

Diploma Thesis

An Intelligent Artificial Player for the Game of Risk

Michael Wolf

Agenda

- **Risk**
- **Risk Framework**
- **Basic Evaluation Player (BEP)**
- **Enhanced Evaluation Player (EEP)**
- **Learning Player (LP)**
- **Human Opponents**
- **Conclusion**

Risk

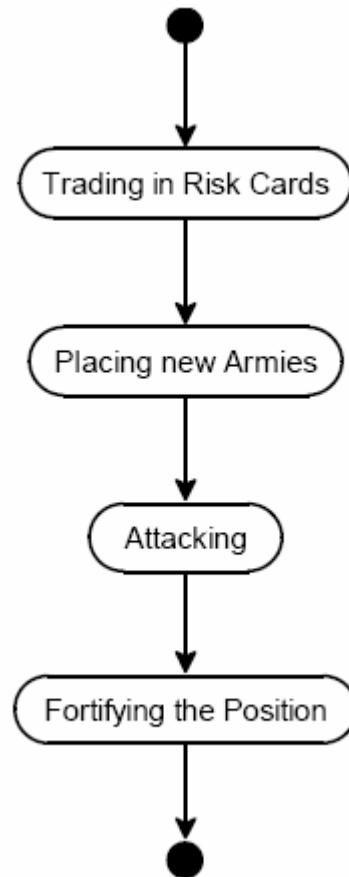


Risk – Overview

- **Popular Strategy Board Game**
- **2-6 Players**
- **Variable Move Sequence**

- **World / Continents / Territories**
- **Armies**
- **Conquer the World**

Risk – Game Flow



Risk – Complexity

- **State-Space Complexity**
- **Game-Tree Complexity**
 - Branching Factor \wedge Game Turns
- **In Risk: Infinite**

→ Estimates Needed

- State-Space Complexity: Cap on Army Number on Game Board
- Game-Tree Complexity: Measure Test Games

