DINaMo

1st PhD Committee Meeting

Sydney Dolan

3/21/2023

Agenda

- Introductions
  - Myself
  - Academic status
- Motivation
- Methods
  - Graph Neural Networks
  - InforMARL description
- Results
- Next Steps
  - Planned work
  - Propose dates for next committee meeting

Note: Include a table of contents to outline your presentation! Some committee members may get distracted if they don't think that you will talk about some specific piece they are interested in

Always have slide numbers

Introductions: Myself

- Education
  - BS Purdue University
  - MS in AeroAstro from MIT
- 4th year graduate student in AeroAstro
  - *Been a lab member for 8 months*

Previous Positions

BLUE ORIGIN

Advanced SPACE

NASA Ames Research Center

AEROSPACE

Nanoracks

Your personal introduction can have a more formal or informal tone depending on the relationship you have with your advisor.

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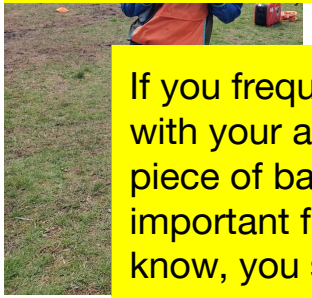

If you frequently discuss non-research topics with your advisor and feel that some hobby or piece of background about your life is important for your committee members to know, you should include it!

Personal Interests

- Ultramarathons
- Ice Climbing
- Drag Shows

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Proposed Set of Classes

Somewhere in your presentation, include your proposed major and minor of study. Including the grades you got in those classes is optional,

Course #	Course Title
16.413	Principles of Autonomy
16.32	Optimal Control
16.485	Visual Navigation for Autonomous Vehicles
18.0651	Matrix Methods in ML
16.332	Formal Methods for Safe Autonomous Synthesis

Proposed Major: Autonomy

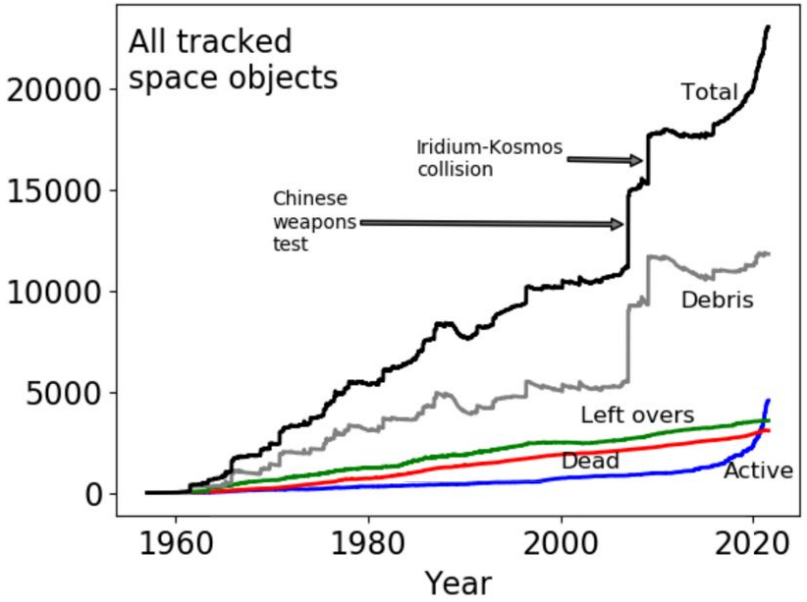
Proposed Minor: Satellite Systems

16.842	Fundamentals of Systems Engineering
16.851	Satellite Engineering
12.540	Principles of GPS

Course #	Course Title
18.0651	Matrix Methods in Machine Learning
6.720	Optimization Methods
16.995	Doc Research & Comm

Motivation: Context

The number of satellites and operators in orbit is growing drastically.

