AI in Games

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Sources

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- http://www.alanturing.net/turing_archive/pages/Reference%20Articles/BriefHistofComp.html
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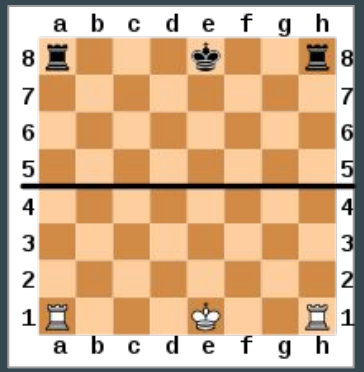
- https://deepmind.com/blog/alphago-zero-learning-scratch/
- https://software.intel.com/en-us/articles/multi-threading-line-of-sight-calculations-to-improve-sensory-system-performance-in-game-ai
- http://www.ign.com/articles/2016/03/29/googles-ai-deepmind-turns-its-gaze-to-hearthstone-and-magic-the-gathering

Overview

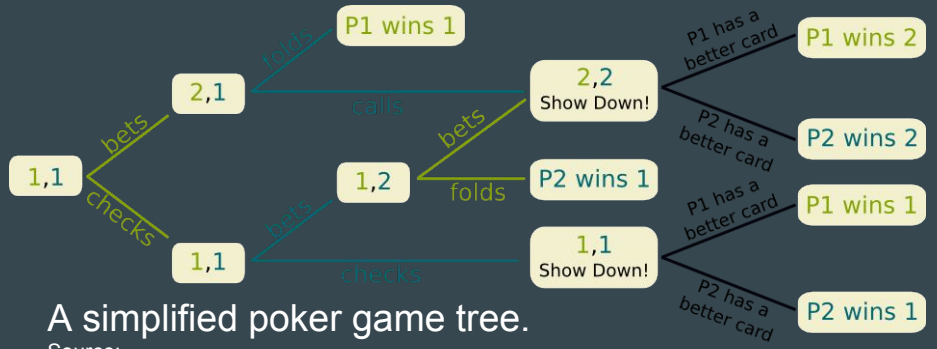
- Context
- A history of AI in Games
- Strategies for AI in Games
- Examples
- Game Development View
- Final remarks

Context

- How is AI used in games?
  - Creating human-like opponents or behaviors
    - Chess
    - Fighting Games
  - Solving Games
    - Complete Information Games (Chess)
    - Incomplete Knowledge Games (Poker)



Source:
https://upload.wikimedia.org/wikipedia/commons/thumb/5/55/ChessCastlingMovie_en.svg/210px-ChessCastlingMovie_en.svg.png

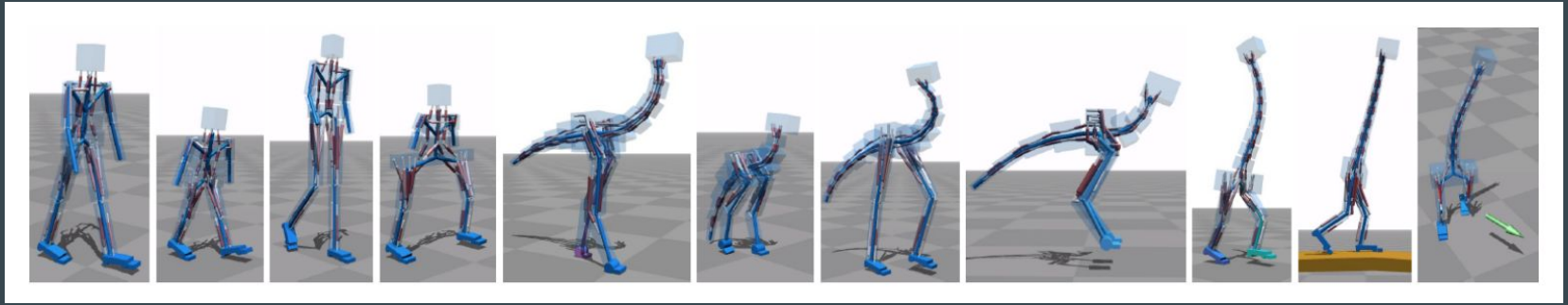


A simplified poker game tree.

