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# A Brief Review on Bio-Medical Application of Radar

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***Abstract:*** *Since, The Radar Was Invented It Was Associated With The Military And Defenceapplications. The Revolution Ofradar Then Offered Medical And Industrial Application Which Ledto Intelligent Environment To Monitor And React On Our Dailyactivity. In This Paper We Present The Survey Of Possibility Ofradar Technology In Medical Application Without Instrumentingour Body. The Survey Explains The Vital Sign Monitoring Like Heartrate And Respiration Rate, Human Fall Detection, Radar Visionsensor For Blind People And Human Brain Stroke And Tumouridentification. Vital Sign Monitoring Exploits The Fact That Thereceived Signal Affected By Motion In Environment Due To Inhaling,Exhaling And Skin Vibration, Change In Speed Due To Fall Event,Distance Estimation By Change In Received Signal For Radar Visionsensor, And Change In Received Signal For Brain Tumour Detectiondue To Defected Tissue.*

***Keywords-****Microwave, Radar, Medical Application, Healthmonitoring.*

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## I. INTRODUCTIONAND MOTIVATION

General Radar System Is Used To Detect The Object In Far Field To Find The Location Of The Object And Corresponding Speed Of The Object. From The Time The Radar Was Invented To 1993 It Was Strongly Focused On Military Purpose [1]. It Was Not Intended To Use In Medical Field Until In 1996, Thomas E. Mcewan From University Of California Registered A Patent In United States [2]. Sincethen After The Interest Increased In Wireless Health Monitoring Or The Contact Less Human Body Examine In Compare To X-Ray Imaging. UWB Radar Are Working On Non-Ionized Electromagnetic Waves Which Are Harmless To Human Body [13]. In 14 February 2002, The Federal Communications Commission Allows To Use In Range Of 3.1ghz To10.6ghz Frequency Without License[3] While The Department Of Telecommunications Ministry Of Communications Information Technology Government Of India Authorize To Use 6ghz To 7.25ghz In National Frequency Allocation Plan 2011[4] With EIRP (Effective Isotopically Radiate Power) Of -41.3 Dbm /Mhz The Power Radiation Of UWB Band Is Strict And Thus It Effect As Noise For Other Equipment Unintended To Transmit Or Receive The Signal And Difficult To Detect By Unauthorized Device. By 1999 There Are Researches Of UWB Radar In Medical Use Like Respiration Rate Measurement, Heart Rate Measurement, Sudden Human Fall Detection, Breast Cancer Detection, Tumour Identification In Brain.

## II. TYPES OF RADAR

Based On Configuration, Scanning Pattern And Application, The Radar Is Classified As,

- Bistatic Radar
- Continuous-Wave Radar
- Doppler Radar
- FM-CW Radar
- Mono Pulse Radar
- Passive Radar
- Planar Array Radar
- Pulse-Doppler
- Synthetic Aperture Radar

**1. Doppler Radar**

A Doppler Radar Is Subjected To Measure The Velocity In Base Of The Doppler Effect. A Microwave Signal Is Transmitted And The Received Signal Will Get Variation If It Is Reflecting By Any Moving Object And Hence The Received Signal Power Would Be Measure Which Is Different Due The Doppler Effect.

**2. Continuous Wave Radar (CW Radar)**

The Continuous Wave Radar Is A RADAR System In Which A Known And Stable Frequency In Form Of Continuous Wave Radio Energy Is Transmitted. Received Frequency Followed By Reflecting Objects Is Measured. Continuous-Wave (CW) Radar Works On Doppler, Which Results A Slow-Moving Speed With Large Object. The Main Advantage Of Continuous Wave Radar Is A Continuous Wave Form Rather Than Pulse Wave Form Which Results The Easy Manufacturing And They Have No Minimum And Maximum Range Although The Broadcast Power Level Imposes The Practical Range. It Can Be Modulated Continuous Wave Radar And Unmodulated Continuous Wave Radar. In Unmodulated Continuous Wave Radar The Reflected Frequency Is Shifted Away From Transmitted Frequency Based On Doppler Effect While The Object Is Moving So It Does Not Depend On Distance. The Doppler Frequency For Unmodulated Continuous Wave Radar Canbe Determine As A

$Fr = Ft [(1+V/Ci) / (1-V/Ci)]$ (1)

