Novelty Assessment Report

Paper: Alternating Diffusion for Proximal Sampling with Zeroth Order Queries
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Abstract

This work introduces a new approximate proximal sampler that operates solely with zeroth-order information of the potential function. Prior theoretical analyses have revealed that proximal sampling corresponds to alternating forward and backward iterations of the heat flow. The backward step was originally implemented by rejection sampling, whereas we directly simulate the dynamics. Unlike diffusion-based sampling methods that estimate scores via learned models or by invoking auxiliary samplers, our method treats the intermediate particle distribution as a Gaussian mixture, thereby yielding a Monte Carlo score estimator from directly samplable distributions. Theoretically, when the score estimation error is sufficiently controlled, our method inherits the exponential convergence of proximal sampling under isoperimetric conditions on the target distribution. In practice, the algorithm avoids rejection sampling, permits flexible step sizes, and runs with a deterministic runtime budget. Numerical experiments demonstrate that our approach converges rapidly to the target distribution, driven by interactions among multiple particles and by exploiting parallel computation.

Core Task Landscape

This paper addresses: **Approximate Proximal Sampling with Zeroth-Order Information**

A total of **32 papers** were analyzed and organized into a taxonomy with **22 categories**.

Taxonomy Overview

The research landscape has been organized into the following main categories:

- **Proximal Sampling and Diffusion-Based Methods**
- **Zeroth-Order Proximal Optimization Methods**
- **Gradient-Free Optimization Without Proximal Structure**
- **Applications and Domain-Specific Methods**

Complete Taxonomy Tree

- Approximate Proximal Sampling with Zeroth-Order Information Survey Taxonomy
- Proximal Sampling and Diffusion-Based Methods
  - Diffusion and Heat Flow Proximal Sampling ★ (2 papers)
  - [0] Alternating Diffusion for Proximal Sampling with Zeroth Order Queries (Anon et al., 2026) View paper
  - [4] Zeroth-order sampling methods for non-log-concave distributions: Alleviating metastability by denoising diffusion (Ye He, 2024) View paper
  - Log-Concave and Convex Body Sampling (1 papers)
  - [24] Zeroth-order log-concave sampling (Kook, 2025) View paper
- Zeroth-Order Proximal Optimization Methods
  - Variance Reduction and Stochastic Estimation
  - Coordinate-Wise and Double Variance Reduction (2 papers)
    - [7] Double Variance Reduction: A Smoothing Trick for Composite Optimization Problems without First-Order Gradient (Di Hao, 2024) View paper
    - [9] A Structured Proximal Stochastic Variance Reduced Zeroth-order Algorithm (Rando, 2025) View paper
  - Momentum and Recursive Variance Reduction (2 papers)
    - [27] Zeroth-Order Proximal Stochastic Recursive Momentum Algorithm for Nonconvex Nonsmooth Optimization (Yuxiang Qian, 2023) View paper
    - [29] Faster Gradient-Free Proximal Stochastic Methods for Nonconvex Nonsmooth Optimization (Huang, 2019) View paper
  - Lightweight Query Complexity Methods (1 papers)
    - [23] Obtaining Lower Query Complexities through Lightweight Zeroth-Order Proximal Gradient Algorithms (Bin Gu, 2024) View paper
  - Basic Zeroth-Order Proximal Algorithms
  - Weakly Convex and Quasar-Convex Optimization (2 papers)
    - [1] Minimisation of Quasar-Convex Functions Using Random Zeroth-Order Oracles (Pun, 2025) View paper
    - [8] A Zeroth-Order Proximal Stochastic Gradient Method for Weakly Convex Stochastic Optimization (Spyridon Pougkakiotis, 2022) View paper
  - Preconditioned and Adaptive Zeroth-Order Methods (2 papers)
    - [5] An Inexact Preconditioned Zeroth-Order Proximal Method for Composite Optimization: S.-L. Liu et al. (SL Liu, 2025) View paper
    - [21] An Inexact Preconditioned Zeroth-Order Proximal Method for Composite Optimization (Shang-Lin Liu, 2025) View paper

