

AUTOMATED REASONING WITH SITUATION THEORY:  
A NOVEL APPROACH TO BELIEFS AND PERCEPTION

by

Lindsey Spratt  
B.S., Massachusetts Institute of Technology, 1977

Submitted to the Department of Computer Science and the Faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Science.

---

Professor in Charge

---

---

Committee Members

---

Date thesis accepted

## Table of Contents

Abstract.....	iii
Acknowledgements.....	iv
List of Exhibits.....	v
Chapter 1: Introduction.....	1
Chapter 2: Knowledge Representation.....	8
Chapter 3: Situation Theory.....	19
Chapter 4: FELIX: A Theorem Prover for Classical and Infon Logics.....	75
Chapter 5: Perception and Belief and Situation Theory.....	137
Chapter 6: Extending FELIX to Multiple Intensional Contexts.....	162
Chapter 7: Execution of FELIX.....	188
Chapter 8: Conclusions.....	192
Appendix 1: Infon Logic Theorem Proofs.....	197
Appendix 2: FELIX Reasons: Classical and Infonic.....	208
Appendix 3: Proofs from FELIX.....	213
Bibliography.....	309

# Abstract

The central claim of this thesis is that situation theory is superior to classical logic as a foundation for knowledge representation in artificial intelligence.

This claim is elaborated by the following hypotheses:

- 1) A version of situation theory can be defined which has a characterizing logic (an “infon” logic) similar in form and expressivity to classical first order logic.
- 2) There is a semi-decision procedure for this new infon logic, and a theorem prover can be devised which implements it. Further, many of the techniques of automated theorem proving developed for classical logic can be applied to automated theorem proving in this new infon logic.
- 3) This new version of situation theory and the associated theorem prover is appropriate as a knowledge representation and reasoning system for theories of perception and belief.
- 4) Theories of perception and belief as defined by their embeddings in the new version of situation theory provide a better account of human reasoning than classical logic-based computational approaches to perception and belief.

The first three hypotheses are proved in this thesis. Also, arguments in favor of the fourth hypothesis are presented.

Novel contributions in pursuit of this research include the following:

- A new “infon” logic is developed for a new version of situation theory,
- Theories of perception and belief are formalized in this new situation theory using the new logic,
- A theorem prover is developed which reasons in both classical and infon logic modes and which reasons in and across multiple intensional contexts of intensional relations (such as belief and support).

## Acknowledgments

I would like to acknowledge the many helpful discussions on logic, intuitionism and situation theory with Dr. Arthur Skidmore. Dr. Frank Brown and Dr. Costas Tsatsoulis helped to focus the research on which this thesis reports. This thesis would not have been possible without the constant encouragement provided by my wife, Dr. Kim Roddis. Also, her editorial comments have made this thesis much more readable than it would otherwise have been.

# List of Exhibits

<i>Exhibit</i>	<i>Title</i>	<i>Page</i>
3.1	Definition of the Supports Relation . . . . .	27
3.2	Hilbert Axiom System for Infon Logic. . . . .	28
4.1	FELIX Data Structures . . . . .	79
4.2	Propositional Example (test 5) . . . . .	98
4.3	Execution Trace for Simple Propositional Example. (test 5) Part 1 of 3 . . .	102
4.4	Execution Trace for Simple Propositional Example. (test 5) Part 2 of 3 . . .	103
4.5	Execution Trace for Simple Propositional Example. (test 5) Part 3 of 3 . . .	104
4.6	Reflexivity (test 8). Quantification Example - Trace. Part 1 of 3. . . . .	116
4.7	Reflexivity (test 8). Quantification Example - Trace. Part 2 of 3. . . . .	118
4.8	Reflexivity (test 8). Quantification Example - Proof. Part 3 of 3. . . . .	119
5.1	Principles of Perception. . . . .	138
5.2	Belief Principles . . . . .	146
5.3	Poker Game Formalization. Given Facts. . . . .	151
5.4	Poker Game Formalization. Domain Rules 1,2, and 3. . . . .	154
5.5	Poker Game Formalization. Domain Rules 4 and 5. . . . .	155
5.6	Two Wise Men Problem: Theorem Statement . . . . .	160
5.7	Two Wise Men Introspection Problem: Theorem Statement . . . . .	161
6.1	An Example Tree of Contexts. . . . .	164
6.2	Proof That Universal Conditional Deduction Supports Theorem. . . . .	165
6.3	Jack's Proof, part 1: Problem Statement. . . . .	174
6.4	Jack's Proof, part 2: Context 1. . . . .	175
6.5	Jack's Proof, part 3: Context 2. . . . .	176
6.6	Jack's Proof, part 4: Contexts 3, 4, and 5. . . . .	177
6.7	Jack's Proof, part 2 Collapsed: Context 1. . . . .	178
6.8	Jack's Proof, part 3 collapsed: Context 2. . . . .	179
6.9	Jack's Proof, part 4 collapsed: Contexts 3, 4, and 5. . . . .	180
6.10	Zack's Proof, part 1: Problem Statement. . . . .	181
6.11	Zack's Proof, part 2: Context 1. . . . .	182
6.12	Zack's Proof, part 3: Context 2. . . . .	183
6.13	Zack's Proof, part 4: Context 3. . . . .	184
6.14	Zack's Proof, part 5: Context 4. . . . .	185
6.15	Two Wise Men Proof . . . . .	186
6.16	Two Wise Men Introspection Proof . . . . .	187