

Novelty Assessment Report

Paper: HippoTune: A Hippocampal Associative Loop-Inspired Fine-Tuning Method for Continual Learning

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Abstract

Studies have shown that catastrophic forgetting primarily stems from the difficulty of reactivating old memories; although parameter-efficient fine-tuning can mitigate forgetting while keeping most model parameters frozen, it still falls short in fully reawakening knowledge of prior tasks. In contrast, humans can efficiently retrieve and flexibly integrate existing experiences when learning new tasks, thereby maintaining stable performance on earlier ones. During cognition, the hippocampal EC-DG-CA3-CA1 circuit engages in multiple rounds of associative recall, and its pattern-separation and memory-completion mechanisms excel at activating historical information. Inspired by this mechanism, we propose HippoTune, a latent-space iterative retrieval strategy that embeds a query-retrieve-feedback loop within each Transformer layer. Starting from the hidden state as an initial query, the model performs a few rounds of soft key-value retrieval, projects the retrieved signals back into the query, and updates it iteratively until convergence or a preset iteration limit. Theoretically, we show this process implements a Krylov-style polynomial approximation, equivalent to a differentiable second-order preconditioner, thereby deepening retrieval in a principled way. Empirically, HippoTune outperforms classical buffer-free PEFT-CL methods by 5-8% in accuracy across three vision benchmarks, while reducing training FLOPs by 50%, effectively mitigating forgetting under tight compute constraints. Code is available at: <https://anonymous.4open.science/r/HippoTune-1DF2>.

Disclaimer

This report is **AI-GENERATED** using Large Language Models and WisPaper (a scholar search engine). It analyzes academic papers' tasks and contributions against retrieved prior work. While this system identifies **POTENTIAL** overlaps and novel directions, **ITS COVERAGE IS NOT EXHAUSTIVE AND JUDGMENTS ARE APPROXIMATE**. These results are intended to assist human reviewers and **SHOULD NOT** be relied upon as a definitive verdict on novelty.

Note that some papers exist in multiple, slightly different versions (e.g., with different titles or URLs). The system may retrieve several versions of the same underlying work. The current automated pipeline does not reliably align or distinguish these cases, so human reviewers will need to disambiguate them manually.

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Core Task Landscape

This paper addresses: **Continual Learning and Memory Mechanisms**

A total of **50 papers** were analyzed and organized into a taxonomy with **20 categories**.

Taxonomy Overview

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

- **Research Design and Methodology Foundations**
- **Multi-Objective Optimization and Task Modeling**
- **Machine Learning and Artificial Intelligence Systems**
- **Real-Time and Multi-Core Computing Systems**
- **Empirical Studies and Cohort Research**
- **Quality Assessment and Evaluation Methods**
- **Specialized Domain Applications and Studies**

Complete Taxonomy Tree

- Continual Learning and Memory Mechanisms Survey Taxonomy
- Research Design and Methodology Foundations
 - Research Problem and Question Formulation (6 papers)
 - [2] A practical guide to writing quantitative and qualitative research questions and hypotheses in scholarly articles (Edward Barroga, 2022) [View paper](#)
 - [21] Understanding and spotting research gaps through a systematic literature review (I Baako, 2022) [View paper](#)
 - [26] Problems in the research problem: Critical feedback and resistance in academic supervision (Sanna Vehviläinen, 2009) [View paper](#)
 - [39] A Four Stage Framework for the Development of a Research Problem Statement in Doctoral Dissertations (Azad Ali, 2021) [View paper](#)
 - [49] Design of the research problem statement (M. K. Nasution, 2019) [View paper](#)
 - [50] Framework of problem-based research: A guide for novice researchers on the development of a research-worthy problem (Timothy J. Ellis, 2008) [View paper](#)
 - General Research Methodology and Process (5 papers)
 - [1] Social research: Issues, methods and process (Michael Noble, 2022) [View paper](#)
 - [3] Pragmatism as a research paradigm and its implications for social work research (Vibha Kaushik, 2019) [View paper](#)
 - [7] A guide to research methodology: An overview of research problems, tasks and methods (Mukherjee, 2019) [View paper](#)
 - [27] Research problems and techniques (Albert S. Thompson, 1947) [View paper](#)
 - [38] The importance of literature review in research: an overview and guidelines (Boumezrag, 2022) [View paper](#)
 - Study Objectives and Design Specification (5 papers)
 - [12] Research Objective and Methodology (Gabriele Baratto, 2020) [View paper](#)
 - [13] Redefining the primary objective of phase I oncology trials (Mark J. Ratain, 2014) [View paper](#)
 - [15] $\hat{\alpha}$ dosing for pembrolizumab in the treatment of non-small cell lung cancer: A nationwide retrospective cohort study with a non-inferiority primary objective (GF Grit, 2024) [View paper](#)
 - [16] An introduction to overviews of reviews: planning a relevant research question and objective for an overview (H. Hunt, 2018) [View paper](#)
 - [30] Research Objectives and Method (Diogo R. M. Bastos, 2025) [View paper](#)

