School of Computing & Information Sciences

Fall 2022 Senior Design Project

Information Theoretic Inequality System Prover

Students: Leonardo Canizares, Jordan Zhu, Alfredo Cabanas, Eduardo Marcucci, Diego Castro Estrada, Renier Luces, Alec Joseph
Product Owner: Farhad Shirani Chaharsooghi, Florida International University
Instructor: *Dr. Masoud Sadjadi*, Florida International University

FIU Engineering & Computing

FIU Knight Foundation School of Computing and Information Sciences

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.

Plot

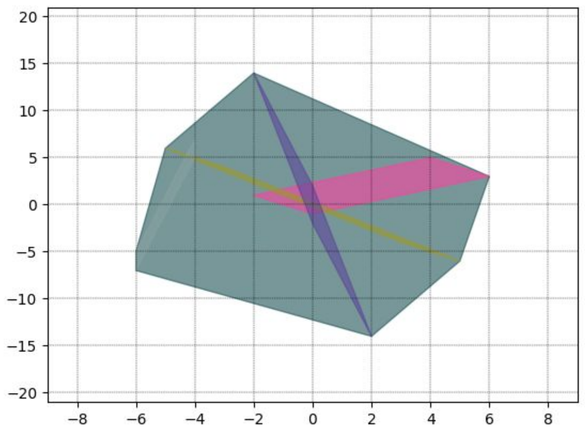

Figure 1: Fourier-Motzkin elimination method test result with random matrix input.

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

Current System

Currently, the system has the ability to check whether a system of linear inequalities is self-consistent, and whether it is consistent with several classical results in information theory. However, because the current iteration of ITISP is based the Fourier-Motzkin elimination method, it cannot solve nonlinear systems of equations.

How it Works

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 a list of classical inequalities in information theory.
- From the list of inequalities, a 2-dimensional array is created which contains all combinations of the variables. For instance, the variables *A, B, C* may be used to form the inequality

$$H(AC) + H(BC) - H(ABC) - H(C) \geq 0$$

- Once the 2-dimensional array has been computed, every combination is assigned a hash table with variables and entropies.
- Then, using this hash table, a combined system of inequalities is created, which is then evaluated using Fourier-Motzkin elimination. This produces a set of coefficients for each inequality that is then used to compute the final evaluation for the system.

Acknowledgement

The material presented in this poster is based upon the work supported by Florida International University Knight Foundation School of Computing and Information Sciences. We would like to thank Professor Eric Peterson for assistance, cooperation and mentorship that I/we received throughout this process