- Nonconvex Nonsmooth Proximal Algorithms (2 papers)
  - [3] Efficient zeroth-order proximal stochastic method for nonconvex nonsmooth black-box problems (Ehsan Kazemi, 2024) View paper
  - [30] A Proximal Zeroth-Order Algorithm for Nonconvex Nonsmooth Problems (Kazemi, 2022) View paper
- Distributed and Decentralized Zeroth-Order Methods
- Consensus and Networked Optimization (1 papers)
  - [20] A Zeroth-Order Proximal Algorithm for Consensus Optimization (Chengan Wang, 2024) View paper
- Decentralized Variance Reduction (1 papers)
  - [12] A zeroth-order variance-reduced method for decentralized stochastic non-convex optimization (Chen Hong-Xu, 2023) View paper
- Projection-Free Distributed Methods (2 papers)
  - [2] Distributed gradient-free and projection-free algorithm for stochastic constrained optimization (Jie Hou, 2024) View paper
  - [32] Zeroth-Order Method for Distributed Optimization With Approximate Projections. (Deming Yuan, 2016) View paper
- Heavy-Tailed and Infinite Variance Settings (2 papers)
  - [18] Zeroth-order Proximal Clipped Gradient Method with Shifts for Distributed Stochastic Composite Optimization Problems with Infinite Variance (Zhenjie Yang, 2025) View paper
  - [19] Zeroth-order Proximal Clipped Gradient Method with Shifts for Distributed Stochastic Composite Optimization Problems with Infinite Variance: Z.-P. Yang et al. (ZP Yang, 2025) View paper

- Gradient-Free Optimization Without Proximal Structure
  - Trust-Region and Global Optimization Methods (2 papers)
  - [13] Inexact Proximal Point Algorithms for Zeroth-Order Global Optimization (Zhang Minxin, 2024) View paper
  - [14] ASTRO-DF: A Class of Adaptive Sampling Trust-Region Algorithms for Derivative-Free Stochastic Optimization (Sara Shashaani, 2016) View paper
  - Projection-Free and Frank-Wolfe Methods (1 papers)
  - [22] Towards gradient free and projection free stochastic optimization (Anit Kumar Sahu, 2019) View paper
  - Simplex-Constrained Gradient-Free Methods (2 papers)
  - [15] Gradient-free proximal methods with inexact oracle for convex stochastic nonsmooth optimization problems on the simplex (Alexander V. Gasnikov, 2016) View paper
  - [31] Gradient-free prox-methods with inexact oracle for stochastic convex optimization problems on a simplex (Gasnikov, 2014) View paper
  - Regularized and Sparse Gradient Methods (1 papers)
  - [16] Zeroth-Order Regularized Optimization (ZORO): Approximately Sparse Gradients and Adaptive Sampling (Cai, 2020) View paper
  - Inexact Oracle and Heavy-Tailed Noise Methods (2 papers)
  - [6] Gradient free methods for non-smooth convex optimization with heavy tails on convex compact (N Kornilov, 2023) View paper
  - [28] Gradient and gradient-free methods for stochastic convex optimization with inexact oracle (Gasnikov, 2022) View paper
  - Adaptive Steplength and Linesearch Methods (1 papers)
  - [25] A Parameter-Free Stochastic LineseArch Method (SLAM) for Minimizing Expectation Residuals (Qi Wang, 2025) View paper
- Applications and Domain-Specific Methods
  - Bayesian Experimental Design (1 papers)
  - [11] Gradient-Free Sequential Bayesian Experimental Design via Interacting Particle Systems (Gruhlke, 2025) View paper
  - Imaging and Inverse Problems (1 papers)
  - [10] Equilibrated Zeroth-Order Unrolled Deep Network for Parallel MR Imaging (Zhuo-Xu Cui, 2023) View paper
  - Climate and Geophysical Modeling (1 papers)
  - [17] An adjoint-free algorithm for conditional nonlinear optimal perturbations (CNOPs) via sampling (Bin Shi, 2022) View paper
  - Quantum Algorithms (1 papers)
  - [26] Quantum Algorithms for Markov Chain Methods in Machine Learning and Optimization (Ozgul, 2025) View paper

Narrative

Core task: Approximate proximal sampling with zeroth-order information. This field addresses optimization and sampling problems where gradient information is unavailable or prohibitively expensive, yet one must still handle composite objectives involving non-smooth regularizers or constraints. The taxonomy reveals four main branches. Proximal Sampling and Diffusion-Based Methods explore connections between proximal operators and diffusion processes, often leveraging heat flow or score-based techniques to sample from complex distributions. Zeroth-Order Proximal Optimization Methods focus on algorithmic designs that estimate gradients via function evaluations alone while respecting proximal structure, including works like Zeroth-Order Proximal Stochastic[3] and Lightweight Zeroth-Order Proximal[23]. Gradient-Free Optimization Without Proximal Structure encompasses classical derivative-free schemes that may not explicitly invoke proximal mappings, such as simplex methods and variance-reduced approaches. Applications and Domain-Specific Methods gather problem-driven studies in areas like Bayesian design, distributed settings, and quantum systems, illustrating how zeroth-order proximal ideas adapt to specialized constraints.

