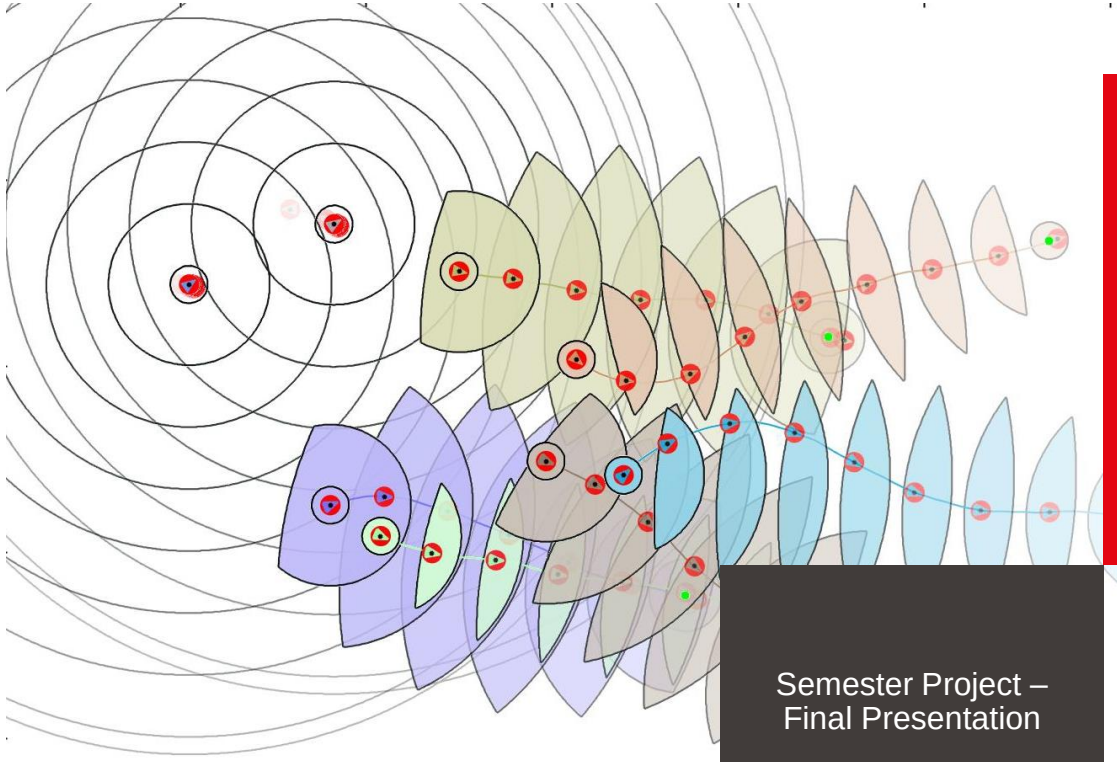


Optimal Task Assignment and Collision Avoidance for Mobile Robots

Semester Project – Final Presentation

Sycamore Lab

sycamore lab

Dimitri Hollosi

1st of July 2022

Overview of talk

What:

Tool to analyse and compare assignment methods and their properties

How:

Using **state of the art simulation techniques** based on ROS2 & Gazebo (open source softwares)

Why:

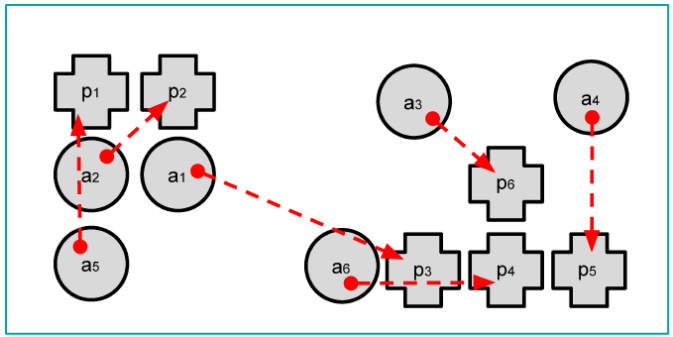
- Route planning is the first decision to be made
- Many different ways to do so
- Requires a **comparative assessment**

