AI-Powered Solutions for Next-Generation Construction Management

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Outline

Self Introduction

Background

- What is AI
- Main types of machine learning
- Large language model (LLM)

Project 1: JRNY – Large Language Model Powered HSE AI Assistant

- Introduction
- Model development
- Demonstration
- Future direction

Project 2:

- Introduction
- Model development
- Case study
- Future direction

Q & A

Who Am I … ?

Lingzi Wu Ph.D., P.Eng, LEED GA (Pronouns: she, her)

Assistant Professor, Department of Construction Management, University of Washington
Adjunct Assistant Professor, Department of Civil and Environmental Engineering, University of Washington
Affiliated Faculty, Interdisciplinary PhD Program in Urban Design and Planning, University of Washington
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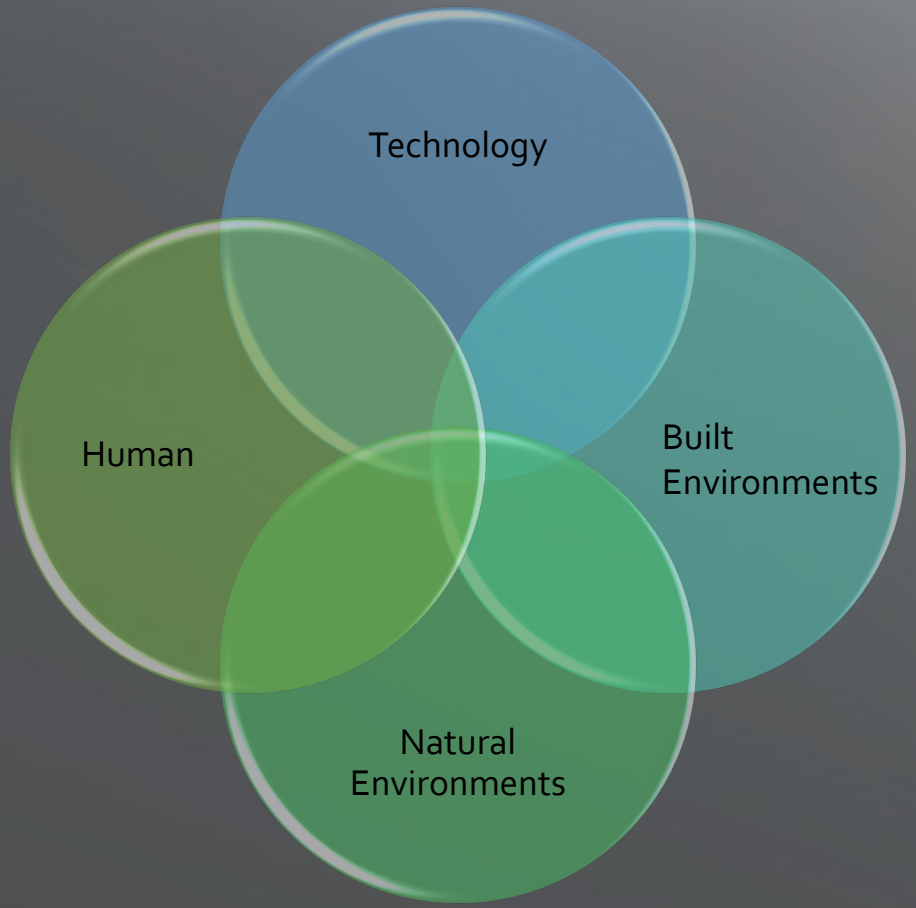
ACADEMIC EXPERIENCE

Postdoctoral Fellow; Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB; January 2021 – June 2022.
Research and Teaching Assistant; Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB; September 2011 – June 2013, and September 2017 – December 2020.

INDUSTRY EXPERIENCE

Project Coordinator; PCL Construction Inc., Various Locations, AB, June 2013 – May 2017.
Site Engineer; Changzhou Erjian Construction, Changzhou, P.R. China, July 2010 – August 2011.

What I do… ?



Smart Construction and Sustainable Infrastructure

T1	Advancing automation and digitalization in construction engineering and management
T2	Strengthening the resilience of critical infrastructure under the duress of extreme weather conditions
T3	Enhancing STEM workforce development and education

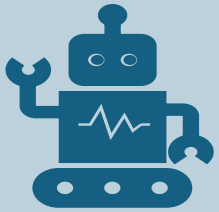
Background

What is AI

Main Types of Machine Learning

LLM

What is AI?



Narrow AI (or Weak AI)

Designed to perform specific tasks

Most current AI applications fall into this category.

General AI (or Strong AI)

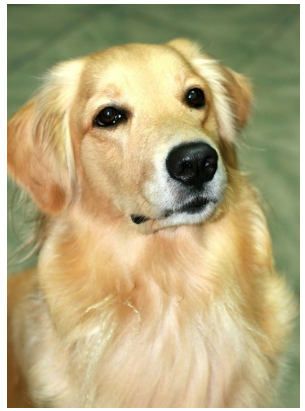
Understand, learn, and apply intelligence across a wide range of tasks, much like a human.

