DRONES Support in Precision Agriculture for Fighting against Parasites

Giuseppe Potrino, Nunzia Palmieri, Venturino Antonello, Abdon Serianni

Abstract—**This paper faces with the support of drones in the precision agriculture domain. In these last years, new technologies allow operators of the sector to face with different threats such as parasites and sudden climatic changes that can severely degrade the crop or the quality of the cultivated products. The use of simulators for this purpose is a necessary help to researcher in order to test these tecnologies and to plan specific strategies and coordination techniques able to efficiently support farmers and achieve the target. In this work, the main contribution is to perform a comparison between two different types of parasites' search algorithms (Random Search and Distributed Search) in order to give an indication of their performance.**

Index Terms—**Drones, Parasites, Agriculture, Search Algorithm.**

I. Introduction

Drones or drones' team equipped with a series of sensors, microcontrollers, multi-spectral cameras, can support farmers during their daily work. In particular, new forms of parasites attack plants and the use of drones can give a valid help to the farmers for intervening suddenly and foiling the threat avoiding great damage to the agriculture products [1]. Often, farmers need to face many issues such as parasites or sudden climate changes that can severely affect the agricultural products quality. Then, the support of drones in these situations allows to preserve the plants life and to kill the parasites able to destroy plants if the countermeasures are not timely and efficient. It is not known where exactly parasites are because they can be distributed in the land too and they can reproduce and move in a distributed manner. In this specific case, a drones' team can be very useful in overseeing the overall area in order to localize through cameras the attacked plants or to see parasites moving among plants. In real situation, unfortunately, drones are powered by a battery with limited lifetime and a pesticide tank, also limited, then the coordination of the drones is an important issue. Moreover, energy harvesting is an attractive technology for Ummanned Aerial Vehicles (UAVs) because it offers the potential to increase their endurance without adding significant mass or the need to increase the size of the fuel system [2]–[5]. Other research works address the use of drones as wifi network [6] where it is important to face with issues of management of flows and call admission control [7], [8]. In order to propose coordination techniques of drones for precision agriculture domain, it is necessary to have a simulator where parasites and drones mobility are implemented. In particular, in this paper, on the basis of previous works [9], [10], we are interesting to investigate on parasites' search algorithms in order to give an indication about precision agriculture issues. The paper is organized in the following way: in section II some related work about the coordination techniques of swarm of drones is presented; an overview about drones is presented in section III; section IV shows the issues on the precision agriculture; section V presents the distributed algorithm for parasites search; the drones simulator is shown in section VI and, finally, performance evaluation are introduced in section VII and conclusions are summarized in section VIII.

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II. Related Work

The topic of precision agriculture is recently object of a lot of attention in the community research as it is possible to view in [1], [11], [12]. Moreover, thanks to the use of new techonologies that allow to equip drones with a series of sensors such as spectrometry or cameras it is possible to evaluate the height of the crops or soil moisture that can be useful to understand how the crop is raising such as shown in [13]. UAVs applications in agriculture are described in [11]. The authors list some fields of applications of UAV spraying different protection chemical like insecticide, fungicides and herbicides. Crops spraying UAVs are suited for these tasks because many fields need of ultra-low application volume of pesticides per hectare and only on some specific zones of a field and only at a specific time. In [13] the authors propose a web-based system that facilitate farmers/extension workers to diagnose insects/pests of major pulse crops link Chikpea, Pigeonpea, Munghbean and Urdbean suggesting the suitable treatments. A novel approach for exploiting a multi-temporal remote sensing data focused on real-time monitoring of agricultural crops is presented in [14]. In this work the authors present also a Kalman filter to perform phonological stage estimation. Rural areas in Africa with their specific issues such as connectivity, water, transport, health and education in the agricultural domain are presented in [15]. An important aspect in this field is to study an opportune routing algorithm in order to help drones movements on the considered area [16]–[21]. Moreover, it could be interesting also to analyze using of UAVs with the help of other platforms as HAP or satellite layer [22],

[23]. In order to support the study of drones, micro-drones or UAV applied to Precision Agriculture, it is necessary to design a simulator able to support in a modular and flexible way the different actors playing in the domain. In previous works [9], [10] the authors have shown coordination protocols in drones environment in precision agriculture domain. In this paper the attention is focused on the search algorithms for finding and fighting parasites inside a considered field. In particular, the contribution of this paper regards mainly the analisys of comparison between random and distributed search algorithms for parasites killing.

III. Precision Agriculture Issues

Smart farming and precision agriculture acquired even more interests in the last few years [1]. Novel technologies in the field of communications permit to offer new solutions for continuous monitoring of the croplands, livestocks, water systems with the final goal to reduce the human activities. The management of the resources is one of the most important topic in the precision agriculture. In fact, the optimized use of resources pushes to achieve better results. To acquire more information and increase the knowledge of the environments image based measurements and smart data mining are required. Aerial images of crops fields and livestocks farming can be achieved using UAVs. Another important field of interest and application scenario in which video analysis may help the develop of plantations is the identification of weeds in the crops fields. The correct identification of this kind of vegetation is an open issue. The more utilized approach to solve weeds infestation is to use herbicides. In precision agriculture drones are used to detect plant growth data, soil moisture, nitrogen in the field or to release accurately and selectively within the field has been modified for diseases, for parasitic infestations or to monitor the harvest. The drones are widely used for area monitoring, spraying and agricultural insurance survey. Area scanning is an area of interest commonly covered by the use of UAV equipped with high resolution cameras [25].

