The 14th U.S.-Korea Forum on Nanotechnology:
Internet of Things (IoT) including Nanosensors and Neuromorphic Computing

SENSOR DEVICES FOR REMOTE SENSING

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1. RADAR FOR REMOTE SENSING

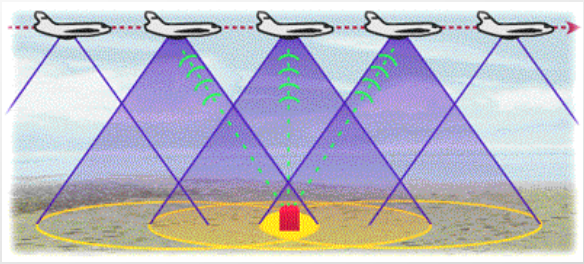
REMOTE SENSING

- 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

google play store


wikipedia

Rain droplet tracking, Thunderstorm tracking



www.quora.com

Earth surface Imaging

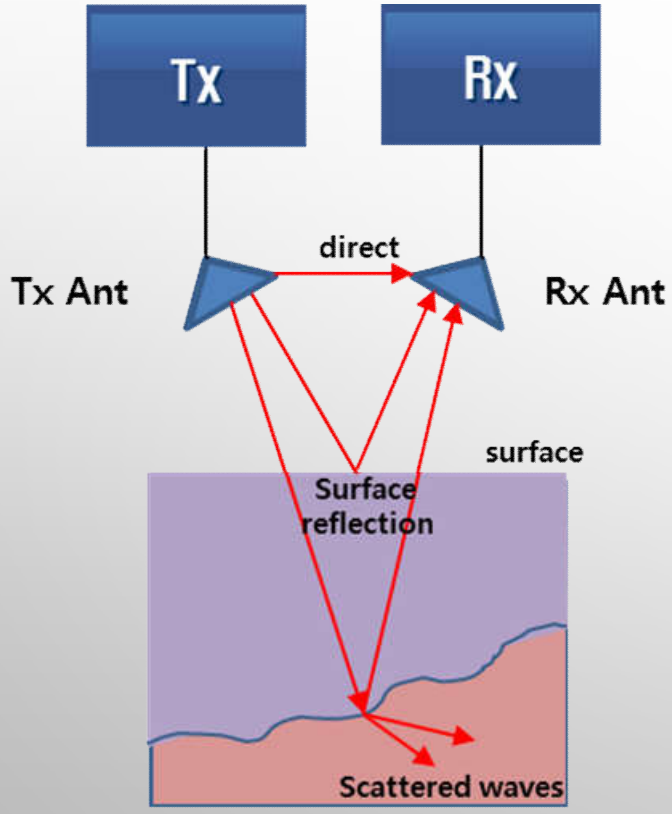
REMOTE SENSING TO OUR LIFE