Main Types of Machine Learning

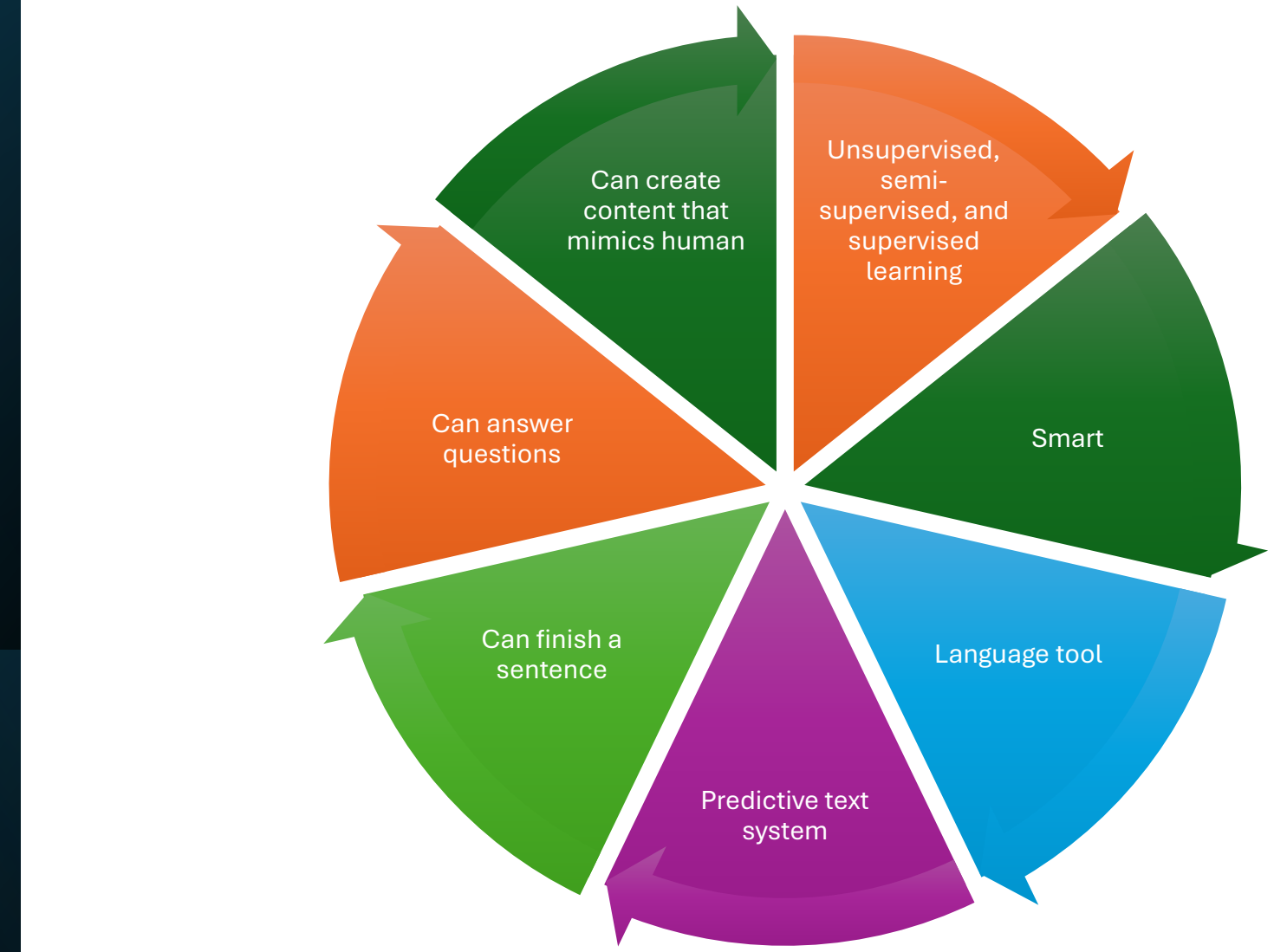
- Supervised learning
  - Learn a pattern from labeled data and predict the outcome of new inputs based on this pattern
- Unsupervised learning
  - Discovers knowledge from unlabeled data and focuses on data reduction and clustering problems
- Reinforcement learning
  - Trial and error-based algorithm







What is a Large Language Model?



Project 1: JRNY – Large Language Model Powered HSE AI Assistant

Introduction

Model Development

Demonstration

Future Direction

Introduction:

Research Team

Advik Mehta, Falak Sethi, Prof. Qipei Mei
University of Alberta

Sean Zhao, Prof. Lingzi Wu
University of Washington

Brian Gue
PCL Industrial Management

Introduction

Background

- Safety is our HIGHEST priority!
- Safety management involves the generation of a large amount of preventative and training documents
  - Daily safety bulletin (DSB)
  - Behavior-based observations (BBO)
  - Job hazard analysis (JHA)

Introduction

Objective

Automate the generation of daily safety bulletins (DSBs) using AI – LLM

Model Development

Overview

Model Development

Base Model Selection

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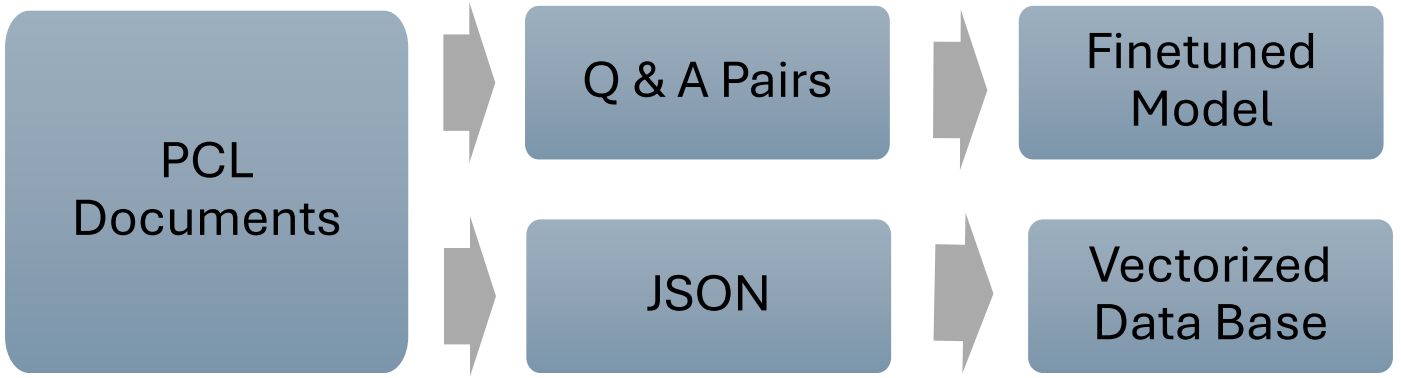
- Open source
- Computationally efficient
- High performance
- Flexible

