Logic and **L**ogical **P**hilosophy
Volume 28 (2019), 195–199
DOI: 10.12775/LLP.2019.008

BOOK REVIEWS

Fibring epistemic and temporal logics

Dariusz Surowik, **Logika, wiedza i czas. Problemy i metody temporalno-logicznej reprezentacji wiedzy** (Logic, Knowledge and Time. Problems and Methods of Temporal-Logical Representation of Knowledge), Wydawnictwo Uniwersytetu w Białymstoku, Białystok 2013, 357 pages, ISBN 978-83-7431-375-9.

The book under review is written in Polish by the logician Dariusz Surowik. Its title *Logika, Wiedza i Czas. Problemy i metody temporalno-logicznej reprezentacji wiedzy* can be translated into English in the following way: "Logic, knowledge and time. Problems and methods of temporal-logical representation of knowledge." As its title suggests, it covers topics from the disciplines of temporal and epistemic logic. It also concerns the issue of fibring logics in a more general form. The book may be seen as something in between a monograph and a textbook. Its rather narrow and specific field of interest (systems of temporal epistemic logic) should alert the reader that he is dealing with a highly specialized monograph. This said, the material contained in the book progresses smoothly, so the reader isn't overwhelmed with complicated formalisms and results right away. Starting form the basics, the author introduces some fundamentals of modal logic which makes the book accessible for non-logicians who are motivated to acquire high-quality information in the field of epistemic and temporal logic. Nonetheless, some familiarity with basic set theoretical notions and classical logic is needed for a full understanding. Its rich, mainly English bibliography supports the claim that the book is a very good, up-to-date coverage of modern epistemic,

Published online March 5, 2019

temporal and epistemic temporal logics. Although the book is highly theoretical, the author does not forget about giving concrete examples and mentioning some practical applications of the tools and results presented in his work. This is why Surowik's work is not only valuable for readers interested in pure logic, but also for researchers in fields as diverse as economics and computer or cognitive science. The book under review consists of seven chapters and an appendix in which some extra proofs of theorems that are mentioned in the earlier parts are contained.

The first chapter focuses on an informal characterization of the notion of knowledge. Different meanings of the term are given. The author makes a distinction between general understanding and strict sense of the word 'knowledge'. Some methodological and epistemological perspectives on knowledge are outlined. The difference between knowledge and belief is highlighted with a reference to a classical understanding of knowledge. The author also brings out the normative aspect of knowledge. Many different types of knowledge are described together with some collective notions: group knowledge, common knowledge and distributed knowledge. The relations between declarative and other types of knowledge are analysed, ending with conclusion that declarative knowledge is in a certain way superior: every other type of knowledge can be reformulated in terms of declarative knowledge. At the end of the chapter, the author recalls the Platonic definition of knowledge.

The next chapter covers static epistemic logic. Some historical remarks are made together with a presentation of some early work on epistemic logic. Some purely syntactic systems of epistemic logic are presented, namely those of Łoś, von Wrightè and Rescherè logics. Worth noticing is the fact that the author recognizes Jerzy Łoś as the first logician who formalised propositional attitudes. Although his contributions to algebra are well known, his pioneering work in epistemic logic is rarely mentioned. Rescher [4] is one of the few exceptions.[1] Hintikka's approach is outlined as the one indicating the modern approach to the logical representation of knowledge. The author presents the basics of modal logic: the notion of a Kripke model, local and global truth, validity and the relation of semantic consequence. The reader can also find some

[1] Happily, Łoś's early work has been rediscovered and developed in recent publications. In [1], the minimal logic of realisation inspired by the Łoś's operator is given a semantic interpretation. Also worth noticing is the book [2], where ideas from [1] are extended, initiating some perspectives on systematic research in the field of positional logic. The research is continued in [3].

basics of proof theory. The author presents well-known modal logic formulas (those which define specific properties of frames) and recalls systems of modal logic in a systematic way. The operation of fusion of logics together with some basic theorems are shown. The author then focuses on epistemic logics with modal operators of M and K read as 'it is possible from the point of view of an agent's knowledge' and 'it is known by the agentè respectively. The system of modal logic S5 is used as an exemplary system of epistemic logic. Multi-agent systems are also presented as those which enable us to formalize the interactions between different agents' knowledge. The author concludes the chapter by mentioning some difficulties concerning modal epistemic logic, namely: unintuitive aspects of the negative introspection axiom, Fitch's paradox and the logical omniscience problem.

