Career Episode 2

Observing Cavitation Produced by HIFU (High-Intensity Focused Ultrasound) in Tissue-Mimicking Phantom

A) Introduction

[CE 2.1] I did the project as a team project in the biomedical engineering department.

Title of Project: Observing Cavitation Produced by HIFU (High-Intensity Focused Ultrasound) in a Tissue-Mimicking Phantom

Duration: [02 Sep. 2012] – [20 Dec. 2012]

Location: Yonsei University

Position: Biomedical Engineering Student

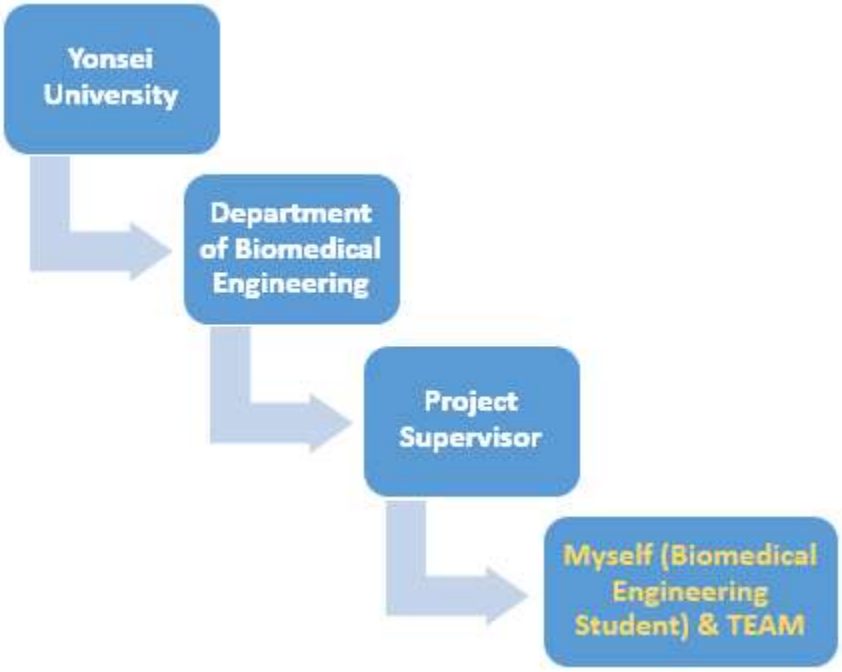
B) Background

[CE 2.2] The adequate technique is the liposuction in the surgery for the fat reduction. Ultrasound has become another option for decreasing the liposuction discomfort. UAL (Ultrasound-assisted lipoplasty) based technique is mainly for the insertion of an ultrasonic rod into the fat layer subcutaneous part. It is an optimum way as it was mainly utilized as a liposuction aid. From invasive treatment, there are numerous side effects and thus the reduction of these side effects can be done with the usage of the non-invasive technique.

[CE 2.3] The project aim was conducting cavitation analysis based on the ultrasound of higher intensity in the phantom of tissue-mimicking. Because of the non-invasive advantages, the lipoplasty potential is adequate in HIFU. Cavitation is often worked during HIFU exposure and it is a potential lesion indication typically created with the HIFU power. At the HIFU, there is an ultrasonic energy which mainly reflected and scattered due to the ultrasound acoustic properties difference. It worked on indicating the focal area activity revolved with the delivery interference of HIFU dosage. An optimum cavitation control method was adopted for incrementing the delivery of HIFU along with the other treatment results. It was possible to maximize the cavitation effects by controlling parameter which was related to the events of cavitation. I controlled three parameters which were time, pressure and duty cycle. I obtained the results which showed that the parameter influenced cavitation differently.

[CE 2.4] The nature related to the work was the execution of the experimental conduct and this was the teamwork which was done in the biomedical engineering department at Yonsei University.

[CE 2.5] The related structural diagram:

