Adaptive AI

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Outline

- What is it?
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- Dynamic Scripting
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- Simulations
- Conclusion

Acknowledgments

- http://ticc.uvt.nl/~pspronck/pubs/DynamicScripting.pdf
  - Pieter Spronck (Universiteit Maastricht - The Netherlands)

Also.

- http://cs229.stanford.edu/proj2008/RicciardiThill-AdaptiveAIForFightingGames.pdf
- http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.109.6055&rep=rep1&type=pdf

Adaptive AI - What is it?

- Online learning. Game grows and adapts to a human's playstyle.
- Can be applied to any game where:
  - The game AI is scripted
  - Success of actions can be recorded and evaluated
- Adaptive AI in FIFA. Not the same.

The Game - https://github.com/Skyman12/AdaptiveAI

- Strategy fighting game.
- Simplistic yet sophisticated
- Each team gets 4 characters to control.
- Kill other team.

Mage	Warrior	Warlock	Priest
160	300	180	180
75	150	85	75
150	75	125	150
Target	Target	Target	Target

Process Turn

| Mage	Warrior	Warlock	Priest
Fireball / Flame Tunnel / Thunder Strike	Quick Slash / Heavy Slash / Counter	Life Tab / Corruption / Mind Zap	Smite / Heal / Cleanse
Ice Lance / Tidal Wave / Freeze / Meditate	Taunt / Protect / Recharge / Fury	Life Drain / Curse / Confusion / Blood Pact	Savior / Life Tran... / Holy Shi... / Healing ...
160	300	180	180
75	150	85	75
150	75	125	150
Target	Target	Target	Target

Characters

- 6 classes
  - Warrior, Rogue, Mage, Warlock, Bard and Priest
- Each character has:
  - 3 basic attacks
  - 4 abilities
  - Health
  - Shield
  - Energy

Basic Attacks and Abilities

- Basic Attacks and Abilities
  - Use 1 of each per turn.
  - Speed.
    - Determines the order in which the attacks and abilities will hit.
  - Basic Attacks have no energy cost.
  - Abilities have different energy costs.
- Variety of functions
  - Damage
  - Buff
  - Heal
  - Stun
  - Confusion

Top row:

Mage panel:
Used Ice Lance on Priest -- Dealt 105 damage
160
5
70
Target
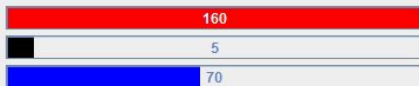
Warrior panel:
Used Protect on Priest
Used Quick Slash on Warrior -- Dealt 15 damage
300
115
55
Target

Warlock panel:
Used Confusion on Warrior -- Confused target
180
85
85
Target
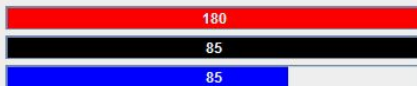
Priest panel:
Used Smite on Warrior -- Dealt 20 damage
180
75
150
Target

Next Attack

Bottom row:

Mage panel:
Used Fireball on Warrior -- Dealt 15 damage
Used Ice Lance on Mage -- Dealt 70 damage
160
75
70
Target
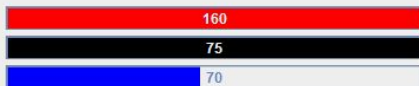
Warrior panel:
Used Protect on Warlock
300
115
55
Target

Warlock panel:
180
85
125
Target
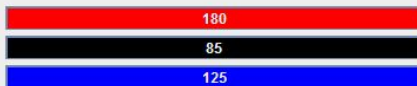
Priest panel:
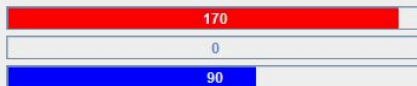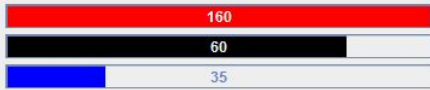Used Smite on Warrior -- Dealt 20 damage
Used Healing Ring on Priest
Used Healing Ring on Warrior
Used Healing Ring on Warrior
Used Healing Ring on Mage
170
0
90
Target

| Used Fireball on Warrior -- Dealt 15 damage | Used Counter on Warrior | | Used Heal on Priest |
| Used Ice Lance on Warrior -- Dealt 105 damage | | | |

