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Unveiling the Unseen: Ultrasonic-Based Forensic Examination for Detection and Recovery of Hidden Physical Evidence

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***Abstract*—** Evidence collection is of utmost importance for the purpose of justice. It forms the foundation of a criminal investigation, assisting in the determination of facts, identification of suspects, support or challenges of witness testimony and maintenance of legal proceedings. Nowadays Ultrasonic techniques has proven to be a useful asset in the detection of concealed drugs or weapons hidden inside walls, earth, water and other inaccessible areas. By analyzing the pattern of sound waves reflected or transmitted by hidden objects investigators can determine their presence, size, shape and composition. Ultrasonic techniques not only reduce the time and cost for the examination, but also increase the reliability and accuracy of the search by quickly scanning large areas or objects without the need for extensive excavation. Ultrasonic techniques find applications in Forensic Science such as locating metallic and plastics evidence, extraction of DNA, imaging of tissues and others. By integrating Ultrasonictechnology as a non-destructive method into evidence collection protocols, law enforcement agencies to strengthen their investigations, capabilities and gather crucial evidence to support the pursuit of justice.

***Keywords*—** Evidence, ultrasonic, hidden weapons and drugs, extraction of DNA, justice.

INTRODUCTION

From the beginning of this decade terrorist organization, hijackers, and people concealed weapons are a constant and increasing threat for both military and non-military personnel. Today's anti-terrorism, crime prevention and law enforcement community facing one of the greatest challenges to detect concealed weapons and to locate hidden evidences[1]. There is anurgent need for effectual, speedy and reliable security methods and techniques to recognize weapon threats utilizing new screening devices [2]. It has been observed that each metallic and plastic weapon can have a unique fingerprint, which is an electromagnetic signal determined by its shape, size, physical and chemical composition. Extracting the signature of each weapon is one of the major tasks of any detection system.The relationship between sensors and Forensic is important in seeking justice through the accurate recovery of evidence at crime scenes. Sensors play a vital role in this endeavour by detecting and recording important physical evidence. Sensors based on electromagnetic waves has been used for many years, but object detection and discrimination proficiency are limited [3,4]. The electromagnetic spectrum ranges from acoustic, ultrasound, radio frequency (RF), Microwave, Millimetre waves (MMw), Terahertz waves (THw), Infrared (IR), visible light, UV to X-ray. The wide range of electromagnetic spectrum has been used for concealed weapon detection such as metallic weapon like gun, knives, landmines and explosives devices [5]. The electromagnetic signals are processed by a system processor and signals indicative of concealed items are recognized [6]. Preferably the acoustic and ultrasonic sensors present a useful option as a sensing technology. Acoustic waves in the audible frequency range roughly between 20 Hz and 20 kHz will be mention as sonic or audible. Acoustic waves with frequencies greater than about 20 kHz will be referred to as ultrasonic [7-9]. The acoustic/ ultrasonic reflectivity of material depends on their composition, shape and orientation of the object. The reliable detection parameters are size of the target, distance of the target and wavelength of the emitted wave [10]. A combination of radar and ultrasonic is being explored by JAYCOR (http://www.jaycor.com). The system produces ultrasound images and can operate at 5m-8m distance having frequency up to 100kHz [11]. The increase in frequency provided the ability to resolve smaller items to a size of 10cm [12,13].The use of ultrasonic waves as non-destructive probes has as a prerequisite the careful examination of crime scene. Ultrasonic Tomographytechnique take advance in the

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field of Forensic to detect concealed weapons and drugs.

Principle of Operation

Ultrasonic Tomography (UT) system consists of two general parts, which are hardware and software. The hardware part of a UT system consists of various sub-parts such as:

Pulse generating part: A microcontroller produces pulses, whose frequency is exactly equal to the resonance frequency of the ultrasonic sensor.

Transmitter: This part amplifies the generated pulses to actuate the ultrasonic sensor.

Ultrasonic sensors: There are two types of applied sensors, transmitter and receiver. On one side of the pipe, ultrasonic transmitter sensors that are attached to the amplifier section transform electrical signals into ultrasonic waves. Ultrasonic receiver sensors on the other side of the pipe, pick up the propagating ultrasonic wave and transform it back into electrical signals.

Receiver: This part is made up of a data acquisition component, a band bass filter, and a low noise amplifier. The received signals are amplified, noises are filtered, and finally the received analogue signals are transformed into digital data.

In the software part, the collected digital data is subjected to image reconstruction utilizing software techniques as filter back projection algorithms to generate the cross-sectional image [14-19].

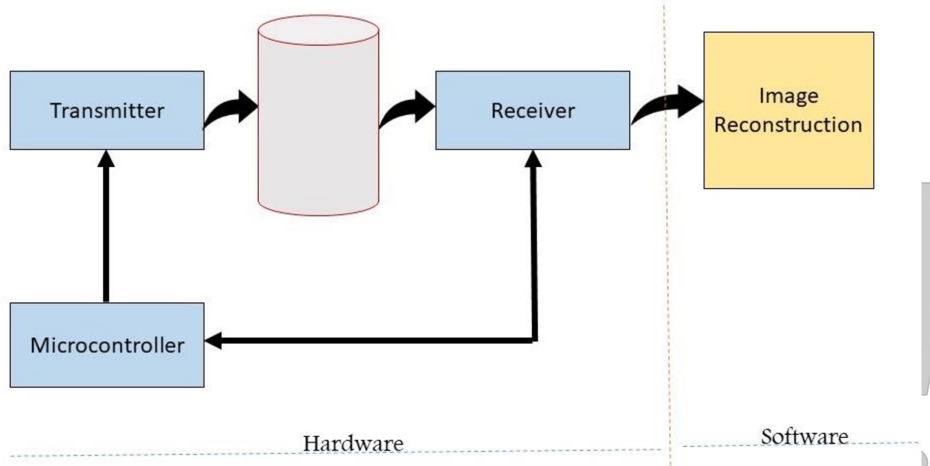

Figure 1. *General block diagram of ultrasonic tomography system*

Limitations

Although ultrasonic sensors present a useful option as a sensing technology, they also have some important limitations. One of the key problems with ultrasonic sensors is that even the most basic measurement the target's distance can be hindered due to the target's characteristics. The shape and composition of an object determine the strength of its reflected wave. A complex shape will produce more reflections at different angles, which will then create a complex signal when collected at the receiver. The sound wave will be diffused and reflected by uneven surfaces in many directions, returning little to the sensors [20]. Textured objects, wool or fur, can ample of the sound wave so that very little wave is reflected back to the sensor [21]. Higher-frequency sound waves are superior for detecting these types of targets as well as can easily distinguish smaller targets[22]. However, sound waves at higher frequencies experience greater attenuation in the atmosphere, resulting in a shorter detection distance [23].

Conclusion

A review on non-destructive ultrasonic tomography showed that it is suitable technique for concealed weapon detection or makes it a valuable tool for security applications. By utilizing advanced imaging algorithms and signal processing techniques, ultrasonic tomography can provide real-time, high-resolution images, enabling security personnel to identify concealed weapons with precision marks a significant advancement in Forensic science. As technology continues to advance, further research and development in this field will likely lead to even more sophisticated and effective crime scene reconstruction systems, ultimately aiding law enforcement in solving crimes and delivering justice.

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