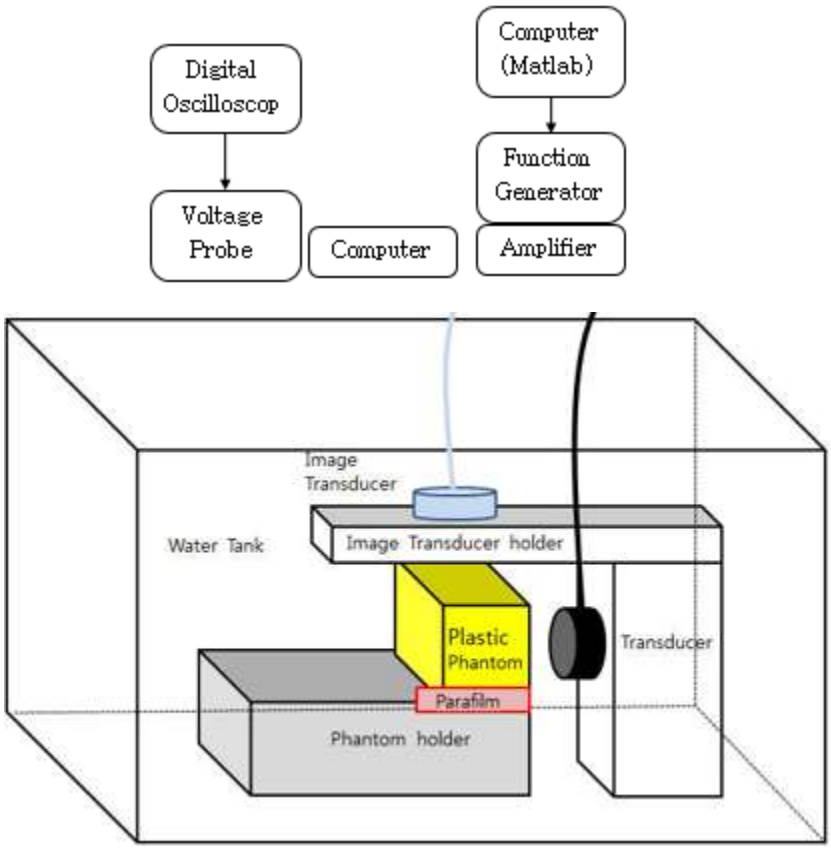


[CE 2.6] I had these core responsibilities:

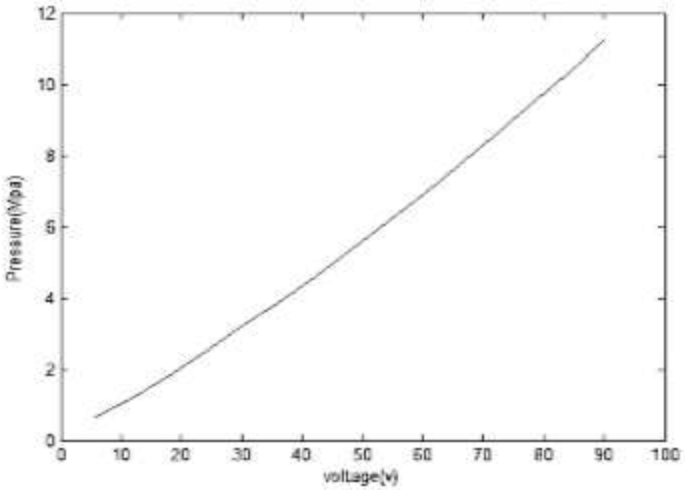
- I applied biomedical engineering knowledge for maintaining the water temperature which was equal to the body condition.
- I did the HIFU transducer controller utilizing a function generator along with the signal generation which was done using a power amplifier.
- I fixed the duty cycle at 1% and the gas bubbles alteration was noted which was in relation to the irradiation time and cavitation.
- I implemented the surface pressure at the transducer which was according to the voltage applied and it was done using biomedical engineering expertise.

C) Personal Engineering Activity

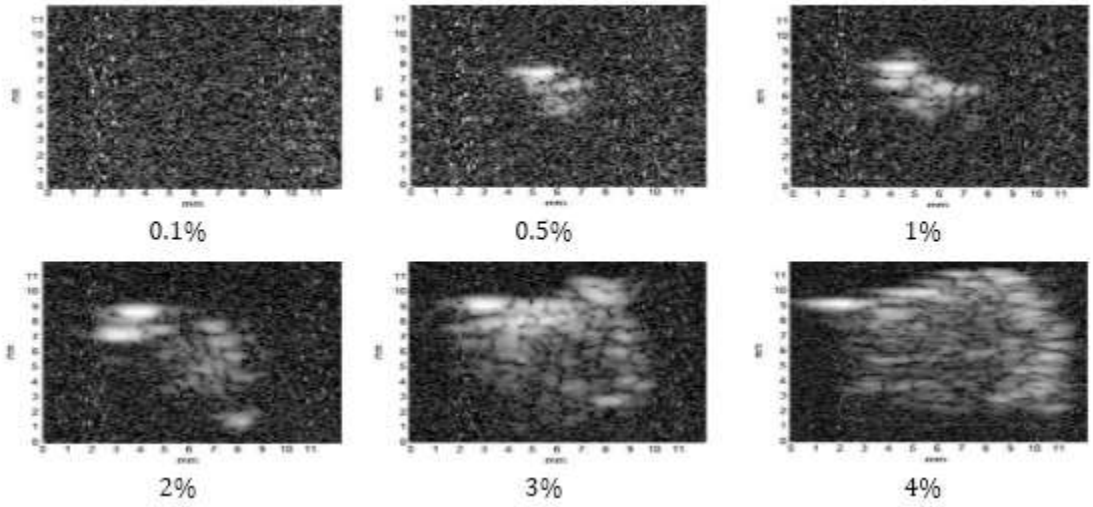
[CE 2.7] I did the usage of the degassing system for the dissolved oxygen amount reduction of the bath in the HIFU system. I worked on using the degassing system with the usage of Gear Pump Drive for one day and reduction of the dissolved oxygen was done by amount 60%. I maintained the water temperature among 35-37 degrees which was similar to the body condition. I utilized the transparent plastic phantom for this research which was similar to the hardener ratio tissue along with the softener which was 5:5. I utilized a degassing system for the gas bubbles removal in the phantom and implemented a phantom with the hardener and softener making which was reacted with the microwave oven and hot plate.