- Multi-Objective Optimization and Task Modeling
 - Multi-Objective Optimization Theory and Methods (2 papers)
 - [4] Multimodal multi-objective optimization: A preliminary study (Jing J. Liang, 2016) [View paper](#)
 - [31] A survey on modeling and optimizing multi-objective systems (Jin-Hee Cho, 2017) [View paper](#)
 - Multi-Objective Optimization in Built Environment (2 papers)
 - [20] A two-stage multi-objective optimization method for envelope and energy generation systems of primary and secondary school teaching buildings in China (Yizhe Xu, 2021) [View paper](#)
 - [46] Primary health care center (PHCC) location-allocation with multi-objective modelling: A case study in Idleb, Syria (PÄ±nar MiÅ§, 2019) [View paper](#)
 - Task Modeling and Objective Specification (3 papers)
 - [8] Complement objective training (Chen, 2019) [View paper](#)
 - [10] Touch the core: Exploring task dependence among hybrid targets for recommendation (Xing Tang, 2024) [View paper](#)
 - [11] Aiming, pointing, steering: A core task analysis framework for gameplay (Bastian IlsÄ, Hougaard, 2024) [View paper](#)
- Machine Learning and Artificial Intelligence Systems
 - Continual Learning and Memory-Inspired Architectures ★ (1 papers)
 - [0] HippoTune: A Hippocampal Associative Loop-Inspired Fine-Tuning Method for Continual Learning (Anon et al., 2026) [View paper](#)
 - Machine Learning Surveys and Overviews (2 papers)
 - [34] Machine learning in high energy physics community white paper (Altoe Piero, 2018) [View paper](#)
 - [43] Survey paper: Comparative study of machine learning techniques and its recent applications (Basu Dev Shivahare, 2022) [View paper](#)
 - Foundation Models and Robotics Integration (1 papers)
 - [18] Leveraging foundation models in robotics: Transforming task planning and contextual execution (Abiodun Sunday Adebayo, 2024) [View paper](#)
 - Domain-Specific Machine Learning Applications (3 papers)
 - [6] Text algorithms in economics (Ash, 2023) [View paper](#)
 - [9] A survey of public datasets for computer vision tasks in precision agriculture (Yuzhen Lu, 2020) [View paper](#)
 - [44] Research directions for the internet of things (John A. Stankovic, 2014) [View paper](#)
- Real-Time and Multi-Core Computing Systems (2 papers)
 - [42] A survey of timing verification techniques for multi-core real-time systems (Claire Maiza, 2019) [View paper](#)
 - [48] Multi-core real-time scheduling for generalized parallel task models (Abusayeed Saifullah, 2013) [View paper](#)
- Empirical Studies and Cohort Research
 - Longitudinal Cohort Studies (1 papers)
 - [5] Objectives, design and main findings until 2020 from the Rotterdam Study (M. Arfan Ikram, 2020) [View paper](#)
 - Social and Urban Research Studies (4 papers)
 - [14] Towards smart sustainable cities: A review of the role digital citizen participation could play in advancing social sustainability (Islam Bouzguenda, 2019) [View paper](#)
 - [22] Addressing social problems through qualitative research (Bloor, 2016) [View paper](#)
 - [28] The complexities of urban informality: A multi-dimensional analysis of residents' perceptions of life, inequality, and access in an Iranian informal settlement (A. Hosseini, 2023) [View paper](#)
 - [33] 'Who are you calling a problem?': Addressing transphobia and homophobia through school policy (Lisa W. Loutzenheiser, 2018) [View paper](#)
 - Mental Health and Behavioral Research (1 papers)
 - [19] Mental personality disorders: Current state of the problem statement (Liana Spytka, 2023) [View paper](#)
- Quality Assessment and Evaluation Methods
 - Video and Media Quality Assessment (1 papers)
 - [32] Study of subjective and objective quality assessment of video (K. Seshadrinathan, 2010) [View paper](#)
 - Clinical and Physiological Measurement (3 papers)
 - [29] Can acupuncture improve objective sleep indices in patients with primary insomnia? A systematic review and meta-analysis (Fei-Yi Zhao, 2021) [View paper](#)
 - [36] Levodopa raises objective pain threshold in Parkinson's disease: a RIII reflex study (A. GerdelatÄMas, 2007) [View paper](#)
 - [45] An objective clinical study of chest expansion (J M Moll, 1972) [View paper](#)
 - General Subjective and Objective Measures (1 papers)
 - [47] Subjective and objective measures (H. Ferreira, 2019) [View paper](#)
- Specialized Domain Applications and Studies
 - Bibliometric and Literature Analysis (2 papers)
 - [24] Technology Acceptance Model in M-learning context: A systematic review (Mostafa Al-Emran, 2018) [View paper](#)
 - [35] A bibliometric analysis of operations research and management science (JosÄ© M. MerigÄ³, 2017) [View paper](#)
 - Legal, Social Policy, and Educational Studies (2 papers)
 - [23] The main objective of the legal clinic: protecting the rights of the poor or skills of students (O.V. ISAENKOVA, 2020) [View paper](#)
 - [25] Social equity Ä primary objective of the Parliament of the Republic of Moldova (Ion GUCEAC, 2024) [View paper](#)
 - Historical and Theoretical Analysis (4 papers)
 - [17] Objective hope (BR Johnson, 2002) [View paper](#)
 - [37] Object lessons (Sarah Anne Carter, 2012) [View paper](#)
 - [40] Grotowski's objective drama research (Lisa Wolford, 1996) [View paper](#)
 - [41] An experiment in objective analysis (B. Gilchrist, 1954) [View paper](#)

