# Dynamic Difficulty Adjustment for a Novel Board Game

Presented by:

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EE 570 – Artificial Intelligence

December 7th, 2010

# Outline

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- **Introduction**
- 1st Paper: “Game Playing: The Next Moves”
- 2nd Paper: “Evolutionary Game Design”
- 3rd Paper: “AI for Dynamic Difficulty Adjustment in Games”
- Implementation: game rules
- Implementation: program
- Implementation: experimental results
- Conclusions and future work

# Introduction

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- Programs can now beat competent players, grandmasters or even solve games.
- Some games are still elusive.
- The field is looking for new challenges.
- Personal goal: design a novel game and implement the AI.

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# Game Playing: The Next Moves

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- By Susan L. Epstein, The City University of New York, 1999.
- Overview:
  - Defines important concepts in game solving.
  - Reviews the state of AI in board games at the time.
  - Proposes three challenges.

# Game Playing: The Next Moves

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- Reasons to continue to do research:
  - Humans have fascination towards games.
  - Some games can provide insight on what current approaches lack.

- What is a game?
  - Multi-agent, noise-free, discrete space with a finite set of pieces and set of rules.

# Game Playing: The Next Moves

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- Concepts:
  - Position, goal, game tree, contest, optimal move, evaluation function (perfect, heuristic), minimax algorithm, reducing search, introducing knowledge.
- Games and strategies:
  - Checkers (Chinook) and Chess (Deep Blue): brute force, enormous subtrees, extensive opening and closing books, evaluation functions carefully tuned.

# Game Playing: The Next Moves

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- Games and strategies (cont.):
  - Backgammon (Logistello), Othello (TD-gammon) and Scrabble (Maven): powerful evaluation functions, trained offline from millions of played games.
  - Current targets:
    - Bridge and Poker: imperfect information.
    - Shogi and Go: branching factor is too big.

# Game Playing: The Next Moves

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- Possible approaches:
  - Spatial cognition: value features by visualizing.
  - Satisfice: good enough decisions, reason from incomplete or inconsistent information, learn from mistakes.
- Challenges:
  - Model a contestant .
  - Annotate a contest.
  - Expert program teaching its skill.

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# Evolutionary Game Design

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- By Cameron Browne, Imperial College London, and Frederic Maire, Queensland University of Technology, 2010.
- Overview:
  - How to create combinatorial games by automatic means.
  - Provides empiric measurements of quality.
  - Uses an evolutionary search to produce new high-quality games.

# Evolutionary Game Design

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- Little attention paid to measure the quality of games themselves.
- Ludi Framework:
  - Uses a Game Description Language (GDL) to define games.
  - General Games Players (GGP) to interpret games and coordinates moves.
  - 3 modules: strategy module (planning), criticism module (quality), synthesis (generate new games).

# Evolutionary Game Design

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- How to rate games:
  - Use 3 aesthetic criteria.
  - Intrinsic (based on rules).
  - Viability (based on outcomes).
  - Quality (based on trend of play).
  - 57 of these criteria
  - Examples: completition, duration, drama and uncertainty.

