**OUTLINE GRADUATION THESIS**

**Tên đề tài:** Định vị trong hệ thống 5G MIMO Millimeter wave bằng phương pháp Distributed Compressive Sensing (S-OMP)

**THESIS TITLE:** Position Estimation Through MillimeterWave MIMO in 5G Systems using Distributed Compressive Sensing (S-OMP)

**ABSTRACT**

Millimeter wave signals and large antenna arrays are considered enabling technologies for future 5G networks. While their benefits for achieving high-data rate communications are well-known, their potential advantages for accurate positioning are largely undiscovered. We derive the Cramér-Rao bound (CRB) on position and rotation angle estimation uncertainty from millimeter wave signals from a single transmitter, in the presence of scatterers. We also present a novel two-stage algorithm for position and rotation angle estimation that attains the CRB for average to high signal-to-noise ratio. The algorithm is based on multiple measurement vectors matching pursuit for coarse estimation, followed by a refinement stage based on the spacealternating generalized expectation maximization algorithm. We find that accurate position and rotation angle estimation is possible using signals from a single transmitter, in either lineof-sight, non-line-of-sight, or obstructed-line-of-sight conditions

***Keywords:***

**TÓM TẮT**

***Từ khóa:***

**AUTHORSHIP**

*“I hereby declare that the work contained in this thesis is of my own and has not been previously submitted for a degree or diploma at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no materials previously published or written by another person except where due reference or acknowledgement is made.”*

Signature:………………………………………………

**SUPERVISOR’S APPROVAL**

*“I hereby approve that the thesis in its current form is ready for committee examination as a requirement for the Bachelor of Electronics and Telecommunication degree at the University of Engineering and Technology.”*

Signature:………………………………………………

**ACKNOWLEDGMENT**

I would like to express my sincere gratitude to … (should be your supervisors)

I am grateful to … (should be your tutor)

I would like to also thank … (should be your colleagues, friends who have helped you along)

I greatly appreciate the following organizations… (the Department/Lab where you did your thesis work, the University of Engineering and Technology, companies involved, …)

This thesis was partly supported by the [e.g., Vietnam National University Hanoi] under the project XYZ.

**TABLES OF CONTENT**

**LIST OF FIGURES**

**LIST OF TABLES**

**ABBREVATIONS**

**CHAPTER 1: INTRODUCTION**

* 1. Motivation
  2. Contributions and thesis overview

Tính cần thiết của đề tài, ý nghĩa khoa học và thực tiễn, đối tượng và phương pháp nghiên cứu, nội dung nghiên cứu

* 1. Related work
  2. Thesis layout

**CHAPTER 2: BASIC THEORIES OF 5G SYSTEM**

2.1. System Model

2.1.1. Transmitter Model

2.1.2. Channel Model

2.1.3. Received Signal Model

2.2. Basic theory of compressed sensing

2.3. Methods for 5G mm-wave channel estimation

2.3.1. L1 trực tiếp

2.3.2. L1 gián tiếp

- FISTA

- L1-LS

2.3.3. Sparse Bayesian Inference

Tổng kết chương II

**CHAPTER 3: POSITIONING PROBLEM THROUGH MILLIMETER WAVE MIMO IN 5G SYSTEM**

3.1. Overview about channel estimation

3.2. OMP Algorithm

OMP (Orthogonal matching pursuit) - single subcarrier

3.3. S-OMP Algorithm

S-OMP (Simultaneous orthogonal matching pursuit) - multiple subcarrier

* Distributed Compressive Sensing
* AOA, AOD => Positioning
* Advantages of S-OMP compared to OMP

3.4. Positioning methods using channel information (channel estimation)

Tổng kết chương III

**CHAPTER 4: SIMULATION**

4.1. Simulation Setup

4.2. Simulation Results

4.3. Discussion

Tổng kết chương IV

**CONCLUSION**

Conclusions

Future Works

**APPENDIX**

**REFERENCES**

**[1] A. Shahmansoori, G. E. Garcia, G. Destino, G. Seco-Granados and H. Wymeersch, *“Position and Orientation Estimation Through MillimeterWave MIMO in 5G Systems,”* in IEEE Transactions on Wireless Communications, vol. 17, no. 3, pp. 1822-1835, March 2018, doi: 10.1109/TWC.2017.2785788.**