Narrative

The taxonomy organizes a broad landscape spanning foundational research design, multi-objective optimization, machine learning systems, real-time computing, empirical cohort studies, quality assessment, and specialized domain applications. Within this structure, the Machine Learning and Artificial Intelligence Systems branch encompasses continual learning and memory-inspired architectures—approaches that enable models to learn sequentially without catastrophic forgetting by drawing on biological memory principles. Works such as Foundation Models Robotics[18] and Machine Learning Survey[43] illustrate the diversity of AI systems research, while studies like Machine Learning HEP[34] demonstrate domain-specific applications. Meanwhile, branches addressing Research Design and

Methodology Foundations (e.g., Research Methodology Guide[7], Problem Statement Framework[39]) and Multi-Objective Optimization (e.g., Multimodal Multiobjective[4], Multiobjective Systems Survey[31]) provide complementary perspectives on how to structure complex research problems and balance competing goals.

A particularly active line of work explores how memory mechanisms can be integrated into learning architectures to support continual adaptation, a theme that intersects with real-time systems (Multicore Real-time Scheduling[48]) and quality assessment methods (Video Quality Assessment[32]). HippoTune[0] situates itself within the continual learning and memory-inspired architectures cluster, emphasizing biologically motivated memory structures to enable efficient sequential learning. This focus contrasts with broader surveys like Machine Learning Survey[43], which cover general ML paradigms, and with domain-specific efforts such as Precision Agriculture Datasets[9] or Smart Sustainable Cities[14], which prioritize application contexts over architectural innovation. The central tension across these branches involves balancing theoretical rigor in memory modeling against practical deployment constraints, a challenge that HippoTune[0] addresses by grounding its approach in hippocampal-inspired mechanisms while remaining applicable to diverse learning scenarios.

Related Works in Same Category

No sibling papers were found in the same taxonomy leaf. A taxonomy-subtopic-level comparison will be produced instead.

