Radar Technology For Acquiring Biological Signals

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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
Radar Technology For Acquiring Biological Signals
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

Radar Technology For Acquiring Biological Signals
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

Radar Technology For Acquiring Biological Signals
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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