Considerations on Detection of Dangerous Items by UWB Radar

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Abstract

We examine application of simple UWB radar to detection of dangerous items concealed by cloth. It is demonstrated through numerical simulation and preliminary experiments that it has capabilities of detection and identification of material.

Keywords : UWB radar, Imaging, Dangerous Item, Identification of material

1. Introduction

Up to now security system using X-ray has been used in the airport. However X-ray system cannot detect such nonmetallic items as plastic bomb. For this reason, the deployment of the millimeter wave imaging device starts recently.

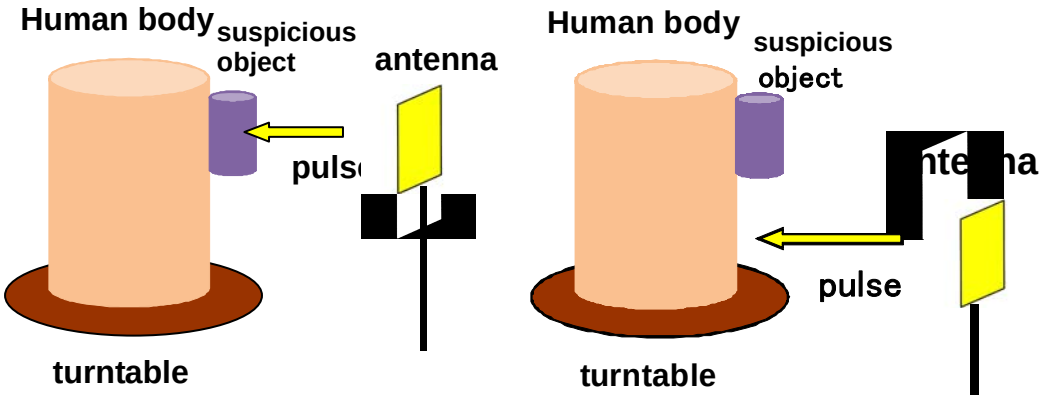
By use of the millimeter wave high resolution is spite of comparative small aperture can be achieved. However, millimeter wave imaging device is expensive. Also problems on privacy are pointed out because body line is displayed clear.

We have developed technologies on early-stage breast cancer detection with microwave imaging since 2007 [1][2]. In this study, three-dimensional scattered power distribution image with high resolution was able to be achieved by the frequency-space-domain beam forming with multi-static radar. This study has been also applied to the security system. We have examined a security system that reconstructs image of a suspicious package. In these applications, we were able to reconstruct image clearly by an UWB radar without frequency-space-domain beam forming technique [3].

In this report, we examine detection of dangerous objects concealed by cloth using an UWB radar. Through numerical simulation and preliminary experiment, we demonstrate that simple UWB radar has capability of detection and identification of dangerous items.

2. Detection system

Outline of the detection system under consideration is shown in Fig.1. Imitating model of human body and suspicious object is set on the turntable. UWB pulse is transmitted by the antenna, and the reflected signal is recorded while rotating and moving up and down the turntable to obtain the reflection profile of three dimensions.



UWB radar antenna and suspicious item are aligned

UWB radar antenna and suspicious item are not aligned

Fig.1 Detection System

When there is a suspicious object , it will be detected due to variation in the reflective wave.

3. Simulation

Table 1 Simulation condition

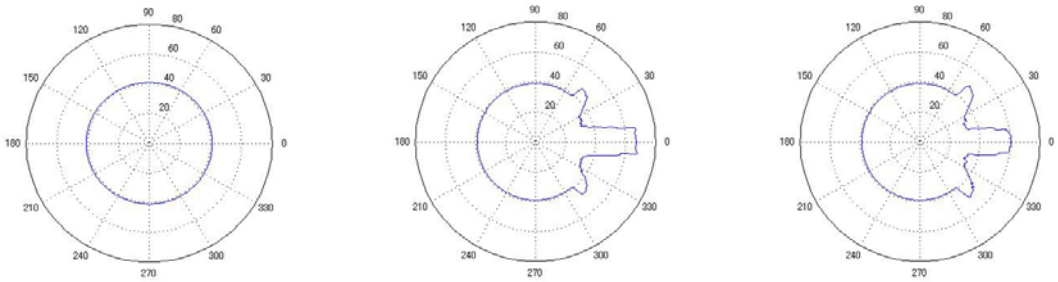
Simulation condition	
Size of cell	1mm
Number of observation points	360
Observation step	1°
Transmitted pulse	Gaussian pulse
Imaging area	Radius of 18cm
Size of human body	Radius of 4cm
Sizes of dangerous article	Radius of 0.8cm
Distance from antenna to human body	5cm

