Research Proposal:
Game Theoretic Indices for Analyzing
Phylogenetic Trees

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1 Introduction

Biologists use phylogenetic trees to graphically represent the evolutionary relationship between various species. Species that share the most characteristics are on the same subtree which is rooted by their common ancestor. The branches of these trees can be given numerical values that represent the frequency of a gene or the time between the evolution of the parent and child species.

In the mathematical study of game theory, trees represent a game tree where each branch is a decision and assigned to each node is a numerical value representing the desirability of that outcome. There are various ways for solving such problems in order to maximize the outcome for a player. What would happen if these methods for solving game trees were applied to phylogenetic trees? Through my work, I hope to pull together the resources available from game theory, combinatorics on trees, and biology to find some relationships between species or groups of species that can be explained mathematically.

2 Proposed Research

As far as I know, there has not been any work using the strategies of game theory to discover anything about the phylogenetic trees of evolutionary biology. I intend to find a biological interpretation of the Shapley value for each species by looking at the various subgroups of species, which are called coalitions in game theory. Some other specific questions I wish to explore are:

- How does changing the topology of the tree affect the Shapley value?

- Are there other notions of index that can be developed to have useful biological interpretations?

Although this research has the possibility of revealing something about the relationship between different species from a mathematical standpoint, knowledge about known biological facts also gives this project the potential to reveal something about the nature or characteristics of trees.
3 Prior Research

Over the summer of 2003, I worked with Professor Naiomi Cameron from Harvey Mudd on a research project dealing with the combinatorics of various types of lattice paths. To prepare for this, I took a discrete math course (Math 55), a graph theory course (Math 104), and read several articles related to the combinatorics of graphs. During the spring semester of 2003, I took a course that analyzed real-world problems utilizing the tools of game theory (Math 188). I have the least background in biology having only taken the required course (Bio 52) but I started to peruse Billera, Vogtmann, and Holmes’ “Geometry of the Space of Phylogenetic Trees” to get a more detailed description of phylogenetic trees. Though I do not have any more specific sources, I am sure that I will be doing plenty of other research on various types of trees and different interpretations of the Shapley value and other power indices.

References


