CE810 - Game Design 2

Artificial Intelligence

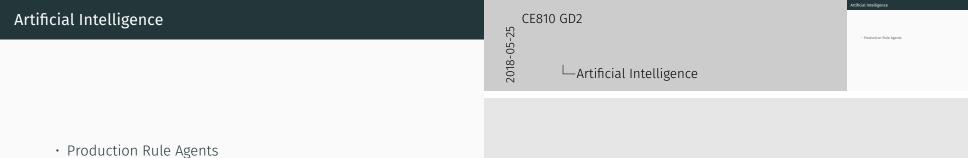
Joseph Walton-Rivers & Piers Williams Monday, 21 May 2018

University of Essex

CE810 GD2

CE810 - Game Design 2 Artificial Intelligence

Joseph Walton-Rivers & Piers Williams Monday, 21 May 2018 University of Essex





Artificial Intelligence

 Production Rule Agents · Monte-Carlo Tree Search

CE810 GD2

2018-05-25

└─Artificial Intelligence

- Production Rule Agents · Monte-Carlo Tree Search

2018-05-25

CE810 GD2

Monte-Carlo Tree Search
 Genetic Algorithms

Artificial Intelligence

- Production Rule Agents

- · Production Rule Agents
- Monte-Carlo Tree Search
- Genetic Algorithms

Artificial Intelligence

- · Production Rule Agents
- · Monte-Carlo Tree Search
- · Genetic Algorithms
- Neural Networks

2018-05-25

Artificial Intelligence

CE810 GD2

Production Rule Agents
 Monte-Carlo Tree Search
 Genetic Algorithms
 Neural Networks

Artificial Intelligence

eural Networks

CE810 GD2

Production Rule Agents

Basic

@FunctionalInterface public interface Rule {

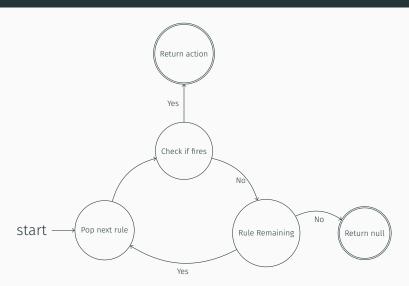
Action execute(int playerID, GameState state);

```
CE810 GD2
2018-05-25
     -Production Rule Agents
          ∟Basic
```

public interface Rule (boolean couldFire(int playerID, GameState state): Action execute(int playerID, GameState state):

```
boolean couldFire(int playerID, GameState state);
```

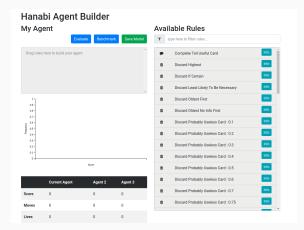
Diagram







Hanabi



Exercise

Try it out!

CE810 GD2
Production Rule Agents
Hanabi



Do live demo - First Agent

- 1. Play If Certain
- 2. Tell Randomly
- 3. Discard Randomly

Second Agent

- 1. Play Probably Safe Card: 0.8
- 2. Tell Randomly
- 3. Discard Randomly

5

Place Discard at ton of order and run. Order of rules important

Basic-TBS

```
public interface ProductionRule {
Map<UUID, Order> perform(
int playerId,
GameState state,
List<UUID> entities
```

```
CE810 GD2

Production Rule Agents

Basic-TBS
```

• Rules now apply to **0** or more Entities

CE810 GD2

└─Production Rule Agents

└─Basic-TBS

2018-05-25

· Rules now apply to 0 or more Entities



• Rules now apply to **0** or more Entities

• Remaining entities considered by lower rules

- 2018-05-25

CE810 GD2

-Production Rule Agents

└─Basic-TBS

· Rules now apply to 0 or more Entities Remaining entities considered by lower rules







Production Rule Agents

Basic-TBS

Rules now apply to 0 or more Entities
 Remaining entities considered by lower rules
 Orders generated by rules are executed by the rule

CE810 GD2

- Rules now apply to **0** or more Entities
- Remaining entities considered by lower rules
- · Orders generated by rules are **executed** by the rule

- Rules now apply to **0** or more Entities
- Remaining entities considered by lower rules
- · Orders generated by rules are **executed** by the rule
 - Simulating their effects for other rules

Basic-TBS

- Rules now apply to 0 or more Entities
- · Remaining entities considered by lower rules
- · Orders generated by rules are **executed** by the rule
 - Simulating their effects for other rules
 - · Allows **lower** rules to make **informed** decisions

CE810 GD2

Production Rule Agents

Basic-TBS

Rules now apply to 0 or more Entities

Remaining entities considered by lower rules

Orders generated by rules are executed by the rule

- Simulating their effects for other rules

- Allows lower rules to make informed decisions

CE810 GD2 CE810 GD2 Production Rule Agents Basic-TBS

Rules now apply to 0 or more Entities
Remaining entities considered by lower rules
Orders generated by rules are executed by the rule
Simulating their effects for other rules
Allows lower rules to make informed decisions
Is why now-determinism is III-advised.