IV. Distributed Algorithm for Parasites Search

The distributed algorithm for parasites search, used by drones, is coordinated by the exchange of messages. Each drone is equipped with a memory used to store information regarding previously visited areas (discretized and stored in this memory). At each movement, the drone updates its map by entering the information just discovered (the presence of healthy or infected plants) and eliminating any information that is no longer valid. This map helps the drone in choosing the next movement. In fact, the drone will not move to an area already visited and disinfected for avoiding waste of time and energy. The next direction is, therefore, chosen randomly among non-unknown areas. The drone then chooses a direction of moving and a distance. Of course, the areas closest to the drone that have not yet been explored will be chosen first. The drone keeps track of the direction of origin in order to avoid going back by choosing this direction.

The local view of the map is exchanged between drones in order to reconstruct the overall map. The knowledge map of the drone is seen as a matrix of areas in which the drone is in the middle, see Fig. 1. At each movement, a shift depends on the distance moved by the drone. The map of the drone is exchanged between the nearby drones that are within the range of the wi-fi, so as to allow such drones to know some areas visited by other drones without visiting them directly. This reduces search time and avoids waste. The exchange of such maps can occur either periodically or on map change driven. When a drone receives a map from another drone, it updates own map with the relevant information. This distributed algorithm uses a Distributed Search Message (DSM) that is information regarding a field area already considered. Each drone, with each new area knowledge, inserts in its memory the information related to this area and represeted by a DSM. This means that drones exchange their known maps exchanging a set of DSMs. The size of a DSM is 25 bytes.

The X and Y field coordinates represent the position on the area. Each area is represented by a square side of 10 meters and these coordinates are referred to the north-west angle of this square. The Time to Live (TTL) field represents the deadline information in milliseconds, see Fig. 2. The State field instead is referred to the considered area that can be:

- ”00000000”: absence of plants and absence of parasites;
- ”00000001”: presence of a plant healthy;
- ”00000010”: presence of a plant treated with pesticide;
- ”00000011”: presence of a plant infected;
- ”00000100”: absence of a plant but presence of parasites;
- the other configurations are for future works.

A. Parasites Moving Algorithm

The parasite can be moved by choosing random directions or by looking for plants. This second moving algorithm is described below. In the moving, the parasite is guided by

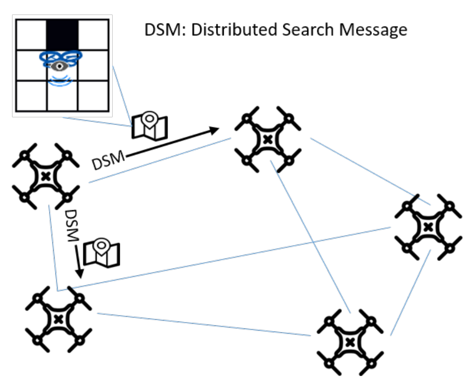

Fig. 1. Map exchange in drone network

X coordinate	Y coordinate	TTL – Time to Live	State
8 bytes	8 bytes	8 bytes	1 byte

Fig. 2. Distributed Packet Format of DSM

the presence of plants, regardless of the behavior of other parasites. It has a limited view of the area surrounding it. If the parasite is on a plant, it remains still to feed until the plant dies. In the case where, instead, it is located in an area of the field without a plant, it goes to search for one. In carrying out a movement, a parasite can be found mainly in three cases:

- If an area near the parasite contains a plant, then it will see the plant to attack.
- If, on the other hand, the parasite is able to see more than one plant, it will be able to choose a plant to attack.
- If no visible area from the parasite contains a plant, it will equally roughly choose an area from the visible ones in which to move until it finds a plant.

B. Drones Communication

Each packet will be sent by the drone that generated it to the destination drone or to all drones. Upon receipt, the type of packet determines the execution of a specific process within the drone determined by the type of packet received. The communication between drones is mainly for three reasons:

- **Recruitment**: a drone sends a request for help on the net when it has detected parasites and one of the following conditions exists: a) the pesticide tank is empty; b) the level of the remaining battery, excluding the reserve, is such as to allow it only to reach the base to recharge.
- **Sending information of already performed detections**: the drones periodically exchange information about the areas already controlled, in order to avoid to visit the same area many times and to better coordinate the drones, speeding up the search and killing of the parasites.
- **Sending information regarding some drone conditions**: the drones can exchange information regarding their conditions such as the remaining pesticide and residual energy.