Thus, Doppler Frequency Fd Is

$Fd= Fr -Ft = 2V [ Ft / (Ci – V)]$ (2)

Where

Ci = Speed Of Light Slower Than Vacuum

V = Speed Of Object

Ft= Transmitted Frequency

Fr = Received Frequency

Modulated Frequency Continuous Wave Or FMCW Radar Isa Short-Range Measuring Radar To Measure A Small Range.The Modulate Frequency Increased Reliability By Offering Thedistance Measurement Along With Speed Measurement Whenmultiple Object Are Present.The Reliability Is About 60 Percent Of The Modulated Frequencythe Range Of FMCW Radar Is,

$Fr -Ft = C / [ 4 * Modulated Frequency]$ (3)

## III. RATIONAL FOR BIO-MEDICAL APPLICATIONS

Electromagnetic Pulses Coming From UWB Radar Are Able To Detect Some Internal Structure Behaviour Of Human Body. In Lawrence Livemore National Laboratory, One Application Was Performed To Examine The Human Body Through UWB Radar Which Was Working On The Movement Of The Heart Wall. The Patent Register By Mcewan Explained The Difference In Reflection Magnitude Between Heart Muscle And The Blood In It [2]. As The Impedance Of The Heart Muscle Is 60 Ohms And The Blood Is50 Ohm, So Relatively 10 Percent Of Reflected Radio Energy Is Expected [2]. The Proposed Model In The Patent Is Uncompleted As The Living Tissues Are Not Accounted Which Are Across The Skin To Heart Wall.

**Table I:**Electromagnetics And Anatomical Properties Of Tissue Layer In The Thorax [5]

| | Independence | Attenuation | Speed | Thickness |
|---|---|---|---|---|
| | Ω | M-1 | M/S | M |
| Air | 376.7 | 0.00 | 2.998 108 | 1.00 10-2 |
| Fat | 112.6 | 8.96 | 8.958 107 | 0.96 10-2 |
| Muscle | 49.99 | 31.67 | 3.978 107 | 1.35 10-2 |
| Cartilage | 58.16 | 31.93 | 4.628 107 | 1.16 10-2 |
| Ling | 52.86 | 29.62 | 4.206 107 | 5.78 10-3 |
| Heart | 49.17 | 38.71 | 3.912 107 | - |

The Data Given In Table 1 Is Obtained From The Visible Human Project [5] And The Data Book Of Gabriel'sDielectric Property Of The Tissue [6]. The Table Describes The Impedance Of The Tissue Layer Of Thorax With Its Thickness And Attenuation From Which The Time Delay Of The Received Signal Can Be Calculated. Even It Seems Accurate; It Is Incorrect As The Experiments Conducted In Certain Condition Like The Living Tissue Were Examined At 1500 Mhz Continuous Waves [6]. So, It Is Important To Sorting The Dielectric Property Of Living Tissue In UWB Band Rather Thannarrow Band.

## IV. MEDICAL APPLICATION

### 1. Fall Detection

In Present Era The Number Of Old Age-Humans Is Increasing Every Day And, In Some Condition, They Require Continuoussupervision.