A particularly active line of work examines trade-offs between sample complexity, convergence rates, and the cost of approximate proximal steps. Some methods achieve faster rates by exploiting variance reduction or preconditioning (Inexact Preconditioned Zeroth-Order[5], Double Variance Reduction[7]), while others prioritize communication efficiency in distributed scenarios (Distributed Gradient-Free Projection-Free[2], Zeroth-Order Consensus[20]). The original paper, Alternating Diffusion Proximal[0], sits within the Diffusion and Heat Flow Proximal Sampling cluster alongside Zeroth-Order Denoising Diffusion[4]. Both works integrate diffusion-based sampling with zeroth-order queries, but Alternating Diffusion Proximal[0] emphasizes an alternating scheme that interleaves diffusion steps with proximal updates, contrasting with the denoising perspective of its neighbor. This positioning highlights ongoing exploration of how continuous-time dynamics and discrete proximal operators can be harmonized when only function values are accessible.

Related Works in Same Category

The following **1 sibling papers** share the same taxonomy leaf node with the original paper:

1. Zeroth-order sampling methods for non-log-concave distributions: Alleviating metastability by denoising diffusion

Authors: Ye He, Kevin Rojas, Molei Tao | **Year/Venue**: 2024 | **URL**: View paper

Abstract

â¦ access to samples that generate a Monte Carlo score estimator. Then we provide an implementation of this oracle, based on rejection sampling, â¦ , RSDMC and the Proximal Sampler: â¦

Relationship Analysis

Both papers belong to the Diffusion and Heat Flow Proximal Sampling category, utilizing forward-backward heat flow dynamics for proximal sampling with zeroth-order information. The original paper proposes an alternating diffusion method that treats intermediate particle distributions as Gaussian mixtures for Monte Carlo score estimation, avoiding rejection sampling with flexible step sizes, while the candidate paper (ZOD-MC) implements the reverse dynamics through rejection sampling combined with Monte Carlo score estimation, requiring access to the global minimum of the potential function. The key distinction is that the original paper explicitly avoids rejection sampling and operates with a deterministic runtime budget, whereas the candidate paper relies on rejection sampling (Algorithm 3) to implement the Restricted Gaussian Oracle, which can suffer from variable computational costs despite parallelization benefits.

Contributions Analysis

Overall novelty summary. The paper proposes a diffusion-based approximate proximal sampler that operates with zeroth-order information, treating intermediate particle distributions as Gaussian mixtures to derive Monte Carlo score estimators. It resides in the 'Diffusion and Heat Flow Proximal Sampling' leaf, which contains only two papers total: the original work and one sibling (Zeroth-Order Denoising Diffusion). This leaf sits under the broader 'Proximal Sampling and Diffusion-Based Methods' branch, indicating a relatively sparse research direction within the taxonomy of 32 papers across the field.

The taxonomy reveals that most zeroth-order proximal work concentrates on optimization methods (variance reduction, distributed algorithms, trust-region approaches) rather than sampling. The sibling paper in the same leaf explores denoising diffusion perspectives, while the neighboring 'Log-Concave and Convex Body Sampling' leaf addresses uniform distributions over convex bodies. The paper's focus on heat flow dynamics and Gaussian mixture score estimation distinguishes it from optimization-centric branches and from rejection-sampling approaches mentioned in the taxonomy's scope notes.

Among 22 candidates examined, the first contribution (diffusion-based sampler with zeroth-order queries) shows 1 refutable candidate out of 10 examined, suggesting some prior work exists but coverage is limited. The second contribution (theoretical convergence analysis) encountered 3 refutable candidates among 9 examined, indicating more substantial overlap with existing convergence theory. The third contribution (multi-particle extension) found no refutable candidates in 3 examined, appearing more novel within this limited search scope. The analysis explicitly acknowledges examining top-K semantic matches rather than exhaustive literature coverage.

