Theme Name	Safer and low-cost breast cancer examination technology by utilizing microwave radar and tomography
Organization Name	University of Electro-Communications Graduate School of Informatics and Enegineering Associate Professor Shouhei Kidera
Technical Field	IT, medical collaboration, life sciences

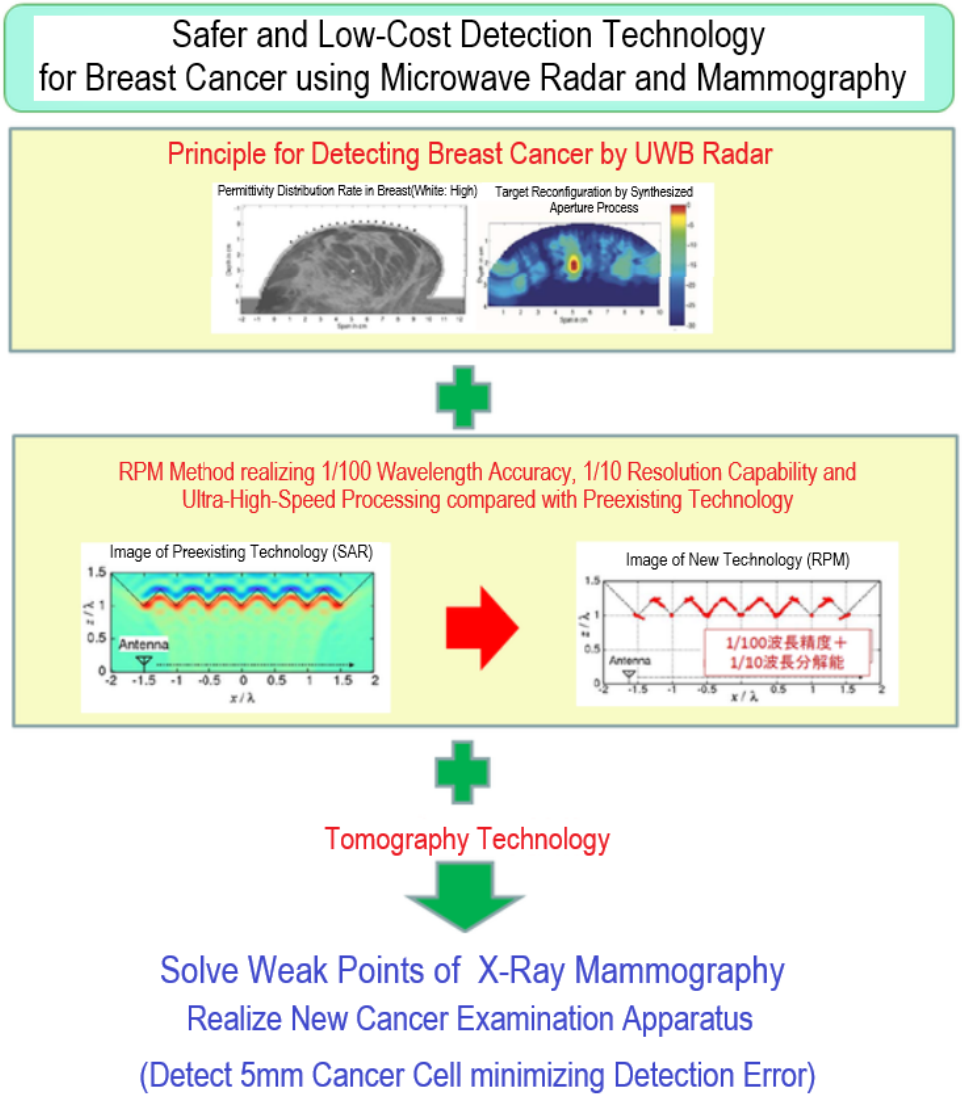
Overview

X-ray mammography is used for breast cancer examination, but females' acceptance rate of examination is only about 15% because the X-ray based examination causes radiation exposure and strong pain with high pressure to the breast.

