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The Radar Echo of Human Body Modeling Based on Matlab

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Abstract: *This paper established the model of radar's transmitting signal, and get theformula of the echo of point target .By using the theory of ten scattering model is equivalent to the human body model for the combination of multiple point target echomodel, considering the various components of Angle with radar, and according tothe RCS of all components, and get the radar echo signal of them.When the man moving,considered of the speed parameter,andalso considered the motion of the arms and legs. Finally obtained the radar echo signal from different parts of the bod respectively, eventually get the echo signal of the human body, and then made the signal simulation based on MATLAB platform.Finally get the radar echo time domain model of the human body as well as the frequency domain radar echo model.*

Keywords: *Radar echo MATLAB human body model ten o 'clock*

I. INTRODUCTION

In recent years, the SIGE technology [1] is applied to semiconductor above the miniaturization of the chip, makes automobile millimeter-waveradarresearchmeaningful.Detection has been the focus of the automotive sensors to the human body, and the millimeter wave radar has obvious have advantages compared with other sensors,millimeter wave radar can work in difficult environments, the implementation of all-weather for target detection, and even can be implemented through obstacles to test the obstacle after the goal [2], and even can detect the human body micro movement such as breathing.Human body based on radar target detection in the security protection, disaster relief, biology mechanics and kinematics research has broad application prospects, and nowadaysto detect the movement of human based on radar has become a research hotspot.

The movement of people's micro movement detect research began in the late 90s.According to the existing data, in the foreign radar target micro feature extraction research is mainly based on the measured date to extract the body characteristic signal.Someone using the coherent x-band continuous wave radar to get the body walking data, used in the study of gait recognition.They walk cycle is also studied and analyzed the physical form of movement, and use the STFT for feature extraction, through the frequency can be clearly see the micro-doppler of each body swaying back and forth motion incentives.TraianDogaru and Lam, Nguyen using FDTD to calculate the electromagnetic scattering of the human body, and get the human body target RCSandSAR images under different incident Angle.T. Thayaparan by analyzing the measured radar data of human body micro-doppler features shows that micro Doppler parameters estimation can be used in the human body.Adrian Lin studied low cost, simple human body tracking technology,using binary array distinguish multiple target doppler signals of human body, to determine the target position.In recent years, P.vanDorp and F.C.A. Groen [3],To study the human body target motion parameter estimation based on Thalmann model, explains the law of human walking, and then they improved the Thalmann model. Use the new model they estimate more human gait parameters.The study mainly focused on the radar echo characteristics of phenomenological research level based on the human body, the lack ofsystem theoretical research[8].This article is a theoretical analysis of the characteristics of human body micro radar walking, firstly to build human body movement model, and get acomposedof homogeneous medium is applicable to study human body motion model characteristic of radar, and then discussedthe radar echo theoretically[4].

II. RADAR SIGNAL

2.1 radar transmitting signal

In MATLAB modeling of radar's transmitting signal, at first we should to set the position of radar in the space.Generally represented by a point in the space coordinate system radar, then according to the launch of radar signal for radar given properties to the radar.In this article, we use radar for linear frequencymodulatedradar[9], so we can set the radar signal as:

$f(t) = \exp(j2\pi f_0 t)$(1)

In the formula $f_0$stand forthe transmission frequency of electromagnetic wave,and t on behalf of the time.In this paper, we set the radar transmitting frequency is 77 GHz.

In the MATLAB associated Settings are asTab.1:

Tab.1 parameters of radar

parameters	The numerical
frequency	77GHz
coordinates	（0,0,0.8）
Azimuth of radar	$\pm 10°$
Pitching Angle	$\pm 5°$

Based on radar set parameters, using MATLAB software can obtain radar signal of time domain and frequency domain graph, as shown in figure 1.

