

COMENIUS UNIVERSITY IN BRATISLAVA  
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS



# ARTIFICIAL NEURAL NETWORK AS AN OPPONENT IN QUORIDOR

Bachelor Thesis

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Bachelor Thesis

**Study programme:** Applied Informatics  
**Study subject:** 9.2.9 Applied Informatics  
**Department:** Department of Applied Informatics  
**Advisor:** Mgr. Peter Gergel'

### **Declaration of Authorship**

I do solemnly declare that I have written the presented thesis by myself under careful supervision of my thesis advisor without undue help from a second person other than that specified.

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## **Acknowledgement**

I would like to thank my advisor Mgr. Peter Gergel' for suggestions, help, guidance and friendly approach.

## **Abstract**

...absctract text here...

## 0.1 Introduction

### 0.1.1 Quoridor Rules

Quoridor is abstract board strategy game for 2 or 4 players with size of 9x9 (81) squares. This thesis covers 2 player version of this game.

Each player starts with a single pawn in the center of the edge on the opposite side as the opponent. The goal for each player is to reach the opposite edge.

Player also starts with 10 walls (fences) in the stock. Walls are two space wide and can be placed in the groove that runs between the spaces. Placed wall blocks pawns paths forcing them to go around it. Walls once placed can not be moved nor removed. Wall can not be placed to the position already occupied or crossing by other wall. Also, wall can not cut off the only remaining path of any pawn to his goal.

When player is on turn, he must place wall, if he has left some, or move his pawn to adjacent (not diagonal and unoccupied) space. If opponent's pawn stands on an adjacent space, current player can jump with his pawn to all the places where the opponent pawn can move.

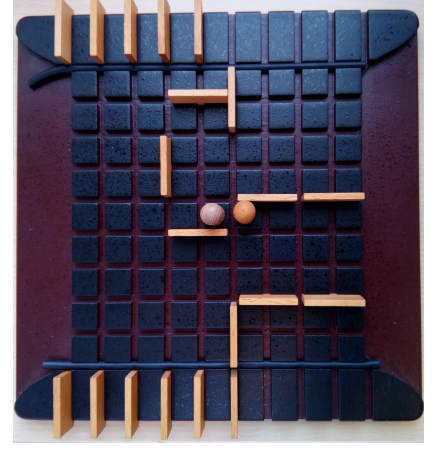


fig. 1: real board

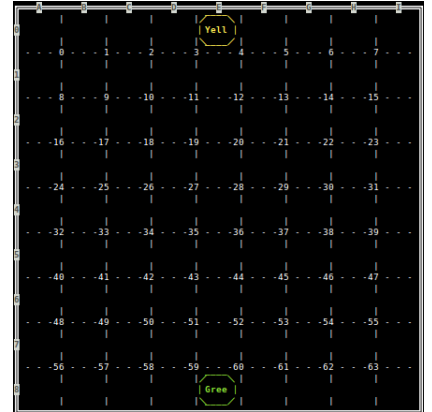


fig. 2: game start

### 0.1.2 Q-Learning

### 0.1.3 Quoridor complexity

Estimated state complexity was  $3.9905 \cdot 10^{42}$  [Mertens (2006)], however, this is very rough estimate, since it includes impossible states such as:

1. both pawns in the winning positions
2. pawn in the winning position where he could not get due to wall
3. pawns not having the path to winning position

Moreover, this estimate does include which player is on move and also how many walls have players in their stock. Both of these could make the game very different in the outcome. At least,  $S_p$  could be corrected to not include both pawns in the winning positions to  $S_p = 81 \cdot 80 - 9 \cdot 9 = 6399$

$$S_p = 81 \cdot 80 = 6480$$

$$S_f = \sum_{i=0}^{20} \prod_{j=0}^i (128 - 4j) = 6.1582 \cdot 10^{38}$$

$$S = S_p \cdot S_f = 3.9905 \cdot 10^{42} \quad (1)$$

### 0.1.4 Perceptron

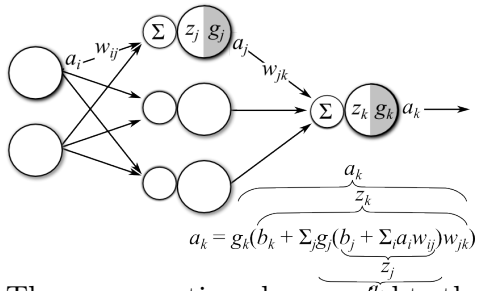


fig. 9: ANN

Artificial neural network (ANN) is a family of models inspired by biological neural networks used in computer science to approximate functions with large number of inputs. Generally, artificial neural network is presented as a system of interconnected neurons exchanging messages between each other.

These connections have weights that can be adjusted based on experience which makes the network capable of learning.

Perceptron is an algorithm for supervised learning of binary classifiers where one neuron has multiple weighted inputs and single output. Single perceptron can learn to decide between two linearly separable classes. Multiple perceptrons in multiple layers (MLP) use arbitrary activation function which makes it able to perform classification or regression based on the activation function chosen.

# Literatúra

P.J.C. Mertens. A quoridor-playing agent. Master's thesis, Maastricht University, June 2006. URL <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.134.5605&rep=rep1&type=pdf>.