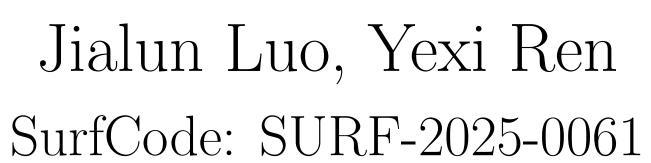


AI METHODS FOR POST-QUANTUM CRYPTOGRAPHY

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Abstract

This poster presents the background and a series of possible evolutionary methods of sieving algorithm (bgj3). We begin with reproducing the original random filtering method, then introduce a deterministic Hybrid-Sieve to replace the randomness with the algebraic structure of the dual lattice. Finally, we explore a powerful shift using Reinforcement Learning (RL), where an intelligent agent learns to produce high quality center sieve vectors.

1. Introduction

The security of post-quantum cryptography hinges on the hardness of the **Shortest Vector Problem** (SVP). Sieving algorithms are the most powerful tools for solving SVP, but their performance is bottlenecked by a single, critical task: efficiently finding pairs of vectors (\mathbf{u}, \mathbf{v}) that combine to form a shorter vector $\mathbf{u} \pm \mathbf{v}$ from a list of billions: $2^{0.2075n + O(n)}$.

Our Contribution: A Principled Evolution

This work charts a clear trajectory, moving from blind randomness towards structured, intelligent search. We demonstrate this evolution through three methodologies:

1. Baseline: The Random Sieve

- Core Idea: Filters vectors using random spherical caps.
- **Represents:** The current "brute-force" state-of-the-art.

2. Innovation: The Hybrid Sieve

- Core Idea: Replaces randomness with structure. We use vectors from the dual lattice (\mathcal{L}^*) to create a deterministic Voronoi partition.
- Represents: A more efficient, reproducible, and lattice-aware algorithm.

3. Paradigm Shift: The RL-based Sieve

- Core Idea: Elevates the search to an intelligent process. A Reinforcement Learning (RL) agent learns an optimal policy to "walk" on the lattice, actively seeking out shorter vectors.
- **Represents:** The future of SVP solvingan adaptive and targeted exploration.

This progression illustrates a clear path from random searching to structurized and intelligent exploration.

3. Key Results

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5. Future Work

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2. Method

Algorithm 1 AllPairSearch bgj3 (Baseline)

Require: A list L of N_0 lattice vectors, repetitions (B_0, B_1, B_2) , radii $(\alpha_0, \alpha_1, \alpha_2)$, goal norm l.

1: $\mathcal{N} \leftarrow \emptyset$

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2: for i = 0, ..., B_0 - 1 do
3: Pick a random center c_0 \in S^{n-1}
4: L_i \leftarrow \{v \in L \mid v \text{ passes } F_{c_0,\alpha_0}\}
5: for j = 0, ..., B_1/B_0 - 1 do
6: Pick a random center c_1 \in S^{n-1}
7: L_{ij} \leftarrow \{v \in L_i \mid v \text{ passes } F_{c_1,\alpha_1}\}
8: for k = 0, ..., B_2/B_1 - 1 do
9: Pick a random center c_2 \in S^{n-1}
10: L_{ijk} \leftarrow \{v \in L_{ij} \mid v \text{ passes } F_{c_2,\alpha_2}\}
11: N \leftarrow N \cup \{(u,v) \in L_{ijk}^2 \mid ||u \pm v|| < l\}
12: end for
13: end for
14: end for
15: return N
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4. Examples

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$$\int \vec{F} \cdot d\vec{q} = -U \tag{1}$$



6. Plots





References

^[1] Zhao, Z., Ding, J., Yang, B.-Y. (2025). Sieving with Streaming Memory Access. IACR Transactions on Cryptographic Hardware and Embedded Systems, 2025(2), 362-384. Available from: https://doi.org/10.46586/tches.v2025.i2.362-384

^[2] Chinberg, T., Kalbach, A. LLLAlgorithmforLatticeBasisReduction. Available from: arXiv:2410.22196v2 [math.NT] 20 Nov 2024.