160		300		180		174	
60		150		80		24	
35		15		60		150	
Target		Target		Target		Target	
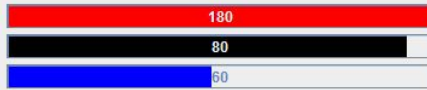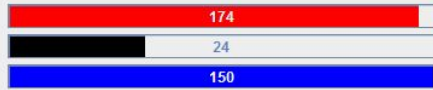
| Mage | Warrior | Warlock | Priest |

Game Over: TEAM1 wins.

| Mage | Warrior | Warlock | Priest |

Pro's of Adaptive AI

- Helps developers.
- Challenges players.
- Fixes "cheats" and "fail proof strategies"

Con's of Adaptive AI

- Can have long learning time.
- Can get "too good".
- Narrow field for application.
- Limited resources and research

Building an Adaptive AI

- Computational Requirements
  - Speed
  - Effectiveness
    - Worried about learning inferior behavior
  - Robustness
    - Deal with randomness
  - Efficiency
- Functional Requirements
  - Clarity
  - Variety
  - Consistency
  - Scalability

Dynamic Scripting

- Online machine-learning technique (Spronck).
- Characters have rulebases associated with them.
  - Each rule has a weight value.
- After each turn, each rule is evaluated on its effectiveness.
  - Success = weight increased.
  - Failure = weight decreased.
  - Total weight is scaled and kept constant.
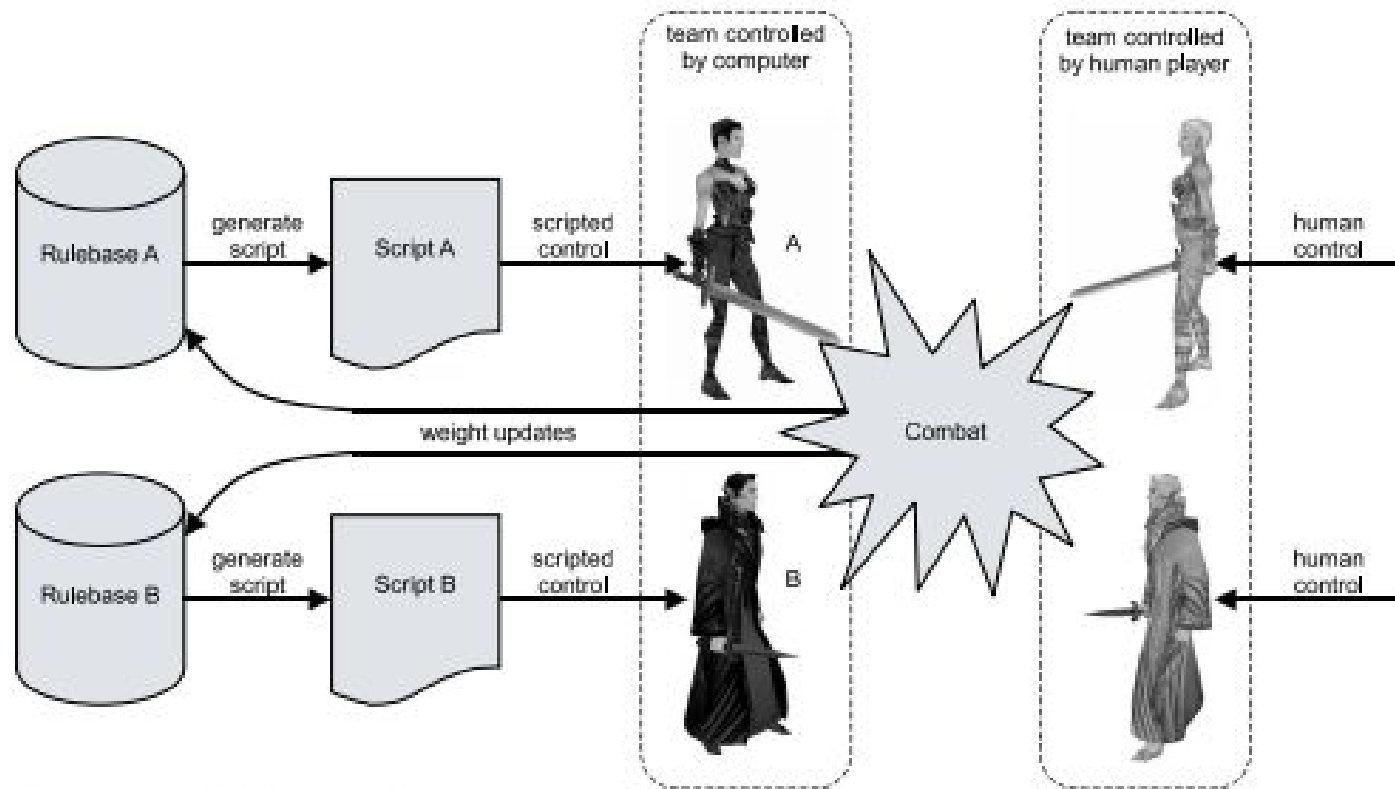
Figure 1. Dynamic scripting.

