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学位論文題名	Study on High Resolution and High Sensitivity Imaging of Scatterer Distribution in Medical Ultrasound （医用超音波における散乱体分布の高解像かつ高感度な画像化に関する研究）
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【論文の内容の要旨】

Ultrasound imaging as an effective method is widely used in medical diagnosis andNDT (non-destructive testing). In particular, ultrasound imaging plays an important role in medical diagnosis due to its safety, noninvasive, inexpensiveness and real-time compared with other medical imaging techniques. However, in general the ultrasound imaging has more speckles and is low definition than the MRI (magnetic resonance imaging) and X-ray CT (computerized tomography). Therefore, it is important to improve the ultrasound imaging quality. In this study, there are three newproposals. The first is the development of a high sensitivity transducer that utilizes piezoelectric charge directly for FET (field effect transistor) channel control. The second is a proposal of a method for estimating the distribution of small scatterers in living tissue using the empirical Bayes method. The third is a super-resolution imagingmethod of scatterers with strong reflection such as organ boundaries and blood vessel walls. The specific description of each chapter is as follows:

Chapter 1: The fundamental characteristics and the main applications of ultrasound are discussed, then the advantages and drawbacks of medical ultrasound are high-lighted. Based on the drawbacks, motivations and objectives of this study are stated.

Chapter 2: To overcome disadvantages of medical ultrasound, we advanced our studyin two directions: designing new transducer improves the acquisition modality itself, onthe other hand new

signal processing improve the acquired echo data. Therefore, the conventional techniques related to the two directions are reviewed.

Chapter 3: For high performance piezoelectric, a structure that enables direct coupling of a PZT (lead zirconate titanate) element to the gate of a MOSFET (metal-oxide semiconductor field-effect transistor) to provide a device called the PZT-FET that acts as an ultrasound receiver was proposed. The experimental analysis of the PZT-FET, in terms of its reception sensitivity, dynamic range and -6 dB reception bandwidth have been investigated. The proposed PZT-FET receiver offers high sensitivity, wide dynamic range performance when compared to the typical ultrasound transducer.

Chapter 4: In medical ultrasound imaging, speckle patterns caused by reflection interference from small scatterers in living tissue are often suppressed by various methodologies. However, accurate imaging of small scatterers is important in diagnosis; therefore, we investigated influence of speckle pattern on ultrasound imaging by the empirical Bayesian learning. Since small scatterers are spatially correlated and thereby constitute a microstructure, we assume that scatterers are distributed according to the AR (auto regressive) model with unknown parameters. Under this assumption, the AR parameters are estimated by maximizing the marginal likelihood function, and the scatterers distribution is estimated as a MAP (maximum a posteriori) estimator. The performance of our method is evaluated by simulations and experiments. Through the results, we confirmed that the band limited echo has sufficient information of the AR parameters and the power spectrum of the echoes from the scatterers is properly extrapolated.

Chapter 5: The medical ultrasound imaging of strong reflectance scatterers based on the MUSIC algorithm is the main subject of Chapter 5. Previously, we have proposed a super-resolution ultrasound imaging based on multiple TRs (transmissions/receptions) with different carrier frequencies called SCM (super resolution FM-chirp correlation method). In order to reduce the number of required TRs for the SCM, the method has been extended to the SA (synthetic aperture) version called SA-SCM. However, since super-resolution processing is performed for each line data obtained by the RBF (reception beam forming) in the SA-SCM, image discontinuities tend to occur in the lateral direction. Therefore, a new method called SCM-weighted SA is proposed, in this version the SCM is performed on each transducer element, and then the SCM result is used as the weight for RBF. The SCM-weighted SA can generate multiple B-mode images each of which corresponds to each carrier frequency, and the appropriate low frequency images among them have no grating lobes. For a further improvement, instead of simple averaging, the SCM applied to the result of the SCM-weighted SA for all frequencies again, which is called SCM-weighted SA-SCM. We evaluated the effectiveness of all the methods by simulations and experiments. From the results, it can be confirmed that the extension of the SCM framework can help ultrasound imaging reduce grating lobes, perform super-resolution and better SNR(signal-tonoise ratio).

Chapter 6: A discussion of the overall content of the thesis as well as suggestions for further development together with the remaining problems are summarized.