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

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KU Leuven - Multi-agent systems

0 Outline

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 position 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 position 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 position 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 position
- Only limited amount of robots can charge at once

2 Outline

2 Objectives

- Analyze performance of a BDI & Delegate MAS algorithm in the described setting

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3 Outline

3 Research questions and hypotheses I

- 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.
- 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.

3 Research questions and hypotheses II

- 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.
- 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.
- How do waiting times change as the amount of pickup locations changes (dynamism)?

4 Outline

4 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 position to open
- $p_{pizzeria\_closes}$ = probability for a pickup position to close
- $p_{road\_works\_start}$ = probability for road works to start
- $p_{road\_works\_finish}$ = probability for existing road works to finish

4 Dependent variables

- t_{wait} = total waiting time for customers & tasksWaitingTime / totalTasksWaitingTime
- $t_{robots\_driving}$ = total time robots spent driving & totalRobotsTimeDriving
- t_{robots_idle} = total time robots were idle & totalRobotsTimeIdle
- $t_{robots\_charging}$ = total time robots were charging & totalRobotsTimeCharging
- $n_{robots\_distance}$ = the cumulative distance all robots have traveled & totalDistance
- $n_{requests}$ = amount of requests in the system & tasks / totalTasks
- $n_{pizzerias}$ = amount of open pizzerias & pizzerias
- n_{road_works} = amount of road works & roadWorks
- $n_{deliveries}$ = amount of finished deliveries & totalTasksFinished
- avg_{pizzas} = average amount of pizzas carried by robots &

4 Other variables

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

5 Outline

5 Multi-Agent System Design

- Ant-based Delegate MAS

5 Delegate MAS Ants

- Desire Ants
- Exploration Ants
- Intention Ants

5 Robot strategy

- strategy

6 Outline

6 Experiments

- Different parameter settings for each hypothesis
- Each experiment's final statistics are written to a file
- Samples are made of X experiment runs for each parameter setting
- Test method: two-sample t-test
- Significance level: 0.05
- Hypotheses entail one-tailed tests. Null hypothesis will be rejected if the mean difference between sample means is too small.
- Could not test with varying dynamism because of a RinSim bug

7 Outline

7 Conclusions

- conclude our Conclusions

Questions?