University of Bordeaux 1
Science and Technology
Computer Science specialty

Second year of Master - Study and Research Project

Mobility Models for UAV Group Reconnaissance Applications

MEMORY

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Introduction

Dans le cadre de notre formation de Master Informatique à l'Université de Bordeaux 1 et notamment dans la matière : projet d'étude et de recherche, nous devions étudier un article de recherche par groupe de 5 personnes. Chaque groupe devait choisir un sujet de recherche parmi ceux proposés. Notre groupe a choisit un sujet en rapport avec les drones. Le titre de cet article est *Mobility Models for UAV Group Reconnaissance Applications* écrit en collaboration par *Erik Kuiper* et *Simin Nadjm-Tehrani* publié en 2006. Les clients qui nous ont proposé d'étudier cet article sont messieurs Serge Chaumette et Vincent Autefage. Notre chargé de TD est monsieur Pascal Desbarats.

Ce projet, d'une durée de 3 mois, nous a permis de voir le cheminement de l'étude d'un article de recherche, de sa lecture en anglais, à l'implémentation d'un algorithme, tout en passant par une étude de l'existant. Le but de cette matière est donc de nous faire étudier un article de recherche, d'en extraire un algorithme et de l'implémenter. Nous devons donc étudier un modèle qui respecte les propriétés aérodynamiques des drones.

As part of our Master Computer formation at the University of Bordeaux 1 particularly in the matter Study and Research Project, we had to study a research article in groups of 5 people. Every group had to choose a subject of research among those proposed. Our group chose a topic related to the drones. The title of this article is *Mobility Models for UAV Group Reconnaissance Applications* written in collaboration by *Erik Kuiper* and *Simin Nadjm-Tehrani* published in 2006. The customers who suggested us studying this article are misters Serge Chaumette and Vincent Autefage. Our teaching assistant is mister Pascal Desbarats.

This project, for a period of 3 months, we were able to see the progress of the study of a research article, its reading in English, with the implementation of an algorithm, while going through a study of the existing. The aim of this material is to make us study a research article, to extract an algorithm from it and to implement it. We must therefore study a model that meets the aerodynamic properties of drones.

Plusieurs modèles de mobilité existent et se base le plus souvent sur des éléments du monde réel. Cet article précisément étudie deux modèles de mobilité qui sont le Random Mobility Model et le Distibuted Pheromon Model.

Nous avons donc essayé de donner la meilleure image possible de notre projet à travers ce mémoire. Il représente chaque étapes de celui-ci, de l'étude de l'existant à l'implémentation d'un algorithme. Il montre également notre organisation ainsi que les multiples tests que nous avons établis et réalisés.

This article specifically discusses two mobility models that are Random Mobility Model and distibuted Pheromon Model.

We tried to give the best possible image of our project through this memory. It represents each stage thereof, the study of the existing in the implementation of an algorithm. It also shows our organization as well as the multiple tests which we established and realized.

Chapter 1

Context

Un drone est un aéronef inhabité télécommandé à distance ou autonome. Il est équipé de différents capteurs (accéléromètre, gyroscope, magnétomètre, caméra, etc.) et ceux-ci lui permettent de se mouvoir dans son environnement.

Les drones aujourd'hui sont de plus en plus présents sur le territoire français et partout dans le monde. Il y a différents types de drones avec différentes missions. Par exemple, certains drones font de la surveillance (de bâtiment, de monuments historiques ...), d'autres sont destinés à collecter des renseignements, d'autres ont des usages militaires ou encore de transport. Deux types de drones sont présents actuellement : les drones dit civils, et les drones militaires. Dans le cadre militaire, les drones peuvent être utilisés pour pénétrer des zones qui peuvent être trop dangereuse pour l'homme. Ils peuvent notamment cartographier des zones pour faire du repérage de zone.

De nombreuses recherches sont dédiées à ces appareils depuis de nombreuses années, notamment sur la coopération et la communication de plusieurs drones entre eux. Ces flottes de drone permettent d'accomplir des tâches le plus efficacement possible. Il faut donc savoir comment ils vont bouger ensemble, éviter les collisions, éviter qu'ils fassent deux fois les mêmes tâches etc... Ces différentes contraintes peuvent être résolues grâce à des modèles de mobilités basés sur la communication.
De nombreux sujets de recherche sont dédiés à ces modèles de mobilité dans le cadre des flottes de drones. Ils étudient les différentes façons qu'on les drones pour se déplacer dans leur milieu tous ensemble.

