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CONSTRUCTION AND EVALUATION OF A GOLD STANDARD SYNTAX FOR FORMAL LOGIC FORMULAS AND SYSTEMS

by

Larry Joshua Crotts

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Approved by

____

Committee Chair

To my Viola.

APPROVAL PAGE

This thesis written by Larry Joshua Crotts has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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[1] https://ap.collegeboard.org/

PREFACE

The basis for this research stems from my love of teaching. When I took my first introduction to formal logic course as an undergraduate, I was taken aback by its amazing appeal and relation to computer science. From my semesters serving as a tutor/teaching assistant in the Philosophy department at UNC Greensboro, I saw many students that struggled with this material. The problems ranged from its confusing syntax, proof techniques, and esoteric notation. At that time, I thought to myself, "Why not make a tool that helps students understand it better?" Of course, that question had already been answered and deeply investigated across multiple disciplines, but I knew that there had to be more. Once I began my exploration, I quickly realized that online solvers, theorem provers, proof assistants, and similar tools do not have a ubiquitous input format, and testing their algorithms was far more cumbersome than I initially expected. This evolved into the desire for a gold standard syntax for both zeroth and first order logic systems.

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CHAPTER I

INTRODUCTION

I.1 Overview

Formal logic, otherwise known as classical formal logic, is a subset of philosophy that branches into other related disciplines such as computer science, statistics, mathematics, and similar sciences. Logic, however, is taught in non-science fields like communicative studies primarily to reinforce critical thinking and improve deductive skills for argumentation. Per Stanford's Encyclopedia on Classical Logic, logic is a tool used for studying correct reasoning. Its existence spawned questions ranging from its use in mathematics as an aid to disambiguate problems and proofs to considering it as an extension to natural language [**?**]. As Hatcher [**?**] states, due to the increased viewing of rhetoric and opinion versus factual knowledge in modern media across television, social media, and other such mediums, the need for strong logical thinking abilities is crucial for evaluating, analyzing, and debating arguments and claims. Hatcher, likewise, mentions that standard logical deductive forms such as methods of inference and syllogisms serve as critical components for a student's ability to determine the validity of an argument and the relation (or lack thereof) of premises to conclusions. A desire for valid and sound arguments from students constitutes and contributes to a wider adoption of formal logic classes in universities, or at the very least, the pedagogy of invalid arguments with how to refute incorrect and, sometimes egregious, contentions. Formal logic's relation to computer science, in particular, ... **talk about how we can use formal logic for mathematical proofs, Boolean logic for circuitry, set theory, etc.**

I.2 Contribution

I.3 Thesis Content

I.4 Terminology

Before we continue, we will define some terms frequently used in formal logic-related work.

Definition I.1 (Well-Formed Formula)**.**

Definition I.2 (Proposition)**.**

Definition I.3 (Proof)**.**

Definition I.4 (Theorem)**.**

CHAPTER II

RELATED WORK

In this chapter, we will discuss the related work and prior contributions to the discipline of natural deduction pedagogy, as well as efforts to modernize and increase its effectiveness for students with a weaker background in, for example, mathematics. Extending formal logic to a technological education is not a new idea—there exist many online solvers, provers, and programming languages designed to suit the needs of logic students, or those that use formal logic in some manner. We will also mention more powerful theorem provers that are aimed at experts/more experienced users.

II.1 Formal Logic Tutors

II.1.1 Propositional Logic

Propositional logic, also known as zeroth-order logic (or in other disciplines as sentence logic, sentential logic, Boolean logic, combinatorial logic, or propositional calculus), according to Hein [**?**], is a language of propositions that conform to rules. Propositional logic is comparatively simpler than first-order predicate logic described in section II.1.2—it does not use variables, constants, or quantifiers of any kind. Rather, in this language, there are four binary (two-place/two-arity) connectives: logical conjunction, logical disjunction, logical implication, and the biconditional, as well as one unary (one-place/one-arity) operator: logical negation. **Show a table and describe different notation by different authors?**

Because of the reducible nature of propositional logic to simple structures and representations, there exist plentiful online truth table generators that provide detailed and immediate feedback for users while solving problems and well-formed formulas. Further, such generators work well not only for formal logic, but also computer science, mathematics, and electrical engineering, allowing students to enter a Boolean truth value (i.e., true/false) for an operand or proposition and the computer will determine if it is valid or invalid for an arbitrary cell.

II.1.2 First-Order Logic

II.1.3 Problem/Solution Generators

Ahmed et al. wrote......... Hladik... Amendola... LLAT... Graham defines a semantic tableau...

II.2 Automatic Theorem Provers

Coq..., αleanTAP,...

II.3 Boolean Satisfiability Solver Input Formats

CHAPTER III

METHODS

In this chapter, we explain our evaluation method and metrics for assessing three publicly-available natural deduction systems against our prover. Additionally, we construct a formal definition for a standardized and uniform syntax for writing and, more importantly, testing differing logic systems and algorithms.

III.1 Evaluation of Natural Deduction Systems

III.2 Gold Standard for Formal Logic System Syntax

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER V

CONCLUSION AND FUTURE DIRECTION

References