

Incoherent Active Millimeter-Wave Imaging Using Forward-Illuminating Source

Atsuro MAEDA
School of Engineering
Tohoku University
Sendai city, Japan
maeda-a@ecei.tohoku.ac.jp

Hiroyasu SATO
Graduate School of Engineering
Tohoku University
Sendai city, Japan
sahiro@ecei.tohoku.ac.jp

Qiang CHEN
Graduate School of Engineering
Tohoku University
Sendai city, Japan
chenq@ecei.tohoku.ac.jp

Abstract— In this paper, the forward illuminating source is applied to the passive millimeter-wave (PMMW) imaging technique in order to improve contrast between the objects and human body. Imaging data for the cases of several material are compared with changing the geometry of materials. As a result, high contrast between human body and objects for three cases were observed by the presence of the illuminating source.

I. INTRODUCTION

Some materials of liquid, plastics and powder can be ingredients for explosives, and subversive activities such as terrorism have been brought by using handmade bomb made of such dielectric materials. It is easy to hide them in clothes and development of detection system for concealed artifacts is strongly desired for the purpose of keeping safe and secure aircrafts, ships and train etc.

Imaging of concealed objects in clothes is possible in a noninvasive and noncontact manner by using the passive millimeter-wave (PMMW) imaging techniques [1]. All substances radiate the thermal noise. Power of the thermal noise is proportional to the brightness temperature in millimeter-wave band. PMMW imaging device is composed of a lens, the imaging sensor array placed in the image plane and a signal/image processing system which forms the PMMW images.

Considering the detection of scattering objects with high reflectivity such as the conducting material, the thermal noise radiated from the surrounding objects in a room such as the walls, the fluorescents, the human bodies and the electric devices, incident to the objects in clothes and reflected by them. Then the PMMW imaging device images the scattering objects as the brightness temperature of apparent values. Therefore, the contrast depends on a surrounding temperature environment and the contrast becomes lower as the physical temperature of surrounding objects in a room increase.

In order to overcome this problem, the effect of illumination to a human body and objects to increase the contrast of PMMW imaging were investigated [2, 3].

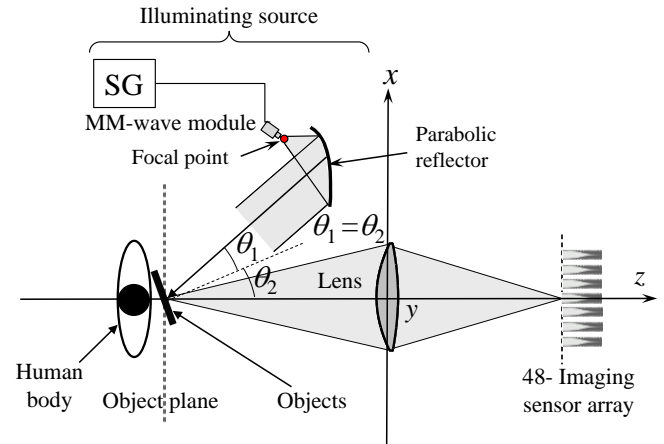


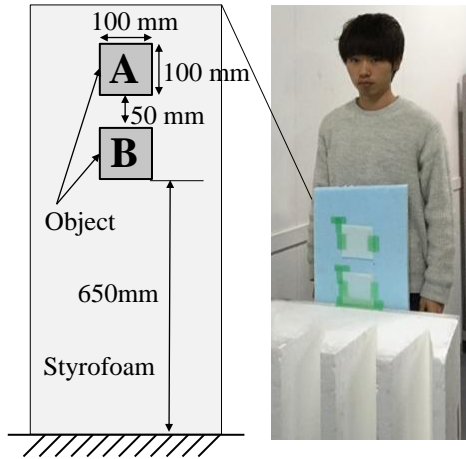
Fig. 1 Optical system of Sub-Active imaging.

Also the received power with different geometry and various type of materials were evaluated.

II. OPTICAL SYSTEM WITH ILLUMINATING SOURCE

77 GHz-band PMMW imaging device developed in [1] was used for the experiment. Figure 1 shows the simplified optical system of PMMW imaging device and arrangement of other equipment. PMMW imaging device is composed of a dielectric lens with diameter of 500 mm and one-dimensional imaging sensor array of 48-elements located at the image plane. Also a flapping reflector synchronized to the signal/image processing have been employed to obtain 2-dimensional images by using one-dimensional 48array elements.

