AI6125 Multi-Agent System

Group Assignment: Tile World

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Agenda

- Introduction
  - Environment
  - Task
  - Objective
  - Agent Specification
- Agent Architecture
  - AStarAgent
  - BondAgent
  - Hybrid Procedural Reasoning Agent
- Code that was modified
- Demo

Introduction

Environment:

MASON agent toolkit, a Java-based tool, that implement agent which can inhabit and perform in Tileworld system.

Task:

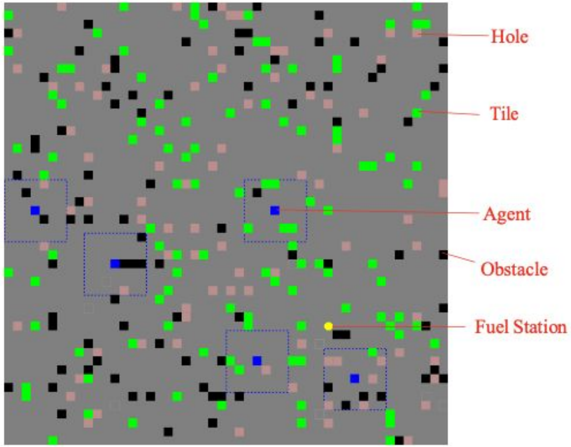
Each member to design and implement one agent.

Introduction

Objective:

Get highest score, score 1 point by filling a hole with a tile.

Symbology:



Introduction

Agent Specification:

Agent’s visibility is 3 tiles in all directions.

Available actions: WAIT, MOVE (UP, DOWN, LEFT, RIGHT), PICKUP, DROP & REFUEL

Agent carries up to 3 tiles.

Every movement consumes one fuel.

Agent perform Sense-Communicate(optional)-Plan-Act cycle once per time step.

Agent Architecture 1 - Simple Reactive Agent

- The agent follows an sense-think-act cycle

Sense:

- The agent observes the tiles in the environment using the TWAgentSensor class and acts upon it.

Think:

- The agent adopts AStarSearch to identify paths between tiles and available holes and the fuel station.

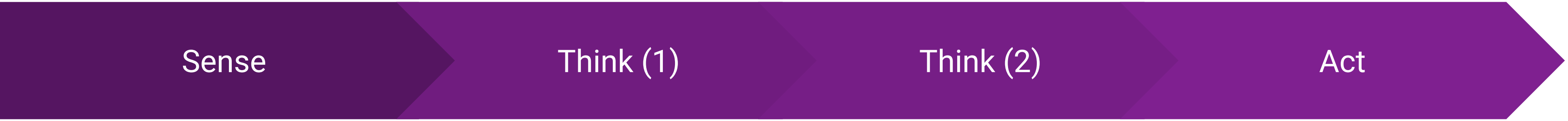
Act:

- The agent performs the intended action

Agent Architecture 1 - Code Modified

- The agent is an extension of the TWAgent class.
- TWPlanner and Memory classes are modified as well.

Agent Architecture 2 - Reactive & Limited Communication



Sense

Identify entities within agent's visibility

Think (1)

Search for fuelStation by going to respective checkpoints

Broadcast fuelStation's location to environment

All agents to remember fuelStation's location and transit to next phase

Think (2)

