AI FOR GAMES
AND
AI FOR GAMERS

31ST MAY, 2018

CASUAL CONNECT

PROF. RICHARD A. BARTLE

UNIVERSITY OF **ESSEX**, UK

INTRODUCTION

- THIS TALK IS ABOUT APPLYING **ARTIFICIAL INTELLIGENCE** TECHNIQUES TO **GAMES**
  - TO GAME **DESIGN**
  - TO GAME **DEVELOPMENT**
  - TO **GAMEPLAY**
- IT'S ONLY A TASTER SO IS **NON-TECHNICAL**
- MY AIM IS TO SHOW YOU WHAT AI **CAN** BE USED FOR IN GAMES, NOT **HOW** TO DO IT
- THIS COMES FROM **ACADEMIC** RESEARCH, **NOT** GAME-INDUSTRY RESEARCH

OMMISSIONS

- AI HAS BEEN USED IN GAMES FOR **YEARS**
  - **RUBBER-BANDING** IS A FORM OF AI
- I'LL THEREFORE **IGNORE** METHODS THAT ARE **ALREADY** WELL-USED AND WELL-UNDERSTOOD
  - A*, FINITE STATE MACHINES, BEHAVIOUR TREES, ANYTHING UTILITY-BASED, MINIMAX, CLUSTERING, ...
- I'LL BE LOOKING AT MORE **MODERN** APPROACHES THAT ARE NOW BECOMING **FEASIBLE** FOR **COMMERCIAL** GAMES
- **BOOK!** YANNAKAKIS & TOGELIUS: *ARTIFICIAL INTELLIGENCE AND GAMES*, SPRINGER, 2018

TECHNIQUES

- THESE ARE THE **GENERAL** TECHNIQUES I'LL BE MENTIONING AND WHAT THEY'RE **GOOD** FOR:
  - **PLANNING**: LOGICAL EXPLANATIONS AND CAUSALITY
  - **MONTE CARLO TREE SEARCH**: BEST-GUESSING, SHORT TIME FRAME
  - **ARTIFICIAL NEURAL NETWORKS**: CLASSIFICATION, PREFERENCE LEARNING
  - **EVOLUTIONARY ALGORITHMS**: CREATIVE SEARCH, PARAMETER TUNING
  - **REINFORCEMENT LEARNING**: LEARNING FROM EXAMPLES
- I'LL **BRIEFLY** OUTLINE HOW EACH **WORKS**

PLANNING

- **PLANNING** ASSUMES THE WORLD CAN BE DESCRIBED AS A **STATE**, AS IN *CHESS*
- IT USES A SET OF **OPERATORS**
  - MADE OF **PRECONDITIONS** AND **EFFECTS**
- **EXECUTING** AN OPERATOR IN **ONE** STATE TRANSFORMS THE WORLD INTO A **NEW** STATE
- AIMS TO FIND A **SERIES** OF OPERATORS THAT GETS FROM AN **INITIAL** TO A **GOAL** STATE
  - **FORWARD** STARTS AT THE INITIAL STATE
  - **BACKWARD** STARTS AT THE GOAL STATE
- SLOW, BUT **VERY** GOOD AT **CAUSALITY**

MCTS

- A FORM OF SEARCH THAT USES **STATISTICS** TO DECIDE WHICH CHOICE IS **PROBABLY** BEST
- RUN **THOUSANDS** OF SEARCHES CHOOSING AT **RANDOM** THEN **AGGREGATE** RESULTS
- **GREAT** FOR GAMES BECAUSE:
  - IT WORKS FOR **ENORMOUS** SEARCH SPACES
  - IT'S **FAST**
  - IT CAN BE RESOURCE-LIMITED AND **STILL** HELP
  - IT'S DOMAIN-**INDEPENDENT**
- CAN PICK UP FROM A **REGULAR** SEARCH
- **VERY** POPULAR IN GAME AI AT THE MOMENT

