Video File Formats	384
6.11 Video Editing Concepts	389
6.12 Video-Processing Software	393
Review Questions	398
<b>7. Animation</b>	<b>399</b>
7.1 Introduction	399
7.2 Historical Background	399
7.3 Uses of Animation	400
7.4 Traditional Animation	400

7.5	Principles of Animation	403	
7.6	Computer-based Animation	404	
7.7	Animation on the Web	411	
7.8	3D Animation	412	
7.9	Rendering Algorithms	416	
7.10	Animation File Formats	422	
7.11	Animation Software	422	
	<i>Review Questions</i>	426	
<b>8.</b>	<b>Compression</b>		<b>428</b>
8.1	Introduction	428	
8.2	Basic Concepts	428	
8.3	Lossless Compression Techniques	432	
8.4	Lossy Compression Techniques	441	
8.5	Image Compression	454	
8.6	Audio Compression	464	
8.7	Video Compression	475	
8.8	MPEG Standards Overview	487	
8.9	Fractal Compression	499	
	<i>Review Questions</i>	510	
<b>9.</b>	<b>CD and DVD Technology</b>		<b>512</b>
9.1	Introduction	512	
9.2	Compact Disc (CD)	512	
9.3	CD Formats	515	
9.4	Magneto-Optical Discs	522	
9.5	DVD	523	
9.6	DVD-Formats	526	
	<i>Review Questions</i>	530	
<b>10.</b>	<b>Multimedia Architecture</b>		<b>532</b>
10.1	Introduction	532	
10.2	User Interfaces	532	
10.3	OS Multimedia Support	536	
10.4	Multimedia Extensions	539	
10.5	Hardware Support	541	
10.6	Distributed Multimedia Applications	544	
10.7	Real-time Protocols	550	
10.8	Playback Architectures	552	
10.9	Synchronization	557	
	<i>Review Questions</i>	561	



<b>11. Multimedia Database</b>	<b>562</b>
11.1 Introduction	562
11.2 What is a Multimedia Database	563
11.3 Content-Based Storage and Retrieval (CBSR)	564
11.4 Designing a Basic Multimedia Database	565
11.5 Image Color Features	569
11.6 Image Texture Features	574
11.7 Image-Shape Features	582
11.8 Audio Features	589
11.9 Video Features	596
11.10 Classification of Data	601
11.11 Artificial Neural Networks	611
11.12 Semantics in Multimedia Data	631
11.13 Prototype Implementations	639
Review Questions	644
<b>12. Multimedia Documents</b>	<b>646</b>
12.1 Introduction	646
12.2 Document and Document Architecture	646
12.3 Hypermedia Concepts	651
12.4 Hypermedia Design	681
12.5 Digital Copyrights	682
12.6 Digital Library	688
12.7 Multimedia Archives	692
Review Questions	695
<b>13. Multimedia Application Development</b>	<b>697</b>
13.1 Introduction	697
13.2 Software Life-Cycle Overview	697
13.3 ADDIE Model	699
13.4 Multimedia Production Steps	699
13.5 Case Study	711
13.6 Authoring Software	718
13.7 Computer Games	721
Review Questions	727
<b>14. Virtual Reality</b>	<b>729</b>
14.1 Introduction	729
14.2 Forms of Virtual Reality	729
14.3 VR Applications	730
14.4 Software Requirements	730

- 14.5 Peripheral Devices 731
- 14.6 Virtual Reality Modeling Language (VRML) 732
- Review Questions 739

**Appendix 740**

- A.1 MPC Level 3 Specifications 740
- A.2 General MIDI (GM-1) Specifications 745
- A.3 Color Names with RGB Values in Hex for Web Design 748
- A.4 MATLAB Command Summary 750
- A.5 HTML Command Summary 752
- A.6 CSS Attribute Summary 753
- A.7 JavaScript Object Summary 754