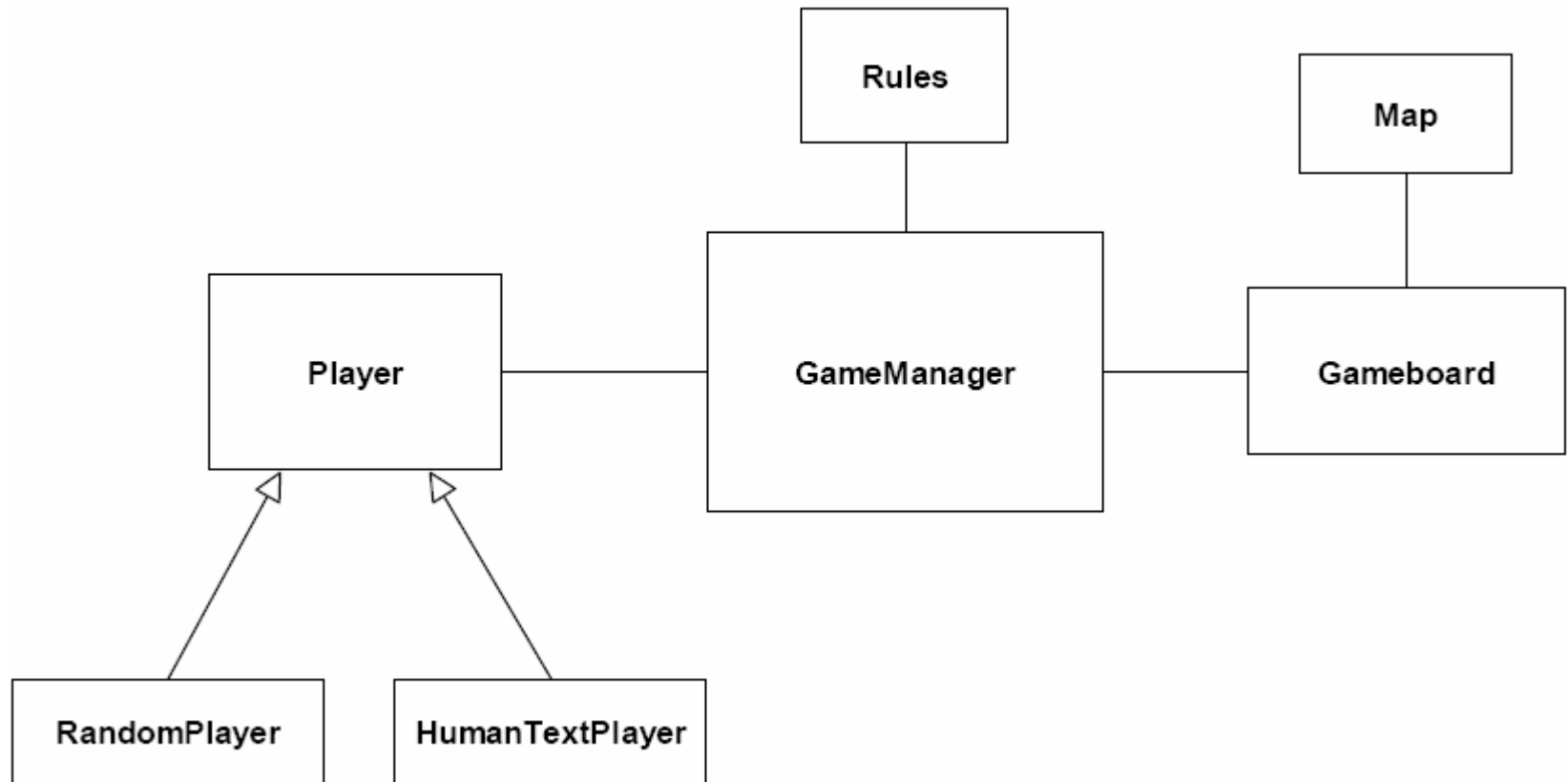
Risk – Complexity Comparison

Game	State-Space Complexity	Game-Tree Complexity
Nine Men's Morris	10^{10}	10^{50}
Checkers	10^{18}	10^{31}
Othello	10^{28}	10^{58}
Chess	10^{46}	10^{123}
Risk (200 armies)	10^{47}	10^{2350}
Shogi	10^{71}	10^{226}
Risk (1000 armies)	10^{78}	10^{2350}
Go (19 x 19)	10^{172}	10^{360}
Risk	∞	10^{2350}

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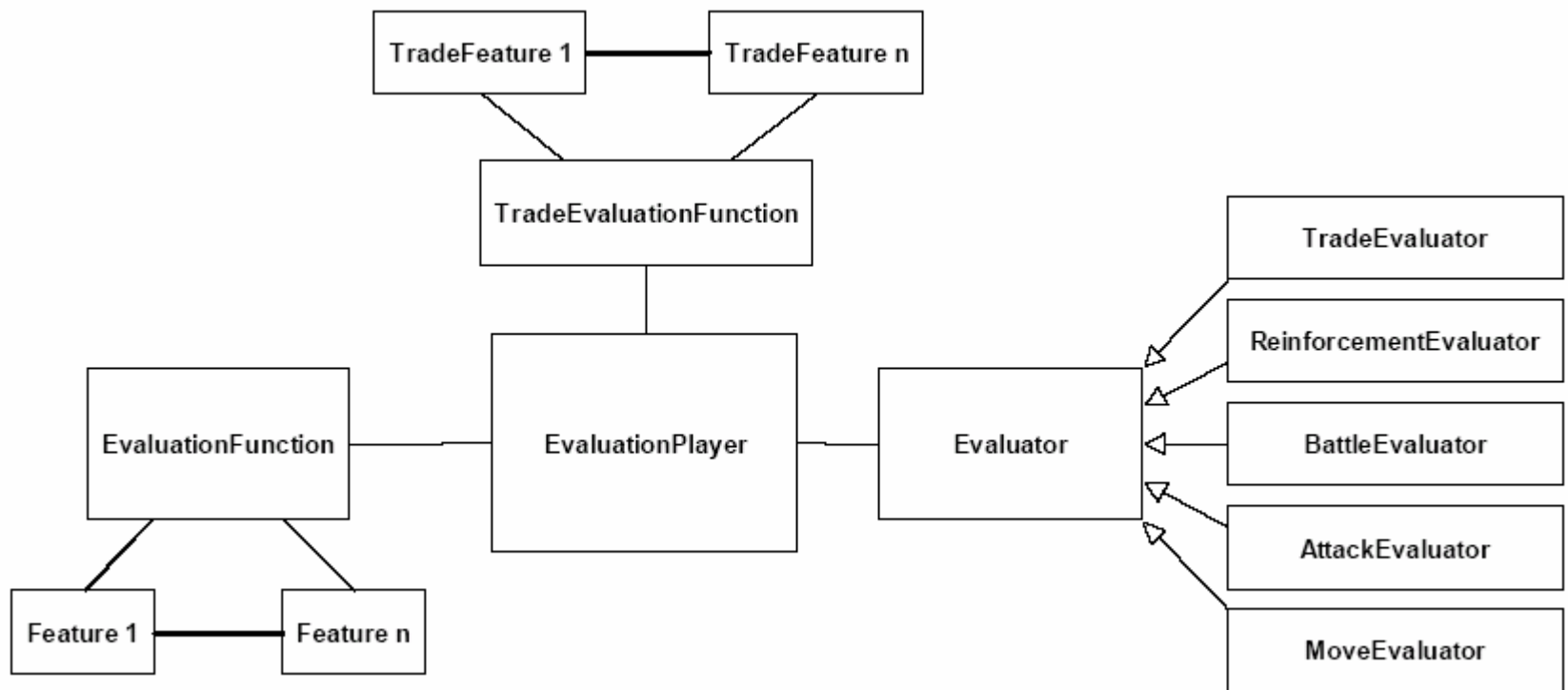
Risk Framework – Architecture



