Task Allocation using Manipulative Dynamic Auctioneering for Multi Robot Systems

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Abstract

This Thesis begins with surveying the evolution of methodologies in Multi-Robot Task Allocation (MRTA). Various classifications of Taxonomy in the domain is compared to the relevance of its application. As a suggestive proposal to improvise standard auctioneering systems in MRTA, an idea for a novel auctioneering strategy inspired from the 'Leaky Integrate and Fire' Neuron Model of the human brain is designed and named 'Manipulative Dynamic Auctioneering System'. This model is developed and simulated as an extension of *MRTeAm*, a ROS based software built to test auctioneering strategies. Performance of Manipulative Dynamic Auctioneering System is compared against a simpler version of Dynamic Auctioneering named Simple Dynamic Auctioneering System and also against a standard Stationary Auctioneering System called the OSI, using a range of experiments. It is observed that Manipulative Dynamic Auctioneering System is faster and more efficient than the Simple Dynamic Auctioneering System. Also, it is more sophisticated in its selection of winners when compared to Stationary Auctioneering Systems like the OSI. Potential for future research lies in building a Hybrid Auctioneering system using a combination of both Stationary and Dynamic Auctioneering Strategies for task allocation.

Introduction

Multi Robot Task Allocation (MRTA) is usually an NP-hard Optimization problem, that is modelled in the form of a Fair Division, Optimal Allocation or Travelling salesman problem [1]. Each of the techniques used for task allocation has its own advantages and disadvantages. The complexity of MRTA increases with the increase in the number of robots and tasks, heterogeneity in robot capabilities, coalition requirement for tasks, time constraints in tasks and unpredictability in the appearance of tasks. The complex structure of the human brain which deals with thousands of competing Neurons at a fraction of second, selecting a winner often comprising of a coalition of Neurons makes it ideal to be scrutinized for a potential inspiration to help with MRTA. Inspired from a popular Neuron Model called 'Leaky Integrate and Fire', this research aims to formulate MRTA as an optimal allocation problem aiming to reduce resource complexity in task allocation while dealing with a large number of robots.

Aims and Objectives

The preliminary aim of this research is to study the effectiveness of novel dynamic bidding auctioneering strategies over traditional auctioneering strategies. The objectives are,

- To develop a software structure based on MRTeAM to carry out experiments to analyze Multi-Robot Task Allocation Techniques on Mobile Robots
- Implement Simple and Manipulative Dynamic Bidding Auctioneer techniques for testing on Multi-Robot Systems
- Compare performance of the newly implemented methods versus traditional auctioneering strategies
- Analysis and documentation of the obtained results.

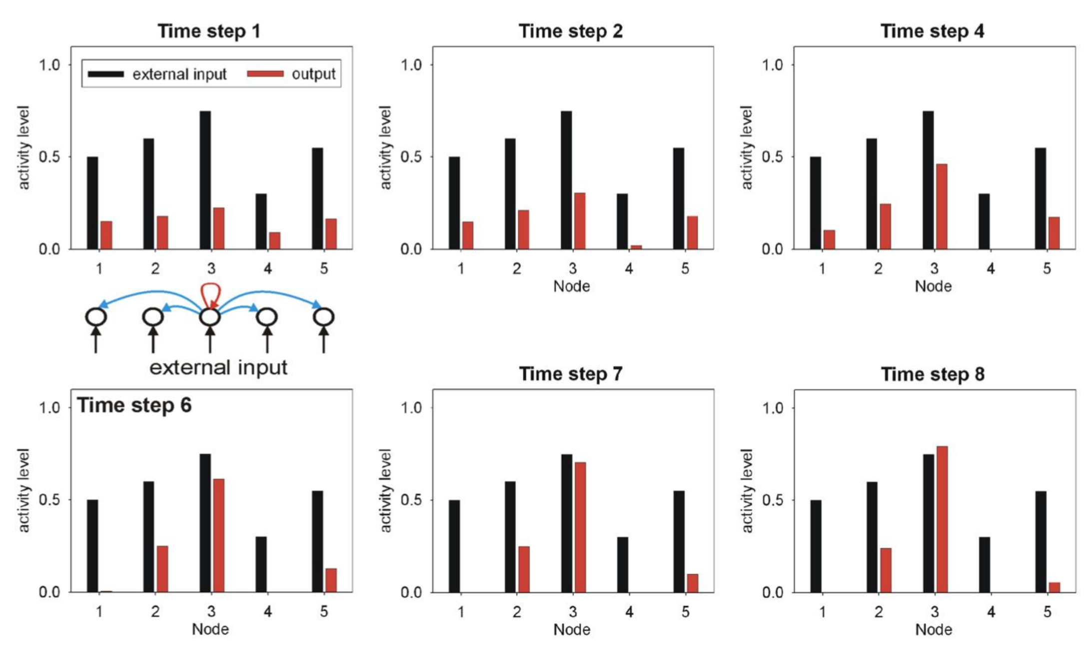

Figure 1: Neurons Competing over distinct time intervals showcasing self excitation and inhibitory behaviour [2].