**Bibliography 755**

- B.1 Books 755
- B.2 Research Articles 759

**Coding 770**

- C.1 MATLAB Coding 770
- C.2 VRML Coding 805

**Index 816**

# Preface

The term 'multimedia' essentially implies 'means of communication through multiple media'. From the earliest times, humans have attempted to communicate their ideas through various means like gestures, sounds, paintings, writings, etc. The multiple sense organs of humans also enable them to comprehend and support such kind of multi-modal communications. In the real world, non-textual form of communication, like cave paintings, were used much before the written form originated. In the computing world, however, the trend has been just the reverse; text was the predominant form of communication over most of the earlier part of computing history. Only in the last 20 years did non-textual forms gain significance. Dealing with text through computers was much easier than dealing with non-textual media like pictures or sound. In recent times, many technical barriers have been overcome and practical problems have been solved. *Principles of Multimedia* gives an insight into these solutions and highlights the landmarks achieved, a theoretical treatise of humankind's endeavor for communicating through multiple means in the digital domain. By multiple means, we now imply the following media: text, image, graphics, audio, video and animation, all in the digital form. Added to the above is an important aspect of multimedia that distinguishes it from television and movies—that of interactivity. At the basic level, this lets the viewer interact with a presentation and decide how he or she wants to view it, e.g. jump from the opening scene to a specific section instead of passively watching it from beginning to end. At a more advanced level, interactivity lets the user change the normal course of action within the presentation by performing certain pre-defined events. Good examples of such interactivity are computer games and simulation packages like aircraft-training simulation. A 'multimedia presentation' is a 'digital show' using most or all of these components in an integrated way to communicate some idea to the target audience. The advantage of such a presentation lies in the fact that one is allowed to present his/her ideas in a variety of forms and ways that increase the comprehension level and retentivity of the subject matter in the viewer's mind. This makes it an important tool in education. Other possible uses of multimedia include home entertainment, industrial training, information kiosks, corporate presentations, computer-aided design applications, video conferencing and telemedicine only to name a few.

## Objectives

With increase in the processing powers of today's computers and decrease in the costs of hardware and software, there has been a definite trend in utilizing the advantages of digital multimedia in industries, educational institutions and the research community. This is evident by the large number of digital repositories of images, audio and video growing up all over the world. We have all heard the phrase "A picture is worth a thousand words". Going along those lines, a video should be worth a million. Added to that is sound and interactivity. In order to use multimedia to its fullest extents, a thorough knowledge of its internals is essential, especially for people who are willing to take up multimedia production as a career option. The *first objective* of this book is to meet this requirement, i.e. to explain as clearly as possible the fundamental concepts behind how different components of multimedia function. The technical level of the book is set at the graduate/post-graduate levels of science/engineering streams. It is expected that after going through the book, the reader would comprehend the issues and standards related to the digitization, processing, compression and playback of various media components, as well as be competent enough to design multimedia presentations for a variety of applications.

Due to the widespread use of multimedia applications worldwide, multimedia as a subject has been introduced in various forms in the curricula of schools and colleges all over the world. However, it being a relatively new subject, the number of related books in the market is still limited. The situation is aggravated by the fact that multimedia deals with a large number of different concepts put together. In fact, multimedia is often seen as a meeting point of three different work areas: computer, communication, and entertainment. Such being the case, a majority of the earlier books on multimedia deal with only specific areas of the subject instead of presenting the entire gamut. The *second objective* of this book is to provide a full and comprehensive view of the most important and relevant aspects of the subject to cater to curricula of educational institutions written in a way that it might be used as a textbook or reference book at the graduate and post-graduate levels. While writing the book, syllabi of major universities have been kept in mind including Anna University, Pune University, Jawaharlal Nehru Technological University (JNTU), West Bengal University of Technology (WBUT), Mumbai University (MU), Rajasthan Technological University (RTU), Biju Patnaik University of Technology (BPUT), Gujarat Technological University (GTU), Uttar Pradesh Technological University (UPTU), Visvesvaraya Technological University (VTU), Rajiv Gandhi Proudyogiki Vishwavidyalaya (RGPV) and Rajasthan Technological University (RTU).