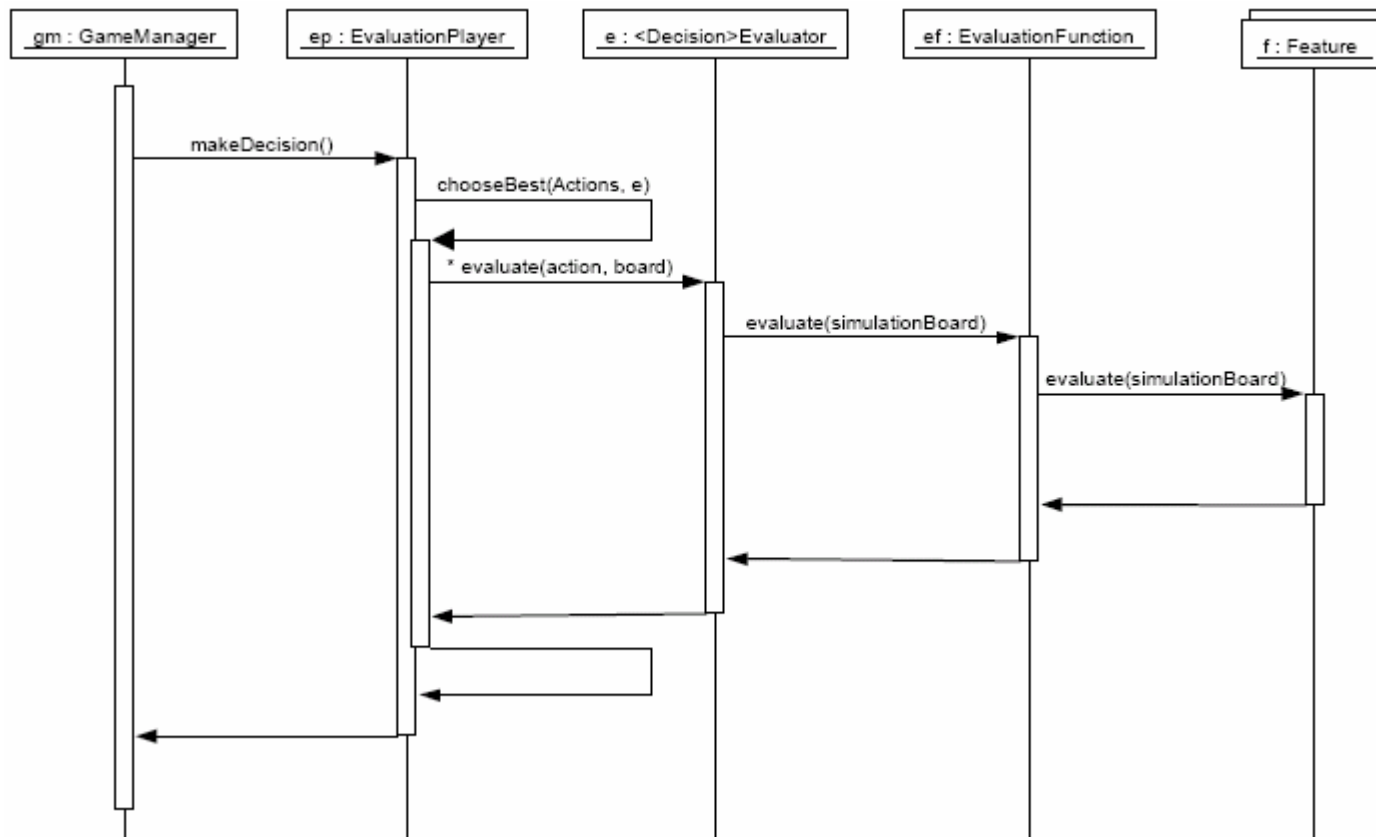
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BEP – Architecture