In order to develop a more comfortable and frequent breast cancer examination technology, we focused on microwave mammography apparatus utilizing a physical basis for the high contrast of complex permittivity between cancer cells and normal cells. Finally, we developed a highly accurate cancer detection method by combining unique radar technology called as PRM (Range Points Migration) method and the tomography technology, also introducing machine learning system upon artificial intelligence. This new examination technology can detect cancer cells less than 1 cm on the early stage.

We welcome companies that are willing to develop new products utilizing this new examination technology.

Simplified diagram



Background

Presently, females' breast cancer affection ratio is extremely high at about 5 to 10%, so simple, frequent, highly accurate detection technology is required. As a preexisting technology, mammography by X-ray is used, but there are big physical burdens for examinees such as radiation exposure and strong pain by pressing the device on the breast, consequently the females' examination acceptance ratio is very low only around 15%. Therefore, the frequency for taking the examination is also low, once per year.

Then, we developed a new safer and low-cost detection apparatus with lower physical burdens for examinees by utilizing a principle that the permittivity of

cancer cells is significantly higher than that of normal cells in the microwave band with cycles about several GHz, and by combining the unique technology called as RPM method and the tomography technology with UWB (Ultra-Wide-Band) radar. This new technology can realize females' higher acceptance rate of examination due to the safer and comfortable examination method, also can realize earlier detection for small cancer cells of a few millimeters on the early stage.

We strongly hope to work with medical institutions and affiliated companies that are willing to conduct clinical trials, practical application, and popularization for this new technology.

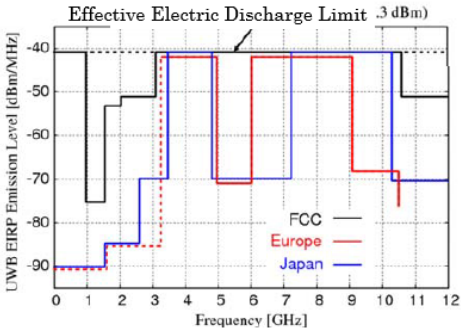
Technical Content

We are studying radar measurement technology using ultra-wideband, UWB band. Compared with the conventional radar, UWB pulse has a characteristic that the distance resolution capability is higher, several centimeters to several millimeters. For example, when 3 GHz band is used, the distance resolution capability becomes 5 cm in space, and 1 cm in vivo.

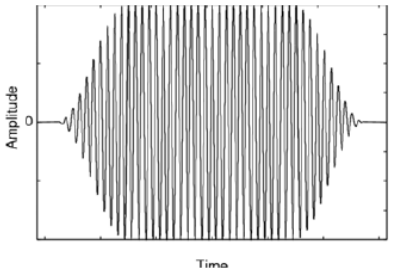
Ultra-Wide-Band (UWB) Signal

UWB (Ultra-Wide-Band) Signal: Recently it is available with low electric power in the space of various

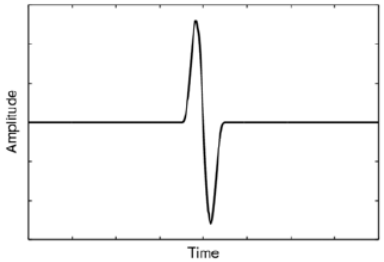
Definition of UWB Signal
・Fractional Band Width 25% or higher
・10dB Band 500MHz or higher
(FCC, 2002)



Preexisting Radar Pulse
Distance Resolution Capability: 1.5m
(Band Range: 100MHz)



UWB Pulse
Distance Resolution Capability: 5cm
(Band Range: 3GHz)



UWB Radar : **High Distance Resolution Capability** (Several cm～Several mm)
Available under severe environments such as dust, darkness, high concentration of gas, strong backlight

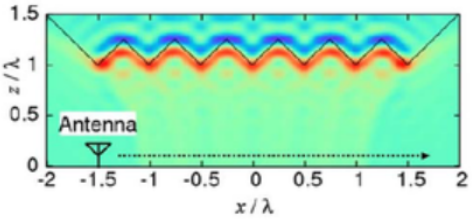
In imaging technology using radar, “Synthetic Aperture Radar (SAR)" was used as a conventional technology. In our study, we focused on a new technology called as RPM (Range Points Migration) method. When 100% monocycle pulse is used in the fractional band width, the accuracy is improved to 1/100 wavelength compared with the central wavelength and the resolution capability becomes 1/10 at high resolution ratio, consequently ultra-high-speed computer processing can be realized.