Static Round Evaluation

- Health + Shield + Energy + Bonus Crit + Turns Cleansed - Turns Stunned - Turns Confused
- Sum all players on each team to get the team score

Round	Team 1 Score	Team 2 Score	Differential
1	2000	2000	-
2	1600	1700	Team 2 +100
3	1500	1500	Team 1 +100
4	800	1200	Team 2 + 400
5	500	700	Team 1 +200
6	0	200	Game Over - Team 2 Wins

Rulebase

- Hard Caps
  - Can I
- Soft Caps
  - Should I

```java
public boolean getHardCap() {
    // Check for energy cap - do they have enough energy
    if (theAttacker.currentEnergy < cost) {
        return false;
    }

    return true;
}

public boolean getSoftCap() {
    return true;
}
```

```java
@Override
public boolean getSoftCap() {
    ArrayList<Class> players = getAliveAllies(theAttacker);
    players.add(theAttacker);
    for (Class p : players) {
        if (p.baseHealth - p.currentHealth > 15) {
            return true;
        }
    }

    return false;
}
```

Weight Updating

- Each rulebase adds up to a constant number.
- Weight increase based on effectiveness of round.
- When the weight of one rule increases, the weight of the other rules in the rulebase decrease.
- Applied after every round.
- Weights represent likelihood of action being performed in the next rounds.

```java
public void processRound() {
    makeAIMoves();
    orderAttacks();

    for (Attacks attack : roundAttacks) {
        attack.executeAttack();
        attack.theTargets.clear();
        checkForGameOver();
        if (gameOver) {
            return;
        }
    }


    assignRoundEvaulation();
    updateDyanmicWeights();
```

Updating Weights cont.

- Each player class has a mapping of their abilities and the weight of those abilities.
- Each ability has different attack parameters.
    - This determines who they are going to target.
- After each round, both abilities and targets are given an adjustment based on the entire round success.
- Each ability is also given an adjustment separate from the round success.
    - This is dependent on how well the individual ability did without respect to the round as a whole.

```java
public class Rogue_Stun extends Attacks {
    public Rogue_Stun(Class attacker) {
        super(attacker);
        attackType = AttackType.ABILITIES;

        attackName = "Stun";
        attackDescription = "Choose an enemy, that enemy is stunned for the remainder of th

        damage = 0;
        speed = 3;
        cost = 50;
        critChance = 0;
        numOfTargets = 1;

        attackParameters.put(AIAttackOptions.PRIEST, 25.0);
        attackParameters.put(AIAttackOptions.BARD, 25.0);
        attackParameters.put(AIAttackOptions.MAGE, 25.0);
        attackParameters.put(AIAttackOptions.RANDOM, 25.0);
    }
}
```

Turning Point

- Represents a point in which the dynamic AI is better than the static AI.
  - Calculated after 10 wins in a row.
- Lower turning points = more realistic for implementation in games.