Source:
http://www.science4all.org/article/advanced-game-theory-overview/

Context

- How is gamification useful in AI research?
  - Games provide a user-friendly framework for testing AI.
    - Genetic Algorithms
    - Machine Learning



Source: http://www.goatstream.com/research/papers/SA2013/

A history of AI in Games

- Heuristic AI (simple rule following, not genuine intelligence)
  - In 1951, AI was used to beat the game Nim (A math strategy game)
  - In 1972, Pong was released
    - AI played as an opponent
  - More and more advanced Heuristic AIs developed as computing power became more available
    - Almost every video game uses Heuristic AI in some way
- True AI
  - More recently, advanced AI techniques such as ML, RL, NN have been used in Game Dev.
    - Improving motion control (ML)
      - Nintendo Wii (2006), Microsoft Xbox Kinect (2010)
    - Design and Balance of Games (2012) (ML)
  - Solving: Chess (1970s-80s); alphaGo (2015, Go playing AI); Claudico, Libratus(2015, 2017, Poker playing AI) (RL, NN)

Heuristic AI in games

- The simplest version of AI
- Rule following
- A simple Pong AI implementation:

```
private void updatePaddlePosition() {

    int direction = EQUATOR - ball.getY();

    if (direction < 0) {
        paddle.setDirection(Direction.DOWN);
    } else if (direction > 0) {
        paddle.setDirection(Direction.UP);
    } else {
        paddle.stop();
    }
}
```

```
while (gamePlaying) {
    updatePaddlePosition();
```

Source: N/A

AI in fighting games

Like Street Fighters V or KOF

Source:
https://www.polygon.com/street-fighter-5-guide/2017/4/24/14597980/attacks

AI in fighting games

- AI level difficulty – based on the AI's frequency of decision making
  - Easy AI :
    - Less desire to defend or attack
    - Limited Combos
  - Hard AI:
    - Increased desire to move
    - Higher level combo

Fan made AI

- Usually designed using the concept of **counter-measure**

Fan made AI

- Designed with individual characters in mind
- Optimize play of each character
- Create best counters to enemy moves
    - choose moves which have no penalty

EX: When character A jumps, but has no skill that can hit character B in time, character B, using fan-made AI, counters with dragon punch.

- Similar to Deep Blue AI in Chess

Source: Touhou 12.3 東方非想天則　～
超弩級ギニョルの謎を追え Screenshot

Why have AI in fighting games?

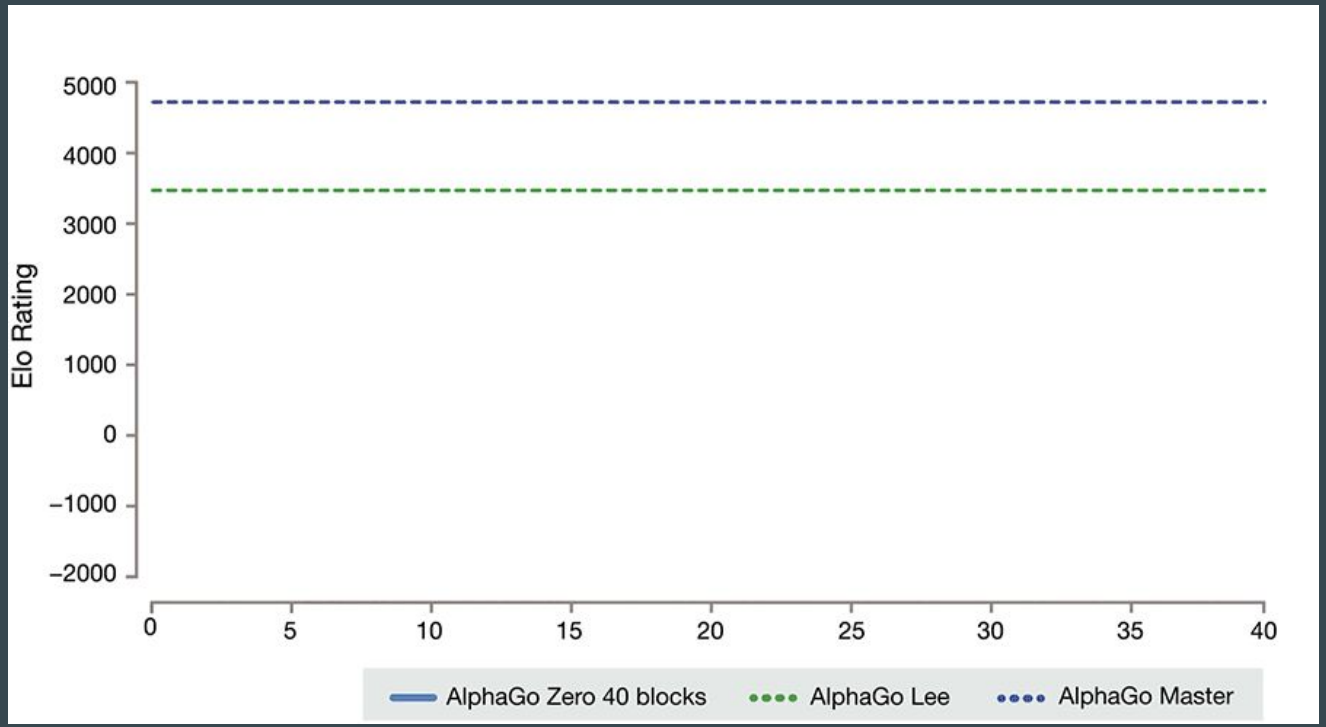
- Default AI: Helps new players to get started
- Fan-made AI: Helps high-level players practice specific counters against different characters
- AI is critical to supporting players in fighting games

