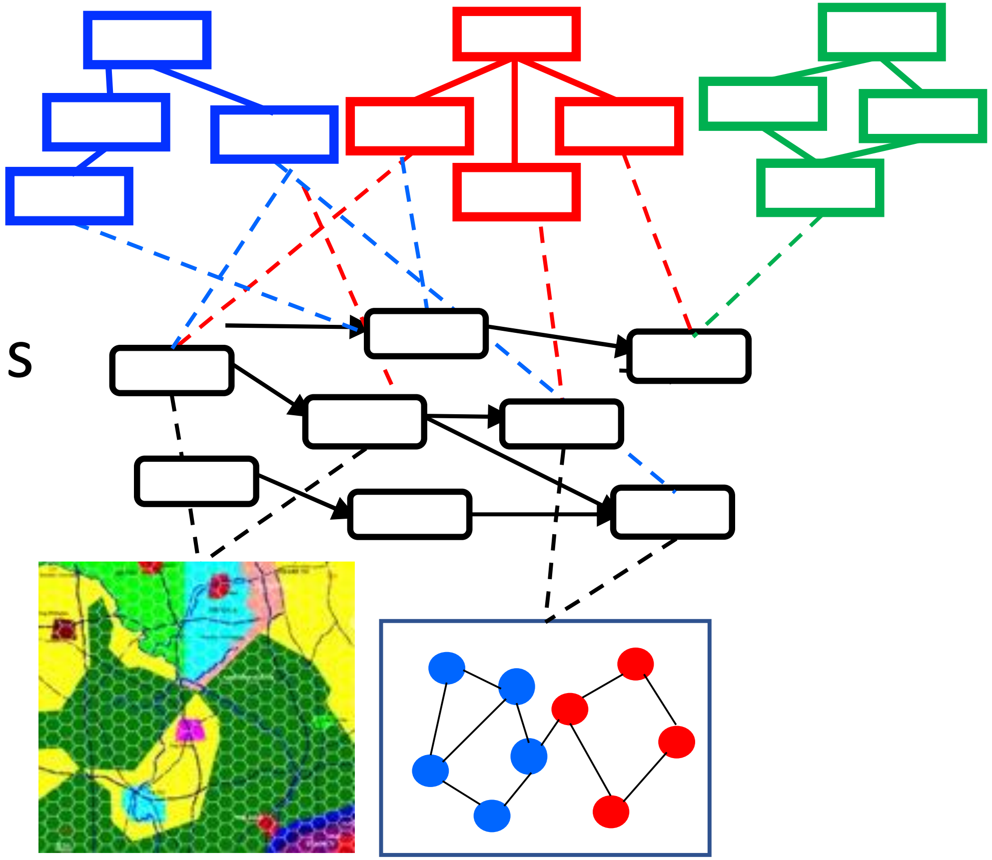
Learning Agent Goal Structures by Evolution

Group **Goal** Hierarchies (HGNs)

Causal Relations among **Events**



Geospatial Movement

Social Interactions

SCAMP

Social
Causality with
Agents using
Multiple
Perspectives

(Friday, Platinum 5-7 11:24, Poster 145)

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Overview

- **What are we trying to do?**
- Applying GP to an HGN
- Test Data
- Experiments
- Lessons Learned