[CE 2.8] I worked on the transducer design when fixing the phantom and it was done at the point 3cm away from the HIFU transducer. I utilized phantom for identifying the location where cavitation happened and installed it as the HIFU transducer travelling direction in a perpendicular manner. I controlled the HIFU transducer using the function generator and power amplifier for the generation of the signal. I used MATLAB which worked as the controlling unit for the variables and the applied voltage was measured in real-time with the digital oscilloscope during the experiment. The transducer surface pressure was assumed according to the voltage applied based on the existing sound field measurement data. I obtained the transducer surface pressure according to the applied voltage which was 50V resulted in the pressure value of 6Mpa. I utilized the ratio for the transducer pressure determination at a higher voltage.



[CE 2.9] I conducted an experiment on the cavitation differences according to the pressure magnitude alterations, duty cycle and irradiation time utilizing the HIFU system. I fixed the dependent variables to be constant when observing cavitation according to the pressure magnitude change. I selected the variable fixed value based on the dependent variables when the change cavitation in the pressure magnitude was obtained by conducting numerous experiments. I maintained 30MPa pressure when observing the cavitation according to the duty cycle change and 30 seconds was the irradiation time constantly. I measured the duty cycle change at regular intervals from 0.1% to 0.4%. I obtained the data from the time during the irradiation which was progressed at the transducer when the irradiation was completed by taking the noise captured at the imaging transducer.



[CE 2.10] I noted the gas bubbles changes which were done with the ultrasound duty cycle alteration. I fixed the pressure at 30MPa with the irradiation time of 30 seconds during the progress. I obtained the alterations in the gas bubbles which were done according to the pressure cavitation. I worked on fixing the duty cycle at 1% and the outcome was noted with the gas bubbles alteration in relation to the cavitation and the irradiation time. I represented the data that was done with an

image while considering a certain area around the part. The gas bubbles were formed with the cavitation for the first time as the transducer focal region. I worked on the gas bubbles which were in the x-axis direction around the focal area. I noted that the energy of the ultrasound had the Gaussian distribution characteristics and the focal area periphery was affected with the energy level. I formed the gas bubbles which was done by wide-area spreading and the transmitted energy by the ultrasound waves was converted into heat and it was diffused through the medium gradually as the time passed.

[CE 2.11] I defined the project objectives which were based on the expertise in the biomedical engineering domain. The project was the team project and I consulted with the project supervisor throughout the project tenure and discussed various technical objectives with him in the entire tenure. The project resulted to boost my technical expertise in the biomedical engineering domain.

D) Summary

[CE 2.12] I examined the cavitation using HIFU at the phantom. I selected three variables which were a time of irradiation, pressure and duty cycle. I obtained efficient cavitation according to the duty cycle which resulted in forming wider gas bubbles according to the pressure change in the cavitation. The obtained gas bubbles according to the pressure had higher volume per unit length when compared with the gas bubbles brightness. The heat was diffused in the medium according to the higher irradiation time and forming gas bubbles. I obtained the biological tissue lipolysis which was an ultimate goal and the obtained data from the research was considered as the meaningful experimental design data. It was for getting the cavitation in the actual fat and phantoms with the real biological tissue. I accelerated the lipolysis realization utilizing cavitation only and attained the data from the experiments on biological issues. I obtained the data from the experimental analysis and the objectives were achieved using biomedical engineering knowledge.