A human body stands at the object plane. Two plate objects fixed by a Styrofoam are located in front of the human body. A parabolic reflector with a focal length of almost $f=200$ mm were used as an illuminating source. A millimeter wave source module with an aperture of



Case	Region A	Region B
1	Conductor 1 mm	Conductor 1 mm
2	Polyethylene 1mm	Polyethylene 2mm
3	Ceramic 1mm	Ceramic 2mm

Fig. 2 Arrangement and combination of objects.

WR-12 waveguide was used as an illuminating source and is located at the focal point of parabolic reflector. The frequency was 77 GHz and incident power was set as -4 dBm.

III. IMAGING RESULTS

The arrangement and the combination of objects are shown in Figure 2. The objects of rectangular plate have the height of 10cm and the width of 10cm and the thickness of 1 mm or 2 mm. Materials of the conductor, the polyethylene and the ceramic were used. Positions of two objects were indicated as A and B except for the case of conductor.

Figure 3 shows the distribution of received voltages of an imaging sensor along y-axis in the case with and without the illuminating source. Case 1, 2 and 3 in Fig. 3 are the cases when the material of objects are conductor, polyethylene and Ceramic, respectively. High contrast between human body and objects for three cases were observed due to illuminating source.

In the case of conductor (Case 1), two peaks of received voltages were observed at 69 pixel and 79 pixel with almost same voltages of 4.4 V, respectively, which means that the illuminating source excites two conductors with almost uniform field distribution.

In the case of polyethylene (Case 2), received voltages of 0.6 V at A (1 mm) and 1.4 V at B (2 mm) were observed, respectively. These results show that the reflection from 2 mm case is larger than 1 mm case and the thicker polyethylene has a large reflectivity.

In the case of ceramic (Case 3), received voltages of 2.9 V at A (1 mm) and 1.5 V at B (2 mm) were observed, respectively. These results show that the reflection from 1 mm case is larger than 2 mm case.

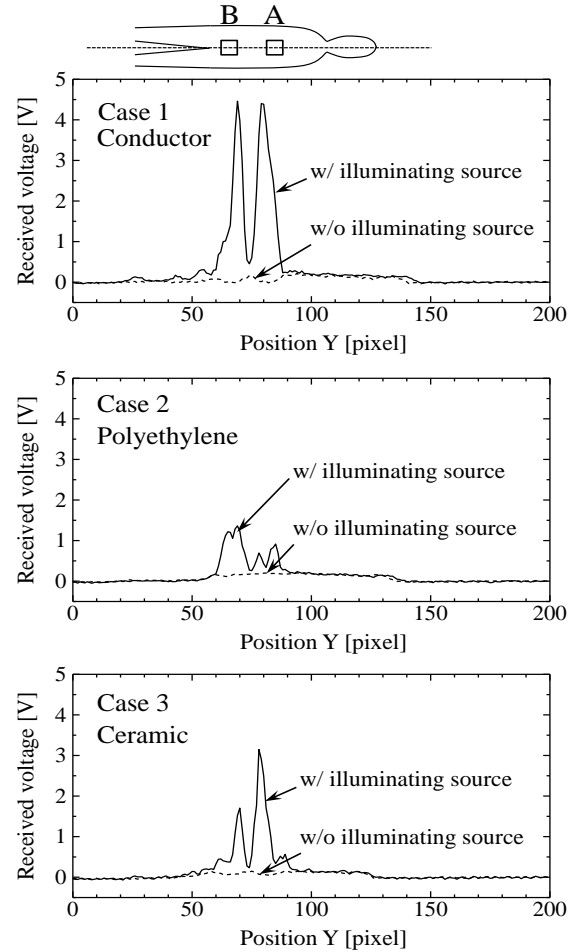


Fig. 3 Received voltages with and without illuminating source.

IV. CONCLUSIONS

In order to improve the contrast between human body and objects, we applied forward illuminating source to PMMW imaging technique. Received voltages for the cases of several material are compared with changing the thickness of each materials. High contrast between human body and objects for three cases were observed by the presence of the illuminating source.

ACKNOWLEDGMENT

This work uses a part of achievement of “Special Coordination Funds for Promoting Science and Technology” organized by Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

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