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Abstract

In this thesis, we provide new computational bases for modal logic of multi-agent communication. One of the most important aspects of multi-agent communication is changes of agent's knowledge or belief [11]. Nowadays, such changes are well-discussed in terms of modal logic, as dynamic epistemic logic (**DEL**) [40]. Since **DEL** provides strong bases to handle agent's knowledge (or belief), development of such bases is an important subject for further studies. In order to obtain such bases, we focus on the following issues in this thesis.

The first issue is about the ordinary model-theoretic approach to Kripke semantics of modal logic. For some situation, we should be careful for, e.g., calculation of the truth of $\Box p$ at a 'dead-end' world where we cannot access any world. Since some conditions or necessary operations might be implicit in the proof of semantic properties, we sometimes might overlook them under the model-theoretic approach. To cover such a point, we propose to use a linear algebraic reformulation of Kripke semantics based on Fitting's approach [8]. His approach allows us to capture behaviors of the standard semantics in terms of Boolean matrix calculation explicitly. We show a matrix representation of Kripke semantics and its relevant properties, and also connect our argument to capture restricted form of quantifications in first-order logic.

The second issue is a deficiency of studies of proof theory for dynamic logic of relation changers (**DLRC**). **DLRC** is a recent approach to **DEL** and provides a general framework to capture many dynamic operators of **DEL** in terms of relation changing operation written by programs in propositional dynamic logic (**PDL**). However, the proof theory for **DLRC** is not well-studied except the sound and complete Hilbert-style axiomatization [39, 25]. Therefore, we propose the cut-free labelled sequent calculus for **DLRC**. We show that our sequent calculus is equipollent with the above Hilbert-style axiomatization.

The third issue is about the integration of the notion of structures among agents into **DEL**. When we study multi-agent communication system, we can naturally assume the existence of communication channels between agents such as phone numbers and email address. However, when we try to integrate such a notion of structures into **DEL**, we cannot avoid facing some problems, e.g., the decidability of resultant logic(s) and management of many indices, such as agent IDs and names of the possible worlds in our syntax and its semantics. Therefore, we propose to implement the above notion as a constant symbol, then we can define decidable and semantically complete doxastic logic with communication channels and dynamic operators. Moreover, we also propose a linear algebraic reformulation of these. Based on the framework of **DLRC**, we reformulate our proposed semantics in terms of Boolean matrices. In order to reformulate our semantics, we also provide matrix representation of programs in **PDL**.

Key Words: **Modal logic; Dynamic logic of relation changers; Linear algebraic reformulation of Kripke semantics; Labelled sequent calculus; Channel based agent communication**