Master Thesis Contents

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0. Abstract

We can control a drone with a joystick two drones with 2 joysticks we discuss here a solution to control more drones using human poses from the drone flight space.
Our solution is based on multiple axis.
- Asynchronous controller kernel for drone manipulation.
- Collision avoidance integration for technological platforms.
- Object detection from cameras.
We research here multiple domains Human Computer Interactions (HCIs), unmaned air vehicules (UAVs), Swarms and Object Detection and Recognition.
Our results show that our approach makes a robust steping stone for other drone swarm indoor installations.

1. Introduction:

rajouter du context général sur les drones
rajouter contexte swarn drone

- expliquer brièvement qu'il n'y a pas de concensus sur le control des essains de drones

Pb : controler les drones en essain en interieur

petit résumé pour dire les future chap qui arrive

General context about drones:
Drones have become pivotal in various sectors, from surveillance to delivery services. However, the control of drone swarms remains a complex issue without a consensus in the field especially

around humans.

Swarm technology in drones presents unique challenges and opportunities, particularly in coordination and control. Understanding these dynamics is essential for advancing UAV technologies.

We research here multiple domains Human Computer Interactions (HCIs), unmaned air vehicules (UAVs), Swarms and Object Detection and Recognition.
We are proposing novel solutions for controlling drone swarms.

2. Related Works:

Collision Avoidance Systems:

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Use sensors like ultrasonic, infrared, and optical flow for obstacle detecti
Ultrasonic sensors have a detection range up to 15 meters.
Infrared sensors can detect objects within a 10-meter range.
Optical flow sensors detect movement within a 3-meter range


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Passive Collision Avoidance Systems:

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Include geofencing, aircraft avoidance systems, and obstacle detection syste
Geofencing uses GPS to create virtual boundaries.
Aircraft avoidance systems detect and avoid other aircraft using sensors and


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Collision Avoidance Algorithms:

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Categorized into reactive, predictive, and cooperative algorithms.
Reactive algorithms respond to immediate obstacles.
Predictive algorithms anticipate future obstacles.
Cooperative algorithms enable drone-to-drone communication to avoid collision

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Robust MADER Algorithm (MIT Research):

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An asynchronous, decentralized multiagent trajectory planner.
Allows individual trajectory formulation for each drone.
Includes a delay-check step for collision-free trajectories despite communica

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Regulatory Aspects and Standards:

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FAA and other regulatory bodies have set standards for drone collision avoida
Standards vary based on drone capabilities and weight
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Multi-Vehicle Cooperation and Collision Avoidance: There's a significant focus on autonomous vehicles (AVs), particularly in how they can cooperate and avoid collisions. The complexities of AVs' interactions, especially in mixed autonomy environments where both human-operated and autonomous vehicles coexist, are a key area of research. This research often includes developing models and frameworks that can handle the varied dynamics of such environments, emphasizing the necessity for robust collision avoidance systems in UAVs.

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Reinforcement Learning for Quadrotor Collision Avoidance: In the realm of UAVs, specifically quadrotors, reinforcement learning techniques are being used to develop collision avoidance strategies. These strategies involve training policies that can efficiently guide drones in complex tasks like formation changes and package delivery. The goal is to achieve efficient task execution while ensuring safety through collision avoidance, even in environments with multiple drones. This kind of approach highlights the potential of machine learning algorithms in enhancing UAV operations in real-time, adaptive scenarios

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UAV Flight Control Regulations and Airworthiness Standards: There are established regulations and standards that dictate the flight activities of UAVs, focusing on reducing collision risks and ensuring airworthiness. These regulations cover aspects like flight area, speed, duration, and operational risks. They also include standards for various types of UAVs, specifying performance requirements that ensure safety and collision avoidance capabilities. This regulatory framework plays a crucial role in guiding the development and implementation of UAV technologies, ensuring that they meet safety standards and can effectively avoid collisions

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In summary, the integration of asynchronous controller kernel, collision avoidance, and object detection technologies in UAVs is an area of active research and development. The focus is on creating systems that can operate autonomously and safely in mixed environments, utilizing advanced algorithms and adhering to rigorous safety standards and regulations. These technologies are not only crucial for the efficient operation of individual UAVs but also for their interaction within larger systems, including those involving human-operated vehicles.