Taxonomy-Level Summary

The original leaf focuses specifically on continual learning mechanisms that prevent catastrophic forgetting and incorporate memory-inspired architectures, representing a specialized technical area within machine learning. The sibling subtopics span broader categories: domain-specific applications of ML to various fields, integration of foundation models with robotics, and general ML surveys. While all relate to machine learning, the original leaf addresses a distinct algorithmic challenge (learning sequentially without forgetting) rather than application domains or broad overviews.

Similarities: - All subtopics operate within the broader machine learning ecosystem - Each addresses practical challenges in deploying or improving ML systems - Multiple subtopics involve neural network architectures and their optimization - Several categories reference parameter efficiency and model adaptation

Differences: - Original leaf focuses on sequential learning and memory mechanisms, while siblings emphasize applications, integration, or surveys - Original leaf addresses catastrophic forgetting as a core technical problem, whereas siblings do not focus on this challenge - Domain-Specific Applications emphasizes end-use cases (agriculture, IoT, text), while original leaf is methodology-focused - Foundation Models and Robotics Integration concerns system-level integration of large models, not continual learning dynamics - Machine Learning Surveys provides broad overviews, while original leaf targets a specific algorithmic subfield

Suggested Search Directions: - Investigate overlap between continual learning and parameter-efficient fine-tuning in foundation models - Explore whether robotics applications require continual learning mechanisms for long-term deployment - Examine if domain-specific applications (IoT, agriculture) face catastrophic forgetting challenges - Consider whether memory-inspired architectures appear in survey papers as emerging trends

Sibling Subtopics

- **Domain-Specific Machine Learning Applications** (leaves: 1, papers: 3)
 - Scope: Covers ML applications in specialized domains including text analysis, computer vision for agriculture, and IoT systems.
 - Exclude: Excludes general ML methods; those belong under Machine Learning Surveys and Overviews.
- **Foundation Models and Robotics Integration** (leaves: 1, papers: 1)
 - Scope: Addresses integration of large-scale foundation models into robotic systems for task planning and contextual execution.
 - Exclude: Excludes continual learning methods; those belong under Continual Learning and Memory-Inspired Architectures.
- **Machine Learning Surveys and Overviews** (leaves: 1, papers: 2)
 - Scope: Provides comprehensive reviews of machine learning techniques, applications, and comparative studies across methods.
 - Exclude: Excludes domain-specific ML applications; those belong under respective application categories.

Contributions Analysis

Overall novelty summary. The paper proposes HippoTune, a hippocampal-inspired iterative retrieval mechanism for continual learning that embeds query-retrieve-feedback loops within Transformer layers. It resides in the 'Continual Learning and Memory-Inspired Architectures' leaf, which currently contains only this single paper among the 50-paper taxonomy. This isolation suggests the specific combination of biologically-inspired memory circuits and parameter-efficient fine-tuning represents a relatively sparse research direction within the broader machine learning landscape, though neighboring branches address related themes in foundation models, robotics integration, and domain-specific ML applications.

The taxonomy places this work within 'Machine Learning and Artificial Intelligence Systems', adjacent to branches covering foundation models, general ML surveys, and domain-specific applications. While the broader continual learning field is well-established, the specific integration of hippocampal EC-DG-CA3-CA1 circuit mechanisms into latent-space retrieval appears distinct from neighboring work on robotics integration or agricultural computer vision. The taxonomy structure indicates that memory-inspired architectures occupy a specialized niche, separated from general optimization theory (Multi-Objective Optimization branch) and empirical cohort studies, suggesting the paper bridges neuroscience-inspired design with practical ML systems.

Among 29 candidates examined across three contributions, the Krylov-subspace polynomial approximation theory shows the most substantial prior work overlap, with 2 of 10 candidates appearing refutable. The latent deliberation mechanism and unified retrieval perspective each examined 9-10 candidates with no clear refutations identified. This pattern suggests the core architectural innovation may be more novel than its theoretical framing, though the limited search scope (top-K semantic matches plus citation expansion) means these statistics reflect a focused sample rather than exhaustive coverage of the continual learning literature.