Given the sparse taxonomy leaf and limited search scope, the work appears to occupy a relatively underexplored intersection of diffusion-based sampling and zeroth-order methods. The theoretical convergence analysis shows more connection to prior work than the algorithmic and multi-particle aspects. However, the 22-candidate search scale means substantial relevant literature may exist beyond the examined set, particularly in adjacent sampling or score-based modeling communities not fully captured by this taxonomy.

This paper presents **3 main contributions**, each analyzed against relevant prior work:

Contribution 1: Diffusion-based approximate proximal sampler with zeroth-order queries

Description: The authors propose a novel approximate proximal sampling algorithm that operates using only zeroth-order (function value) information of the potential function. Unlike existing implementations that rely on rejection sampling, this method directly simulates diffusion dynamics by treating intermediate particle distributions as Gaussian mixtures, enabling Monte Carlo score estimation without requiring gradients or learned models.

This contribution was assessed against **10 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

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1. On the computation of equilibria in monotone and potential stochastic hierarchical games

URL: View paper

Brief Assessment

Stochastic Hierarchical Games[44] focuses on hierarchical game equilibria using variance-reduced proximal schemes and zeroth-order methods for MPECs, not on proximal sampling for probability distributions or diffusion-based Monte Carlo methods.

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2. An Inexact Preconditioned Zeroth-Order Proximal Method for Composite Optimization

URL: View paper

Brief Assessment

Inexact Preconditioned Composite[21] addresses composite optimization problems using zeroth-order function values for gradient estimation, not probabilistic sampling from distributions. The original paper develops a Monte Carlo sampling method for probability distributions using diffusion dynamics, which is fundamentally different from deterministic optimization.

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3. Two-Stage Estimation and Variance Modeling for Latency-Constrained Variational Quantum Algorithms

URL: View paper

Brief Assessment

Two-Stage Variational Quantum[42] addresses variance modeling in quantum optimization algorithms (QAOA), not proximal sampling or diffusion-based Monte Carlo methods. The technical domains are entirely distinct.

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4. Preconditioned Regularized Wasserstein Proximal Sampling

URL: View paper

Brief Assessment

Preconditioned Wasserstein Proximal[43] focuses on preconditioned regularized Wasserstein proximal operators with anisotropic heat equations and Cole-Hopf transformations, not on diffusion-based proximal sampling with zeroth-order queries and Gaussian mixture score estimation as in the original paper.

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5. Inexact Proximal Point Algorithms for Zeroth-Order Global Optimization

URL: View paper

Brief Assessment

Inexact Proximal Point[13] focuses on global optimization using proximal point methods with zeroth-order function evaluations, not on proximal sampling for Bayesian inference. The candidate addresses optimization via inexact proximal operators, while the original paper develops a sampling algorithm for probability distributions.

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6. Subspace Selection based Prompt Tuning with Nonconvex Nonsmooth Black-Box Optimization

URL: View paper

Brief Assessment

Subspace Prompt Tuning[41] focuses on black-box prompt optimization for language models using zeroth-order methods with nonsmooth regularizers, not on proximal sampling algorithms for probability distributions. The technical domains and problem settings are fundamentally different.

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7. Zeroth-order sampling methods for non-log-concave distributions: Alleviating metastability by denoising diffusion

URL: View paper

Prior Art Analysis

Zeroth-Order Denoising Diffusion[4] demonstrates prior work on diffusion-based proximal sampling using zeroth-order queries without rejection sampling. The candidate paper presents a framework (DDMC) that approximates scores via Monte Carlo estimation from conditional distributions, and implements this through ZOD-MC using rejection sampling. Both papers address the same core problem: implementing proximal sampling through diffusion processes using only function evaluations, without requiring gradients or learned models.

Evidence

Evidence 1 - **Rationale**: Both papers use Monte Carlo score estimation from Gaussian mixture approximations of intermediate distributions. The candidate's approach of approximating conditional distributions through sampling directly parallels the original's Gaussian mixture treatment. - **Original**: our method treats the intermediate particle distribution as a gaussian mixture, thereby yielding a monte carlo score estimator from directly samplable distributions. - **Candidate**: due to (5), to approximate the score function ∇ln pt(x), it suffices to generate samples that approximate p0|t(·|x). [26, 27] proposed to use langevin-based algorithms to sample from p0|t(·|x). the first step of our work is to generalize this, with refined and more general theoretical analysis later...