- 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



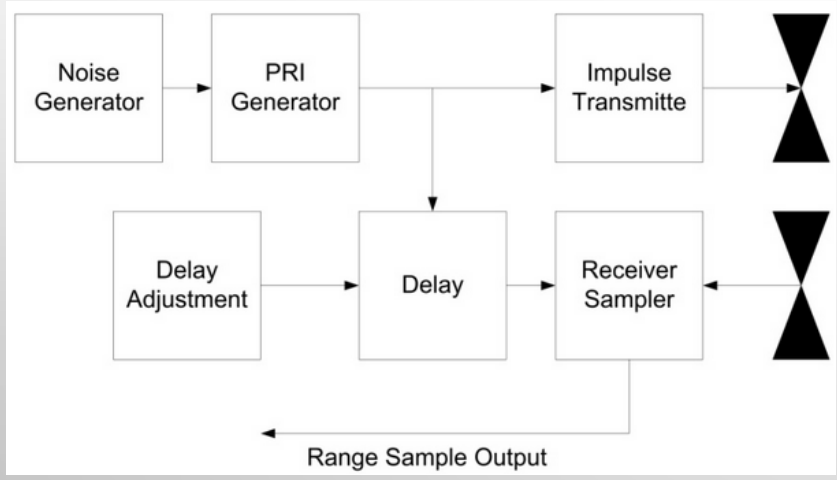

2. PENETRATION RADAR

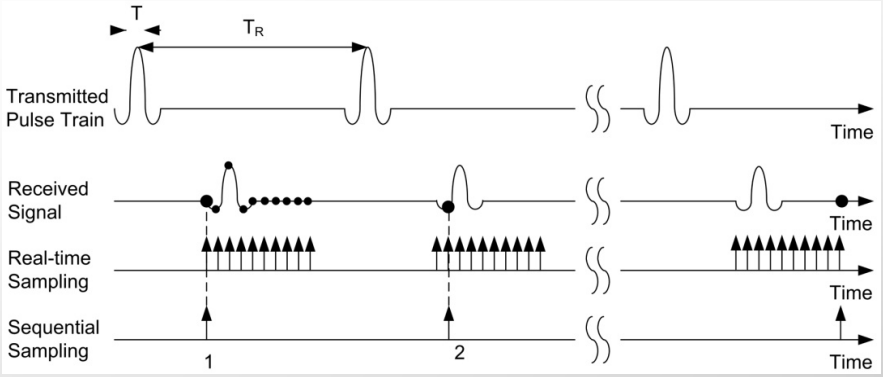
GROUND PENETRATION RADAR (GPR)



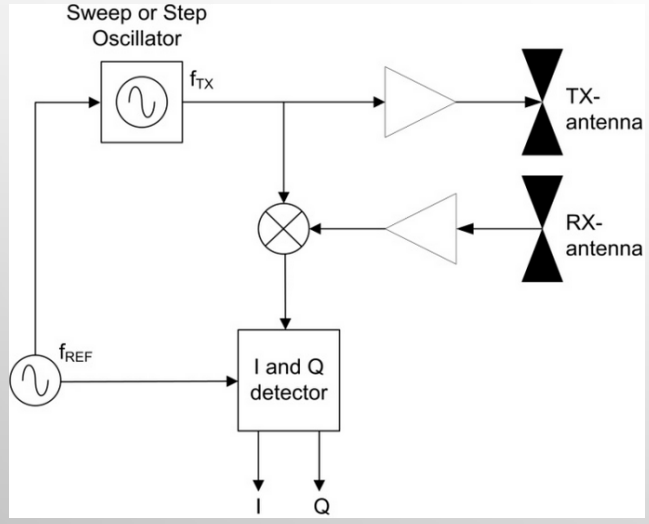
- TRANSMIT ELECTROMAGNETIC WAVES.
- BOUNDARIES WITH DIFFERENT MATERIALS REFLECT WAVES.
- PENETRATION IMAGE CAN BE OBTAINED BY THE REFLECTED WAVES.

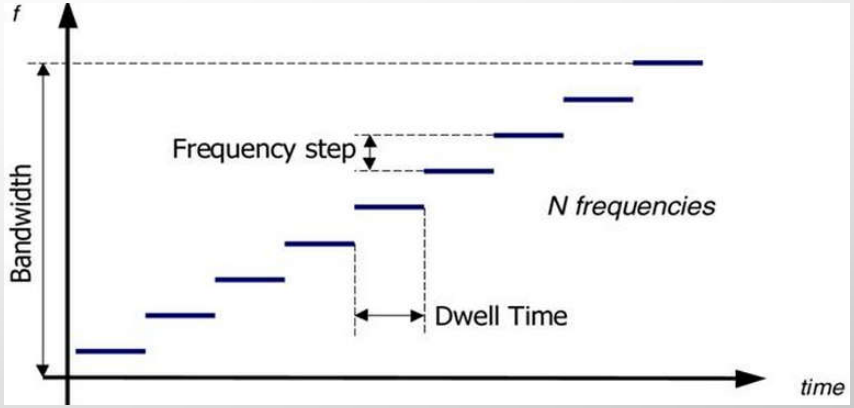
IMPULSE GPR


Noise Generator
PRI Generator
Impulse Transmitte
Delay Adjustment
Delay
Receiver Sampler
Range Sample Output