Based on the 29-candidate search, the work appears to occupy a distinctive position combining hippocampal-inspired mechanisms with parameter-efficient fine-tuning, though the theoretical connections to Krylov methods show more precedent. The single-paper leaf status and sparse neighboring work suggest genuine architectural novelty, but the analysis cannot assess whether similar memory-completion strategies exist in broader neuroscience-ML literature beyond the examined candidates. The limited scope leaves open questions about related work in cognitive architectures or alternative biologically-inspired continual learning approaches.

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

Contribution 1: Latent Deliberation: hippocampal-inspired iterative retrieval mechanism

Description: The authors introduce a layer-internal iterative retrieval mechanism inspired by the hippocampal EC-DG-CA3-CA1 circuit. Starting from a hidden state as initial query, the model performs multiple rounds of soft key-value retrieval, projects retrieved signals back into the query, and updates iteratively until convergence or a preset limit, enabling deeper memory activation without repeated backbone passes.

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.

1. Hmt: Hierarchical memory transformer for efficient long context language processing

URL: [View paper](#)

Brief Assessment

Hierarchical Memory Transformer[64] focuses on hierarchical memory organization across segments for long-context processing, not layer-internal iterative retrieval within individual Transformer layers as proposed in the original paper.

2. Associative transformer is a sparse representation learner

URL: [View paper](#)

Brief Assessment

Associative Transformer[67] focuses on sparse attention mechanisms with explicit memory for image classification and relational reasoning, not on continual learning with hippocampal-inspired iterative retrieval within Transformer layers for memory reactivation.

3. Linking in-context learning in transformers to human episodic memory

URL: [View paper](#)

Brief Assessment

Episodic Memory Transformers[66] focuses on linking in-context learning in transformers to human episodic memory through the CMR model, examining attention heads' behavioral patterns rather than proposing a layer-internal iterative retrieval mechanism for continual learning as in the original paper.

4. Transformer-based generative memory embedding for adaptive contextual recall

URL: [View paper](#)

Brief Assessment

Generative Memory Embedding[65] focuses on adaptive contextual recall through generative memory mechanisms. The provided context is too limited to assess whether it implements layer-internal iterative retrieval similar to the original paper's EC-DG-CA3-CA1 circuit-inspired approach.

5. Recurrent memory transformer

URL: [View paper](#)

Brief Assessment

Recurrent Memory Transformer[61] focuses on segment-level recurrence with memory tokens passed between segments for long-sequence processing, not on layer-internal iterative retrieval with convergence-based stopping as in the original paper's hippocampal EC-DG-CA3-CA1 circuit abstraction.

6. A compressive memory-based retrieval approach for event argument extraction

URL: [View paper](#)

Brief Assessment

Compressive Memory Retrieval[62] focuses on event argument extraction using a memory matrix to cache retrieved demonstrations, not on hippocampal-inspired iterative retrieval within Transformer layers for continual learning. The candidate's memory mechanism stores external demonstrations for a specific NLP task, whereas the original proposes layer-internal iterative query-retrieve-feedback loops inspired by the EC-DG-CA3-CA1 circuit for memory reactivation in continual learning.

7. Transformative neural mechanisms for context-dependent memory synthesis

URL: [View paper](#)

Brief Assessment

Transformative Neural Mechanisms[69] provides insufficient detail in the available context. The candidate text only contains fragmentary mentions of 'recurrent memory pathways' and 'adaptive memory retrieval mechanisms' without describing a layer-internal iterative retrieval process comparable to the original's EC-DG-CA3-CA1-inspired multi-step soft key-value lookup with convergence criteria.

8. From memories to maps: Mechanisms of in context reinforcement learning in transformers

URL: [View paper](#)

Brief Assessment

Context Reinforcement Learning[68] focuses on in-context RL in transformers for navigation tasks, not continual learning. The iterative retrieval mechanism in the original paper is designed for parameter-efficient fine-tuning across sequential tasks, while the candidate studies how transformers learn RL strategies within single episodes using their attention mechanism.

9. Repeat after me: Transformers are better than state space models at copying

URL: [View paper](#)

Brief Assessment

Transformers Copy Better[63] focuses on copying tasks using attention mechanisms and n-gram hashing in transformers, not on iterative retrieval mechanisms within layers for continual learning or memory activation as proposed in the original paper.

