

Dungeon Crawl Stone Soup as a Goal Reasoning Challenge Problem

Dustin Dannenhauer



Outline

Dungeon Crawl Stone Soup (~17 min)

DCSS as an AI Challenge Problem and GR Problem

Thoughts on Building an AI to Win DCSS

The API: *DCSS-AI-Wrapper*

What is Dungeon Crawl Stone Soup?

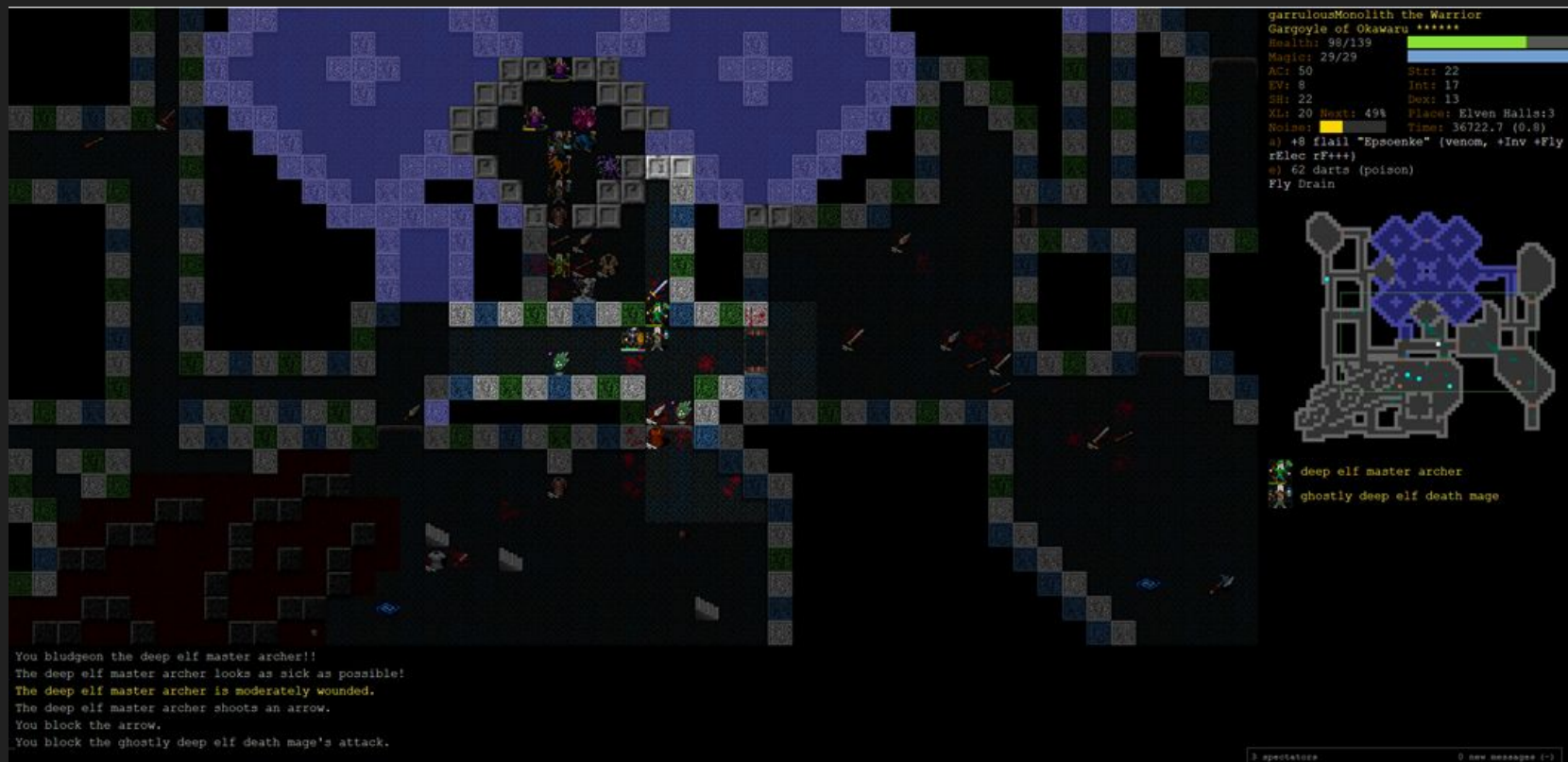
Rogue-like video game under active development since 2006

Game Objective: Navigate your character through a series of 2D grid-based levels to retrieve the Orb of Zot, and return to the entrance.

Open-source, available on Github: <https://github.com/crawl/crawl>

Often referred to as Crawl or DCSS

Screenshot of DCSS



Screenshot of DCSS (annotated)

The screenshot shows a top-down view of a game level with various elements annotated:

- Items:** Indicated by pink boxes and arrows pointing to various items on the ground.
- Enemies:** Indicated by orange circles and arrows pointing to enemy units.
- Player:** Indicated by a red circle and arrow pointing to the player unit.
- Player Stats:** A cyan box in the top right corner displays the player's statistics and a mini-map.
- Text description of events:** A green box in the bottom left corner displays the game's text log.

Player Stats:

```
garrulousMonolith the Warrior
Gargoyle of Okawaru *****
Health: 98/139
Magics: 29/29
AC: 50      Str: 22
EV: 8      Int: 17
SH: 22     Dex: 13
XL: 20 Next: 49%  Place: Elven Halls:3
Name:      Time: 36722.7 (0.8)
a) +8 flail "Epscoenke" (venom, +Inv +Fly
rElec rF++)
e) 62 darts (poison)
Fly Drain
```

Text description of events:

```
You bludgeon the deep elf master archer!!
The deep elf master archer looks as sick as possible!
The deep elf master archer is moderately wounded.
The deep elf master archer shoots an arrow.
You block the arrow.
You block the ghostly deep elf death mage's attack.
```

Mini-map:

```
deep elf master archer
ghostly deep elf death mage
```

Game Modes

4 primary modes:

- Trunk (*main game mode*)
- Trunk w/ Seed
- Tutorial
- Sprint

Game Mode Selection in Desktop Client:

Choices:



Dungeon Crawl



Choose Game Seed



Tutorial for Dungeon Crawl



Hints Mode for Dungeon Crawl



Dungeon Sprint



Instructions



The Arena



High Scores

Browser:

Welcome to WebTiles!




























Hello, midca!

Play now:

Play trunk | (edit rc) | Custom seed | Tutorial | Sprint

Picking your starting character

Welcome. Please select your species.

