Radar Technology For Acquiring Biological Signals

Gene Greneker

RADAR Flashlight, LLC, Powder Springs, Georgia
Radar Technology For Acquiring Biological Signals

The Ability of Radar to Sense Biological Signals
Background of Gene Greneker

- Principal Research Scientist, Georgia Tech Research Institute 33 years
  - Radar Vital Signs Monitor (heart and respiration) Project Director
  - RADAR Flashlight Project Director
    - Through the wall detection of the human respiration radar signature
  - DARPA radar gait analysis program Project Director
    - Identification of a subject by radar sensed gait characteristics
- Retired From GTRI on 12-01-03 and started RADAR Flashlight, LLC.
- Working 49% part-time at Georgia Tech Research Institute
- Working 51% time for RADAR Flashlight, LLC on DARPA SBIR program to develop next generation RADAR Flashlight

The Ability of Radar to Sense Biological Signals

- Types of biological signals that radar can sense at present
  - Heart and respiration (vital signs)
  - Body tremor and very slight movement to maintain balance
  - Gait signature to allow identification of a subject
  - Heart signature (ballistocardiogram) of person hidden in vehicle
- Other attributes of radar sensing of biological signals
  - Detection of slight motion of the human body induced by a biological process
  - Detection of vital signs through clothes and heavy outer wear

The Ability of Radar to Sense Biological Signals
Applications of Radar Vital Signs Monitoring

- Medical
  - Tele-medicine  no connection required for heart and respiration monitoring
  - Heart disease screening
- Law Enforcement and Corrections
  - Finding persons behind walls and in closed areas
  - Suicide watch monitoring
  - Finding persons in shipping containers and border crossing inspection
  - Deception detection (heart and respiration channels of polygraph)
- Military
  - Clearing buildings in urban warfare scenario (through the wall human sensing)
  - Battlefield casualty assessment (dead or alive)
  - Vital signs monitoring through uniforms and chem/bio suits
History of Georgia Tech Research Institute’s Radar Vital Sign Monitoring Research Program

- **RADAR Vital Signs Monitor** developed for military applications
  - Remote evaluation of battlefield casualties from 100 meters away
  - Monitoring of vital signs (heart and respiration rate) of injured person
    - Sealed in contaminated chemical or biological suit
    - Monitor of subject without opening suit and contaminating subject
- **RADAR Vital Signs Monitor** developed for 1996 Olympic application
  - Monitoring of archer and rifle competitor’s vital signs at a distance of 30 feet
    - Do rifle competitors shoot between heartbeats?
    - Do archery competitors shoot between heartbeats?

**GTRI Olympic Athlete Monitoring System**

Olympic Athlete Monitor – Front View

**GTRI Olympic Athlete Monitoring System**

Radar Vital Sign Monitor - Rear View
GTRI Olympic Athlete Monitoring System
Respiration Signature at 30 feet

GTRI Olympic Athlete Monitoring System
Radar Cardiogram Taken at 15 Feet

Thorax Aspect
Range To Subject = 15 feet
GTRI Human Gait Program
Radar Measured Gait

- Radar Measured Gait Analysis
  - Investigation of radar sensed gait to identify subjects after they have been enrolled in a ‘gait’ data base

GTRI Human Gait Program
Processed Human Gait Signal

- Gait research program performed for DARPA
  - Registered almost 100 subjects by having them walk toward radar
  - Took gait data 6 months later on same subjects used to build data base
  - Developed recognition algorithm to compare ‘probe’ to ‘gallery’
  - Had 80% and higher recognition rate with low false alarm rate

- Doppler signature produced by body members (walking subject)
**Radar Flashlight, LLC Clip-on Monitor**  
**Heart and Respiration Rate Sensed Through Clothes**

- RADAR Flashlight, LLC is commercializing radar vital signs instrumentation  
  - Clip-on radar heart and respiration rate monitor is first product  
  - Stand-off long range non-contact radar vital signs monitoring system also planned as product

**Radar Flashlight, LLC Clip-on Monitor**  
**Clip-on Sensor Specifications**

- Sensor unit is clipped on uniform over thorax area  
- Battery operation  
- Up to 10 patients monitored simultaneously  
- Patient monitoring performed on hand held unit  
- Sensors data sent to hand held unit via radio link  
- Distance Between clip-on sensor and hand held monitor = 50 feet  
- Loss of signal alarm  
  - Radio link  
  - Patient vital signs

**Radar Flashlight, LLC Clip-on Monitor**  
**Heart and Respiration Rate Sensed Through Clothes**

- Applications for RADAR Flashlight, LLC Clip-on System  
  - Small military units behind operating behind lines with wounded  
    - Wounded stays in body armor and battle dress while system monitors  
    - Victim can be moved on short notice without usual wired system mobility problems  
  - Civilian heart and respiration rate monitoring applications  
    - No removal of clothes required to monitor  
    - Next generation system may be very inexpensive (disposable)

**Radar Flashlight, LLC Clip-on Monitor**  
**Radar System**

Radar System Used in Clip-on Sensor Package

Sensor weight is 2 ounces
Radar Flashlight, LLC Clip-on Monitor
Heart Signature Taken Through Clothes

Clip-on Sensor’s Heart Signal Channel Output

Time in seconds

RADAR Flashlight, LLC Clip-on Sensor
Respiration Signature Taken Through Clothes

Clip-on Sensor’s Respiration Signal Channel Output

Time in seconds
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What Radar Can’t Do (Yet)

- Monitor low level biological electrical signals in body
  - EKG
  - EEG
- Recover heart and respiration signals from all parts of the body
  - Thorax - front aspect best to monitor
  - Heart and respiration signal can be picked up from back area
  - If vessel or artery comes close to surface heart signal detectable

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Current Radar Vital Signs Challenges

- Any subject motion currently causes artifacts in signal from stand-off radar system
  - Moving body motion induces signal larger than small heart and respiration signal
  - Techniques to isolate heart and respiration signature from small body motion signature needs to be developed
  - Covert deception analysis on basis of heart and respiration rate at checkpoint possible if subject body motion artifact problem can be solved
- Motion artifact not same magnitude problem in clip-on system
- Recovery of radar developed heart and respiration signal from walking subject topic for future research
  - Data is in the Doppler sidebands but only as “micro-Doppler” components
  - Micro-Doppler recovery techniques should be subject of future research efforts

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Future Research Topics in the Area of Radar Based Deception Detection

- Heart and respiration signal recovery while subject is being questioned at Customs or Immigration counter
  - Motion artifact suppression research
  - Method to determine deception from only 2 channels of information
- Detection and recovery of heart and respiration signal when subject of interest is walking
- Techniques to isolate heart and respiration rates of subject moving in crowd

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Representative References


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