It is well known that the capabilities of our computers are increasing in leaps and bounds. Keeping pace with this, the functionalities of multimedia hardware and software are also improving day by day. In such a scenario, students and professionals working in this field need to keep their knowledge updated. In the commercial arena too, the markets are flooded with gadgets having newer functionalities and improved features. People often come across a variety of terms in their day-to-day lives without fully understanding what they stand for. A few examples are: 5.1 channel, surround sound, 3D monitor, ATRAC audio, digital audio broadcasting (DAB), digital Dolby (DD), digital theatre systems (DTS), laserdisc, MP4, super audio CD, torrent, virtual reality, video conferencing and so on. A *third objective* of this book is to provide the reader with an up-to-date knowledge of the recent advances in this field, which is more often seen in magazines and on Websites than in textbooks. Attempts have been made to bring to light details about the state of the art in each field in an easy-to-understand manner.

A *fourth objective* is to give the reader an idea about the major research advances in the field of multimedia which includes image processing, audio processing, video processing, computer vision, pattern recognition, multimedia databases, content based retrieval and non-textual data classification. The user is introduced to tools and techniques like Artificial Neural Networks (ANN), Principal Component Analysis (PCA), Wavelet decomposition and Eigen-space decomposition employed for handling such problems and their implementations using MATLAB coding. Discussions on case-studies from research papers published in conferences and journals also help highlight research issues pertaining to these areas.

## Who Will Benefit From This Book?

Students at the under-graduate and the post-graduate levels having technical backgrounds (science/engineering), who have some idea of creation and usage of non-textual media like image/graphics and audio/video especially in digital form can benefit from this book. Primary readers include students at the graduate (BE/BSc/BTech/BCA) and the post-graduate levels (ME/MSc/MTech/MCA) who have multimedia related subjects as part of their curricula. This would include the technical colleges and institutions having streams like computer science, communication and information technology. The book would also be useful for short courses like certificate or diploma in subjects like image processing, audio/video processing, 2D and 3D graphics and animation, Web design and multimedia production.

Secondary readers will be researchers in the field of computer science and information technology specializing in the areas of computer vision, pattern matching, medical imaging, content-based retrieval and data classification. Research-based portions of the book include Chapter 3 (image processing), Chapter 5

(audio processing), Chapter 6 (video processing), Chapter 11 (computer vision, pattern matching, medical imaging, content-based retrieval and data classification). A list of 212 research articles included in the Bibliography and numerous website references in each chapter help the researcher in further readings.

## About The Book

The book essentially discusses the characteristics, representation, compression, storage (file format) and processing tools for understanding and utilization of various multimedia components, e.g. text, image, graphics, audio, video, animation. The second edition additionally focuses on programming concepts using which practical tasks and tutorials related to media processing and presentations, can be carried out by the reader to gain a deeper understanding of the underlying theoretical concepts.

An objective is to give the reader an idea about the major advances in the area, e.g. image processing, audio processing, video processing, analysis of graphical splines and curves, 3D based transformation and projection, creation of multimedia based learning materials/GBTs, as well as research-oriented topics like computer vision, pattern recognition, medical imaging, multimedia databases, fractal imaging, speech coding and content-based retrieval. Numerous MATLAB coding examples have been included for performing tasks related to media processing. Hypermedia concepts have been explained using numerous examples on Web programming languages like HTML, CSS, JavaScript, Dynamic HTML, VRML, etc. The book also introduces research-based concepts using state-of-the-art techniques like artificial neural networks, feature representation through mathematical vectors, reduction of feature-space dimension using Eigen-space and principal component analysis (PCA).

The book deals with salient aspects of creation, representation and analysis of various aspects of non-textual media components as well as various aspects of lossless and lossy compression for their efficient utilization. The reader is introduced to the field through theoretical discussions of basic concepts, practical tasks involving programming examples, and research-oriented discussions with references from numerous research articles published in conferences and journals.

Future editions if any will include more research-oriented materials in the above-mentioned fields.