Simple	Intermediate	Advanced
 a - Hill Orc	 j - Human	 s - Vine Stalker
 b - Minotaur	 k - Kobold	 t - Vampire
 c - Merfolk	 l - Demonspawn	 u - Demigod
 d - Gargoyle	 m - Palentonga	 v - Formicid
 e - Draconian	 n - Spriggan	 w - Naga
 f - Halfling	 o - Tengu	 x - Octopode
 g - Troll	 p - Deep Elf	 y - Felid
 h - Ghoul	 q - Ogre	 z - Barachi
 i - Gnoll	 r - Deep Dwarf	 A - Mummy

Half fish, half human, Merfolk are citizens of both water and land. They are strong combatants, and adept at using magic to assist in battle.

Welcome, unnamed Minotaur. Please select your background.

Warrior	Zealot	Mage
 a - Fighter	 i - Berserker	 p - Hedge Wizard
 b - Gladiator	 j - Abyssal Knight	 q - Conjurer
 c - Monk	 k - Chaos Knight	 r - Summoner
 d - Hunter		 s - Necromancer
 e - Brigand	Warrior-mage	 t - Fire Elementalist
	 l - Transmuter	 u - Ice Elementalist
Adventurer	 m - Warper	 v - Air Elementalist
 f - Artificer	 n - Arcane Marksman	 w - Earth Elementalist
 g - Wanderer	 o - Enchanter	 x - Venom Mage
 h - Delver		

Hunters carry a ranged weapon of their choice, and are also equipped with light armour and a short sword.

Starting the Game (GIF)

Actions

Movement: Melee

To move in a direction or to attack, use the numpad (try Numlock off and on) or vi keys:

7 8 9	y k u
\ /	\ /
4-5-6	h-.-l
/ \	/ \
1 2 3	b j n

Other Gameplay Actions: Magic

a : use special Ability (a! for help)
z : cast spell, abort without targets
Z : cast spell, no matter what
I : list all memorised spells
M : Memorise a spell from your library
t : tell allies (tt to shout)

Rest: Do-nothing

. : wait a turn (also s, Del)
5 : rest and long wait; stops when Health or Magic become full or something is detected. If Health and Magic are already full, stops when 100 turns over (numpad-5)

Dungeon Interaction and Information:

O/C : Open/Close door
</> : use staircase
; : examine occupied tile and pickup part of a single stack
x : eXamine surroundings/targets
X : eXamine level map (X? for help)

Item Interaction:

{ : inscribe item
c : Chop up a corpse on floor
e : Eat food (tries floor first)
f : Fire next appropriate item
F : select an item and Fire it
Q : select item slot to be Quivered
q : Quaaff a potion
r : Read a scroll (or book on floor)
w : Wield an item (- for none)
' : wield item a, or switch to b (use = to assign slots)
v : eVoke power of wielded item
V : eVoke wand and miscellaneous item
W/T : Wear or Take off armour
P/R : Put on or Remove jewellery

Sensing Actions

Everything in the game has a text description.

Sometimes additional information too.

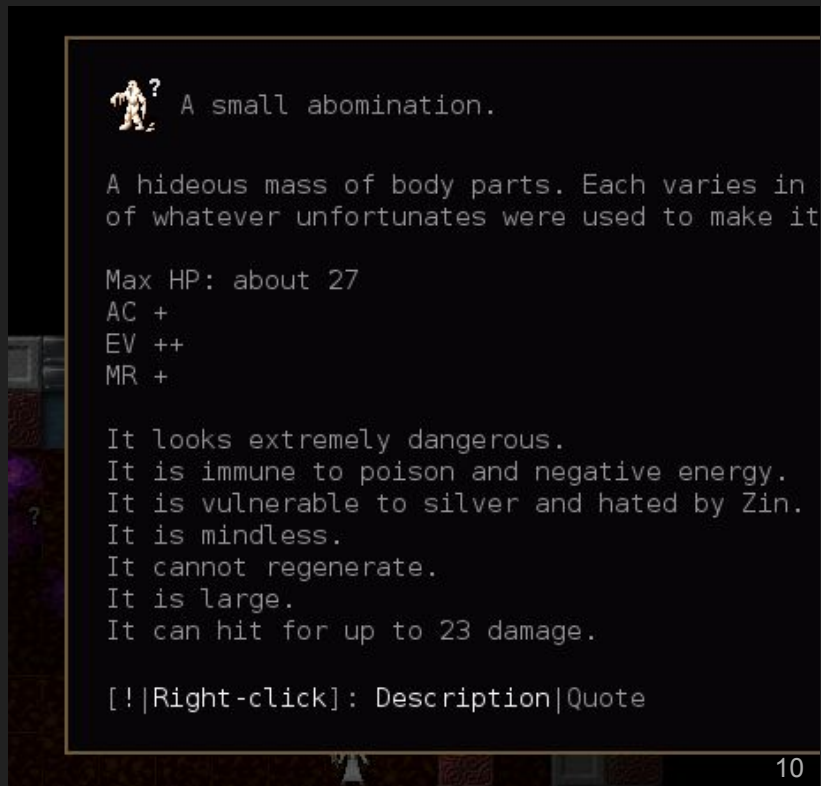
Pressing x switches to examine mode



Move the
yellow box
to the tile
you want
more info
for



Press v
to
describe



A small abomination.

A hideous mass of body parts. Each varies in
of whatever unfortunates were used to make it

Max HP: about 27

AC +

EV ++

MR +

It looks extremely dangerous.

It is immune to poison and negative energy.

It is vulnerable to silver and hated by Zin.

It is mindless.

It cannot regenerate.

It is large.

It can hit for up to 23 damage.

[!|Right-click]: Description|Quote

Sensing Actions

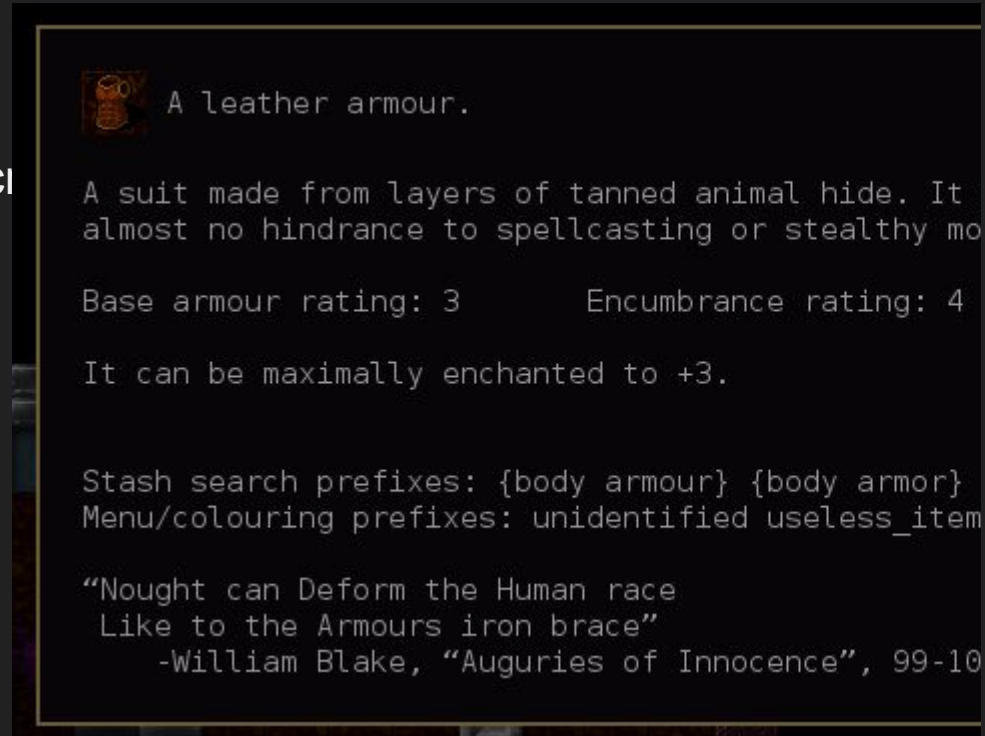
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
