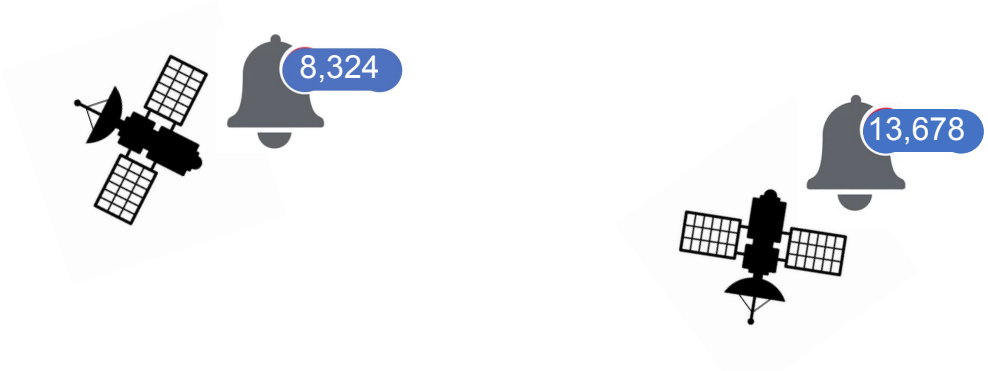


Source: https://ww

Even if your committee members are all experts in your area, its still best to start with a high level motivation for your work - pretty graphics work great here

Motivation: Context

This process is highly manual, and will not scale well as the number of conjunction data messages increase.



Therefore, **autonomous decision making** for space traffic management will become essential.

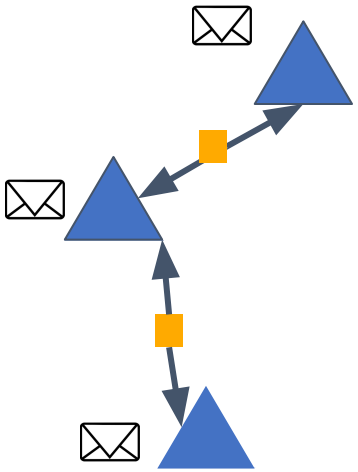
The decision whether or not to move is fundamentally a question about the relationship between *uncertainty* and *information sharing.*

Graph Neural Networks

To use a graph neural network, first we have to create a graph representation of the environment. We assume that each satellites can communicate to other satellites and pieces of debris within their sensing radius.

For committee members unfamiliar with the methods you use, you should provide a high level explanation of how your technique works. It doesn't have to be a proof, you only need to list key assumptions and the inputs and outputs

Information Aggregation



Recurrent Unit

FF Neural Net

Get message from a neighbor

( ) =

The neural net produces an encoded variant of the observations from other agents

Combine Information Together

‘ = (, Σ)

Each agent aggregates all messages with its own knowledge

Graph Information Aggregation

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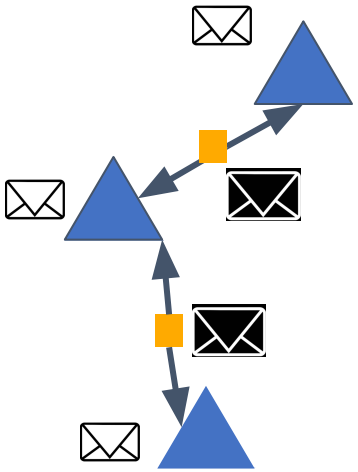