Methodology

- The novel suggestion for a task allocation auctioneering system with manipulative bidding named as Manipulative Dynamic Auctioneering Strategy, is inspired based on the Leaky Neuron Model interpretation of the human brain. (Figure 1)
- For ease of understanding, the Manipulative Dynamic Auctioneering Strategy can also be described as 'reverse handicap bidding'. The term is used in reference to the handicap provided to winning horses in standard Horse Racing.
- In Horse Racing, the horses with a history of winning are provided an additional weight in proportion to their competence.
- This additional weight serves as a disadvantage or a 'handicap' thereby increasing a probabilistic uncertainty in the outcome of future races. In Manipulative Dynamic Auctioneering Strategy, the idea is to provide a 'handicap' or a negative cost to the *losing* robots (therefore the term 'reverse handicap') and an advantage of a positive cost to the winning robot.
- The net cost given out by each of the robots is observed at each time step over a set time period after which the robot bidding the maximum cost is announced the winner of the task. In the case of a robot's cost exceeding a set maximum threshold, the auction is cut short ahead of the set time period and the winner is awarded with the task.
- This strategy is intuitively expected to make the winner win faster, while still giving a chance to the losing robots to overcome their disadvantage and win the task if competent enough.
- Figure 2 demonstrates an example scenario of Dynamic auctioneering amongst Multiple Robots.

