**Proposal for Undergraduate Research Project (MATH444)**

**To:** Dr. Victoria Baramidze (Chair, Department of Mathematics)  
**From:** Kinshuk Mangal  
**Date:** 09/16/24

**Instructor:** Dr. Mokhtar Aouina

**Project Title:**  
**Markov Chains, Modeling, and Simulations**

**Introduction:**

A stochastic process can be described as a collection of random variables defined on a common probability space, where t=0, 1, 2, …, and t is thought of as the discrete time parameter. Assume that for all takes values in a fixed set **M** called the state space of the process. Many stochastic processes of theoretical and applied interest are memoryless. That is the probability for transitioning from a present state to a state tomorrow is independent of the past history of the process. Such processes are named Markov chains. If in addition, we suppose that:

* **M** is a finite set that means the Markov chain has a finite number of states, and
* the Markov chain is homogeneous meaning the transition probability does not depend on the time for all in M,

then we end up with a finite Markov chain.

**Objective:**

1. To study the fundamental properties of finite Markov chains mainly its evolution through its associated transition matrix.
2. To derive an efficient algorithm to compute the state vector at any time and program it using Python to find a stationary distribution vector. In particular, find pertinent information about a system under study.
3. To find another characterization for Markov chains for the sake of visualization, interpretation, and modeling.
4. To classify the sates of Markov chains.
5. To analyze real situations that can be modeled by Markov chains such as random walk, particle motion, or/and others if time permits.
6. To explain the main ideas behind Google’s PageRank Algorithm. In particular model the web, then simulate different situations to calculate the importance of a page. Discuss the results in each case and make suggestion(s) if necessary for this algorithm to work properly (as expected).

**Timeline:**

* **September-October:** Literature review, develop and test Python programs, study small datasets.
* **October-November:** Apply the program to larger datasets, conduct a detailed analysis.
* **November:** Finalize results and prepare the project talk.
* **End of November:** Give a talk on Project outcomes and present findings.

**Expected Outcome:**

**The primary deliverables will include a presentation to the Math Department.**