Press v
to
describe

Leveling up in DCSS - Skill Points

Defeating an enemy provides experience

Wiki: “Allocating your XP to align with your aptitudes, available equipment, and playstyle will make or break your character.”

	Skill	Level	Train	Apt
	a + Fighting	6.1	17%	+2
	b + Short Blades	0.6		+1
	c + Long Blades	0.3		+2
	d + Maces & Flails	4.4		+2
	e + Axes	7.4	50%	+2

Skill	Level	Train	Apt	Skill	Level	Train	Apt
 a + Fighting	6.1	17%	+2	 p + Spellcasting	0.0		-4
 b + Short Blades	0.6		+1	 q + Conjurations	0.0		-3
 c + Long Blades	0.3		+2	 r + Hexes	0.0		-4
 d + Maces & Flails	4.4		+2	 s + Summonings	0.0		-3
 e + Axes	7.4	50%	+2	 t + Necromancy	0.0		-3
 f + Polearms	5.0		+2	 u + Translocations	0.0		-3
 g + Staves	1.0		+2	 v + Transmutations	0.0		-2
 h + Unarmed Combat	0.0		+1	 w + Fire Magic	0.0		-3
 i + Bows	0.0		+1	 x + Ice Magic	0.0		-3
 j + Crossbows	0.0		+1	 y + Air Magic	0.0		-3
k + Throwing	0.0		0	z + Earth Magic	0.0		-2
l + Slings	0.0		+1	0 + Poison Magic	0.0		-3
m + Armour	3.0		+2	1 + Invocations	0.0		0
 n + Dodging	4.4	15%	+1	 2 + Evocations	0.0		-1
 o + Shields	0.0		+2	 3 + Stealth	1.7	10%	-1

The percentage of incoming experience used to train each skill is in brown.
Skills enhanced by cross-training are in green.

[?] Help [=] set a skill target
[/] auto/manual mode [*] useful/all skills [_] enhanced/base level
[!] training|cost|targets

Characters have 33 Skills

Inventory Management

52 Slots in Inventory; Permanent vs. consumable items


Inventory: 52/52 slots


Permanent; Equippable

Hand Weapons


 R - a +9 bardiche of electrocution (weapon)


Missiles


 F - 15 javelins (quivered)


 S - 4 silver javelins


Armour


 m - the +2 pair of gloves of the Evening Star (worn) {rF+ rN+}

 y - a +2 cloak of stealth (worn)


 0 - a +2 pair of boots (worn)

 W - the +3 helmet of Leruluf (worn) {Rampage rC++ Int-2 Stlth+}

 Y - the +7 plate armour of Refuge (worn) {rCorr}


 s - the +2 pair of gloves of the Black Skies {rElec}

Jewellery

 v - a +4 ring of evasion (right hand)


 C - the amulet of the Four Winds (around neck) {rN+ Will+++ Clar}


 G - a ring of poison resistance (left hand)


 h - a +6 ring of strength


Scrolls


Consumables

 b - 5 scrolls of fear


 d - 11 scrolls of enchant armour

 l - 2 scrolls of silence

 p - 4 scrolls of amnesia


 q - 28 scrolls of remove curse


 t - 16 scrolls of teleportation


 u - 4 scrolls of magic mapping


 H - 10 scrolls of immolation

 K - 6 scrolls of fog

 M - 4 scrolls of vulnerability


 N - 16 scrolls of identify

 T - 2 scrolls of blinking


 V - 2 scrolls of torment

Potions


Consumables


 a - 2 potions of heal wounds


 c - 14 potions of lignification

 e - 18 potions of curing

 f - a potion of might

 g - 5 potions of resistance


 j - 9 potions of brilliance

 k - 6 potions of magic

 x - 2 potions of ambrosia

 B - 2 potions of cancellation

 E - 6 potions of invisibility

 P - 3 potions of haste

 U - 3 potions of berserk rage

 X - 5 potions of flight

Combat

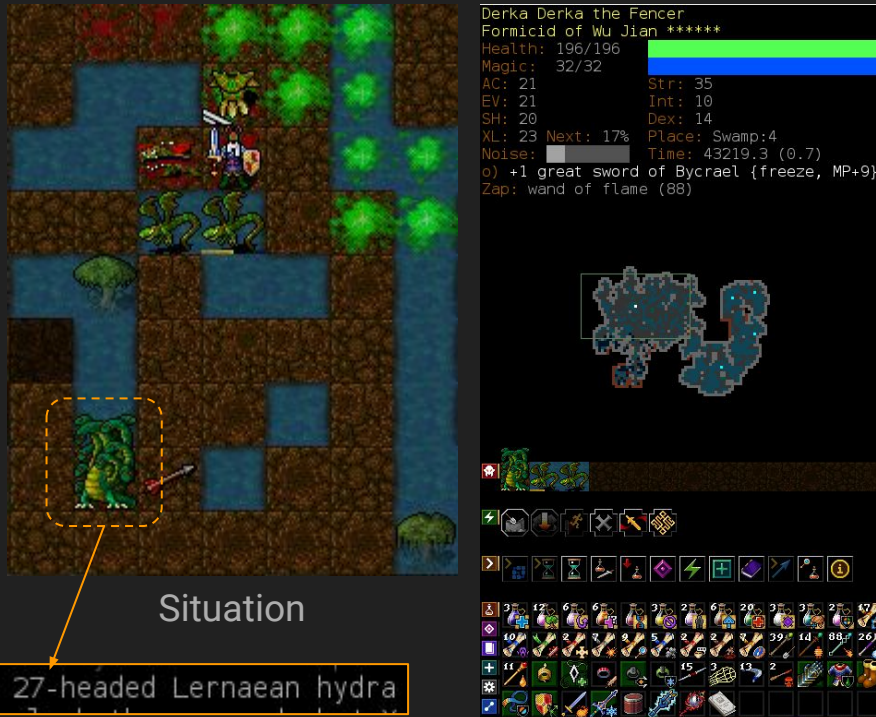
Primary activity of the game

Many different play styles

- Melee
 - Stealthy backstabber
 - Antimagic berserker worshipping Trog
 - Ranged character
- Spells
 - Situational magic: traps and clouds
 - Transformations - become a dragon, etc.
 - Summoning - control a horde of zombies, orcs
- Hybrid
 - Battlemage