- Rules now apply to **0** or more Entities
- Remaining entities considered by lower rules
- · Orders generated by rules are **executed** by the rule
 - Simulating their effects for other rules
 - · Allows **lower** rules to make **informed** decisions
 - Is why **non-determinism** is ill-advised



Many rules are provided



 Many rules are provided Some complications:

- 2018-05-25

CE810 GD2

—Production Rule Agents

└─Built-Ins

· Many rules are provided - Some complications:

2018-05-25 -Production Rule Agents

CE810 GD2

└─Built-Ins

· Many rules are provided · Some complications: · Rules deal with EntityTypes and Actions

- Many rules are provided
- Some complications:
 - Rules deal with **EntityTypes** and **Actions**

- Many rules are provided
- Some complications:
 - Rules deal with **EntityTypes** and **Actions**
 - · When I write the rules, you haven't written them yet

- CE810 GD2
- 2018-05-25 -Production Rule Agents

- Many rules are provided
- · Rules deal with EntityTypes and Actions · When I write the rules, you haven't written them yet

└─Built-Ins

- · Many rules are provided
- Some complications:
 - Rules deal with EntityTypes and Actions
 - When I write the rules, you haven't written them yet
 - Luckily they are **dynamically** built at **runtime**

CE810 GD2 └─Production

2018-05-25

-Production Rule Agents

└─Built-Ins

Many rules are provided
 Some complications:
 Rules deal with EntityTunes

Rules deal with EntityTypes and Actions
 When I write the rules, you haven't written them yet
 Luckity they are dynamically built at runtime

- Some complications:

Many rules are provided

- Rules deal with EntityTypes and Actions
- · When I write the rules, you haven't written them yet
- Luckily they are **dynamically** built at **runtime**
- I suppose we should list the included rules

Many rules are provided
 Some complications:
 Nules deal with EntityTypes and Actions
 When I write the rules, you haven't written them yet
 Luckily they are dynamically built at runtime

When I write the rules,
 Luckily they are dynam
I suppose we should list to

- Many rules are provided
- · Some complications:
 - Rules deal with EntityTypes and Actions
 - · When I write the rules, you haven't written them yet
 - Luckily they are **dynamically** built at **runtime**
- I suppose we should list the included rules
- · And how to use them

AttackMeleeRule AttackRangedClosestRule
AttackRangedMostDamagedRule

Module NoopProductionRule
RandomRule Filter
RunAwayRule
RunTowardsRule RunTowardsResource
UseActionOnEntity UseActionOnResource

Some rules are similar - Will cover them together





Two main types

ProductionRule

2018-05-25 -Production Rule Agents └─Rule Types

CE810 GD2

Not all rules can be done this way - What about EnsureEntity?

- Two main types

- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule

Not all rules can be done this way - What about EnsureEntity?

└─Rule Types

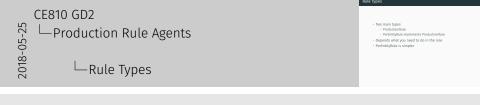
- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule
- · Depends what you need to do in the rule

CE810 GD2

Not all rules can be done this way - What about EnsureEntity?

· PerEntityRule implements ProductionRule

- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule
- · Depends what you need to do in the rule
- PerEntityRule is simpler



- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule
- · Depends what you need to do in the rule
- PerEntityRule is simpler
 - Executes the orders automatically



on main types

- Productionfluib

- Productionfluib

- Performing maintenance Productionfluib

perpende what you need to do in the nule

rificility fluid is simpler

- Executes the orders automatically

- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule
- · Depends what you need to do in the rule
- PerEntityRule is simpler
 - Executes the orders automatically
 - What a **single** Entity does



- Two main types
 - ProductionRule
 - PerEntityRule implements ProductionRule
- · Depends what you need to do in the rule
- PerEntityRule is simpler
 - Executes the orders automatically
 - What a **single** Entity does
 - · Removes Entity from consideration for you

CE810 GD2

Production Rule Agents

- Two man types
- Production Rule Agents
- Production are to do in the rule
- Performance agents do in the rule
- Performance agents and the first production are already and the rule
- Performance are already and the



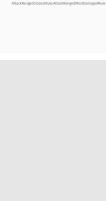
PerEntityRule

AttackMeleeRule,

Attack Ranged Closest Rule, Attack Ranged Most Damaged Rule

2018-05-25 -Production Rule Agents -Attack Rules

CE810 GD2





CE810 GD2

AttackRangedClosestRule,AttackRangedMostDamagedRule · Melee rule will also move unit towards target

