Interactive FOL Resolution Explorer

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1 Introduction

The goal of this project is to develop a comprehensive tool as a web page for visualizing the process of First-Order Logic (FOL) resolution. FOL is a fundamental technique in automated reasoning because it allows machines to represent and infer logical statements systematically. In this project, we seek to provide a step-by-step breakdown of how FOL formulas are transformed into Clause Normal Form and illustrate the key unification process using class algorithms.

This tool allows users to explore various strategies (Unit Resolution, Set of Support (SOS), Linear Resolution) for clause selection at each step of the resolution process. Users can mix strategies as they go, visualizing how each choice impacts the outcome and the evolution of learned clauses. This interactivity helps make abstract concepts more concrete by offering a hands-on approach to the logic resolution process.

The project emphasizes interactive visualization, making it a valuable educational tool for logic and computational theory courses. It combines logic, algorithms, and a user-friendly interface to simplify complex processes. By offering different resolution strategies, users gain insights into each approach's strengths and weaknesses, deepening their understanding of how resolution techniques can be optimized for applications like theorem proving and AI. Notably, no existing webpage offers this combination of functionality and interactivity, designed for easy access by general users.

2 Related Works

Logic Workbench (Renz, 2021) (Renz, 2021) is a tool for students to visualize formal logic, supporting both propositional and First-Order Logic (FOL) with transformations into Clause Normal Form (CNF) and resolution process visualization. It focuses on making logic accessible to learners with an interactive component for understanding resolution strategies.

Prover9 and **Mace4** (Arthan & Oliva, 2019) are tools for automated reasoning in FOL and model searching. While lacking visualization, they implement resolution and clause selection strategies, providing a foundation for exploring FOL resolution.

Prolog (Korner et al., 2022) is used for logic reasoning and AI, but unlike dedicated theorem provers, it doesn't generate step-by-step resolution proofs.

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3 Objectives

This project will create an interactive, web-based interface for First-Order Logic (FOL) resolution. Users can visualize transformations, like converting to Clause Normal Form (CNF) and performing unification, either as animations or step-by-step. They can choose which clauses to resolve or let the algorithm proceed automatically. At each decision point, a backtracking feature allows users to explore alternatives. After transformations, the Resolution Strategy Assistant will guide users in selecting the next step, offering insights into strategies like Unit Resolution, SOS Resolution, or Linear Resolution.

While traditional automated reasoning tools generate proofs automatically, delivering the result in one go without user intervention. While effective at handling reasoning, unification, and resolution, they lack interactive features that allow users to manipulate individual steps, limiting their utility for users who want to guide the process incrementally. Here is our contributions:

1. Web-Based Visualization: The project provides an interactive, web-based tool for FOL resolution with no need for downloads.
2. Step-by-Step FOL Transformation: It visually breaks down each step of the transformation process, including Skolemization and conversion to CNF
3. User-Driven Resolution: Users can select which clauses to resolve, allowing exploration of different resolution strategies in an educational, interactive manner.
4. Resolution Strategy Assistant: The web-based tool will also include an assistant that helps guide users in selecting clauses based on their desired resolution strategy

4 Methodology

The frontend visualization will be developed using p5.js, a creative library that enables engaging designs. To implement the backtracking feature, the animation history—corresponding to steps in the FOL resolution process—will be tracked either manually or using an existing data versioning library. Rx.js or a similar library will handle the connection between the algorithm and the user interface, though the final choice may change.The backend will use Tau Prolog, a JavaScript-based Prolog interpreter, ensuring seamless integration between Prolog's logical reasoning and JavaScript's versatility.

5 Conclusion

Our proposal, Interactive FOL Resolution Explorer, aims to bridge the gap between automated reasoning and user-driven exploration of First-Order Logic (FOL) resolution. We provide a step-by-step visualization of FOL transformations and an interactive resolution process. By experimenting with different resolution strategies and visualizing their effects, learners gain deeper insights into complex logical concepts. This web-based, user-friendly tool serves as a valuable resource for students and researchers in computational theory and logic.

6 References

Arthan, R., & Oliva, P. (2019, August 14). *[1908.06479] Studying Algebraic Structures using Prover9 and Mace4*. arXiv. Retrieved September 25, 2024, from https://arxiv.org/abs/1908.06479

Korner, P., LEUSCHEL, M., & BARBOSA, J. (2022, March 14). *2201.10816v3 [cs.PL] 14 Mar 2022*. arXiv. Retrieved September 27, 2024, from https://arxiv.org/pdf/2201.10816

Renz, B. (2021, Oct 11). *Logic WorkBench*. LWB. https://github.com/esb-lwb/lwb/wiki

Note: We used ChatGPT to help rephrase, shorten, and refine paragraphs for clarity and presentation. The content and ideas are entirely our own.