Susskind Pipe Theory

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Introduction

Introduction

- Leveraging the power of graph theory and Q-learning to optimize the flow of water in a network of pipes.

Environment

- Multiple input water sources
- Multiple output water sinks
- Junction nodes
- Pipes (have a chance to break, get clogged or increase capacity under pressure)

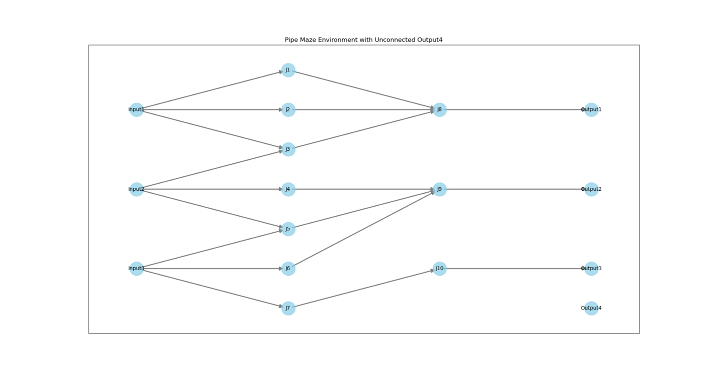

Figure: Pipe Network

Algorithm

Currently used algorithms

- graph theory
- Q-learning

Other algorithms in consideration

- Monto Carlo
- integrate Fuzzy Rule Interpolation and use sparse fuzzy rule-bases to approximate the Q-function
- wire-fitted Neural Network Q-learning

Problem Description

Maze Configuration

- Hidden layers of junction nodes between input and output
- Connection pipes have different characteristics: fixed capacity, adjustable capacity, potential for blockage or breakage.

Flow Dynamics

- Water divides at junction nodes based on downstream pipe capacity.
- Some pipe may increase capacity under pressure or may fail (break or clog)
- the output sinks have capacity. In case of extra water, It will overflow to next sink.

The challenge is to find the optimal input sources for desired output amounts.

- It's possible that there exist no exact solution. A close answer is preferred.

Input

- Maze Configuration:
  - List of node IDs and their connections.
  - Pipe characteristics and capacities.
- Desired Water Output:
  - Specified water amounts for output sinks.

Output

- Optimal input sources and corresponding water pressures.
- Results can be printed or saved for further analysis.

Class and Functions

- Q-learning
- Reward function
- Exploration function
- Approximation function (planned)
- Environment class
- Pipe class
- Junction class
- Sink class
- input valve class

Parameters

- Learning rate $= 0.1$
- Discount factor $= 0.5$
- Exploration rate $= 0.1$
- Number of episodes $= 1.0$

Simulation

amount of water in nodes, pipes and sinks are shown by color intensity.

Evaluation

- Time taken to find the optimal policy.
- Accuracy of the policy in achieving the desired water distribution.

Results

- The algorithm is able to find the optimal policy in a reasonable amount of time.
- The policy is able to achieve the desired water distribution with high accuracy.

Challenges I faced

- The dynamic nature of the problem makes it difficult to find the optimal policy using traditional Q-learning.

Extensions

- Customizable nodes to adjust water pressure dynamically.
- Time constraints and priorities for output sinks.
- Consideration of water consumption rates over time.

Relatable Problems

- Design of computer networks.
- Circuit or chip connectivity.
- Understanding brain connectivity and potential applications in neural prosthetics.

Q&A

Any Questions?

Thank you for your time!