Optimal TA & Collision Avoidance

- Linear Sum Assignment Problem (LSAP), Bottleneck Assignment Problem (BAP), Lexicographic BAP…
  - Solve for **different cost functions**
    - Minimise overall sum (LSAP)
    - Minimal *longest* distance (bottleneck),…
- Analysis of derived properties
  - ***Collision Avoidance***
  - ***Dynamic Consistency*** *(initial optimal assignment remains optimal for all time)*
- Desire and need for a simulation environment
  - Benchmark testing for N agents
  - Validation of approaches
  - Monitoring of derived properties

Example :

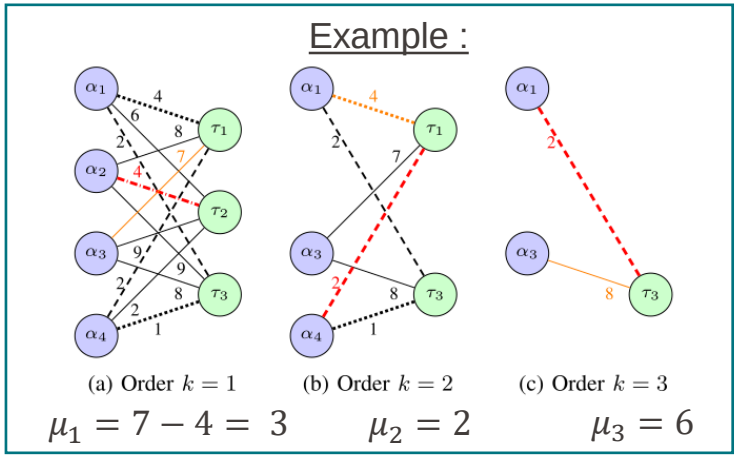
Valid mapping :
$a_1 \rightarrow p_3$
Minimal *longest* distance

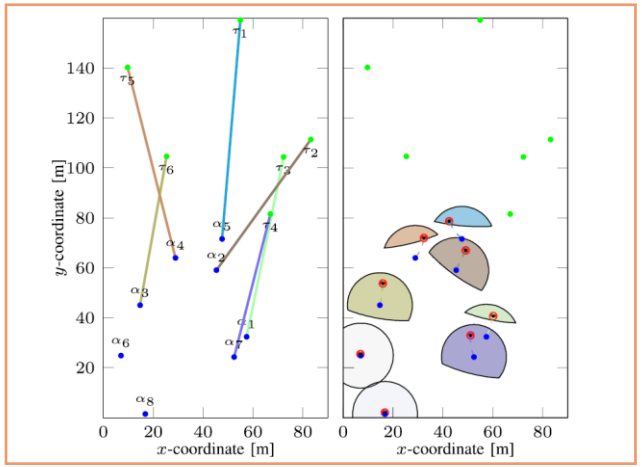


Derivable properties from Lexico-BAP

- **Robustness margins :**
  - Measure of how *sensitive/robust* the current bottleneck is
  - Bottleneck can be increased by "up to" μ_k before the assignment may change

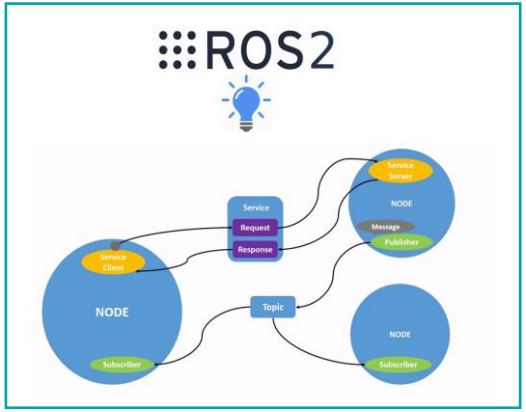
- **Local safe sets**
  - *Time-varying*
  - *Basically a set where many Lexico-BAP assumptions hold*
    - *No collisions*
    - ***Dynamically consistent*** *(assignment remains the same)*

