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AI-Based Detection of Jamming Attacks In 6G Drone Networks

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Keywords: keyword 1; keyword 2; keyword 3 (List three to ten pertinent keywords specific to the article; yet reasonably common within the subject discipline.)

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1. Introduction

The shift from 4G to 5G has been a generational leap has revolutionized connectivity around the world. Despite 5G being still in its early adoption rate at the time of writing [1], the research community is already working on the next generation of wireless communication technologies, 6G. 6G technology is expected to enable a wide variety of new use cases, thanks to the increases in both data rates and latency but this in turn will also bring forth new security challenges, specific to those applications.

One of the main differences between 5G and 6G technology will be the focus of the 6G standard in regards to AI integration. While Software Defined Networks (SDN) have played a key role in improving the efficiency and security of 5G networks, 6G is expected to take this a step further, by integrating artificial intelligence and machine learning directly into the network. This is what the authors of [2] define as the shift from *Softwarization* to *Intelligentization*.

AI integration in 6G networks will greatly strengthen the security of the network against security threats. By leveraging Diagnostic Analytics, a collection of insights into the status of the networks, security teams will be able to train specific AI models to detect and respond to security threats in real-time.

In this paper we will focus on a specific aspect of the security of 6G networks, namely we will provide a machine learning based approach for the detection of jamming attacks in networks of drones.

The paper is divided in 5 sections:

1. **Topic overview:** In this section we will discuss how drones can benefit from integration in 6G network, analyze jamming attacks, their types, mitigation and detection. Finally we will discuss the advantages of an edge AI approach for jamming detection.
2. **Materials and methods:** In this section we will define the scenario that we decided to analyze as well as the dataset, algorithm and evaluation metrics we chose for our tests.

3. **Numerical Results:** In this section we will present the testing methodology as well as the numerical results that we obtained.
4. **Discussion:** In this section we will discuss the results obtained in the previous section and highlight notable trends.
5. **Conclusions:** In this section we will summarize the results and discuss possible future research directions.

2. Related Works

3. Topic Overview

3.1. Drones in 6G Networks

Drones, also known as Unmanned Aerial Vehicles (UAVs) are defined as *all aircraft designed to fly without a pilot on board* [3]. This technology has experienced rapid growth in recent years and is expected to keep growing in both the consumer sector as well as the commercial and military sectors [4].

In report 22.886 [5] 3GPP, the organ responsible for the development and maintenance of the 5G standard, identifies some of the envisioned use cases for 5G V2X (Vehicle-to-Everything) communication services. Among these use cases, the report identifies vehicle platooning, advanced and remote driving end extended situational awareness as some of the main benefits of V2V communication. All these use cases can be leveraged by a 6G drone network to achieve fast and reliable drone-to-drone communication, that, with the integration of artificial intelligence would allow the drones to act autonomously in a coordinated manner.

This would prove useful in a variety of fields: from autonomous soil and crop health assessment as well as irrigation in agriculture, delivery of life saving supplies and locating of survivors in disaster response, in the delivery sector as a more eco friendly alternative to traditional delivery options and possibly in the mobility sector as a complement to traditional taxis and public transportation [6].

The effectiveness of drones in the military sector is widely recognized, both for high and low end models. For example, in the Ukraine war even cheap FPV drones mounted with explosives were successfully used to destroy much more expensive equipment [7].

Security against Jamming attacks is crucial in all these applications, especially in a safety critical environment.

3.2. Understanding Jamming Attacks

Jamming attacks are a type of Denial of Service (DoS) attack that aims at disrupting the communication between two or more devices. This is achieved by transmitting a powerful signal on the same frequency as the one used by the devices to communicate. If the jamming signal is strong enough, it is able to overwhelm the legitimate signal, effectively blocking the communication between the devices [6]. Since the ability to communicate is affected, Jamming attacks falls under the umbrella of attacks that target the *Availability* of the service in the CIA triad classification [8]. Jamming attacks can be classified into 5 main categories, based on the attack pattern of the jammer:

- **Constant Jamming:** Constant jamming is the simplest form of jamming attack. In constant jamming, the jammer is active all the time.
- **Periodic Jamming:** The jammer simply transmits a strong signal on the same frequency as the devices it wants to disrupt for a certain period of time t_a, then stops transmitting for another period of time t_b. This type of jamming attack is particularly effective against devices that are not able to change their frequency and has the ability to disrupt the transmission of a sequence of consecutive packets. [9]
- **Random Jamming:** In random jamming, the jammer is active at random intervals, giving each transmitted packet a probability p of being jammed [9].
- **Reactive Jamming:** A reactive jammer starts transmitting its jamming signal only when it senses energy in the communication channel, indicating that a legitimate

transmission is taking place. This type of jamming attack is more power efficient compared to other operation types, as it only transmits its signal when it is needed[10].