Ultra-Wavelength Resolution Imaging Technology: (RPM=Range Points Migration)

Preexisting Technology (Beamformer, SAR)
Principle: Image-Formation Process upon Signal Integral

- Space Resolution Capability: Half Wavelength
- Consecutive Targeting: Accuracy Deteriorated
- Solid Reconfiguration: Huge Processing Time

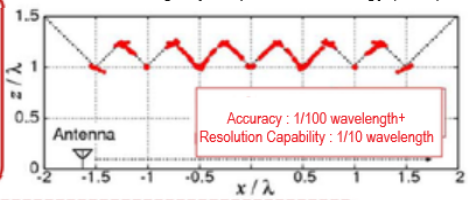
Estimated Image by Preexisting Technology (SAR)



Proposed Technology (RPM)
Principle: Boundary Extraction upon Distance Points Distribution Image

- Accuracy : 1/100 wavelength
- Resolution Capability : 1/10 wavelength
- High-speed Processing: (a few seconds for 3rd Dimension)

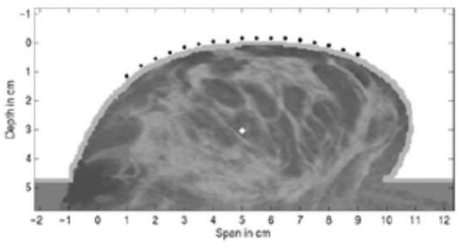
Estimated Image by Proposed Technology (RPM)



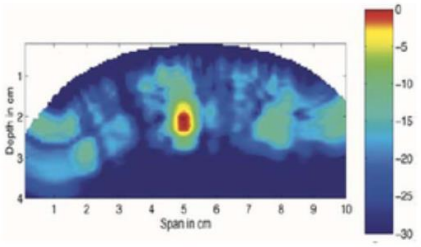
Benefits for Various Applications
→Improve detection accuracy for cancer cells, drugs
→Improve image quality for nondestructive examination

According to S. C. Hagness, and B. Van Veen, IEEE Transactions on Antennas and Propagation, 2003., cancer cells in the breast can be detected by using UWB radar as shown in the following images. (The left-side image shows the distribution of relative permittivity and the white circle in the center indicates cancer cell. The right-side image shows cancer cell visualized and emphasized by UWB radar. The scale unit of vertical and horizontal axis of images is centimeter.

Permittivity Distribution Rate in Breast (White: High)



Target Reconfiguration by Synthesized Aperture Process



There are 2 factors for the detection mechanism as follows.

1. The permittivity of cancer cells is higher than of normal cells (adipose tissue).
   (The above images graph the difference of permittivity between cancer cells and normal cells)
2. The penetration of UWB microwave in 1 to 10 GHz band is so high to examine the deep part from the skin.
   Also, applying RPM method can significantly reduce processing time.

On the other hand, it became clear in the recent study that the permittivity of mammary glands is relatively high and the permittivity of cancer tissue is only10 to 20% higher than that of mammary glands. Therefore, there is a problem that the accuracy for detecting cancer cells by using only the above radar method and RPM method is not enough.