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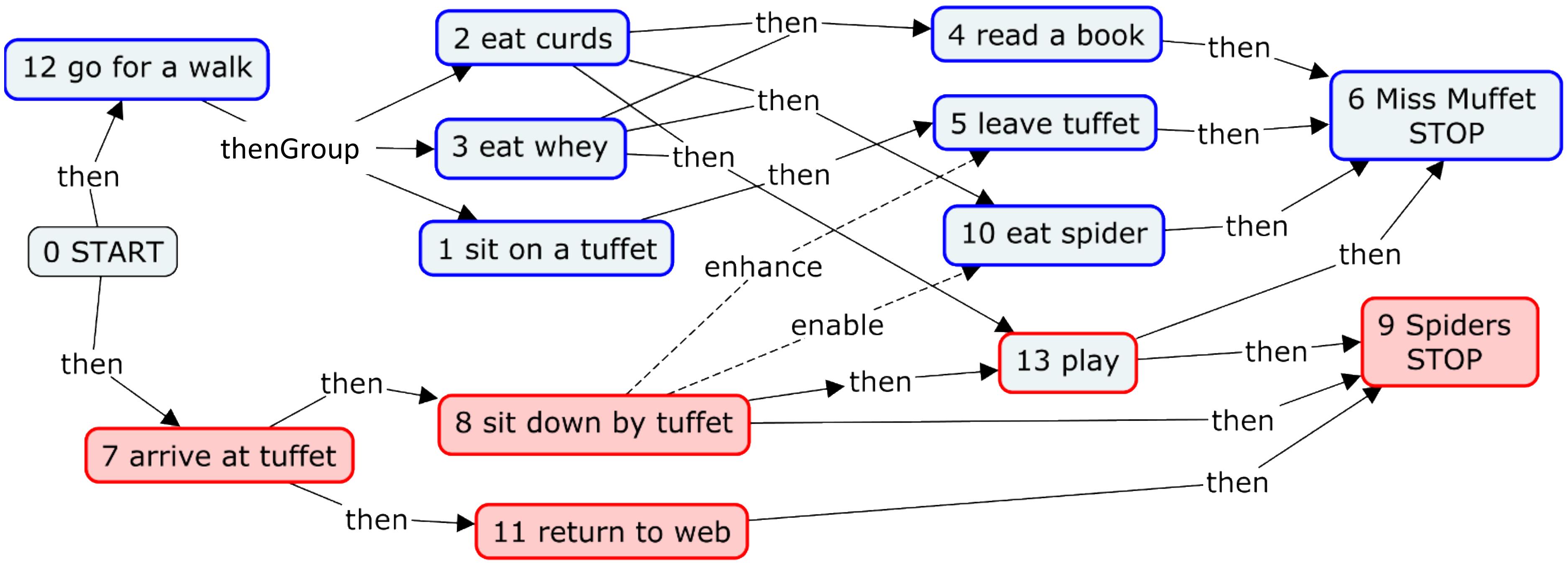
What are we Trying to Do? Decision *Environment*



- Group-specific subgraphs: Miss Muffet, spiders, (nature)
- Agency edges (solid) → accessibility
- Influence edges (dashed) → likelihood

First grade:

Little Miss Muffet
Sat on a tuffet
Eating her curds and whey.
Along came a spider
And sat down beside her
And frightened Miss Muffet away.

Fifth grade boys:

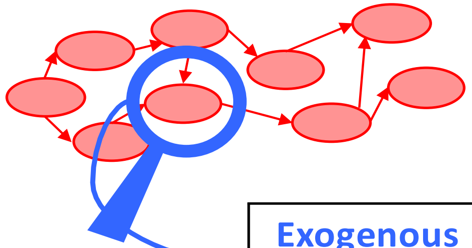
Little Miss Muffet
Sat on a tuffet
Eating her curds and whey.
Along came a spider
And sat down beside her
And she ate that too.

Woodstock:

Little Miss Muffet
Sat on a tuffet
Eating her curds and whey.
Along came a spider
And sat down beside her
And they began to play

What are we Trying to Do? Decision *Process*

Feature-Preference Decision Process



Hierarchical Goal Network

Exogenous			Urgency		Presence	
-.2	.4	.7	.0	-.4	.8	.2

Option **Features**

Dot product, Exponentiate

Weighted selection

Exogenous			Urgency		Presence	
.1	-.3	.4	.8	-.7	.7	.5

Actor **Preferences**

Quality-Based HGN (< TÆMS)