Evidence 2 - **Rationale**: While the original claims to avoid rejection sampling, the candidate's ZOD-MC explicitly uses rejection sampling (Algorithm 3) to implement the oracle. This shows the candidate addresses the same technical challenge but with a different implementation approach, demonstrating prior work exists in this space. - **Original**: the algorithm avoids rejection sampling, permits flexible step sizes, and runs with a deterministic runtime budget. - **Candidate**: rejection samplng (algorithm 3) can generate i.i.d. monte carlo samples required in algorithm 2. therefore, zod-mc, as a combination of rejection sampling and ddmc, can efficiently sample from non-logconcave distributions.

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8. A Zeroth-Order Proximal Algorithm for Consensus Optimization

URL: View paper

Brief Assessment

Zeroth-Order Consensus[20] addresses consensus optimization in distributed networks using zeroth-order information, not proximal sampling for probability distributions. The candidate focuses on cooperative minimization of objective functions across network nodes, while the original paper develops a sampling algorithm for probability distributions using diffusion processes.

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9. Zeroth-order log-concave sampling

URL: View paper

Brief Assessment

Zeroth-Order Log-Concave[24] focuses on uniform sampling from convex bodies using membership oracles, not on general proximal sampling with diffusion dynamics for arbitrary log-concave distributions. The candidate's proximal sampler operates on convex bodies with specific restart mechanisms, while the original paper proposes a diffusion-based method that directly simulates backward dynamics via Gaussian mixture score estimation without rejection sampling.

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10. A Parameter-Free Stochastic LineseArch Method (SLAM) for Minimizing Expectation Residuals

URL: View paper

Brief Assessment

SLAM[25] focuses on stochastic optimization with zeroth-order oracles for computing stationary points, not on proximal sampling for probability distributions. The methods address fundamentally different problems: optimization versus sampling from target distributions.

Contribution 2: Theoretical convergence analysis for diffusion-based proximal sampling

Description: The authors establish theoretical guarantees showing that their diffusion-based approximation maintains exponential convergence to the target distribution under isoperimetric conditions, similar to the ideal proximal sampling framework. This analysis demonstrates that the method converges without requiring initialization from the Gaussian limit, unlike standard diffusion models.

This contribution was assessed against **9 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

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1. Fast Convergence of -Divergence Along the Unadjusted Langevin Algorithm and Proximal Sampler

URL: View paper

Brief Assessment

Divergence Langevin Proximal[36] analyzes convergence of φ-divergence for discrete-time Langevin algorithms (ULA and proximal sampler) under φ-Sobolev inequalities, not diffusion-based approximations of proximal sampling. The original paper studies a different method that approximates proximal sampling through diffusion processes with score estimation.

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2. Mirror Langevin Monte Carlo: the case under isoperimetry

URL: View paper

Brief Assessment

Mirror Langevin Isoperimetry[38] focuses on mirror descent variants of Langevin dynamics under isoperimetric conditions, not diffusion-based proximal sampling frameworks. The candidate analyzes different discretization schemes for mirror Langevin MCMC, while the original paper develops a diffusion-based approximation of proximal sampling with Gaussian mixture score estimation.

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3. Parallel simulation for sampling under isoperimetry and score-based diffusion models

URL: View paper

Brief Assessment

Parallel Isoperimetry Diffusion[37] focuses on parallel simulation methods for log-concave sampling and score-based diffusion models with emphasis on adaptive complexity reduction. The original paper addresses diffusion-based approximation of proximal sampling with convergence under isoperimetric conditions without Gaussian initialization, which is a distinct theoretical framework not directly addressed in the candidate.

4. Algorithmic aspects of the log-Laplace transform and a non-Euclidean proximal sampler

URL: View paper

Brief Assessment

Log-Laplace Proximal Sampler[39] focuses on non-Euclidean geometries using log-Laplace transforms with isoperimetric inequalities in Riemannian settings, not diffusion-based approximations of heat flow dynamics under Gaussian convolutions.

5. Zeroth-order sampling methods for non-log-concave distributions: Alleviating metastability by denoising diffusion

URL: View paper

Prior Art Analysis

Zeroth-Order Denoising Diffusion[4] provides theoretical convergence guarantees for diffusion-based sampling under minimal assumptions. The candidate's Theorem 1 establishes KL-divergence convergence for their DDMC framework without requiring isoperimetric conditions, similar to the original paper's claim of convergence under isoperimetric conditions. Both papers analyze how diffusion-based approximations maintain convergence properties.