T
T_R
Transmitted Pulse Train
Time
Received Signal
Time
Real-time Sampling
Time
Sequential Sampling
1
2
Time

STEP-FREQUENCY GPR



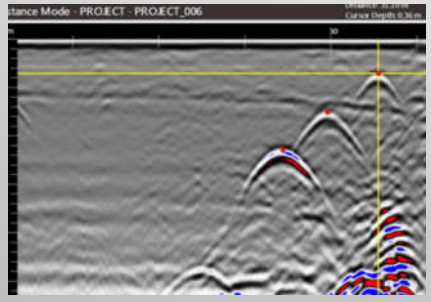


TIME-DOMAIN REFLECTED WAVE IMAGING

Radar signal transmission

Signal Record

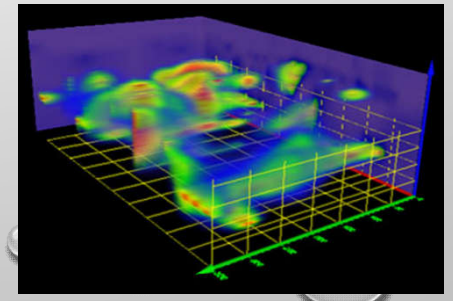
Reflected Wave Image



Background Noise reduction, Clutter removal

Focusing, migration

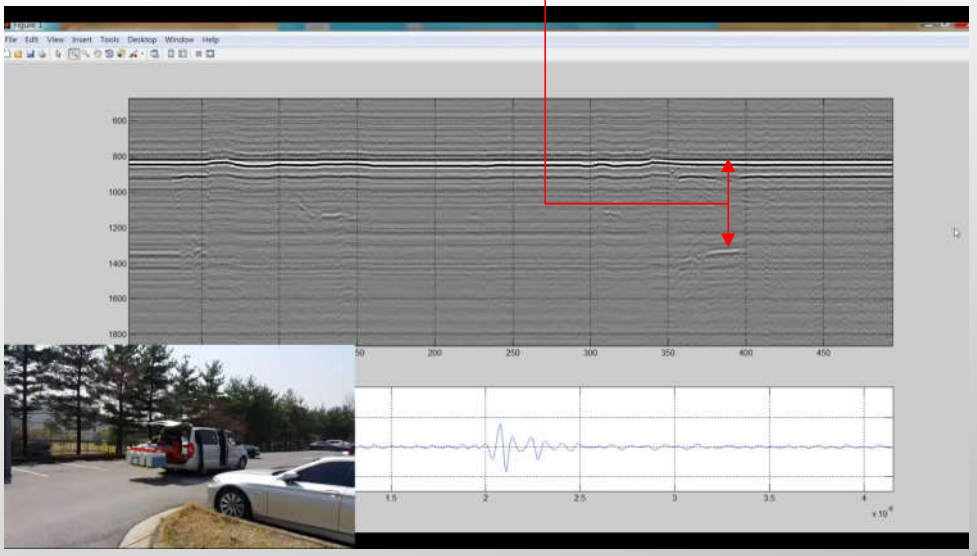
Visualization



GROUND PENETRATION TEST

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

time: 13nsec
distance:1.12m(@ε_r=3)

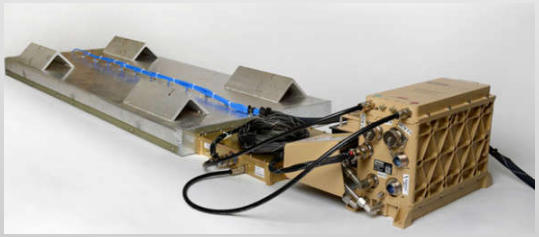


LOCALIZING GPR (LGPR)

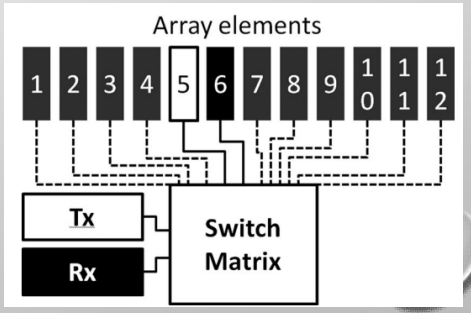
- LGPR COMPLEMENTS EXISTING VISION-BASED AUTONOMOUS VEHICLE TECHNOLOGIES
- WORKS WELL IN ALL WEATHER CONDITIONS, DAY AND NIGHT
- REAL-TIME ARRAYED TD RW IMAGING

