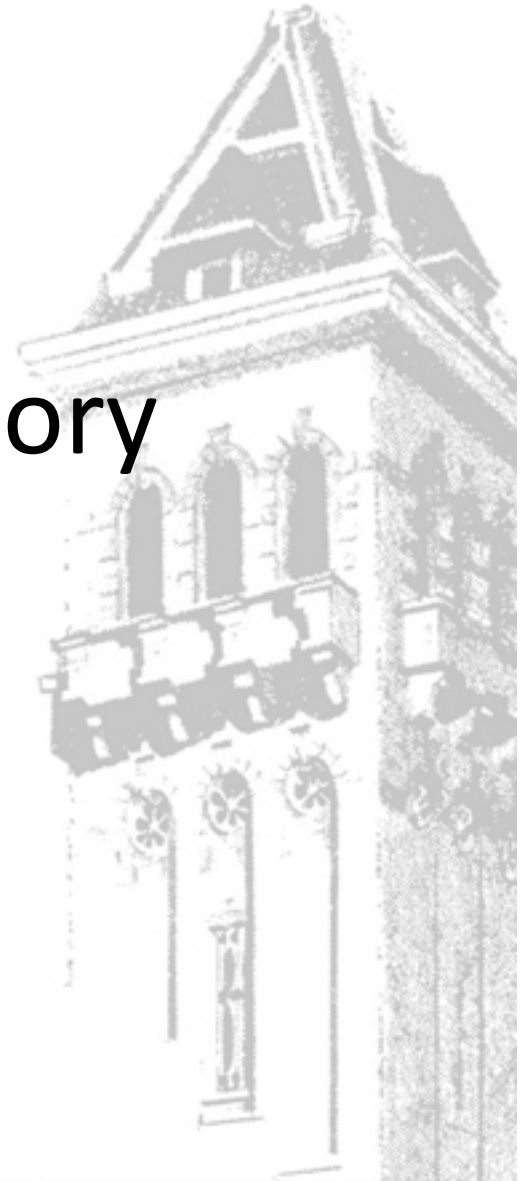




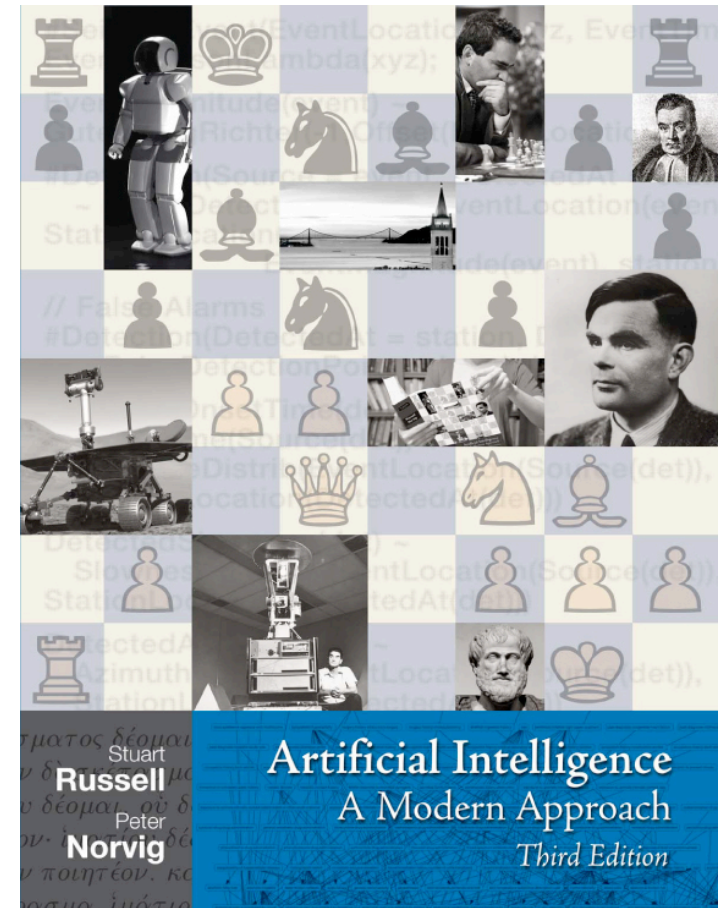
Wumpus World in Introductory Artificial Intelligence

