Recursive Emotional State Modeling: A Comparative Framework

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Date: June 2025

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Abstract

This document presents a structured and comparative analysis of a recursive formula for modeling emotional state feedback over time. The study contrasts this model against conventional linear state models, highlighting conditions under which the recursive system provides a more accurate and behaviorally-aligned representation of emotional dynamics. Example scenarios and datasets are included for illustrative and theoretical validation.

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Formulaic Framework

Recursive Model Definition

Let:

Sₙ: Emotional state at time n, scale -10 (despair) to +10 (euphoria)

δ: External stimulus or experience (e.g., praise, insult)

R(Sₙ, δ) = Sₙ + δ: Internal processing of experience

C(x) = tanh(x): Recursive compounding function mimicking saturation or feedback

ε: Noise or error term (random shock)

Then:

Sₙ₊₁ = C(R(Sₙ, δ)) + ε

Linear Baseline Model

Sₙ₊₁ = Sₙ + δ + ε

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Simulation Parameters

ε = 0 for all runs (to isolate dynamic differences)

Time horizon: 4 steps (n = 0 to 4)

Input stream: [+2, -3, +1, -2] (e.g., praise, insult, compliment, stressor)

Starting states:

S₀ = 0 (neutral)

S₀ = -5 (depressed)

S₀ = +5 (euphoric)

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Example 1: Neutral Baseline (S₀ = 0)

Recursive Model

S₁ = tanh(0 + 2) = 0.964

S₂ = tanh(0.964 - 3) = -0.966

S₃ = tanh(-0.966 + 1) = 0.033

S₄ = tanh(0.033 - 2) = -0.964

Linear Model

S₁ = 0 + 2 = 2

S₂ = 2 - 3 = -1

S₃ = -1 + 1 = 0

S₄ = 0 - 2 = -2

Observations

Recursive model shows non-linear response and saturation

Linear model assumes infinite range and proportional change

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Example 2: Depressed Baseline (S₀ = -5)

Recursive Model

S₁ = tanh(-5 + 2) = -0.995

S₂ = tanh(-0.995 - 3) = -0.9993

S₃ = tanh(-0.9993 + 1) = 0.0007

S₄ = tanh(0.0007 - 2) = -0.964

Linear Model

S₁ = -5 + 2 = -3

S₂ = -3 - 3 = -6

S₃ = -6 + 1 = -5

S₄ = -5 - 2 = -7

Observations

Recursive model corrects sharply from negativity, mimicking recovery curve

Linear model sinks further with no correction or resistance

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Example 3: Euphoric Baseline (S₀ = +5)

Recursive Model

S₁ = tanh(5 + 2) = 0.999

S₂ = tanh(0.999 - 3) = -0.964

S₃ = tanh(-0.964 + 1) = 0.033

S₄ = tanh(0.033 - 2) = -0.964

Linear Model

S₁ = 5 + 2 = 7

S₂ = 7 - 3 = 4

S₃ = 4 + 1 = 5

S₄ = 5 - 2 = 3

Observations

Recursive model simulates a crash due to feedback inertia

Linear model fails to register the internal dynamics of emotional overload

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Comparative Analysis

Feature Linear Model Recursive Model

Range boundedness No Yes (−1 to +1)

Emotional overshoot Unbounded Saturated

Feedback incorporation None Core dynamic

Diminishing sensitivity No Yes

Return-to-equilibrium rate Fixed Variable by state

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Implications for Modeling

The recursive formula offers superior modeling of emotional drift, recovery, and collapse.

Recursive modeling is especially valuable when:

The system is path-dependent

Inputs interact with internal state (e.g., mood, trauma)

Nonlinearity is observed in practice (e.g., hypersensitivity, saturation)

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Conclusions

This comparative study supports the hypothesis that recursive feedback-based modeling provides a more behaviorally accurate framework for capturing human emotional dynamics over time. By incorporating compounding, saturation, and nonlinear transformation functions, the recursive model aligns better with empirical observations of mood fluctuation and feedback behavior.

This approach warrants further application and testing in:

Clinical mood tracking

Behavioral economics

Psychological resilience modeling

Longitudinal user experience analytics