Recurrent Unit

FF Neural Net

Information Aggregation

Get Messages

Combine at Agent Level

Develop Full Environment Representation

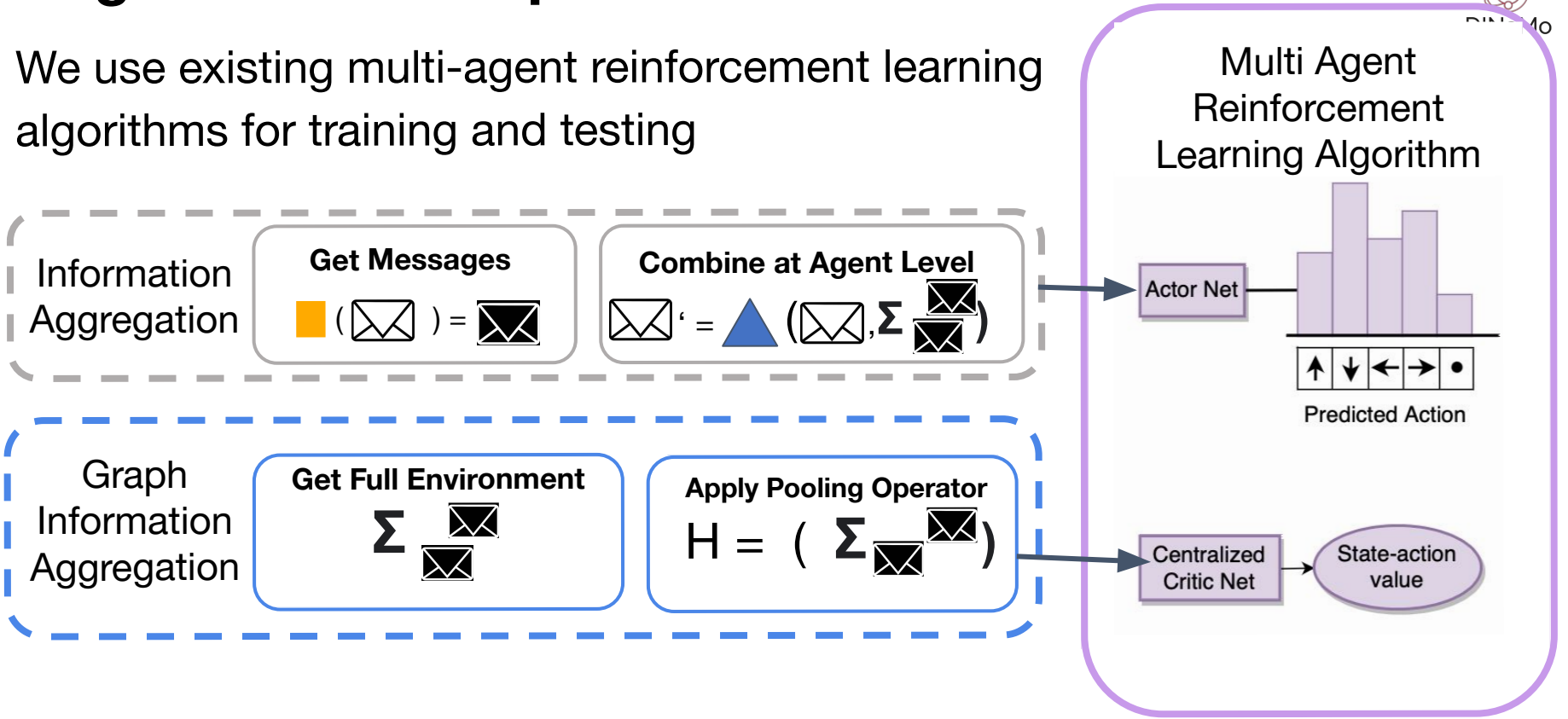
Collect all the encoded messages

Apply Pooling Operator

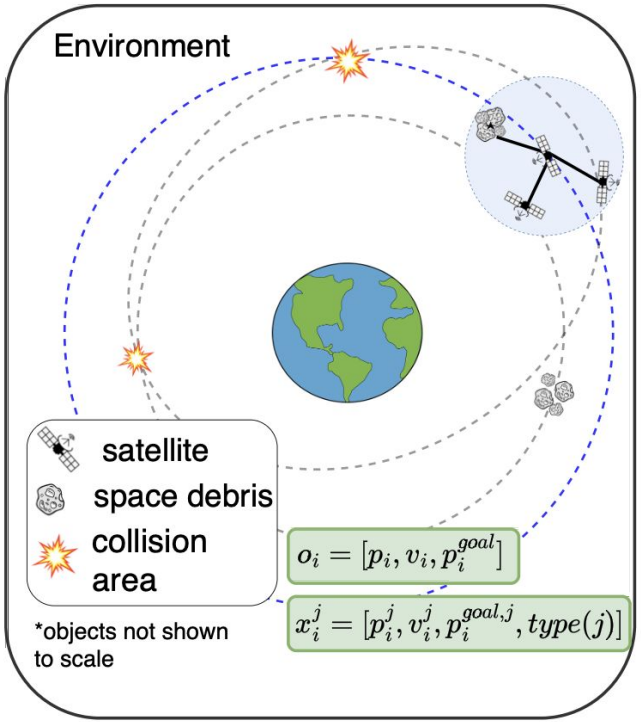
This step makes training transferable to a variable number of agents