- PerEntityRule
- AttackMeleeRule,
- Attack Ranged Closest Rule, Attack Ranged Most Damaged Rule· Melee rule will also **move** unit towards target

- CE810 GD2 └─Production Rule Agents
- PerEntityBulco
 AttackRangs
 - AttackRangedClosestRule,AttackRangedMostDamagedRule
 Melee rule will also move unit towards target
 Be careful:

PerEntityRule

• Be careful:

- AttackMeleeRule, AttackRangedClosestRule,AttackRangedMostDamagedRule
- · Melee rule will also **move** unit towards target

2018-05-25

-Attack Rules

Attack Rules

- PerEntityRule
- AttackMeleeRule,
 AttackRangedClosestRule,AttackRangedMostDamagedRule
- · Melee rule will also **move** unit towards target
- Be careful:
 - Carerut. • These rules do **not** check

CE810 GD2

AttackMeleeRule,
 AttackRangedClosestRule,AttackRangedMostDamagedRule
 Melee rule will also move unit towards target
 Be careful:

Be careful:
 These rules do not check

Attack Rules

- PerEntityRule
- AttackMeleeRule,
 AttackRangedClosestRule,AttackRangedMostDamagedRule
- Melee rule will also **move** unit towards target
- · Be careful:

 - These rules do not checkThey can issue an invalid order

CE810 GD2

- Production Rule Agents

- Production Rule Agents

- Production Rule Agents

- Attack Rules

- Attack Rules

- Attack Rules

Example

EnsureEntity[blue_town:blue_civilian:3]

· Producer, Product, Quantity

2018-05-25 ☐ EnsureEntity

-Production Rule Agents

CE810 GD2

EnsureEntity[blue town:blue civilian:3]

· Producer, Product, Quantity

Example

EnsureEntity[blue_town:blue_civilian:3]

- · Producer, Product, Quantity
- · Simple:

CE810 GD2

-Production Rule Agents

☐ EnsureEntity

2018-05-25

EnsureEntity[blue town:blue civilian:3]

· Producer, Product, Quantity

12

Example

EnsureEntity[blue_town:blue_civilian:3]

- · Producer, Product, Quantity
- · Simple:
 - Counts how many Product we have

☐Production Rule Agents
☐EnsureEntity

CE810 GD2

2018-05-25

EnsureEntity[blue_townblue_civilianc3]

Producer, Product, Quantity

Simple:

Counts how many Product we have

12

Example

EnsureEntity[blue_town:blue_civilian:3]

- Producer, Product, Quantity
- · Simple:
 - Counts how many Product we have
 - Finds Producer for each missing Product

2018-05-25 -Production Rule Agents

☐ EnsureEntity

CE810 GD2

EnsureEntity[blue town:blue civilian:3]

· Counts how many Product we have · Finds Producer for each missing Product

Example

EnsureEntity[blue town:blue civilian:3]

- Producer, Product, Quantity
- · Simple:
 - · Counts how many Product we have
 - Finds Producer for each missing Product
 - · Issues order for Producer to build Product

CE810 GD2 2018-05-25 -Production Rule Agents

· Producer Product Quantity · Counts how many Product we have · Finds Producer for each missing Product · Issues order for Producer to build Product

EnsureEntity[blue town:blue civilian:3]

☐ EnsureEntity

Example

EnsureEntity[blue_town:blue_civilian:3]

- · Producer, Product, Quantity
- · Simple:
 - · Counts how many Product we have
 - Finds Producer for each missing Product
 - · Issues order for Producer to build Product
- · Supports abstract types:

CE810 GD2

— Production Rule Agents

- Outst bearing Product Journal to Support Suppor

2018-05-25

Example

EnsureEntity[blue_town:blue_civilian:3]

- · Producer, Product, Quantity
- · Simple:
 - · Counts how many Product we have
 - Finds Producer for each missing Product
 - Issues order for Producer to build Product
- Supports abstract types:
- EnsureEntity[abstract civilian:abstract town:1]

2018-05-25

Example

EnsureEntity[blue_town:blue_civilian:3]

- · Producer, Product, Quantity
- · Simple:
 - · Counts how many Product we have
 - Finds Producer for each missing Product
 - Issues order for Producer to build Product
- Supports abstract types:
- EnsureEntity[abstract civilian:abstract town:1]
- Uses BuildOrder.





