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# Exploration and Rescue of Shipwreck Survivors using Reinforcement Learning-Empowered Drone Swarms

Leonardo D. M. de Abreu[1], Luis F. S. Carrete[1], Manuel Castanares[1], Enrico F. Damiani[1], José Fernando B. Brancalion[2], Fabrício J. Barth[1]

[1]Insper, São Paulo/SP - Brasil

[2]Embraer, São José dos Campos/SP - Brasil

***Abstract*— The goal of this project is to create a reinforcement learning algorithm that locates shipwrecked individuals using a swarm of drones. A simulated environment was developed to train and visualize the outcome of the trained algorithm considering the ocean's dynamic circumstances. This project does not discuss image recognition of shipwrecked people, since the true focus of this project is to optimize the search routine of a drone to find the target in the most efficient way possible. The implemented Reinforce algorithm takes into account a dynamic map of probabilities, representing the chances of a person being found, as well as the position of other agents. Outcomes include an open-source Python package for the environment and the implementation of the reinforcement learning algorithm. The algorithm demonstrates superiority over the predefined approach, proving the advantages of reinforcement learning in efficiency and effectiveness.**

***Keywords*— Multi-Agent Systems, Reinforcement Learning, Simulation**

## I. Introduction

Every year, vast bodies of water worldwide claim numerous missing individuals. According to the World Health Organization (WHO), there are an estimated 236,000 annual drowning deaths worldwide, making it the third leading cause of unintentional injury/death worldwide and accounting for 7% of all injury-related deaths [1]. With over 71% of the earth's surface covered by oceans[2], finding these missing individuals is no easy task, due to the complexity of oceanic environments and the vastness of the search areas. However, drone swarms have emerged as a promising tool for searching for missing individuals.

The use of drones in rescue operations has resulted in successfully saving 940 people while being utilized in 551 rescue incidents so far [3]. The capacity of drones to reach difficult terrain and inaccessible areas, as well as their ability to capture real-time images and videos, has proved to be helpful in search and rescue missions.

The success rate of search and rescue missions is believed to be significantly increased by the incorporation of Artificial Intelligence (AI) technology [4], as it can leverage probabilistic models based on the ocean's behaviors, as well as the last known location of the people being rescued. Several solutions have been proposed in the last years to solve this problem [5], [6], [7], in special, using reinforcement learning algorithms. By utilizing AI and Reinforcement Learning (RL), the project aims to investigate algorithms that can improve the effectiveness of search and rescue operations in dynamic environments, ultimately resulting in more lives saved [5], [6], [7].

This paper focuses on the demonstration and explanation of two distinct search algorithms. An algorithm that uses predefined paths to search for the target, and a multi-agent reinforcement learning algorithm, which is expected to learn and optimize the search autonomously. The objective is to create an algorithm that is capable of finding a shipwrecked person in the most efficient way possible. Furthermore, the environment that will be developed will replicate the circumstances of the ocean simply. To do so, a scenario will be created, where the environment changes dynamically, to update the probabilities in which the target could be. This does not require an accurate representation of how the ocean acts. Moreover, since the project deals strictly with simulated environments, image recognition, and real-life testing will not be considered. However, parameters regarding real-life issues are explored, for example, the number of drones needed and their technical limitations, as well as different deployment strategies.

## II. Literature review

To improve the performance of Unmanned Aerial Vehicles (UAVs) in Search and Rescue (SAR) missions, Alotaibi [5] proposes the Layered SAR (LSAR) algorithm. The key idea is, that in disasters, there is a location where most of the possible survivors are located. Therefore, the algorithm initially, focuses the search on this specific location and gradually moves away.

This technique uses a single command base, utilizing a cloud server as the drone mission controller. This cloud server is implemented through a cloud-based management system that is used to facilitate communication and collaboration among a swarm of drones, as well as control UAVs and schedule their missions.

While searching for survivors, if a person is found, the UAV records his location. Concurrently, the searcher UAV periodically reviews the locations to determine whether it meets a predefined threshold. When this threshold is met, the searcher UAV aircraft signals the cloud server for assistance. Following this, the server initiates an inward shift, beginning from the layer where the request for help originated. Once a drone sends a request for help, it is reassigned as a rescuer. Meanwhile, the remaining aircraft that underwent layer shifting continue their search activities as searchers in