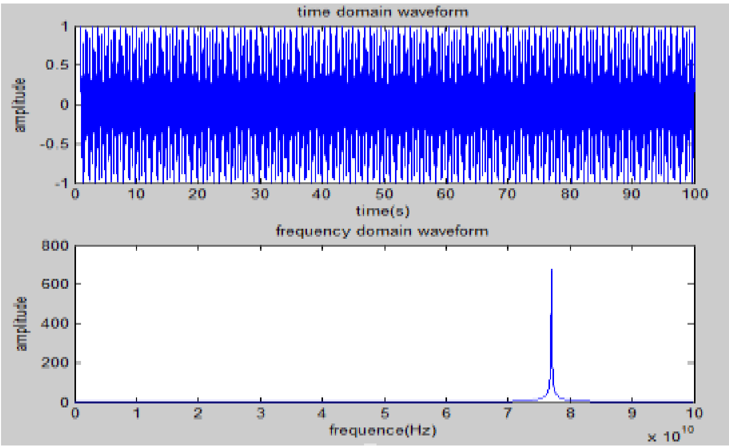

Fig.1 the waveform of 77G radar

2.2 radar echo signal of point target

The basic principle of radar is through the radio waves togetecho, and thentheform and motion stateof the target can do modulation to the echo of the target, so that the echo of the targetcarried theinformationoftheobstacles.Then the radar receiving echo and demodulation, demodulation will live us some information of the obstacles,combined with recognition algorithm can realize the recognitionoftarget. From its corresponding echo from radarwe can get the transmitting signal as:

$$s_r(t) = a(t)\exp\left[j2\pi f_0\left(t - \frac{2r(t)}{c}\right)\right] = a(t)\exp[j\varphi(t)]\exp(j2\pi f_0 t)$$

$$= s(t)\exp(j2\pi f_0 t) \qquad (2)$$

Among them, $a(t)$as the reflection ccoefficient as the speed of light,$\varphi(t)$ as the instantaneous phase, $r(t)$as the distance from radar for scattering point, $h(t)$as the echo shock response, $s(t)$for complex envelop.

III. ECHO MODE OF HUMAN

The human as a complex target, generallytreatthe body to be a 10 point target model.10 point here refers to 10 parts of the human body, each point as a target scattering center, then each local center combined to become the target scattering center.To the human body into ten regions, as we can see from the figure 2.

Fig. 2ten point mannequins

The body size determined from the sampling test results according to our schoolstudents.we get10 points to the human body model related parameters as shown in table 2.

Tab.2 size of the body parts

Points name	Code	Size
The head height	Hh	0.255
body height	Hb	0.595
shoulder breadth	Ls	0.460
big arm length	Hua	0.333
length of forearm	Hla	0.253
The arm width	Wa	0.08
Neck height	Hn	0.05
Thigh length	Hul	0.495

For the human body model, we only consider the humanfrontal. According to Lund & Browder table [5]we can calculated for different parts of the human frontalreflection coefficient as shown in table:

Tab.3Reflection coefficient of the body parts

Area	code	proportion
The head	Rh	10.02%
The body	Rb	28.36%
left upper arm	Rlua	4.71%
Rightupper arm	Rrua	4.71%

Left forearm	Rlla	6.8%
Right forearm	Rrla	6.8%
Left thigh	Rlul	11.6%
Right thigh	Rrul	11.6%
Leftcalf	Rlll	7.9%
Right calf	Rrll	7.9%

IV. SIMULATION

To simulate each part of the human body model, firstly we should determine the positions of the human body in the coordinate system.HereSet the trunk As the center of the human torso .we set the trunk x axis coordinates of x0 = 5, y coordinates of y0 = 50, the goal and the relative motion of the vehicle's direction along the y axis direction, speed of 10 m/s.Each part of thehuman body's coordinates expression as follows:

Tab.4 Spatial coordinates of the body parts

Regional point	Coordinate expression
The head	（x0,y0,Hul+Hll+Hb+Hn+Hh/2）
The body	（x0,y0,Hul+Hll+Hb/2）
left upper arm	（x0+Ls/2+Wa/2,y0,Hul+Hll+Hb-Hua/2）
Left forearm	（x0+Ls/2+Wa/2,y0,Hul+Hll+Hb-Hua-Hla/2）
Rightupper arm	（x0-Ls/2-Wa/2,y0,Hul+Hll+Hb-Hua/2）
Right forearm	（x0-Ls/2-Wa/2,y0,Hul+Hll+Hb-Hua-Hla/2）
The left thigh	（x0+Ls/2,y0,Hll+Hul/2）
The left leg	（x0+Ls/2,y0,Hll/2）
On the right side of the thigh	（x0-Ls/2,y0,Hll+Hul/2）
The right leg	（x0-Ls/2,y0,Hll/2）

4.1 The echo ofhead and torso

According to the radar echo expressions, if we want certain parts of the human body echo here, we need to find out the distance betweentherelated parts and the radar, for here the human body have relative motion with radar, so it must be consideredofthe change of the distance in different time which is caused by the relative motion[10].