BEP – Decision Making Process



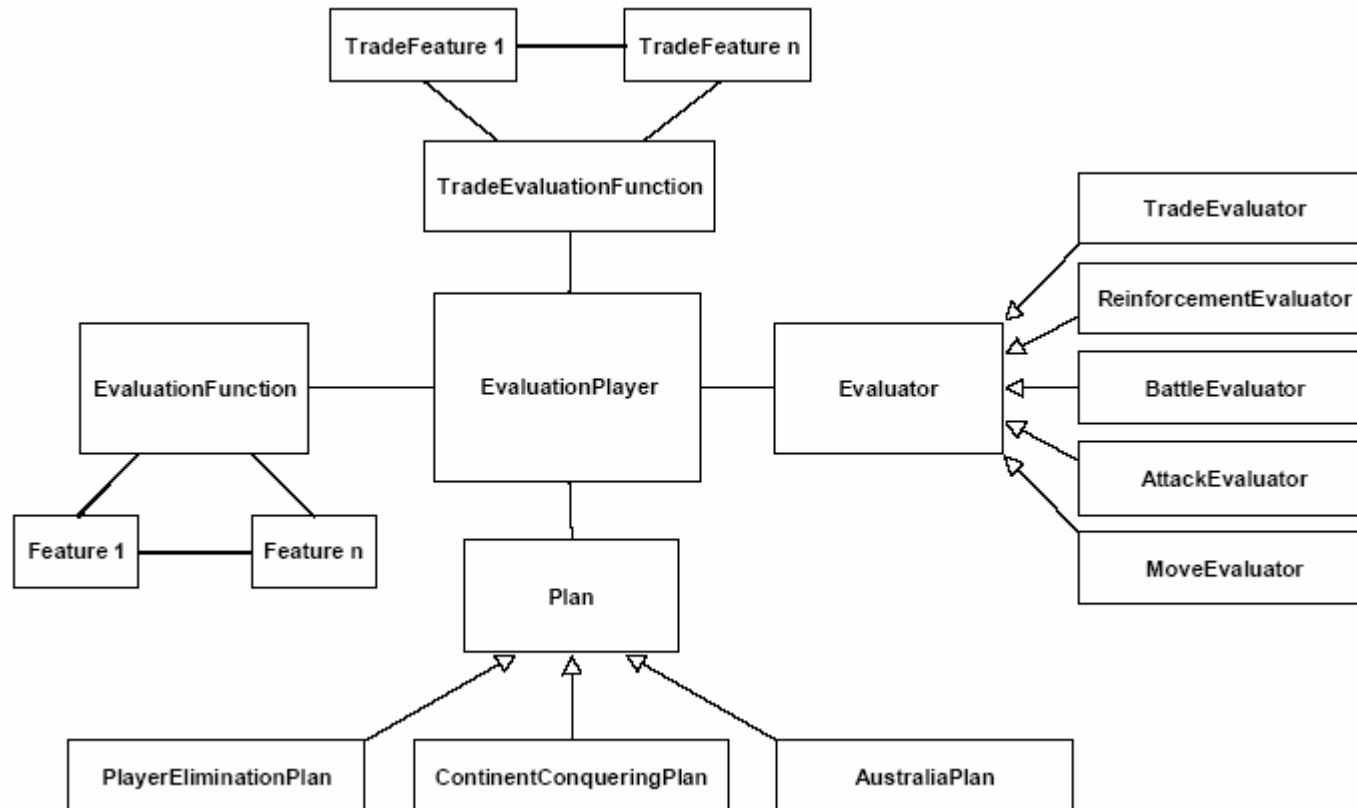
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EEP – Enhancements

- **Motivation: Uncoordinated Decisions of the BEP**
- **Target Continent (TC)**
 - Two new Features
- **Plans**
 - Player Elimination Plan (PEP)
 - Australia Plan (AP)
 - Continent Conquering Plan (CCP)
- **Reinforcement Distribution**
 - Several Variations