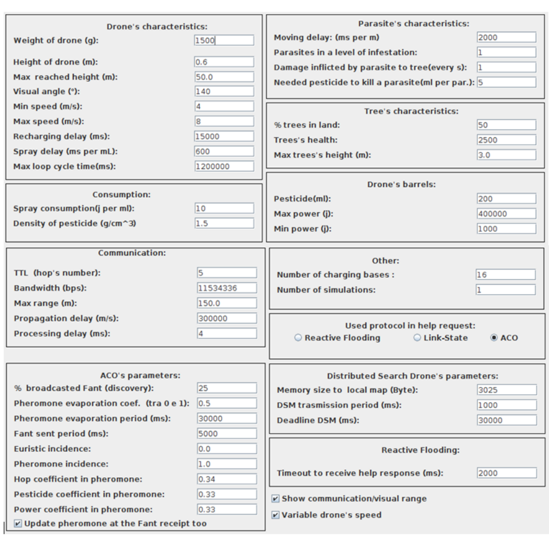

Fig. 3. Default parameters used in the simulations

V. PERFORMANCE EVALUATION

In this section the performance evaluation is shown in terms of killed parasites varying time and varying position and number of recharge bases. The simulator has a set of setted parameters and a set of other varying parameters. It presents a Graphical User Interface (GUI) in which it is possible to change parameters' value in order to simulate a specific scenario, see Fig. 3, [9], [10]. In particular, it will be shown the comparison between the random and the distributed search algorithm. The two algorithms are compared in three different cases as shown in the Fig. 4.

	Drones number	Field dimension	Parasites number	Base number	Base position	Max loop cycle time
Case 1	20	700*700	2000	4	Angles	20 minutes
Case 2	32	1500*1500	2500	8	Angles and sides	40 minutes
Case 3	48	3000*3000	3000	16	Anlges, sides and center	40 minutes

Fig. 4. Considered three cases

The following graphics, Fig. 5, 6 and 7, show how many parasites have been killed in each time in the three considered cases.

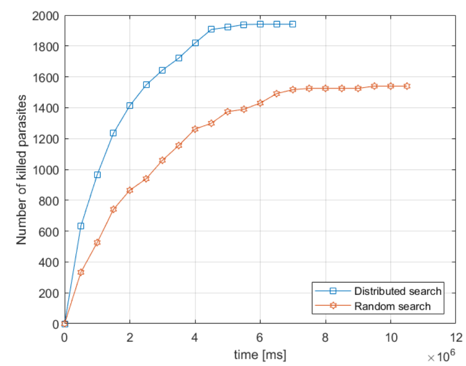

Fig. 5. Case 1: Killed parasites varying time

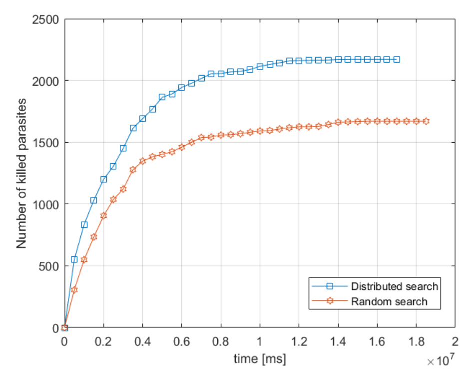

Fig. 6. Case 2: Killed parasites varying time

How it is possible to view, the drones that use the distributed search algorithm reach the convergence much more suddenly of those using the random search one. These last ones, besides ending later, kill much less parasites in all three considered

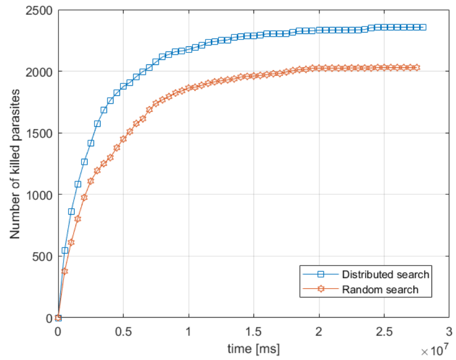

Fig. 7. Case 3: Killed parasites varying time

cases. Moreover, increasing the field size the number of drones is not increased in a proportinal way, much more parasites will be alive with the consequent problems to the crops. Observing Fig. 5 it is possible to note that the percentage of alive parasites is really very small. Observing Fig. 6, instead, that percentage increases due to an increase of field dimension, it is in fact about four time more than in the first case, while the bases are solely doubled and the number of drones is going from 20 to 32 units. In the third figure, Fig. 7 the field dimension is quadrupled in respect to the second case while the number of bases is doubled and the number of drones is passed from 32 to 48 units. Observing these graphics it is possible to deduce that for having high performance it is necessary to respect the proportion indicated in the first case where we have observed that the parasites are killed almost all.

VI. Conclusions and Future Works

In this work we have considered three different cases varying number of drones, field dimension, base number and parasites number for the simulations. The performed simulative campaigns have shown the behaviour of two differents search algorithms, one based on a random choice criteria and another based on a distribute one. The results have shown the performance of the two algorithms showing how the distributed one is more suitable and indicated in the parasites fight.

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