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Terahertz Wave Plethysmography

Heart rate and other cardiac function monitoring is conventionally performed in a healthcare setting utilizing devices such as EKGs and finger pulse oximeters. While effective, this requires physical contact with the patient and a doctor visit, making continuous or long-term monitoring difficult.

Microwave radars have been used extensively for detecting human vital signs such as heart rate, breathe rate and body temperature. However, these systems are hindered by limitations including low operation frequency and limited radio frequency resources in the bandwidths they were developed for. The signal processing techniques created for these systems have difficulty providing accurate pulse measurements with dynamic breathing or other body motion, as well as clutter noise from other scatterers such as clothing. Further, because of the need for small apertures, these systems have wide beams that capture the backscattered signals of multiple targets leading to additional clutter noise.

Researchers at Arizona State University have developed a non-contact vital sign sensing system that uses Terahertz (THz)-Wave-Plethysmography (TPG). This system detects blood volume changes in the dermis tissue layer by measuring the reflectance of THz waves. It forms narrow beams focusing the waves on different parts of the body to extract the pulse signals. Through the use of higher operating frequencies and smaller physical apertures, cluttering noise from undesired scatterers is decreased. Pulse measurements, taken at several different body parts of interest, were found to accurately detect the heart rate of the subject. This could also potentially provide further valuable information such as blood circulation inspection and remote blood pressure measurements through clothes.

The ability to use high spatial resolution THz images to detect pulse information, through clothing, and from multiple regions of interest offers new and exciting opportunities for biomedical applications.

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Potential Applications

- Non-contact vital sign sensing in healthcare or non-healthcare facilities
  - Inspecting blood circulation
  - Extracting blood pressure related biometrics including blood pulse pressure and pulse wave velocity

- Sleep monitoring
- Intensive care or home health care monitoring
- Non-clinical applications – pilots, firefighters, military personnel, etc.
- And many more applications

Benefits and Advantages

- Stepped-frequency continuous wave radar operates in frequency domain and not time domain – helps achieve a larger effective bandwidth
- Allows for pulse measurements through clothes (or bedding) and from various regions of interest: palm, inner elbow, temple, fingertip, forehead, etc. – distortionless vital sign sensing is possible by strategically choosing the body part to focus on
- THz waves constitute a unique frequency band for remote vital sign sensing
- Generates better heart rate estimation in the form of empirical cumulative distribution function of HR estimation error
- Operates in any weather conditions
- Privacy-preserving sensing

For more information about this opportunity, please see

Rong et al - Nature Scientific Reports - 2022

For more information about the inventor(s) and their research, please see

Dr. Bliss' laboratory webpage

Dr. Rong's departmental webpage

Dr. Trichopoulos' departmental webpage