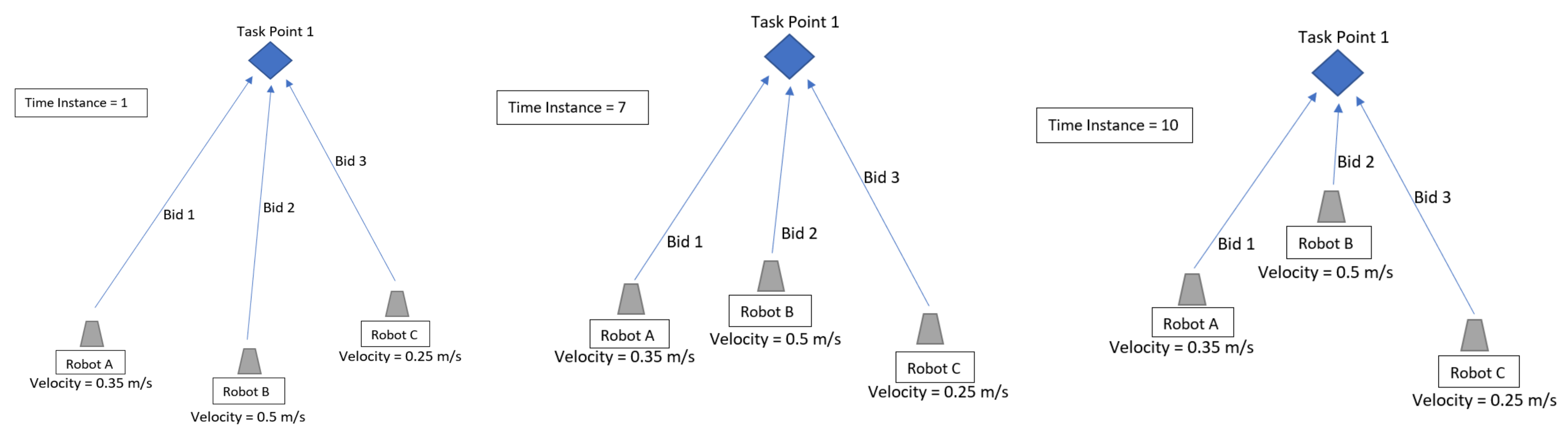

Figure 2: Dynamic Auctioneering in a Multi-Robot System

Experiments

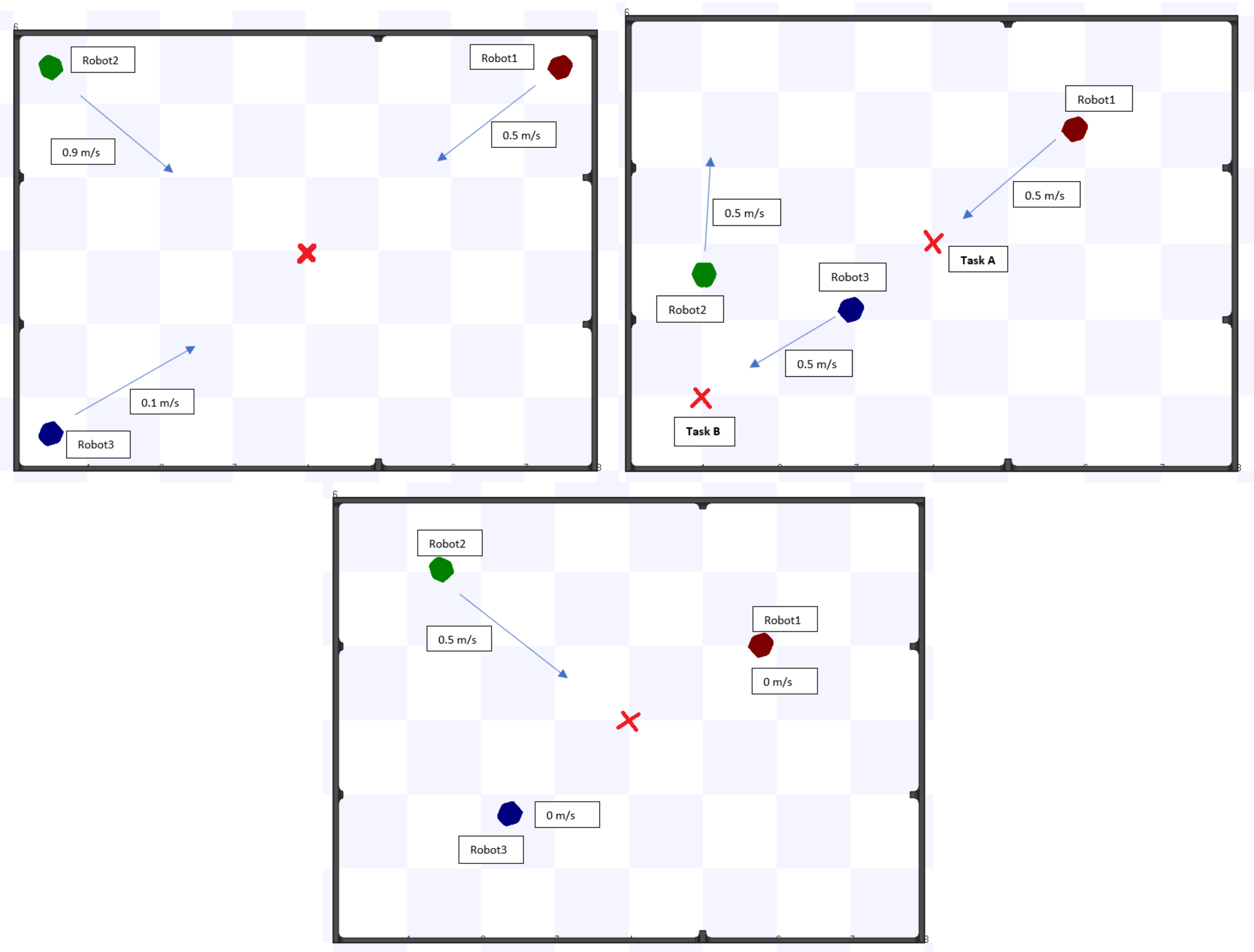

Figure 3: Demonstrative Screenshots of a few Experiments on the Stage Robot Simulator

Results

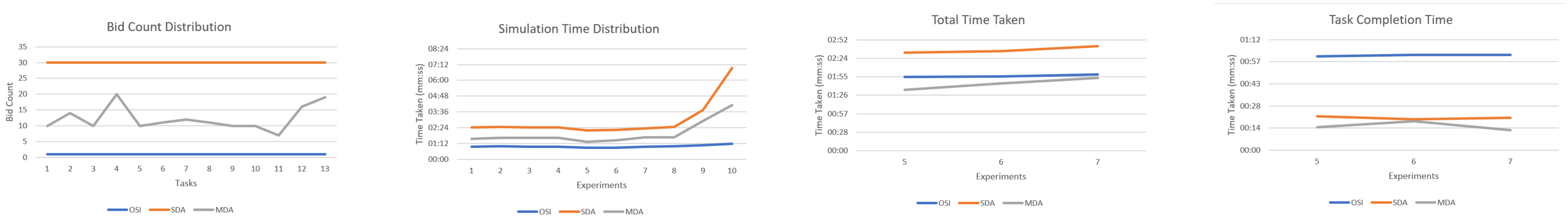

Figure 3: Comparison of performance between OSI, SDA And MDA

References

[1] 2020. [Online]. Available: https://www.researchgate.net/publication/ 277075091_Multi-robot_Task_Allocation_A_Review_of_the_State-of- the-Art. [Accessed: 25- Apr- 2020].

[2] K. Gurney, "Levels of description, Marr's strategy, bottom-up v top-down", University of Sheffield, 2018.