Model Development

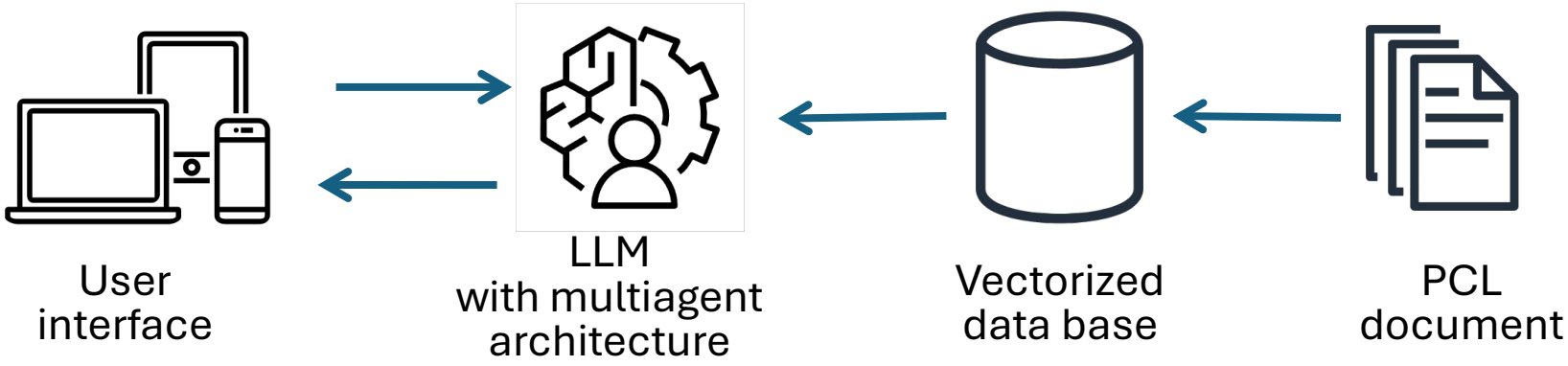
Model Finetuning and Vectorized Database Setup

37 Files,
1000+ Pages



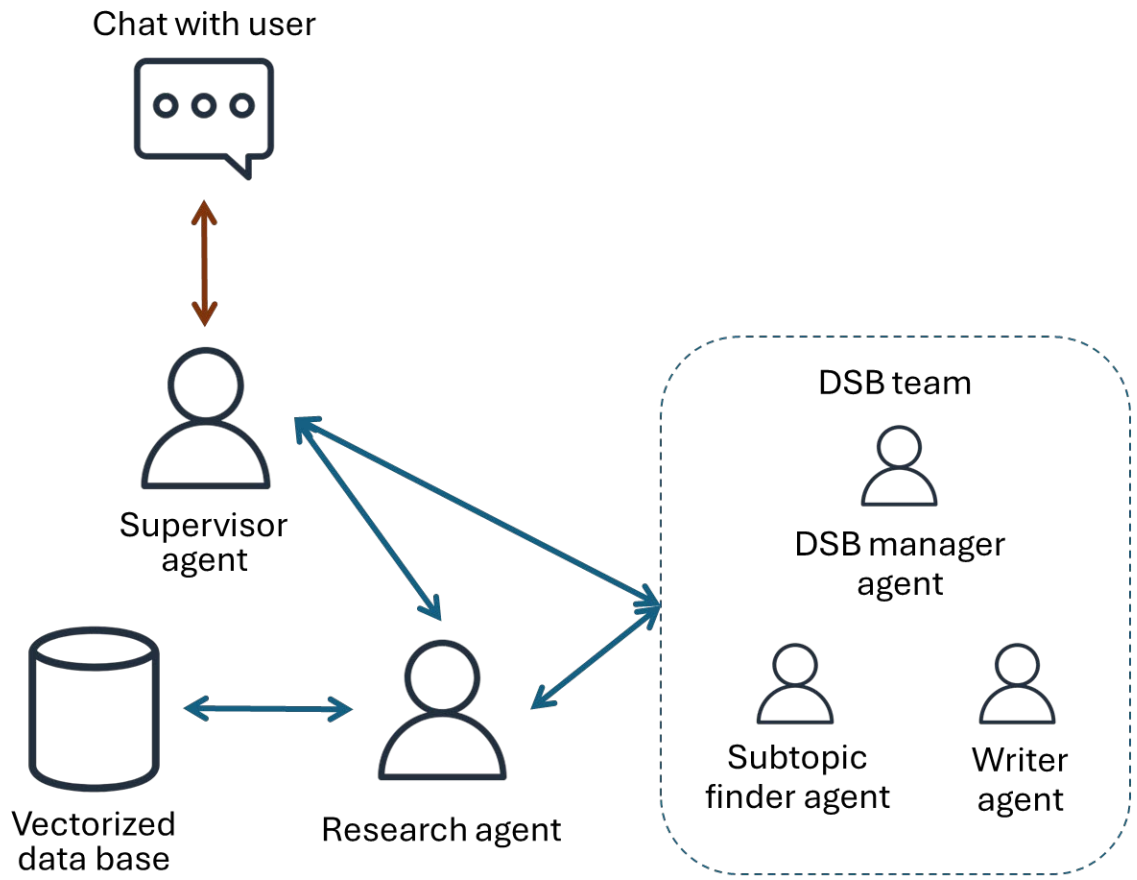
Model Development

System Architecture Design



Model Development

Agent Architecture Design



Demonstration

Link

- Prompt:
  Please create today’s DSB covering drainage installation along the foundation trench, formwork setup in the basement, and fire watch after hot work. Highlight safety protocols and PPE requirements for each task. We have a mandatory safety training coming up on 25th November from 12-2pm. Please include that in the DSB.