Table 2 Permittivity

Permittivity	
Air	1
Human body (muscle)	48
Dangerous object (methanol)	19.7
Dangerous object (alcohol)	58.4

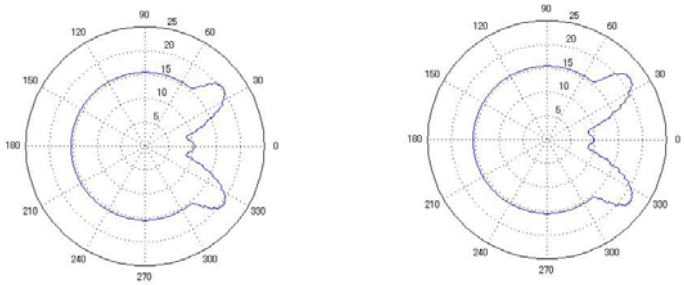
Radio propagation analysis in 2-dimension was carried out by the FDTD method, and the reflected wave was calculated. For simplicity, human body was imitated by a cylinder and a scaled model was used taking consideration of experiment. The simulation conditions are shown in Table 1, and permittivity of each object is shown in Table 2. Permittivity of objects (methanol and liquor) was obtained by measurement.

Delayed time of the reflected wave and the amplitude were measured in the case that there is a suspicious object and not. The simulation result is shown in Fig. 2(a). Suspicious object was set in the direction of 0°. The unit is 1.67ps. When there is no suspicious object the profile becomes an outline of human body. It is clear that time delay and amplitude of the reflective wave have varied obviously by the suspicious object. In addition, since the permittivity is different between methanol and liquor, difference between the profiles can be seen as shown in Fig. 2(b)



Without dangerous object M ethanol Liquor With dangerous object

(a) Time Delay



Methanol Liquor

(b) Amplitude of the reflective wave

Fig.2 Simulation result

4. Experiment

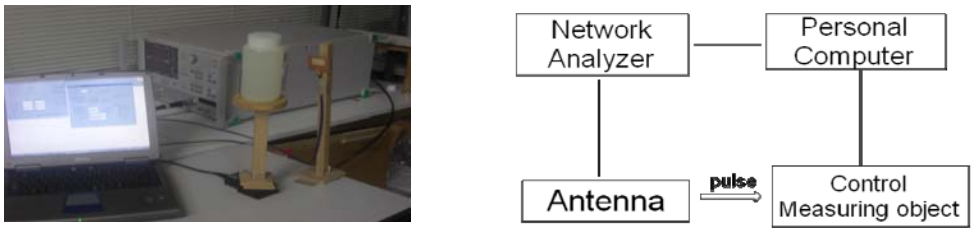


Figure 3 Photograph and system of experiment

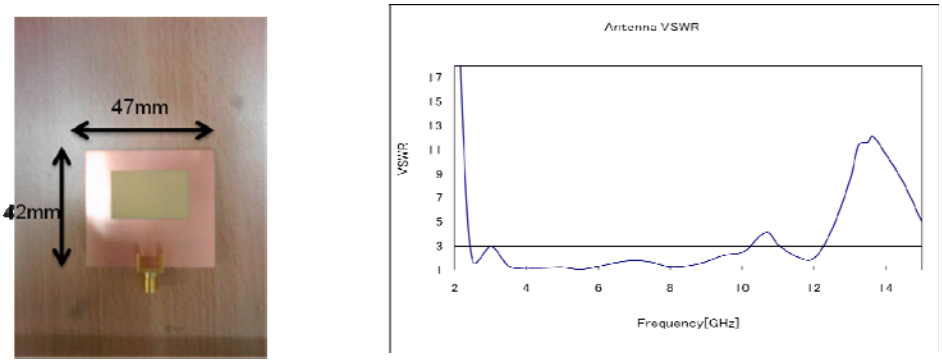
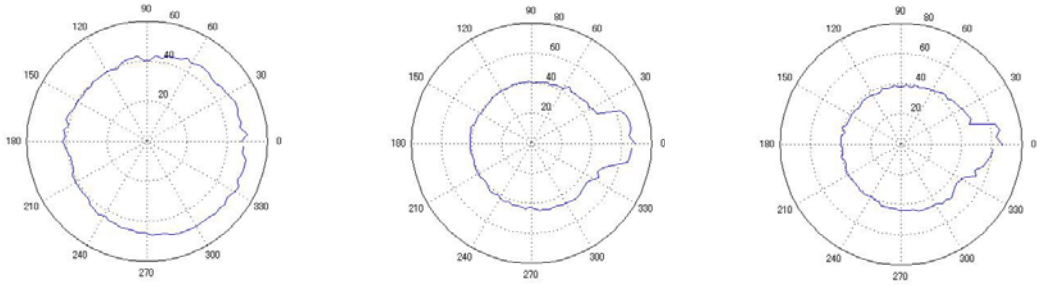