EEP – Architecture

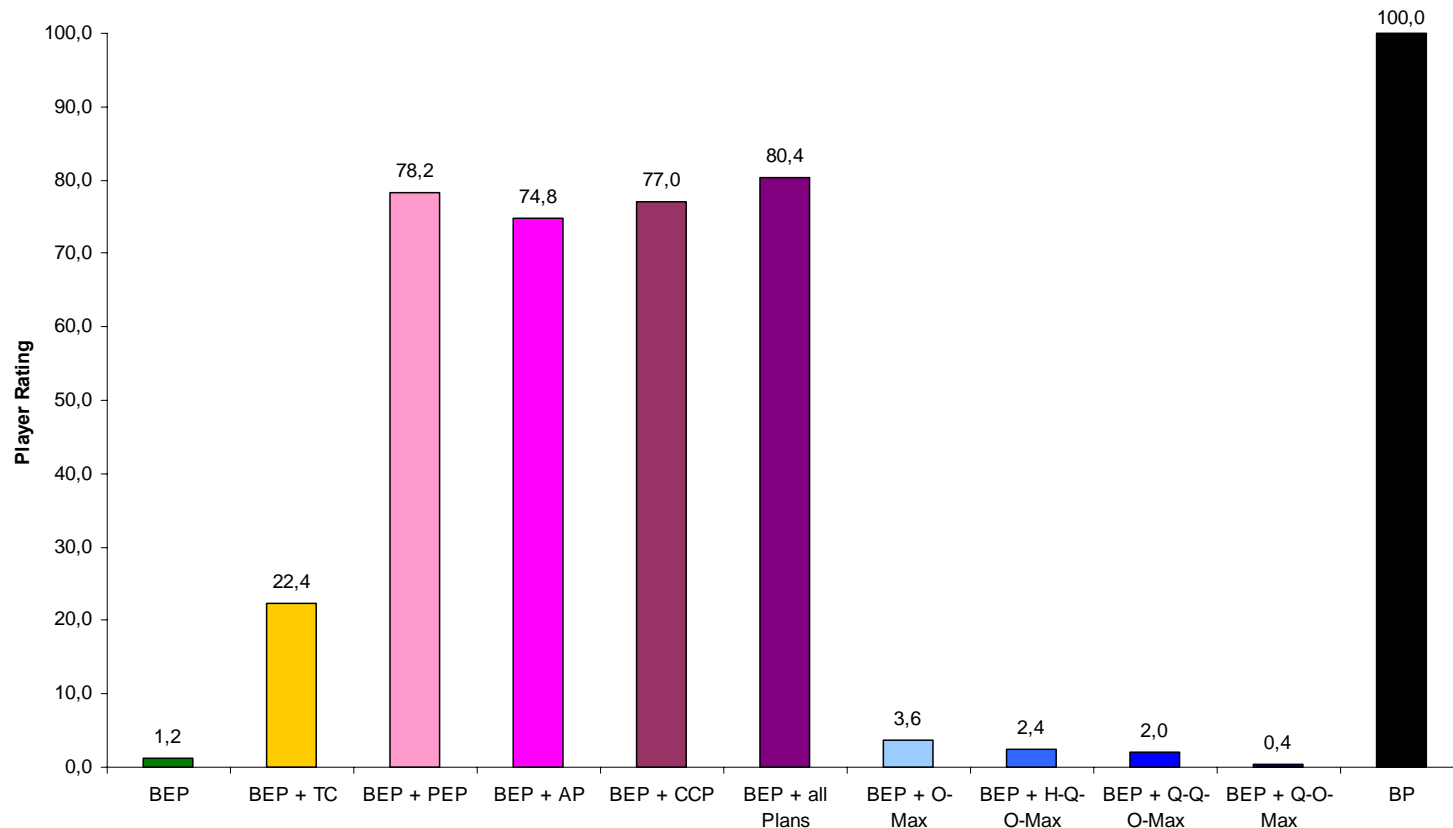


Rating System

- **Benchmark Player (BP)**
 - EEP with One-Max Reinforcement Distribution
- **Player Rating (PR)**
 - Four Players, One Test Player, Three BPs
 - Games Won (GW)
 - Games Played (GP)

$$PR = \frac{GW}{GP} \times 4$$

EEP – Enhancement Results



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Learning Player – Overview

- **Temporal Difference (TD) Learning**
 - Learning a Guess from a Guess (Bootstrapping)
 - Learning while Playing
 - Changing previous Estimates towards the current One
- **TD(λ) Learning Algorithm**

$$w_{t+1} = w_t + \alpha \times (P_{t+1} - P_t) \times \sum_{k=1}^t \lambda^{t-k} \Delta_w P_k$$