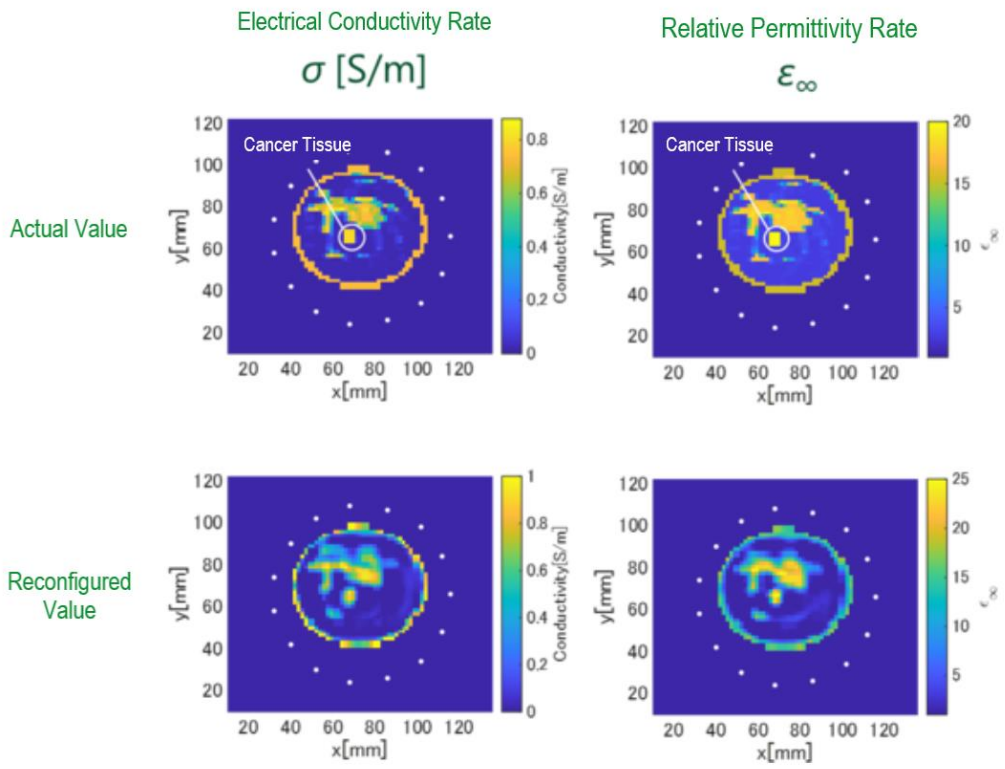
Then, we focused on a new method for improving the detection accuracy to discriminate mammary gland tissue and cancer tissue by combining the tomography technology which directly presumes the complex permittivity from scattered data.

Electrical conductivity rate -> Conductivity

Relative Permittivity rate -> Relative permittivity at infinite frequency

Actual value -> Original profile

Reconfigured value -> Reconstructed profile



The above images show the distributions of conductivity and relative permittivity extracted from the actual breast MRI data and reconfigured by tomography technology. The size of cancer tissue is only 5mm, but it indicates higher value than that of mammary grand tissue after reconfiguration. So, it will be possible to improve the detection accuracy by combining the radar technology for imaging and we can expect to utilize the technology for commercial product as a practical device. Also, we have a simple microwave mammography device and we are ready for the clinical trial.

Strengths of the Technology and Know-How (Novelty, Superiority, Utility)

Currently, X-ray mammography is used as a medical examination device for breast cancer. The advantages of this technology are as follows.

□ Very small physical burdens for examinees

X-ray mammography causes radiation exposure to human body even if the radiation dose is controlled. Also, a strong pain is caused by pressing the device on the breast.

This technology can realize noninvasive examination for breast cancer without touching human body. Therefore, there are no pains. Since low-level electromagnetic wave is used like that for cellular phone, there is almost no effect on human body. Consequently, it is possible to take frequent examination i.e. once per month. The operation cost is low since the it's made up by ordinary telecommunication antenna and pulse generator.

□ Early detection of cancer can be realized.

As described previously, this technology can discriminate cancer cell tissue and normal cell tissue in the breast, so it can find small, gradually growing cancer cells on the early stage.

In particular, the size of cancer cell tissue that can be detected by X-ray mammography is about 1 cm, but this technology can detect 5 mm. Also, if the sensitivity of device is raised up to increase detection rate, the false rate also increases. For example, if the detection rate of X-ray mammography is 99.9%, the false rate is 50%. However, it's confirmed by simulations that this technology can reduce the false rate from 50% to 20% even to detect 5mm cancer cells.

□ Low price.