AI in collection trading card games

- Used in HearthStone and Magic the Gathering
- Increases enjoyment/difficulty
- Lightweight
- Incomplete implementation

Source: https://edge.alluremedia.com.au/m/k/2016/03/cardgen2.png

Something Else...



Source:https://deepmind.com/blog/alphago-zero-learning-scratch/

AlphaGo Zero

- reinforcement learning
- playing games against itself

Is such advanced AI needed?

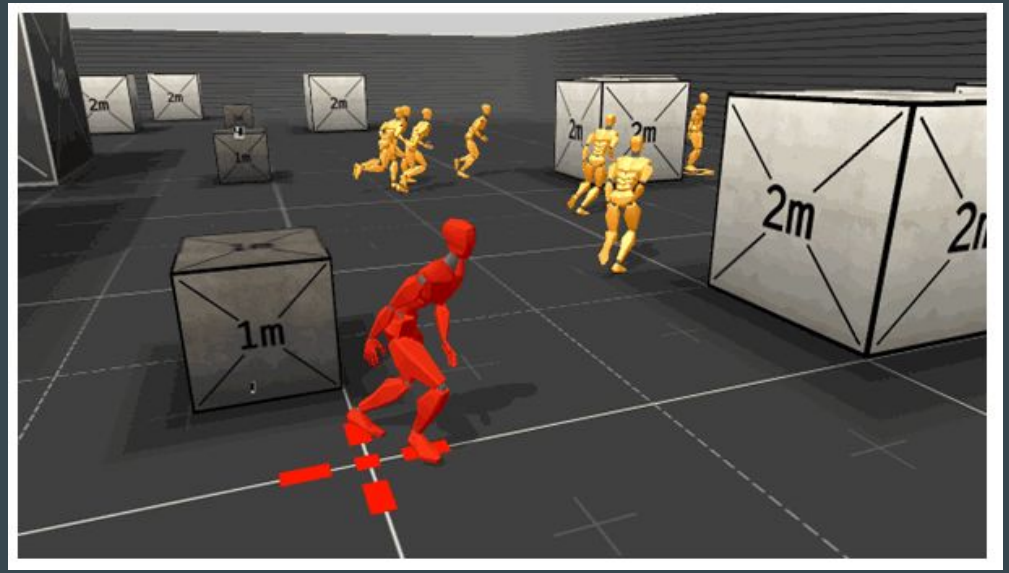
AI in Game Development

Game Design:

- Progressive Gameplay
- Emergent Gameplay

AI Framework:

- FSM (Finite State Machine)
- DT (Decision Tree)
- BT (Behavior Tree)



Source:https://software.intel.com/en-us/articles/multi-threading-line-of-sight-calculations-to-improve-sensory-system-performance-in-game-ai