ANN

- THESE ARE **FUNCTION**-APPROXIMATORS
- THEY TAKE **INPUTS** AND GIVE CORRESPONDING **OUTPUTS**
- MADE OF **NEURONS** ARRANGED IN **LAYERS**
- EACH NUERON COMBINES A NUMBER OF INPUTS AS A **WEIGHTED SUM** AND OUTPUTS ACCORDING TO AN **ACTIVATION** FUNCTION
- ANNS NEED TO BE **TRAINED** ON EXAMPLES
  - THE MORE **LAYERS**, THE MORE **EXAMPLES**...
- GOOD FOR **CLASSIFICATION**, **PREFERENCE** LEARNING AND **REGRESSION** ANALYSIS

EA

- EVOLUTIONARY ALGORITHMS TRY TO MAXIMISE A **FITNESS** FUNCTION FOR A SET OF **VALUES**
  - THE VALUES COULD REPRESENT **ACTIONS**, OPINIONS, RESPONSES, **WHATEVER**
  - USUALLY REPRESENTED AS AN **ARRAY**/VECTOR
- IT KEEPS A SET OF **POTENTIAL** SOLUTIONS THAT IT **MUTATES** TO GIVE **NEW** SOLUTIONS
- **BEST** OF EACH GENERATION ARE **RETAINED**
- **COMBINING** SOLUTIONS TO GIVE THE NEXT GENERATION MAKES IT A **GENETIC** ALGORITHM
- **NEUROEVOLUTION** IS ANN/EA **HYBRID**

RL

- REINFORCEMENT LEARNING TRIES TO MAXIMISE **REWARDS** FROM THE **ENVIRONMENT**
- YOU **TRY** SOMETHING, THEN THE WORLD TELLS YOU IF IT WAS **GOOD** OR **BAD**
- **LEARNING** GOOD STATES OCCURS USING:
  - IF YOU **KNOW** THE WORLD MODEL, **DYNAMIC PROGRAMMING** (JUST STORE THE ANSWERS)
  - ELSE **MCTS** OR **T**EMPORAL **D**IFFERENCE LEARNING
- **TD** LEARNING **ESTIMATES** HOW GOOD **THIS** STATE IS BASED ON HOW GOOD IT ESTIMATES THE **NEXT** STATE TO BE

POT POURRI

- SO, WHAT I'M GOING TO DO IS SPEND A **SLIDE EACH** ON A NUMBER OF **AREAS** WHERE THESE METHODS CAN **HELP** WITH GAMES
- OFTEN, IT'S NOT SO MUCH "**CAN** HELP" AS "**ARE** HELPING"
  - THERE'S A PHD PROGRAMME IN THE UK, IGGI, WHICH HAS **50+** STUDENTS WORKING ON GAMES AND AI
  - THEY **DO** GO ON INDUSTRIAL **PLACEMENTS**, SO YOU **MAY** BE ABLE TO SNAG ONE – SEE ME AFTER
- I'M **HOPING** THAT THIS TALK WILL **SPARK** IDEAS THAT YOU CAN INVESTIGATE AT **LEISURE**

GAME BALANCE

- SUPPOSE YOU HAVE A GAME WITH A **TON** OF CARDS, SPELLS, SKILLS, UNITS OR WHATEVER
  - LIKE *HEARTHSTONE* OR *M:TG*
- HOW DO YOU KNOW THERE'S NO **DOMINANT** STRATEGY? THAT NONE ARE **OVERPOWERED**?
- **GENETIC** (EVOLUTIONARY) **ALGORITHMS** CAN **TUNE** PARAMETERS TO FIT DESIGN NEEDS
  - PROBLEM: THEY TAKE **AGES** TO RUN ENOUGH TIMES
  - SOLUTION: USE **ANN**S TO **PREDICT** FITNESS
- ONE OF OUR IGGI STUDENTS **DID** THIS FOR MINDARK'S *COMPET* GAME

RAPID TESTING

- SUPPOSE YOU MAKE A **CHANGE** TO YOUR GAME DESIGN
- HOW DO YOU KNOW YOU HAVEN'T **BROKEN** ANYTHING?
- USE **REINFORCEMENT LEARNING** TO **TRAIN** AN AGENT TO PLAY YOUR GAME
- TAKE **PERFORMANCE** METRICS
- DO THE **SAME** FOR THE **CHANGED** VERSION
- **COMPARE** THE METRICS
- SLOW TO **SET UP**, BUT IT THEN RUNS **FAST**