Example RunTowards[0.0]

RunAway[0.5] RunTowardsResource[gold]

Causes Entity to travel

13

└─Run Rules



2018-05-25 -Production Rule Agents └─Run Rules

CE810 GD2

· To or from somethin

RunTowards[0.0] RunAway[0.5]

Example

- RunTowards[0.0] RunAway[0.5]
- RunTowardsResource[gold]
 - Causes Entity to travel • To or from something

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

• Causes Entity to use an Action on either:

└─Use Rules

CE810 GD2

14

2018-05-25 -Production Rule Agents

2018-05-25 -Production Rule Agents

CE810 GD2

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- Causes Entity to use an Action on either:
 - Another Entity

└─Use Rules

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- Causes Entity to use an Action on either:
 - Another Entity
 - A resource

2018-05-25 -Production Rule Agents └─Use Rules

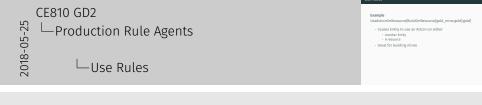
CE810 GD2

· Causes Entity to use an Action on either:

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- · Causes Entity to use an Action on either:
 - Another Entity
 - · A resource
- · Great for building mines



Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- · Causes Entity to use an Action on either:
 - Another Entity
 - · A resource
- Great for building mines
- Great for supporting custom actions.

CE810 GD2

Production Rule Agents

- cause first to use an Action on ather:
- cause first to use an Action on ather:
- cause first building mines
- deat for building mines.

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- · Causes Entity to use an Action on either:
 - Another Entity
 - · A resource
- Great for building mines
- · Great for supporting custom actions.
- · Attack actions could have been written with this

CE810 GD2

Production Rule Agents

Use Rules

Example

UseActionOnResource[BuildOnResource[gold_mine:gold]:gold]

- · Causes Entity to use an Action on either:
 - Another Entity
 - · A resource
- Great for building mines
- · Great for supporting custom actions.
- · Attack actions could have been written with this
- But they predate this

CE810 GD2

Production Rule Agents

Use Rules

CE810 GD2

Use Rules



Example

PerEntityRule

Filter[AttackMelee:abstract_knight]

CE810 GD2

-Production Rule Agents

└─Filter Rules

2018-05-25

Filter[AttackMelee:abstract_knight]

- PerEntityRule



2018-05-25

Filter Rules

-Production Rule Agents

Filter[AttackMelee:abstract_knight]

· PerEntityRule usually consults every Entity

CE810 GD2

- Example
- Filter[AttackMelee:abstract_knight]
 - PerEntityRule
 - PerEntityRule usually consults **every** Entity

2018-05-25

-Production Rule Agents

Filter[AttackMelee:abstract_knight] PerEntityRule usually consults every Entity · This doesn't usually make sense

Example

Filter[AttackMelee:abstract_knight]

- PerEntityRule
- PerEntityRule usually consults **every** Entity
- · This doesn't usually make sense

Filter Rules

CE810 GD2

15

Example

Filter[AttackMelee:abstract knight]

- PerEntityRule
- PerEntityRule usually consults **every** Entity
- This doesn't usually make sense
- Rather than write **conditions** on other rules

CE810 GD2 -Production Rule Agents

Filter[AttackMelee:abstract_knight] PerEntityRule PerEntityRule usually consults every Entity

This doesn't usually make sense - Rather than write conditions on other rules

Filter Rules

2018-05-25

Example

Filter[AttackMelee:abstract knight]

- PerEntityRule
- PerEntityRule usually consults every Entity
- This doesn't **usually** make sense
- Rather than write **conditions** on other rules
- Wrap rules with this condition

CE810 GD2 └─Producti

2018-05-25

-Production Rule Agents

PerEntityRule usually consults every Entity
 This doesn't usually make sense
 Rather than write conditions on other rules
 Was sules with this conditions

Filter[AttackMelee:abstract_knight]

- PerEntityRule

└─Filter Rules

15

CE810 GD2

-Production Rule Agents

Filter[AttackMelee:abstract_knight] - PerEntityRule PerEntityRule usually consults every Entity This doesn't usually make sense

Rather than write conditions on other rules

Example

Filter[AttackMelee:abstract knight]

- PerEntityRule
- PerEntityRule usually consults **every** Entity
- This doesn't usually make sense
- Rather than write **conditions** on other rules
- Wrap rules with this condition
- Takes 1 or more type as an array

2018-05-25 Filter Rules

• These are largely designed for civ style games

2018-05-25

16

CE810 GD2

-Production Rule Agents └─Custom Rules

· These are largely designed for civ style games

• These are largely designed for civ style games

· Great news if you have made one

16

2018-05-25

CE810 GD2

-Production Rule Agents

· Great news if you have made one

CE810 GD2

-Production Rule Agents

- Great news if you have made one - Less than great news if your game is radically different

2018-05-25

└─Custom Rules

- These are largely designed for civ style games
- · Great news if you have made one
- Less than great news if your game is radically different

CE810 GD2

—Production Rule Agents

└─Custom Rules

These are largely designed for civ style games
 Great news if you have made one

Less than great news if your game is radically different
 You'll need to provide new rules

