

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

Sergio Cibecchini ^{1,†,‡} , Francesco Chiti ^{2,‡} and Firstname Lastname ^{2,*}

¹ Affiliation 1; e-mail@e-mail.com

² Affiliation 2; e-mail@e-mail.com

* Correspondence: sergio.cibecchini@gmail.com; Tel.: (optional; include country code; if there are multiple corresponding authors, add author initials) +xx-xxxx-xxx-xxxx (F.L.)

† Current address: Affiliation.

‡ These authors contributed equally to this work.

Abstract: A single paragraph of about 200 words maximum. For research articles, abstracts should give a pertinent overview of the work. We strongly encourage authors to use the following style of structured abstracts, but without headings: (1) Background: place the question addressed in a broad context and highlight the purpose of the study; (2) Methods: describe briefly the main methods or treatments applied; (3) Results: summarize the article's main findings; (4) Conclusions: indicate the main conclusions or interpretations. The abstract should be an objective representation of the article, it must not contain results which are not presented and substantiated in the main text and should not exaggerate the main conclusions.

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

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.

Citation: Cibecchini, S.; Chiti, F.; Lastname, F. AI-Based Detection of Jamming Attacks in 6G Drone Networks. *Future Internet* **2024**, *1*, 0. <https://doi.org/>

Received:

Revised:

Accepted:

Published:

Copyright: © 2024 by the authors. Submitted to *Future Internet* for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

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. Topic Overview

2.1. 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 [7].

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 [6].

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

3. 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.

Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

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.

This is an example of a quote.

4. Results

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn.

4.1. Subsection	89
4.1.1. Subsubsection	90
Bulleted lists look like this:	91
<ul style="list-style-type: none">• First bullet;• Second bullet;• Third bullet.	92
Numbered lists can be added as follows:	93
<ol style="list-style-type: none">1. First item;2. Second item;3. Third item.	94
The text continues here.	95
4.2. Figures, Tables and Schemes	96
All figures and tables should be cited in the main text as Figure 1, Table 1, etc.	97
	98
	99
	100
	101



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
Entry 1	Data	Data
Entry 2	Data	Data ¹

¹ Tables may have a footer.

The text continues here (Figure 2 and Table 2).

102



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.

103

104

4.3. *Formatting of Mathematical Components*

105

This is the example 1 of equation:

106

$$a = 1,$$

(1)

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

107

108

This is the example 2 of equation:

109

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

(2)

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

110

111

Theorem 1. *Example text of a theorem.*

The text continues here. Proofs must be formatted as follows:

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. □

The text continues here.

5. 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.

6. Conclusions

This section is not mandatory, but can be added to the manuscript if the discussion is unusually long or complex.

7. Patents

This section is not mandatory, but may be added if there are patents resulting from the work reported in this manuscript.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used “Conceptualization, X.X. and Y.Y.; methodology, X.X.; software, X.X.; validation, X.X., Y.Y. and Z.Z.; formal analysis, X.X.; investigation, X.X.; resources, X.X.; data curation, X.X.; writing—original draft preparation, X.X.; writing—review and editing, X.X.; visualization, X.X.; supervision, X.X.; project administration, X.X.; funding acquisition, Y.Y. All authors have read and agreed to the published version of the manuscript.”, please turn to the [CRediT taxonomy](#) for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

Funding: Please add: “This research received no external funding” or “This research was funded by NAME OF FUNDER grant number XXX.” and “The APC was funded by XXX”. Check carefully that the details given are accurate and use the standard spelling of funding agency names at <https://search.crossref.org/funding>, any errors may affect your future funding.

Institutional Review Board Statement: In this section, you should add the Institutional Review Board Statement and approval number, if relevant to your study. You might choose to exclude this statement if the study did not require ethical approval. Please note that the Editorial Office might ask you for further information. Please add “The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of NAME OF INSTITUTE (protocol code XXX and date of approval).” for studies involving humans. OR “The animal study protocol was approved by the Institutional Review Board (or Ethics Committee) of NAME OF INSTITUTE (protocol code XXX and date of approval).” for studies involving animals. OR “Ethical review and approval were waived for this study due to REASON (please provide a detailed justification).” OR “Not applicable” for studies not involving humans or animals.