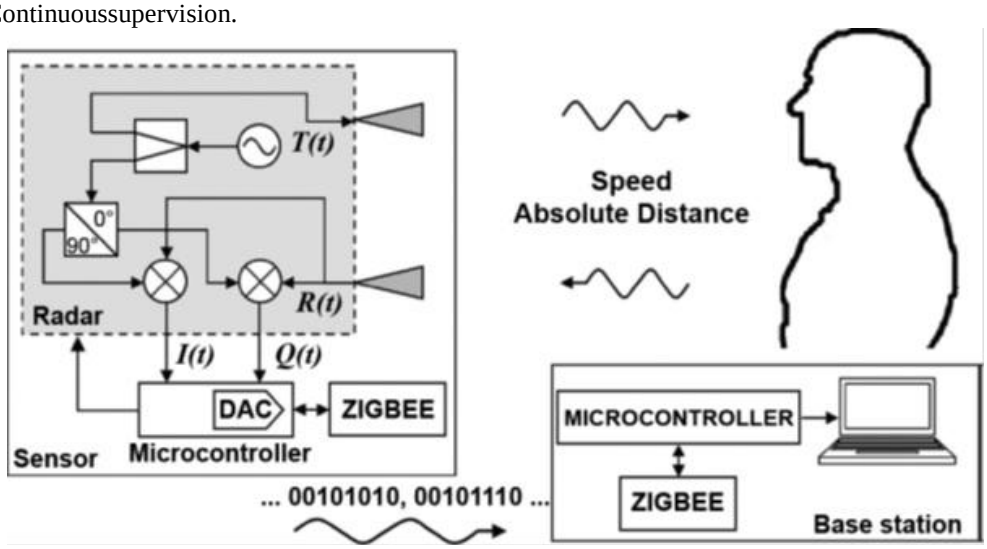


**Fig. 1**: System Block Diagram. [7]

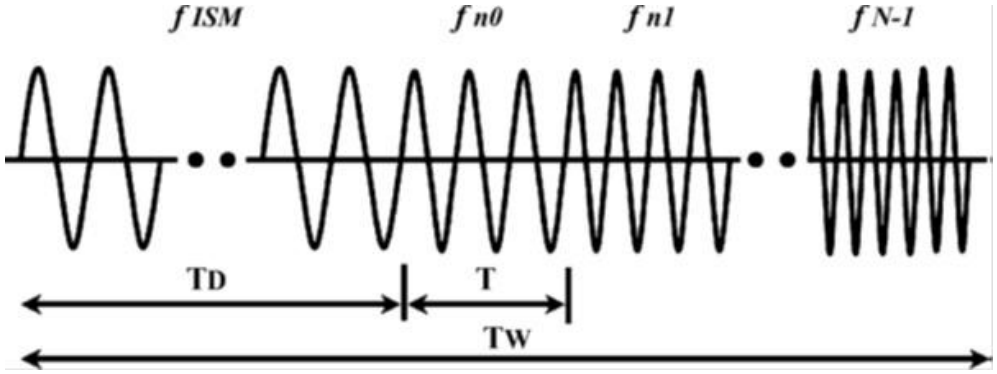


**Fig. 2:**Waveform Design. [7]

It Can Be Acquiring Using Camera Too But It Cannot Be Enough Reliable Compare To The UWB Radar Device. Camera Can Detect The Fall Detection But Alarming At Which Time Of Instant It Occurs Require High Signal Processing With High Definition Camera Which Result In Expensive System With Lake In Some Feature Like Alarming And Night Vision Ability. This Can Be Overcome In Radar Technology As It Does Not Depend On Light Source It Can Able To Detect The Human Fall With The Time Marking And At Distance Of The Person. In [7] Author Represents The Contact Less Radar-Based Fall Detection System. Figure 1 Shows The Simplified Block Diagram Of The System.

It Consists The Combination Of Radar Sensor With Wireless Communication And Signal Processing Inbuilt. The Sensor Generates The Waveform And Transmits It To The Object Then The Signal Which Is Reflected By The Object Is Received By The Receiver Which Contains The Time And Distance Information Of The Object. The Received Analog Signal Is Converted To Digital Form And Wirelessly Transmitted To Zigbee Module. Zigbee Is Connected To Laptop Through Micro-Controller Which Determines The Difference Between Location And The Time Marking Of Fall Event Compare To Normal Signal. In This System The Data Processing Is Not Acquired By The Radarsystem To Avoid Complexity Of Processing Unit On Board. The Approach Of Radar Waveform Is Similar To [8] With Signal Tone At 5.8 Ghz In ISM Band Alternated With Step Frequency Continuous Wave Of UWB Band Shown In Figure 2 Below. Each Tone Of 5.8 Ghz Is Transmitted For 1 Second To Detect The Speed Of Object By Doppler Effect; Meanwhile The Step Frequency Is Determining The Distance Of The Object. The Step Frequency Waveform Is Divided In 40 Coherent Continuouswave Pulses And Each Pulse Consist A Frequency Of 25mhz So That The Time Period Of Each

Pulse Is 50 Micros Second Long In Increment Order At Every Coherent. Resultant Duration Is 40*50*10-6 Which Is 2 Mili Second With Band Of 1ghz (40*25mhz). It Is Positioned Between 6 To 7 GHZ To Gain Smallest Resolution Of 15 Centi Meter. The Full Waveform Is1.002 Second Compare To [8]. The Spectral Analysis Is;

$\phi_{S=2} \prod$ FISM [(2DISM/C) $+2 \prod$ (2fismv (T) T/C) +ΘISM] (4)

And

$\phi_{N=}$ (4 $\prod$ F0 D0/C)+ (2 $\prod$ $\Delta$ F 2d0nt / TC) + (2 $\prod$ 2v (Tn) F0nt / C) +

(2 $\prod$ 2v (Tn) N $\Delta$ F Nt/C) + Θn (5)

Equation (4) And (5) Are Responsible For Wave Form Designing And Signal Processing.