Road surface change

- Freq:100M~400MHz
- Method: Step-Frequency
- Spacing: 6MHz



- Array: 12 antennas
- TRX: 11 channels



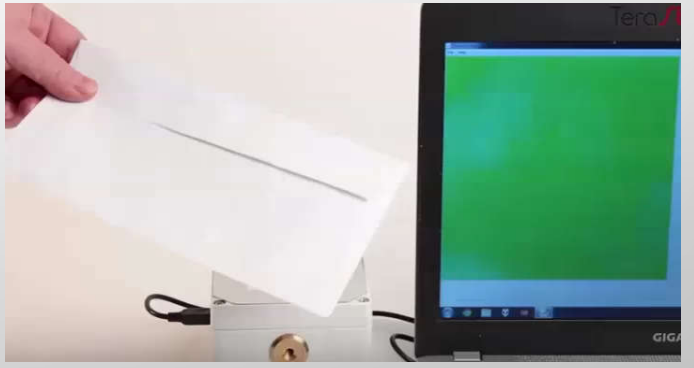
M. Cornick, et al., "Localizing Ground Penetrating RADAR: A Step Toward Robust Autonomous Ground Vehicle Localization," J. Field Robot., 2015

TERAHERTZ PENETRATION IMAGING

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

Penetration Camera

- Freq: 50GHz~0.7THz
- Resolution: 1mm
- High speed: 5000 fps

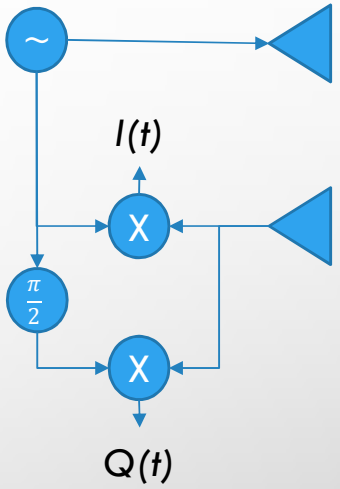


3. BIO RADAR

MICRO-DOPPLER RADAR

- SMALL ANGLE APPROXIM

$$S(t) = I(t) + j \cdot Q(t) = \exp\left\{ j\left[\frac{4\pi x_h(t)}{\lambda} + \frac{4\pi x_r(t)}{\lambda} + \phi \right] \right\}$$
$$= 2j\left[C_{10}\sin(\omega_r t) + C_{01}\sin(\omega_h t) + \cdots \right] \cdot e^{j\phi}$$
$$+ 2\left[C_{20}\cos(2\omega_r t) + C_{02}\cos(2\omega_h t) + \cdots \right] \cdot e^{j\phi}$$