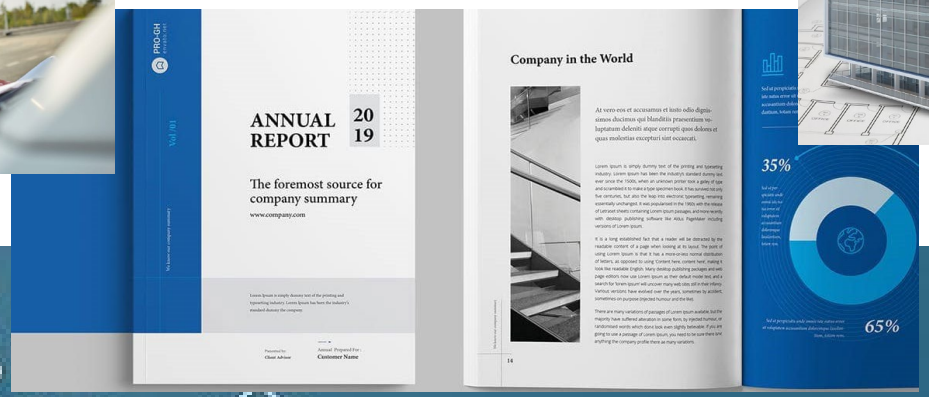
Future Directions

Document management

Information retrieval

More specific

More general



Project 2: Reinforcement Learning for Scheduling Pipe Spools for Industrial Construction Projects

- Introduction
- Model development
- Case study
- Future direction

REINFORCEMENT LEARNING FOR SCHEDULING PIPE SPOOLS FOR INDUSTRIAL CONSTRUCTION PROJECTS

Presenter: Lingzi Wu

Co-authors:

Mohamed ElMenshawy, Lingzi Wu, Brian Gue, and Simaan AbouRizk

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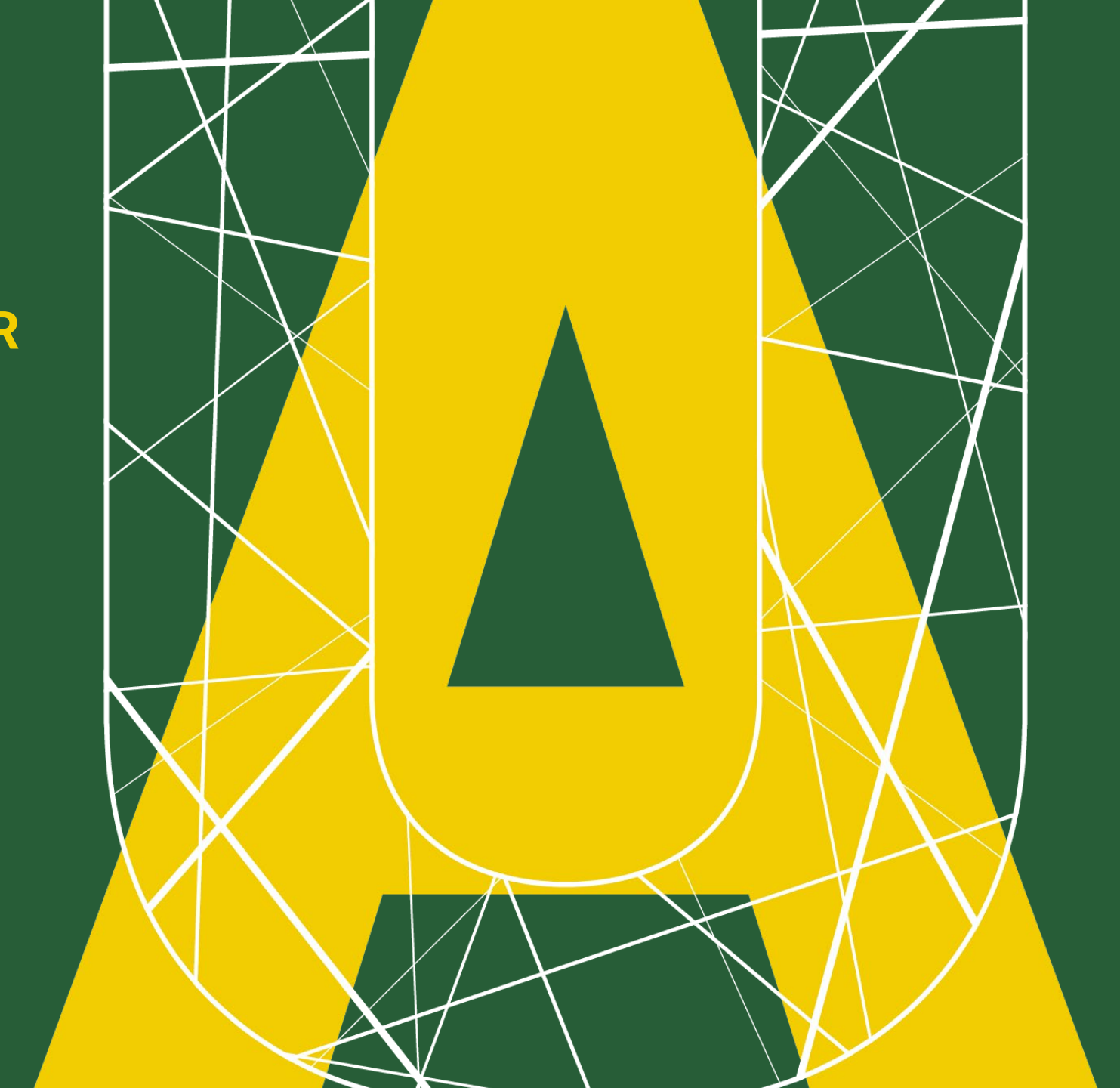
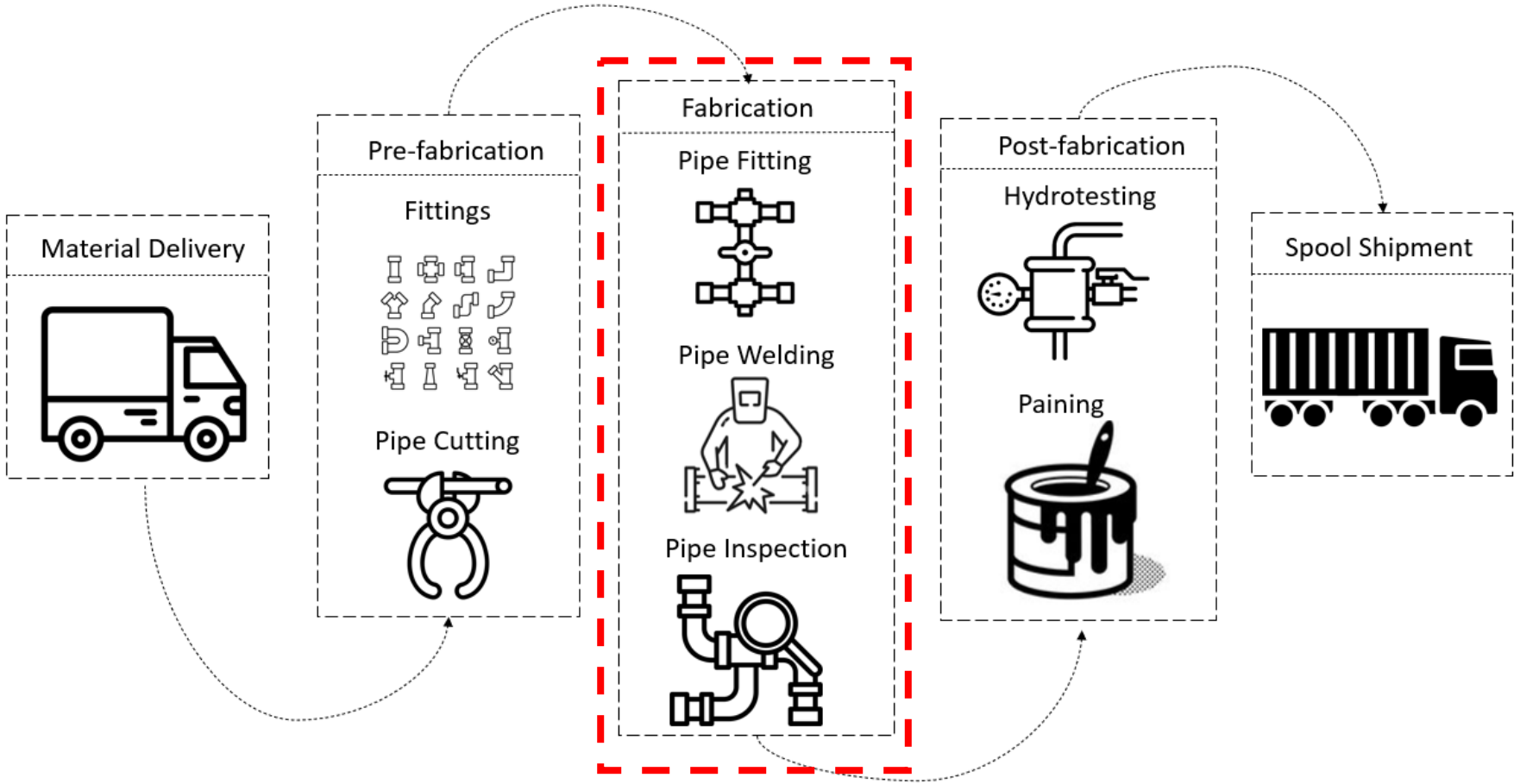


