# 2P5-4

## US and MR Multimodality Imaging of The Heart
## 心臓における超音波と MR によるマルチモダリティイメージング

Kazumasa KANAI[1†], Mana MASUMOTO[2], Iwaki AKIYAMA[3] ([1]Doshisha Univ.)
金井　一将 [1†]，増本　真菜 [2]，秋山　いわき [3] ([1] 同志社大学超音波医科学研究センター)

### 1. Introduction

The first cause of death in the world is ischemic heart disease and continues to be the leading cause of death in the world in the past 15 years [1]. Currently, various examination modalities such as MRI, CT and ultrasonic diagnostic systems exist as imaging systems for heart diseases, and research on multi-modality diagnosis that combines the diagnostic modalities to realize more accurate diagnosis is progressing. A MR image has a higher contrast than an ultrasonic image, and it is possible to image information of muscle tissue in detail. However, there is a weak point that the time resolution is low and the number of imaging per heartbeat is short. Therefore, we propose multi-modality imaging to create composite images by MRI and real time imaging ultrasonic diagnostic equipment. In this method, accurate and quantitative alignment of the image must first be performed.

However, since the MR image and the ultrasonic image are generated in different ways, it is required to quantitatively acquire correlation. Thus, the effectiveness of mutual information (MI) [2] used for registration of CT image and MRI image are studied.

In this paper, we show the result of imaging the phantom using the pig's heart and using the mutual information value for the registration of the ultrasonic image and the MR image [2].

### 2. Methods and Materials

### 2.1 Mutual Information

The mutual information amount is used in the information communication field as an index of similarity of images based on the concept of entropy expressing the ambiguity of what information amount and pixel value actually takes. Let *a* and *b* be the reference image and the observation image, respectively, and let *h (a, b)* be a two-dimensional histogram. Then, the simultaneous occurrence probabilities of the two images are obtained from Eq.(1). At that time, the mutual □information amount is expressed by Eq. (2). As the mutual information value increases, the correlation between the two images is increased.

$$p(a_i,b_i) = \frac{h(a_i,b_i)}{\sum_{i=1}^{n}\sum_{j=1}^{n} h(a_i,b_i)} \quad (1)$$

$$MI(A,B) = \sum_{i=1}^{n}\sum_{j=1}^{n} p(a_i,b_j)\log_2 \frac{p(a_i,b_j)}{p(a_i)p(b_j)} \quad (2)$$

Since the mutual information value depends on the distribution of pixel values, it is effective for image registration of multi-modality imaging which has great difference in contrast.

### 2.2 Phantom Preparation

In this experiment, the left ventricular short axis image was taken using the extracted pig heart as a phantom. The phantom of pig heart embedded in acrylamide gel (concentration 7%) was imaged. Ammonium peroxodisulfate and Temed were used as curing agents.

### 3 Experiments

For this experiment, MRI (Hitachi Echelon Vega, 1.5 T) and ultrasonic imaging system (Prosound α 7, Hitachi) was used. The imaging method of ultrasound image using the plane detection marker is shown in Fig1.

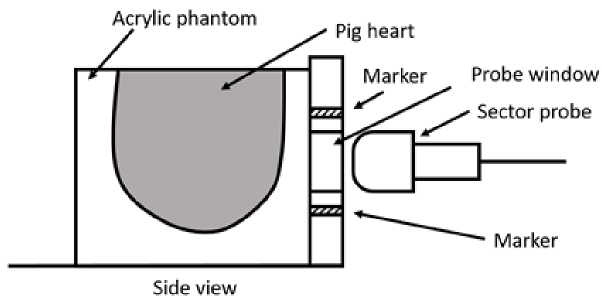


Fig. 1 Experimental system for US image.

---

iakiyama@mail.doshisha.ac.jp

The left ventricular short axis image was taken by MRI and ultrasonic imaging system respectively. A B-mode image was taken with the sector probe with 128 elements and a center frequency of 3.0 Hz. In order to image the same cross section, the same cross section as the ultrasonic image was detected by MRI image using a 7 mm diameter marker. Fig. 2 shows the ultrasound image and the MRI image taken.

