Automomous Control of Aircraft for Communications and Electronic Warfare: The Promises of Recent Artifical Intelligence Literature

Sean Carver, Ph.D. at Data Machines Corporation

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Abstract

We pose an unsolved problem in autonomous control of aircraft for communications and jamming (electronic warfare). We aim to provide helpful pointers to literature offering approximately optimal solutions to related problems—such as cyber-security, precision farming, and search and rescue. Solutions to these related problems promise applicability to diverse scenarios beyond the scope of the original works—including the scenario considered here.

The problem we address lies within the fields of adversarial Multi-Agent Reinforcement Learning (MARL) and active sensing. In our problem, two opposing factions (labeled "blue" and "red") compete to win a zero-sum/purely adversarial game. The blue side tries to maintain communication links between ground-based assets with a fleet of "comms" whereas the red; whereas the red side tries to jam this network with a fleet of "jammers." An Unmanned Aerial Vehicle (UAV) becomes a comm or a jammer when fitted for one of these purposes.

Each faction lacks access to the state of the opposing side, and must infer this state probabilisticly through positioning its fleet for best sensory performance and localization (active sensing). Moreover, the ground troops of each side, positioned appropriately, have the possibility of shooting down any of their adversary's UAVs. Finally, the blue side must simultaneously achieve its objective of keeping units on the ground in communication. Despite best efforts, different units/UAVs can fall in and out of communication with their respective headquarters, making each of the blue and red factions a multi-agent collection, fully cooperating among itself, but with different information, to fight its adversary having opposing goals.

Our contribution poses this problem while pointing to literature for possible ideas for moving the field forward. Finally, we pose certain simpler-than-reality mini-games for efficiently investigating solutions leading to a successful implementation for the full adversarial problem in real-world combat.

1 Introduction

If unfortunate circumstances compel our leaders to order our armed forces to take a city from an adversary, the command headquarters on the ground would benefit from constant two-way communication with all its other units during the conflict.

In the fog that accompanies such struggles, our forces cannot rely on our enemy's network of cell towers to keep in touch. Instead, two way radios, linked by a network of "comms" will hopefully allow our friendlies to stay connected. A comm is an unmanned aerial vehicle (UAV) fitted for communication.

While vastly better than cell phones, such a network has it own set of issues. Indeed, our adversaries clearly prefer that we not speak to each other. To pursue this preference, they may send up jammers (UAVs blocking communication) to keep us isolated. Thus begins a delicate dance of each side positioning its fleet to best find the other's birds and in so doing best keep or block communications.

We study the question of how each side can control its fleet by autonomously ordering and carrying out flight and communications- electronics operation instructions (CEOI) to optimally achieve objectives. We are interested in the strategies for both sides, because to defeat our enemy, we must understand the intelligent countermeasures they may take. Moreover, in a real war, our side may choose to put up both comms and jammers, requiring strategies for both roles.

Much recent literature has tackled the problem of optimal search and rescue. This effort clearly relates to the problem at hand because, as with rescue, each side benefits from successfully inferring the positions of the other. But there is a difference between search and rescue and electronic warfare. People being rescued presumably want to be found and will presumably cooperate with this effort. In electronic warfare, it is always best if the other side cannot find you. Thus search and rescue can succeed with a purely active sensing and optimal control solution. In our scenario, we need to learn to counter our opponents strategy, whatever it may be. To this end, we propose to apply artificial intelligence (specifically, adversarial multi-agent reinforcement learning).

This paper reviews the literature relevant to the comms and jammers problem just posed. This paper will close with a very brief discussion presenting ideas for applying this work to other relevant domains, notably cyber-security.

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