Check fuel

Check nearby holes

Check current load

Check nearby tiles

Act

Refuel

Drop tiles in hole

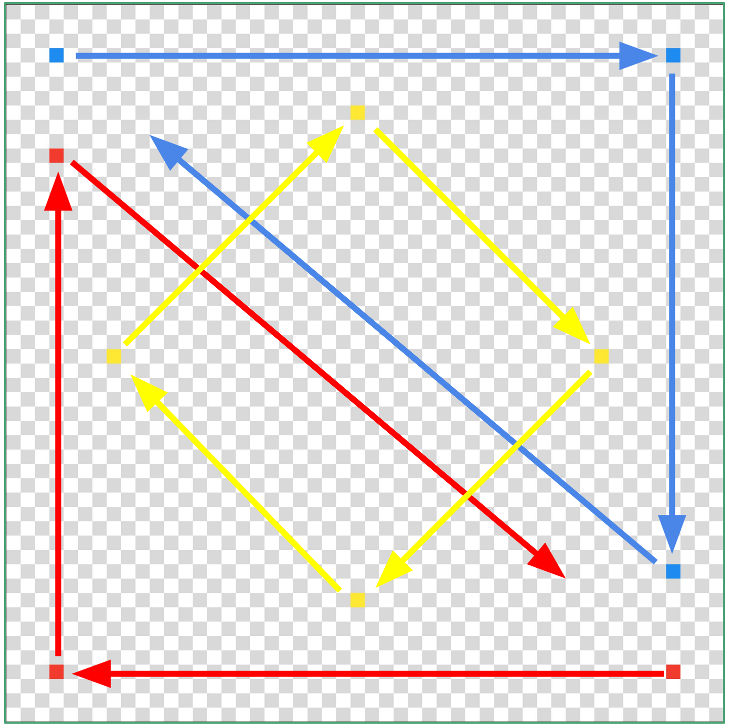
Pickup tiles

Random walk

Agent Architecture 2 - Search for fuelStation

Each agent is assigned with a few unique checkpoints.

They will use AStarSearch to find the path to their checkpoints in ascending order - 1, 2, 3, 4, ...



Agent Architecture 2 - Code Modified

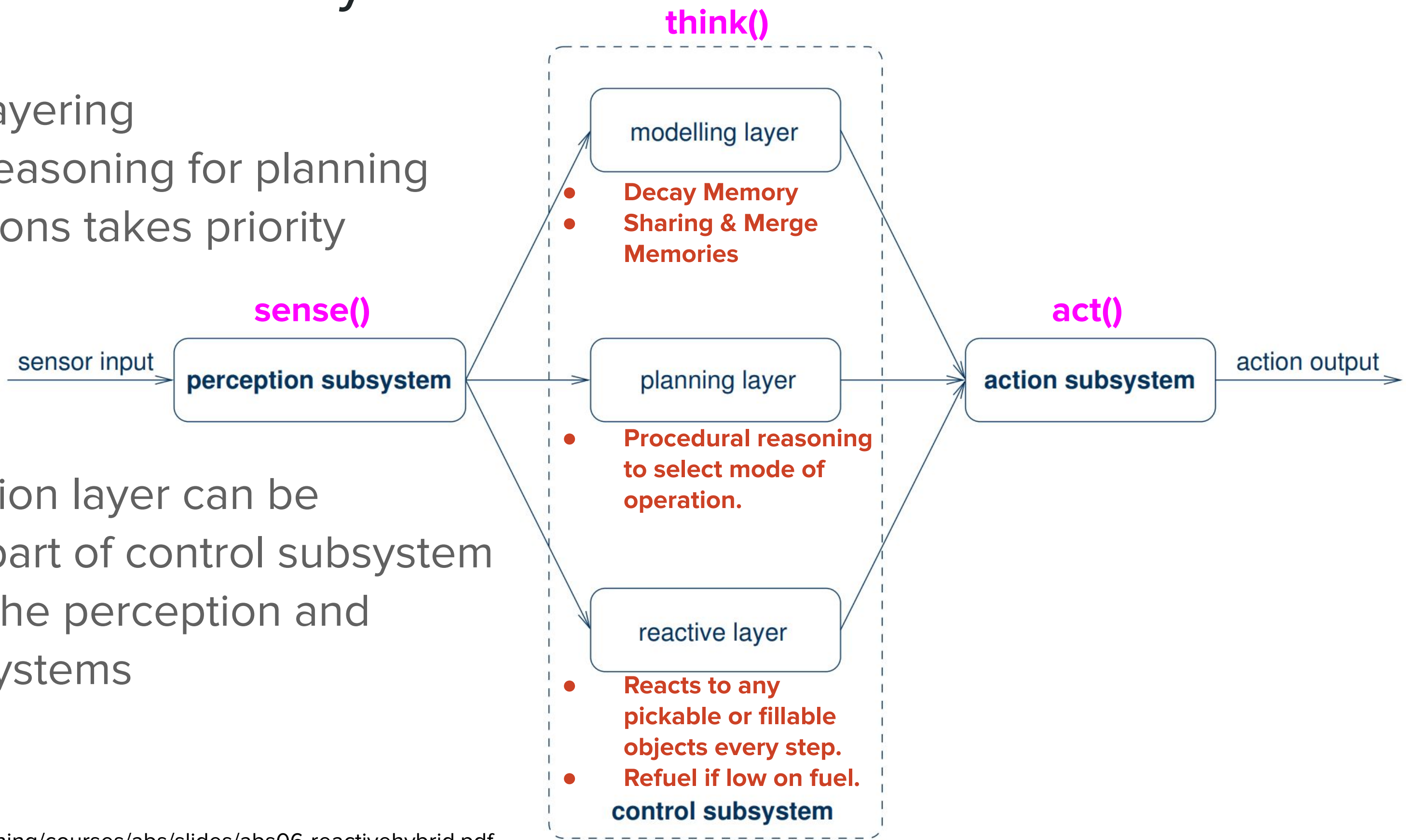
Agent 2 is fully coded using the extension to the TWAgent class.