These systems are made for outdoors use where the drones stay far from humans.

2.1: Asynchronous controller kernel

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2.2: Collision Avoidance

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2.3: Object Detection

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conclusion part 2:

résumé des related works
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3. Contribution 1: *Control drones :* An Asynchronous controller kernel

- 3.1 Intro : Link to the Vision and reason to build an asynchronous controller

Importance of an Asynchronous API for Controlling Drones

Instantaneous API Calls and Background Processing: Asynchronous APIs enhance the functionality of drone control applications by handling requests in the background. This approach maintains application functionality while keeping resources free to process new requests. Especially in drone operations where real-time responsiveness is crucial, this capability ensures efficient handling of multiple tasks simultaneously.

Adaptability to Connectivity and Execution Time: Asynchronous APIs are particularly beneficial in environments with variable connectivity or where requests have longer execution times. They allow for the processing of complex operations without causing delays in the application's responsiveness, crucial for real-time drone control where delay can have significant consequences

Event-Driven Communication: Asynchronous APIs, enable more intelligent communication between internal and external services. This is especially important in drone operations where multiple events or commands may need to be handled in real time, ensuring smoother and more efficient workflows

Support for Various Protocols: These APIs support a range of messaging protocols and transports such as WebSockets and GraphQL subscriptions, which are essential for the dynamic and varied requirements of drone control. This flexibility allows for more robust and versatile drone operation management.

We were provided a synchronous control driven api we have worked around it to handle practial asynchronous calls. We shore here this work. The use

- 3.2 Extend radio python library to web API

Multi-User Accessibility: Web-accessible asynchronous APIs allow multiple users to simultaneously interact with drone control systems. This is particularly important in scenarios involving multiple drones or when drone operations are managed by a team.

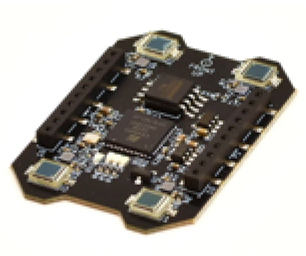
Handling Conflicting Commands through Non-Blocking Operations: The non-blocking nature of asynchronous APIs is critical in drone control applications, as it allows the system to handle conflicting commands effectively. This ensures that the operation of drones remains smooth and uninterrupted even when multiple commands are issued simultaneously.

- 3.3 Results

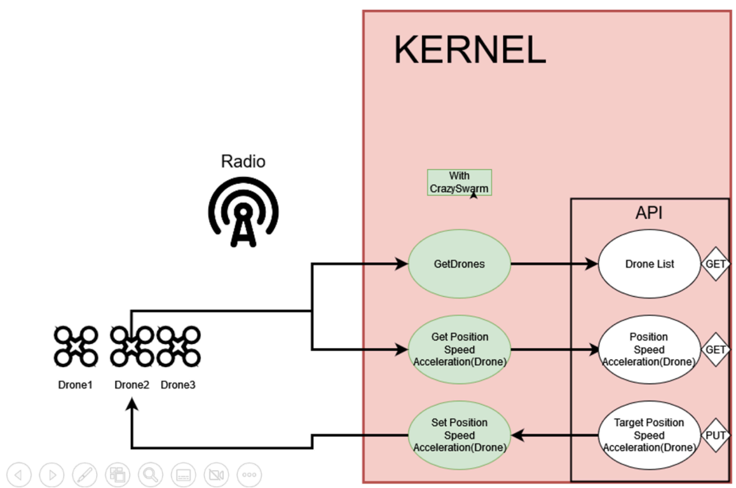
- Results interpretation and analysis.
- Asynchronous controller kernel outcomes.
- Effectiveness of handler of conflicts

- 3.4 Discussion

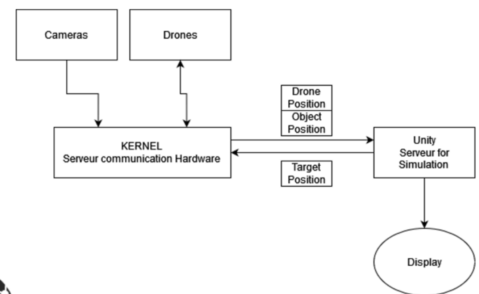
- System comparison with existing technologies.
- Implications and potential applications.