Daniel Bryce



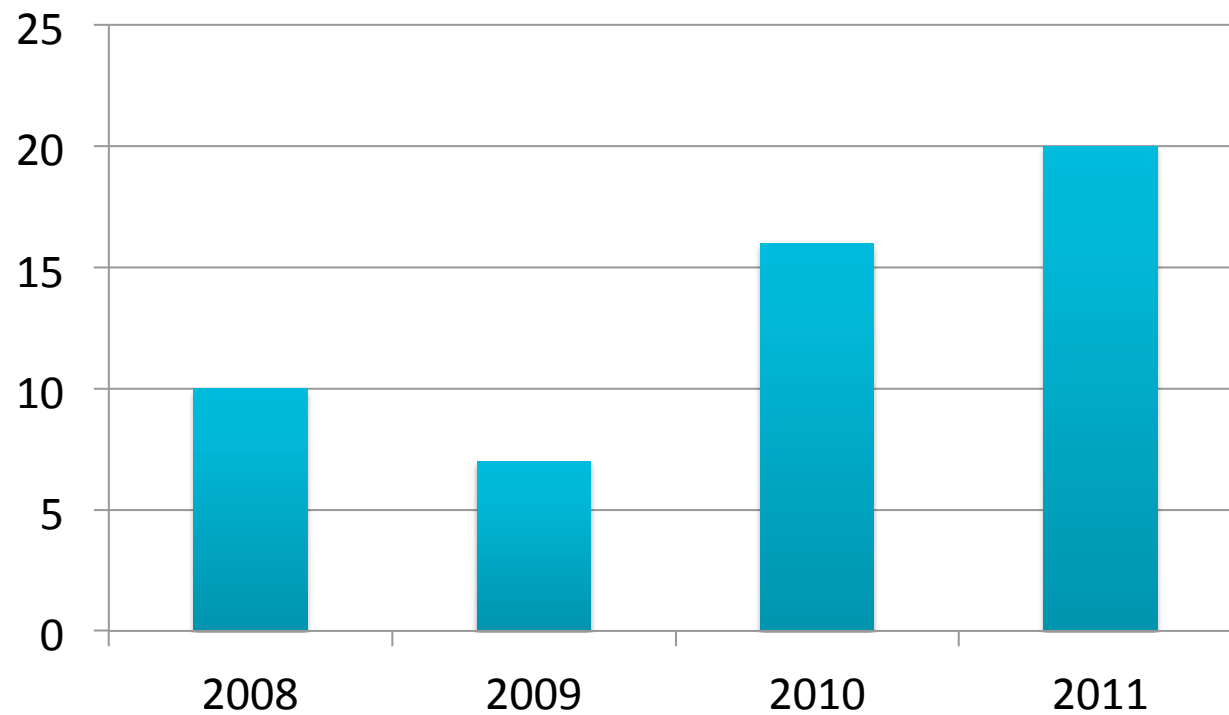
Objectives

- Intensive Project-Based Course
- Focus on Algorithms, not Code
- Increasing Capabilities
- Deceptively Simple Problems
- Improve Retention