## Salient Features

- Introduction to topics on image processing, audio processing, and video processing along with numerous MATLAB coding examples for performing related tasks
- Studies on concepts related to 2D and 3D graphics and animation including splines, polynomials, transformations, projection, modeling, surface mapping, light, camera and rendering
- Overview of lossless and lossy compression techniques with emphasis on JPEG and MPEG standards
- Discussions on hardware and OS supports for multimedia including optical storage technologies, transmission standards, real-time protocols and playback architectures
- Focus on research issues in the fields of multimedia database, content-based storage and retrieval, pattern recognition and computer vision
- Information on text formats and standards, multimedia document architecture, interchange formats, IPR, digital copyrights, digital library and multimedia archives
- Exploration of Web-enabled multimedia content creation, hypermedia design and Web programming languages like HTML, Dynamic HTML, CSS, JavaScript, XML, SMIL, SVG and VRML
- Guidelines and case studies for multimedia application development and authoring

- **Pedagogy**

- About 50 Solved examples including 115 coding samples included in chapters.
- Small code snippets have been included in many chapters, especially chapter 12, to illustrate theoretical and practical examples.
- Introduction provides a background of the concepts to be covered in a chapter and the conclusion lists the important topics discussed in the chapter as bulleted points.
- A set of about 470 figures are included in the book to illustrate key points.
- A list of 260 abbreviations and their full forms are included in the beginning of the book for ready reference.
- A list of 105 book references and 212 references of research articles are included in the bibliography for further readings. In addition, numerous online references and websites are included in each chapter for further readings.
- Review questions have been included in each chapter to test and verify the knowledge of readers.
- In addition, problems will be included in the book website (OLC) to check problem-solving skills of readers.

## Organization of The Book

**Chapter 1** provides an overview of what multimedia means and implies, what media types are involved, characteristics of multimedia presentations, major uses and application areas, concepts on digital media and digitization processes, parameters for determining quality and degradations, concepts related to visual display systems like CRT and LCD, their major components and working principles, with associated parameters for determining quality of visual media.

**Chapter 2** is related to Text and discusses concepts related to text creation, representation, processing and storage, differences between different types of text, ASCII and Unicode standards, factors for determining appearance of text like font and style, insertion of text, optical character recognition (OCR), text file formats.

**Chapter 3** is related to Image and discusses concepts related to pixels, types of images and their data representations, image acquisition using scanner and digital camera, basic operations on images, binary image processing including morphological and logical operators, gray-scale image processing including intensity transformations, histogram processing, noise modeling and filtering in spatial and frequency domain, color image processing including color models and color transformations, factors related to displaying images on output devices monitors and printers, issues related to color management and gamma correction, image file formats, major features of image editing softwares.

**Chapter 4** is related to Graphics and discusses concepts related to vector graphics and differences with bitmap images, components of graphics systems, 2D coordinate systems, 2D transformations, line drawing and circle drawing algorithms, curves and splines, spline representation using polynomials, parametric representations, blending functions, basis matrix, equations of linear quadratic and cubic curves, Hermite-splines, CR-splines, Cardinal-splines, Bezier-splines, B-splines, spline conversions, 3D coordinate systems and transformations, projection, 3D modeling, surface texture, lights, fractals, file formats, major features of 2D and 3D graphics softwares.

**Chapter 5** is related to Audio and discusses concepts related to sound waves, tone and note, psycho-acoustics and masking, components of audio systems, synthesizers and MIDI protocol, digital audio processing, temporal domain and frequency domain representations, speech coding and companding,

cepstral and wavelet analysis, pulse code modulation (PCM), linear predictive coding (LPC), code excited linear prediction (CELP), components of sound cards, audio transmission, audio connectors, surround sound systems, digital audio broadcasting (DAB), audio file formats, major features of audio editing softwares.

**Chapter 6** is related to Video and discusses concepts related to analog video camera, analog video transmission, generation of YC signals, chroma sub-sampling, television systems, digital video processing, video color spaces, video recording and storage formats, video editing concepts, analog and digital video connectors, video file formats, major features of video editing softwares.

**Chapter 7** is related to Animation and discusses concepts related to keyframes and tweening, cel animation, computer based animations, interpolations, parameter curve editing, motion paths, hierarchical animation, inverse kinematics (IK), camera locations and movements, particle systems and space warps, rendering algorithms, Web based animation techniques, animation file formats, major features of 2D and 3D animation softwares.