02| Drone Control Kernel



HTTP



High Level Relations Diagram

Unity

Human computer interface for drone swarm control

- 3.5 Conclusion

Our research has shown that an asynchronous API functions effectively for controlling drones, especially in scenarios involving multiple users. Its ability to handle conflicting commands through non-blocking operations enhances the efficiency and reliability of drone operations. This makes asynchronous APIs a vital component in the development of advanced drone control systems.

Lien

communiquer maintenant ça marche (ptit résumé comme quoi quoi ça marche)
sauf que communiquer c'est bien mais alala où va-t-on? (soulève un pb)

4. Contribution 2: Motion planning/ Collision Avoidance

Mini intro

éviter des obstacles c'est important
qu'est-ce qu'un venv
on peut mettre les drones dans un venv
Pb : plannifier mvt drone dans/via venv

- 4.1 *ton projet*

-

- 4.2 Results:

- Effectiveness of collision avoidance (%).
- Speed

- 4.3 Discussion:

- Results interpretation and analysis.
- System comparison with existing technologies.
- Implications and potential applications.

![]

Lien

résumé, on arrive à bouger les drones où on veut
mais comment détecter les obstacles pour les éviter

5.Contribution 3: Object Detection

Mini intro

pour éviter les objets il faut les localiser

et il faut placer dans les venv
Comment faire ?
trouver l'objet dans l'image
profondeur, ya differents types de cameras
on utilise donc celle làe

- 5.1 *ton projet*

- Image segmentation
- object depth

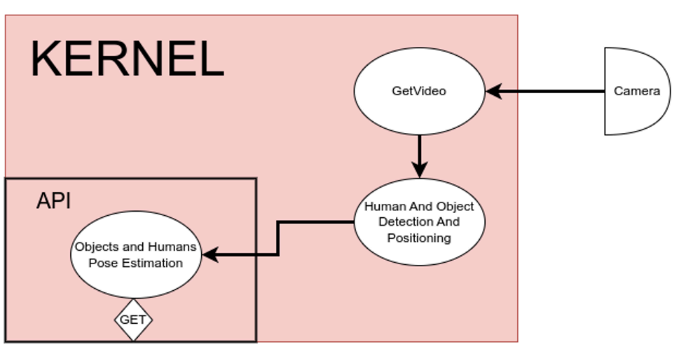
- 5.2 Results:

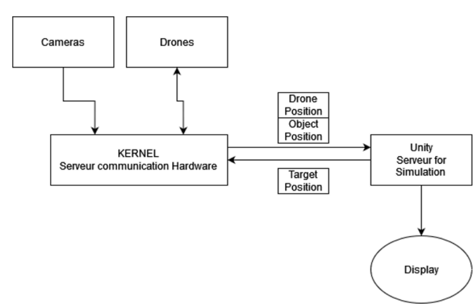
- Object detection results.

- 5.3 Discussion:

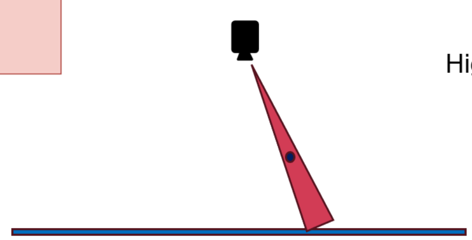
- Results interpretation and analysis.
- System comparison with existing technologies.
- Implications and potential applications.