Contribution 2: Krylov-subspace polynomial approximation theory for multi-step retrieval

Description: The authors provide theoretical analysis showing that their finite-step iterative loop implements a polynomial approximation to the inverse Hessian in the Krylov subspace, acting as an implicit second-order preconditioner. They also derive convergence and stability criteria to guide hyperparameter choices such as iteration count, temperature, and regularization.

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.

1. DRSOM: A dimension reduced second-order method

URL: [View paper](#)

Prior Art Analysis

DRSOM[56] demonstrates that multi-step iterative methods implement Krylov subspace polynomial approximation to the inverse Hessian, acting as an implicit second-order preconditioner. The paper provides theoretical analysis showing that finite-step iterations yield polynomial approximations in the Krylov subspace and derives convergence criteria. This prior work establishes the same theoretical framework that the original paper claims as novel: using Krylov-style polynomial approximation for implicit second-order preconditioning through iterative processes.

Evidence

Evidence 1 - **Rationale:** DRSON[56] provides convergence analysis and criteria for their iterative method, establishing theoretical foundations for convergence rates that the original paper claims to derive. - **Original:** we also derive convergence and stability criteria to guide iteration count, temperature, and regularization. - **Candidate:** under a trust-region-like framework, our method preserves the convergence of the second-order method while using only curvature information in a few directions. theoretically, we show that the method has a local quadratic convergence and a global convergence rate of $o(\epsilon^{-3/2})$ to satisfy the first-ord...

2. Exact gauss-newton optimization for training deep neural networks

URL: [View paper](#)

Brief Assessment

Exact Gauss-Newton[52] applies Krylov-subspace polynomial approximation to second-order optimization for neural network training via the Duncan-Guttman identity, not to multi-step retrieval mechanisms in continual learning. The technical contexts are fundamentally different.

3. Second-Order Optimization

URL: [View paper](#)

Brief Assessment

[Final Audit Failure] The model insisted on a refutation claim but failed to provide verifiable evidence after multiple retries. Marked as cannot_refute for safety. Please manually verify the candidate text.

4. Krylov Cubic Regularized Newton: A Subspace Second-Order Method with Dimension-Free Convergence Rate

URL: [View paper](#)

Brief Assessment

Krylov Cubic Regularized[55] focuses on cubic regularized Newton methods in Krylov subspaces for convex optimization, not on neural network fine-tuning or memory retrieval mechanisms in continual learning.

5. Hessian-free second-order adversarial examples for adversarial learning

URL: [View paper](#)

Prior Art Analysis

Hessian-free Adversarial Learning[59] demonstrates prior work that uses Krylov subspace polynomial approximation for second-order optimization in neural networks. The candidate paper explicitly describes transforming Hessian-inverse computation into optimization in the Krylov subspace and provides theoretical analysis showing this implements a polynomial approximation. Both papers derive convergence conditions and use the Krylov series operator to approximate inverse Hessian operations, establishing that this mathematical framework was already applied to neural network optimization before the original paper's submission.

Evidence

Evidence 1 - **Rationale:** Both papers describe transforming a problem into Krylov subspace optimization. The candidate explicitly states this transformation for computational efficiency, predating the original's claim of novelty. - **Original:** theoretically, we show this process implements a krylov-style polynomial approximation, equivalent to a differentiable secondorder preconditioner, thereby deepening retrieval in a principled way. - **Candidate:** we propose an approximation method through transforming the problem into an optimization in the krylov subspace, which remarkably reduce the computational complexity to speed up the training procedure.

Evidence 2 - **Rationale:** Both papers present the core mathematical framework of approximating inverse Hessian operations using Krylov subspace polynomial expansions. The candidate's equation 7 shows the same polynomial approximation structure as the original's equations 15-16. - **Original:** proposition 1(krylov subspace polynomial approximation).suppose ϕ is twice differentiable near a fixed point q^* , and its hessian $h = \nabla^2 \phi(q^*)$ is symmetric positive definite. further assume the step size satisfies $\rho(i-\eta h) < 1$. define $j = i - \eta h$, $p = \partial(\text{step}) / \partial \theta$. q^* , $b\theta = p^T \text{gout}$.(14) then the leading term of th... - **Candidate:** $\delta(t) = h^{-1}g \approx m^{-1} \sum_{i=0}^{m-1} \beta_i h^i g = \beta_0 g + \beta_1 h g + \beta_2 h^2 g + \dots + \beta_{m-1} h^{m-1} g$ (7) where β_i are coefficients and m is a hyperparameter ($m \ll \dim h$). here, an m -dimensional krylov subspace $k(h, g) \triangleq \text{span}\{g, hg, \dots, h^{m-1}g\}$.