X-ray mammography is awfully expensive. On the other hand, UWB radar is much cheaper than X-ray mammography since UWB radar uses higher cycle band although it's more expensive than other radio oscillators.

Image of Collaborative Companies

We welcome companies such as medical device manufacturers that are willing to commercialize and penetrate the new device using this technology. Since we have enough knowledge about radar in the laboratory, it is possible to establish a partnership with any companies even if the companies don't have the knowledge about radar.

Utilization of Technologies and Know-How (Images)

This technology can be used for breast examination apparatus. In addition, this technology is applicable to cancer cell detection in other parts of human body as well if there is the cancer cell in lower depth from the surface of human body.

Also, this technology can be utilized for other examination devices applying the difference of permittivity.

UWB radar has high capability for distance resolution even under severe

environments such as dust, darkness, high concentration of gas, strong backlight, etc. Therefore, UWB radar is also applicable to robot sensors for rescue or resource exploration in terms of the characteristics.

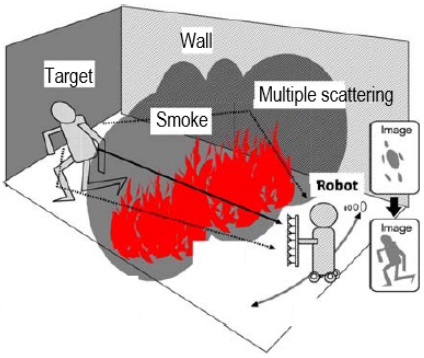
Near Field Distance Measurement by UWB Radar

UWB (Ultra-Wide-Band) Signal: 500MHz or higher cycle band.
Recently it is available with low electric power in U.S., Europe, Japan.

UWB (Ultra-Wide-Band) Radar: High Capability for Distance Resolution
(a few cm, a few mm) under dust, darkness, high concentration of gas, strong backlight.

Applications of USB Radar

- Robot Sensors for rescue or resource exploration (target recognition and obstacle detection under severe environment)
- Security Sensors (privacy protection and high monitoring capability for single elderly and disability)



Flow of Technology and Know-How Application

If you are interested in this technology, please feel free to contact us. We will provide a detailed explanation about UWB radar using demonstration apparatus and technology contents.

Description of the Technical Terms

【 UWB (Ultra-Wideband) 】

UWB is one of the radio communication systems, which can send and receive data dispersing into wide range of cycle band around 1 GHz. Since the data transmitted to each cycle band has small intensity at noise level, so it does not cause confusions with other radio equipment using the same cycle band, and the electric power consumption is small. UWB has 3 functions such as position measurement, radar, and radio communication as a unique radio application technology.

【 Radar 】

Radar is an apparatus that clarifies the distance and direction of object by sending radio wave toward the object and measuring the reflected radio wave.

Radar is used for recognizing and indicating the positions of aircrafts / ships, measuring rainfall cloud quantity, speed of movement as well as detecting obstacles by measuring the distance between objects with radio wave.

【 Mammography 】

Mammography is X-ray device to examine breast cancer. If the radiation dose is high, it causes negative impact on human body, therefore it is required to detect cancer cells at high visual resolution and clarity by taking appropriate dose (about 1 MeV).

Strong pain is caused by pressing the device on breast. The comparison with other medical examination technologies is indicated as follows.

Ultrasonic	• Advantage : Low Cost, Easy, Non-electrolytic Dissociation • Disadvantage : High Cycle Decrease, Electricity Dependency
X-ray CT	• Advantage : High Resolution Capability, High Penetraion • Disadvantage : Radiation Exposure, Complex Screening
MRI	• Advantage : High Resolution Capability • Disadvantage : High Cost, High Electric Power, Magnetism Shield
THz Wave	• Advantage : High Resolution Capability(0.1-1.0 mm) • Disadvantage : Low Penetration (1mm)
Microwave UWB	• Advantage : HighPenetration(50mm) • Non-Electrolytic Dissociation and Radiation • Complex Permittivity(Effective for Discriminating Camcer) • Measurable for Speed • Application for Cure (Thermal Treatment, Ablation) • Disadvantage : Low Resolution Capability in Space (a few cm)