SENSOR DEVICES
FOR REMOTE SENSING

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1. RADAR FOR REMOTE SENSING
REMOTE SENSING

- **Definition (WIKI):** The acquisition of information about an object or phenomenon without making physical contact with the object.

- **Examples:** Weather radar, airborne radio map radar.

- **Usually industrial or military product.**

Rain droplet tracking, Thunderstorm tracking

Earth surface imaging
REMOTE SENSING TO OUR LIFE

- REMOTE SENSING TECHNOLOGY COMES TO OUR LIFE
- MILITARY, INDUSTRIAL DEVICE TO CONSUMER ELECTRONIC DEVICE
- BIG SYSTEM TO SMALL Sized MODULE
- RESEARCH AREA: PENETRATION, BIO, GESTURE RADAR
2. PENETRATION RADAR
GROUND PENETRATION RADAR (GPR)

- Transmit electromagnetic waves.
- Boundaries with different materials reflect waves.
- Penetration image can be obtained by the reflected waves.
IMPULSE GPR
STEP-FREQUENCY GPR
TIME-DOMAIN REFLECTED WAVE IMAGING

Radar signal transmission

Signal Record

Reflected Wave Image

Background Noise reduction, Clutter removal

Focusing, migration

Visualization
GROUND PENETRATION TEST

- PAVED ROAD PENETRATION
- FREQ: 400MHZ ~ 4.5GHZ
- BIG ARRAY ANTENNA

Time: 13nsec
Distance: 1.12m (@\(\varepsilon_r = 3\))
LOCALIZING GPR (LGPR)

- LGPR COMPLEMENTS EXISTING VISION-BASED AUTONOMOUS VEHICLE TECHNOLOGIES
- WORKS WELL IN ALL WEATHER CONDITIONS, DAY AND NIGHT
- REAL-TIME ARRAYED TD RW IMAGING

- Freq: 100M~400MHz
- Method: Step-Frequency
- Spacing: 6MHz
- Array: 12 antennas
- TRX: 11 channels

TERAHERTZ PENETRATION IMAGING

- Terahertz: submillimeter radiation
- ITU-designated band: 0.3~3THz
- High resolution due to high bandwidth
- Thin surface penetration

- Freq: 50GHz~0.7THz
- Resolution: 1mm
- High speed: 5000 fps
3. BIO RADAR
MICRO-DOPPLER RADAR

- **Small Angle Approximation**

  \[ S(t) = I(t) + jQ(t) = \exp\left\{ j \left[ \frac{4\pi x_1(t)}{\lambda} + \frac{4\pi x_2(t)}{\lambda} + \phi \right] \right\} \]
  \[ = 2j\left[ C_0 \sin(\omega t) + C_0 \sin(\omega t) + \cdots \right] e^{j\phi} \]
  \[ + 2\left[ C_{20} \cos(2\omega t) + C_{20} \cos(2\omega t) + \cdots \right] e^{j\phi} \]

- **Arc-Tangent Demodulation**

  \[ \phi(t) = \arctan \left( \frac{B_0(t)}{B_1(t)} \right) = \arctan \left( \frac{V_0 + A_0 \sin(\theta + 4\pi \Delta x(t)/\lambda)}{V_0 + A_0 \cos(\theta + 4\pi \Delta x(t)/\lambda)} \right) \]
METHOD

Permittance checklist
Displacement of the checked sub-carriers are only combined.
DISPLACEMENT OF BIOLOGICAL SIGNAL

- Phase shift by chest movement of respiration and heartbeat is different.
- Respiration makes 230 degrees of Doppler phase shift.
- Heartbeat makes 11 degrees of Doppler phase shift.
EXAMPLE

- HEARTBEAT SIGNAL CAN BE DETECTED BY 24GHZ MICRO-DOPPLER RADAR
- HEARTBEAT SIGNAL: BLUE LINE
4. GESTURE RADAR
WORLD’S SMALLEST VIOLIN

World's Smallest Violin – Google's Project Soli (Youtube)
GESTURE RADAR

- EMITS ELECTROMAGNETIC WAVES.
- HAND REFLECTS THIS WAVE ENERGY.
- CAPTURES ENERGY, TIME DELAY, AND FREQUENCY SHIFT.
- ESTIMATES HAND DYNAMICS.
- DETERMINES GESTURES.
BEING SMALLER

• 8MM X 10MM CHIP WITH RADAR TECHNOLOGY THAT USES GESTURE CONTROLS TO MAKE DEVICES TOUCHLESS.

• 7GHZ MAKES 140PSEC PULSE WAVE.

• FOUR ANTENNAS ARE PLACED TO ACQUIRE AOA INFORMATION.

• BEING TESTED FOR WATCH AND SPEAKER.
CONCLUSIONS

• THREE EMERGING RADAR TECHNOLOGY: PENETRATION, BIO, GESTURE

• TECHNICAL ISSUES
  • ARRAY ANTENNA SIZE REDUCTION FOR HIGH QUALITY PENETRATION IMAGING.
  • DETECTION RELIABILITY AGAINST MOTION ARTIFACT FOR BIO RADAR.
  • REAL-TIME ALGORITHM FOR GESTURE RADAR FOCUSING ALGORITHM (RMA,RDA.)
  • TRANSCEIVER ARCHITECTURE, DENSE ARRAY SIGNAL PROCESSING WHEN FREQUENCY CHANGES FROM GHZ TO THZ.

Thank you