**[2] M. F. Duarte, S. Sarvotham, D. Baron, M. B. Wakin and R. G. Baraniuk, “*Distributed Compressed Sensing of Jointly Sparse Signals,”* Conference Record of the Thirty-Ninth Asilomar Conference onSignals, Systems and Computers, 2005., Pacific Grove, CA, USA, 2005, pp. 1537-1541, doi: 10.1109/ACSSC.2005.1600024**

[3] L. Dai, X. Gao, S. Han, I. Chih-Lin and X. Wang, *"Beamspace channel estimation for millimeter-wave massive MIMO systems with lens antenna array,"* 2016 IEEE/CIC International Conference on Communications in China (ICCC), Chengdu, China, 2016, pp. 1-6, doi: 10.1109/ICCChina.2016.7636854.

[4] X. Li, J. Fang, H. Li and P. Wang, *“Millimeter Wave Channel Estimation via Exploiting Joint Sparse and Low-Rank Structures,”* in IEEE Transactions on Wireless Communications, vol. 17, no. 2, pp. 1123-1133, Feb. 2018, doi: 10.1109/TWC.2017.2776108.

**[5] A. Beck and M. Teboulle, *“A fast iterative shrinkage-thresholding algorithm for linear inverse problems,”* SIAM J. Imag. Sci., vol. 2, no. 1, pp. 183–202, 2009**

**[6] .Dror Baron, Marco F. Duarte, Michael B. Wakin, Shriram Sarvotham, and Richard G. Baraniuk2*, “Distributed Compressive Sensing,”*, 2019**

**[7] J. A. Tropp and A. C. Gilbert, *"Signal Recovery From Random Measurements Via Orthogonal Matching Pursuit,"* in IEEE Transactions on Information Theory, vol. 53, no. 12, pp. 4655-4666, Dec. 2007, doi: 10.1109/TIT.2007.909108.**

[8] D. Needell and R. Vershynin, *“Uniform uncertainty principle and signal recovery via regularized orthogonal matching pursuit,”* Dec. 2007. Preprint

[9] D. L. Donoho, Y. Tsaig, I. Drori and J. -L. Starck, *"Sparse Solution of Underdetermined Systems of Linear Equations by Stagewise Orthogonal Matching Pursuit,"* in IEEE Transactions on Information Theory, vol. 58, no. 2, pp. 1094-1121, Feb. 2012, doi: 10.1109/TIT.2011.2173241. Trang

[10] J. Lee, G.-T. Gil, and Y. H. Lee, *“Channel estimation via orthogonal matching pursuit for hybrid MIMO systems in millimeter wave communications,”* IEEE Trans. Commun., vol. 64, no. 6, pp. 2370–2386, Jun 2016.

[11] R. Mendrzik, H. Wymeersch, G. Bauch and Z. Abu-Shaban, *“Harnessing NLOS Components for Position and Orientation Estimation in 5G Millimeter Wave MIMO,”* in IEEE Transactions on Wireless Communications, vol. 18, no. 1, pp. 93-107, Jan. 2019, doi: 10.1109/TWC.2018.2877615. 12

[12] M. Koivisto, A. Hakkarainen, M. Costa, P. Kela, K. Leppänen, and M. Valkama, *“High-efficiency device positioning and locationaware communications in dense 5G networks,”* IEEE Commun. Mag., vol. 55, no. 8, pp. 188–195, 2017.

[13] C. Xiang et al., “*Robust Sub-Meter Level Indoor Localization With a Single WiFi Access Point—Regression Versus Classification,”* in IEEE Access, vol. 7, pp. 146309-146321, 2019, doi: 10.1109/ACCESS.2019.2946271.

[14] Shai Shalev-Shwartz, Alon Gonen, and Ohad Shamir *“Large-scale convex minimization with a low-rank constraint,”* in Proceedings of the 28th International Conference on International Conference on Machine Learning (ICML’11), pp. 329–336, 2011.

[15] Conceição, Paulo & Rocha, Flávio. (2023) *“Adaptive DCS-SOMP for Localization Parameter Estimation in 5G Networks,”* Sensors. 23. 9073. 10.3390/s23229073.