The other classes remained as default.

Agent Architecture 3 - Hybrid & Communication

- Horizontal Layering
- Procedural reasoning for planning
- Reactive actions takes priority

- Communication layer can be considered part of control subsystem or between the perception and control subsystems



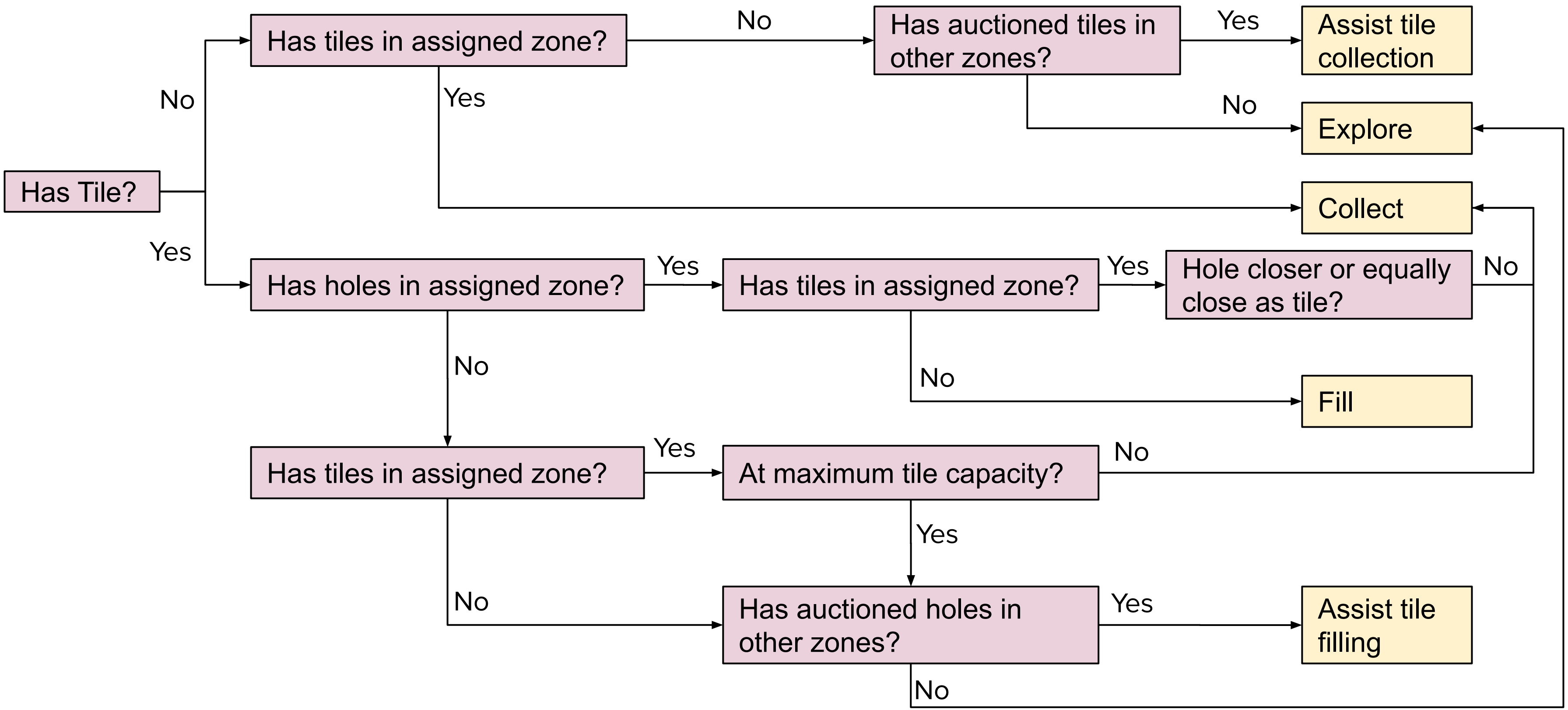
- Decay Memory
- Sharing & Merge Memories

- Procedural reasoning to select mode of operation.