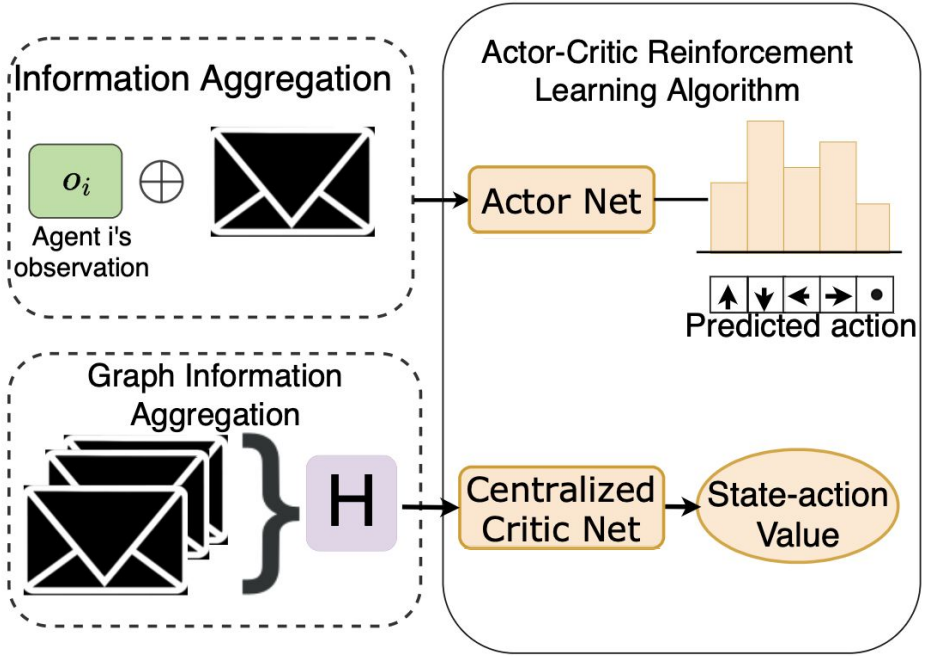
Algorithm Description

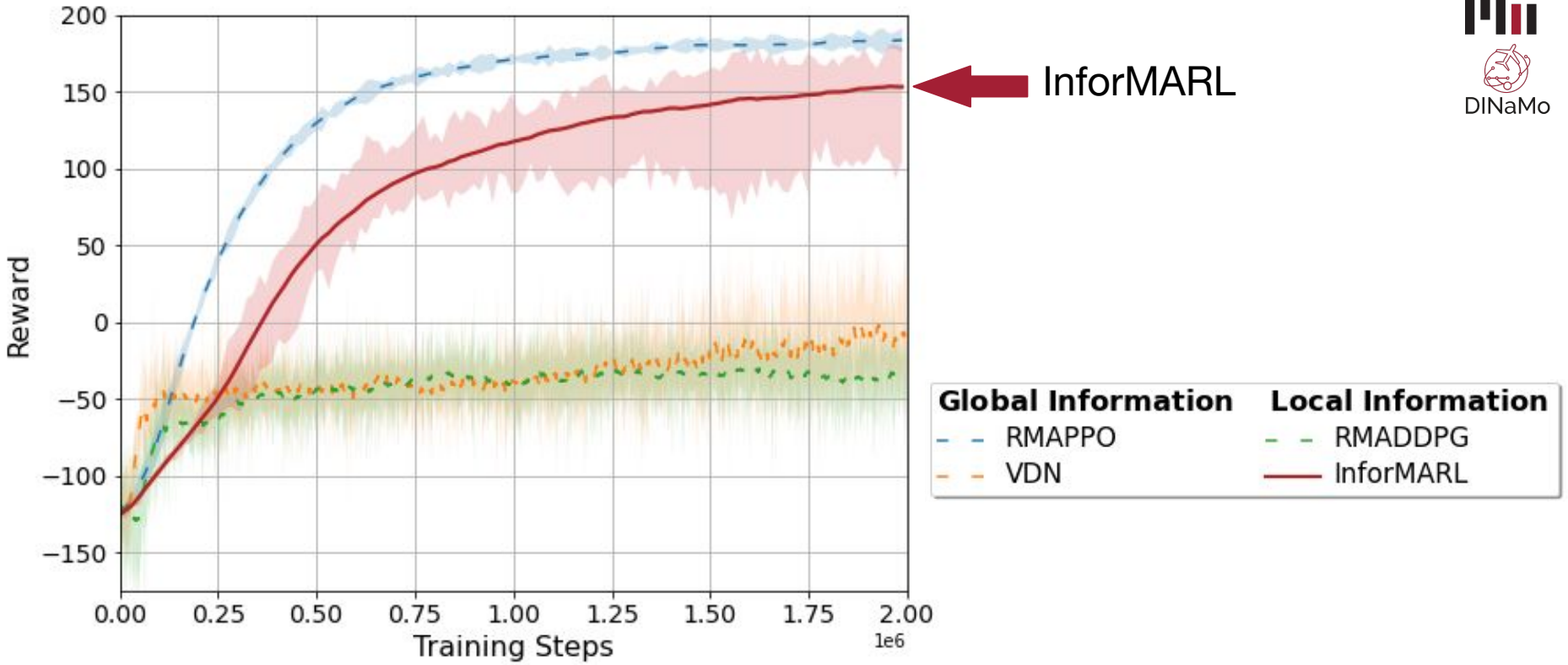
We use existing multi-agent reinforcement learning algorithms for training and testing