A Difficult Combat Situation



Solutions recommended by other players:

- Use a Phantom's Mirror
 - Must have in inventory
 - Requires sufficient evocations skill
- Use a Scroll of Summoning
 - Must have in inventory
- Use a Wand of Scattershot
 - Must have in inventory
- Fight directly if AC > 30 and mid-tier weapon
- Summoning Scroll + Immolation Scroll
- Invis potion + run north + wall jump boost to slow "Lernie"
- Run away?
 - Are you fast enough?
 - How close are the nearest stairs?

Dungeon Map

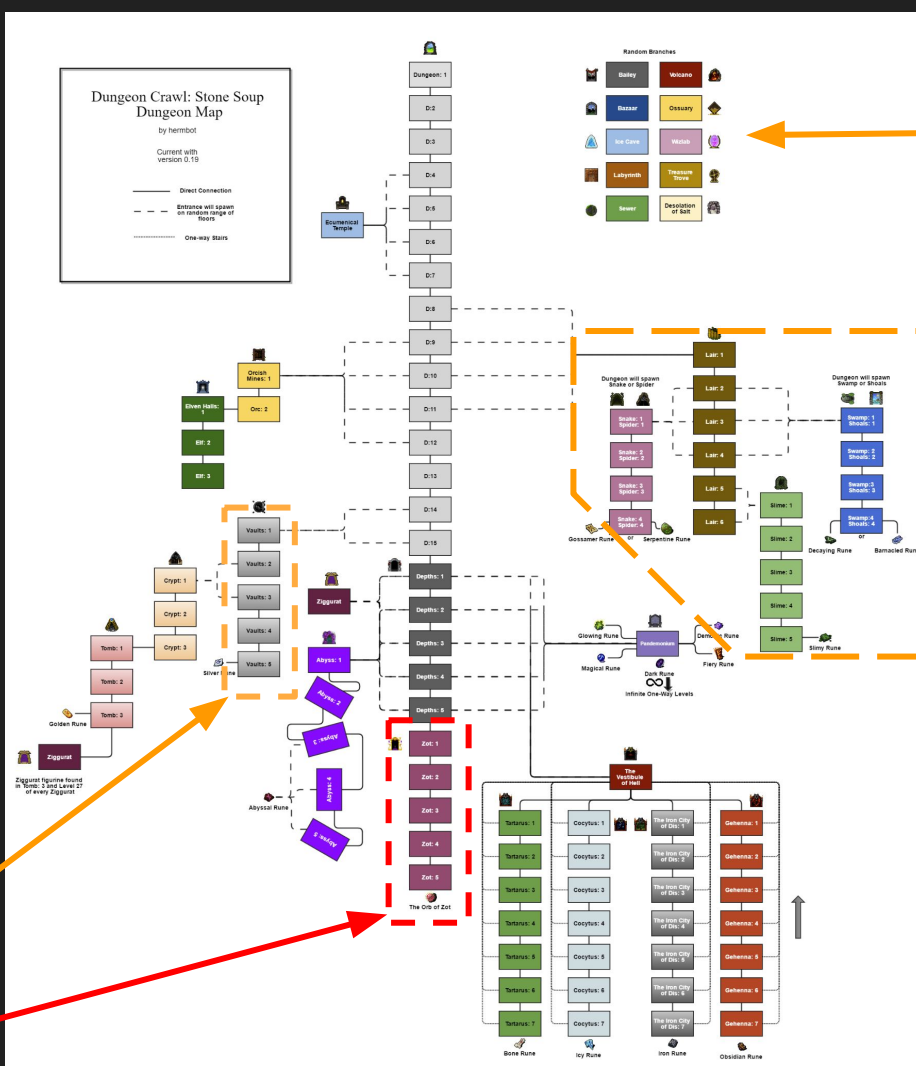
- More than 100 Levels
- 17 possible runes
- 3 runes needed to enter Zot

2 infinite realms:

- Pandemonium
- Abyss

Easier rune

Orb of Zot



8 Random Branches

Easiest runes

DCSS as an AI Challenge Problem

Features of Dungeon Crawl Stone Soup

- Stochastic Actions and Events
 - Ex: melee attacks may miss, hit for partial health, or kill a monster
- Non State Changing Sensing Actions
- Partially observable, unknown until explored
 - Line of sight is 7 tiles in all directions
- Procedurally Generated World
 - Unique every playthrough except if seed value specified
- Complex State Space
 - Minimum requirements to win include visiting ~70k tiles, thousands of monsters and items
 - 2 levels are infinite, change with every turn (abyss, labyrinth)
 - 650+ types of monsters
- Complex Action Space
 - More than 100 spell and melee action types, many actions requiring choosing targets
- Permanent Death

State Space Complexity - Lower Bound, 3-rune Game

Assumptions:

- 70,000 Tiles
- 900 Items
- 2000 Monsters

$$|S| = 70000^{2900} \approx 10^{14000}$$

Action Space Complexity

~50 action types

- 24 directional move / attack actions
- 2 macros for moving and fighting (o, tab)
- 2 resting actions
- 18 item actions (firing a missile, equip armour, evoke)
- 4 dungeon interaction actions (doors, stairs)

Players can learn up to 21 spells; carry multiple ranged weapons

Most spells and ranged weapons can target any creature in Line of Sight (7 tiles)

- Therefore up to 225 targets for a spell, including player tile

Result - upper bound could be ~30 types of ranged attacks... yielding 6750 possible instantiated actions

15 tiles



15 tiles

Features of a Good AI Challenge Problem

- Challenging
- Popular
- Available
- Easy to start
- Supported and maintained
- Publishable

Rogue-like Games as an AI Challenge Problem

Property	Dungeon Crawl Stone Soup	Nethack
Challenging	Currently Humans > AI	Currently Humans > AI
Popular	Active subreddit, IRC, wiki, discord	Active community
Available	AI API: <i>dcss-ai-wrapper</i>	AI API: <i>Nethack Learning Env.</i>
Easy to Start	Yes - tutorials available	Yes - tutorials available
Supported and maintained	Yes - under development (me) <i>Open invitation to contribute!</i>	Yes - supported by Facebook AI Research
Publishable	Yes	Yes

Additional Benefit: It's hard for most humans

↑
6
↓
Posted by u/moonmancer 6 years ago
I just won my first game ever... with a FoFi^Ru

After years of playing very casually, I finally did it! I have no idea how to link my morgue so you guys can have a look and give me some advice but I'm really really really happy. Formicid are awesome for orb escape and Ru has amazing abilities!

