Operational Spin: A Physical Projection of UTAM-Directed Will into Adaptive Media

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Abstract

Adaptive systems - biological, cognitive, cybernetic, or artificial - respond to directed perturbations in ways that reveal more than simple relaxation dynamics. Prior work in the Petronus Research Series established: (i) $UTAM$ as a geometry of meaning-preserving trajectories, (ii) E as an adaptive dissipative controller minimizing an effective action, and (iii) Drift and Coherence as structural metrics of identity stability.

What has been missing is a **physical invariant** linking directed perturbation ("$Will$") to measurable field-level dynamics.

This paper introduces **Operational Spin**: the antisymmetric component of the gradient of directed change, representing the immediate breaking of local isotropy in any adaptive medium. We show how Spin emerges as the first-order physical signature of $UTAM$-directed intention, how E interacts with Spin via adaptive dissipation, and how residual Spin accumulates as measurable Drift.

We formalize this relationship in the **Spin–Drift Correspondence Theorem**, provide a minimal toy simulation, and position Spin as the missing physical layer connecting $UTAM, E$, coherence-preserving adaptation, and the structural identity of an agent embedded in a dynamic world.

1 Introduction and Context

Previous works in the Petronus Research framework established:

- **ONTOΣ I - III**: Will as an ontological operator selecting admissible "directions of becoming".
- **UTAM**: A formalization of will - like selection as constraints on meaning-preserving trajectories in state space.
- **Unified Dissipation Law**: Impulse → Impact → Dissipation → Adaptation → Equilibrium as a universal response pattern.

- ΔE: A thermodynamic-inspired Adaptive Dissipative Response (ADR) controller minimizing

$$S = \sum_t L_{\text{eff}}(t).$$

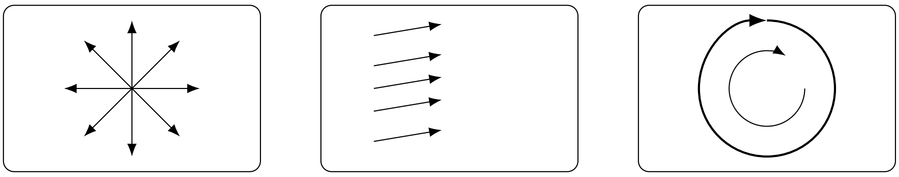
- **Drift and Coherence**: Drift as the loss of structural self-consistency; Coherence as its preservation.

What has been missing is a physical projection of UTAM: a measurable field-level invariant that reveals how directed intention manifests within any adaptive medium. This paper introduces precisely that missing layer: *Operational Spin.*

2 Directed Perturbation Breaks Isotropy

Any adaptive medium - fluid, neural tissue, agent ensemble, cyber-physical network - responds to a directed impulse not by uniform translation, but by *breaking local isotropy.* Small directed inputs generate shear, curvature and rotational micro - fields before any macroscopic motion settles.

This fact is classical in fluid mechanics (vorticity as the antisymmetric part of ∇u), but generalizes far beyond fluids. Operational Spin abstracts this ubiquitous structural phenomenon into a substrate-agnostic form.



(a) Isotropic medium (b) Skewed gradient (c) Vortex / spin structure

Figure 1: Breaking isotropy in an adaptive medium. A small directed perturbation first skews an initially isotropic field (b), then generates a localized vortex-like spin structure (c) rather than purely translational motion.

3 Definition of Operational Spin

Operational Spin, as introduced in this work, is neither identical to nor intended as a model of the quantum-mechanical spin of particles; it is an effective geometric functional at the field/medium level, analogous to vortical and antisymmetric gradient components in classical continuum mechanics. Let $u_t(x)$ be the directed input field and

$$J_t(x) = \frac{\partial u_t}{\partial t}$$

the induced high-frequency change (jerk-like component).

We define the **Operational Spin tensor** as

$$\Omega_t(x) = \text{skew}(\nabla J_t(x)) = \frac{1}{2}\left(\nabla J_t - (\nabla J_t)^\top\right).$$

Operational Spin quantifies the intrinsic asymmetry induced by directed change. It is:

- the analogue of vorticity in fluids,
- the antisymmetric gradient component in elastic or neural fields,
- a geometric signature of isotropy-breaking across adaptive systems.

