A Dog's Breast Cancer Screening Trial by Using UHF Band Microwave Tomography System

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Abstract

This paper presents a dog's breast cancer screening trial by using UHF band microwave tomography system. The system was developed originally for women, but it was used to test its cancer screening ability for a dog at veterinary science before human trial. It is operated by UHF band frequencies.

Keywords : Dog breast Microwave tomography Cancer detection

1. Introduction

In conventional medical X-ray tomography, clinical staff makes sectional images through a body by moving an X-ray source and the film in opposite directions during the exposure. Now the technology concept can be extended by using harmless microwave instead of dangerous X-ray, which is called as microwave tomography. The X-ray case is well-known by computed tomography. The microwave tomography is based on the microwave electro-magnetic field scattering by a body object and the solving of inverse scattering problem. This procedure makes object properties (permittivity and conductivity) sectional images by microwave tomography. This is clearly different from CT which gives only object density sectional images.

This paper presents a dog's breast cancer screening trial by using UHF band microwave tomography system. The system was developed originally for women, but it was used to test its cancer screening ability for a dog at veterinary science before human trial. The system is operated by UHF band frequencies from 500 MHz to 3 GHz. During some years, several prototypes have been developed by ETRI and this prototype is the final version now for UHF band version. The system gives us results of three-dimensional images as well as two-dimensional images. This is more convenient for diagnosis. However, it has been difficult to be implemented in the system until now with several reasons, its sensing hardware realization and long time computing, operation frequency limit. This trial images show us the feasibility of this new technology and also give us the next issues to be resolved for extending operation frequency in the future version. They are also introduced in the paper.

2. Dog Breast Exam

The dog's breast cancer screening test was carried out by using the UHF band microwave tomography system developed by ETRI [1]. The veterinary science team jointly worked for this animal trial. A dog with breast cancers was screened. She has 10 breasts and mutiparity experiences in her history. The palpation, a physical examination with hands, was done by veterinarian before microwave tomography screening. This is shown in Fig. 1. It shows that she has cancers in the location of L5 and R5. They are verified by MRI scans and their biopsies. There is no cancer in other breasts like L4 and R4.

The microwave tomography conditions are the screening frequencies from 500 MHz to 2.9 GHz, and the screening coronal planes of 14 layers. The dog's pose for breast cancer screening is

shown in Fig. 2 (a), and the dog's breast under screening is shown in Fig. 2 (b). The posts around the dog’s breast are microwave tomography sensing antennas of the system.

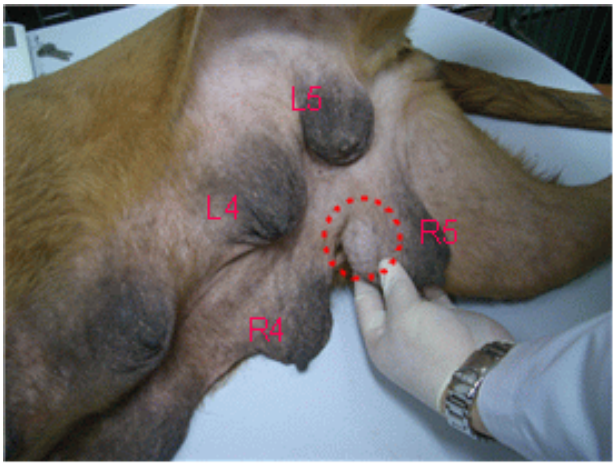

Figure 1: Dog used for the animal trial; the cancers exist at L5 and R5 breasts only.

(a) (b)

Figure 2: (a) Dog position for exam and (b) dog’s breast surrounded by sensing antennas.

3. Two-dimensional Image

The computing time for image reconstruction is important. The system operator specially wants to know the system working and its processing is going well in this laboratory experiment. The two-dimensional image reconstruction consumes less time. In the system, it takes a few minutes to see one image with its efficient algorithm. It gives us intuition about results. The two-dimensional image in this system shows it is stable at 900 MHz and we used it only at the frequency in the system.

The two-dimensional reconstruction images show position R5 has a suspected cancer which has dark red colour at layer 1 and layer 2. The red colour means 65 at permittivity and 1.5 S/m at conductivity. They are cancers’ electric property values at 900 MHz. They are shown in Fig. 3. We can see the shapes of the image boundaries are similar to the boundary shapes from photo images which are shown at the bottom of Fig. 3.

The reconstructed image of L5 gives us a different result because it doesn’t show any cancer spot on the image. We know L5 has a cancer already and it should have a cancer. However this is not strange because the error doesn’t converge under 0.75. This divergence makes it clear

that the image is not valid now. We can avoid a diagnosis mistake by this. Other images for L4 and R4 including R5 show convergence error under 0.5, and there are no cancer spots on their images. These coincide with MRI and X-ray results.