- These are largely designed for civ style games
- · Great news if you have made one
- · Less than great news if your game is radically different
- · You'll need to **provide** new rules

2018-05-25

16

- These are largely designed for civ style games
- · Great news if you have made one
- Less than great news if your game is radically different
- · You'll need to **provide** new rules
 - · Same way you did for Actions

CE810 GD2

2018-05-25

-Production Rule Agents

-Custom Rules

You'll need to provide new rules · Same way you did for Actions

These are largely designed for civ style games

Great news if you have made one Less than great news if your game is radically different

- These are largely designed for civ style games
- · Great news if you have made one
- · Less than great news if your game is radically different
- You'll need to **provide** new rules
 - Same way you did for Actions
 - Dynamically scanned at runtime

CE810 GD2

2018-05-25

—Production Rule Agents

—Custom Rules

These are largely designed for civ style games
 Great news if you have made one

Less than great news if your game is radically different
 You'll need to provide new rules

Same way you did for Actions
 Dynamically scanned at runtime

"RangedRush": "PRA[EnsureBase,EnsureWorker,EnsureArchery,BuildGoldMine,BuildWoodMine,EnsureEntity[ab-

stract_civilian:farm:3],TravelToGold,TravelToWood,EnsureArcher,ArcherAttack,ArcherChase,WorkerEvade]",

└─Production Rule Agents

Production Rule Agents



2018-05-25

-Production Rule Agents Production Rule Agents

CE810 GD2

- That was a lot in one line

That was a lot in one line

Production Rule Agents

2018-05-25

CE810 GD2

−Production Rule Agents

└─Production Rule Agents

- That was a lot in one line - Sorry, but that is how it is

• That was a lot in one line

· Sorry, but that is how it is

Production Rule Agents

- · That was a lot in one line
- · Sorry, but that is how it is
- · These do tend to be quite in-flexible.

CE810 GD2 2018-05-25 -Production Rule Agents

└─Production Rule Agents

That was a lot in one line Sorry, but that is how it is

Production Rule Agents

Production Rule Agents

- That was a lot in one line
- · Sorry, but that is how it is
- These do tend to be quite in-flexible.
- More on that later



2018-05-25

└─Production Rule Agents

Production Rule Agents

That was a lot in one line
 Seems but that is how it is:

Production Rule Agents

Sorry, but that is how it is
 These do tend to be quite in-flexible
 More on that later

• Powerful algorithms for variety of uses

2018-05-25

CE810 GD2

—Genetic Algorithms └─Genetic Algorithms

· Powerful algorithms for variety of uses

CE810 GD2 2018-05-25 —Genetic Algorithms

└─Genetic Algorithms

- Powerful algorithms for variety of uses · Can even play games

Genetic Algorithms

- Powerful algorithms for variety of uses
- · Can even **play** games

2018-05-25

CE810 GD2

Genetic Algorithms

rithms

Genetic Algorithms

Powerful algorithms for variety of uses
 Can even play games
 Apologies to those that have encountered GA's

Genetic Algorithms

• Powerful algorithms for variety of uses

- · Can even **play** games
- · Apologies to those that have encountered GA's

19

2018-05-25

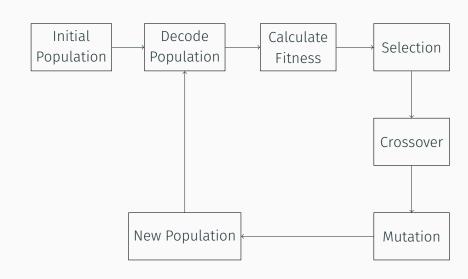
- CE810 GD2
 - -Genetic Algorithms

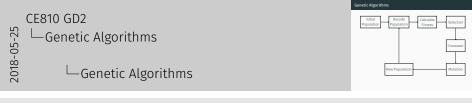
Genetic Algorithms

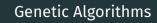
Powerful algorithms for variety of uses
 Can even play games
 Apologies to those that have encountered GA's
 Even more apologies to those that have encountered
RHEA'S

Genetic Algorithms

- Powerful algorithms for variety of uses
- · Can even **play** games
- · Apologies to those that have encountered GA's
- Even more apologies to those that have encountered RHEA's







• You all have some experience using these

2018-05-25

CE810 GD2

Genetic Algorithms └─Genetic Algorithms

· You all have some experience using these



2018-05-25

CE810 GD2

└─Genetic Algorithms

- Asteroids assignment had one built in

Genetic Algorithms

- · You all have some experience using these
- · Asteroids assignment had one built in

Genetic Algorithms

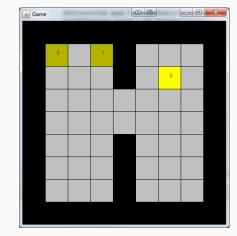
Genetic Algorithms

Genetic Algorithms

- You all have some experience using these
- · Asteroids assignment had one built in
- But how to play a game with a GA?