- Reacts to any pickable or fillable objects every step.
- Refuel if low on fuel.

Figure source:http://www.inf.ed.ac.uk/teaching/courses/abs/slides/abs06-reactivehybrid.pdf

Agent Architecture 3 - PRS Reasoner

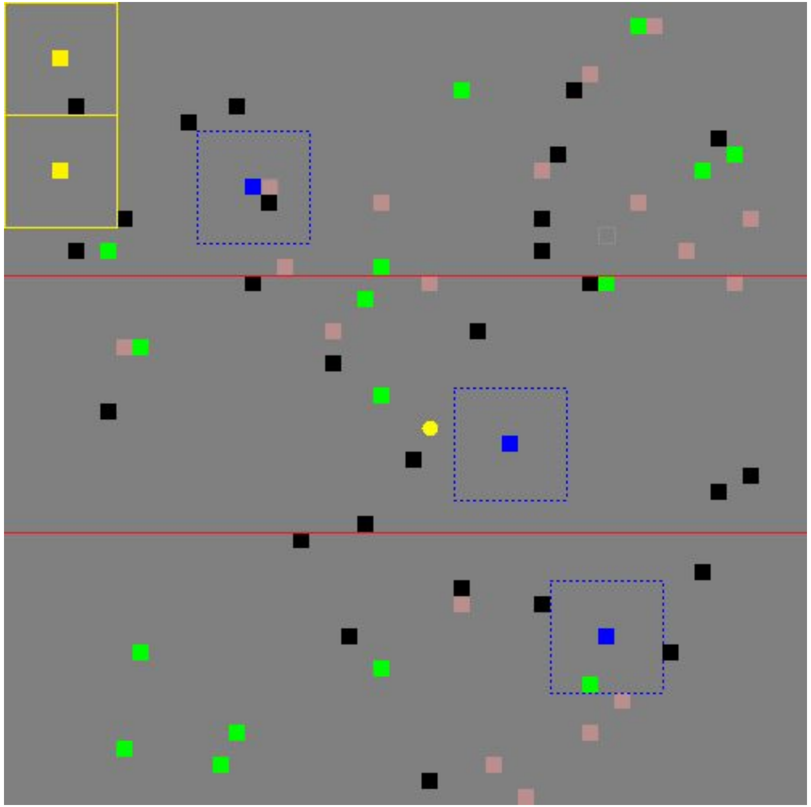

Has Tile?
No
Yes
Has tiles in assigned zone?
No
Yes
Has auctioned tiles in other zones?
Yes
No
Assist tile collection
Explore
Collect
Has holes in assigned zone?
Yes
No
Has tiles in assigned zone?
Yes
No
Hole closer or equally close as tile?
No
Fill
Has tiles in assigned zone?
Yes
No
At maximum tile capacity?
No
Yes
Has auctioned holes in other zones?
Yes
No
Assist tile filling

Agent Architecture 3 - Exploration Strategy

- Divides map into as many zones as agents detected in environment
- Detect agents through checking unique identifier in broadcasted messages
- Division of map and computation of boundaries is decentralized to prevent systemic failure in case of communication breakdown
- Division logic is deterministic and every agents arrive at the same results using the same agent position messages broadcasted
- Major zones are further subdivided into anchor zones determined by sensor range