1 Agent choice → **participation** on events

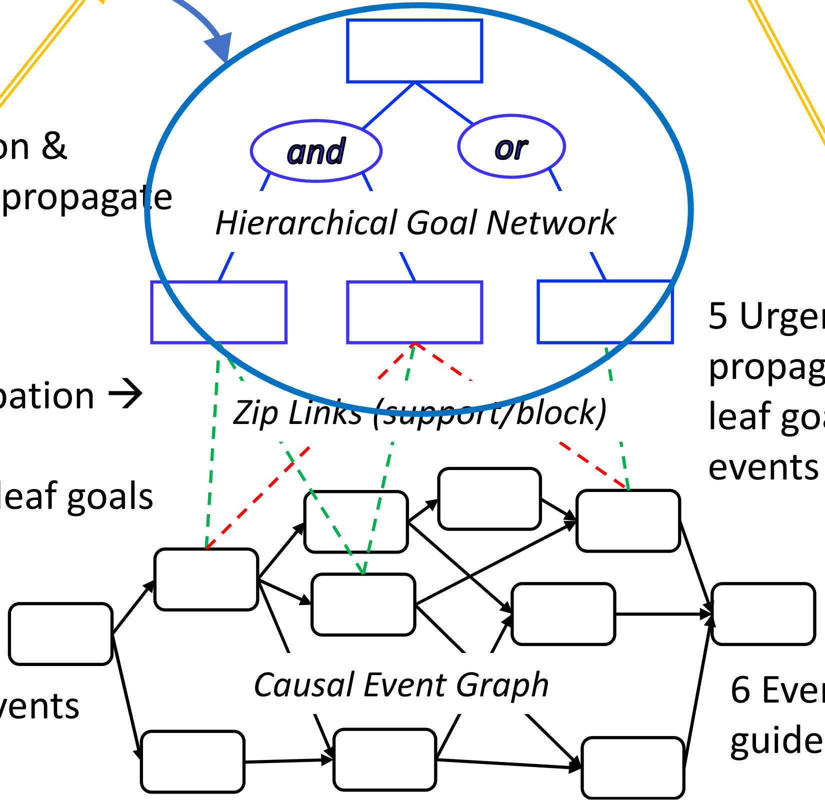
2 Event participation → Satisfaction & Frustration on leaf goals

3 Satisfaction & Frustration propagate up to root

4 Root Urgency = 1 – Satisfaction
Root Tolerance = 1 - Frustration

5 Urgency & Tolerance propagate down to leaf goals & zipped events

6 Event **Urgency** guides agent choice



H. V. D. Parunak. Learning Actor Preferences by Evolution. In Proceedings of The 2021 Conference of The Computational Social Science Society of the Americas, Santa Fe, NM, pages 85-97, Springer International Publishing, 2022. https://www.abcresearch.org/abc/papers/CSS21BehaviorModeling.pdf

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Applying Genetic *Programming* to an HGN

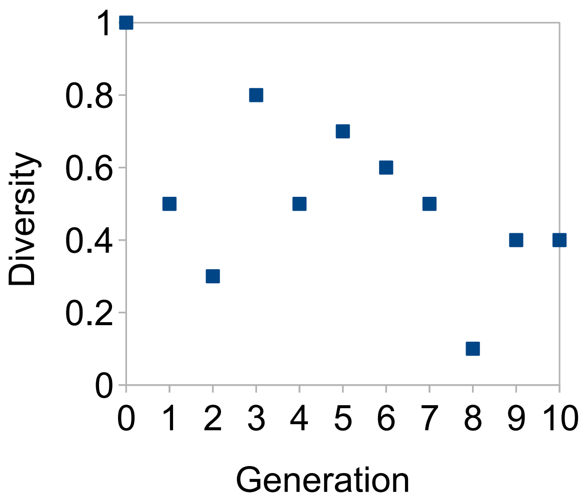
Genome: Preorder traversal of goal tree

Mutation / crossover: one child by each per generation → 3 children per generation

- Mutation: replace node with randomly generated node
  - If leaf, grow a subtree
  - If not, inherit children
- Crossover: replace node and descendants

Issue with crossover: diversity loss

→ Solution: repeat operation until it produces an individual not already in the population



Fitness: compare **target** trajectory (sequence of actor choices to be matched) with **test** trajectory (generated by candidate HGN, repeated runs). Can compare

- **Paths** of nodes visited, e.g., 0-32-159-14-32-292-21-14-201
- **Node sets,** e.g., {0, 32, 159, 14, 292, 21, 201}
- **Node spectra** (counts of nodes visited), e.g., [0:1, 32:2, 159:1, 14:2, 32:1, 292:1, 201:1]
- **Path spectra** (counts of distinct paths generated)

