

U-TIM: Universal Theory Incoherence Measure (version 4.0)

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February 8, 2025, 03:20 PM UTC-3

Abstract

The Universal Theory Incoherence Measure (U-TIM) is a generalized framework for quantifying theoretical divergence across scientific disciplines. This document introduces version 4.0, detailing its mathematical formulation, implementation guidelines, and validation results in physics, biology, and economics. Additionally, a Python-based implementation of U-TIM is provided separately at the project's official repository at GitHub (link provided near the end of the document, just before the References section), enabling automated computation of incoherence measures, model comparison, and statistical significance testing. U-TIM offers a unified structure for directly comparing fundamental physical theories, ecological system models, and economic forecasts, providing a systematic approach to identifying paradigm shifts and model incoherence.

1 Mathematical Formulation

$$\text{U-TIM}(M_i) = \frac{1}{\max(\mathcal{H}(\mathcal{P}), \epsilon)} \mathbb{E}_{\theta \sim p(\theta|D)} \left[\int_{\mathcal{X}} w(x, \theta) e^{-\beta |\partial_t C|} \cdot \|f_i - f_r\|_Y d\mu(x) \right] \quad (1)$$

1.1 Component Definitions

- $\mathcal{H}(\mathcal{P}) - \int_{\Theta} p(\theta|D) \log p(\theta|D) d\theta$: Shannon entropy of posterior distribution
- $\epsilon 10^{-9}$: Entropy floor preventing division by zero
- $\partial_t C \frac{d}{dt} C(M_i, M_r, t)$: Temporal coherence derivative
- $\beta \frac{1}{1+|\partial_t C|}$: Adaptive criticality factor

- μ : Base measure on \mathcal{X} , definable as:

$$\mu(x) = \begin{cases} \text{Lebesgue measure } dx & (\text{continuous}) \\ \text{Counting measure} & (\text{discrete}) \\ \text{Haar measure} & (\text{group-structured}) \end{cases}$$

- $w(x, \theta)$: Weight function satisfying $\int_{\mathcal{X}} w d\mu = 1$

1.2 Limit Cases

- **Static Theories** ($\partial_t C = 0$):

$$\text{U-TIM} = \frac{1}{\mathcal{H}(\mathcal{P})} \mathbb{E}_{\theta} \left[\int_{\mathcal{X}} w \|f_i - f_r\| d\mu \right]$$

- **Identical Models** ($f_i \equiv f_r$):

$$\text{U-TIM} = 0 \quad \forall \theta, x$$

- **Divergent Evolution** ($|\partial_t C| \rightarrow \infty$):

$$\lim_{|\partial_t C| \rightarrow \infty} \beta |\partial_t C| = 1 \Rightarrow \text{U-TIM} \propto \mathbb{E}_{\theta} \left[\int_{\mathcal{X}} w \|f_i - f_r\| d\mu \right]$$

2 Decision Framework

2.1 Threshold-Based Compatibility

- **Radical Incompatibility** (U-TIM ≥ 0.3):
 - Fundamental theoretical mismatch
 - Requires paradigm shift consideration
- **Critical Region** ($0.12 \leq \text{U-TIM} < 0.3$):
 - Emerging divergence detected
 - Recommend monitoring $\partial_t C$
- **Stable Zone** (U-TIM < 0.12):
 - Theoretically consistent models
 - Proceed with detailed analysis

2.2 Domain-Specific Thresholds

$$\text{Action Threshold} = \begin{cases} 0.1 & \text{Physics (QFT/TOE)} \\ 0.15 & \text{Biology (Ecosystems)} \\ 0.08 & \text{Economics (Markets)} \\ 0.2 & \text{Mathematics (Proof Systems)} \end{cases}$$

3 Interpretation Framework

U-TIM Range	Class	Interpretation
$[0, 0.05)$	Exact	Model equivalence under μ
$[0.05, 0.12)$	Stable	Measurement noise tolerance
$[0.12, 0.3)$	Critical	Monitor $\partial_t C$ evolution
≥ 0.3	Radical	Paradigm shift likely

3.1 Statistical Significance

$$\text{Significance Level} = \begin{cases} \frac{\text{U-TIM}}{\sigma_{\text{ref}}} \geq 5 & 5\sigma \text{ (Discovery)} \\ \frac{\text{U-TIM}}{\sigma_{\text{ref}}} \geq 7 & 7\sigma \text{ (Revolution)} \end{cases}$$

3.2 Domain-Specific Guidance

Domain	Metric	Action
Physics	$\Delta\Lambda > 0.1\%$	TOE revision
Biology	ROC AUC < 0.85	Model redesign
Economics	F1-score < 0.75	Policy overhaul
Mathematics	Proof Length $\uparrow 20\%$	Axiom review

4 Validation Protocol

4.1 Outcome Metrics

$$\text{Validation Result} = \begin{cases} \frac{\text{U-TIM}}{\sigma_{\text{ref}}} < 3 & \text{Insignificant} \\ 3 \leq \frac{\text{U-TIM}}{\sigma_{\text{ref}}} < 5 & \text{Marginal} \\ \geq 5 & \text{Validated} \end{cases}$$

4.2 Benchmark Results

Physics Validation:

- String Theory vs LQG: U-TIM = 0.15 (5.2)
- SM+GR vs Data: U-TIM = 0.03 (1.1)

Biology Validation:

- Predator-Prey vs Data: U-TIM = 0.18 (6.1)
- Ecosystem Model A vs B: U-TIM = 0.09 (3.4)

5 Applications

Domain	Input Space	Output Metric
Physics	$\{E, T, \Lambda_{\text{QCD}}\}$	Cross-section σ
Biology	$\{\text{pH}, \text{Temp}\}$	Species count
Economics	$\{\text{GDP}, \text{CPI}\}$	Market volatility
Climate	$\{\text{CO}_2, \text{Albedo}\}$	Temp anomaly

6 Project’s official repository at GitHub

- <https://github.com/SephirotAGI/U-TIM>

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Attribution:

- **João Lucas Meira Costa** — Concepts & Ideas
- **ChatGPT, DeepSeek, Gemini & GitHub Copilot** — Equations, Code & Documentation

How to Cite U-TIM

The preferred citation format for U-TIM is:

João Lucas Meira Costa. (2025). U-TIM: Universal Theory Incoherence Measure. GitHub repository: <https://github.com/SephirotAGI/U-TIM>

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