Le but de notre article est de scanner une aire définit auparavant le plus rapidement possible et si possible une fois par heure. La problématique de cet article est donc : **How well scan an area? As much as quickly possible, in a limited time and at least, once every hour**.

A drone is an unmanned aircraft remote-controlled or autonomous. It is equipped with different sensors (accelerometer, gyroscope, magnetometer, camera, etc..) And they allow it to move in its environment.

Today, UAVs are increasingly present on French territory and around the world. There are different types of drones with different missions. For example, some drones are monitoring (building, historical monuments ...), others are designed to collect information, others have military uses or transport.Two types of UAVs are currently present: the drones said civilian and military drones. In the military context, UAVs can be used to penetrate areas that may be too dangerous for humans. They may include mapping areas for the tracking area.

Much research has been dedicated to these devices for many years, including on cooperation and communication between them several drones. These fleets of drone used to perform tasks as efficiently as possible. We need to know how they will move together, collision avoidance, avoid them to do twice the same work etc ... These constraints can be resolved through mobility models based on communication.
Many research topics are dedicated to these types of mobility within fleets drones. They study the different ways that the drones to move in their environment all together.

The purpose of this article is to scan an area previously defined as soon as possible and if possible once per hour. The problem of this article is: **How well scan an area? As much as Quickly as possible in a limited time and at least, once every hour**.

Chapter 2

Analysis Of Existing

Comme dit auparavant, les flottes de drones sont régis entres elles par des modèles de mobilités. Notre étude de l'existant s'est donc décomposée en plusieurs parties.

As said before, fleets drones are governed by these models mobility. Our study of the current is therefore divided into several parts.

2.1 Summary of the problem

La problématique de notre article est de scanner une zone le plus efficacement possible et le plus rapidement possible, au maximum une fois par heure. Cette zone sera scannée par une flotte de drone qui devront coopérer entre eux et communiquer.

The issue of this paper is to scan an area as efficiently as possible and as quickly as possible, at most once per hour. This area will be scanned by a fleet of drones that will cooperate and communicate.

2.2 Existing models

De nombreux modèles de mobilité existent avec chacun des caractéristiques différentes. Tous ces modèles permettent de définir des mouvements à des flottes de drones. La plupart des modèles sont basés sur des situations de la vie réelle comme la cartographie routière, ou encore sur le comportement de nombreux animaux (fourmis, oiseaux, thermites etc). Nous allons vous en exposer certains que nous considérons les plus importants et les plus intéressants pour notre cas.

Many mobility models exist each with different characteristics. All these models are used to define movements fleets drones. Most models are based on real-life situations such as road maps, or on the behavior of many animals (ants, birds, termites, wolves etc). We will expose some of which we consider the most important and most interesting for our case.

2.2.1 Random Walk

First described by Einstein in 1926 [29], it was developed to mimic the extremely unpredictable movement of many entities in nature [9]. An MN moves from its position to a new one by randomly choosing a direction and speed choosen by pre-defined ranges, [speedmin, speedmax] and [0, 2PI]. At the end of a constant time interval t or a constant distance traveled d, a new speed and direction are calculated. If a MN during his travel reaches a simulation boundary, it « bounces » off the simulation border with an angle determined by the incoming direction and continues to this new path. It's a memoryless mobility pattern because it retains no knowledge of its old locations and speed values [19]. Therefore, the current position and speed of a MN is independent of its past location and speed. This can generate unrealistic movement because of sudden stops and sharp turns. If the specified time or distance of a MN motion is short, the area of the simulation will be small.

