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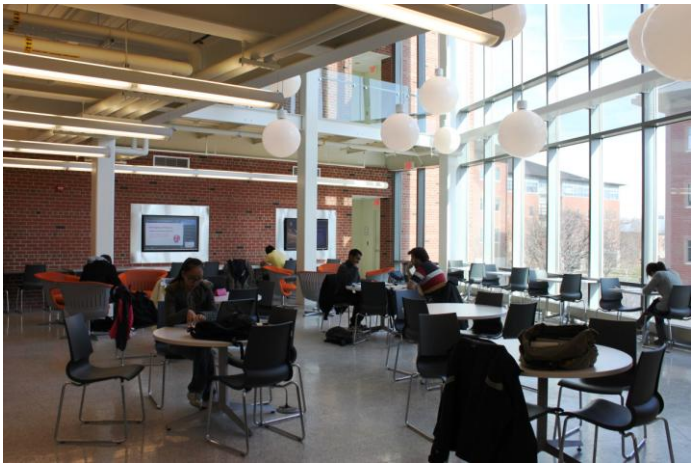
受入研究者（職・氏名）：Professor Daniel A. Tortorelli
派遣期間：2012 年 9 月 10 日 ～ 2012 年 11 月 27 日（79 日間）
派遣先での研究テーマ：Structural topology optimization of acoustic metamaterial

【研究実施概要】

In Prof. Tortorelli's lab, they are hammering at the transformation of the existing analysis tools into design optimization tools. They have investigated the finite element method and develop a systematic methodology used to evaluate sensitivity expressions for numerical analysis. The methodology has been applied to optimize a variety of engineering systems and manufacturing processes. Due to the same research field, it is easy for me to bring my going-on research and continue it in the hostlab.

As in the past decade, acoustic metamaterials have attracted much attention, since these properties can provide promising opportunities to design new acoustic devices that cannot be made with natural materials. Although acoustic metamaterials have been obtained experimentally by trial and error, our aim is to develop a topology optimization method for the direct design of acoustic metamaterials. And our design is based on the concept of local resonant mechanisms, which ensures that the lattice constant is orders of magnitude functionally smaller than the corresponding sonic wavelength, and avoids unwanted effects of Bragg scattering mechanisms. To achieve the acoustic metamaterial, we propose to make the effective bulk modulus be negative at certain desired frequency.



We proposes a level set-based topology optimization method for the structural design of acoustic metamaterials, which avoids the presence of grayscales and ensures that clear boundaries are obtained in optimized configurations. The optimization problem is formulated for a two-dimensional wave propagation problem. An effective medium description based on S-parameters is introduced to describe the acoustic metamaterial. The finite element method (FEM) is used to solve the Helmholtz equation for acoustic waves, sensitivities are obtained with the adjoint variable method (AVM), and a reaction-diffusion equation is used to update the level set function.

Prof. Tortorelli applys density method for the topology optimization. I also learn the implementation of the method and how this method is used for the structure design problem. We decided to apply both level set-based method and density method to the acoustic waveguide problem later. Through the comparison the result can be verified each other and make sure the characteristics of these two methods respectively further.

【研究成果概要】

(1) The design of acoustic metamaterials based on localized resonant mechanisms is compact with a functional scale.

(2) For analysis, it is meaningful and valid to replace the entire composite by an effective medium.

(3) The level set method, based on a reaction-diffusion equation, was successfully applied to obtain clear boundary expressions in all examples.

(4) A two-step optimization method enabled the handling of effective bulk modulus curves with unusual characteristics. The proposed method should facilitate the design of acoustic metamaterials without the need for physical experiments or trial and error approaches.

(5) We hope to extend the current two-dimensional cases to three-dimensional or three material phase problems in the future, which may broaden and improve the prospects for developing effective applications of acoustic metamaterials.

【外国語のスキルアップ・コミュニケーション能力の向上，海外におけるネットワークづくり】

The internship really helped me improve my English a lot. When you landed the overseas city, the only way you can smoothen your going is to talk in English. It is not only the compulsory thing, but the surrounding helps you to communicate in English more easily as well. In the hostlab, we have the labmates from

different countries with different background, some of them speak in a little bit different accents, after several days talking, I didn't find any problem to communicate with them. Some of them even thought I have stayed in US or other English speaking countries for a long time. I introduced my research areas and we discussed the research problems in English which improved my speaking skills in more professional way. Based on the introduction of my research and the research conducted in my lab, my host labmates showed their interests to visit our lab as well. I also have been an audit student to join them in a clas which was related to my research work. In this class, I learned the knowledge more intensively in English, which helped me to know how I can explain some points in English well. What's more, as I had a comparable long living in US, I also can get opportunities to be involved in the daily life and learn some knowledge won't be taught from class or study.

【派遣の感想】

Studying and living abroad for a period time allow me to broaden my view and have the ability to get used to different envioronment quickly. The practise has important and far-reaching consequencies for young students and researchers who have the dream to be an international scholar. Being global is also the fundamental and necessary condition for a good scholar. During the stay, I can see what they are doing and how they are doing. It is the best way to learn from them compared to read more papers alone.

Being in a new environment and talking to different people always bring new ideas to you as well. Besides the learning thing, working with people from other groups with various backgrounds practise my communication skill and presentation skill.

Last but bot least, thanks to Japan Society for the Promotion of Science (JSPS) and the organizers for actualizing the institutional program for young researchers to be provided the opportunity of studying overseas. Hope that more and more student and young researchers have such kind of chance to know and explore the world more.