21

· Consider this game



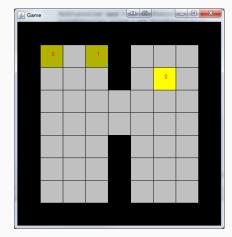
CE810 GD2

Genetic Algorithms

Simpler Games



- · Consider this game
- · More like a maze



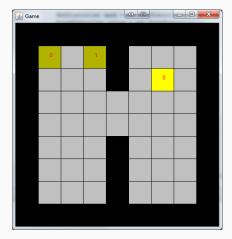
CE810 GD2

Genetic Algorithms

Simpler Games

- Consider this game
- More like a maze

- · Consider this game
- · More like a maze
- Get each Agent to the goal



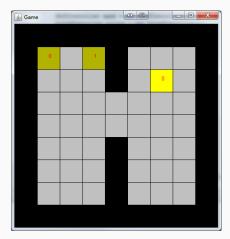
CE810 GD2
Genetic Algorithms
Simpler Games

- Consider this game

More like a maze

- Get each Agent to
the goal

- · Consider this game
- · More like a maze
- Get each Agent to the goal
- 5 possible moves



CE810 GD2
Genetic Algorithms
Simpler Games

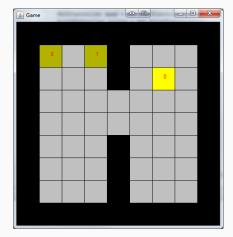
- Consider this game

- More like a maze

- Get each Agent to
the goal

- 5 possible moves

- · Consider this game
- · More like a maze
- Get each Agent to the goal
- 5 possible moves
- · Controller returns a single move per turn



CE810 GD2 —Genetic Algorithms

└─Simpler Games

2018-05-25

· More like a maze · Get each Agent to the goal Controller returns a single move per turn

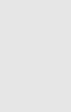


Given a time budget

2018-05-25

CE810 GD2

└─Genetic Algorithms └─GA for Simple Game



- Given a time budget

Given a time budget

Spend it evolving "plans"



2018-05-25

CE810 GD2

└─Genetic Algorithms

└─GA for Simple Game

GA for Simple Game

2018-05-25

−Genetic Algorithms └─GA for Simple Game

CE810 GD2

it evolving "plans" a sequence of possible actions

GA for Simple Game

- · Given a time budget
- · Spend it evolving "plans"
- Plan is a **sequence** of possible actions

- Given a time budget
- Spend it evolving "plans"
- Plan is a **sequence** of possible actions
- · Simulate the plan and evaluate resultant state for score

CE810 GD2 2018-05-25

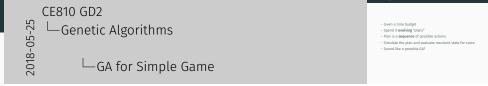
-Genetic Algorithms

└─GA for Simple Game

Simulate the plan and evaluate resultant state for score

GA for Simple Game

- · Given a time budget
- · Spend it evolving "plans"
- Plan is a **sequence** of possible actions
- · Simulate the plan and evaluate resultant state for score
- Sound like a possible GA?



GA for Simple Game

23

- Given a time budget
- Spend it evolving "plans"
- Plan is a **sequence** of possible actions
- · Simulate the plan and evaluate resultant state for score
- · Sound like a possible GA?
- This is called a Rolling Horizon Evolutionary Algorithm

CE810 GD2

2018-05-25 -Genetic Algorithms

☐GA for Simple Game

GA for Simple Game

This is called a Rolling Horizon Evolutionary Algorithm

· Length of the sequence increases parameters for GA

Genetic Algorithms

Boosting the

CE810 GD2

∟Boosting the horizon

Boosting the horizon

· Length of the sequence increases parameters for GA

24

2018-05-25 —Genetic Algorithms

☐ Boosting the horizon

RHEA is quite jerky in games

Boosting the horizon

· Length of the sequence increases parameters for GA

• RHEA is quite **jerky** in games

24

CE810 GD2

2018-05-25

CE810 GD2

—Genetic Algorithms

☐ Boosting the horizon

Macro Actions can sometimes solve this

oosting the horizon

- · Length of the sequence increases parameters for GA
- RHEA is quite **jerky** in games
- · Macro Actions can sometimes solve this

2018-05-25

CE810 GD2

-Genetic Algorithms

Length of the sequence increases parameters for GA RHEA is quite jerky in games Macro Actions can sometimes solve this Lockine the agent to consider each move N times

osting the horizon

□Boosting the horizon

- Length of the sequence increases parameters for GA
- RHEA is quite **jerky** in games
- · Macro Actions can sometimes solve this
- Locking the agent to consider each move N times