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2.2.2 Random Waypoint

Includes pause times between changes in direction and/or speed.Once this time expires, the MN chooses a random destination and a speed, that is uniformly distributed between [minspeed, maxspeed]. The movement pattern of a MN who uses the RWaypointMM is similar to the RwalkMM if pause time is zero and [minspeed, maxspeed] = [speedmin, speedmax]. During a performance investigation, MNs are initially distributed randomly around the simulation area. Figure 4 shows the average MN neighbor percentage of the MNs. For example, if there are 50 MNs in the network and a node has 10 neighborns, then the node's current neighbor percentage is 20%. Moreover, during the first 600 seconds, due to initially distributed randomly of the MNs around the simulation area, there is an high variability in the average MN neighbor percentage. In the paper, there is presented three possible solutions to avoid this initialization problem. The first is to save the location of the MNs after the initial high variability and use this position as the initial starting point of the MNs in all future simulations. Second, initially distribute the MNs in a specific area to be a distribution more common the model, like fore example, initially placing the MNs in a triangle distribution. Lastly, discard the initial 1000 seconds of simulation time in each simulation trials, to ensure thatthe initialization problem is removed even if the MNs move slowly. But if the MNs move fastly, we can discard fewer seconds of simulation time. This third solution ensures that each simulation has a random initial configuration. Figure 5 : thre is a complex relationship between node speed and pause time. A scenario with fast MNs and long pause times actually produces a more stable networks than a scenario with slower MNs and shorter pause times. Hence, long pause times(over 20 seconds) produce a stable network even at high speeds.

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2.2.3 City section

Similar to Random Waypoint MM but here, the simulation area is a city where the ad hoc network exists and each MN begins the simu at a defined point(opposite to RwaypointMM) on some street of the city. There exists also safe driving characteristics such as a speed limit or minimum distance allowed between the current position and the new location.

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2.2.4 Natural Agent

Ants

Le modèle de mobilité des fourmis se base sur le fait que les fourmis construisent des réseaux de sentiers qui relient leurs nids avec des sources de nourritures disponible. Chaque fourmi qui se nourrit à le même programme :

- Elle doit éviter les obstacles.
- Aller ou elle veut (déplacement aléatoire) tant qu'il n'y a pas de phéromones.
- Si elle arrive à trouver de la nourriture, elle laisse des phéromones pendant un temps t pour pouvoir indiquer aux autres fourmis l'emplacement de la nourriture.
- Si la fourmi trouve de la nourriture, elle l'a ramène à son nid.

Les fourmis peuvent mourir. Soit elles ne trouvent pas de la nourriture assez rapidement et meurt de faim, soit elles se font tuer par d'autres prédateurs. Tous les chemins de phéromones conduisent à de la nourriture. Mais les phéromones s'évaporent dans le temps. Le taux de phéromone peut être renforcé si plusieurs fourmis passent par le même chemin.

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Termites

Wasps

le modèle basé sur les guêpes est composé de plusieurs caractéristiques :

- un chef qui répartit les différentes guêpes dans différents groupes
-

2.2.5 Birds and Fish

2.2.6 Wolves

Chapter 3

Scenarios

Chapter 4

Needs Analysis

4.1 Functional Requirements

4.2 Non-Functional Requirements

Chapter 5

Architecture

Chapter 6

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Chapter 7

Works Done

7.1 What we did

7.2 Difficulties Encountered & Solutions

Chapter 8

Results

Chapter 9

Tests

Chapter 10

Improvements

Chapter 11

Development Environment and Conventions

In this part, we will see the development environment we used, and the programming conventions we've applied.

11.1 Development Environment

- GitHub
- ...

11.2 Programming Conventions

First, we've choosed to used the Java Coding Conventions, which we can see in the following link - http://www.oracle.com/technetwork/java/codeconventions-150003.pdf

Then, in order to create our documentation, we've used the Doxygen Convention, viewable here - `http://www.stack.nl/~dimitri/doxygen/manual/docblocks.html` We've relied heavily on this documentation and have mostly employed these protocoles below.

Doxygen Convention for classes

```
/**
* @class name of the class
* @brief Description of herself
*/
```

Doxygen Convention for methods

```
/**
* @brief Description of the method
* @param the parameters and their descriptions
* @return the description of what return the method (optional)
```

```
*/
```

Doxygen Convention for members

```
int var; /**< Detailed description after the member */
```

We've also resorted to programming conventions that we defined between us.
For example, when a part of a code, was not finished yet, we put the following lines above the concerning part.

Programming convention for unfinished code

```
/**
* @TO_DO
* Description
*/
```

We've also used a convention for the bugs found and wrote these protocoles, depending on whether the bug was resolved or not.
We used it, in line with the Bug Tracking of GitHub.

Programming convention for bugs

```
/**
* @BUG
* @Unfinished/finished
* Description
*/
```

To finish, we've created the five essential files for a project :

- INSTALL.txt : Installation instructions for the project,
- LICENCE.txt : Licence and copyright © of the project,
- README.txt : General description of the project,
- AUTHORS.txt : Authors of the project,
- MANIFEST.txt : Tree structure and files list of the project.

Chapter 12

Conclusion