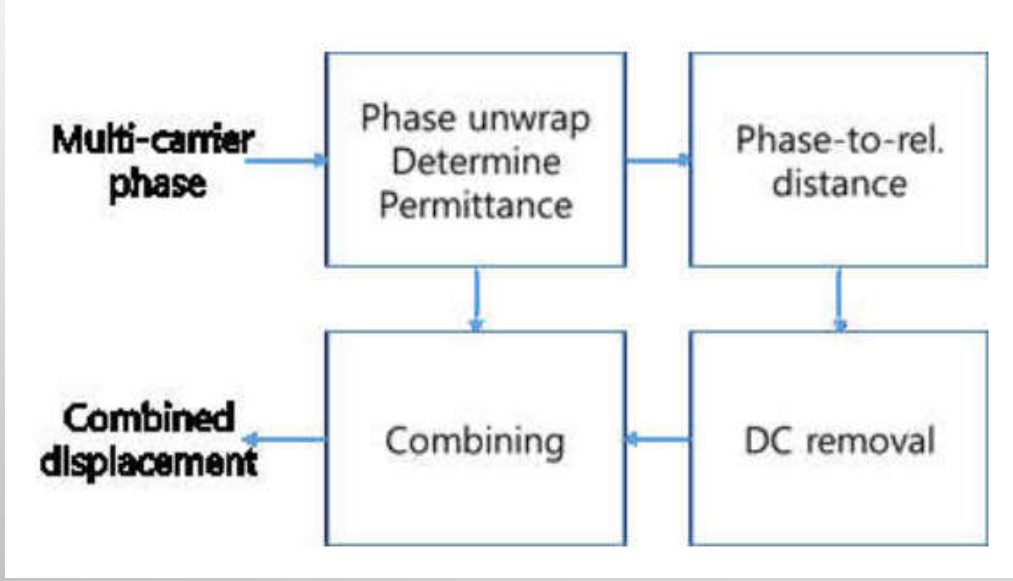


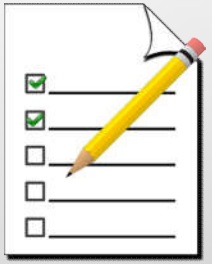
Doppler radar

- ARC-TANGENT DEMODULATION

$$\phi'(t) = \arctan\left(\frac{B_Q(t)}{B_I(t)} \right) = \arctan\left(\frac{V_Q + A_r \sin\left(\theta + 4\pi\Delta x(t)/\lambda\right)}{V_I + A_r \cos\left(\theta + 4\pi\Delta x(t)/\lambda\right)} \right)$$

METHOD

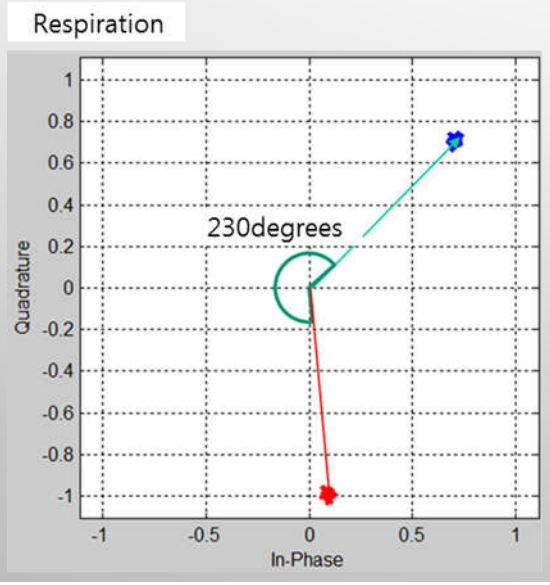


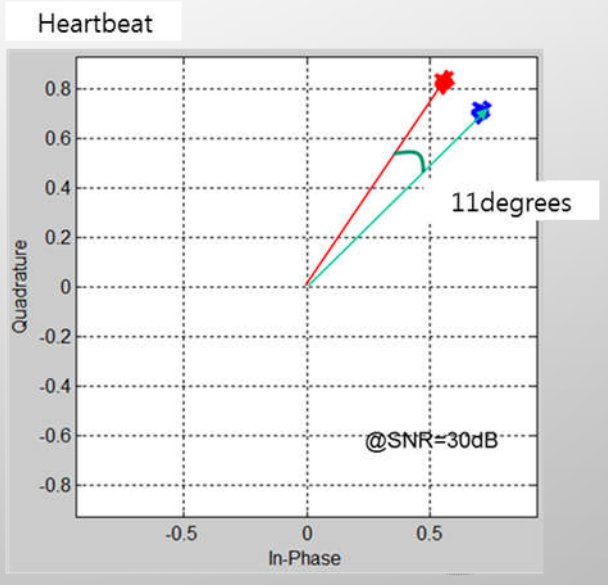


Permittance checklist
Displacement of the checked sub-carriers are only combined.