2018-05-25

- CE810 GD2
 - -Genetic Algorithms

Boosting the horizon

Macro Actions can experimens solve this
 Locking the agent to consider each move N times
 Means you can think for Nurs

osting the horizon

RHEA is quite jerky in games

Length of the sequence increases parameters for GA

- Length of the sequence increases parameters for GA
- · RHEA is quite **jerky** in games
- Macro Actions can sometimes solve this
- Locking the agent to consider each move N times
- Means you can think for N turns

24

- Length of the sequence increases parameters for GA
- RHEA is quite **jerky** in games
- Macro Actions can sometimes solve this
- Locking the agent to consider each move N times
- Means you can think for *N* turns
- Works great in real-time engines like PTSP

CE810 GD2

1 - .

2018-05-25

-Genetic Algorithms

Boosting the horizon

osting the horizon

Length of the sequence increases parameters for GA
 RHEA is quite jerky in games

· Macro Actions can sometimes solve this

Locking the agent to consider each move N times
 Means you can think for N turns

Works great in real-time engines like PTSP

- Length of the sequence increases parameters for GA
- RHEA is quite **jerky** in games
- · Macro Actions can sometimes solve this
- Locking the agent to consider each move N times
- Means you can think for *N* turns
- Works great in real-time engines like PTSP
- Getting N wrong means poor performance

CE810 GD2

JE010 GD2

2018-05-25

-Genetic Algorithms

Boosting the horizon

sting the horizon

Length of the sequence increases parameters for GA
 PALEA in quite include in games.

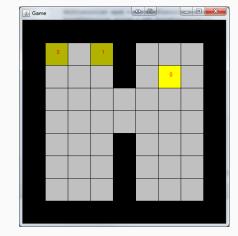
RHEA is quite jerky in games
 Macro Actions can sometimes solve this

Locking the agent to consider each move N times

Works great in real-time engines like PTSP
 Getting N wrong means poor performance

Problem with Macro Actions

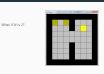
• What if *N* is 2?



CE810 GD2

Genetic Algorithms

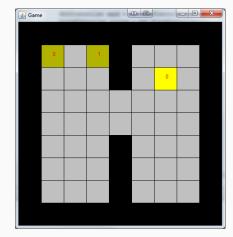
Problem with Macro Actions



Problem with Macro Actions

Problem with Macro Actions

- What if *N* is 2?
- Can we reach the Goal?



CE810 GD2

Genetic Algorithms

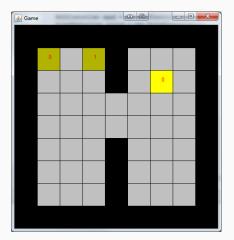
Problem with Macro Actions



Problem with Macro Actions

Problem with Macro Actions

- What if *N* is 2?
- Can we reach the Goal?
- MacroActionGA is poor at discrete boards



CE810 GD2

.E810 (L.Gon

2018-05-25

—Genetic Algorithms

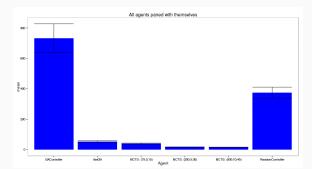
What if N is 2?
Can we reach the Goal?
MacroActionGA is poor at discrete boards

Problem with Macro Actions



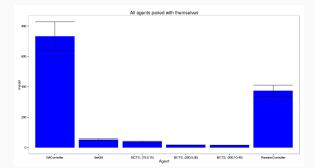
Problem with Macro Actions

• What if *N* wasn't fixed?



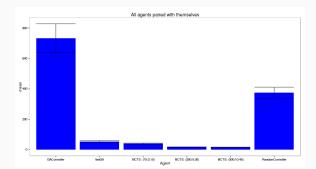


- What if N wasn't fixed?
- What if N wasn't the same for each action?





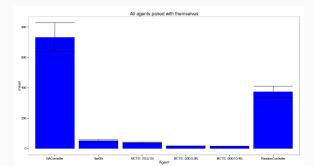
- What if N wasn't fixed?
- What if N wasn't the same for each action?
- Learn the values for *N* as well as the actions





2018-05-25

- What if N wasn't fixed?
- What if N wasn't the same for each action?
- Learn the values for *N* as well as the actions
- Include them in the GA







More complex games

• This is great for simple games

CE810 GD2

└─Genetic Algorithms

· This is great for simple games

More complex games

2018-05-25 —Genetic Algorithms

CE810 GD2

└─More complex games

· This is great for simple games · More complex games are too large

More complex games

- This is great for simple games
- · More complex games are too large

└─More complex games

More complex games

- This is great for simple games
- More complex games are too large
- · Action space in our game is huge!

27

└─More complex games

More complex games

- This is great for simple games
- · More complex games are too large
- · Action space in our game is huge!
- · Macro actions don't make sense either!

