See through the Rubble: A Multimodal Bioradar Life Detection System for Search and Rescue Applications

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During the twenty-first century, more than 522 significant earthquakes have occurred, resulting in a death toll exceeding 430,000 worldwide. These natural disasters leave many individuals trapped beneath rubble and dense construction material. Traditional approaches, such as search dogs and other blind methods, are ineffective. Therefore, it is vital to create a low-cost, sensitive system for detecting human presence under debris. Continuous-wave Doppler radar was explored as a method of life detection since it has shown to be useful in contactless vital signs monitoring due to its ability to detect micromotion. Doppler radar sensors of 10 GHz and 24 GHz transmission frequencies were investigated, and a loudspeaker was used to approximate the micromotions of the heart and lungs. Since the sensor output signal showed very low voltage output, an OPA 2365 two-stage amplifier circuit with an 84dB gain was developed. The first iteration of testing consisted of placing the radar sensor one meter away from a 15 cm depth wooden board with the loudspeaker oscillating at 2 Hz. The second iteration of testing involved the construction of a horn antenna and using layers of brick and wood as a barrier. The data were acquired with an Arduino ADC and relayed to a MATLAB script for smoothing and applying frequency spectrum representations that demonstrate the system's capability of capturing the micromotion of the loudspeaker victim simulation. Voice activity detection through microphone sensors is being explored as a supplement to the radar data to create a multimodal detection system. UWB impulse and FMCW radars also provide implications for improving the system. This life detection framework can be applied to sleep apnea monitoring, combat situations, and disaster search and rescue.