Audun Sørheim

Misinformation...

Any undertitle is written here

Master's thesis in Physics and Mathematics
Supervisor: Astrid Silvia de Wijn
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January 2026

Norwegian University of Science and Technology
Faculty of Natural Sciences
Department of Physics

NTNU

ABSTRACT

Write an abstract/summary of your thesis, and state your main findings here

A summary should be included in both English and any second language, if this is applicable, regardless if the thesis is written in English or in your preferred language. These should be on separate pages, the English version first.

PREFACE

Write the preface of your thesis here.

You may include acknowledgements and thanks as part of your preface on this page, or you may add it as a new chapter after the preface.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

List of all abbreviations in alphabetic order:

- **BA**: Barabási-Albert
- **CD**: Cognitive Dissonance
- **DHT**: Distributed Hypothesis Model
- **ER**: Erdős-Rényi
- **NTNU**: Norwegian University of Science and Technology

CHAPTER

ONE

INTRODUCTION

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1.1 Motivation

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At vero eos et accusamus et iusto odio dignissimos ducimus qui blanditiis praesentium voluptatum deleniti atque corrupti quos dolores et quas molestias excepturi sint occaecati cupiditate non provident, similique sunt in culpa qui officia deserunt mollitia animi, id est laborum et dolorum fuga. Et harum quidem rerum facilis est et expedita distinctio. Nam libero tempore, cum soluta nobis est eligendi optio cumque nihil impedit quo minus id quod maxime placeat facere possimus, omnis voluptas assumenda est, omnis dolor repellendus. Temporibus autem quibusdam et aut officiis debitis aut rerum necessitatibus saepe eveniet ut et voluptates repudiandae sint et molestiae non recusandae. Itaque earum rerum hic tenetur a sapiente delectus, ut aut reiciendis voluptatibus maiores alias consequatur aut perferendis doloribus asperiores repellat.

1.2 Project description

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1.2.1 Stakeholders

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CHAPTER

TWO

SOCIOLOGY

This chapter will contain all the relevant theory on humans, humans behavior and more which help drive the dynamics of the DHT model. This chapter is heavily inspired by my project thesis "Beliefs and the Propagation of Misinformation in Social Networks" at NTNU in 2025 [1]. Specifically, this chapter is inspired by subsections 2.1-2.5 "Existing Literature".

That section covers a lot of the literature that was researched for the project thesis, relevant to the model or not. This chapter will mostly contain the topics related to the numerical model and simulations.

2.1 Social Science and Psychology and Misinformation

CHAPTER

THREE

GRAPH THEORY

Here all relevant theory on graphs will be presented, only graphs used for simulation will be presented, and the methods for creating them will be described in section 5.1. This chapter is heavily inspired by my project thesis "Beliefs and the Propagation of Misinformation in Social Networks" at NTNU in 2025 [1]. Specifically, this chapter is inspired by subsection 3.1 "Graph Theory".

3.1 Graphs

CHAPTER

FOUR

DISTRIBUTED HYPOTHESIS TESTING MODEL

This chapter will contain all the relevant theory of the Distributed Hypothesis Testing (DHT) model, not including graphs or sociology. The model is applied on a network or graph of nodes, which are able to interact. First, I will introduce the developments of the model since its inception, then I will define it as it has been used for this Master thesis (with relevant constraints). Lastly I will present the algorithms which have been used and any potential differences from the project thesis preceding this Master thesis.

This chapter is inspired by my project thesis "Beliefs and the Propagation of Misinformation in Social Networks" at NTNU in 2025 [1] (specifically section 3.2), Diana Riazi's papers and PhD thesis [2, 3, 4, 5], and the paper on the DHT model by Anusha Lalitha et al. [6].

4.1 History

This section contains a brief history of developments of the DHT model from its inception by Robert Tenney and Nils Sandell Jr. in 1981[7] until its formulation by Lalitha et al. in 2014[6].

The earliest work done on the subject was motivated by the fact that in a distributed sensor network, it can be costly or inefficient to make all sensors communicate with a central hub. Thus, the sensors must be able to process signals themselves using an optimal decision rule. Tenney et al. created a model based on the formulation of decentralized hypothesis testing [7]. They found that the optimal decision rule is that the sensors perform likelihood ratio tests on the statistically independent observations they make.

Over the following decades, research further developing the model was mostly concerned on distributed sensor networks. By minimizing loss, Firooz determined the structure of the optimal decision rule given an arbitrary number of sensors and hypothesis [8]. Viswanathan et al. made a review study of the entire filed in 1997 [9]. In 2004 Alanyali et al. applied belief propagation, and thus interaction between sensors, to make the network reach a consensus concerning an observation [10]. Halme et al. included spatial dependency in the model [11].

In 2014 (and revised in 2018), Lalitha et al. published "Social Learning and Distributed Hypothesis Testing" [6]. This paper included social learning in the

DHT model, implying that the nodes in the network interact in such a way that they can learn from each other. Lalitha et al. introduced the notion of public and private beliefs, such that interactions between nodes happened through public beliefs. These were formed by a bayesian update of private beliefs using likelihood functions made from observations. This formulation of the model was inteded to be used on directed graphs.