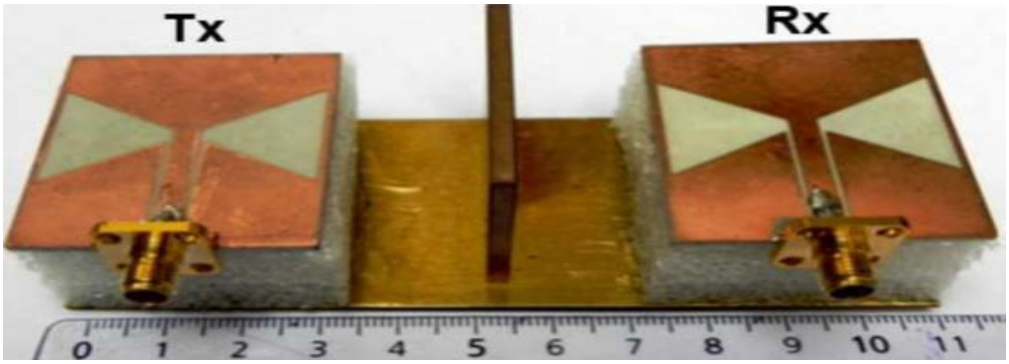


**Fig. 3**: Prototype Of The System. [7]

**2.Respiration And Heart Rate Monitoring**

Vital Sign Monitoring Can Help To Classified Human Health According To Change In Vital Sign. E.G. The Respiration Rate Of Human In Normal Condition Is 10 To 12 Breaths Per Minute [10]. Thus, Change In Breathing Rate Exceeds Than Minimum And Maximum Breathing Rate Indicates The Change In Human Health Condition And Require The Medical Attention To The Patient. So, The Respiration Rate Monitoring Can Help To Know The Human Health Condition. Also, The Normal Heart Rate Of Adult Person Is 60 To 100 Bpm [11]. The Bits Per Minute Exceed Then This Limit Indicated The Chances Of Disease [12]. So, The Monitoring Of Heart Rate Can Also Help To Monitor Human Health Condition. In [9] The Authors Have Demonstrated The Human Respiration And Heart Rate Monitoring. The Author Differentiates The Change In Distance With Respect To Sensor To The Person Due To The Inhale And Exhale Process. Thus, Some Minor Mm Distance Can Identify By Radar. Each Time When Inhale And Exhale The Chest Start Compressing And Expanding By Which The Respiration Rate Can Be Obtain.

The Author In [9] Introduces The New Device Name Vital Radio; Which Monitors The Vital Sign Of The Human Without Physical Connection To Human Body. It Operates At 5.46 Ghz To 7.25 Ghz With Frequency Swapping At Every 2.5 Mili Second Vital Radio Work Perfectly Even The Multiple Persons Are In The Room. The Device Performs Simultaneous Process For Vital Sign Monitoring

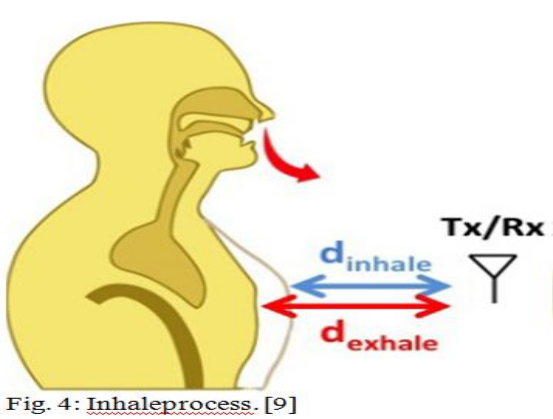


Fig. 4: Inhaleprocess. [9]