Evidence

Evidence 1 - **Rationale**: Both papers analyze convergence of diffusion-based sampling with controlled score estimation error. The candidate explicitly discusses convergence under minimal assumptions, showing prior work on theoretical guarantees for diffusion-based proximal sampling. - **Original**: theoretically, when the score estimation error is sufficiently controlled, our method inherits the exponential convergence of proximal sampling under isoperimetric conditions on the target distribution. - **Candidate**: compared to existing analyses on diffusion models, theorem 1 extends result in [3] from exponentialdecay step-size to general choices of step-size, and recovers their sharp linear dimension dependence in the discretization error, with minimal assumptions on the target distribution.

6. In-and-out: Algorithmic diffusion for sampling convex bodies

URL: View paper

Prior Art Analysis

In-and-Out Diffusion[33] demonstrates prior work on convergence analysis of diffusion-based sampling under isoperimetric conditions. The candidate paper establishes exponential convergence guarantees for their diffusion-based algorithm using functional inequalities (Poincaré and log-Sobolev) on the target distribution, showing contraction to the uniform distribution without requiring Gaussian initialization. This directly parallels the original paper's claim of establishing convergence guarantees for diffusion-based proximal sampling under isoperimetric conditions without Gaussian limit initialization.

Evidence

Evidence 1 - **Rationale**: Both papers establish convergence without requiring Gaussian initialization, demonstrating that diffusion-based methods can converge from arbitrary warm starts. - **Original**: we extend the theory of proximal sampling to show that our diffusion-based approximation inherits comparable convergence rates under suitable assumptions. this implies that our algorithms which alternate perturbation and denoising converge to the target distribution without requiring initialization ... - **Candidate**: our analysis will in fact show that the bound on the number of proper steps holds for generalnonconvex bodies and any feasible start in k. this is deduced under an m-warm start in corollaries 2 and 3. we remark that such a bound for non-convex uniform sampling is not known for the ball walk or the s...

Evidence 2 - **Rationale**: Both papers reduce convergence analysis to functional inequalities (isoperimetric conditions) on the target distribution, establishing the same theoretical framework. - **Original**: theoretically, when the score estimation error is sufficiently controlled, our method inherits the exponential convergence of proximal sampling under isoperimetric conditions on the target distribution. - **Candidate**: the final result reduces the problem of obtaining a mixing guarantee to that of demonstrating a functional inequality on the target distribution. for this, it is not strictly necessary that k be convex.

Evidence 3 - **Rationale**: The candidate paper presents an identical convergence bound in Rényi divergence under log-Sobolev inequality, with the exact same mathematical form as the original paper's cited theorem. - **Original**: theorem 1(chen et al. (2022), theorem 3).assume thatπ x satisfies lsi with constantc lsi. for anyh >0and any initial distributionρ x 0 , thek-th iterateρ x k of the proximal sampler with step size hsatisfies, forq≥1, rq,πx (ρx k)≤ rq,πx (ρx 0) (1 +h/c lsi)2k/q . - **Candidate**: theorem 3. let µx k be the law of the k-th output of in-and-out with initial distribution µx 0 . let clsi be the (lsi-i) constant of the uniform distribution πx over k. then, for any q ≥ 1, rq(µx k ∥ πx) ≤ rq(µx 0 ∥ πx) (1 + h/clsi)2k/q .

7. Improved analysis for a proximal algorithm for sampling

URL: View paper

Prior Art Analysis

Proximal Algorithm Sampling[35] demonstrates that prior theoretical work established exponential convergence guarantees for proximal sampling under isoperimetric conditions (specifically log-Sobolev inequality) without requiring initialization from a Gaussian limit. The candidate paper proves that the proximal sampler converges exponentially fast under α-LSI with rate (1+αη)^(-2k) in KL divergence and (1+αη)^(-2k/q) in Rényi divergence. This directly addresses the same theoretical problem of convergence under isoperimetric conditions that the original paper claims as novel, showing that such analysis was already established in prior work.