0: Levenshtein distance over paths

1: Cosine similarity of node spectra

2: Cosine similarity of path spectra

3: Normalized length of longest common prefix

4: **Normalized intersection of node sets visited**

5: Correction of #4 by missing nodes

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Test Data

Test Graph:
Digraph of 300 nodes
Target node degree: 6

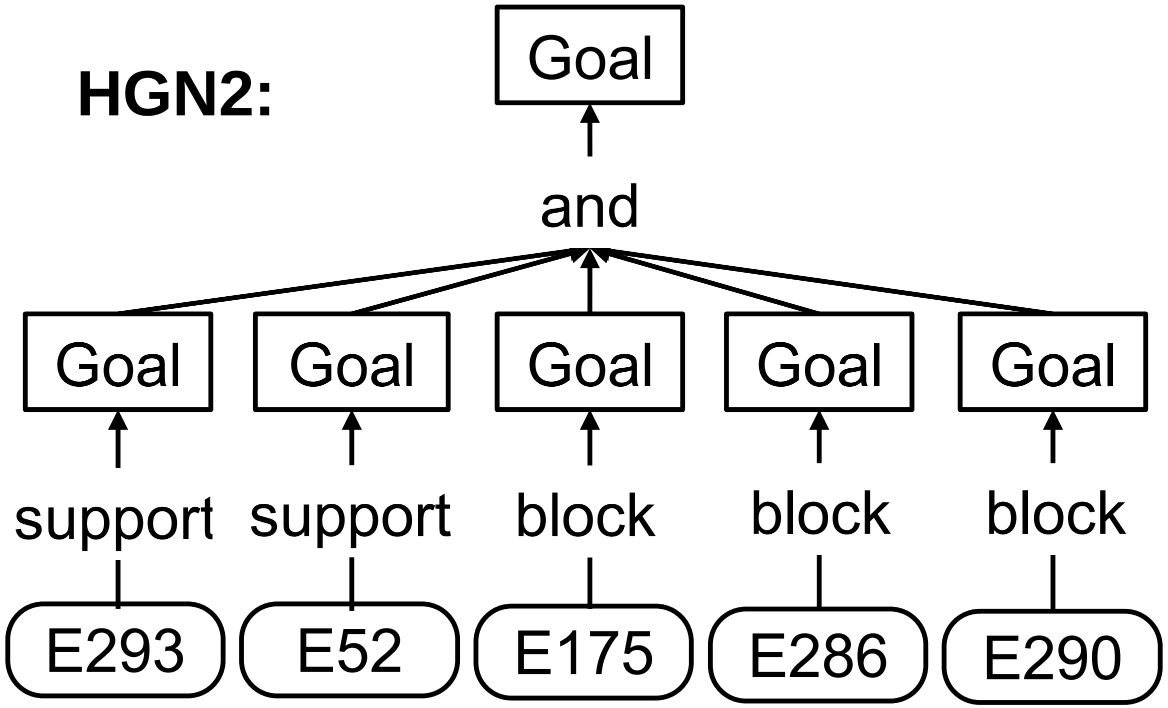
Use Cases:
1. Match trajectory of target HGN
2. Match arbitrary trajectory

Beh1: Manually Constructed Path
0-293-52-47-**124**-263-171-301

HGN1: Goal(support(E126))
Generated by running most promising fitness function (4) backwards (evolve *maximally* different trajectory from null HGN)

HGN2:
Manually constructed to include 124

HGN2:



Overview

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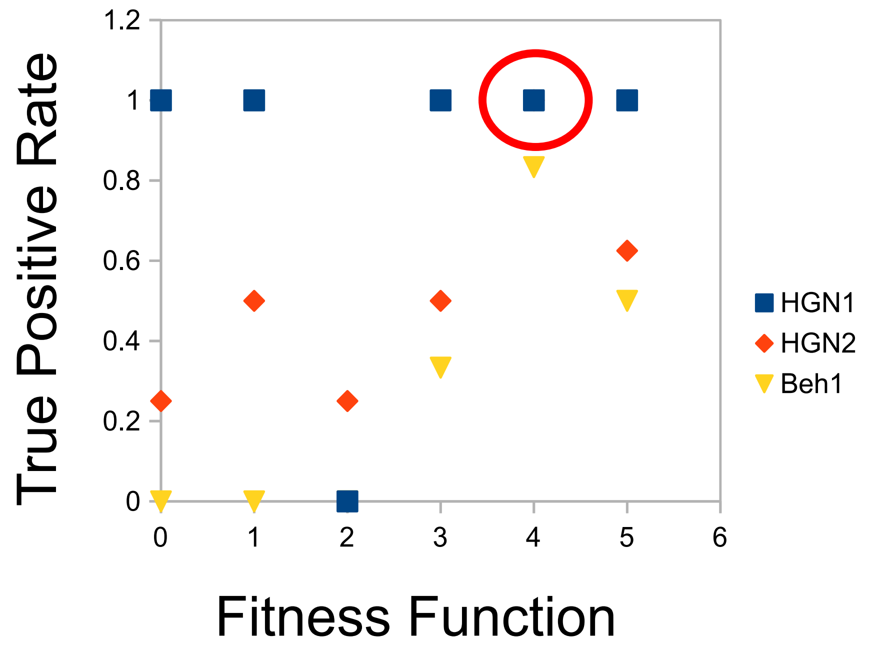
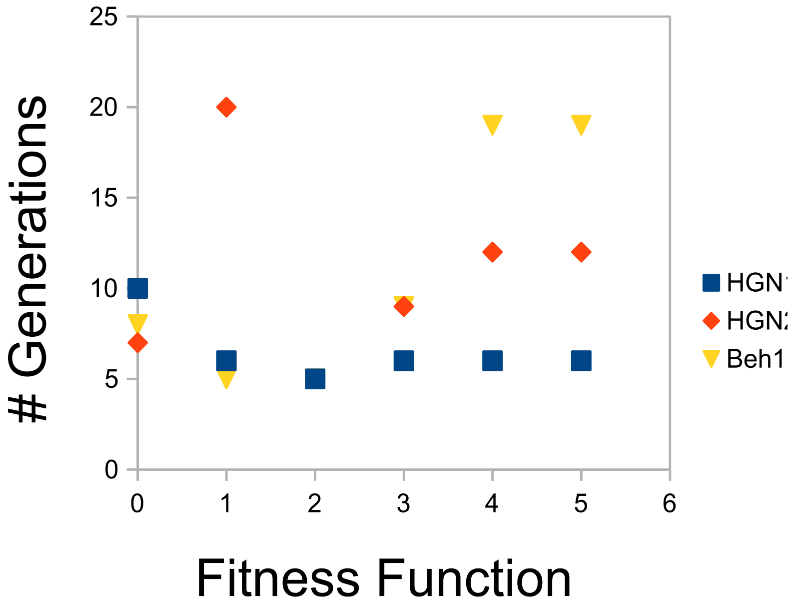
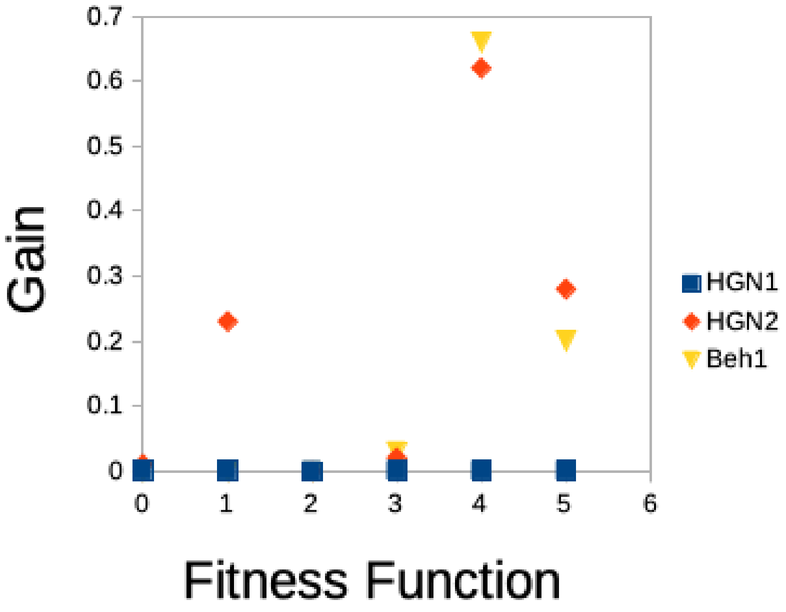
Experiments

Three inputs: HGN1, HGN2, Beh1
Six fitness functions: 0-5
Metrics:
- # generations (no improvement in 5 generations, or gen 20)
- Fittest HGN found ('=': recovered input)
- Gain in fitness from first to last generation
- # of distinct nodes in target trajectory
- # of hits (nodes in target also in test)
- # of false positives







Overview

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Lessons Learned

- **We can recover an HGN** that generates (most of) an input trajectory
  - Exception: node 124 in Beh1
- **The recovered HGN may not be the original HGN.**
  - Comparable to experience with preference vectors
  - Much of behavior is constrained by environment other than HGN (Nature-Nurture tension)
- **Problem with node 124:** inconsistent with dynamics of overall environment?
- **Fitness matters.** Fitness 2 consistently fails; fitness 4 dominates
- **Opportunities for future work:**
  - Explore variations to the directed graph (decision topology)
  - Explore the GP parameter space
  - Can we combine evolution of preference space with goal space (two-armed bandit)? (might allow recovering node 124)

Discussion and Questions

http://clipart-library.com/clipart/1422294.htm