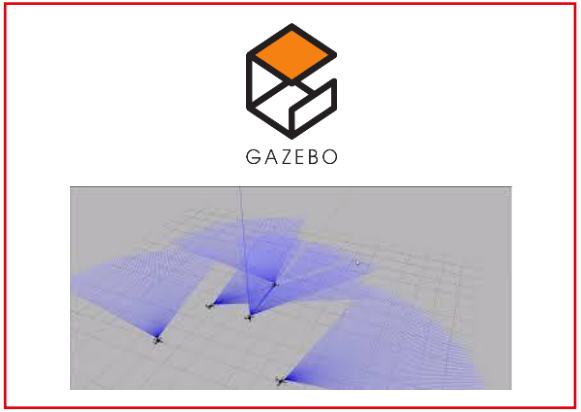


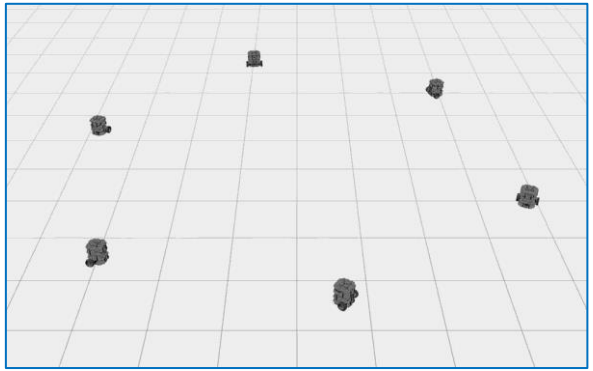


Approach

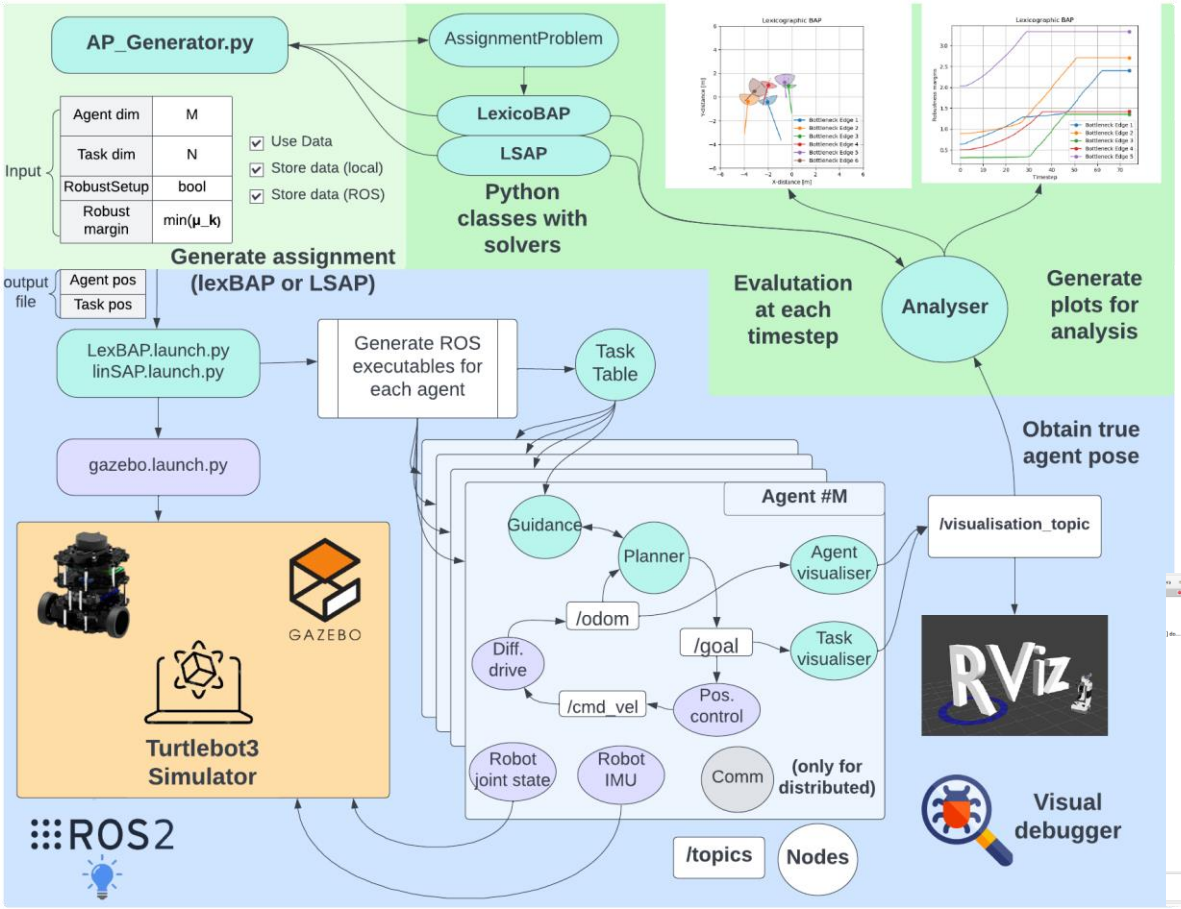
- **ROS2 :**
  - **Robotic Operating System #2**
  - State of the art robotic program development
  - Middleware enabling inter-program communication
    - Nodes, topics, services, actions
- **Gazebo**
  - Open-source **3D robotics simulator**
  - Sensor simulation and actuation control
  - Wide-array of available robots
- **ChoiRbot:**
  - **Open source**
  - Modular robotics ROS2 toolbox
  - Used for **low level actuation** & control of robots