Learning Player – Learning Risk

- **Learning the weights of the linear EF**

$$w_{i,t+1} = w_{i,t} + \alpha \times (F(x_{t+1}) - F(x_t)) \times \sum_{k=1}^t \lambda^{t-k} f_i(x_k)$$

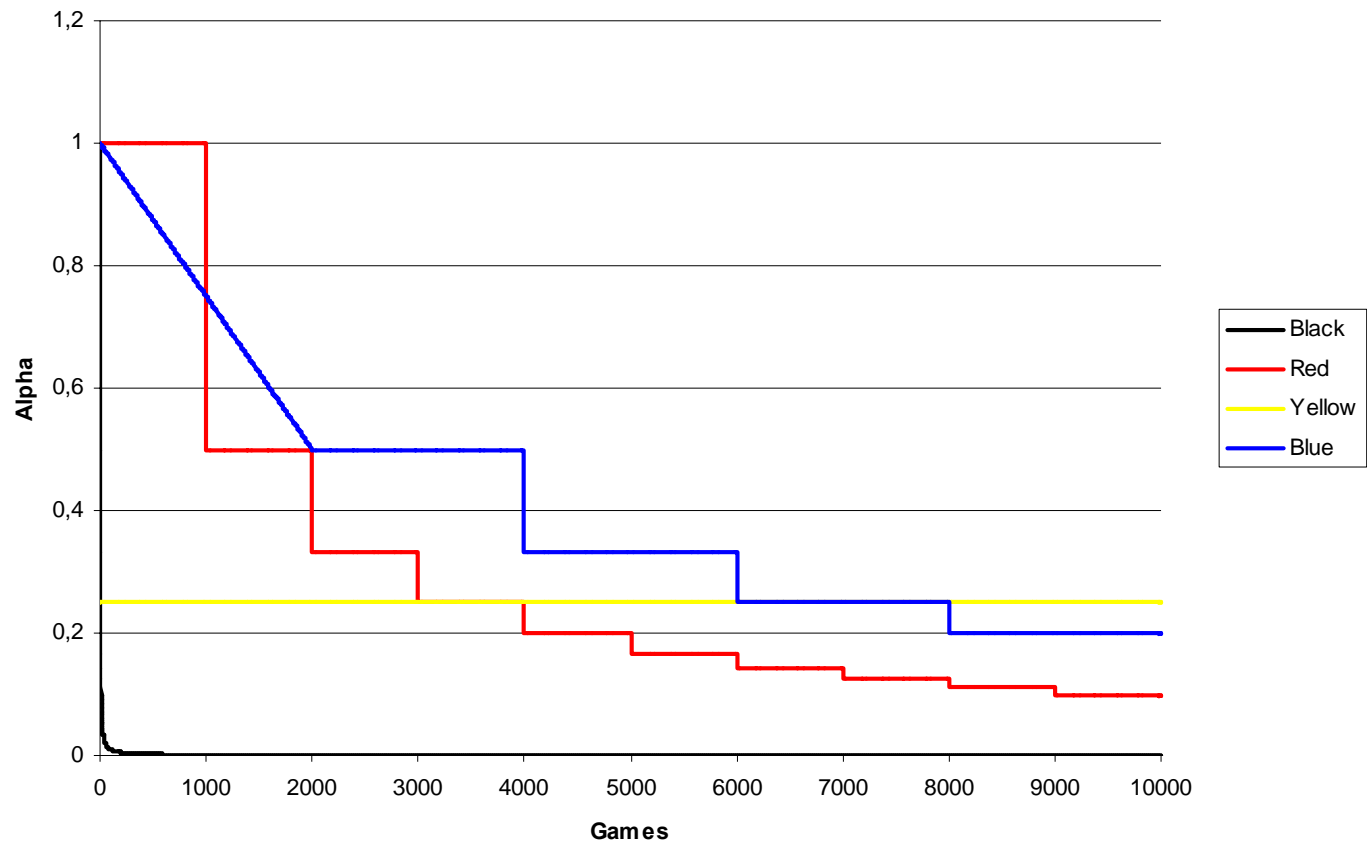
- **Reinforcement**
 - Zero or One
- **Learning Steps**
 - Once every Game Turn
- **Normalization**