The third chapter is an introduction to temporal logics. Languages and semantics of various temporal logics are briefly presented. The author elaborates the minimal system of tense logic K_t. Different extensions of K_t are outlined. The logic of the temporal operators S (since) and U (until) is discussed. The author presents Computational Tree Logic CTL. The language and semantic specification of the logic together with some basic definitions are given. A completeness result is stated without the proof. The author also presents the logic CTL^* whose language is slightly different than CTL'ès. In addition, two two Alternating-time Temporal Logics are introduced: ATL and ATL^*.

The fourth chapter focuses on the temporalisation of logical systems. The aim of the chapter is to present a general method of mixing sentential logics with temporal logics. First, the Finger-Gabbay method of internal temporalisation is presented. Its restriction to temporal logics of linear time is highlighted. The proof of completeness is presented in a very informative way: the reader first gets to know the general strategy of the proof (outlined in verbal and graphic way) before being introduced to the technical aspects of the proof. The decidability, and conservativity of $T(L)$ systems are also proven. At the end, the generalization of the method is presented. This method allows the underlying temporal logic not to be linear.

In the fifth chapter, the author describes epistemic temporal logics. The starting point is the single-agent S5 epistemic logic of linear time. The author uses simplified models for $S5$ (relation is omitted and worlds are treated as classical valuations). Then, the author moves to a single-agent temporal logic of operators U and S. Basic metalogical theorems

are stated without proofs (soundness, completeness, decidability). The third part of the chapter is the multiagent logic of linear time. The author gives basic definitions, presents an axiomatisation of the logic and states its soundness with completeness. After that, the author presents seven properties of temporal epistemic logic which together form the criterion for the classification of those logics. The reader gets to know some specific semantics for synchronic logics, branching time logics, unique initial state logics, etc. Some metalogical theorems of those systems are stated, mainly the completeness theorems. The reader then encounters an epistemic logic of alternating time. Basic definitions are given and an axiomatisation is presented. The chapter concludes with exemplary applications of the aforementioned logics. These systems are shown to be useful tools for analysis of some philosophical problems, namely determinism and the omniscience problem. At the end, the expressive power and application of alternating time epistemic logic to game theory is presented.

The next chapter deals with intuitionistic temporal logic. The author claims that the use of modal logics is not the only way to represent knowledge. The other way to do it — as the author suggests — is by means of intuitionistic logic. Although epistemic operators do not appear in the syntax, due to models of intuitionistic logic a notion of knowledge can be understood on the semantic level. The minimal system IK_t is presented. Two types of semantic structures for the logic are shown. Different axiomatisations are given and completeness is proven. The mutual undefinitability of the temporal operators 'H', 'P' and 'G', 'F' is shown[2].

The last chapter is about the temporal epistemic formalization of algorithmic knowledge. The definition of algorithmic knowledge is given. Two different types of epistemic operators are introduced: K^n and $K^{\exists}$, where $K^n\varphi$ is read: the agent will know φ in n time units and $K^{\exists}\varphi$ means there is n such that the agent will know φ after n time units. The axiomatisation is given together with some examples of applications.

Acknowledgement. I would like to thank dr Matthew Carmody for some valuable comments on an earlier version of this review.

[2] These operators are read as 'it always has been', it was (at a certain time/moment)', 'it is always going to be', 'it is always going to be', 'it will be (at a certain time/moment)' respectively.

References

[1] Jarmużek, T., and A. Pietruszczak, 'Completeness of minimal positional calculus', *Logic and Logical Philosophy* 13 (2004): 147–162. DOI: 10.12775/LLP.2004.009

[2] Jarmużek, T., and M. Tkaczyk, *Normalne logiki pozycyjne* (Normal Positional Logics), Wydawnictwo KUL, Lublin 2015.

[3] Karczewska, A. M., 'Maximality of the minimal $\mathcal{R}$-logic', *Logic and Logical Philosophy* 27, 2 (2018): 147—162. DOI: 10.12775/LLP.2017.008

[4] Rescher, N., 'Assertion logic', pages 250–286 in *Topics in Philosophical Logic*, D. Reidel Publishing, Dordrecht 1968.

Krzysztof Aleksander Krawczyk
Department of Logic
Faculty of Humanities
Nicolaus Copernicus University in Toruń, Poland
krawczyk@doktorant.umk.pl