- **Smart Jamming:** A smart jammer is a more sophisticated type of jammer that is able to adapt its jamming signal to maximize the disruption of the communication between the devices. Smart jammers are able to modify their attack pattern based on the transmission specifics of the devices they are targeting and are able to adapt to changes in the communication channel[11].

An effective Jamming detection AI model should achieve a high detection score against all the different types of jamming attacks.

3.3. Jamming attacks against drone networks

Jamming attacks are particularly effective against drone networks, as drones usually rely on external input to navigate and operate correctly. If a jammer were able to completely block the communication between the drone and the base station, the drone would be left without any indication on how to behave and would need to activate an internal failsafe mechanism. This usually comes in the form of either a return to base procedure, a landing procedure or a hover in place procedure. All of these procedures leave the drone in a vulnerable position, as a bad actor could potentially capture the drone and use it for malicious purposes. This is especially true when jamming attacks are used in combination with other types of attacks, such as spoofing attacks.

One real world example of this is the capture of an American drone by Iran in 2011. In December 2011 a Lockheed Martin RQ-170 Sentinel drone operated by the United States Air Force was flying over Iran when its operators lost control of the vehicle. The US government initially claimed that the drone had crashed due to a technical malfunction, but later reports revealed that the drone had been captured by the Iranian military. Iranian electronic warfare specialists claimed to have brought it down using a Jamming attack, that forced the drone into a return to base procedure, in combination with a GPS spoofing attack, that made the drone land into a designated area [12]. After successfully capturing the drone, the Iranian government managed to reverse-engineer the drone and produce a working replica, which was then used in their military operations [13].

3.4. Centralized vs Edge approach for Jamming detection

4. Materials and Methods

Materials and Methods should be described with sufficient details to allow others to replicate and build on published results. Please note that publication of your manuscript implicates that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose at the submission stage any restrictions on the availability of materials or information. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

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Interventionary studies involving animals or humans, and other studies require ethical approval must list the authority that provided approval and the corresponding ethical approval code.

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5. Results

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5.1. Subsection

5.1.1. Subsubsection

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All figures and tables should be cited in the main text as Figure 1, Table 1, etc.

Figure 1. This is a figure. Schemes follow the same formatting. If there are multiple panels, they should be listed as: (**a**) Description of what is contained in the first panel. (**b**) Description of what is contained in the second panel. Figures should be placed in the main text near to the first time they are cited. A caption on a single line should be centered.

Table 1. This is a table caption. Tables should be placed in the main text near to the first time they are cited.

Title 1	Title 2	Title 3
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Entry 2	Data	Data [1]

[1] Tables may have a footer.

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Figure 2. This is a wide figure.

Table 2. This is a wide table.

Title 1	Title 2	Title 3	Title 4
Entry 1 *	Data Data Data	Data Data Data	Data Data Data
Entry 2	Data Data Data	Data Data Data	Data Data Data
Entry 3	Data Data Data	Data Data Data	Data Data Data
Entry 4	Data Data Data	Data Data Data	Data Data Data

* Tables may have a footer.

Text.

Text.

5.3. Formatting of Mathematical Components

This is the example 1 of equation:

$$a = 1, \tag{1}$$

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

This is the example 2 of equation:

$$a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z \tag{2}$$

Please punctuate equations as regular text. Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

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Proof of Theorem 1. Text of the proof. Note that the phrase "of Theorem 1" is optional if it is clear which theorem is being referred to. □

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6. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

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Abbreviations

The following abbreviations are used in this manuscript:

SDN	Software Defined Networks
UAVs	Unmanned Aerial Vehicles
3GPP	3rd Generation Partnership Project
V2X	Vehicle to Everything
FPV	First Person View
DOS	Denial Of Service
MDPI	Multidisciplinary Digital Publishing Institute
DOAJ	Directory of open access journals
TLA	Three letter acronym
LD	Linear dichroism

Appendix A

Appendix A.1

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data are shown in the main text can be added here if brief, or as Supplementary Data. Mathematical proofs of results not central to the paper can be added as an appendix.

Table A1. This is a table caption.

Title 1	Title 2	Title 3
Entry 1	Data	Data
Entry 2	Data	Data

Appendix B

All appendix sections must be cited in the main text. In the appendices, Figures, Tables, etc. should be labeled, starting with "A"—e.g., Figure A1, Figure A2, etc.

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