Learning Player – Experiment

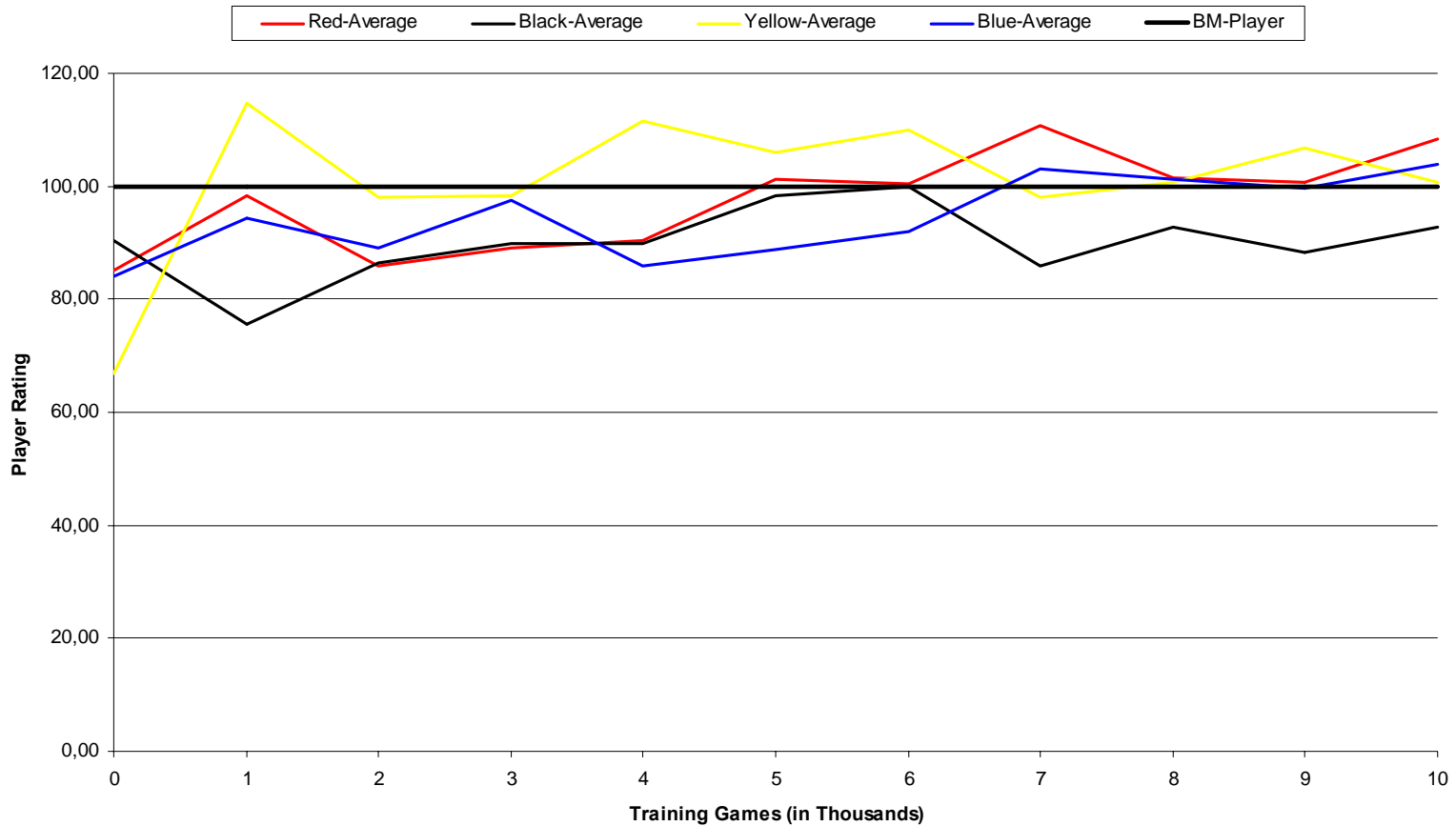
- **Four Alpha Functions, Four LPs Each**
- **10,000 Training Games**
 - Six Players, Four LPs with equal Alpha, Two BPs
- **Rating every 1,000 Training Games, Averaging**

Player	α	λ
Learning Player Red	$1 / \lceil n / 1,000 \rceil$	0.5
Learning Player Black	$\frac{1}{n}$	0.5
Learning Player Yellow	0.25	0.5
Learning Player Blue	if $n < 2,000$: $1 - 0.00025 \times n$ else: $1 / \lceil n / 2,000 \rceil$	0.5