# Evolutionary Game Design

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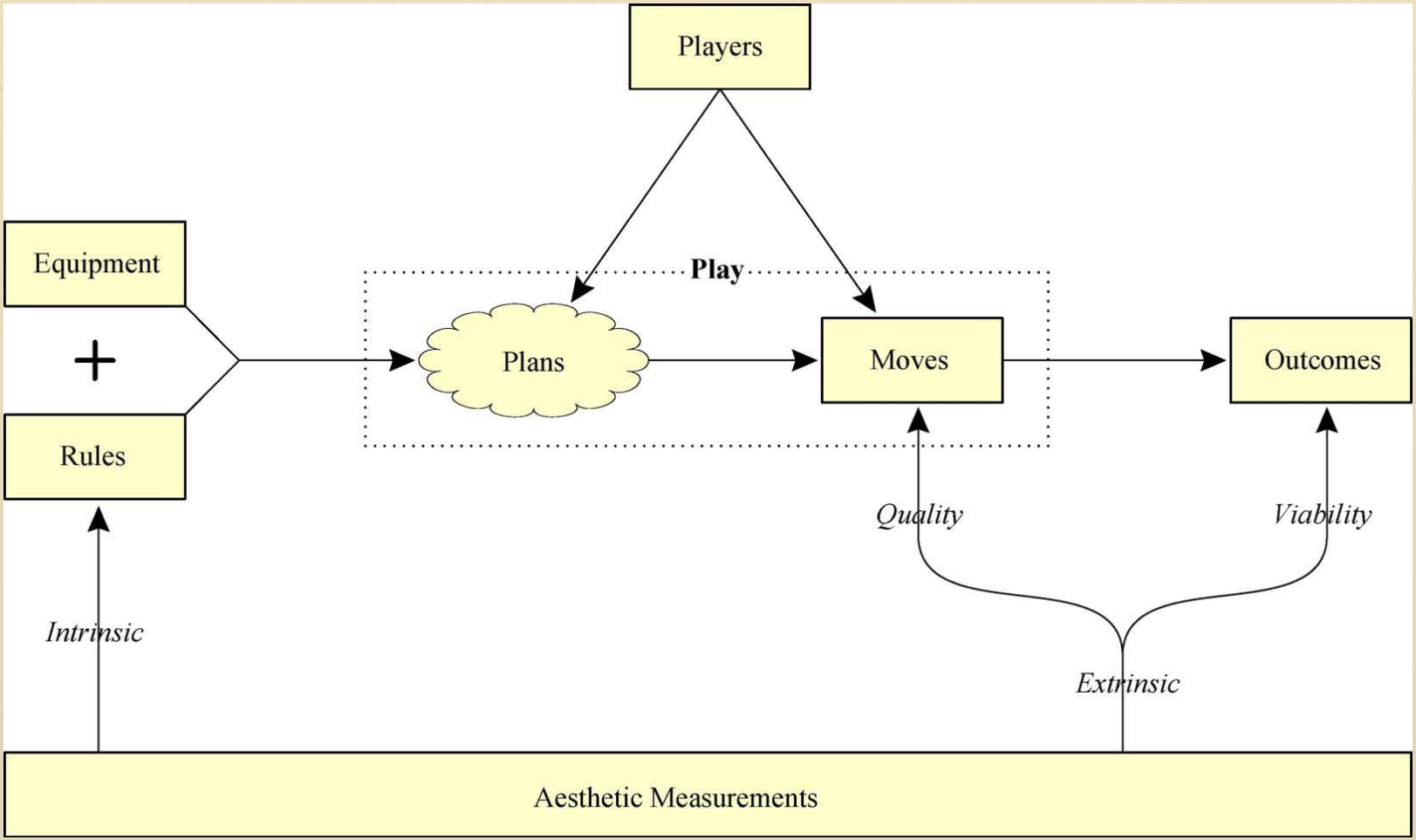

# Evolutionary Game Design

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- How to create new games:
  - Mating other games.
  - Two parents, one is a template.
  - Mutate child.
  - Perform validity check.
  - Score game.
  - Insert into population.