Informed Consent Statement: Any research article describing a study involving humans should contain this statement. Please add “Informed consent was obtained from all subjects involved in the study.” OR “Patient consent was waived due to REASON (please provide a detailed justification).” OR “Not applicable” for studies not involving humans. You might also choose to exclude this statement if the study did not involve humans.

Written informed consent for publication must be obtained from participating patients who can be identified (including by the patients themselves). Please state “Written informed consent has been obtained from the patient(s) to publish this paper” if applicable.

Data Availability Statement: We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting

reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required. Suggested Data Availability Statements are available in section “MDPI Research Data Policies” at <https://www.mdpi.com/ethics>.

Acknowledgments: In this section you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

Conflicts of Interest: Declare conflicts of interest or state “The authors declare no conflicts of interest.” Authors must identify and declare any personal circumstances or interest that may be perceived as inappropriately influencing the representation or interpretation of reported research results. Any role of the funders in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish the results must be declared in this section. If there is no role, please state “The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results”.

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	
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.

References

1.

5G - statistics & facts. Available online: <https://www.statista.com/topics/3447/5g/topicOverview> (accessed on 13 September 2024).

2.

Letaief, K.B.; Chen, W.; Shi, Y.; Zhang, J.; Al, B. The Roadmap to 6G: AI Empowered Wireless Networks. *IEEE Communications Magazine* **2019**, *57*, 84–90. <https://doi.org/10.1109/MCOM.2019.1900271>.

3.

Unmanned aircraft (drones). Available online: https://transport.ec.europa.eu/transport-modes/air/aviation-safety/unmanned-aircraft-drones_en (accessed on 13 May 2024).

4. Laricchia, F. Consumer and commercial drones - statistics and facts. Available online: <https://www.statista.com/topics/7939/drones/#topicOverview> (accessed on 13 September 2024). 197
5. Sultan, A. Study on enhancement of 3GPP support for 5G V2X services. Tech. Rep. 3GPP, 2018. 198
6. Rao, A.; Zafra, M.; Hunder, M.; Kiyada, S. How drone combat in Ukraine is changing warfare. Available online: <https://www.reuters.com/graphics/UKRAINE-CRISIS/DRONES/dwpkeyjwkpm/> (accessed on 13 May 2024). 199
7. Hassija, V.; Kumar, R.; Gupta, H.; Singh, S.; Sharma, P. Fast, Reliable, and Secure Drone Communication: A Comprehensive Survey. *IEEE Communications Surveys and Tutorials* **2021**, *23*, 2802–2832. <https://doi.org/10.1109/COMST.2021.3097916>. 200
8. Author 1, T. The title of the cited article. *Journal Abbreviation* **2008**, *10*, 142–149. 201
9. Author 2, L. The title of the cited contribution. In *The Book Title*; Editor 1, F., Editor 2, A., Eds.; Publishing House: City, Country, 2007; pp. 32–58. 202
10. Author 1, A.; Author 2, B. *Book Title*, 3rd ed.; Publisher: Publisher Location, Country, 2008; pp. 154–196. 203
11. Author 1, A.B.; Author 2, C. Title of Unpublished Work. *Abbreviated Journal Name* year, phrase indicating stage of publication (submitted; accepted; in press). 204
12. Author 1, A.B. (University, City, State, Country); Author 2, C. (Institute, City, State, Country). Personal communication, 2012. 205
13. Author 1, A.B.; Author 2, C.D.; Author 3, E.F. Title of presentation. In Proceedings of the Name of the Conference, Location of Conference, Country, Date of Conference (Day Month Year); Abstract Number (optional), Pagination (optional). 206
14. Author 1, A.B. Title of Thesis. Level of Thesis, Degree-Granting University, Location of University, Date of Completion. 207
15. Title of Site. Available online: URL (accessed on Day Month Year). 208

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content. 209