Evidence

Evidence 1 - **Rationale**: This pair shows that the candidate paper already established exponential convergence under log-Sobolev inequality (an isoperimetric condition) for proximal sampling, directly addressing the theoretical contribution claimed in the original paper. - **Original**: Theoretically, when the score estimation error is sufficiently controlled, our method inherits the exponential convergence of proximal sampling under isoperimetric conditions on the target distribution. - **Candidate**: theorem 3 assume that πx ∝ exp(-f) satisfies α-lsi. for any η >0 and any initial distribution ρx 0 , the k-th iterate ρx k of the proximal sampler with step size η satisfies hπx (ρx k) ≤ hπx (ρx 0) (1 + αη)2k . (3) furthermore, for all q ≥ 1: rq,πx (ρx k) ≤ rq,πx (ρx 0) (1 + αη)2k/q . (4)

Evidence 2 - **Rationale**: This shows that the proximal sampler framework in the candidate paper operates without requiring Gaussian initialization, establishing the same property claimed as novel in the original work. - **Original**: this implies that our algorithms which alternate perturbation and denoising converge to the target distribution without requiring initialization from the gaussian limit, unlike standard diffusion models. - **Candidate**: the proximal sampler is initialized at a point x0 ∈ rd and performs gibbs sampling on the joint target π. that is, the proximal sampler iterates the following two steps: 1. from xk, sample yk | xk ∼ πy |x(· |xk) = n(xk, ηi). 2. from yk, sample xk+1 | yk ∼ πx|y (· |yk).

Evidence 3 - **Rationale**: The candidate paper explicitly states it provides convergence theory for proximal sampling under functional inequalities including log-Sobolev, which is the same theoretical framework claimed in the original paper. - **Original**: we extend the theory of proximal sampling to show that our diffusion-based approximation inherits comparable convergence rates under suitable assumptions. - **Candidate**: in this paper, we greatly expand the classes of targets to which the proximal sampler is applicable by providing new convergence guarantees. first, we consider the case whenf is weakly convex... next, we assume that πx satisfies a functional inequality, e.g., a poincar´e inequality or a logsobolev i...

8. Rapid Convergence of the Unadjusted Langevin Algorithm: Isoperimetry

URL: View paper

Brief Assessment

Unadjusted Langevin Isoperimetry[40] focuses on the convergence of the unadjusted Langevin algorithm under isoperimetric conditions, not on diffusion-based proximal sampling frameworks. The candidate addresses a different algorithmic approach (Langevin dynamics) rather than the proximal sampling with diffusion-based approximations discussed in the original paper.

9. Direct distributional optimization for provable alignment of diffusion models

URL: View paper

Brief Assessment

Direct Distributional Optimization[34] focuses on alignment of diffusion models through dual averaging and Doob's h-transform for distribution optimization, not on proximal sampling convergence under isoperimetric conditions. The candidate addresses isoperimetry-free sampling for alignment tasks, while the original analyzes exponential convergence of diffusion-based proximal sampling.

Contribution 3: Multi-particle extension with empirical validation

Description: The authors develop a multi-particle version of their algorithm that exploits parallel computation and particle interactions. Numerical experiments demonstrate faster convergence compared to existing proximal sampler implementations, with improvements in both computational efficiency and sample diversity through the multi-particle framework.

This contribution was assessed against **3 related papers** from the literature. Papers with potential prior art are analyzed in detail with textual evidence; others receive brief assessments.

1. Geometry-Aware Collaborative Multi-Solutions Optimizer for Model Fine-Tuning with Parameter Efficiency

URL: View paper

Brief Assessment

Geometry-Aware Collaborative Optimizer[47] focuses on parameter-efficient fine-tuning of foundation models using multiple lightweight modules with geometric structure, not on proximal sampling methods or diffusion-based Monte Carlo techniques.

2. Machine learning for online control of particle accelerators

URL: View paper

Brief Assessment

Particle Accelerators Learning[45] focuses on machine learning for particle accelerator control using on-policy RL and beam simulation programs. This is a domain-specific application unrelated to the original paper's multi-particle proximal sampling framework for general probability distributions.

3. Gigastep-one billion steps per second multi-agent reinforcement learning

URL: View paper

Brief Assessment

Gigastep[46] focuses on multi-agent reinforcement learning in game-like environments with thousands of agents, not on multi-particle proximal samplers for statistical sampling. The domains and technical approaches are fundamentally different.

Appendix: Text Similarity Detection

No high-similarity text segments were detected across any compared papers.

References

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