02| Object Localization Kernel





High Level Relations Diagram



Unity

Human computer interface for drone swarm control

Lien

6. Global Solution The technological platform

Mini intro

- 6.1 *ton projet*

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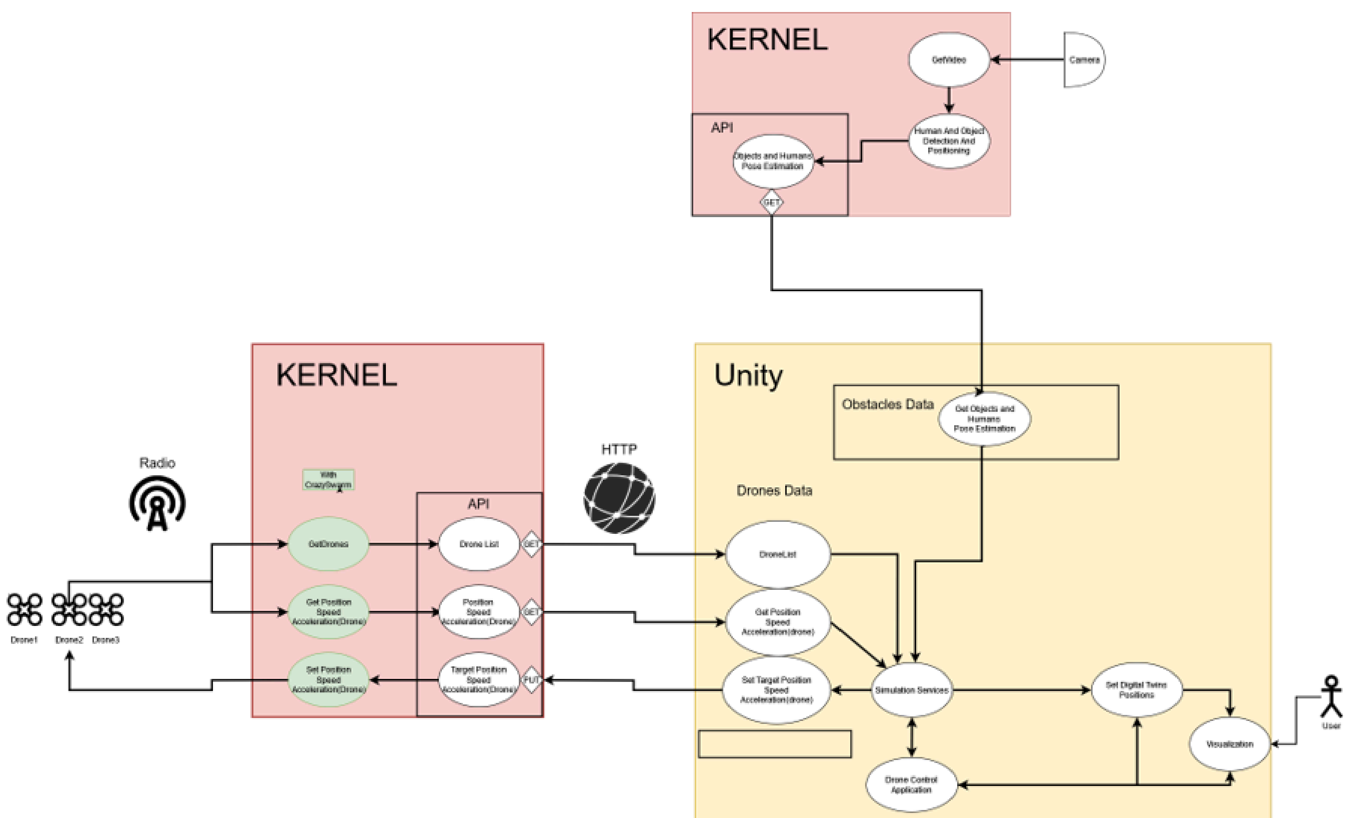
- 6.2 Results:

- 6.3 Discussion:



Discussion:

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Results interpretation and analysis.
System comparison with existing technologies.

Implications and potential applications.
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Results:

```
Asynchronous controller kernel outcomes.
Effectiveness of collision avoidance.
Object detection results.
```

Appendix

terms definitions

API
cflib
kernel

thread
UAV

The cflib API, used for communicating with the Crazyflie quadcopters, operates in an asynchronous manner. This asynchronous nature is primarily managed through callbacks for various events. For example, when you open a link, the function returns immediately, and a connected callback is called when the link is successfully opened. This design is a core part of the library's functionality, ensuring that the library doesn't block the main thread of your application and responds to events as they occur.