Learning Player – Alpha Functions



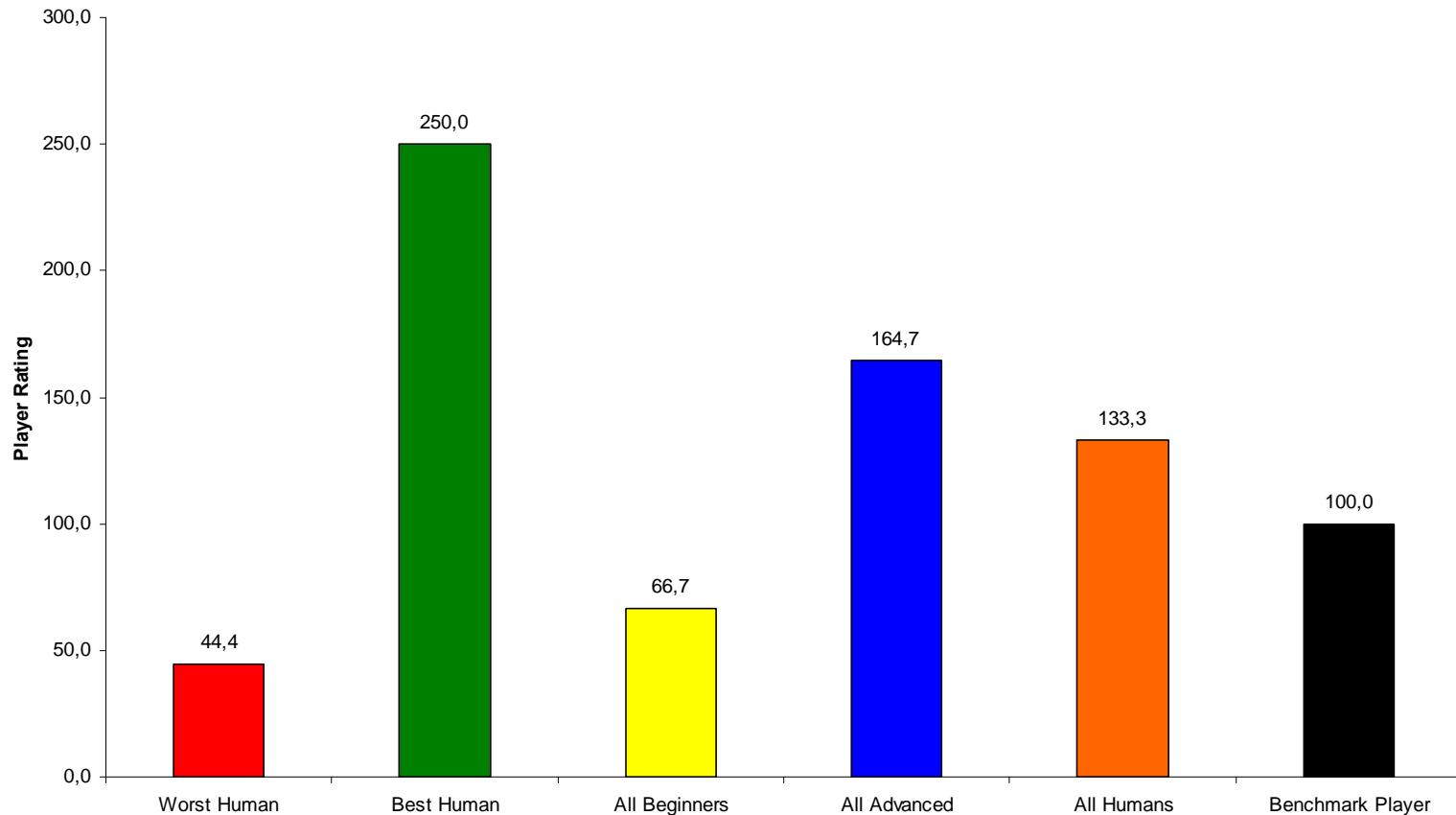
Learning Player – Results



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Human Opponents – Results



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Conclusion

- **Risk is very Complex**
- **Coordination of Moves is Crucial**
- **EEP is remarkably Strong**
 - Having just three predefined Plans
- **TD Learning seems Promising**

→ Learn Dynamic Plan Creation

Questions?

Thank You

Erfahrungen

- **Zeitaufwand**

- Geschätzt 
- Real 

- **Testen/Kommentieren**
- **Notizen Machen**
- **Schreiben Parallel zur Praxis**
- **LaTeX**