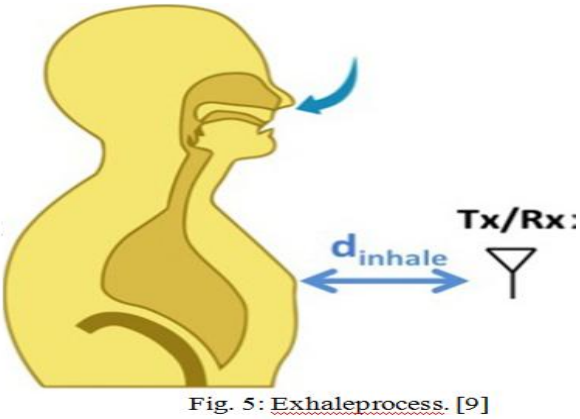


Fig. 5: Exhaleprocess. [9]

For Each Person Present In The Room As Shown In Figure 6. The Main Advantages Of This Contact Less Device Are; Human Does Not Need To Face It, Even They Are Sitting, Sleeping, Walking, And Watching Television, Still The Device Can Work On Them. It Transmits Low Power Signal Which Is Not Harmful To Human Body And Identified The Time Delay For The Received Signal Due To Inhale And Exhale.

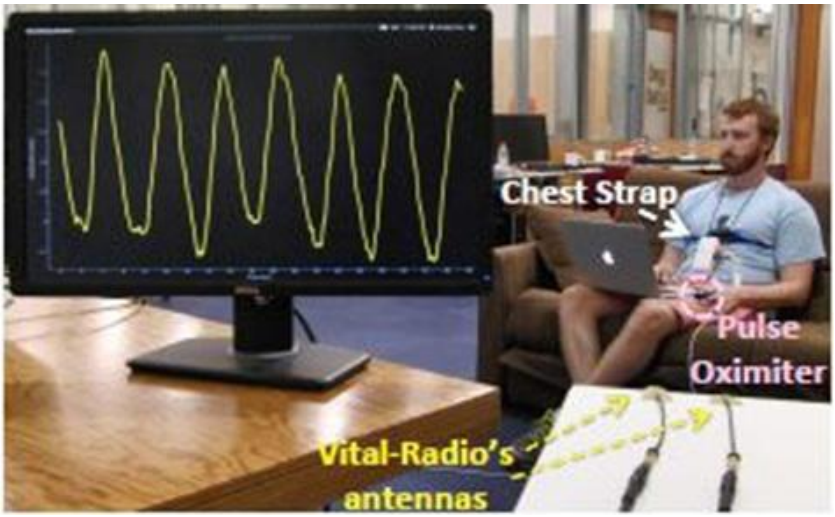


**Fig. 6**: Experiment For Vital Sign Monitoring. [15]

**3. Radar Vision Sensor**

The Radar Vision Sensor Was Presented In Analog Design Contest 2014 Of Texas Instruments University Program [14]. The Goal Of The Contest Is To Focus The On Advance High-Resolution Radar System Application In Medical And Industrial Applications. TheRadar Vision Sensor Works On Frequency Modulated Continuous Wave Principle In Which The Frequency Of The Continuous Signal Is Modulated And Transmitted To The Object And The Received Signal Is Time Delay Signal Which Contain The Distance Information Of The Object.

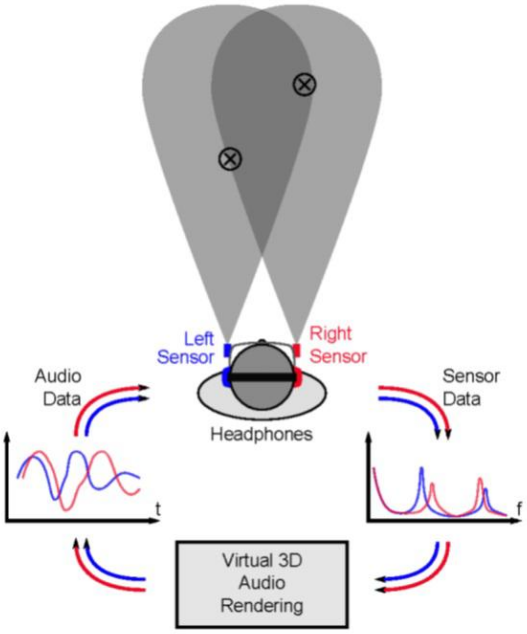


**Fig. 7**: Radar Vision Sensor. [15]

From The Front End Of The System The 80 Ghz Frequency Is Generated For Transmission. At The Back End High Performance Digital Signal Processing Is Done By 2 High Speed 16-Bit ADC At 250MSPS Rate With Inbuilt Ultra-Low Jitter Clock Manager And 4 Micro Volts Power Supply Circuitry Of Texas