💬 14 Comments ➦ Share 📌 Save

↑
35
↓
r/ dcss · Posted by u/loewenheim 3 months ago 🐾
[YAVP] First win with a MiBe, only took me hundreds of games

I think I was pretty overpowered at the end, but Realm of Zot wasn't easy regardless.

<https://crawl.xtahua.com/crawl/morgue/MoonlitKnight/morgue-MoonlitKnight-20210808-202226.txt>

💬 6 Comments ➦ Share 📌 Save 🙏 Hide 🚩 Report

100% Upvoted

↑
15
↓
r/ dcss · Posted by u/Odexios 3 months ago
[YAVP] 3 runes, my first victory! MiFi of Oka

Morgue here.

After more than 10 years from my first game, I've finally won for the very first time! I got a couple of

Features of a Good Goal Reasoning Challenge Problem

- Multiple Types of Goals
 - Achievement goals
 - Maintenance goals
 - Learning goals
- Goals over varying time horizons
 - Near term and long term goals
- Rich goal space
 - Many specific state features are desirable as goals
 - Not just a short list of goal types that a human provides (such as navigation)
- Pursuing more than one goal at a time improves performance

Achievement Goals in DCSS

A non-exhaustive list:

- Exit the dungeon with the orb of Zot (Highest goal)
- Obtain a rune (direct pre-req. to get orb)
- Acquire strength in:
 - Player stats / skills / weapons & armour
- Defeat a monster
- Acquire items
- Navigate to a tile

Maintenance Goals in DCSS

A non-exhaustive list:

- Keep health points high
- Keep magic points high
- Keep other player stats high
- Piety
- Stealth

```
MrFoo the Spear-Bearer
Merfolk of Xom ..*...
Health: 87/87
Magic: 10/10
AC: 8 Str: 18
EV: 26 Int: 8
SH: 0 Dex: 15
XL: 10 Next: 32% Place: Dungeon:10
Noise: Time: 9197.7 (19.0)
w) +2 spear (flame)
H) 2 throwing nets
```

Knowledge to Learn in DCSS

State Transitions:

- Player's actions
 - Only living monsters will follow you up stairs
- Events
 - Fire spells over water may produce steam
- Processes
 - The rate at which health regenerates
 - Damage from actions change as you get stronger

Strategy:

- Bees travel in groups, most characters cannot outrun bees
- Bladed weapons against hydras will make them stronger unless they are branded with fire
- It is often easier to fight many enemies in a hallway 1v1 than in large open areas

Fighting in a hallway (GIF)

Winning DCSS

Some speculative thoughts

Learning as a Requirement

Intractable to human-author a complete, accurate model

- Hint: It's always changing

Any AI that's going to solve DCSS must be a learning agent

Which approach is best to solve DCSS:

Cognitive System approach? Or Deep RL End to End system?

Measuring Performance in DCSS

Well-known Metrics:

- # of wins / attempts
- Efficiency of wins
- Resources required for training (simulations, etc.)

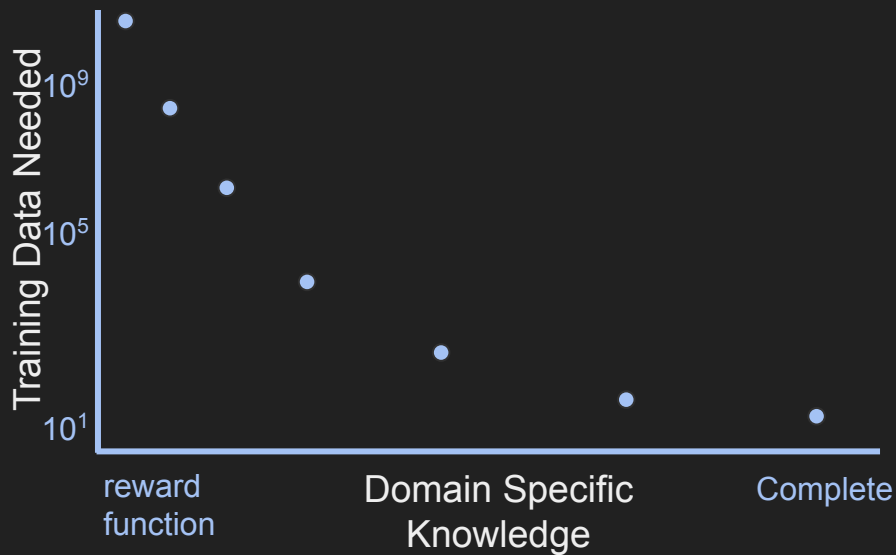
Less-obvious, critical metrics should address:

- How much knowledge is given to the agent?
- How much human time is spent encoding the knowledge to the agent?
 - *Wishful thinking?*

Measuring Human-Authored Knowledge

How much knowledge has been given to the agent?

Speculative Hypothesis:



Common phrase heard from
cog. sys. folks:

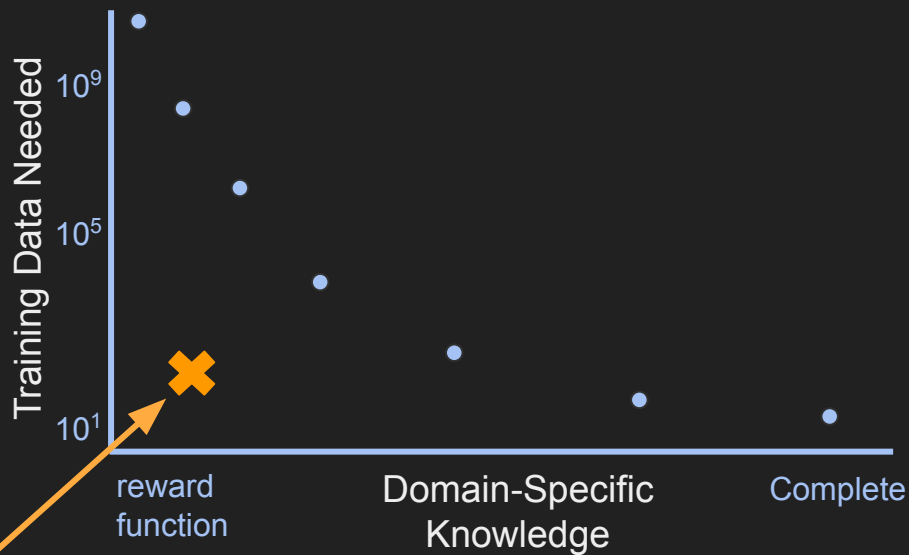
*“With just a little bit of
knowledge, it could learn way
faster. After all, humans don’t
need so many examples”*

*DCSS-AI-Wrapper seeks to
measure this precisely!*

Types of Knowledge to Measure:

- Reward functions (incl. curriculums)
- Action / Event / Process Models
 - Varied by accuracy and completeness
- Strategy Knowledge
 - May take many forms
 - Schedules
 - Sub-goal Trees
 - Facts (ex: monster X weakness)

Bigger Goal: Can we do better?



