C9 Media Forensics and Microphones

Eddy B. Brixen, BA, EBB-Consult, 108 Aeblevangen, Smorum DK-2765, DENMARK*

After attending this presentation, attendees will better understand microphone transducer principles that can be applied in audio forensic examinations. Basic specifications/limitations, performance of pressure vs. pressure-gradient types, beamforming, and the influence on recorded audio will be discussed.

This presentation will impact the forensic science community by highlighting microphone performative characteristics which are important for those working with media forensics.

Nearly all acoustic recordings include a microphone in the recording chain. Recordings may stem from dashboard cameras, cell phones, smartphones, car phones, dispatcher headsets, video cameras, surveillance systems, dictaphones, computers of all sorts, and others.

It is very seldom that the result of a forensic examination of a recording device includes any findings related to the microphone/microphones; however, the microphone may add valuable information to findings of the recording.

A microphone is not just a microphone. Devices responsible for the majority of recordings that become subject to forensic examination are either electret condenser types or Micro-Electro-Mechanical Systems (MEMS). The sound quality in good electret microphones is clearly superior to the MEMS types; however, the MEMS are extremely inepensive and can more or less directly deliver a digital code (density modulation). As with most coding, this may leave traces in the signal.

Any microphone can be specified by different data (i.e., sensitivity or how much output for a given Sound Pressure Level (SPL), self-noise (all microphones have a noise floor), max SPL (the SPL at which the microphone will start clipping/distorting), and frequency response (how wide is the range of the given microphone).

The directivity of microphones are especially of great interest. Two ways of coupling the diaphragm to the surrounding air are responsible for the directivity.

Pressure microphones (the sound can only access the diaphragm from one side) are by definition omnidirectional; however, this also depends on the practical mounting in/on the device or in the room. For instance, mounting on a surface changes the directivity dramatically, depending on the size of that surface. Pressure microphones are the least sensitive to wind and vibrations. In regard to frequency response, it decreases to DC and lets one consider whether to open or close doors in rooms due to the pressure variation.

Pressure gradient microphones can provide a variety of first-order directional characteristics: figure eight (bi-directional), super cardioid, cardioid, subcardioid, etc. The final directivity is primarily determined by the relationship between the front and rear inlet. The pressure gradient microphones normally have “looser” diaphragm to reproduce some amount of low frequencies. This fact also leads to a higher sensitivity (approximately 10-15 dB) to vibrations, wind-noise, and handling-noise.

Pressure gradient microphones exhibit proximity effect. This means that the low frequencies are boosted as the microphone gets closer to the sound source (i.e., point source). On the other hand, sound sources moving away from the microphone lose bass. This is practical in phone calls; however, it also provides information on distance when examining the spectral changes of recordings’ content.

When applying more than one microphone capsule in a device, arrays can be formed.

Two-channel recordings contain directional information depending on the directivity and angling of the microphones (XY stereo) or the distance between them (AB stereo and near-coincident set-up). Here, there is considerable information to extract. This also provides possibilities of signal enhancement when one channel can be utilized to improve the other (i.e., cross-lattice filtering and the like). Shot-spotting systems also form a type of array, although with much larger distances between the microphones.

Arrays can be used for directivity beamforming. Today, most computers and smartphones contain two or three microphones for this purpose. This means that certain frequencies coming from certain angles are either boosted or cut. This is why it is essential to gain as much knowledge as possible of the recording devices to include/exclude sound sources. Accordingly, the difference in the individual microphone's sensitivity provides information for the authentication of the device or for the scene.

Casework (test sound-files to be presented) has shown that the characteristics of the recording devices, and the microphone in particular, have provided evidence or led to the better choice of enhancement technique.

Which (fixed-line) phone was used for the emergency call? Why was the background sound lower than expected? The saturation of the input was pure microphone clipping; hence, de-clip was possible. Crime scene analysis has been made possible because of the wide frequency range of the microphone.

Examiners sometimes neglect the characteristics of the microphone; however, microphone specifications and implementation influence the signal recorded. For the purposes of selecting the right microphone for forensic recordings, rescuing bad recordings, authenticating recordings, and extracting valuable crimescene information, practitioners in media forensics should acquire a basic knowledge regarding microphones.

Microphones, Forensic Recordings, Audio Forensics