Instruments As Shown In Figure. In The Device The Targets Absolute Distance And Angle Information Is Collected By The Sensor And Virtual 3D Audio Rendering Technique [15] Is Used To Form In Audio Of Received Data Asshown In Figure. Then The Audio Data Is Synthesized To Representthe Simplified Information Of Surrounding Area.

**4. Brain Stroke And Tumour Detection**

Cancer Is The One Of The Most Dangerous Disease In Which The Human Life Is Risky If Medical Attention Is Not Initiated Within 4 To 5 Hours. The Report Statics Sows That The 13.2 Million People Expected To Died Till 2030[16]. It Happens Due To The Insufficient Blood Supply To The Brain Due To Blood Vessel Is Partially Or Fully Blocked [17-18]. The Microwave Technique Used To Detect Dielectric Difference Between Healthy And Defected Brain Tissue; Where The Defected Tissue Is Responsible For Brain Cancer. The Device In [19] Operated At 3.3568-12.604 Ghz Frequency Tested On Real Human Head. It Is Also Simulated On Rectangular Human Head Model Consisting Three Layer Of Skull Skin And Brain With Property Given In Table II

**Table II:**Skull Skin And Brain Property

| | Electric Permittivity | Electric Conductivity |
|---|---|---|
| Brain | 49.7 | 0.59 |
| Skull | 17.8 | 0.16 |
| Skin | 46.7 | 0.69 |

In Below Figure The Experimental Result Of Human Head Model With Tumour And Without Tumour Is Shown In Which The Return Loss Of The Signal Is Measured Which Help To Find The Dimension And Location Of The Tumour.

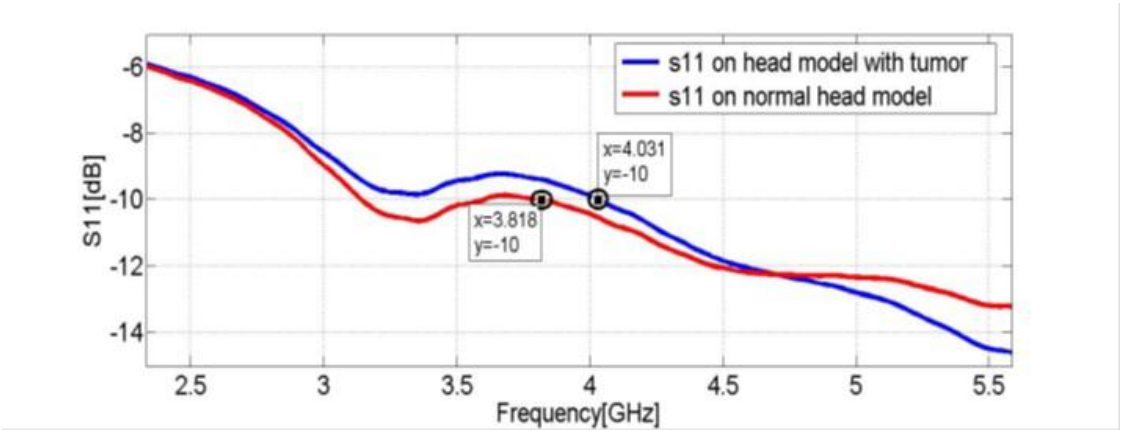


**Fig. 8:**Result Of Brain Scanning. [16]

## V. CONCLUSION

In This Article We Give Brief Survey Of Radar In Bio-Medicalapplications. The Term Radar Which Was Appeared With Themilitary And Defence Application Till Now But After Mcewanpatent [2] In 1996, The Radar Also Affiliated With The Medicalapplication. In This Article We Understand How Radar Can Implementedfor Contact Less Human Health Monitoring Like Heartrate Measurement, Respiration Rate Measurement, Detection Ofcancer Like Brain Cancer, Detection Of Tumours Etc. Moreover,Still Radar Can Be Used In Many Applications Which Require Somemore Effort To Shape It For Implementation In Real Life.

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