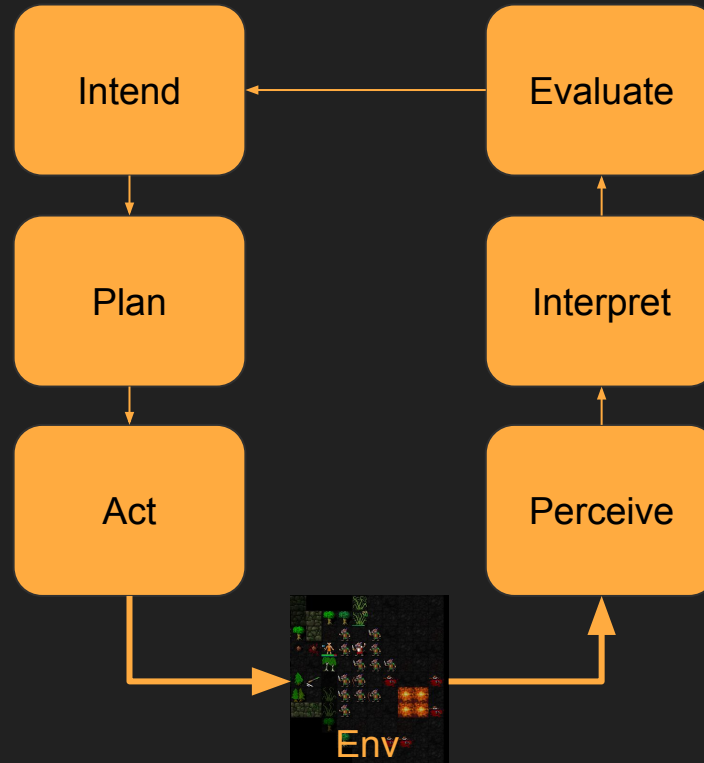
Can we build a cognitive architecture to achieve this?

Learning as a Metacognitive Process

Cognition is Reasoning About the World

Examples:

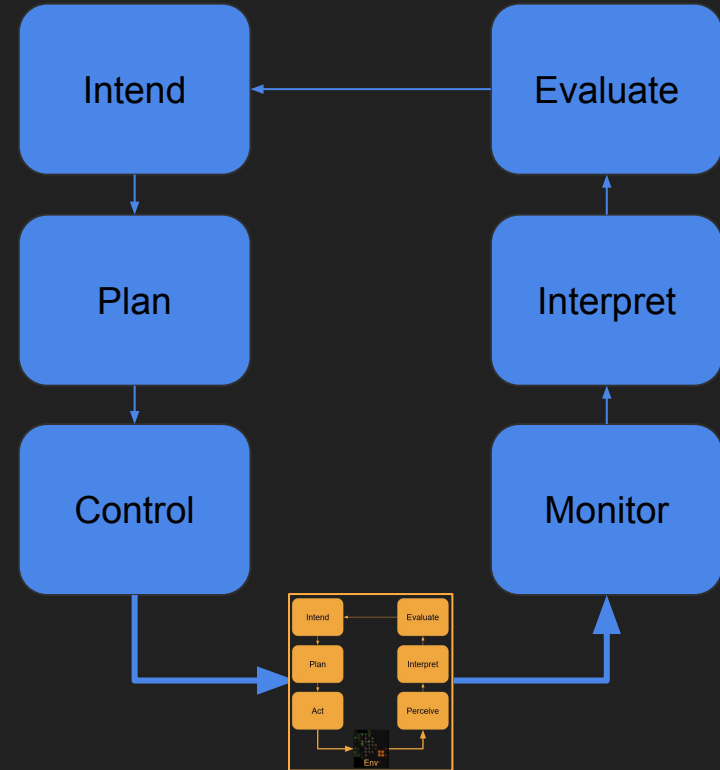
- Beliefs and Goals are World States
- Actions change world states
- Interpret detects anomalous world states



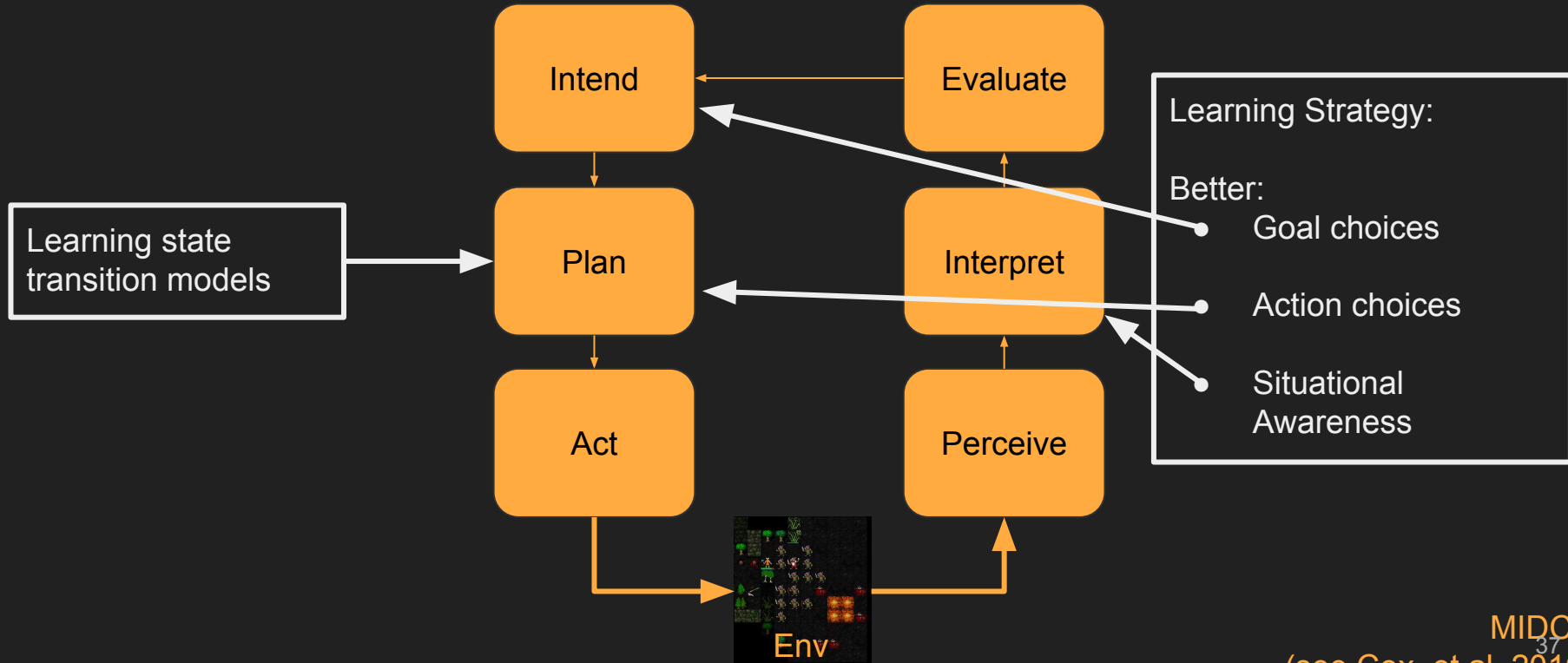
Metacognition is reasoning about Cognition