AI OPPONENTS

- MANY GAMES ARE SINGLE-**PLAYER** BUT HAVE BUILT-IN COMPUTER **OPPONENTS**
- DO YOU WANT THESE TO TRY TO **WIN**?
  - USE **MONTE CARLO TREE SEARCH**!
- DO YOU WANT THEM TO BEHAVE **HUMAN**-LIKE?
  - USE AN **ARTIFICIAL NEURAL NETWORK**!
- DO YOU WANT THEM TO **ADAPT** THEIR STRATEGIES **WHILE** THEY PLAY?
  - USE A **GENETIC ALGORITHM**!
- YOU CAN **COMBINE** ALL THREE IF YOU WANT
  - OR JUST USE **PLANNING**, BUT IT'S **SLOW**

AI NPCS

- SOME NPCS ARE THERE TO DO **boring** THINGS THAT PLAYERS DON'T **WANT** TO DO
  - SUCH AS STANDING **GUARD**
- THESE OFTEN DON'T NEED **MUCH** AI, SO NORMAL BEHAVIOUR-AUTHORING WORKS JUST **FINE**
  - FINITE STATE MACHINES, BEHAVIOUR TREES
- HOWEVER, SOME **DO** NEED TO BE MORE *sophisticated*
  - FOR EXAMPLE **LOVE** INTERESTS
- FOR THESE, USE **PLANNING** OR **MCTS**
  - DEPENDING ON HOW MUCH **TIME** YOU HAVE

PLAYER EXPERIENCE

- SOME OF WHAT I'VE DESCRIBED SO FAR NEEDS SOME FORM OF PLAYER **MODELLING**
  - SIMULATING HOW A **HUMAN** WOULD PLAY
- THE **BEST** WAY IS TO USE AN **ANN**, BUT THESE HAVE TO BE **TRAINED** ON HUMAN PLAY
- HOWEVER, IT **TURNS OUT** ROUGH-AND-READY APPROXIMATIONS ARE STILL PRETTY **GOOD**
  - CREATED USING **GA** OR UNSUPERVISED **RL**
- YOU CAN USE THE **SAME** APPROACH TO FIND OUT IF YOUR GAME WILL BE **FUN**!
  - IF YOU CAN DEFINE "FUN" AS A FITNESS FUNCTION...

PCG

- **P**ROCEDURAL **C**ONTENT **G**ENERATION CREATES NEW CONTENT IN AN **AUTOMATED** WAY
  - **AUTONOMOUS** DOES IT WITH NO OVERSIGHT
  - **ASSISTED** PROPOSES WORKABLE SUGGESTIONS
- EVOLUTIONARY ALGORITHMS ARE THE GO-TO METHOD FOR **BOTH**
- PCG IS **MAINLY** USED FOR WORLD-CREATION, BUT CAN **ALSO** HELP WITH GRAPHICS AND AUDIO
- COMBINE WITH **PLAYER MODELLING** TO CREATE **ADAPTIVE** GAMES
  - WARNING: SOME PLAYERS **HATE** THESE!

STORY GENERATION

- IF YOU WANT TO GENERATE **STORIES** THAT MAKE **SENSE**, YOU'LL USE **PLANNING**
- IT'S COMPARATIVELY **SLOW**, BUT STORIES AREN'T **NEEDED** MOMENT-TO-MOMENT
  - THEY CAN THEREFORE BE CREATED OVER **TIME**
  - NOT A PROBLEM IN TURN-BASED GAMES **ANYWAY**
- PLANNING WORKS **BEST** BECAUSE THE WAY IT FIGURES OUT **WHAT** IS TO HAPPEN TELLS YOU **WHY** IT WILL HAPPEN
- MCTS WILL PRODUCE STORIES **FASTER**, BUT THEY LOOK **BONKERS** TO THE HUMAN EYE

DATA MINING

- IF YOUR GAME IS **SUCCESSFUL**, IT WILL PROVIDE YOU WITH A LOT OF **DATA**
  - FORMALLY KNOWN AS **BIG DATA**
- THERE ARE WELL-KNOWN **STATISTICAL** TECHNIQUES FOR ANALYSING SUCH DATA
  - **CLUSTERING** AND SO ON
- **REINFORCEMENT LEARNING** COUPLED WITH ARTIFICIAL NEURAL NETWORKS ALLOW YOU TO CREATE **PREDICTIVE** MODELS
  - WHEN WILL THIS PLAYER **QUIT**?
  - WHAT WOULD THIS PLAYER GIVE ME **MONEY** FOR?