Simulations

- Dynamic vs Static AI's.
- Simulated 10,000 games, 100 times.
- Took averages to account for outlying simulations.
- Same team complexion (Mage, Bard, Warrior and Warlock)

Static vs Static

- Expected: Should get close to 50% win ratio if the game works correctly.

```
---------Simulation Complete -------------
Average number of Team 1 Wins over 100 simulations: 4974
Average number of Team 2 Wins over 100 simulations: 4976
Average number of Ties over 100 simulations: 48
```

Non Biased Rulebase

- Dynamic AI's are set with balanced weights initially.
  - Each ability has same likelihood of being used.
- Allows to see which abilities rise and which fall.

Simulations - Against Balanced Static AI

```
--------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 2604
Average number of Team 2 Wins over 100 simulations: 7394
Average number of Ties over 100 simulations: 0
---------Turning Point Found------------
Average turning point over 100 simulations: 937
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 683
Average number of Team 2 Wins over 100 simulations: 253
Average number of Ties over 100 simulations: 0
---------After Turning Point-----------------
Average number of Team 1 Wins over 100 simulations: 1920
Average number of Team 2 Wins over 100 simulations: 7141
Average number of Ties over 100 simulations: 0
```

Simulations - Against Aggressive Static AI

```
--------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 2144
Average number of Team 2 Wins over 100 simulations: 7855
Average number of Ties over 100 simulations: 0
---------Turning Point Found-----------
Average turning point over 100 simulations: 1143
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 771
Average number of Team 2 Wins over 100 simulations: 371
Average number of Ties over 100 simulations: 0
---------After Turning Point-----------------
Average number of Team 1 Wins over 100 simulations: 1372
Average number of Team 2 Wins over 100 simulations: 7483
Average number of Ties over 100 simulations: 0
```

Simulations - Against Defensive Static AI

```
--------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 4899
Average number of Team 2 Wins over 100 simulations: 5095
Average number of Ties over 100 simulations: 4
---------Turning Point Found------------
Average turning point over 100 simulations: 939
---------Before Turning Point --------------
Average number of Team 1 Wins over 100 simulations: 781
Average number of Team 2 Wins over 100 simulations: 357
Average number of Ties over 100 simulations: 0
---------After Turning Point----------------
Average number of Team 1 Wins over 100 simulations: 4118
Average number of Team 2 Wins over 100 simulations: 4737
Average number of Ties over 100 simulations: 4
```

Simulations - Against CC Static AI

```
---------Simulation Complete -------------
Average number of Team 1 Wins over 100 simulations: 3984
Average number of Team 2 Wins over 100 simulations: 6014
Average number of Ties over 100 simulations: 0
---------Turning Point Found-------------
Average turning point over 100 simulations: 617
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 562
Average number of Team 2 Wins over 100 simulations: 254
Average number of Ties over 100 simulations: 0
---------After Turning Point-----------------
Average number of Team 1 Wins over 100 simulations: 3421
Average number of Team 2 Wins over 100 simulations: 5760
Average number of Ties over 100 simulations: 0
```

Results - Non Biased Rulebase

Team Type	Turning Point	Overall Win Percentage	Before Turning Point	After Turning Point
Balanced	937	73%	27%	78%
Aggressive	1143	78%	32%	84%
Defensive	939	51%	31%	53%
CC	617	60%	31%	62%

Using Biased Rulebase

- Seeded with Defensive template

Simulations - Against Balanced Static AI

```
---------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 3674
Average number of Team 2 Wins over 100 simulations: 6323
Average number of Ties over 100 simulations: 2
---------Turning Point Found------------
Average turning point over 100 simulations: 586
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 377
Average number of Team 2 Wins over 100 simulations: 208
Average number of Ties over 100 simulations: 0
---------After Turning Point------------------
Average number of Team 1 Wins over 100 simulations: 3296
Average number of Team 2 Wins over 100 simulations: 6114
Average number of Ties over 100 simulations: 2
```

