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| Title | Model Reduction and Control of Boolean Networks Using Binary Decision Diagrams [an abstract of dissertation and a summary of dissertation review] |
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| Degree Grantor | 北海道大学 |
| Degree Name | 博士(情報科学) |
| Dissertation Number | 甲第16518号 |
| Issue Date | 2025-03-25 |
| Doc URL | https://hdl.handle.net/2115/95206 |
| Rights(URL) | https://creativecommons.org/licenses/by/4.0/ |
| Type | doctoral thesis |
| File Information | Fuma_Motoyama_abstract.pdf, 論文内容の要旨 |

学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称　　博士（情報科学）　　氏名　本山　風馬

学　位　論　文　題　名

Model Reduction and Control of Boolean Networks Using Binary Decision Diagrams
（二分決定グラフを用いたブーリアンネットワークの低次元化と制御）

A BN is well known as a discrete model for analysis and control of complex networkssuch as gene regulatory networks. In the last decade, there has been much attention onanalysis and control of BNs. There, the semi-tensor product (STP) method is widely usedfor calculations on BN. However, STP has a weakness in that it cannot represent largeBNs. Since complex networks are large-scale in general, it is important to consider themodel reduction. In this thesis, a model reduction method and control method of BNsusing a BDD (binary decision diagram) is proposed. A BDD is a data structure used torepresent Boolean functions. Logical operations of Boolean functions using a BDD aremore efficient than using the STP method. The organization of thisthesis is as follows.
In Chapter 1, we illustrate this study’s background and the motivation.
In Chapter 2, we explain BNs, BDDs, and the existing BN reduction method in prepa-ration for the main topics in Chapters 2 to 4. We explain interaction graphs, transitiongraphs, and fixed points as important elements of BNs. In explaining the existing BNreduction method, we provide examples of calculations using semi-tensors and show thatthis method cannot be applied to large-scale BNs.
In Chapter 3, we consider implementing the existing reduction method using BDDs.Since the calcula-tions of the existing method cannot be simply replicated using BDDs,it is necessary to redevelop the procedures that assume the use of BDDs. In order touse BDDs efficiently, we consider utilizing the interaction graph expressing interactionsbetween elements of the state. We show that this method is effective in large-scale BNswhere STP method is not applicable.
The reduction method in Chapter 3 does not pursue minimality. In Chapter 4, weconsider reduction method to further reduce the reduced model obtained in Chapter 3.We construct a reduction policy that is different from the existing reduction method thatis used as the basis in Chapter 3. Like the method in Chapter 3, this method makes itpossible to perform calculations using BDDs by utilizing interaction graphs. We show thatthis method is effective for BNs that cannot be further reduced by the method in Chapter3.
In Chapter 5, we consider the finite-time control problem of BNs. The finite-timecontrol problem is to find all sequences of initial states and control input sequences thatcan reach the target state at a given final time. This problem has been proven to beNP-hard.In this chapter, we present a method for solving finite-time control problemsusing BDDs. Although BDDs have worse computational complexity in the worst case,they provide efficient solutions in many cases. In addition, We consider the problem ofapplying some control specifications to a typical finite-time control problem. We show anexample of calculation to find all solutions for a large-scale BN, and an example to extractsolutions that satisfy the control specification from that solutions.

In Chapter 6, this thesis is concluded with a summary of the obtained results and someperspectives on the open problems.