Examples:

- **Monitor** perceives the state of cognition
- **Interpret** detects anomalies in cognition
 - Failure to explain
 - Failure to plan
 - Failure of cyclic behaviors
- **Control** modifies cognition
 - Change parameter of an algorithm
 - Change algorithm
 - Change knowledge



Changing Knowledge in MIDCA



DCSS-AI-Wrapper

DCSS-AI-Wrapper

An AI-friendly API to DCSS

Goals:

- Make it easy for AI researchers to use DCSS as a test environment
- Preserve the DCSS game engine

Motivation:

- Push the field to use more complex domains as testbeds in every-day research
 - Only as an addition, not to replace other domains!

Features of the DCSS-AI-Wrapper

- Multiple state representations
 - Currently vector-based representations and PDDL 2.2
 - Low-effort to add new representations (such as other PDDL variants)
- An approximate, high-level PDDL domain file
 - ~2100 lines, includes all types of objects, monsters, spells, items, etc. & basic actions
 - Currently works with the FastDownward planner
- Cross-platform - works on Windows, Mac, Linux
- Support for running many experiments
 - Configuration options to easily set parameters
 - Auto-restart a game
 - End a game after X actions

Code to create an agent

```
1  from dcss.agent.base import BaseAgent
2  from dcss.state.game import GameState
3  from dcss.actions.action import Action
4
5  class MyAgent(BaseAgent):
6
7      def __init__(self):
8          super().__init__()
9          self.gamestate = None
10
11     def get_action(self, gamestate: GameState):
12         self.gamestate = gamestate
13         # get all possible actions
14         actions = Action.get_all_move_commands()
15         # call your planner or policy instead of random:
16         return random.choice(actions)
```

Only Requirements:

1. Subclass BaseAgent
2. Override get_action()

Code to run an agent

Option to set configuration values when running

```
1  from dcss.websocketgame import WebSocketGame
2  from dcss.connection.config import WebserverConfig
3
4  def main():
5      my_config = WebserverConfig
6
7      # set game mode to Tutorial #1
8      my_config.game_id = 'tut-web-trunk'
9      my_config.tutorial_number = 1
10
11     # create game
12     game = WebSocketGame(config=my_config,
13                           agent_class=MyAgent)
14
15     game.run()
```

Set your agent here

game.run() is a blocking call

Planning Agent Demo

Hallmark of DCSS-AI-Wrapper: Both Vectors & PDDL

Vector Based Representation

- Player stats (vector)
- Player inventory (vector)
- Player spells (vector)
- Player abilities (vector)
- Player skills (vector)
- Map data Line-of-Sight (LOS) (vector)
- Map data current level (vector)
- Map data all (vector)

PDDL State Representation

- Player stats (PDDL)
- Player inventory (PDDL)
- Player skills (PDDL)
- Map data Line-of-Sight (LOS) (PDDL)
- Map data current level (PDDL)
- Map data all (PDDL)
- Static Background Knowledge (PDDL)

PDDL Model of the game (~2k lines):

- Works with the FastDownward planner
- In the repo:
models/fastdownward_simple.pddl

Hallmark of DCSS-AI-Wrapper: Both Vectors & PDDL

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The map data LOS vector is comprised of 225 tile vectors, with each tile vector length 30 (total vector size being 6750)

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- Player stats (PDDL)
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 - Map data Line-of-Sight (LOS) (vector)
 - Map data current level (vector)
 - Map data all (vector)
- Available**
- Next up on the dev agenda**

The map data LOS vector is comprised of 225 tile vectors, with each tile vector length 30 (total vector size being 6750)

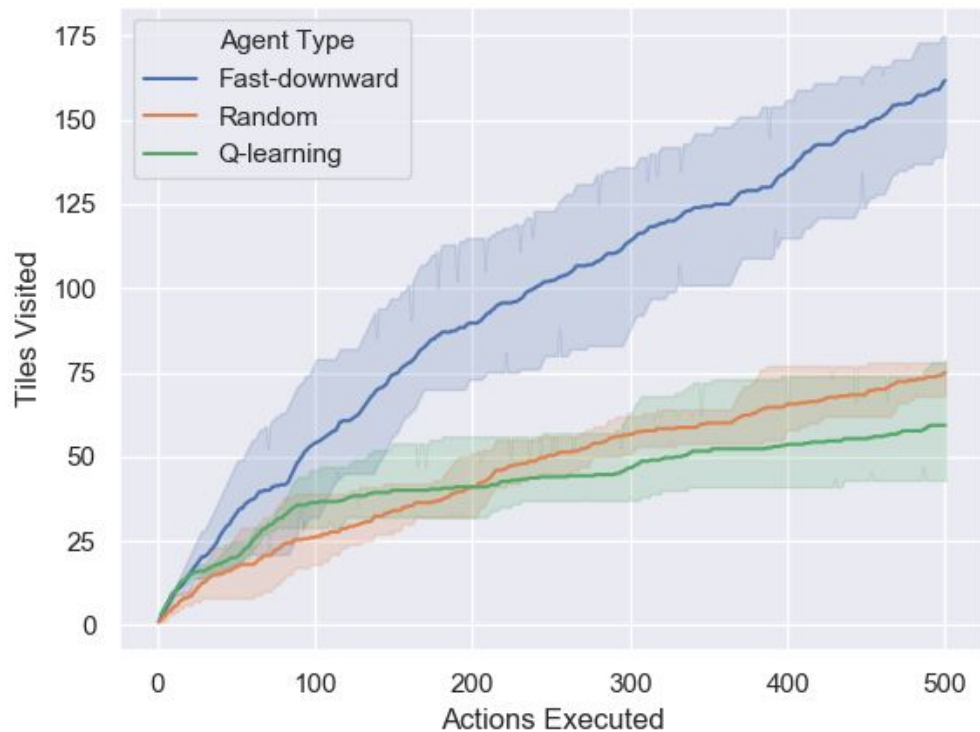
PDDL State Representation

- Player stats (PDDL)
 - Player inventory (PDDL)
 - Player skills (PDDL)
 - Map data Line-of-Sight (LOS) (PDDL)
 - Map data current level (PDDL)
 - Map data all (PDDL)
 - Static Background Knowledge (PDDL)
- Available**
- Next up on the dev agenda**
- Available**