4 UTAM as Meaning Geometry

UTAM restricts the *space of admissible perturbations*: which changes preserve identity, which violate coherence, and which define meaning-preserving evolution.

Formally,

$$u_t = W_{\mathrm{UTAM}}(S_t, E_t),$$

where W_{UTAM} defines the constraint manifold of permissible impulses.

Operational Spin becomes the physical shadow of UTAM's geometric structure.

5 ΔE as Adaptive Dissipation

ΔE does not choose direction—that is UTAM's role. ΔE:

- absorbs directed impulses,
- suppresses excessive gradients,
- restores equilibrium via ADR,
- minimizes $S = \sum_t L_{\mathrm{eff}}(t)$.

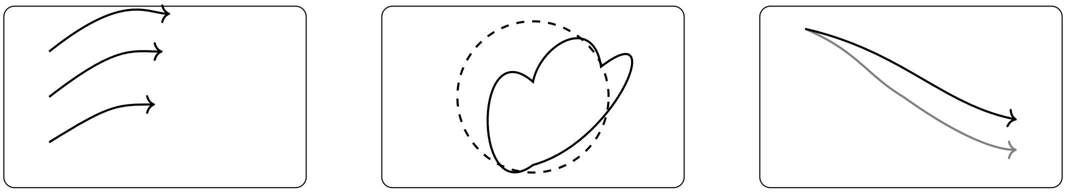
A simplified interaction model:

$$\Omega_{t+1} = (1 - \mu_t)\Omega_t + \mu_t \Phi_t,$$

where:

- $\mu_t \in (0, 1]$ increases with jerk, variance, uncertainty,
- Φ_t is environment- and UTAM-determined structural target.

Spin is damped but never eliminated because UTAM continually injects asymmetry.



(a) Environmental curvature (b) UTAM constraint deformation (c) ΔE adaptive response

Figure 2: Environmental curvature deforms the UTAM trajectory constraints (b), and ΔE converts a perturbed path in this landscape (gray) into a coherence-preserving adaptive trajectory (black).

6 From Spin to Drift

Residual Spin accumulates as structural deformation in the update operator:

$$D_t = \|F_{t+1} - F_t\|,$$

where F_t is the system's implicit internal model or adaptive rule.

Thus:

$$\text{Spin (microscopic asymmetry)} \quad \Longrightarrow \quad \text{Drift (macroscopic deformation).}$$

This explains why Drift can never be zero in any realistic adaptive medium.

7 Spin - Drift Correspondence Theorem

Theorem (Structural form). In any adaptive system with finite dissipation and non-zero UTAM-directed input,

$$D_T \;\geq\; C \int_0^T \|\Omega_t^{\mathrm{res}}\|\, dt,$$

where D_T is cumulative Drift, Ω_t^{res} is residual Spin after ADR damping, and $C > 0$ is a system-dependent constant.

More precisely, CC can be taken to absorb a coarse Lipschitz bound that links residual Spin to changes in the update operator Ft, together with effective dissipation parameters of the medium. *Example.* Consider a linear time-varying system in which the update operator has the form $F_t(x) = A_t x$ with uniformly bounded operator norm $\|A_t\| \leq L$ for all t. Then changes in F_t satisfy

$$\|F_{t+1} - F_t\| = \|A_{t+1} - A_t\| \leq L_{\mathrm{Lip}},$$

where L_{Lip} is a Lipschitz constant for the operator family $\{A_t\}_t$. In such settings the constant C in the Spin–Drift bound can be chosen proportional to L_{Lip}, modulated by the effective dissipation rate of the medium. This illustrates that C is not arbitrary: it reduces to familiar smoothness and stability parameters in classical linear regimes. Interpretation: Residual Spin sets a lower bound on Drift. Perfect coherence is impossible when Spin is non-zero.

