Project Guide for Notions of Positivity Project

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This document intends to provide a simple map for anyone wanting to familiarize themselves with this project. This can be used for review or as a guide. I am working on this project with Darshini Rajamani (LinkedIn), Abbas Dohadwala (LinkedIn), and Luke Luschwitz (LinkedIn). Professor Thomas Sinclair (website) of Purdue Mathematics supervises this project.

The GitHub to the project is linked below, where you can also access the GitHubs of all the contributors

https://github.com/karim-sharkawy/Notions-of-Positivity-and-Complexity-in-Quantum-Information-Theory

An understanding of linear algebra concepts (norm, isomorphism, etc) will be needed before tackling the theory of this project. Experience in a proof-based linear algebra course is helpful as well as going over the Professor's notes. Some concepts in the professor's notes are expanded upon below. It's good to learn some of the new material as you go so it's not overwhelming in the beginning.

Before going over the notes, it's important to know what a positive matrix is

+ What Does It Mean For a Matrix to be POSITIVE? The Practical Guide to Semidef…
+ The Practical Guide to Semidefinite Programming (2/4)

Important topics to read about:

+ Ordered Vector Spaces: https://en.wikipedia.org/wiki/Ordered_vector_space
    + Summary:
+ Preorders & Partial Orders: https://en.wikipedia.org/wiki/Preorder
    + Summary:
+ Extendability
    + Summary:
+ Positive Lifting
    + Summary:
+ Hyperplane

The use of Python packages is essential to understand the code. What you need to know:

1. NumPy: Python NumPy Tutorial for Beginners
    a. Follow along with the video: GitHub - KeithGalli/NumPy: Jupyter Notebook & Data Associated with my Tutorial video on the Python NumPy Library
2. SciPy: SciPy v1.11.4 Manual
    a. More specifically, we used scipy.optimize.linprog: scipy.optimize.linprog — SciPy v1.11.4 Manual
3. Matplotlib
    a. Matplotlib Full Python Course - Data Science Fundamentals
    b. Plot types — Matplotlib 3.8.2 documentation
4. Random
    a. Not important, used to generate random numbers
5. Machine learning packages will be explained later
6.

Explaining the code

1. The first code block recursively creates a positive semidefinite matrix that satisfies the E(2,2), linearity, and positivity constraints
    a. The E(2,2) constraint is …
    b. The linearity constraint is …
    c. The positivity constraint is …
2. The second block checks for liftability, which is the same as extendability in this case. We use the ‘linprog’ function in SciPy to check for extendability. How this works is that …
    a. We tell it how many mappings to create, and after creating all the mappings along with their identifications (extendable or non-extendable), it appends them to a list depending on whether they’re extendable or not
    b. It then saves the lists as files. This is used to decrease the wait time and with testing
    c. In the linprog function,
    d. ‘c’ is …
    e. ‘A_ub’ is … and ‘b_ub’ is …
    f. ‘A_eq’ is … and ‘b_eq’ is …
3. Each block of code has the name of the contributors on it, please check the file to know who created what

Before explaining the rest of the code, it's important to have a basic understanding of how machine learning works

IDEAS:

- Linear classifier: Linear classifier - Wikipedia
- Different types of algorithms like classification, regression, etc.
- ScitKit Learn
    - 1. Supervised learning — scikit-learn 1.3.2 documentation
    - Scikit-learn Crash Course - Machine Learning Library for Python

Other random things

+ Farkas' theorem
    + Farkas' lemma - Wikipedia
    + Proof: A NICE PROOF OF FARKAS LEMMA 1
    + Deutsch
    + This is used to prove …
+