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Multi-agent systems based solution for Pickup-and-delivery

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KU Leuven - Multi-agent systems

0 Outline

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1 Outline

1 Problem definition - Setting

- Pizzeria chain RoboPizza
- Pizza delivery using robots (AGVs)
- RoboPizza receives pizza delivery requests (tasks), robots deliver the pizzas
- Manhattan style city blocks

1 Problem definition - Robots

- Can move from and to any location in the city
- Have maps and can compute paths between locations
- Can carry up to 5 pizzas at once
- Can only communicate with entities that are close to them

1 Problem definition - Tasks

- Consist of picking up (multiple) pizzas and delivering them to a location before a certain timepoint
- If there are more than 5 pizzas in a task, it will have to be split up
- Pizzas have no preparation time / can be picked up instantly
- Will be created every time step with low probability:
  - Delivery time window based on distance from pizzeria + randomness
  - Amount of pizzas from Gaussian distribution
  - Delivery location uniformly random in city

1 Problem definition - World

Dynamism

- Streets can become closed off due to road works
- Amount of pizzerias can increase/decrease

Potential AGV crashes

- Running out of battery
- ?

Efficiency measure

- Total waiting time for task

Charging

- Happens on one location
- Only limited amount of robots can charge at once

2 Outline

2 Objectives

- Analyze performance of BDI & delegate MAS algorithm the setting described above

3 Outline

3 Research questions (1)

- What is the relation between the amount of requests that RoboPizza receives and the waiting time for customers?
- Are robots on the road more often when there are more requests in the system?
- Does increasing the amount of robots decrease the customer waiting time when there are many requests?
- How does the amount of robots impact the average workload (occupancy rate) of the charging station?

3 Research questions (2)

- What is the relation between the amount of charging robots and the amount of clients we have to decline?
- How do waiting times change as the amount of road works changes (dynamism)?
- How do waiting times change as the amount of pickup locations changes (dynamism)?

4 Outline

4 Hypotheses (1)

- What is the relation between the amount of requests that RoboPizza receives and the waiting time for customers?
  - H_1: The waiting time increases with the amount of requests.
  - H_0: The waiting time does **not** increase with the amount of requests.

- Are robots on the road more often when there are more requests in the system?
  - H_1: Robots are on the road more often when there are more requests in the system.
  - H_0: Robots are **not** on the road more when there are more requests in the system.

4 Hypotheses (2)

- Does increasing the amount of robots decrease the customer waiting time when there are many requests?
  - H_1: Increasing the amount of robots decreases the customer waiting time when there are many requests.
  - H_0: Increasing the amount of robots does **not** decrease the customer waiting time when there are many requests.

- How does the amount of robots impact the average workload (occupancy rate) of the charging station?
  - H_1: A larger amount of robots increases the average workload of the charging station.
  - H_0: A larger amount of robots does **not** increase the average workload of the charging station.

4 Hypotheses (3)

- What is the relation between the amount of charging robots and the amount of clients we have to decline?
  - H_1: The amount of charging robots has no influence on the amount of clients that have to be declined.
  - H_0: The amount of charging robots **influences** on the amount of clients that have to be declined.

- How do waiting times change as the amount of road works changes (dynamism)?
  - H_1: Waiting times increase as the amount of road works increase.
  - H_0: Waiting times do **not** increase as the amount of road works increase.

4 Hypotheses (4)

- How do waiting times change as the amount of pickup locations changes (dynamism)?
  - H_1: Waiting times decrease as the amount of pickup locations increase.
  - H_0: Waiting times do **not** decrease as the amount of pickup locations increase.

5 Outline

5 Independent variables

- n_{robots} = amount of delivery robots
- $p_{request}$ = probability for a new request
- $\mu_{pizza}, \sigma_{pizza}$ = Gaussian distribution parameters for amount of pizzas
- $p_{pizzeria\_opens}$ = probability for a pickup location to open
- $p_{pizzeria\_closes}$ = probability for a pickup location to close
- $p_{road\_works\_start}$ = probability for road works to start
- $p_{road\_works\_finish}$ = probability for existing road works to finish

5 Dependent variables

- t_{wait} = total waiting time for customers
- $t_{robots\_driving}$ = time robots spent driving
- t_{robots_idle} = time robots were idle
- $n_{requests}$ = amount of requests in the system
- $n_{pizzerias}$ = amount of open pizzerias
- n_{road_works} = amount of road works
- $n_{robots\_charging}$ = amount of robots that are charging
- $n_{deliveries}$ = amount of finished deliveries
- avg_{pizzas} = average amount of pizzas carried by robots

5 Other variables

- v_{robots} = moving speed of the robots
- t_{pizza} = the baking time of a pizza
- $battery\_size$ = the capacity of a robot's battery
- t_{robot_charge} = time it takes to recharge a battery

6 Outline

6 Plan

1. Create a map
2. Generate pizzeria and charging station
3. Create random delivery tasks
4. Implement task-allocation & route planning
5. Calculate statistics
6. Report results

Questions?