# Evolutionary Game Design

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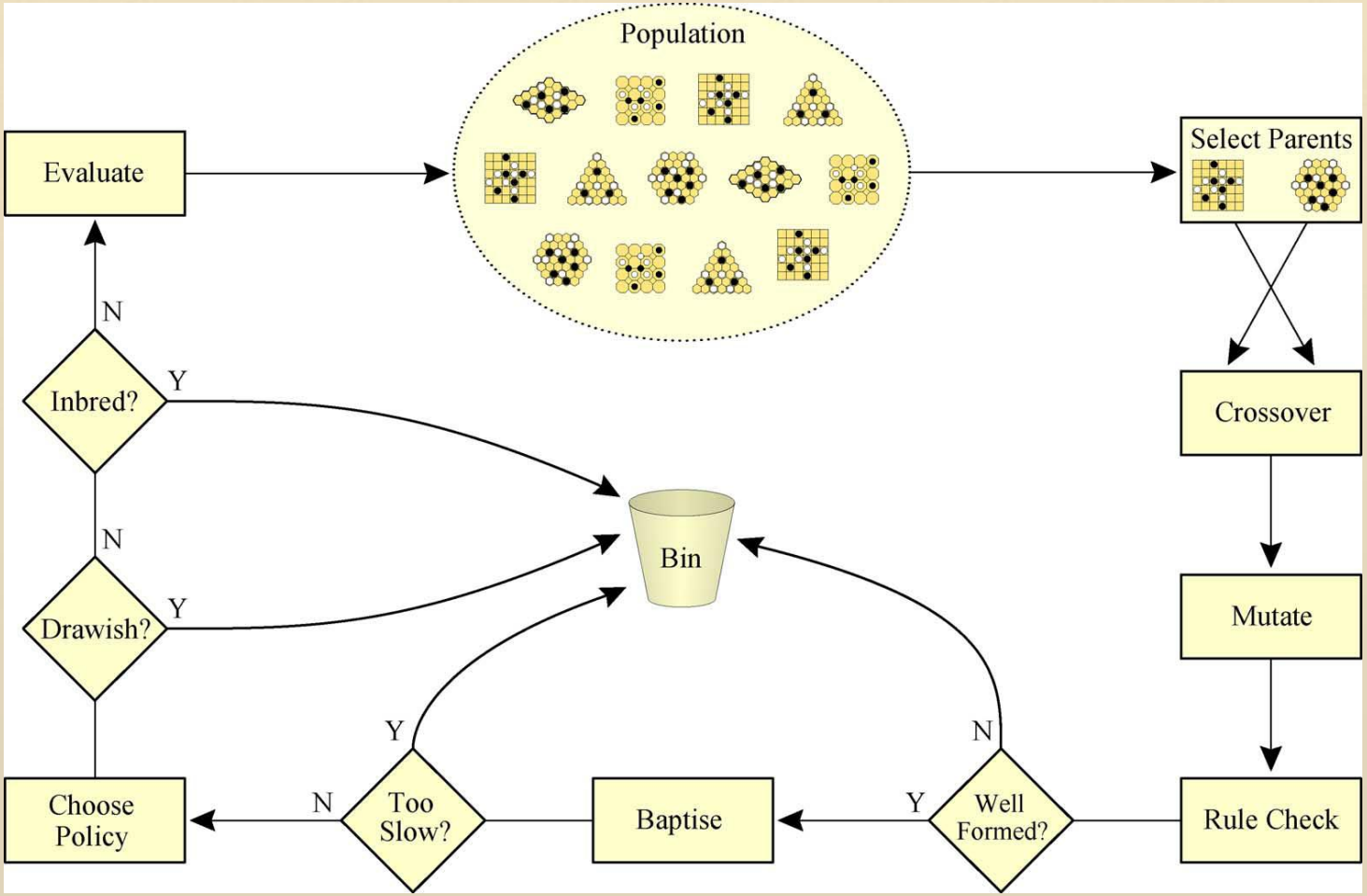

# Evolutionary Game Design

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- Experiments and results:
  - 79 existing games evaluated and ranked.
  - Results were correlated with aesthetic measurement .
  - 1389 games evolved from the original set, 19 deemed viable.
  - New games were scored and correlated.
  - Top 2 games are now commercially available.

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## AI for Dynamic Difficulty Adjustment in Games

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- By Robin Hunicke and Vernell Chapman, Northwestern University, 2004.
- Overview:
  - Games are meant to be engaging.
  - Use probabilistic methods to adjust challenge on-the-fly.
  - Creates more flexible and enjoyable experiences.

# AI for Dynamic Difficulty Adjustment in Games

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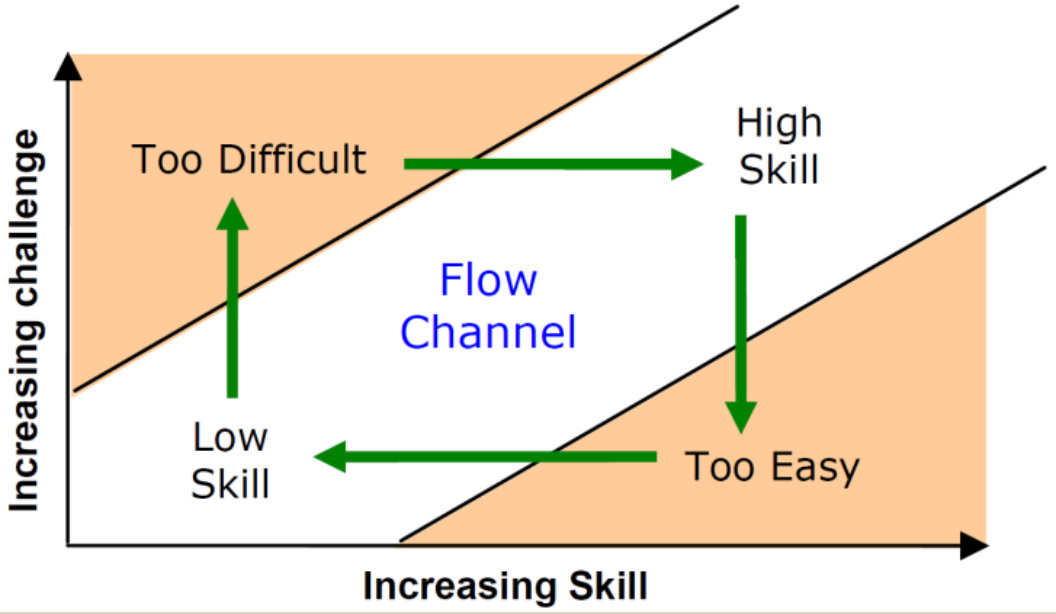
- Approach: maintain the player on the "flow" channel.
- Use Dynamic Difficulty Adjustment (DDA).



