Natural Deduction Proofs for Educational Feedback

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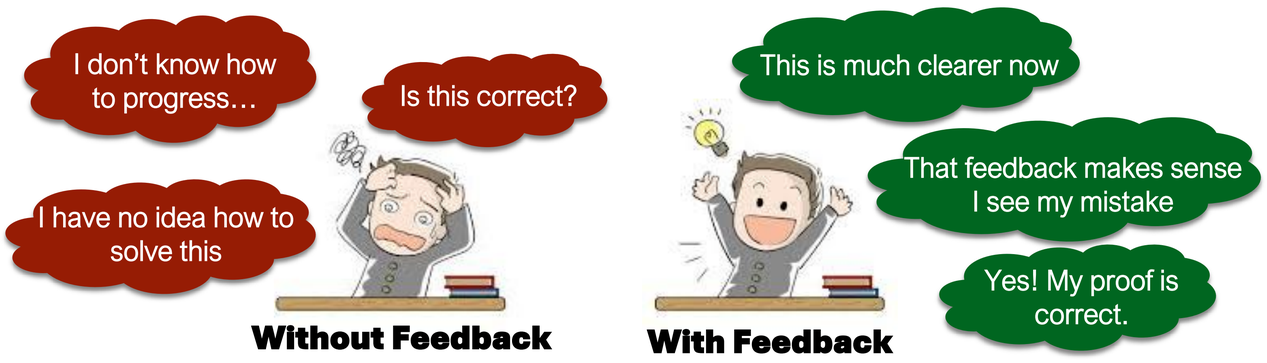
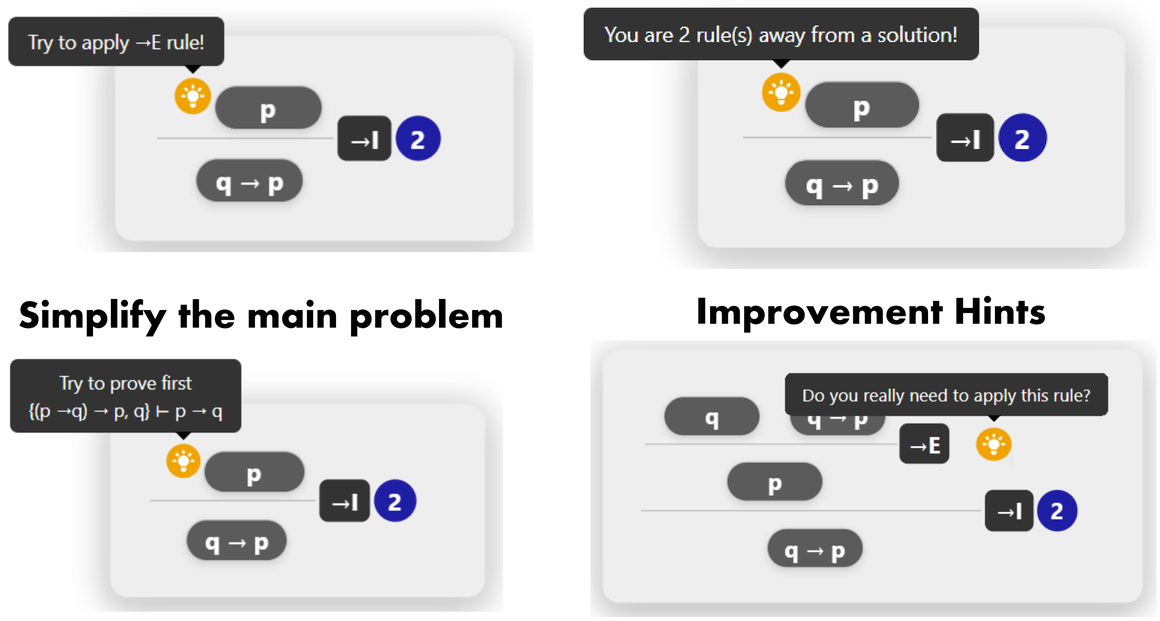
Motivation

Natural deduction proofs are **essential** but challenging for students to master.
Few learning resources exist, and most lack meaningful feedback.
Existing platforms provide only **very basic or generic guidance**.



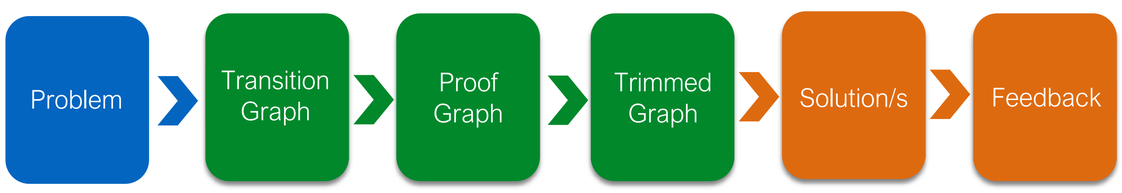
Feedback Objectives

Our feedback system was designed with four key goals to support students in learning natural deduction proofs.