DISPLACEMENT OF BIOLOGICAL SIGNAL

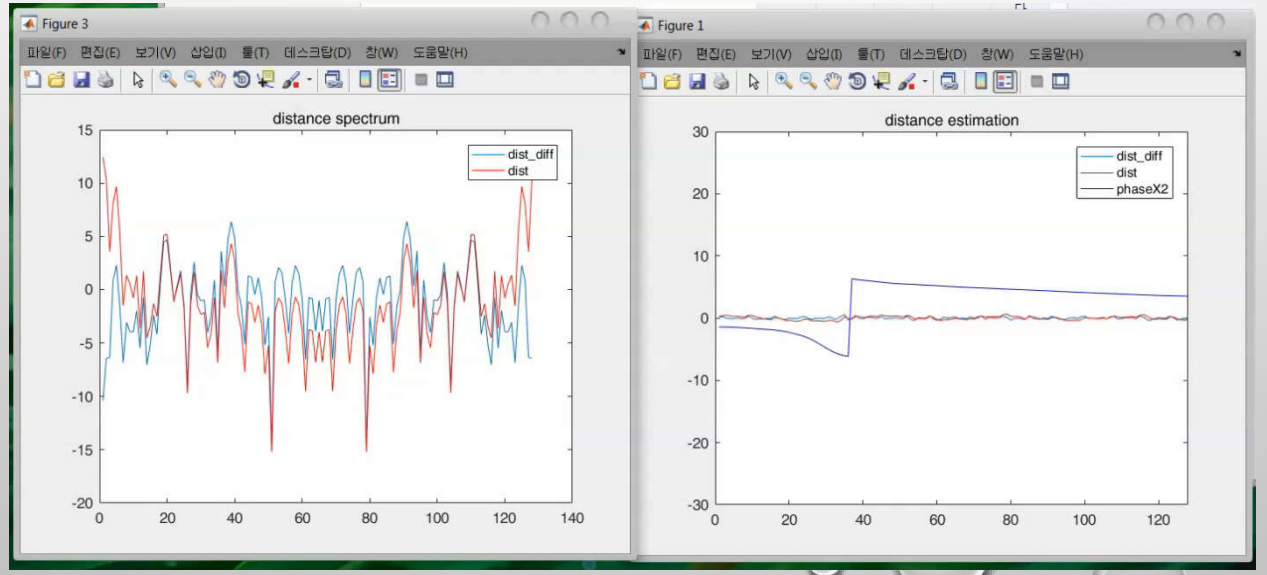
- PHASE SHIFT BY CHEST MOVEMENT OF RESPIRATION AND HEARTBEAT IS DIFFERENT.
- RESPIRATION MAKES 230 DEGREES OF DOPPLER PHASE SHIFT.
- HEARTBEAT MAKES 11 DEGREES OF DOPPLER PHASE SHIFT.