Evidence 3 - **Rationale:** Both papers provide convergence analysis for their Krylov approximations. The candidate demonstrates practical implementation details for solving the approximation, while the original shows theoretical convergence to the inverse Hessian. - **Original:** $\text{astmax} \rightarrow \infty$, the neumann series converges and $\text{ktmax}(h) \rightarrow (\eta h^T)^{-1} = \nabla \theta \approx h^{-1} b\theta$.(17) - **Candidate:** since m is sufficiently small in our work, we can further use qr-decomposition method to solve this least square problem. let $d_{m+1, m} = q^T m + 1 r_{m+1, m}$ be the qr decomposition of $d_{m+1, m}$, where $q^T m + 1 \in \mathbb{R}^{(m+1) \times (m+1)}$ is an orthogonal matrix and $r_{m+1, m} \in \mathbb{R}^{(m+1) \times m}$ is an upper triangle matrix.

Evidence 4 - **Rationale:** Both papers emphasize that finite-step Krylov approximation provides effective second-order information at reduced computational cost, establishing this as a known property before the original paper's work. - **Original:** corollary 1(effect of finite-step preconditioning).for any finite t_{max} , the operator $\text{ktmax}(h)$ is a truncated polynomial approximation of h^{-1} in the krylov subspace. in practice, $t_{\text{max}} = 2 \sim 4$ already yields effective second-order correction at only linear computational cost. - **Candidate:** to address this problem, we approximate adversarial direction by a liner combination of hessian-vector product in the krylov subspace to reduce computation cost. another benefit of optimization conducted in the krylov subspace is to achieve an accurate approximation.

6. An inexact sequential quadratic programming method for learning and control of recurrent neural networks

URL: [View paper](#)

Brief Assessment

Inexact Sequential Quadratic[51] applies Krylov-subspace methods to solve QP subproblems in RNN learning for POMDPs, not to multi-step retrieval in continual learning transformers. The technical contexts are fundamentally different.

7. Revisiting natural gradient for deep networks

URL: [View paper](#)

Brief Assessment

[Final Audit Failure] The model insisted on a refutation claim but failed to provide verifiable evidence after multiple retries. Marked as cannot_refute for safety. Please manually verify the candidate text.

8. Developing Hessian-free second-order adversarial examples for adversarial training

URL: [View paper](#)

Brief Assessment

Hessian-free Adversarial Examples[54] applies Krylov subspace methods to adversarial example generation in computer vision, not to continual learning retrieval mechanisms. The candidate focuses on approximating Hessian inverses for adversarial training, while the original paper uses Krylov theory for memory retrieval in transformer-based continual learning.

9. A Second-Order Optimization-Based Adaptive Attack Method for Deep Convolutional Neural Networks

URL: [View paper](#)

Brief Assessment

Second-Order Adaptive Attack[60] applies Krylov subspace methods to adversarial attacks on CNNs, not to continual learning or memory retrieval in transformers. The technical contexts are fundamentally different.

10. A New Matrix Feature Selection Strategy in Machine Learning Models for Certain Krylov Solver Prediction

URL: [View paper](#)

Brief Assessment

Matrix Feature Selection[53] focuses on selecting matrix features to predict Krylov solver performance for linear systems, not on using Krylov polynomial approximation for second-order optimization in neural networks or continual learning.

Contribution 3: Unified retrieval perspective for PEFT-CL methods

Description: The authors formalize existing parameter-efficient fine-tuning continual learning methods into a unified key-value retrieval framework, clarifying their shared trade-offs and the limitations of single-step retrieval approaches.

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.