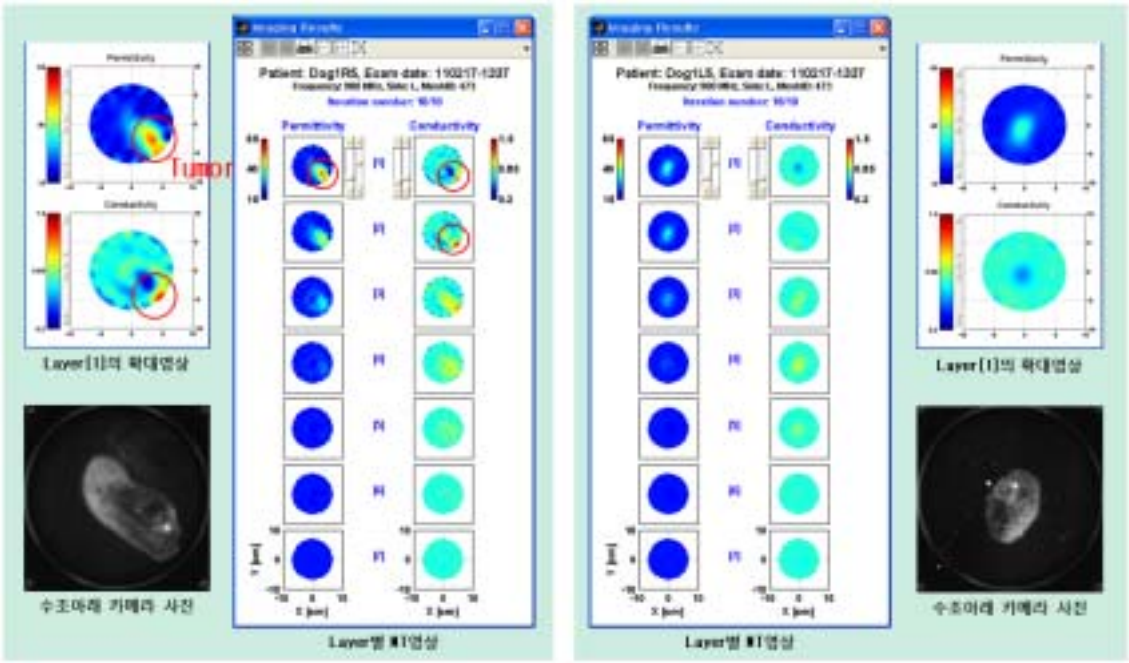

Figure 3: Two-dimensional reconstruction images; left is R5, right is L5.

4. Three-dimensional Image

The computing time for a three-dimensional reconstruction image depends on each cases but it takes typically about 5 hours in this system now. The measured data for the dog is transferred to the other computer dedicated only for three-dimensional image reconstruction in the system. In this progress, at first, we verified it can show the object surface well. The example is the dog breast skin and the three-dimensional surface matched well to the real surface. To analyze images easily, the three-dimensional image figure can be converted to two sectional images, one vertical image and the other horizontal image. The convergence errors for these are under 0.1 which are less than two-dimensional reconstruction errors. More than this is that its valid operating frequency is extended to 3 GHz. In this paper the most stable image is used at 2100 MHz. After taking microwave tomography, the medical team confirmed it by X-ray mammogram images. This is shown in Fig. 4.

The red circle with arrow at the right on Fig. 4 indicates a cancer spot of R5 from X-ray mammography. This is clearly shown at the same position on the microwave tomography images. The dark red spot at the left on Fig. 4 is 59 at permittivity and the dark red spot at the middle on Fig. 4 is 2.4 S/m at conductivity, of which values are electric property values at 2100 MHz corresponding to real cancer. The conductivity zone on the figure looks like a little more spread compared to the real cancer size.

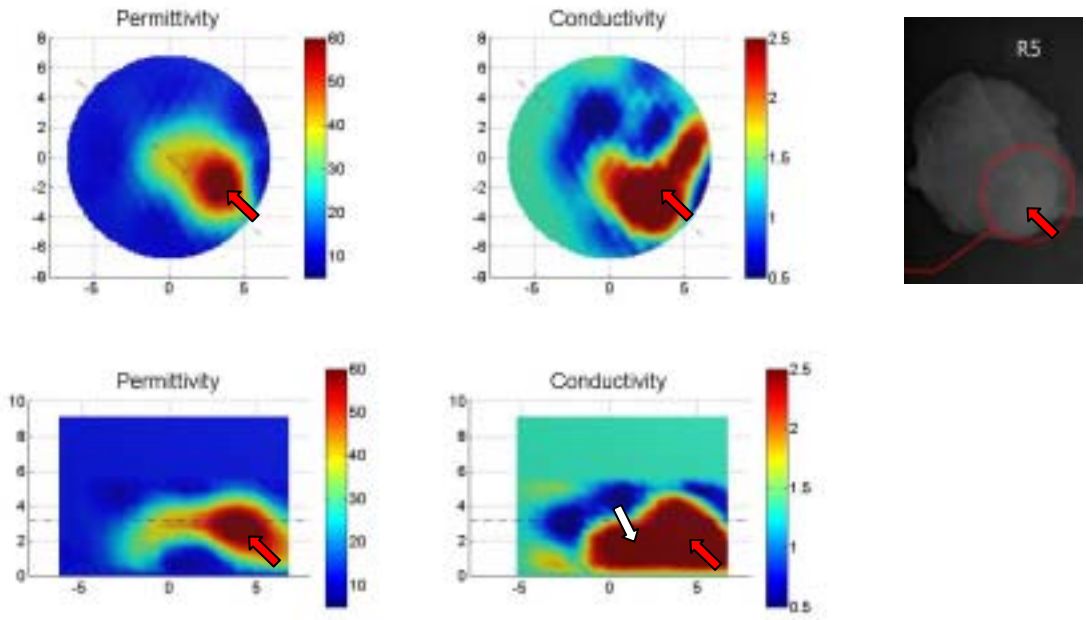

Figure 4: Sectional images of three-dimensional image reconstruction for R5; top is coronal, bottom is inclined sagittal.

5. Conclusions

The dog's breast cancer screening test was carried out by using the UHF band microwave tomography system. The two-dimensional reconstruction showed good screening performance at 900 MHz if there is no convergence error indication. The three-dimensional image reconstruction in the system gave us better image results and it matched well to the X-ray mammogram images.

To have more precise images, the operating frequency becomes higher and the image reconstruction algorithm should be more stable at three-dimensional image reconstruction. Most requested is to reduce its computing time to show images instantly at clinic sites.

References

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