More complex games

- This is great for simple games
- · More complex games are too large
- · Action space in our game is huge!
- Macro actions don't make sense either!
- · Need something **higher** level

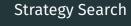
CE810 GD2 Genetic

-Genetic Algorithms

└─More complex games

More complex games

- This is great for simple games
 More complex games are too large
- Action space in our game is huge!
- Need something higher level



Instead of choosing actions

CE810 GD2

└─Genetic Algorithms

· Instead of choosing actions

Strategy Search

2018-05-25 └─Genetic Algorithms

CE810 GD2

└─Strategy Search

· Choose between strategies

- Instead of choosing actions
- · Choose between **strategies**



- 2018-05-25
 - └─Genetic Algorithms

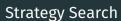
└─Strategy Search

CE810 GD2

Choose between strategies
 But where will we get those?

Strategy Search

- Instead of choosing actions
- · Choose between **strategies**
- · But where will we get those?



- 2018-05-25
- −Genetic Algorithms └─Strategy Search

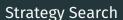
CE810 GD2

Map<fatityType, List<ProductionRuleAgent>> rules;
- Choose between PRA's for each EntityType

Strategy Search

- Map<EntityType, List<ProductionRuleAgent>> rules;
- Choose between PRA's for each **EntityType**

29



2018-05-25

CE810 GD2 —Genetic Algorithms

└─Strategy Search

Map<EntityType, List<ProductionRuleAgent>> rules;

Strategy Search

Map<EntityType, List<ProductionRuleAgent>> rules;

- Choose between PRA's for each **EntityType**
- Why not per Entity?

Why not per Entity?

29

Variable Length Macro Action GA

"MedievalGA": "VLMAGA[1000:10:EandM:abstract_civilian,abstract_town,abstract_knightery,abstract_archery,abstract_knight,abstract_archer:noopRule/Resource-Builder/BuildBase/BuildMilitary,noopRule/Build-Worker,noopRule/BuildKnights,noopRule/BuildArchers,KnightAttack,ArcherAttack:noop:RangedRush]"

· Will do automatic single actions first

CE810 GD2

Genetic Algorithms

Genetic Algorithms

Will do automatic single actions first

└─Variable Length Macro Action GA

2018-05-25

Variable Length Macro Action GA

"MedievalGA": "VLMAGA[1000:10:EandM:abstract_civilian,abstract_town,abstract_knightery,abstract_archery,abstract_knight,abstract_archer:noopRule/Resource-Builder/BuildBase/BuildMilitary,noopRule/Build-Worker,noopRule/BuildKnights,noopRule/BuildArchers,KnightAttack,ArcherAttack:noop:RangedRush]"

- · Will do automatic single actions first
- Then will follow its learned policy

CE810 GD2

2018-05-25

Genetic Algorithms

└─Variable Length Macro Action GA

ngth Macro Action GA

Medievalus : VLMMusq (UUVIUE anomaisstrat C, chillistrat, brown jabstract injinghengalstract, archenyabstract, archer, brown jabstract, archer, broop Rule / Resource-Builder / Buildfasso / Buildmilitary, noop Rule / Buildd Worker, noop Rule / Buildd Knights, noop Rule / Builddriche tättack, Archer Attack, noop Ranged Rush | "

Will do automatic single actions first
 Then will follow its learned policy

Variable Length Macro Action GA

"MedievalGA":"VLMAGA[1000:10:EandM:abstract_civilian.abstract_town,abstract_knightery,abstract_archery,abstract_knight,abstract_archer:noopRule/Resource-Builder/BuildBase/BuildMilitary,noopRule/Build-Worker, noopRule/BuildKnights, noopRule/BuildArchers, KnightAttack, Archer Attack: noop: Ranged Rush]"

- · Will do automatic single actions first
- Then will follow its learned policy
- Then will use the fallback agent for the rest

CE810 GD2

2018-05-25

Genetic Algorithms

└─Variable Length Macro Action GA

tAttack,ArcherAttack:noop:RangedRush]*

Then will follow its learned policy Then will use the fallback agent for the rest.

Problems

Controller	ops/min	Error
random	512.840	13.846
noop	509.314	5.730
RangedRush	273.362	2.345
MixedRush	284.875	7.453
MedievalGA	3.538	2.286

- · An "op" is building a full game and playing it to the end
- MedievalGA is the VLMAGA
- I wish that were an error for MedievalGA

CE810 GD2
└─Genetic Algorithms
1
└─ Problems

Controller	ops/min	Error
random	512.840	13.846
поор	509.314	5.730
RangedRush	273.362	2.345
MixedRush	284.875	7.453
MedievalGA	3.538	2.286

[·] An "op" is building a full game and playing it to the end · I wish that were an error for MedievalGA