PLAYER MODELLING

- THINGS ARE STARTING TO LOOK **DARKER** NOW...
- IT'S **ONE** THING TO USE AI TO INCREASE PLAYER **ENGAGEMENT**
- IT'S **ANOTHER** THING **ENTIRELY** TO EMPLOY IT IN THE SERVICE OF **MIND CONTROL**
- WANT TO IDENTIFY PLAYERS WHOM YOU CAN **ADDICT** TO YOUR GAME?
- YOU CAN **DO** THAT AND FAR, **FAR** WORSE
  - SUICIDES, GASLIGHTING, HEART ATTACKS, ...

GAME CREATION

- GAME DESIGN AND CREATION IS **EXPEN$IVE**
- WHY NOT **AUTOMATE** THE PROCESS?
- GENETIC ALGORITHMS ARE GREAT FOR **PARAMETER** TUNING
  - THEY CAN ALSO BE USED TO ADD, REMOVE AND CHANGE GAME **RULES**
- TIE TO PCG TO CREATE A **WHOLE GAME**
- IT NEEDS A PLAYER MODEL TO BE A **GOOD** GAME
- HOWEVER, **FLOODING** THE MARKET WITH **MILLIONS** OF GAMES **ALSO** WORKS
  - STATISTICALLY, SOME **WILL** BE GOOD BY **LUCK**!

COMING SOON!

- THERE ARE **OTHER** TECHNIQUES NOT **YET** READY FOR SYNDICATION
- THE ONE YOU'LL HAVE **HEARD** OF IS GOOGLE DEEPMIND'S **ALPHAGO**
- THIS USES **MCTS**, GUIDED BY A DEEP **ANN**
  - THE ARTIFICIAL NEURAL NETWORK WAS **INITIALLY** TRAINED ON RECORDS OF **HUMAN** GAMES, THEN IT USED **REINFORCEMENT LEARNING** TO PLAY AGAINST ITSELF UNSUPERVISED **BILLIONS** OF TIMES
- IT'S **IMPRACTICAL** FOR MOST GAMES TODAY
  - DO PLAYERS **WANT** A PERFECT OPPONENT ANYWAY?

SUMMARY

- THERE'S A **BUNCH** OF AI TECHNIQUES THAT **CAN** BE AND **ARE** BEING APPLIED TO GAME DESIGN AND DEVELOPMENT
- THIS TALK WAS A **TASTER** MENU TO SHOW WHAT'S CURRENTLY **OUT** THERE
- I DIDN'T EXPLAIN HOW ANY OF THE TECHNIQUES ACTUALLY **WORK**
  - IT'S ONLY A 40-MINUTE TALK!
- IT SHOULD BE ENOUGH, THOUGH, THAT IF YOU SEE SOMETHING THAT **RESONATES**, YOU CAN INVESTIGATE ITS **USE**

END NOTES

- **ME**: DR RICHARD A. BARTLE, HON. PROF. GAME DESIGN AT THE UNIVERSITY OF ESSEX
  - HTTP://MUD.CO.UK/
- **IGGI**: INTELLIGENT GAMES, GAMES INTELLIGENCE
  - HTTP://IGGI.ORG.UK/
- **BOOK**: GEORGIOS YANNAKAKIS & JULIAN TOGELIUS: *ARTIFICIAL INTELLIGENCE AND GAMES*, SPRINGER, 2018
  - HTTP://GAMEAIBOOK.ORG/
  - DIGITAL COPY AVAILABLE FOR **FREE**, BUT PLEASE BUY THE **HARD** COPY BECAUSE ACADEMIC SALARIES...