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The topic we are proposing to investigate is the application of eigenvalues in dynamical systems, specifically in areas such as the heart and in detecting cardiac arrhythmias and alternans. We will be referencing *Estimating Eigenvalues of Dynamical Systems from Time Series with Applications to Predicting Cardiac Alternans* by Adam Petrie and Xiaopeng Zhao. This topic is directly related to linear algebra because of its use of eigenvalues, specifically in analyzing the Monodromy matrix, a matrix of the system of ODE's governing the periodic behavior of the heart as a dynamical system. Because of the size and complexity of these matrices, different techniques must be utilized to calculate the eigenvalues which are of interest because of their indication of the long term behavior of the system.

We are interested in this topic because we want to know how to analyze the dynamical systems that are prevalent in many areas of engineering, academia and research. It is a complicated topic, but it is crucial to understand well. In this case it is very important because heart disease is the leading cause of death in the United States, and this model claims to be able to provide potentially life saving insight into the strength and health of a heart based on the eigenvalues of the dynamical system.

Readers must have a basic understanding of how the heart operates. Alternans are heartbeat patterns that are unstable or irregular, "characterized by long-short, beat to beat variation in the electrical impulses." These occur as a result from a period doubling bifurcation, where the period splits into two parts. It is also worth noting that there is no explicit formula or method for creating the matrices that determine the behavior of the heart as a dynamical system. State variables of the system may be ill-defined and there is no clear method as to what to study, measure, or model. Many acronyms will be used in this paper. *BCL* stands for Basic Cycle Length, or the time interval between two consecutive stimuli to the heart. *APD* stands for Action Potential Duration, and is the time when the voltage is elevated in the heart. APD_n refers to the time interval required to return to n percent polarization, and APD_*^n is the state vector of the system. λ_i is the symbol used for the i^{th} eigenvalue of the matrix.

Additionally, readers should have a basic understanding of matrices, eigenvalues, and differential equations. There is also some math relating to probability theory, specifically conditioning and independent events. Understanding how dynamical systems change over time or portray reality would increase a reader's understanding as well, however extensive additional research should not be required. No prior research would be necessary for readers to understand the project, however, research on alternans and their influence on the heart and health may increase a reader's interest and provide more motivation.

We would like to follow along with the paper in performing calculations to be able to gain an understanding of how the math is actually operating. We will create a MATLAB script as we study this topic to gain a sense of what is happening and to be able to analyze our own data. We found some experimental data online from MIT research on heartbeat classification, which was collected with the goal of training deep neural networks to detect abnormalities in heart beat data. The dataset includes cardiac arrhythmias, which we would like to analyze with our code by setting up the corresponding state matrices using the methods in this paper and applying them to this data to be able to predict alternans and period bifurcation with analytical eigenvalue techniques.