

Contents

1	Introduction to Forensic Audio Analysis: Authenticity, Enhancement, and Interpretation	1
	References.	2
2	Fundamentals of Audio Signals and Systems	3
2.1	Sound	3
2.2	Sound Pressure Level.	5
2.3	Wavelength, Frequency, and Spectrum	6
2.4	Wave Propagation and Spherical Spreading	10
	2.4.1 Reflections and Reverberation	14
	2.4.2 Microphone Directionality.	16
2.5	Human Hearing Characteristics	16
	2.5.1 Anatomy and Physiology of the Ear	18
	2.5.2 Psychoacoustics	21
	2.5.3 Frequency Weighting in SPL Measurements.	23
	2.5.4 Speech Intelligibility	24
2.6	Signal Processing	26
2.7	Digital Audio	26
2.8	Perceptual Audio Coding	27
	References.	28
3	History of Audio Forensics	29
3.1	McKeever Case	29
3.2	McMillan Case.	31
3.3	FBI Procedures.	31
3.4	The Watergate Tapes	32
3.5	Reevaluation of the Assassination of President Kennedy	33
3.6	Talker Identification and “Voiceprints”	35
	References.	37

4 Handling Forensic Evidence	39
4.1 Basic Tools: Audio Playback, Waveform View, and Spectrographic View	39
4.1.1 Audio Playback System	39
4.1.2 Waveform View	40
4.1.3 Spectrographic View	42
4.2 Starting the Examination	44
4.2.1 Initial Aural Evaluation	47
4.2.2 Critical Listening	48
4.2.3 Waveform Analysis	48
4.2.4 Spectral Analysis	49
References	50
5 Authenticity Assessment	51
5.1 Historic Context: Authenticity of Analog Magnetic Tape Recordings	51
5.1.1 Physical Inspection	53
5.1.2 Magnetic Development	53
5.2 Current Context: Authenticity of Digital Audio Recordings	55
5.2.1 Identifying Edits: Splicing and Mixing	55
5.2.2 Other Authenticity Observations	58
5.2.3 Electrical Network Frequency (ENF) Analysis	61
5.2.4 Metadata Consistency	62
References	67
6 Audio Signal Enhancement	69
6.1 Enhancement Assessment	69
6.2 Speech: Quality Vs. Intelligibility	70
6.3 Techniques for Forensic Audio Enhancement	72
6.3.1 Filtering and Equalization	73
6.3.2 Gain Compression and Expansion	76
6.3.3 Other Important Techniques	80
References	84
7 Forensic Interpretation	85
7.1 Scientific Integrity	85
7.2 Methods and Reliability	86
7.2.1 Example 1: Simultaneous Recordings from Different Locations	87
7.2.2 Example 2: Recording Involving Doppler and Converting to Speed	90
7.2.3 Example 3: Sound Level Vs. Distance	92
7.3 Likelihood Ratios	93
References	95

8	Expert Reports and Testimony	97
8.1	Qualification as an Expert	97
8.2	The Expert Report	99
8.3	Expert Testimony	101
8.3.1	The Role of the Expert.	101
8.3.2	Deposition	101
8.3.3	Testimony and Demeanor	102
8.3.4	Cross-Examination.	103
	References.	103
9	Application Example 1: Gunshot Acoustics	105
9.1	Firearm Principles	105
9.2	Firearm Acoustics	110
9.2.1	Muzzle Blast	110
9.2.2	Mechanical Action	111
9.2.3	Supersonic Projectile	111
9.2.4	Surface Vibration	113
9.3	Example Demonstration Gunshot Recordings.	113
9.3.1	Rifle Shot with Supersonic Projectile	114
9.3.2	Pistol Shot with Subsonic Projectile	120
9.3.3	Revolver Shot with Subsonic Projectile.	122
9.4	Example Forensic Gunshot Recordings.	124
9.4.1	Example Forensic Recording 1: Gunshots, Taser, and Speech	124
9.4.2	Example Forensic Recording 2: Gunshots with Multiple Recordings	131
	References.	135
10	Application Example 2: Cockpit Voice Recorders	137
10.1	CVR Operation and Interpretation.	139
10.2	The Future Role of Audio Forensics in Transportation Safety Systems	141
	References.	141
11	Conclusion	143
	References.	144
	Index	145