Fig.4 UWB antenna and VSWR

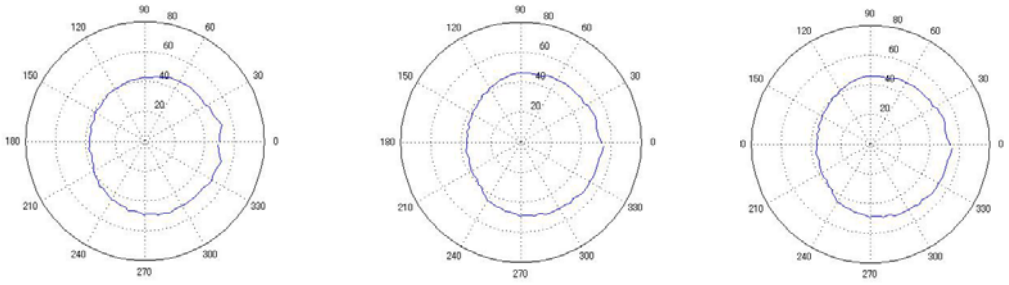


M

Methanol Liquor

Without suspicious object With suspicious object

Antenna irradiates the suspicious object



M

Methanol Liquor

Without suspicious object With suspicious object

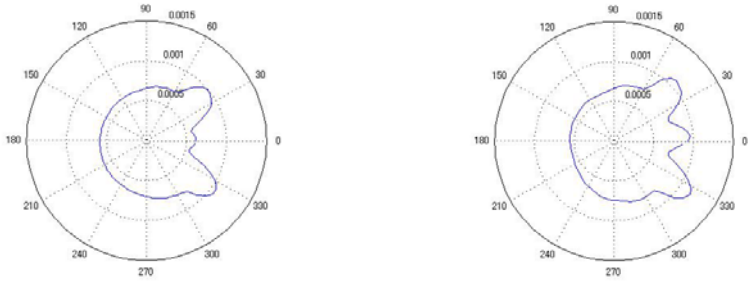
Antenna does not irradiate the suspicious object

Fig.5 Experiment results: Time delay

We have experimented in order to confirm validity of the simulation. The photograph and the system of experiment are shown in Fig.3. UWB antenna [4] and its VSWR are shown Fig.4. The network analyzer was connected with the UWB antenna, and S_{11} was measured in the range of 3-

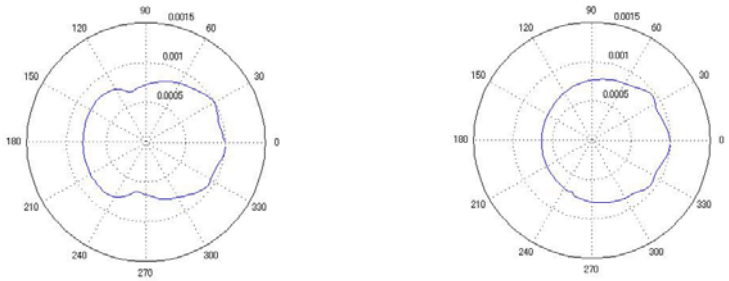
13GHz while rotating the turntable. Frequency response was converted into time response by IFFT. And delay time and amplitude of the reflective wave was calculated as well as numerical simulation. In experiment, observation point was decreased to 90 (every 4°).

Fig.5 shows the time delay in the conditions that the antenna irradiates the dangerous object or not as shown in Fig.1. When it does not irradiate the object, the time delay is almost same as that of no object. The profiles are similar to the simulation results. Fig.6 shows the amplitude profiles of reflective wave. When it does not irradiate the object, there is not large variation in the profile. Also, profiles are similar to the simulation results.



Methanol Liquor

Antenna irradiate the suspicious object



Methanol Liquor

Antenna does not irradiate the suspicious object

Fig.6 Experiment results: Amplitude

5. Concluding

We will be able to detect a dangerous object from amplitude or time delay profile of reflective UWB pulse. In addition, because amplitude profile is different due to the permittivity of the object, we will identify kind of material. In the future, we are to experiment using different size and object to make the data base and to identify kind of material automatically.

References

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Acknowledgments

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