**Background:**

Shapley Additive exPlanations (SHAP) are a method for distributing gains in coalitional game theory introduced by mathematician Lloyd Shapley in 1951. The equation for Shapley values is presented as a sum of weighted averages, and each term represents the expected marginal contribution of a player, feature, or variable.

**Description:**

The method for calculating Shapley values is simple with low numbers of contributing players/variables. Essentially, the gains of a player on their own are subtracted from the gains of each possible coalition that includes that player. The average of these individual contributions is the Shapley value, or the weight of that player’s expected contribution. This becomes much more computationally expensive as more features are added to the model, so approximations such as Monte Carlo sampling and using computational SHAP packages in Python are used to perform these calculations. There are four axioms of Shapley values: efficiency, symmetry, null player, and additivity. Efficiency means that the marginal contributions of each player sum to the whole with none unaccounted for. Symmetry means that players’ values are considered interchangeable if they make the same contributions. The null player characteristic awards zero value to a player who does not contribute. There are no points for lack of participation. And additivity means that the combined gains from two games are the sum of the contributions from each of the two games; games are independent.

**Applications:**

While SHAP comes from game theory, meant to award credit to participants in a contest, this method can be used to describe the contributions of individual features to machine learning algorithms or variables in physics problems such as a multi-body problem or predicting nuclear binding energy. I used Shapley values to visualize the relative impact of each k\_i slope in an RK4 method of modelling a particle moving along a sine wave. Essentially, any prediction or result that depends on multiple factors can be described using SHAP. For a technical assignment for an interview, I recently created a series of models for biomechanical analysis of a baseball swing. I used the shap package in python to generate plots to help me visualize the importance of different variables on the prediction of the model. This allowed me to easily understand the impact of each factor on the overall model prediction, as well as to quantify the impact each factor had so I could tune the model to be as efficient as possible.

**References:**

[Introduction to SHAP YouTube Playlist](https://youtube.com/playlist?list=PLqDyyww9y-1SJgMw92x90qPYpHgahDLIK&si=W_E_hF4MyqcKKj1b)

ChatGPT, Claude, and GitHub Copilot were also used to ideate applications, explain nuance of SHAP, and generate and edit example code to demonstrate the use of Shapley values.