*Neurogammon*

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Keywords—Neural Network, Game Theory, Artificial Intelligence, Backgammon

# Introduction

Backgammon at the basic level is a game where two adversarial players take turn rolling dice and moving their pieces. The game is won once a player has moved all their pieces off the board. The game however becomes complex after considering how the game allows one player to send opponent pieces back to the other end of the board. That is the defining rule to backgammon that causes human players to use advanced strategies while playing [1]. Due to the highly nondeterministic nature of the game, it is a good candidate for a neural network as an artificial intelligence opponent.

# Neural Network Training

## Introduction To Neural Networks

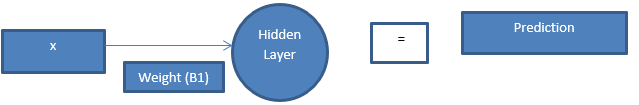
Neural networks endeavor to recognize relationships between a set of data through a process. It is designed in such a way that it can mimic biological neurons. In other words, it has simulated neurons that replicate human thinking processes. Neural networks are generally multilayer to classify series of data. It generally has 3 layers: Input Layer, Hidden Layer, Output Layer. Consider the single neuron pictured in figure 1, X is our input layer and B1 is the slop estimator of logistic regression. In the hidden layer, we use the sigmoid function for activation. Assuming B0 is the network’s bias, the outputted predicted probability is equal to the sigmoid function of B1\*x+B0

Figure - Single Neural Network Neuron

When this neuron is expanded for multilayer, the network looks something like Figure 2, there are 2 inputs and 2 neurons to support the inputs, and WX,Y is a weight associated with input X and neuron Y. The output of the hidden layer will be calculated as: Z1=W1,1\*In1+W2,1\*In2+bias\_n1. Neuron 1 activation =sigmoid (Z1). So, we can summarize this as:

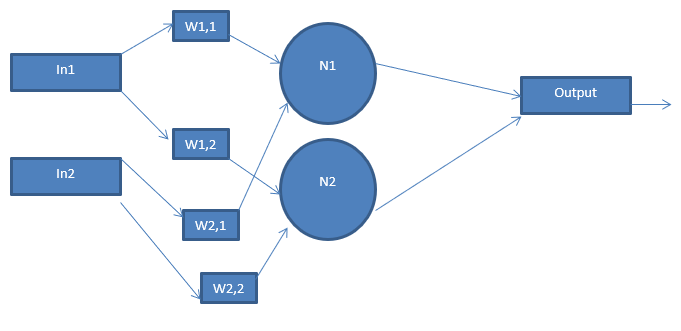


Figure - Multilayer Neural Network

## Training Data

For our neural network to function, we must first train it from some generated data. Our model utilizes 30 features: number of checkers in each position of the board (24 features), dice roll (2 features, 1 per die), number of checkers in jail (2 features, 1 per player), number of checkers in the home (2 features, 1 per player). Our data originated by capturing the 30 features for some observed games. We accounted for the adversarial nature of the game by using negative numbers for the opponent player.

## Neural Network Layout

As described in the multilayer neural network introduction, our neural network will consist of 31 inputs (one for each feature) and 5 hidden layers. The output of the network will classify using the sigmoid function, outputting a binary 0 for current player loss, or 1 for current player win.

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*a**b* 

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* The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
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1. Tesauro, Gerald. “Practical Issues in Temporal Difference Learning.” Reinforcement Learning, vol. 8, 1992, pp. 33–53., doi:10.1007/BF00992697
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4. K. Elissa, “Title of paper if known,” unpublished.
5. R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.
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7. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

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