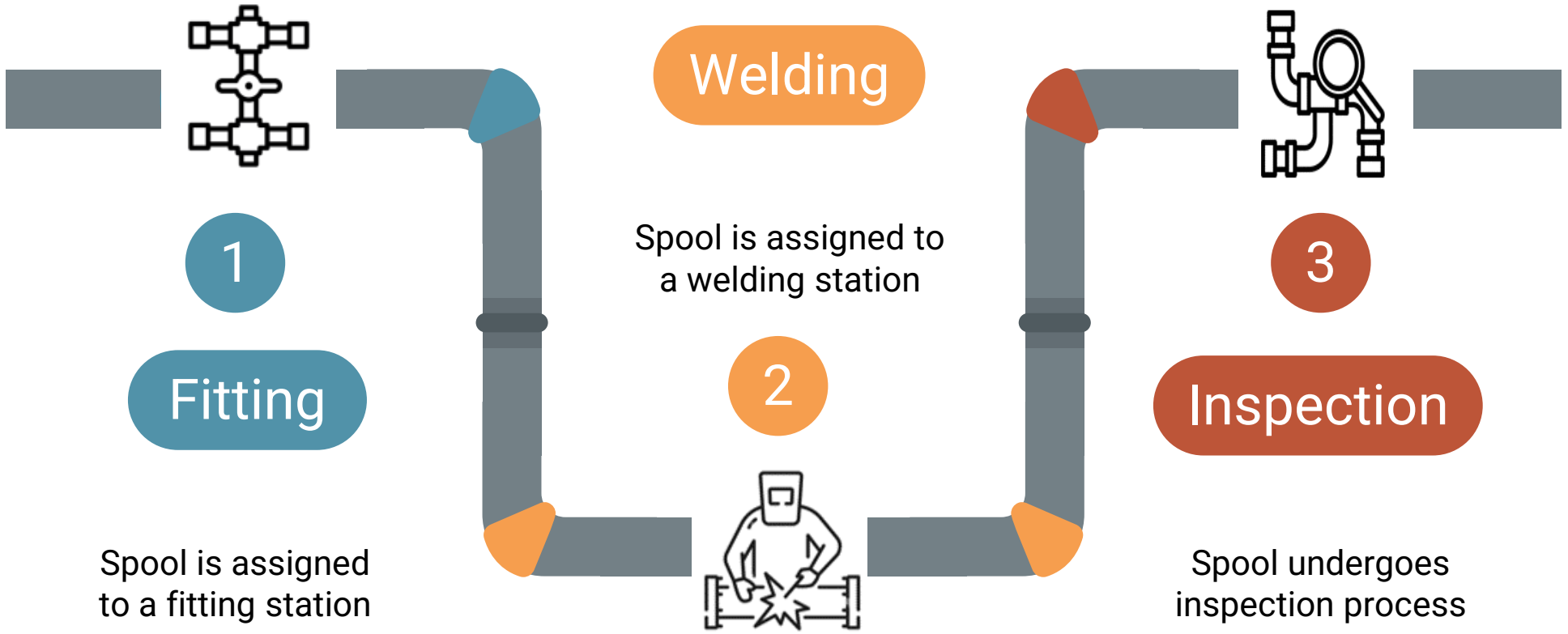
Introduction

- Piping is considered as major components in building industrial projects

Pipe Spool Fabrication



Pipe Spool Scheduling



Research Aim: Automate the pipe spool scheduling process by developing a Reinforcement Learning (RL) model

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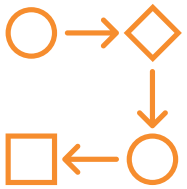
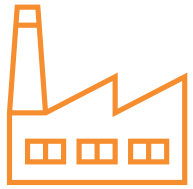
Literature Review



Pipe fabrication scheduling

Simulation based approach

- Fabrication time
- Bottleneck
- Resource utilization



Job shop dynamic scheduling

Manufacturing domain

- Metaheuristics algorithms (genetic algorithm, particle swarm, etc.)

Reinforcement learning in job shop scheduling

Manufacturing domain

- Q-learning (not reliable with large number of states)
- Deep RL (not relatively explored and limited real-life application)

Overview of Reinforcement Learning (RL)

Definition of RL

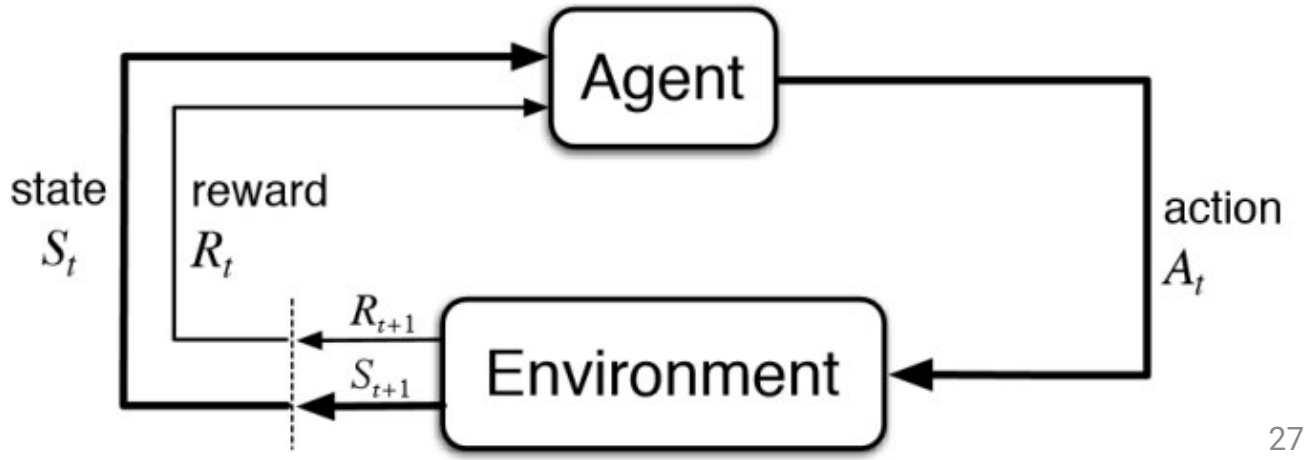
A type of Machine Learning where an agent learns how to behave in an environment by performing actions and observing the rewards of those actions

Goal of RL

Maximize the total reward obtained

Key Concepts in Reinforcement Learning

- **Agent**: Takes actions that affect the environment
- **Action**: Set of choices the agent can choose from
- **Environment**: Medium where the agent takes action
- **State**: Observations or state after taking an action
- **Reward**: Feedback from environment



Reinforcement Learning Algorithms

Model-based RL:

Involves creating a model of the environment

Predicts what the next state and reward will be for each action

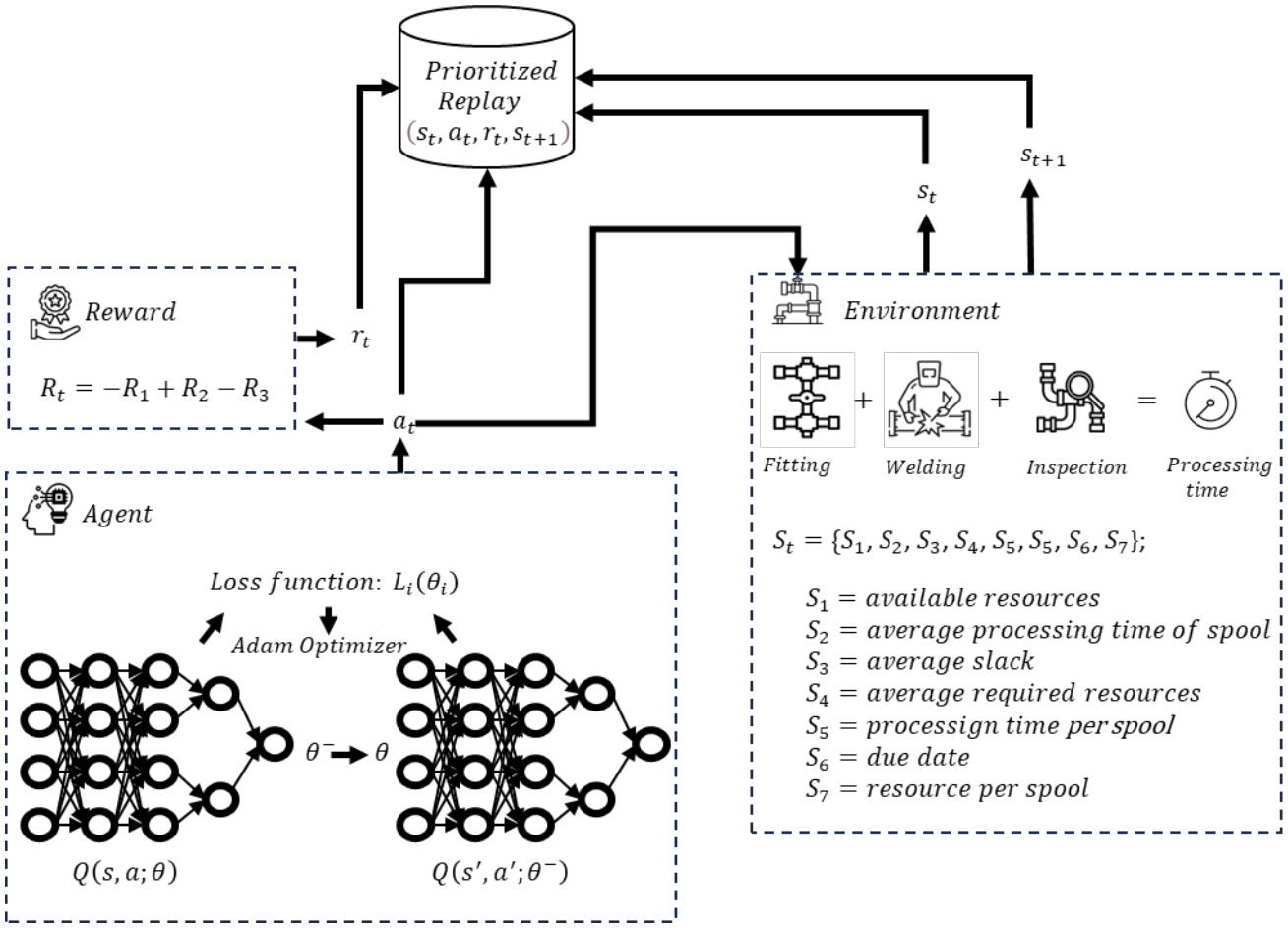
Model-free RL:

Does not require a model of the environment

Learns directly from interaction with the environment

Model Development

- Model free RL
- Dueling DQN algorithm
  - Q-value:
    - Denoted as Q(s,a) represents the expected cumulative future reward for taking an action (a) in state (s)
    - DQN (deep Q neural network) to estimate the Q-value
- Prioritized replay