# AI for Dynamic Difficulty Adjustment in Games

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- Implementation:
  - Hamlet system.
  - Runs on Half-Life engine.
  - Metric chosen: damage.
- Types of adjustments:
  - Reactive (interacting elements).
  - Active (off-stage elements).

# AI for Dynamic Difficulty Adjustment in Games

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- Policies regulate the supply and demand of inventory.
- Abstract simulations estimate outcome.
- Changes are made based on this.

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# Game Rules

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- Game: Tlamatini.
- Elements:
  - Turned based board game.
  - Two players.
  - Hexagonal board, with hexagonal tiling.
  - 4 pieces per player, 3 types of pieces.
  - 3 tile states: neutral, owned or owned by rival.
- Goal: Make a specific piece reach the other side.

# Game Rules

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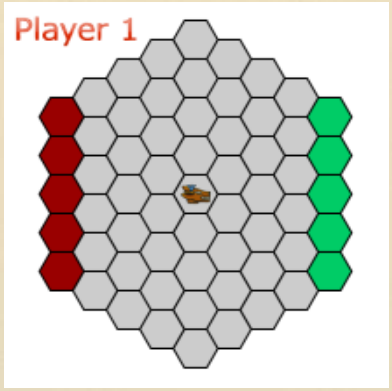




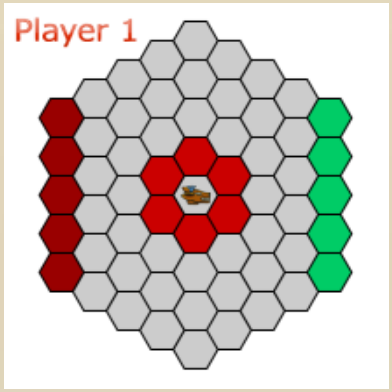


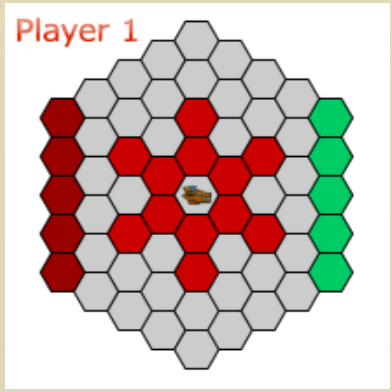


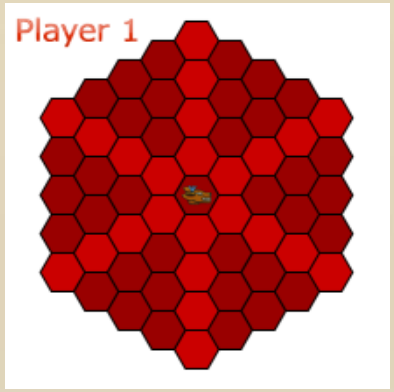

# Game Rules

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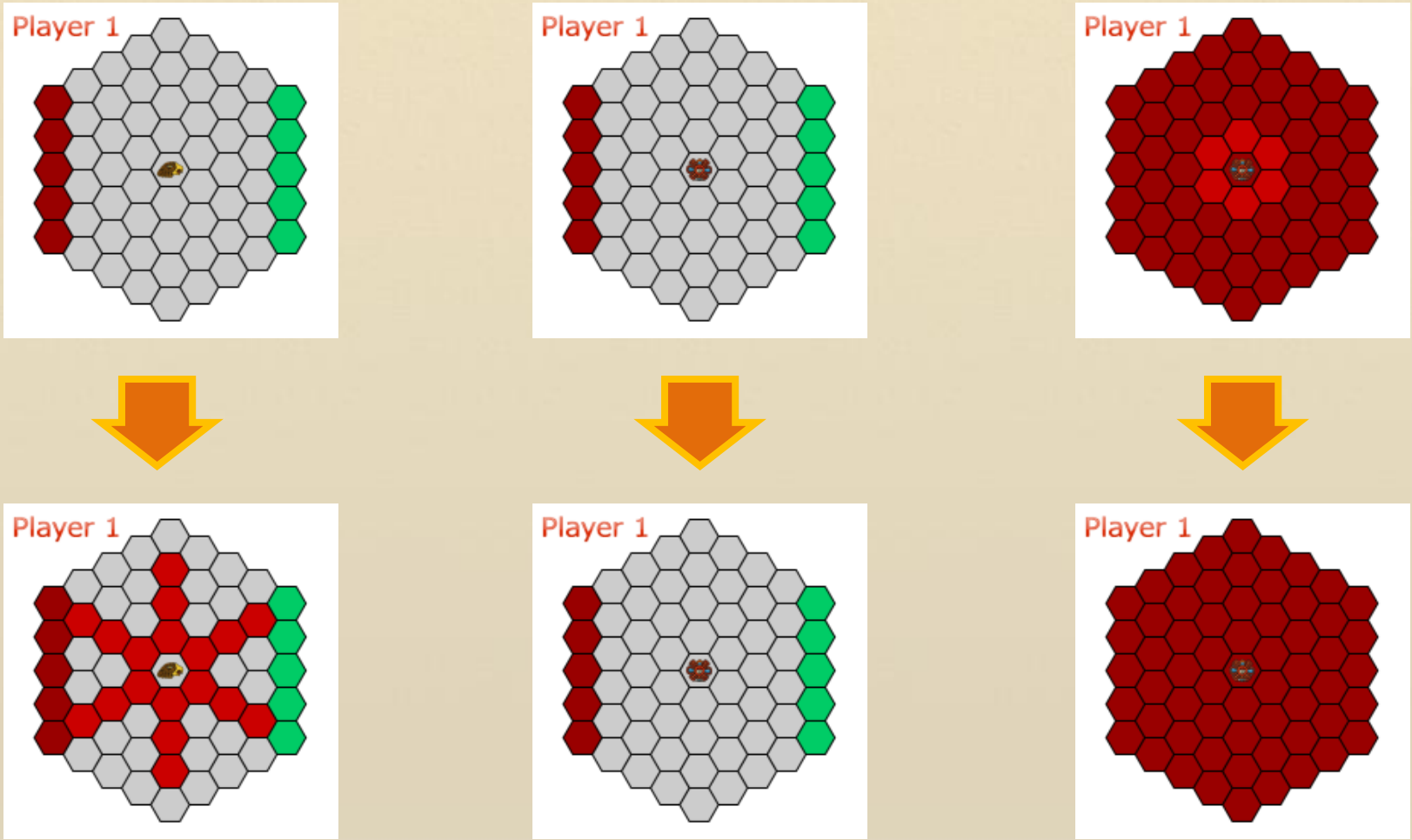

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# Program

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- Implemented in:
  - Adobe Flash CS5.
  - ActionScript 3.
- Benefits:
  - Rapid prototyping.
  - Easy integration of multimedia elements.
  - Platform independent.
  - Playable online.

# Program

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- AI approaches:
  - General Game Playing (GGP).
  - Minimaxing game tree.
- Tree searching:
  - Alpha-beta algorithm (negamax framework, fail-soft approach).
  - Two functions; one for root.
- Static evaluator: considers amount of tiles and proximity of king.