Decision Tree In Game Development

- No more if/else
- Let's try LINQ!
  - brief and easier to read

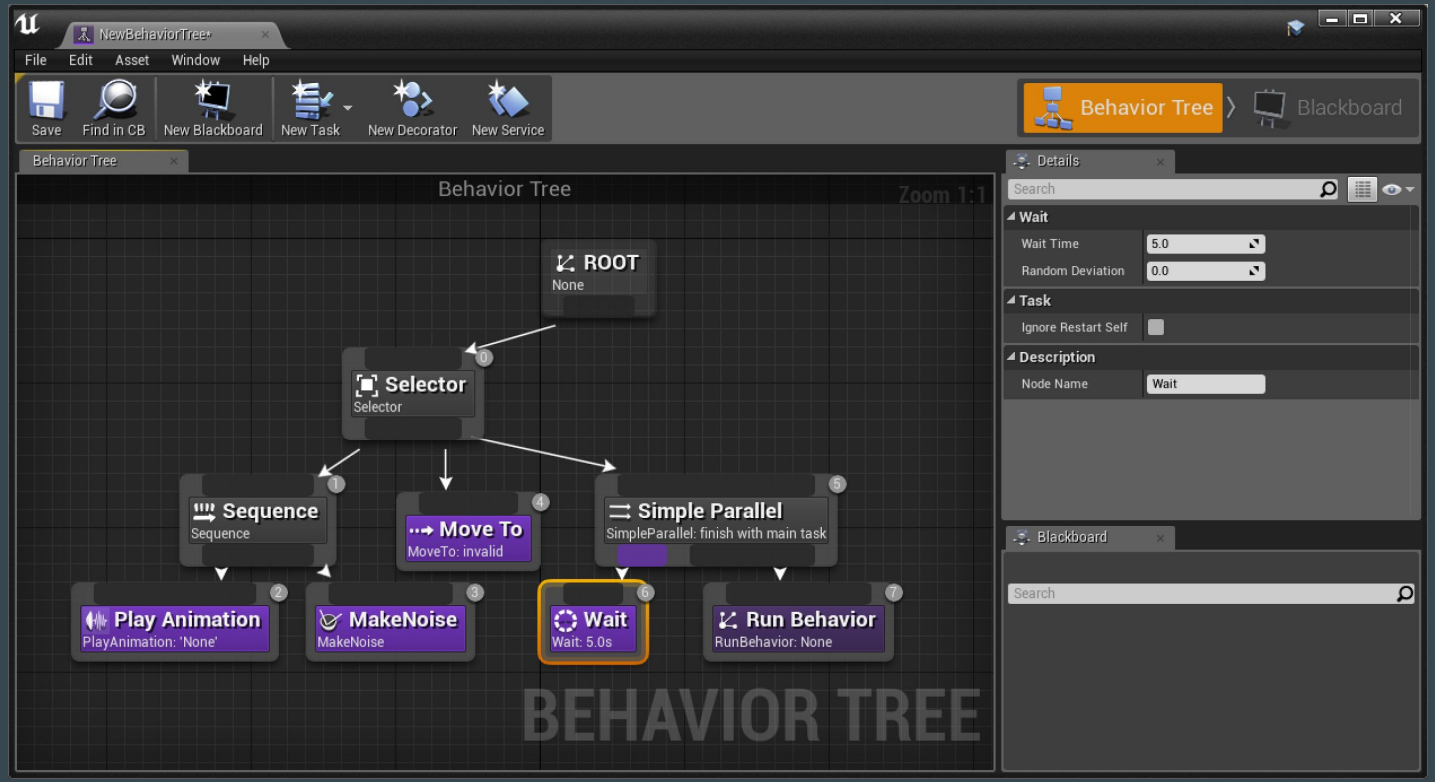
In "Designing Emergent AI"


```
var targets =
    //30% chance to ignore damage enemy can do to them, and just go for highest-value targets
    ( unit.UnitType.AIAlwaysStrikeStrongestAgainst ||
    AILoop.Instance.AIRandom.Next( 0, 100 ) < 30 ?
    from obj in rollup.EnemyUnits
    where ( unit.GuardingObjectNumber <= 0 ||
    //must not be guarding, or guard target must be within certain range of guard post
    Mat.ApproxDistanceBetweenPoints( unit.GuardingObject.LocationCenter,
    obj.LocationCenter ) < Configuration.GUARD_RADIUS )
    orderby obj.UnitType.ShipType == ShipType.Scout ascending,
    //scouts are the lowest priority
        obj.GetHasAttackPenaltyAgainstThis( unit ) ascending,
        //ships that we have penalties against are the last to be hit
        (double)obj.GetAttackPowerAgainstThis( unit, usesSmartTargeting ) / (double)obj.UnitType.MaxHealth de
        //how much damage I can do against the enemy out of its total health
        obj.IsProtectedByForceField ascending,
        //avoid ships that are under force fields
        obj.NearbyMilitaryUnitPower ascending,
        //strength of nearby enemies
        Mat.ApproxDistanceBetweenPoints( obj.LocationCenter, unit.LocationCenter ) ascending,
        //how close am I to the enemy
        obj.UnitType.ShieldRating ascending,
        //how high are their shields
        unit.UnitType.AttackPower ascending,
        //go for the lowest-attack target (economic, probably)
        obj.Health ascending
        //how much health the enemy has left
    select obj
    :
        from obj in rollup.EnemyUnits
        where ( unit.GuardingObjectNumber <= 0 ||
        //must not be guarding, or guard target must be within certain range of guard post
            Mat.ApproxDistanceBetweenPoints( unit.GuardingObject.LocationCenter,
            obj.LocationCenter ) < Configuration.GUARD_RADIUS )
        orderby obj.UnitType.ShipType == ShipType.Scout ascending,
        //scouts are the lowest priority
            ( chooseWeaklyDefendedTarget ?
            obj.UnitType.TripleBasicFirePower >= obj.NearbyMilitaryUnitPower :
            ( chooseStronglyDefendedTarget ?
            obj.UnitType.TripleBasicFirePower < obj.NearbyMilitaryUnitPower : true ) ) descending,
            //lightly defended area
            (double)obj.GetAttackPowerAgainstThis( unit, usesSmartTargeting ) / (double)obj.UnitType.MaxHealt
            //how much damage I can do against the enemy out of its total health
            obj.IsProtectedByForceField ascending,
            //avoid ships that are under force fields
            obj.NearbyMilitaryUnitPower ascending,
            //strength of nearby enemies
            obj.GetHitPercent( unit ) descending,
            //how likely I am to hit the enemy
            unit.GetAttackPowerAgainstThis( obj, false ) descending,
            //how much damage the enemy can do to me
            obj.Health ascending //how much health the enemy has left
        select obj
    );
```