CS5600 Enrollment

CS5600 Enrollement



Wumpus World



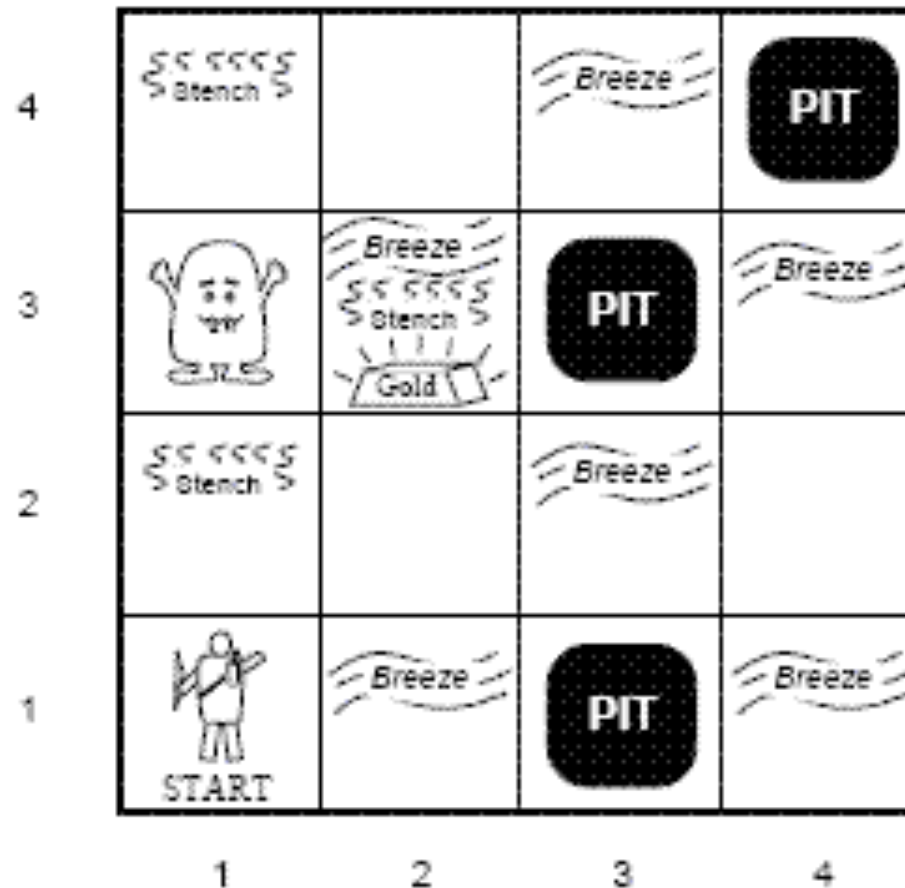
Wumpus World

Actions:

Turn-Right
Turn-Left
Move-Forward
Shoot
Grab

Percepts:

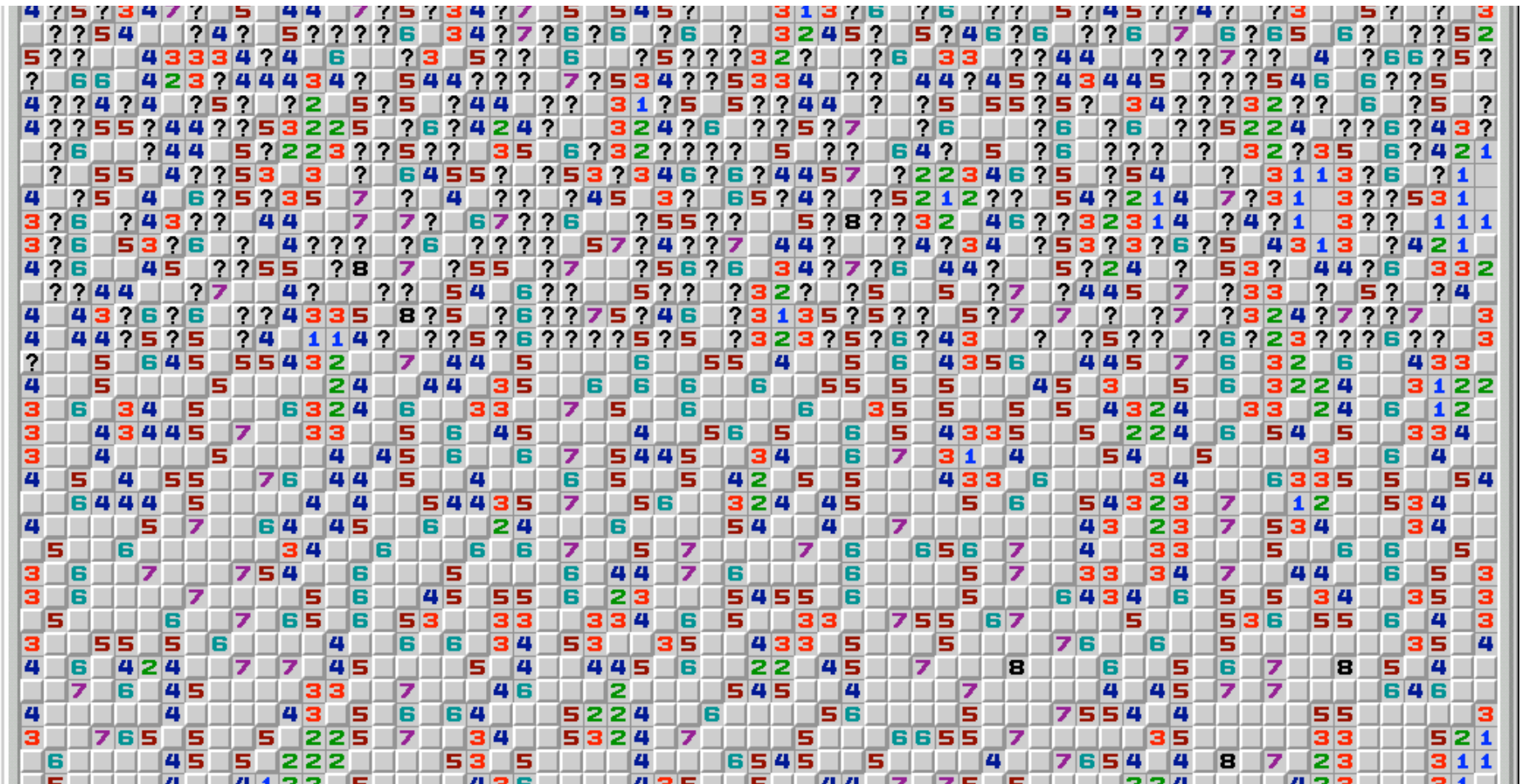
Breeze
Stench
Glimmer



Solution:

Turn-Right
Move-Forward
Shoot
Move-Forward
Turn-Right
Move-Forward
Grab

WW == Minesweeper++



Introductory Artificial Intelligence

- Topics
 - Agents
 - Search
 - Logic
 - Planning
 - Probabilistic Reasoning
 - Learning

Course Timeline

Week	1	2	3	4	5	6	7	8
Topic	History, Rationality, Agents	Uninformed Search	Informed Search	Game Playing	Constraint Satisfaction	Propositional Logic	Propositional Inference	First-Order Logic
Project	P0: Build Your Own Agent		P1: Search				P2: Satisfiability	
Week	9	10	11	12	13	14	15	16
Topic	Knowledge Representation	Planning	Probability Theory	Bayesian Networks	Advanced Bayesian Networks	Markov Decision Processes	Machine Learning	Applications
Project	P2 cont'd	P3: Planning			P4: Probabilistic Inference			

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P0: Build Your Own Agent

- Task: Find sequence of turn, move, shoot, and grab that results in having gold and not dying
- Approach: No Rules
- Results: Rediscover AI concepts
 - End Game Databases
 - Belief Maintenance
 - Planning

Course Timeline

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Project	P2 cont'd	P3: Planning			P4: Probabilistic Inference			

P1: Search

- Task: Find sequence of turn, move, shoot, and grab that obtains the gold. Assume full-observability
- Approach:
 - Search Infrastructure: States, Nodes, Successor Functions, Goal Test, Closed Lists/Cycle checks
 - Uniformed Search: Breadth First, Depth First, Iterative Deepening Depth First Search, Uniform Cost Search
 - Informed Search: A*, Greedy Best First, Heuristics
- Results: Discuss Algorithm Trade-offs using data
 - Solvable and Unsolvable problems
 - Informed vs Uninformed Search
 - Use of Closed Lists and Cycle Checks
 - Scalability in Grid dimension