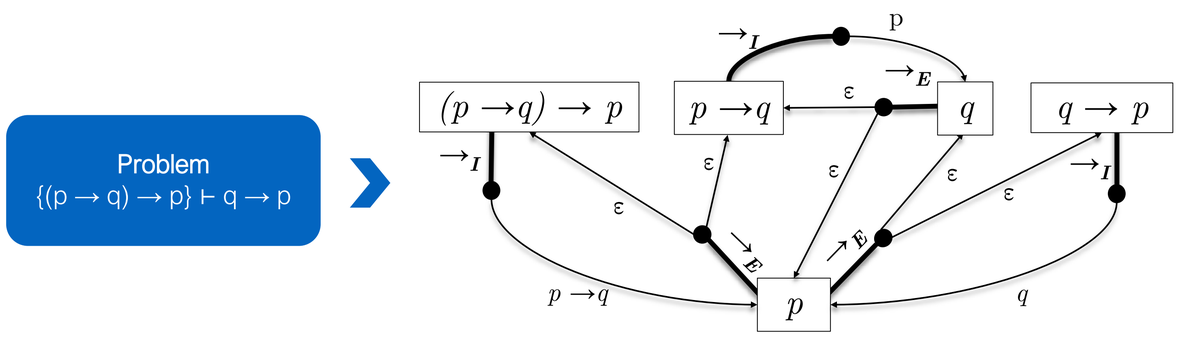


Proposed Solution

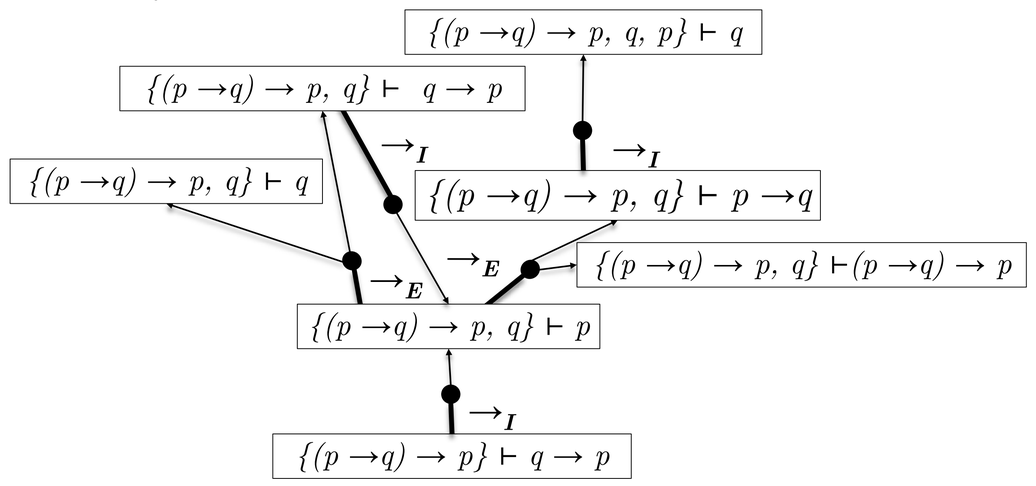
We developed an algorithm that automatically generates natural deduction proofs for propositional and first-order logic.
Our algorithm has three steps, each using **hypergraphs** to represent proofs.
The final graph can be queried to generate a solution and provide feedback.



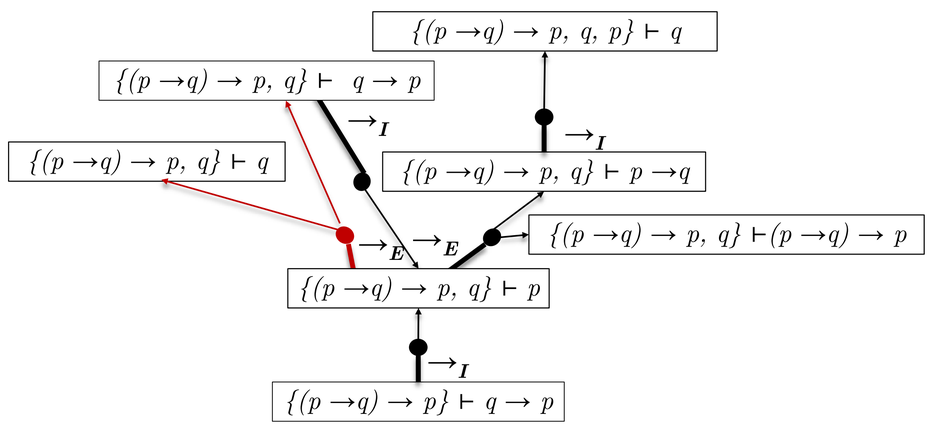
Transition Graph ("rules of the game")
Stores information about the formulas and rules that can be applied in the proofs