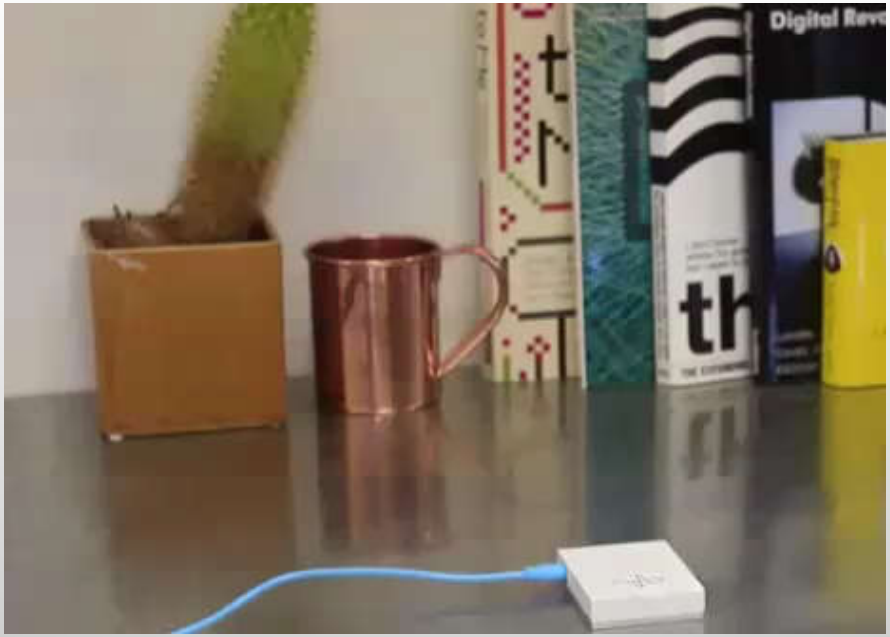
EXAMPLE

- HEARTBEAT SIGNAL CAN BE DETECTED BY 24GHZ MICRO-DOPPLER RADAR
- HEARTBEAT SIGNAL: BLUE LINE



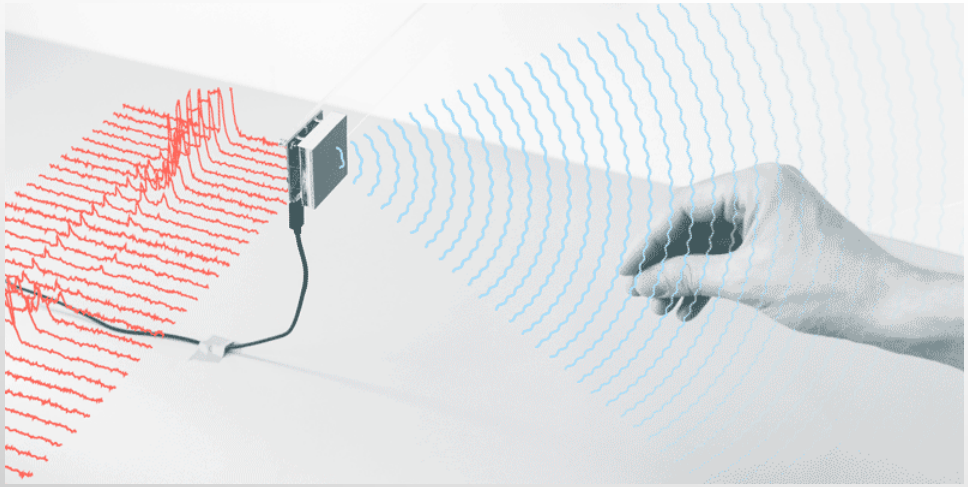
4. GESTURE RADAR

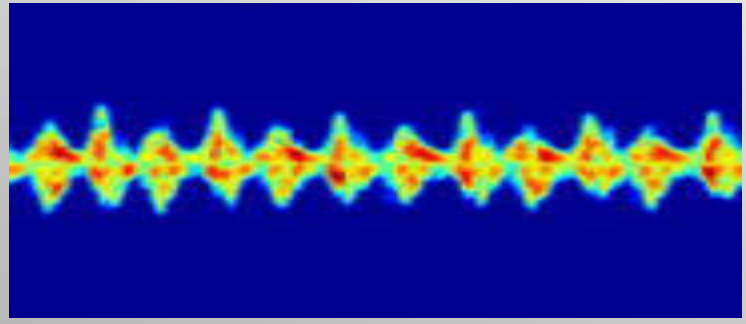
WORLD'S SMALLEST VIOLIN



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

GESTURE RADAR



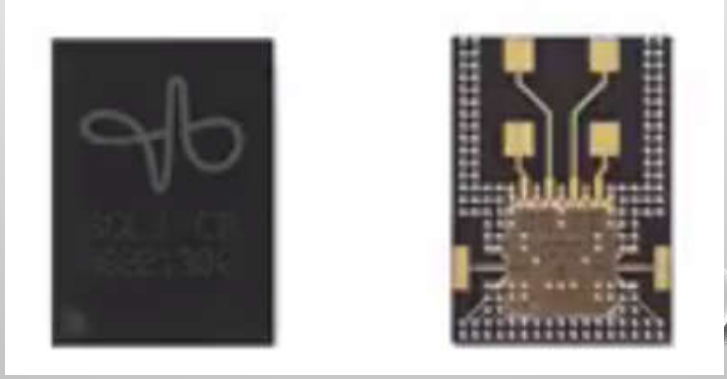


Micro-Doppler signature

- 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