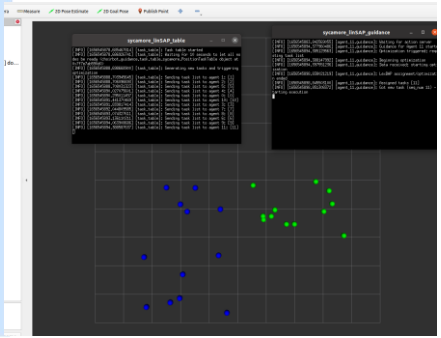




Methodology- developed software

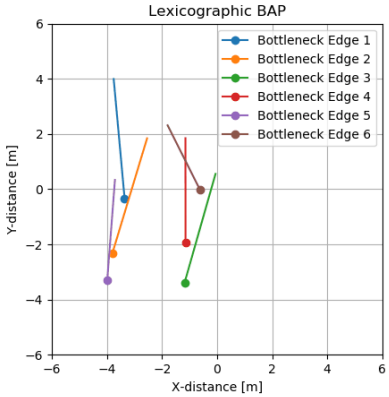


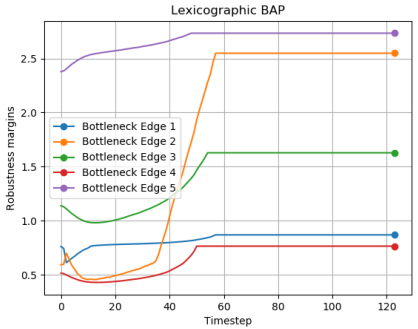
- **Analysis tool**
  - "Centralised Observer"
  - Does not modify robot trajectories!
- User input parameters
  - # agents, tasks
  - LSAP, LexBAP, …
- Software outputs graph
  - Derivable properties