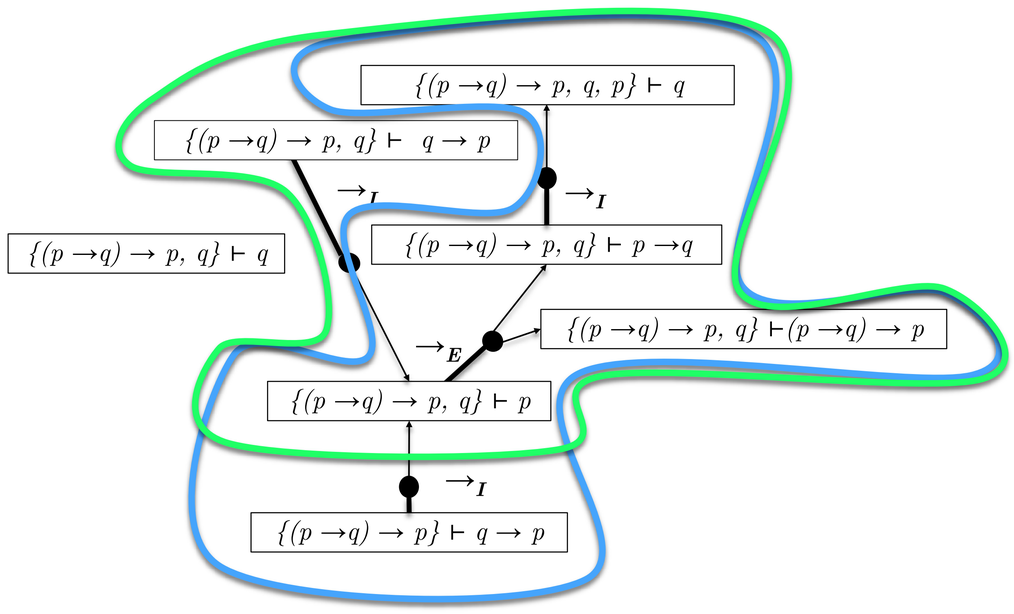
Proof Graph ("explores multiple possible games")
Stores multiple proofs for the initial problem, using the transition graph.
Stopping conditions (timeouts, node limits) are applied to prevent overly large graphs and keep feedback fast.



Trimmed Graph ("selects winning games only")
Using well-known **graph algorithms**, it removes the nodes and edges that do not lead to a solution.

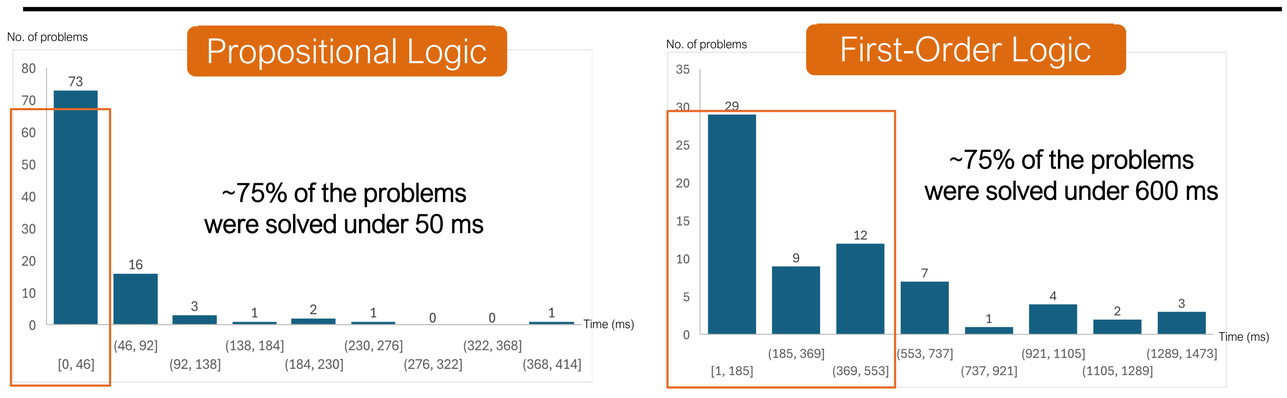


Solutions Extraction
From the last graph we can then extract solutions to generate feedback



Finally, these solutions can be queried multiple times to generate feedback.

Results



Conclusion

Main Contributions

Algorithm generates human-readable natural deduction proofs.
Feedback aligns with student reasoning for more effective learning.
Stores multiple solutions per problem, improving response time.

Future Work

Generate exercises with adjustable difficulty.
Improve scalability and efficiency of real-time feedback.

Try out our app

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