Source:http://arcengames.com/designing-emergent-ai-part-2-queries-and-code/

Behavior Tree In Game Development

- What are BTs?
- How are BTs used?
- Opening UE4...



Source: Unreal Engine 4 Screenshot

Incomplete Information Game Solving AI

- Incomplete information games are games played with incomplete information
  - Rock / Paper / Scissors
  - Poker
- Game theory can be used to find optimal (Nash Equilibrium) solutions
  - Rock / Paper / Scissors : Randomly select each ⅓ of the time
  - Poker : ... extremely complicated
    - Hand selection
    - Check/Call/Fold/Bet/Raise
    - Accounting for position
    - Bet sizing
    - Optimal Value:Bluff ratio
  - Attempts to Solve Poker:
    - Neural Networks, Repetitive Play (Brute force-esque)

Incomplete Information Game Solving AI

- Libratus (2017)
  - First Poker program to outperform professional HUNL specialists
    - Over a sample of 120,000 hands (a reasonable sample size)
    - Win-rate of 14.7 BB / 100 hands (extremely high)
  - Does not have a fixed strategy
    - Procedurally generates a strategy
    - “Learns” the best hands to use as bluffs, value bets
      - Considers “removal effects” (Holding a card makes it impossible for opponent to hold)
      - Follows game theory concepts (Balance, optimal Value:Bluff)
      - Randomization (in hand selection, hand play, bet sizing)
  - Creators are looking for applications in Cybersecurity, business negotiation, and medicine

Closing remarks

- AI is constantly being used to improve the enjoyment in video games
  - Started with simple rule following
  - Now we see Machine Learning being used

Source: https://www.polygon.com/street-fighter-5-guide/2017/4/24/14597980/attacks

Source: Touhou 12.3 Screenshot

Closing remarks

- AI is advancing rapidly
  - 1980s Chess, 2015 Go, 2017 HUNL Poker
  - In more complex incomplete information games, human thinking still holds an edge
  - This edge will continue to shrink as more AI is developed
  - Will AI ever be able to beat any human at *any* strategy game?

Source:
http://www.onlinepokeracademy.com/img/pokerstars_screen5.jpg

Closing remarks

- Games are used to advance AI algorithms
  - Efficient for testing
    - Define clear objectives
  - Applications of gamified AI: cybersecurity, business, medicine

Source:
https://innovatemedtec.com/images/img/digital_health_apps_success.jpg