Each part of the human body's reflection coefficient is determined by the RCS values to the values[15]. It is assumed thatthe surface roughnesses of different parts are in same values. So the RCS of parts is mainly based on the area of the surface .The original reflection coefficient is analyzed by facing the body[6].Here, there is a certain Angle with radar and the human body, so we need to consider the factor of the Angle to the reflection coefficient of each place on the human body.Theecho expressionof human torso after we modified the reflection coefficient is:

$$RXb = Rb \times \sin(AngLrb) \times e^{(j\times 2\times\pi\times f_c\times(t-{2\times RLrb}/{c}))} \quad (4)$$

And in the expression AngLrb represent the angle between the radar and the trunk.

Through MATLAB simulation, we can get the echo model of the trunk as shown in figure 3.

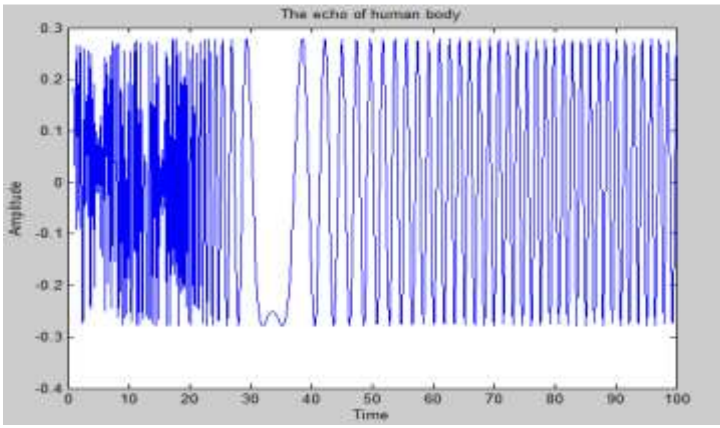

Fig.3 echo signal of trunk

4.2 The echo of left arm

Different to the torso and head of the body, the body of the upper arm swinging during human's moving. Firstly set the upper arm to leave the maximum Angle is $\varphi_{luam} = 2\pi/36$.The initial Angle is 0.period cycle for 1s, in the initial time the arm swinging forward.Depending on the set, five special moments can be obtained as shown in the table 5:

Tab.5

Time	0	0.25	0.5	0.75	1
radian	0	$\pi/2$	π	$3\pi/2$	2π
Sine	0	1	0	1	0
Angle	0	$2\pi/36$	0	$-2\pi/36$	0

Relative to the motion of the upper arm, forearm will be swing on the basis of the upper arm swing, and there will be larger oscillation amplitude[7].Set here, the forearm is swing around the lateral axis, and the maximum swing Angle is φ_{llam} $=2\pi/18$, initial Angle of 0 degree, and the initial moment swing direction with the left arm in the same direction, oscillating cycle for 1s.five special moments can be obtained as shown in the table 6:

Tab.6

time	0	0.25	0.5	0.75	1
Radian	0	$\pi/2$	π	$3\pi/2$	2π
Sine	0	1	0	1	0
Angle	0	$2\pi/18$	0	$-2\pi/18$	0

Similar to swing of the left upper arm and the left forearm, the left thigh and the left upper arm can swing like the same, and only difference is the initial direction contrary to the initial swing direction of the upper arm, and the same like of the left calf.Respectively in the same way, we can get theecho signal of right thigh, right calf, right forearm, and rightupperarm.The right leg and left arm has the same direction, the left leg and right arm too. Figures 4 and 5respectively stand for the human body left upper arm echoes, and the human right forearm[11].