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P2: Satisfiability

- Task: Answer Queries about WW, given observations.
- Approach:
 - Encode Rules (e.g., pits cause breeze in adjacent squares) and observations (e.g., there is breeze in 3,4) as a knowledge base (KB) in CNF
 - Pose queries α (e.g., is there a pit in 2,3?)
 - Compute answer by proving unsatisfiability of $\text{KB} \wedge \neg\alpha$
 - Use 2 of 4 algorithms: Resolution, DPLL, WalkSAT, and ROBDDs
- Results:
 - Transform Logical Sentences to normal form
 - Understand tradeoff between search and inference
 - Understand diagnosis of causes from observations

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Project	P2 cont'd	P3: Planning			P4: Probabilistic Inference			

P3: Planning

- Task: Model WW from P1 in Planning Domain Description Language (PDDL)
- Approach:
 - Model state predicates and actions.
 - Use three types of automated planners with PDDL
- Results:
 - Understand Knowledge Representation and First-Order Logic
 - Understand alternative planning algorithm trade-offs

Course Timeline

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P4: Probabilistic Inference

- Task: Answer probabilistic queries by computing conditional probabilities $\Pr(\text{pit}(x,y) \mid \text{breeze}(j,k)\dots)$
- Approach:
 - Design Bayesian Network for WW
 - Implement algorithms: Enumeration, Variable Elimination, and MCMC
- Results:
 - Understand Probability Theory
 - Understand essential uses of Bayesian Networks
 - Appreciate tradeoffs of exact and approximate inference algorithms

Graduate Projects

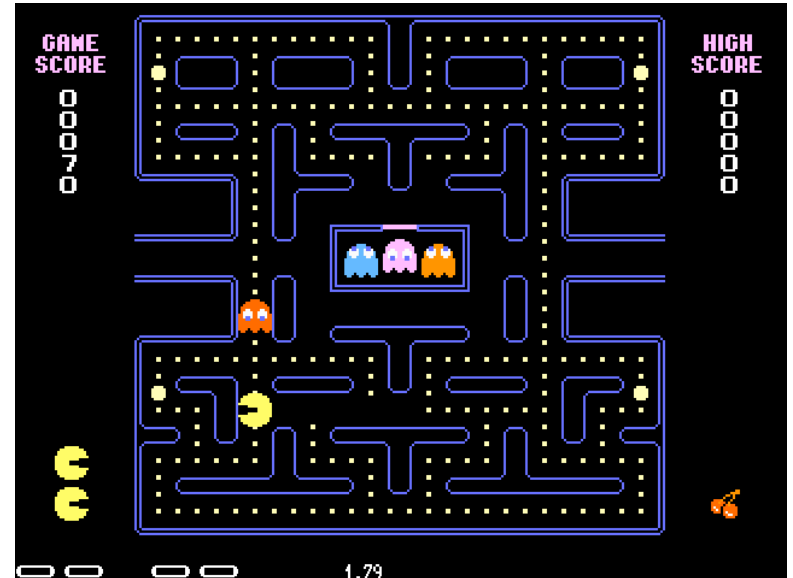
- Integrate P1/P3 and P2/P4 to plan with incomplete information and probabilities (POMDP)
- GUIs for teaching agents and machine learning
- Relax Simulator Assumptions
 - Moving Wumpus, different observations, Bats

Results

- Preliminary evidence suggests that average time per project is reduced considerably (~80 hrs down to ~40 hrs).
- Student Enrollment up 2x.

Related Work

- PacMan [Klein, 2010]
 - Search, Reinforcement Learning, Multi-agent search, Game Playing
- Educational Advances in AI (co-located w/ AAAI)
 - Model Assignments
 - Not Semester-long projects



Resources

- Source Code: Coming Soon (licensing issues)
 - see <http://www.cs.usu.edu/~danbryce>
- Class Videos: <http://ai.cs.usu.edu>
- Book and Slides: <http://aima.cs.berkeley.edu>

Summary

- Uniform Environment for project implementation reduces “ramp-up” time.
- Simple, but captivating environment illustrates core differences between algorithms
- Lots of materials to share for use in your classroom!

Thanks

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- <http://www.cs.usu.edu/~danbryce>