Algorithm Overview



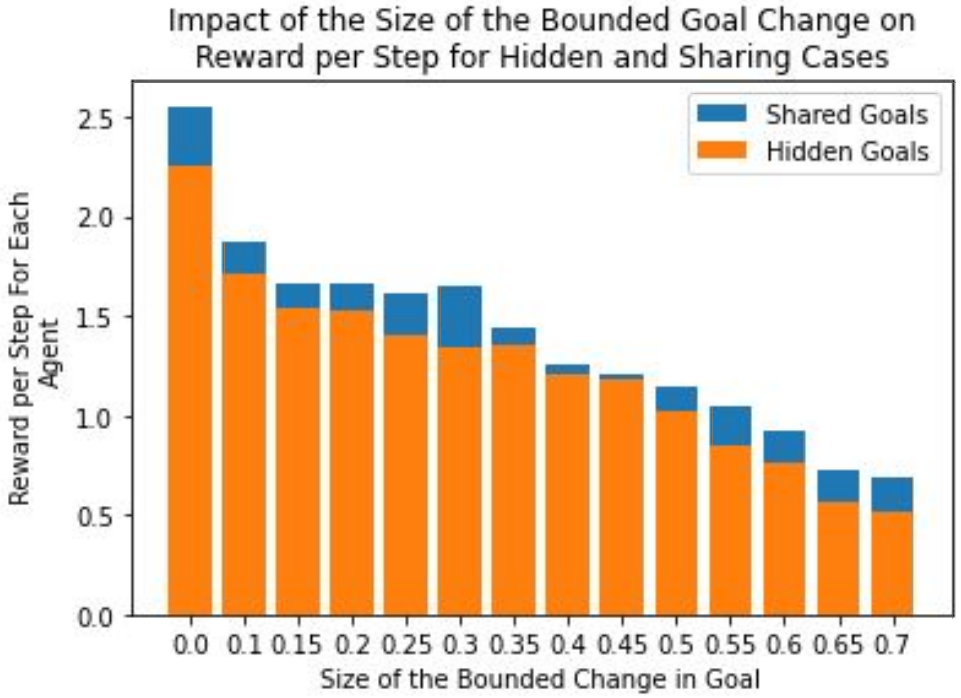




Key Takeaway:InforMARL, which uses only *local* information, achieves a similar reward to RMAPPO, which uses global

Sensitivity Study (In Progress)

You can share results you are still working on! Your first committee meeting is to get your committee up to speed, you don't have to have all the answers



Sharing

in reward per step, collision rates, and task completion rates

However, reward/task completion rates are closely linked with episode length, and time step. As a result, we are investigating these further to determine their impact on sharing.

Summary and Takeaways

- Graph neural networks are a valuable abstraction to successfully model cooperative local information sharing between satellite operators
- Preliminary Results on goal sharing demonstrate that sharing this information improves agent performance

Your first committee meeting can range anywhere from 30-90 minutes, so include a summary slide as a refresher of the key points of your work

Ongoing and Planned Future Work

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- Sensitivity Work
- Heterogeneous Decision Making Windows
    - How does cooperation change when operators have different abilities/observation times
- Developing strategies for non-cooperative scenarios
    - Relying on game-theory to recommend manuevers for different ability levels and confidence intervals

Your future work can outline work you plan as your contributions for your proposal – this gets you early feedback from your committee if they approve about your intended phd contributions

Next Steps

Planning Proposal Defense June/July

Always include when you want to meet with your committee next! Get it on their radars now.

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Backup Slides

Backup slides are a great way to include:

- Information you don't have time to talk about but might get questions on
- Prepared answers to questions you might get
- More detailed versions of presented slides