VIETNAM NATIONAL UNIVERSITY, HANOI
VNU UNIVERSITY OF ENGINEERING AND TECHNOLOGY

SOCIALIST REPUBLIC OF VIETNAM
Independence – Freedom – Happiness

INFORMATION ON DOCTORAL THESIS

1. Full name : Tran Dinh Tan ..... 2. Sex: Male.....
3. Date of birth: 09/02/1991..... 4. Place of birth: Ha Tinh.....
5. Admission decision number: 45/QĐ-CTSV. Dated 12/01/2023 .....
6. Changes in academic process: Change the thesis title from "Development of Approximation Algorithms for Submodular Function Maximization Problems and Applications" to "Development of Approximation Algorithms for Submodular Function Maximization Problems" in accordance with Decision No. 2947/QĐ-ĐHCN dated December 16, 2025, on the revision of the doctoral dissertation title of PhD candidate Trần Đình Tân.
7. Official thesis title: Development of Approximation Algorithms for Submodular Function Maximization Problems.....
8. Major: Computer sciense ..... 9. Code: 9480101 .....
10. Supervisors: Assoc. Prof. Dr. Hoang Xuan Huan, Assoc. Prof. Dr. Pham Van Canh
11. Summary of the **new findings** of the thesis:

The thesis focuses on the study of approximation algorithms for submodular function optimization problems. The core approach lies in exploiting the special mathematical structure of submodular functions, combined with approximation algorithm design techniques, to develop algorithms with rigorous theoretical guarantees in terms of approximation ratios and query complexity. Moreover, the thesis emphasizes the practical implementation on real-world datasets to evaluate the effectiveness of the proposed algorithms for large-scale problems. The overarching perspective is to establish methods that balance theoretical performance with practical applicability. Based on the theoretical gaps identified in submodular function optimization, the thesis investigates four representative problems:

1. Submodular Maximization under Knapsack Constraint: This thesis develops three algorithms - DLA, RLA, and AST - with approximation ratios of $1/6 - \epsilon, 1/4 - \epsilon$ *and* $1/7 - \epsilon$, respectively. The results have been published at two A*-ranked international conferences: IJCAI 2023 and IJCAI 2024.

2. k-Submodular Maximization under Individual Knapsack Constraints: This thesis proposes a streaming algorithm, STR, which achieves an approximation ratio of $\frac{1-\epsilon}{2(k+1)}$ in the monotone case and $\frac{1-\epsilon}{2k+3}$ in the non-monotone case, with low query and memory complexity. The algorithm is well-suited for large-scale data environments and represents the first efficient streaming approach for the k-submodular maximization problem under individual knapsack constraints. The research outcomes have been published in the international conference SOICT 2023 (SCOPUS) and the international journal APJOR (SCIE, Q3).

3. DR-submodular Maximization under Size Constraint: This thesis develops two novel algorithms, FastDrSub and FastDrSub+, which achieve approximation ratios of 0.044 and $\frac{1}{4} - \epsilon$, respectively, with low query complexity. These are the first algorithms to attain constant-factor approximation for this problem, and they exhibit outstanding performance in the Revenue Maximization problem with DR-submodular objectives. The results have been published in the international journal JOCO (SCIE, Q2).

4. Minimum cost Submodular Cover: This thesis develops three efficient streaming algorithms (SingStr, ThreeStr, and MultiStr) that enable processing large-scale streaming data. These algorithms achieve approximation ratios close to the Greedy method while significantly reducing the number of queries and memory usage. Moreover, they demonstrate practical effectiveness in applications such as Revenue threshold and Coverage threshold. The results have been published at the international conference CSONET 2023 (SCOPUS).

12. Practical applicability, if any: The algorithms proposed in the thesis can be applied to solve specific problems such as influence maximization in social networks, revenue maximization, the Max-Cut problem, image summarization, sensor placement, and the set cover problem.

13. Further research directions, if any: Several promising research directions include: (i) extending the algorithms to problems with more complex constraints such as matroid and fairness constraints; (ii) developing machine learning methods with theoretical guarantees for submodular optimization; and (iii) applying the algorithms to domains such as machine learning, efficient data selection for training, and sensor network design.

14. Thesis-related publications:

1. Canh V. Pham, Tan D. Tran, Dung K.T Ha, My T. Thai. "*Linear query approximation algorithms for non-monotone submodular maximization under knapsack constraint"*, 2023, In Proceedings of the Thirty-Second International Joint Conference on Artificial Intelligence (IJCAI 2023), 4127-4135 (RANK A*).

2. Tan D. Tran, Canh V. Pham, Dung K.T Ha. "*Maximizing a k-Submodular Maximization Function under an Individual Knapsack Constraint",* 2023, In Proceedings of the 12th International Symposium on Information and Communication Technology (SoICT 2023), 56-62 (SCOPUS).

3. Tan D. Tran, Canh V. Pham, Dung T. Pham, Uyen T. Nguyen. "*Improved Streaming Algorithm for Minimum Cost Submodular Cover Problem*", 2023, In Proceedings of the 12th International Conference on Computational Data and Social Networks (CSONET 2023), 222-233 (SCOPUS).

4. Tan D. Tran, Canh V. Pham, Dung K.T Ha, Phuong N.H. Pham. "*Improved parallel algorithm for non-monotone submodular maximization under knapsack constraint*", 2024, In Proceedings of the Thirty-Third International Joint Conference on Artificial Intelligence (IJCAI 2024), 1961-1969 (RANK A*).

5. Tan D. Tran, Canh V. Pham, Dung K.T Ha. "*k-Submodular Maximization Under Individual Knapsack Constraints: Applications and Streaming Algorithm*", 2025, Asia-Pacific Journal of Operational Research (SCIE, Q3).

6. Tan D. Tran, Canh V. Pham. "Fast Approximation Algorithm for Non-Monotone DR-submodular Maximization under Size Constraint", 2026, Journal of Combinatorial Optimization (SCIE, Q2).