Agent Architecture 3 - Exploration Strategy

- 50x16 zone
- 50x16 zone
- 50x18 zone



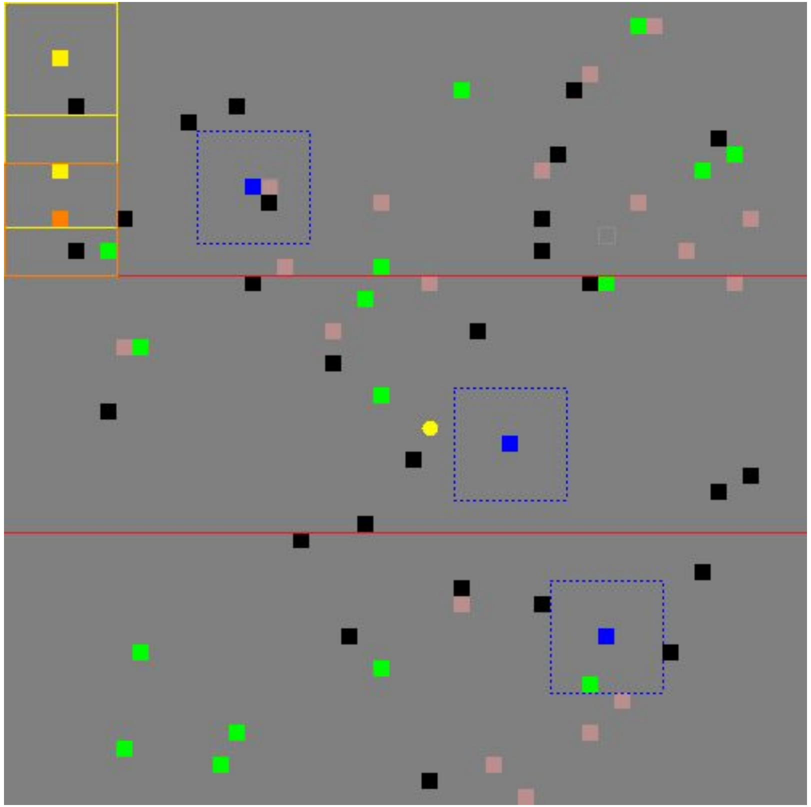
Zone assignment determined by closest agent to zone at step 1

Agent Architecture 3 - Exploration Strategy

- 50x16 zone

- 50x16 zone

- 50x18 zone



Zone assignment determined by closest agent to zone at step 1

Agent Architecture 3 - Exploration Strategy

- Exploration prioritizes anchor zone that is least explored
- Keep a record of anchor zone exploration with a decay map
- Arithmetic decay (+1/timestep) can cause rubberbanding sometimes
- Geometric decay (x2/timestep) to reduce rubberbanding and does not appreciate as fast as exponential decay
- Anchor zones initialized to infinity to force exploration of entire map at least once until fuel station is found

Agent Architecture 3 - Target Prioritization

- Tileworld task analogical to a Travelling Salesman Problem with additional time and resource constraints e.g. ride sharing driver route planning
- Targets can be ordered using a heuristic suitable for resource-bounded time-critical Travelling Salesman Problem
- Simple ordering uses Manhattan distance for ordering objects
- Modify Manhattan distance with a time factor:

$$\mathit{TSP\ Distance}(\mathit{Obj}) = \frac{\mathit{Estimated\ Remaining\ Life}(\mathit{Obj})}{\mathit{Max\ Lifetime\ of\ Objects}} \times \mathit{Manhattan\ Distance}(\mathit{Obj})$$

$$\mathit{Estimated\ Remaining\ Life}(\mathit{Obj}) = (\mathit{Max\ Lifetime\ of\ Objects} \times \mathit{Threshold}) - \big(\mathit{Current\ Step} - \mathit{Step\ First\ Sensed}(\mathit{Obj})\big)$$

Agent Architecture 3 - Information Sharing

- Agent perceives environment during sensing phase
- Broadcast objects found in own memory during communication phase
- Objects are encoded into messages using TypedMessage class
- Message field of parent Message class used for indicating object type
- Merge objects shared by other agents into own memory at start of thinking phase

Agent Architecture 3 - Task Sharing

- In the planning phase, determine which objects in own zone is too far to reach in time i.e. Estimated Lifetime > Manhattan Distance
- Also determine which tiles and holes are surplus
    - More than a set limit of reservable objectives, auction out surplus
    - Already at maximum tile capacity, auction out tiles
    - No tiles to fill holes with, auction out holes
- Auction out surplus and untenable objectives
- Before defaulting back to exploration mode when no objectives found in own zone, agents can bid for the nearest contract
- Broadcast scheduled goals up to a reserved limit for other agents to check for goal collisions

Agent Architecture 3 - Code Modified

- TWEnvironment.java modified to create custom agent class
- HybridPRSTWAgent extends TWAgent
- TWAgentDecayMemory extends TWAgentWorkingMemory
- TypedMessage extends Message
- DefaultTWPlanner modified to use AstarPathGenerator and implements abstract methods in TWPlanner
- Custom agent parameters specific for each environment setup stored in Parameters(*).java

Individual Agent Score

Grid Size	Simple Reactive	Reactive + Communication	Hybrid + Communication
50x50	268	304	**395**
80x80	317	484	**502**
150x40*	98	174	**188**

* for reference only, extended using 50x50 parameters for object creation rate and life time

Demo Time!