Simulations - Against Aggressive Static AI

```
--------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 2891
Average number of Team 2 Wins over 100 simulations: 7104
Average number of Ties over 100 simulations: 4
---------Turning Point Found------------
Average turning point over 100 simulations: 353
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 225
Average number of Team 2 Wins over 100 simulations: 127
Average number of Ties over 100 simulations: 0
---------After Turning Point-----------------
Average number of Team 1 Wins over 100 simulations: 2666
Average number of Team 2 Wins over 100 simulations: 6976
Average number of Ties over 100 simulations: 4
```

Simulations - Against Defensive Static AI

```
---------Simulation Complete -------------
Average number of Team 1 Wins over 100 simulations: 4594
Average number of Team 2 Wins over 100 simulations: 5401
Average number of Ties over 100 simulations: 4
---------Turning Point Found------------
Average turning point over 100 simulations: 337
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 245
Average number of Team 2 Wins over 100 simulations: 91
Average number of Ties over 100 simulations: 0
---------After Turning Point------------------
Average number of Team 1 Wins over 100 simulations: 4348
Average number of Team 2 Wins over 100 simulations: 5310
Average number of Ties over 100 simulations: 4
```

Simulations - Against CC Static AI

```
Average number of Team 1 Wins over 100 simulations: 3477
Average number of Team 2 Wins over 100 simulations: 6521
Average number of Ties over 100 simulations: 1
-----------Turning Point Found-------------
Average turning point over 100 simulations: 357
----------Before Turning Point ----------------|
Average number of Team 1 Wins over 100 simulations: 244
Average number of Team 2 Wins over 100 simulations: 112
Average number of Ties over 100 simulations: 0
----------After Turning Point-------------------
Average number of Team 1 Wins over 100 simulations: 3232
Average number of Team 2 Wins over 100 simulations: 6408
Average number of Ties over 100 simulations: 1
```

Results - Biased Rulebase (Seeded with Defensive)

Team Type	Turning Point	Overall Win Percentage	Before Turning Point	After Turning Point
Balanced	586	63%	35%	65%
Aggressive	353	71%	36%	72%
Defensive	337	54%	27%	67%
CC	357	65%	31%	66%

Comparison of Biased vs. Unbiased Rulebases

Team Type	Turning Point	Overall Win Percentage	Before Turning Point	After Turning Point
Balanced	**586 --** *937*	**63% --** *73%*	**35% --** 27%	**65% --** 78%
Aggressive	**353 --** *1143*	**71% --** *78%*	**36% --** *32%*	**72% --** *84%*
Defensive	**337 --** 939	**54% --** 51%	**27% --** 31%	**67% --** 53%
CC	**357 --** *617*	**65% --** *60%*	**31% --** *31%*	**66% --** *61%*