## 4. Results and Discussion

Fig. 3 shows the MI distribution calculated at each position of the MR image and the ultrasound image shifted to the right by 20 pixels as a bird's-eye view. The profile in the x-axis direction passing through the peak is shown in Fig. 4. As a result, it can be seen that the value of MI becomes maximum at the position of 19 pixels right. Since 1 pixel is 0.416 mm, the misregistration error calculated by MI was 0.416 mm. Since the spatial resolution of the MRI used in the experiment is 1 mm, the error is within the resolution range. Finally, the image infused by this method is shown in Fig. 5.

## 5. Conclusion

In this study, we have used a homogeneous medium phantom, whereas the objective was to examine the mutual information amount effective for alignment of biological ultrasound images and MR images by algorithm. As a result, it was confirmed that positioning is performed at or below the spatial resolution of MRI by extracting the contour of the heart in the ultrasonic image and obtaining the mutual information amount. For the next step, it is important to do for the actual heart.

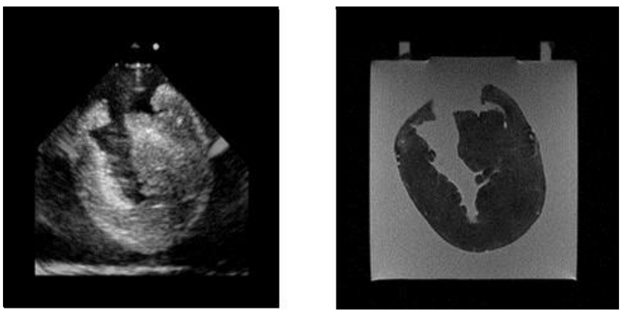

Fig. 2 The left and right images of the phantom of pig heart embedded in acrylamide gel taken by US and MR, respectively.

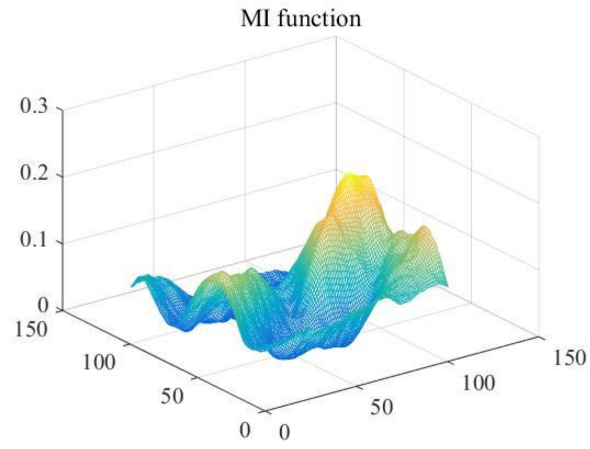


Fig. 2 MI value mapping

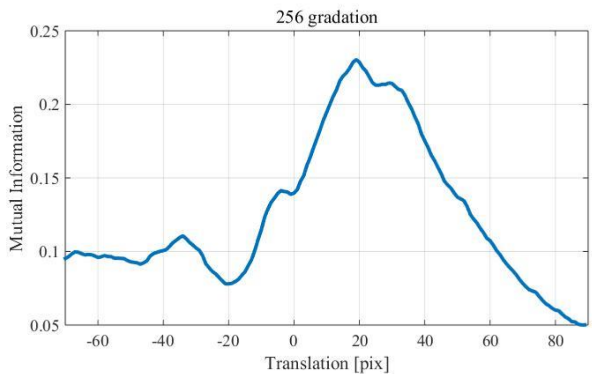


Fig. 4 x-direction plot of MI value

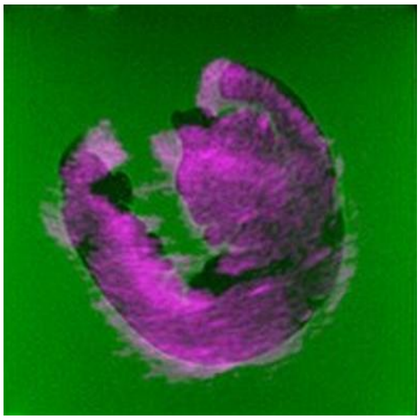

Fig. 5 Infused image of US and MRI

**Acknowledgments**
This study was supported by MEXT - Supported Program for the Strategic Research Foundation at Private Universities, 2013 - 2017.

**References**

1) Wright JS, Wall HK, Briss PA, Schooley M. Million heartsd where population healthand clinical practice intersect. Circ Cardiovasc Qual Outcomes. 2012;5(4):589-591.

2) Barbara Zitova, Jan Flusser, "Image resistration methods: a survey", Image and Vision Computing 21, 2003.