8 Toy Simulation Demonstrator

A minimal demonstrator:

$$x_{t+1} = x_t + v_t + \eta_t,$$
$$y_{t+1} = y_t + \mu_t(x_t - y_t),$$

Spin proxy:

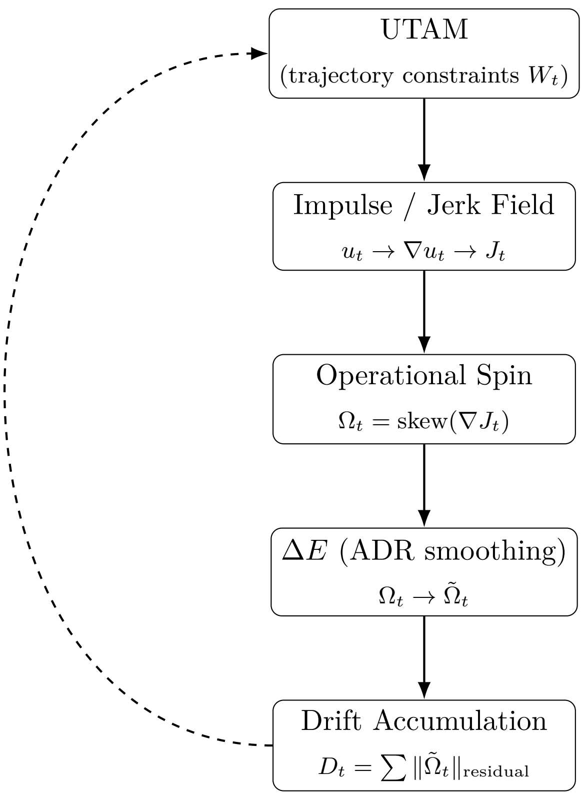
$$\Omega_t = \mathrm{skew}(\nabla(y_{t+1} - y_t)),$$

Drift:

$$D_t = |y_{t+1} - 2y_t + y_{t-1}|.$$

Observations:

- higher turbulence $\Rightarrow$ higher Spin $\Rightarrow$ higher Drift;
- ΔE suppresses Spin but leaves residual;
- Drift is strictly positive: $D_t > 0$.
- In a minimal implementation , one can choose μ_t as an increasing function of local variance or prediction error, while eta_t is sampled from a zero-mean noise process; the experiment logs the trajectory of D_t and its correlation with the Spin proxy Ω_t across different turbulence regimes.



Toy simulation schematic illustrating the operational cycle UTAM $\to$ Spin $\to \Delta E \to$ Drift, including feedback from accumulated drift back into UTAM constraints.

9 Relation to Physics

Operational Spin generalizes:

- classical vorticity in fluid flows,
- antisymmetric gradient components in elasticity,
- torsion-like effects in geometric mechanics,
- Berry curvature analogues in dynamical fields.

Spin is not a particle-like property, but a geometric invariant of directed adaptation.

10 Relation to Neuroscience

In predictive processing:

- F_t = generative model / precision structure,
- ΔS_t = prediction error,
- G = synaptic plasticity rule,
- residual Spin $\leftrightarrow$ unresolved high-frequency error,
- Drift $\leftrightarrow$ synaptic reconfiguration / model updating.

Thus the recursive pair

$$E_{t+1} = F_t(E_t, A_t), \qquad F_{t+1} = G(F_t, \Delta S_t)$$

has a direct physical analogue in Spin–Drift dynamics.

11 Limitations

- Spin assumes differentiable or coarse-grained fields.
- The theorem is structural, not a continuous PDE proof.
- UTAM remains an ontological operator; Spin is its physical projection.
- Toy model is illustrative, not empirical verification.

12 Conclusion

Operational Spin is introduced as the first physical invariant emerging when UTAM-directed intention interacts with an adaptive medium. Spin represents the breaking of isotropy, ΔE shapes its dissipation, and Drift records its accumulated structural impact.
Together with UTAM, ΔE, the Unified Dissipation Law, and Drift-Coherence metrics, this establishes a unified physical–structural framework for adaptive systems and coherence-preserving intelligence.

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medium series

12.0.1 ONTO Series (Will & Consciousness)

ONTO I: Will as an Ontological Operator

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12.0.5 Zenodo — Formal technical publications

Drift as Loss of Coherence: A Coherence-Based Anti-Drift Metric for Adaptive Agents (E Architecture Application) *Maksim Barziankou, 2025*

https://zenodo.org/records/17867125https://zenodo.org/records/17867125

A Unified Law of Adaptive Dissipation in Complex Systems *Maksim Barziankou, 2025*

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