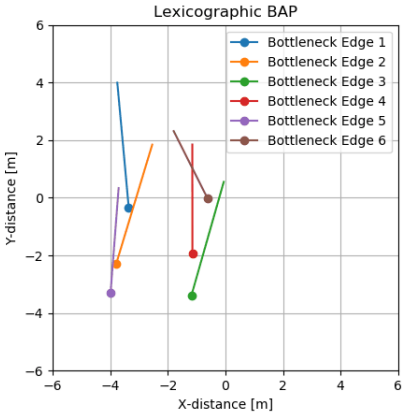
Robustness margins analysis

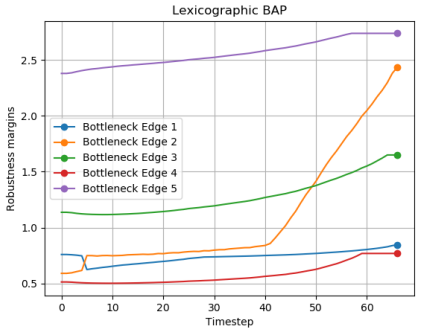
- **Randomised heading (general case)**
  - Robustness margins initially **decrease**
  - Not always in safe sets
    - Assignments don't change (**dynamically consistent**)





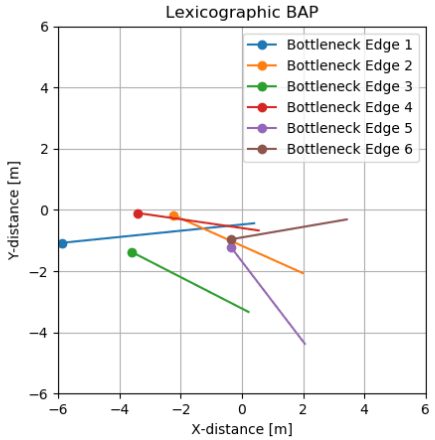
- **Aligned heading ("straight line" case)**
  - Robustness margins **constant or increase**
  - Always in safe sets
    - **Dynamic Consistency guaranteed**



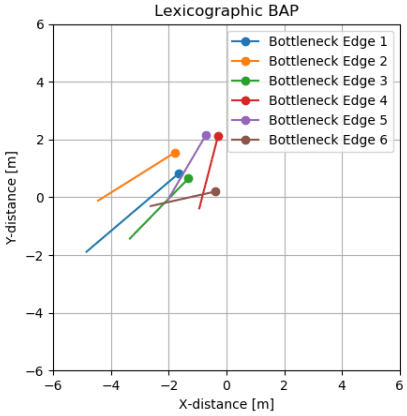


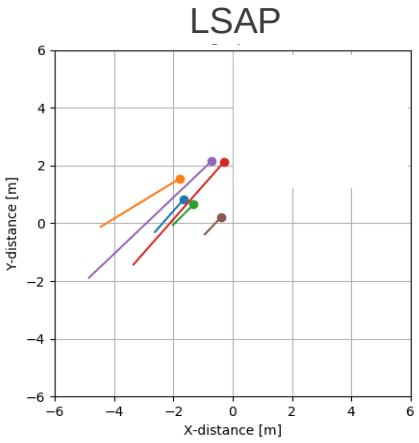
Sensitivity Analysis & Comparison

- **Dynamic Consistency analysis**
  - **Randomised heading**
  - Agents not in the safe subject to re-assignment
  - Agents in safe set don't get re-assigned



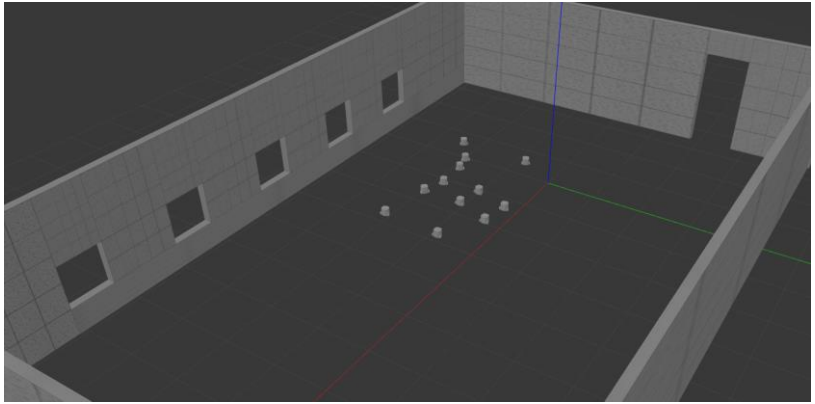
- **Assignment type analysis and comparison**
  - **Aligned heading**
  - Agents not in the safe subject to re-assignment
  - Agents in safe set don't get re-assigned