PDDL Model of the game (~2k lines):

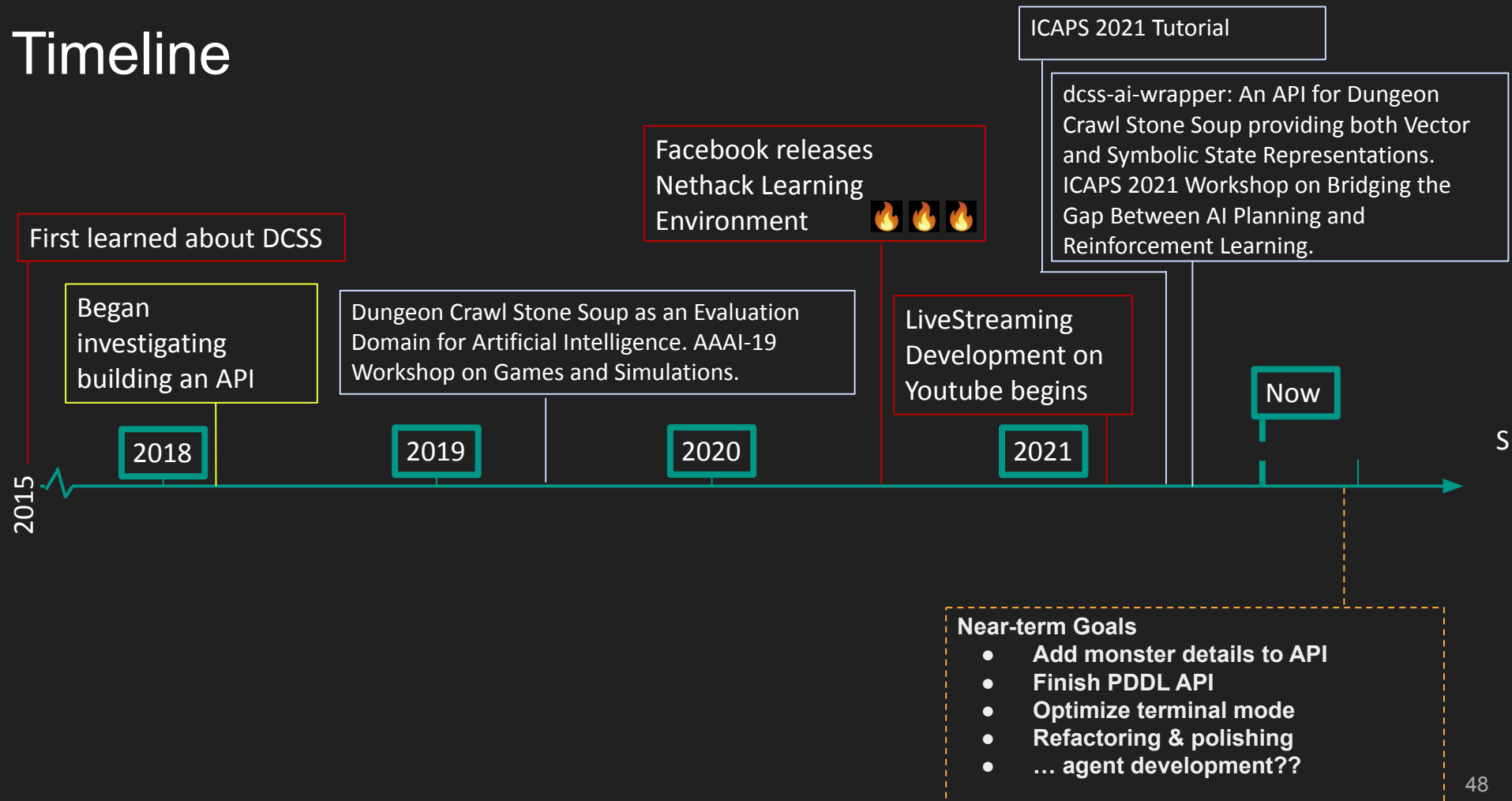
- Works with the FastDownward planner
- In the repo:
models/fastdownward_simple.pddl

Comparing Diverse Agents



Data collected from agents using the dcss-ai-wrapper API

Timeline



Getting Started

Code:

[Github: dcss-ai-wrapper](#) & [Documentation](#)

Resources:

[Recent ICAPS Tutorial Documentation](#)

[ICAPS Tutorial Youtube Video](#)

Join the conversation and ask questions at the [Gitter](#)

Thank you to my collaborators

Michael W. Floyd @ *Knexus Research Corporation*

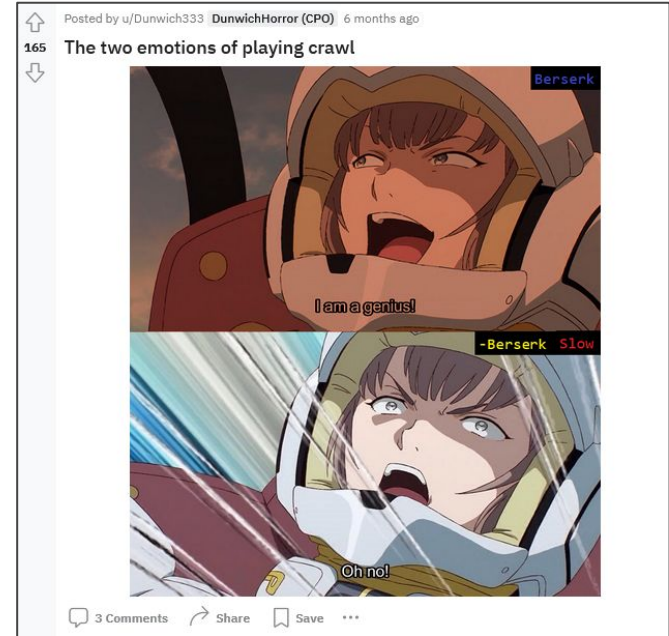
Zohreh A. Dannenhauer @ *Knexus Research Corporation*

Adam Amos-Binks @ *Applied Research Associates*

Jonathan Decker @ *Naval Research Laboratory*

David Aha @ *Naval Research Laboratory*

Noah Reifsnyder @ *Lehigh University*



End