In 2024 and 2025, Diana Riazi published three papers with her PhD thesis using the DHT model to simulate misinformation propagation in social networks [2, 3, 4, 5]. This is the first and, so far, only study using the DHT model to simulate propagation of beliefs in a network consisting of humans. The mathematical formulation will be presented in section **??**.

4.2 Differences from project thesis

CHAPTER

FIVE

METHODS

Include the complete description of the methods used in your research here.

Below is an example of how subsectioning works. The sections and subsections will be included in the table of contents, while subsubsections will not be in the table of contents but still have their own title in the text.

5.1 Creating graphs

5.1.1 Subsection one

5.1.1.1 Subsubsection one

5.1.1.2 Subsubsection Two

5.1.2 Subsection Two

5.2 Section two

CHAPTER

SIX

RESULTS

Here results will be presented, but not discussed.

6.1 More figures

page fill page fill.

CHAPTER

SEVEN

DISCUSSION

Discuss your results here.

7.1 Future work

Include a section about what should or could be done in future research, or explain any recommended next steps based on the results you got. This should be the last section in the discussion.

CHAPTER

EIGHT

CONCLUSIONS

Give a concise summary of your research and finding here, and include a short summary of any future work as well.

REFERENCES

[1] Audun Sørheim. *Beliefs and the Propagation of Misinformation in Social Networks*. 2025.

[2] Diana Riazi and Giacomo Livan. "Public and private beliefs under disinformation in social networks". In: *Physica A: Statistical Mechanics and its Applications* 637 (2024), p. 129621. DOI: https://doi.org/10.1016/j.physa.2024.129621.

[3] Diana Riazi and Giacomo Livan. *Who should fight the spread of fake news?* 2024. URL: https://arxiv.org/abs/2410.08753.

[4] Diana Riazi and Giacomo Livan. "Mitigating Disinformation in Social Networks through Noise". In: *Advances in Complex Systems* (Feb. 2025). DOI: 10.1142/S0219525925500079.

[5] Diana Riazi. "Agent-based Models of Social Learning in Opinion Dynamics". Ph.D. thesis. University College London, 2025. URL: https://discovery.ucl.ac.uk/id/eprint/10205241/.

[6] Anusha Lalitha, Tara Javidi, and Anand D. Sarwate. "Social Learning and Distributed Hypothesis Testing". In: *IEEE Transactions on Information Theory* 64.9 (2018), pp. 6161–6179. DOI: 10.1109/TIT.2018.2837050.

[7] Robert R. Tenney and Nils R. Sandell. "Detection with distributed sensors". In: *IEEE Transactions on Aerospace and Electronic Systems* AES-17.4 (1981), pp. 501–510. DOI: 10.1109/TAES.1981.309178.

[8] Firooz A. Sadjadi. "Hypotheses Testing in a Distributed Environment". In: *IEEE Transactions on Aerospace and Electronic Systems* AES-22.2 (1986), pp. 134–137. DOI: 10.1109/TAES.1986.310747.

[9] R. Viswanathan and P.K. Varshney. "Distributed detection with multiple sensors Part I. Fundamentals". In: *Proceedings of the IEEE* 85.1 (1997), pp. 54–63. DOI: 10.1109/5.554208.

[10] M. Alanyali et al. "Distributed Bayesian hypothesis testing in sensor networks". In: *Proceedings of the 2004 American Control Conference*. Vol. 6. 2004, 5369–5374 vol.6. DOI: 10.23919/ACC.2004.1384706.

[11] Topi Halme, Martin Gölz, and Visa Koivunen. "Bayesian Multiple Hypothesis Testing For Distributed Detection In Sensor Networks". In: *2019 IEEE Data Science Workshop (DSW)*. 2019, pp. 105–109. DOI: 10.1109/DSW.2019.8755597.

APPENDICES

A - GITHUB REPOSITORY

All code and latex-files used in this document are included in the Github repository linked below. Further explanations are given in the readme-file.

Github repository link

- `https://github.com/ninasalvesen/thesis_latex_template`

B - SIDENOTE STATISTICS

B1 - Some random table

Remember to only include one thing per page in the appendices.

Statistic	One	Two
Count	387317	283960
Mean	130.66	134.18
Std	248.09	230.32
Q1	31.00	21.00
Median	67.00	63.00
Q3	142.00	159.00
Min	0.00	0.00
Max	14519.00	14253.00

Table B.1: Table of statistics on some sidenote data.

B2 - Some other random table

Statistic	Three	Four
Count	387317	283960
Mean	130.66	134.18
Std	248.09	230.32
Q1	31.00	21.00
Median	67.00	63.00
Q3	142.00	159.00
Min	0.00	0.00
Max	14519.00	14253.00

Table B.2: Table of statistics on some other sidenote data.