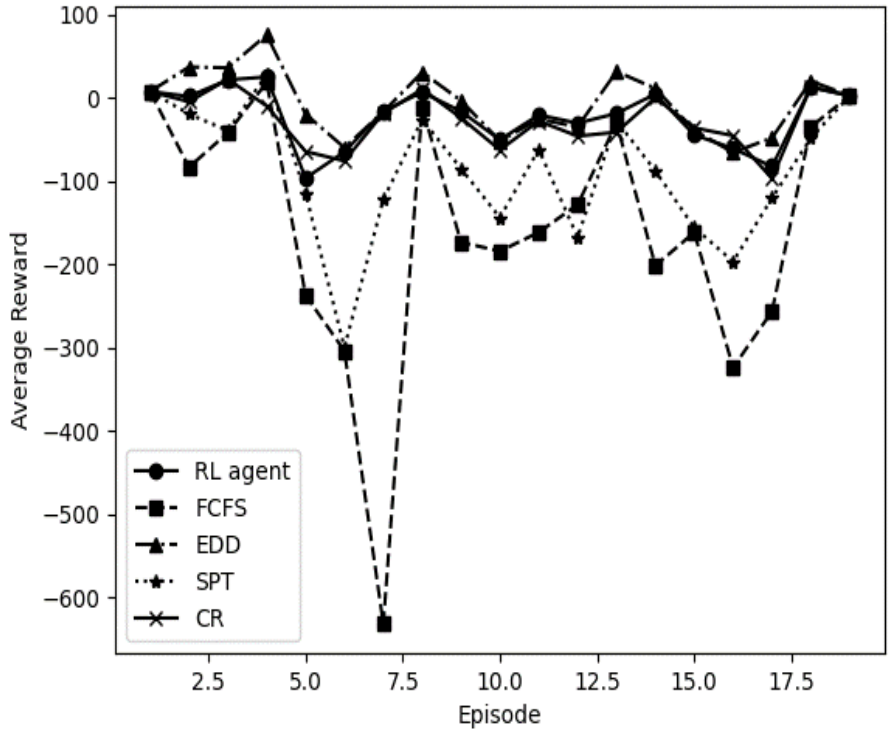
Case Study

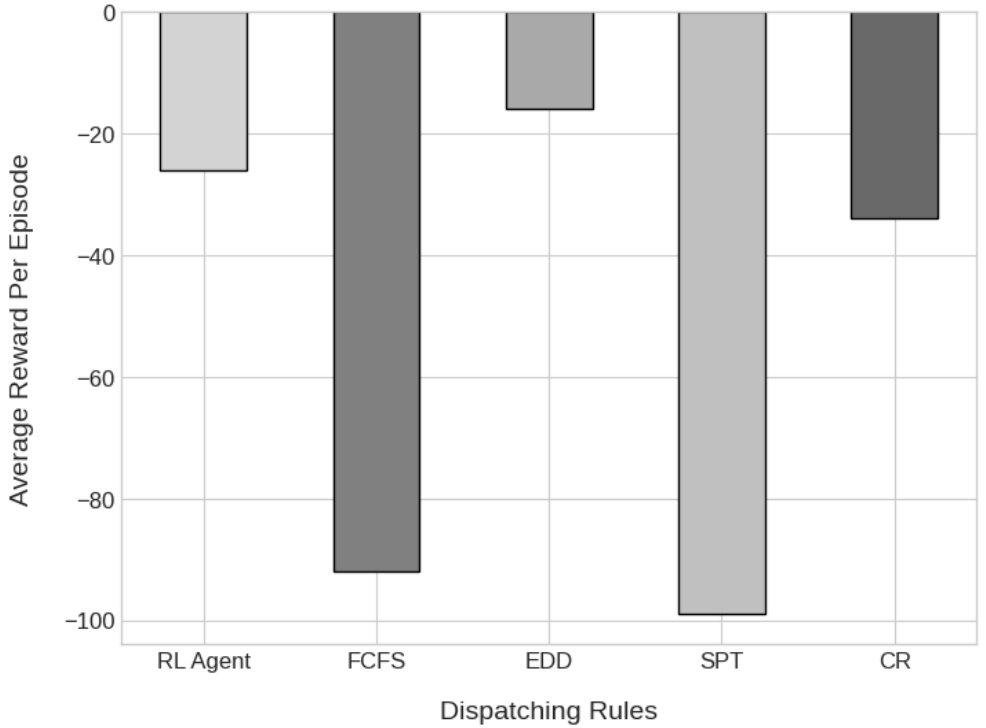
- 2,400 records (pipe spools)
- The research method was implemented using:

- Actions: one of the scheduling rules in each timestep:
  - Earliest Due Date (EDD)
  - Shortest Processing Time (SPT)
  - Critical Ratio (CR)
  - First Come First Serve (FCFS)

Case Study

- Model evaluation

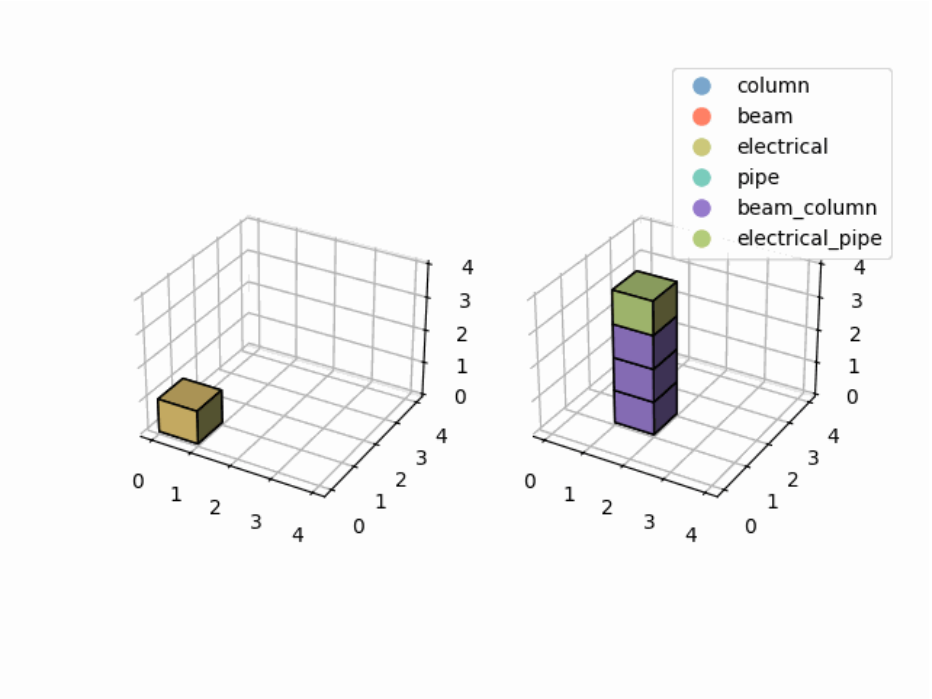




Future Direction

RL planner

Activity planning and scheduling using RL



Q&A

Thank You

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