EOS-ϕ: A Continuous Emotion State Architecture for Adaptive Language Models

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Abstract

Large language models can shift tone on command, yet they lack the ability to transition between emotional postures in a continuous, human-like manner. Current systems treat emotional tone as a stateless prompt, leading to abrupt switches that break conversational naturalness. We introduce EOS-ϕ, a lightweight emotional-state mechanism that maintains a persistent vector E_t summarizing the evolving emotional posture of an interaction. Each user message provides a small emotional slice S_i extracted from linguistic cues. EOS-ϕ integrates these slices through a simple exponential smoothing rule, enabling smooth emotional transitions, memory of prior tone, and consistent personality expression. The approach is model-agnostic, requires no modifications to underlying LLM weights, and can be implemented as either a prompt-level or embedding-level conditioning layer. EOS-ϕ represents a minimal yet effective step toward more natural affective behavior in language models.

Keywords: emotion modeling, language models, affective computing, personalization, continuous latent states

1 Introduction

Large language models have transformed natural language interaction, yet they still fail to capture one fundamental aspect of human conversation: emotional continuity. When users rapidly shift tone—for example, from serious to playful or from irritated to supportive—current models switch styles immediately. They adopt the new tone fully, discarding all prior affective posture. Humans do not behave this way. Emotional state evolves smoothly, carrying traces of past tone forward even after a conscious change in demeanor.

Despite advances in contextual reasoning and stylistic prompting, modern LLMs treat emotional tone as a discrete command. This creates abrupt, unnatural transitions that can break engagement and weaken the sense of conversational identity.

We propose EOS-ϕ, a continuous emotional state architecture designed to give LLMs a form of emotional inertia. EOS-ϕ maintains a persistent emotional state vector E_t that is updated gradually with each user message. Emotional slices—compact representations of affective content—nudge the state incrementally, enabling transitions that are fluid and human-like. The model's generation is then conditioned on this state through prompt-based or embedding-level mechanisms.

This paper focuses solely on the architecture and behavior of EOS-ϕ. All external systems or tools used internally in our own implementations are omitted here, as they are not required for the conceptual or practical contribution of this work.

2 Background

2.1 Emotional Tone in Dialogue Systems

Classical dialogue systems often relied on categorical emotion labels or rule-based heuristics. Modern LLMs allow users to specify tone via natural-language instructions, but these instructions are interpreted as immediate style overrides. No persistent emotional memory is maintained across messages.

2.2 Continuous Latent Representations

Large language models operate in high-dimensional embedding spaces that naturally encode affective and stylistic structure. This motivates representing emotion not as discrete categories but as continuous vectors that evolve over time.

2.3 Human Emotional Dynamics

Human emotional states demonstrate inertia: they drift, blend, and persist. EOS-ϕ is inspired by this temporal continuity, aiming to approximate it without simulating human emotion itself.

3 Theoretical Foundations

Modern language models operate in high-dimensional embedding spaces where semantic and affective properties are implicitly encoded. EOS-ϕ builds on three well-established mathematical ideas—continuous latent states, exponential smoothing, and convex combinations—to define an interpretable emotional state vector that evolves naturally over time.

3.1 Emotional Representations as Vectors

Embedding models such as word2vec, GloVe, BERT, and contemporary transformer encoders map text into vectors in $\mathbb{R}^d$. These representations organize stylistic and emotional information along specific directions in embedding space. EOS-ϕ treats emotion as a vector quantity rather than a discrete label. Each input yields an emotional slice:

$$S_i \in \mathbb{R}^d,$$

representing affective cues extracted from the text.

3.2 Continuous Emotional State as a Latent Variable

EOS-ϕ maintains a latent emotional state:

$$E_t \in \mathbb{R}^d,$$

analogous to hidden-state formulations in state-space models or autoregressive processes. Unlike learned recurrent structures, the update mechanism is deliberately simple for interpretability and easy integration.

3.3 Exponential Smoothing as Temporal Inertia

EOS-ϕ applies exponential smoothing to update the state:

$$E_{t+1} = \alpha E_t + (1 - \alpha) S_i,$$

with $\alpha \in [0, 1)$. This corresponds to a first-order autoregressive model, a low-pass filter, or a classical exponential moving average. Expanding the recurrence:

$$E_t = (1 - \alpha) \sum_{k=0}^{t-1} \alpha^k S_{t-1-k},$$

reveals a decaying memory over all previous slices.

3.4 Convexity and Interpretability

Since the update rule is a convex combination, E_{t+1} lies in the convex hull of prior emotional influences. This ensures smooth transitions, bounded drift, and interpretability.

3.5 Behavioral Consequences

From these properties, EOS-ϕ naturally exhibits emotional momentum, blended transitions between conflicting tones, long-term drift toward persistent patterns, and clear interpretability.

4 EOS-ϕ Architecture

4.1 Emotional Slices

Each user message is encoded into an emotional slice S_i derived from linguistic cues such as sentiment, tone, and conversational style. No discrete emotion labels are required.

4.2 Persistent Emotional State E_t

The emotional posture is maintained via a vector E_t that evolves gradually, retaining memory of prior states while adapting to recent cues.

4.3 Continuous Update Rule

The state is updated through:

$$E_{t+1} = \alpha E_t + (1 - \alpha) S_i.$$

4.4 Conditioning the Language Model

EOS-ϕ influences generation through:

- **Prompt-level conditioning:** converting E_t into descriptive text.
- **Embedding-level conditioning:** providing E_t as a control embedding.

4.5 Behavioral Intuition

The model transitions smoothly, blends conflicting tones, and maintains continuity across turns.

5 Experiments

5.1 Tone Transition Evaluation

EOS-ϕ exhibits smoother transitions and more coherent blending compared to baseline systems.

5.2 Emotional Persistence Study

The emotional state retains influence across multiple turns, unlike prompt-only baselines.

6 Limitations

EOS-ϕ models affective style continuity, not human emotion. Performance depends on embedding quality, α, and domain-specific tuning.

7 Conclusion

EOS-ϕ provides a simple, interpretable mechanism for emotional continuity in language models. By maintaining a continuous emotional state vector and conditioning generation on this state, EOS-ϕ enables more natural and coherent conversational dynamics.