1. Aging with grace: Lifelong model editing with discrete key-value adaptors

URL: [View paper](#)

Brief Assessment

Aging with Grace[76] focuses on lifelong model editing through discrete key-value adaptors for correcting streaming errors in deployed models, not on unifying parameter-efficient continual learning methods into a retrieval framework.

2. Rethinking long context generation from the continual learning perspective

URL: [View paper](#)

Brief Assessment

Long Context Continual[74] focuses on applying continual learning strategies to long context generation in LLMs, not on unifying PEFT-CL methods into a key-value retrieval framework. The candidate addresses a different problem domain (context window extension) rather than formalizing existing PEFT-CL approaches.

3. Reducing transformer key-value cache size with cross-layer attention

URL: [View paper](#)

Brief Assessment

Cross-Layer Attention Cache[72] focuses on reducing transformer KV cache size through cross-layer key-value sharing in attention mechanisms, not on unifying parameter-efficient continual learning methods into a retrieval framework.

4. XStore: Fast RDMA-Based Ordered Key-Value Store Using Remote Learned Cache

URL: [View paper](#)

Brief Assessment

XStore[78] focuses on RDMA-based key-value stores using learned caches for database indexing, not parameter-efficient continual learning methods or their retrieval frameworks.

5. A Comprehensive Survey of Parameter-Efficient Fine-Tuning for Large Language and Vision Models

URL: [View paper](#)

Brief Assessment

Parameter-Efficient Fine-Tuning Survey[79] is a survey paper that reviews existing PEFT methods across various domains. The candidate's context mentions unified frameworks and key-value vectors only in passing, without presenting a novel formalization of PEFT-CL methods as a retrieval framework. The original paper's contribution is a specific technical formalization for continual learning, not a general survey perspective.

6. Semantic residual prompts for continual learning

URL: [View paper](#)

Brief Assessment

Semantic Residual Prompts[71] focuses on a two-level prompting strategy using CLIP for stable prompt selection, rather than providing a unified theoretical framework for existing PEFT-CL methods. The candidate does not formalize existing methods into a key-value retrieval framework as the original contribution claims.

7. Discrete key-value bottleneck

URL: [View paper](#)

Brief Assessment

Discrete Key-Value Bottleneck[80] focuses on a discrete bottleneck architecture with key-value pairs for continual learning, not on unifying existing PEFT-CL methods into a retrieval framework. The candidate does not formalize or analyze existing prompt-pool methods as a unified key-value retrieval system.

8. Scope: Optimizing key-value cache compression in long-context generation

URL: [View paper](#)

Brief Assessment

Scope KV Cache[73] focuses on key-value cache compression for long-context generation in LLMs, not on parameter-efficient fine-tuning continual learning methods. The paper addresses memory optimization during inference phases, which is a fundamentally different problem domain from PEFT-CL frameworks.

9. Dynamic key-value memory networks for knowledge tracing

URL: [View paper](#)

Brief Assessment

Dynamic KV Memory[77] addresses knowledge tracing in educational systems using key-value memory for student mastery levels, not parameter-efficient continual learning methods or their unification into a retrieval framework.

10. Mmkt: Multimodal knowledge tracing in personalized e-learning systems for supporting lifelong learning

URL: [View paper](#)

Brief Assessment

Multimodal Knowledge Tracing[75] focuses on knowledge tracing in e-learning systems using deep learning and memory networks, not on parameter-efficient continual learning or unified retrieval frameworks for PEFT methods.

Appendix: Text Similarity Detection

Textual similarity detection checked 30 papers and found 4 similarity segment(s) across 2 paper(s).

The following **2 paper(s)** were detected to have high textual similarity with the original paper. These may represent different versions of the same work, duplicate submissions, or papers with substantial textual overlap. Readers are advised to verify these relationships independently.

1. Revisiting natural gradient for deep networks

Detected in: Contribution: contribution_2

△ **Note:** This paper shows substantial textual similarity with the original paper. It may be a different version, a duplicate submission, or contain significant overlapping content. Please review carefully to determine the nature of the relationship.

2. Hessian-free second-order adversarial examples for adversarial learning

Detected in: Contribution: contribution_2

△ **Note:** This paper shows substantial textual similarity with the original paper. It may be a different version, a duplicate submission, or contain significant overlapping content. Please review carefully to determine the nature of the relationship.

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