Conclusions of Rulebases

- Biased rulebases drastically reduce the turning point.
- Why does the winning percentage decrease?
  - Biased rulebases means that some less inferior rules are going to rise because of initial weights.
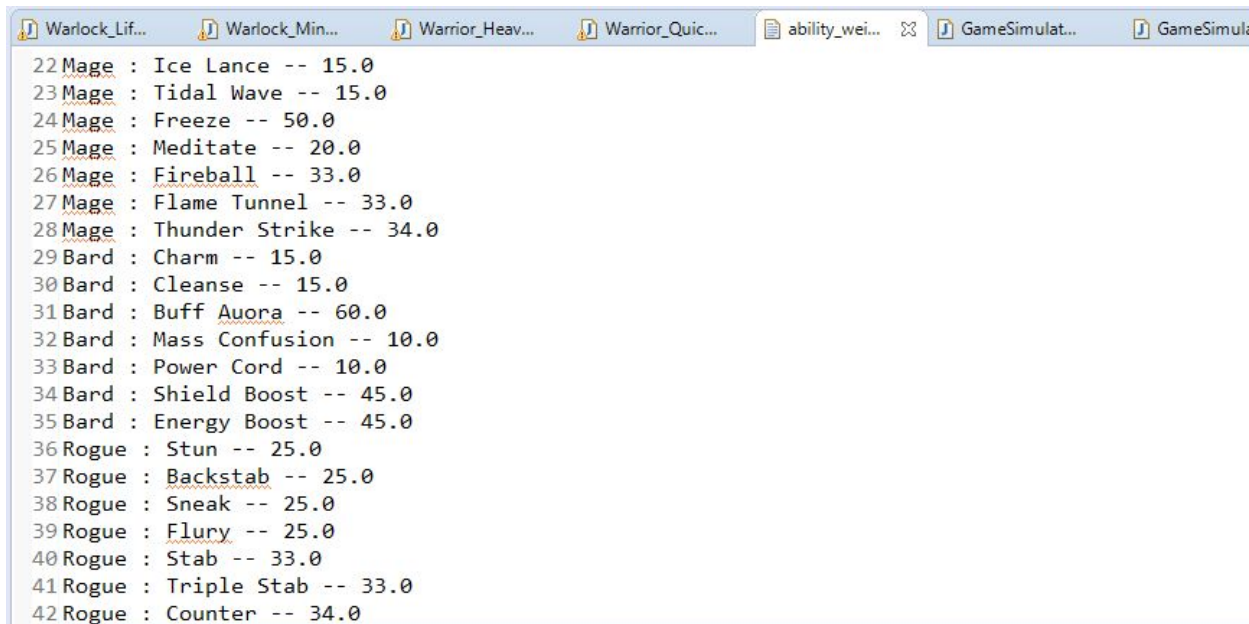- Hard to create evaluation criteria to accurately weigh the actions of each ability.

Mutating Static AI Play Styles

- More realistic to how a human would play.
- Test the viability of Adaptive AI in games.

```
--------Simulation Complete ------------
Average number of Team 1 Wins over 100 simulations: 3250
Average number of Team 2 Wins over 100 simulations: 6746
Average number of Ties over 100 simulations: 2
---------Turning Point Found------------
Average turning point over 100 simulations: 466
---------Before Turning Point ---------------
Average number of Team 1 Wins over 100 simulations: 342
Average number of Team 2 Wins over 100 simulations: 123
Average number of Ties over 100 simulations: 0
---------After Turning Point----------------
Average number of Team 1 Wins over 100 simulations: 2908
Average number of Team 2 Wins over 100 simulations: 6622
Average number of Ties over 100 simulations: 2
```

For use against Player

- Weights are written to a text file.
- This can be read from and changed after each round.


```
   Warlock_Lif...   Warlock_Min...   Warrior_Heav...   Warrior_Quic...   ability_wei...  ⅹ   GameSimulat...   GameSimula
22 Mage  : Ice Lance -- 15.0
23 Mage  : Tidal Wave -- 15.0
24 Mage  : Freeze -- 50.0
25 Mage  : Meditate -- 20.0
26 Mage  : Fireball -- 33.0
27 Mage  : Flame Tunnel -- 33.0
28 Mage  : Thunder Strike -- 34.0
29 Bard  : Charm -- 15.0
30 Bard  : Cleanse -- 15.0
31 Bard  : Buff Auora -- 60.0
32 Bard  : Mass Confusion -- 10.0
33 Bard  : Power Cord -- 10.0
34 Bard  : Shield Boost -- 45.0
35 Bard  : Energy Boost -- 45.0
36 Rogue : Stun -- 25.0
37 Rogue : Backstab -- 25.0
38 Rogue : Sneak -- 25.0
39 Rogue : Flury -- 25.0
40 Rogue : Stab -- 33.0
41 Rogue : Triple Stab -- 33.0
42 Rogue : Counter -- 34.0
```

Conclusions

- Neat concept.
- Long learning time (408 rounds with biased rulebase).
- Overpowered abilities rise to the top too fast.
  - Need a truly balanced game.
  - Great for testing the balance of the abilities in a game.

Questions?