SUMMARY OF Ph.D. DISSERTATION

School	Student Identification Number	SURNAME, First name
Integrated Design Engineering		SATO, Koichiro

Title

A System of Deriving Diverse Solutions for Structural Design Problem

Abstract

In design, it is necessary to consider various characteristics such as exterior design and handleability, which are difficult to evaluate quantitatively, as well as mechanical characteristics. Therefore, for structural design problem, it is required to derive not only an optimum solution by quantitative evaluation (strength and stiffness) but also a number of diverse solutions by global solution search. Then, a definitive design solution is to be decided from diverse solutions. In past studies, we proposed a basic system for deriving design solutions through the two processes of bottom-up and top-down. In the bottom-up process, diverse solution candidates are generated self-organizationally by increasing voxel elements with the local rules of induction and apical dominance which are generation characteristics in morphogenesis of organism. In the top-down process, the diverse solution candidates generated in the bottom-up are optimized and then diverse solutions are derived. However, this basic system faces difficulties in deriving diverse solutions for structural design problems because the efficiency of derived solution is decrease as the number of element is over 10,000 and also need enormous calculation time. Hence, in this study, an advanced system for deriving diverse solutions based on basic system is constructed to respond to a structural design problem.

Chapter 1 describes the purpose and the objective of this study.

Chapter 2 describes the outline of basic system mentioned above. In addition, a parametric analysis to generate diverse solution candidates in bottom-up and the necessity for extension of the basic system to respond to over 10,000 elements are described.

Chapter 3 describes parametric analysis to generate diverse solution candidates in bottom-up. The result of analysis indicates that composite ratio (combination rate of induction and apical dominance) is extracted as the most effective parameter. Then, the effectiveness for diversity is shown when composite ratio is set up minimum value (maximize action of apical dominance) under the restriction of generation efficiency.

Chapter 4 describes an extension of basic system to respond to structural design problem which has over 10,000 elements. As the result of application to artificial hip stem design, diverse design candidates are generated when an action of apical dominance is maximized as well as the result in Chapter 3. In addition, it is confirmed that diverse solutions with over 10,000 elements are derived using the homogenization method in the top down.

Chapter 5 describes a further extension of the system shown in Chapter 4 for corresponding to structural design problem which has over 100,000 elements and some hole in generation space. As the result of application to car frame body design, diverse design candidates are generated when an action of apical dominance is maximized within the range where the solution candidates are generated. Moreover, in the top down, it is confirmed that diverse solutions with over 100,000 elements are derived using the density method in the complex space.

Chapter 6 discusses the mechanism of deriving diverse solutions. Concretely, a conventional solution by topology optimization method and diverse solutions are compared from the viewpoint of form and mechanical characteristic in a beam design problem. As a result, a mechanism is shown that the density distribution in form changes and diverse solutions are derived when the generated form in bottom-up does not contain all of the density distribution of the conventional solution. Moreover, the two possibilities are shown; when the influence of apical dominance is increased, diverse solutions with different topology are able to be derived, and when the influence of induction is increased, diverse solutions with more than equal to conventional solution stiffness and strength are able to be derived. Finally, the system for deriving diverse solutions is constructed responding to a structural design problem.

Chapter 7 summarizes the results of this study including future research challenge and prospects.