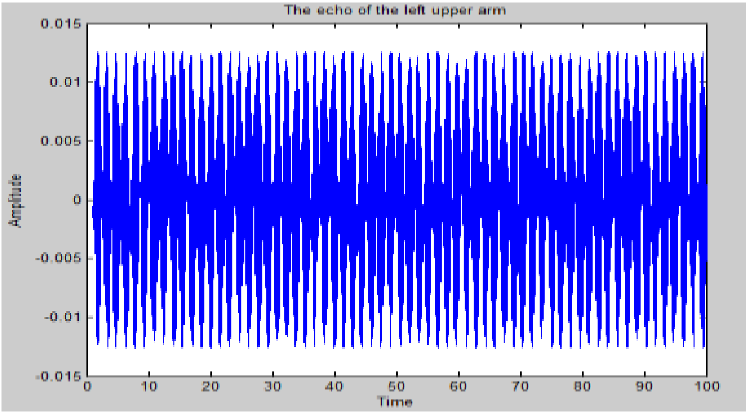

Fig.4 echo signal of the left upper arm

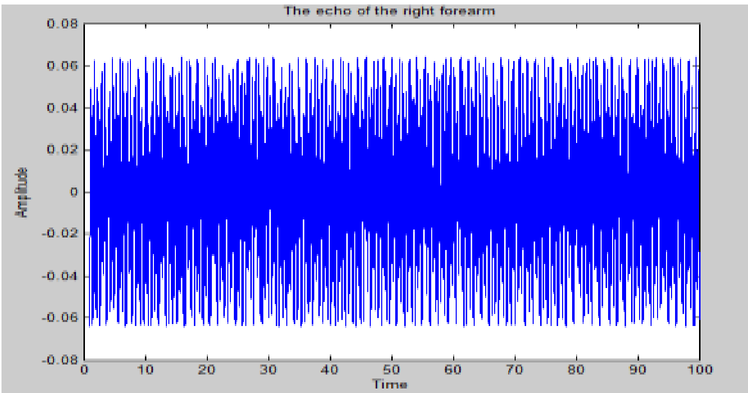

Fig.5 echo signal of the right forearm

4.3 The echo of body

By the echo formula 1, the echo signal of human body can be carried out by the human body parts echo signal superposition.Then we can get the echo of the human body are expressed as:

S=RXh+RXb+RXlua+RXrua+RXlla+RXrla+RXlul+RXrul+RXlll+RXrll (5)

In the expression RXh stand for the echo for the head, and RXbstand for theechooftorso, RXlua is the left upper arm echo, RXrua as right upper arm echo RXllastandfor the left forearm echo, RXrla for right forearm echo, RXlul for left thigh echo, RXrul right thigh echo, RXlllstand for the left calf echo, RXrllstand for the right calf echo[12].

At first we let the echo signal of human body to down-conversionprocessing[13], then we simulated the processed signals to get the time domain waveform, as we can see from figure 6.

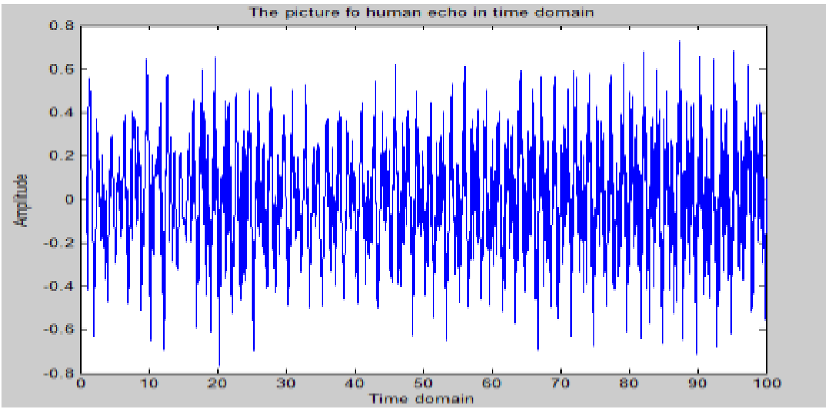

Fig.6 echo signal of people in time domain

The time domain signal after FFT transform to frequency domain signal[14].As shown in figure 7.

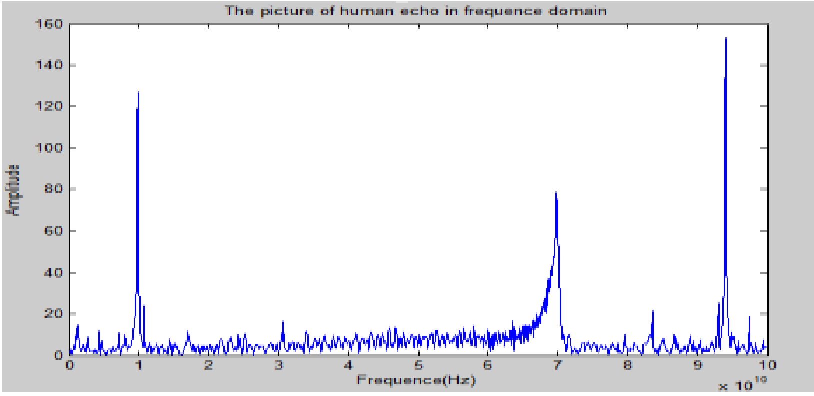

Fig.7 echo signal of people in frequency domain

SUMMARIZE

(1) Based on the MATLAB platform, realized the echo simulation of human body parts

(2) The simulation considering of the human walking, and also the existence of the motion of the arms, legs and micro-doppler information.

(3) Get the echo model of human body, and the echo time domain, frequency domain simulation.

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