# Program

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- Iterative deepening: start at depth 1 and increase while times allows.
- Dynamic difficulty:
  - Limit amount of computation (depth searched).
  - Policy approach: calculate the probability of player winning, act accordingly.
- Implemented policy:
  - Threshold value on when to help.
  - Counter value to not help too often.

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# Experimental results

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- Search results:
  - Game has a branching factor of 20-30.
  - Program search up to 4 plies.
  - Flash has a 15 s. execution limit.
- Gameplay results:
  - Presented to half a dozen players.
  - Good concept.
  - Too easy to beat.

# Experimental results

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- Actionscript limitations:
  - AS3 has speedups of 10x over AS2.
  - Is still 5-10 times lower than java; 100-500 than C.
- Other people results:
  - flashCHESSIII.
  - Alpha evaluated 1000 nodes per move. Final version +10000 (~4 plies).
  - The Elo rating of the engine at around 1500-1800.

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# Conclusions

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- Many open options of development of AI on board games.
- Not possible to evaluate the implemented policy effectiveness.
- Speed-up opportunities:
  - Refactor and decouple.
  - Profiler based optimizations.
  - Fine-tune evaluation function.

# Conclusions

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- Speed-up opportunities (cont.):
  - Implement other common tree searching techniques:
    - Transposition tables.
    - Null move forward pruning.
    - MTD(f) search or negascout.
    - Opening and closing books.

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# Questions?

(Thank you!)