School of Computing & Information Sciences

Fall 2022 Senior Design Project

Information Theoretic Inequality System Prover

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Engineering & Computing

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Problem

Information measures like entropy and mutual information play a large role in various areas of computer science, such as cybersecurity, communications, and machine learning. Specifically, many important problems in these fields require evaluating linear systems of equations involving these quantities. While there already several techniques for evaluating systems of inequalities in the general case, there is no system which leverages information theoretical knowledge to more effectively evaluate in-domain systems of inequalities.

Current System

The system is based on the theories of our understanding of System Principles. How System can be viewed by mere entropy as well as while understanding the proof regards to those theories and checking for inequality by system of equations. Thus, this project is based on the logic of understanding and how to absolve these problems.

Goal

We present the Information Theoretic Inequality System Prover (ITISP), a Fourier-Motzkin-based system which leverages in-domain knowledge to automatically evaluate the validity of linear systems of inequalities involving information-theoretical measures.

Development Stack

python

NumPy

SciPy

matplotlib

Plot

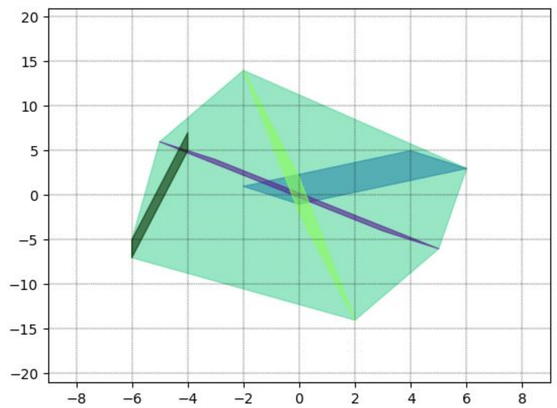
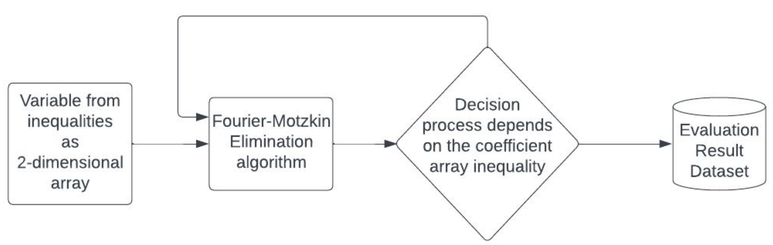


Figure 1: Fourier-Motzkin elimination method test result with random matrix input.

System Design



System Functionality

The system functions through the following steps:

- Users input a number of variables along with names for the variables in which the list of classical inequalities will be created and saved as int and string variables respectively.
- The system then creates and saves the list of classical inequalities following the standard X1, X2, X3, etc.
- From the list a 2 dimensional array is created for the variables containing all combination sets for the variables.(Ex: A, B, C variables form equation H(AC)+H(BC)-H(ABC)-H(C) >= 0.)
- Given the 2 dimensional array every combination is assigned a variable and returns a hash map of their corresponding variable and entropies.
- Using the created hash map the variables form inequalities eg. X + Y - Z - Q >= 0 which is used for input arrays for the fourier motzkin elimination algoithm the prover employs to produce coeffectient for each inequality to prove or disprove said inequalities.

Summary

The prover functions mainly through user input. The user inputs the desired integer variables to be used to generate inequalities as well as names for the variables if applicable. After, arrays are generated for the inputs and converted to a hashmap to form inequalities. The fourier motzkin algorithm takes the inputted inequalities to generate coefficients that either prove or disprove them.

Acknowledgement

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