**Chapter 8** is related to Compression and discusses concepts related to types of compressions, types of redundancies, compression performance measurements, lossless compression techniques like run length encoding (RLE) differential pulse code modulation (DPCM) Lempel-Ziv-Welsh (LZW) coding Shannon-Fano coding Huffman coding and Arithmetic coding, lossy compression techniques involving various transforms like discrete Fourier transform (DFT) discrete cosine transform (DCT) discrete wavelet transform (DWT), image compression, audio compression, video compression, overview of MPEG standards including MPEG-1 MPEG-2 MPEG-4 MPEG-7 MPEG-21, fractal compression.

**Chapter 9** is related to CD and DVD storage technology and discusses concepts related to working principles of optical storage, constant linear velocity (CLV) vs. constant angular velocity (CAV), data transfer rate and X-rated speeds, various CD formats like CD digital audio CD-ROM photo-CD video-CD CD recordable CD rewritable magneto optical discs laserdiscs, various DVD formats, CD vs. DVD, blu-ray disc, multi-layered DVDs.

**Chapter 10** is related to Multimedia Architecture and discusses concepts related to graphical user interfaces, support for multimedia in operating systems, multimedia extension features in chipset like MMX, hardware transmission cables like USB SCSI and FireWire, distributed multimedia systems, real-time applications and protocols, multimedia playback architectures, synchronization types and techniques.

**Chapter 11** is related to Multimedia Databases and discusses concepts related to content based storage and retrieval, design and components of a multimedia database, low-level and high-level features, similarity measurements, image features based on color texture and shape, audio features, video features, classification of data, clustering, indexing, Eigen vectors and values, principal component analysis (PCA), artificial neural networks (ANN), character recognition, single-layer multi-layer perceptrons (MLP), semantics in multimedia data, prototype implementations of multimedia databases.

**Chapter 12** is related to Multimedia Documents and discusses concepts related to document architectures, multimedia interchange formats, open media frameworks (OMF), hypertext and hypermedia, hypermedia design models, Web programming languages like HTML CSS JavaScript XML SGML Dynamic-HTML SMIL SVG, Digital copyrights and digital rights management, digital library standards and initiatives, multimedia archives.

**Chapter 13** is related to Multimedia Application Development and discusses concepts related to multimedia production steps involving conceptualization, story, script, flowline, storyboard, implementation, testing and feedback, documentation, case studies, major features of multimedia authoring softwares, computer game design and development.

**Chapter 14** is related to Virtual Reality and discusses concepts related to forms of virtual reality, hardware and software components, virtual reality application, virtual reality modeling language (VRML).



In addition to this the Appendix provides details of relevant specifications and summaries of commands of various programming languages used in this book. The Bibliography provides details of over 100 books and over 200 research articles in this field. Lastly, the Coding section lists out about 90 MATLAB program codes and 25 VRML program codes for various tasks and examples discussed throughout the book.

## Online Learning Center

The Online Learning Center for this book is available at <https://www.mhhe.com/parekh/multimedia2>

- Presentation slides will be available on the OLC to provide teaching guidelines to instructors
- Solved examples, coding examples, review questions, problems are provided for students to check their understanding of the subject matter

The readers can also post technical queries regarding matters in the book at the OLC to which the author will attempt to provide appropriate answers, hints and guidelines.

## Acknowledgements

Reviewers had asked for practical examples to be included in the book which has led to the inclusion of about 100 MATLAB examples related to various tasks related to image-, audio-, and video-processing. I am thankful to all of them. Some names are given below.

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## Feedback

In conclusion it must be emphasized that unlike the basic sciences, multimedia is a laboratory-oriented subject. We are learning a set of principles and procedures for utilizing them in the creation of better and improved applications. Hence, practical utilization of the knowledge acquired is at the heart of multimedia. In other words, theoretical aspects alone do not provide a complete understanding of the subject; learners must also know how to build presentations or implement research ideas using necessary software editing, authoring and programming tools.

In general, all readers are encouraged to provide feedback about the content matter of book as well as any omissions or typing errors. The author can be contacted at [author.principlesofmultimedia@yahoo.com](mailto:author.principlesofmultimedia@yahoo.com)

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