Moreover, the API provides the SyncCrazyflie class, which is a wrapper around the normal Crazyflie class. This wrapper turns the asynchronous nature of the Crazyflie API into blocking functions. This is particularly useful for simpler scripts where tasks need to be performed sequentially. The SyncCrazyflie class offers methods for handling connections and links in a synchronous manner, which means that the calls will wait until the operation is completed, like establishing a connection and downloading the TOCs (Tables of Contents) for log and parameters.

Eelements of architecture

References

- Karaman, S., & Frazzoli, E. (2011). Sampling-based Algorithms for Optimal Motion Planning. arXiv.
- Adiyatov, O., & Varol, A. (2013). Rapidly-exploring random tree based memory efficient motion planning. In *2013 IEEE International Conference on Mechatronics and Automation* (ICMA) (pp. 359).
- Lim, H., Jie, M., & Choi, W. (2016). Developing a Safety Flight Assurance Control (SFAC) System using a Quadcopter.
- Unity Technologies. Powering the World’s Digital Twins.
- Jerald, J., Giokaris, P., Woodall, D., Hartholt, A., Chandak, A., & Kuntz, S. (2014). Developing virtual reality applications with Unity. In *2014 IEEE Virtual Reality (VR)* (pp. 1-3).
- Tang, L., Wang, H., Li, P., & Wang, Y. (2019). Real-time Trajectory Generation for Quadrotors using B-spline based Non-uniform Kinodynamic Search. arXiv.
- Terven, J., & Cordova-Esparza, D. (2023). A Comprehensive Review of YOLO: From YOLOv1 and Beyond. arXiv.
- Greiff, M., Robertsson, A., & Berntorp, K. (2019). Performance Bounds in Positioning with the VIVE Lighthouse System. In *2019 22nd International Conference on Information Fusion (FUSION)* (pp. 1-8).
- Giernacki, W., Skwierczynski, M., Witwicki, W., Wronski, P., & Kozierski, P. (2017). Crazyflie 2.0 quadrotor as a platform for research and education in robotics and

control engineering. In *2017 22nd International Conference on Methods and Models in Automation and Robotics (MMAR)* (pp. 37-42).

- Wawrla, L., Maghazei, O., & Netland, T. (n.d.). Applications of drones in warehouse operations.
- codevia-io/{Codevia}.{Centurion}.{Net}.{API}
- {DVIC} - {De} {Vinci} {Innovation} {Center}
- Sampling-based Algorithms for Optimal Motion Planning
- Rapidly-exploring random tree based memory efficient motion planning
- Plan 3D Paths for Drones | Motion Planning with the RRT Algorithm, Part 4
- Path Planning with A* and RRT | Autonomous Navigation, Part 4
- Effective Python
- Playing Atari with Deep Reinforcement Learning
- Deep Reinforcement Learning with Unity and Python
- Github Deep Reinforcement Learning Playground
- Crazyflie + Crazyswarm + Microservice implementation - YouTube
- Overview — Crazyswarm 0.3 documentation
- Developing a Safety Flight Assurance Control (SFAC) System using a Quadcopter
- Powering the World’s Digital Twins | Unity
- Developing virtual reality applications with Unity
- Real-time Trajectory Generation for Quadrotors using B-spline based Non-uniform Kinodynamic Search
- A Comprehensive Review of YOLO: From YOLOv1 and Beyond
- Performance Bounds in Positioning with the VIVE Lighthouse System
- Crazyflie 2.0 quadrotor as a platform for research and education in robotics and control engineering
- Applications of drones in warehouse operations
- **codevia-io/{Codevia}.{Centurion}.{Net}.{API}**
- **DVIC - De Vinci Innovation Center**
- **Karaman, Sertac and Frazzoli, Emilio. "Sampling-based Algorithms for Optimal Motion Planning", arXiv, May 2011**
- **Adiyatov, Olzhas and Varol, Atakan. "Rapidly-exploring random tree based memory efficient motion planning", August 2013**
- **MATLAB. "Plan 3D Paths for Drones | Motion Planning with the RRT Algorithm, Part 4", August 2022**
- **MATLAB. "Path Planning with A* and RRT | Autonomous Navigation, Part 4",**

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