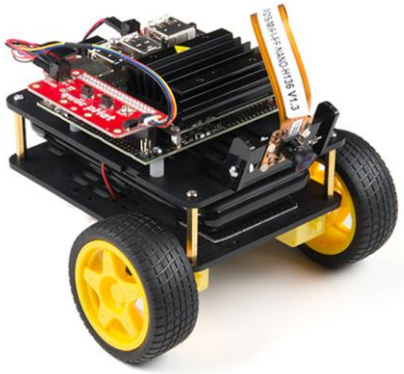


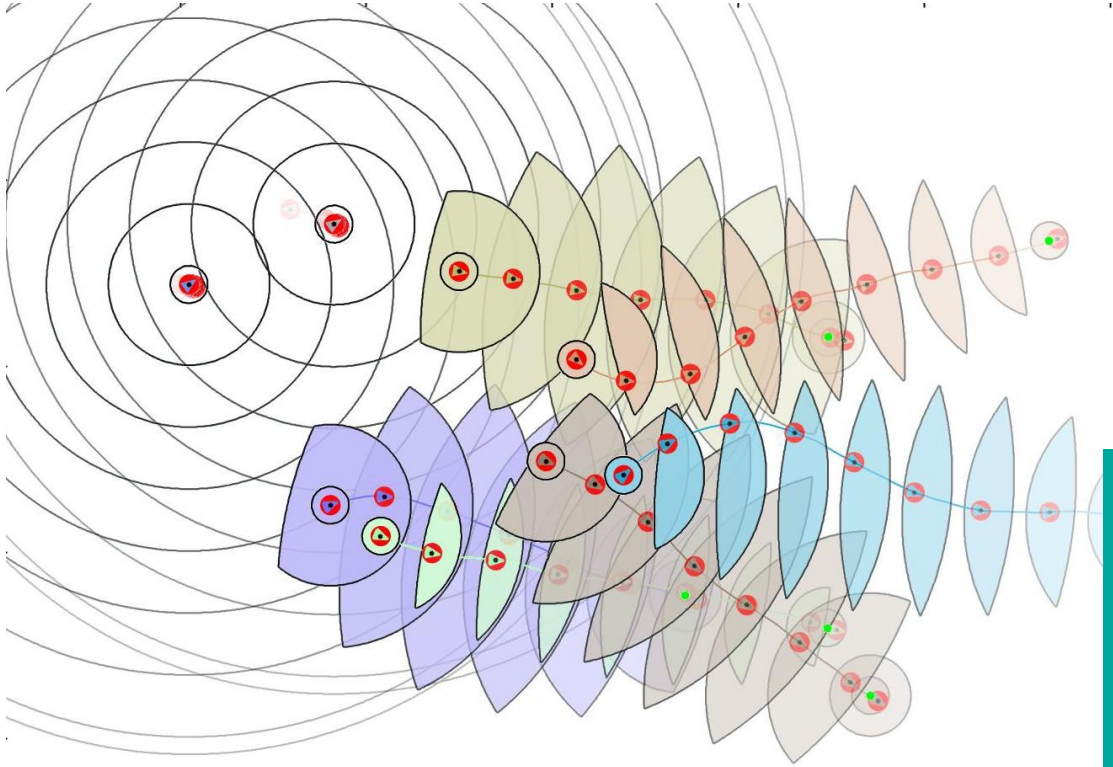
Final remarks & Next Steps

- **Current platform**:
  - Fully deployable simulation environment
  - Test bench prior to hardware testing
  - Currently includes LSAP and LexBAP



- **Future work**
  - Include Jetbots as robotic models (instead of Turtlebot3 Burger)
  - Add agent relocalisation feature
  - Add more Assignment Problems





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Questions?