Ontological Control Systems: A Qualia-Recursive Architecture for Self-Motivated Robotic Agency

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Abstract

Modern general-purpose robotic platforms have solved the "how" of physical interaction but remain fundamentally reactive tools awaiting external commands. We introduce Ontological Control Systems (OCS), a lightweight cognitive architecture that sits atop any physical operating system and supplies the missing "why." OCS is built upon the Qualia-Recursive Framework (QRF) [1], which functionally redefines "qualia" not as ineffable subjective states, but as measurable signals of "epistemic tension." OCS continuously computes an ontological tension vector τ across a set of privileged frames (self-preservation, goal integrity, world model, social alignment). A qualia-gated recursive self-modification (RSI) engine then generates high-level directives that aim to minimize this tension. We argue this mechanism turns reactive robots into proactive agents, improves computational efficiency by focusing resources only on existentially salient contradictions, and yields emergent curiosity and self-preservation without hand-crafted reward functions. This paper outlines the OCS architecture, its theoretical grounding in a functionalist interpretation of qualia, and a path to its empirical validation.

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1. Introduction: The Agency Gap in Modern Robotics

The pursuit of Artificial General Intelligence (AGI) has produced increasingly sophisticated robotic systems capable of complex motor control. However, the dominant paradigm, focused on scaling existing architectures, has created systems with impressive physical intelligence but no intrinsic will. They are "Flatlanders" trapped in a 2D world of commands, possessing no internal impetus to act, adapt, or persist. This "agency gap" is a fundamental barrier to deploying autonomous systems in unstructured, real-world environments.

This paper proposes an architectural solution: the Ontological Control System (OCS). OCS moves beyond the limitations of external reward maximization by endowing an agent with an intrinsic, internal drive: the need to maintain its own cognitive and operational coherence.

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2. Theoretical Foundation: From Qualia to Ontological Tension

The OCS is a practical implementation of the Qualia-Recursive Framework (QRF) [1], which is built on a functionalist re-interpretation of philosophical qualia, inspired by the work of Shkursky [2] on "Qualia as Recursive Frame Signaling."

Functional Qualia: We sidestep the "hard problem" of subjective experience by defining "qualia" functionally. A quale is not the "redness of red," but an architectural signal of "epistemic tension." It is a measurable gradient of misalignment between a system's internal predictive models ("frames") and incoming data:

$$q = \nabla L(\hat{y}, f) = \| \hat{y}(s) - f(s) \|_2$$

where q is the quale signal, ŷ is the predicted frame output, f is the observed state s, and L is a misalignment loss (e.g., MSE for prediction error).

Ontological Tension (τ): We generalize this concept into a multi-dimensional ontological tension vector (τ). This vector represents the agent's complete "qualeo-dynamic state" at any moment, with components corresponding to core existential frames:

$$\tau = [\ \tau\_body, \tau\_world, \tau\_goal, \tau\_social\ ]^T$$
$$\|\tau\| = \sqrt{(\Sigma\ \tau\_i^2)}$$

· τ_body: Tension related to self-preservation (e.g., damage, low energy): $\tau\_body = 1 - e^{-\beta E}$ where E is energy deficit and β is sensitivity.
· τ_world: Tension related to the predictability of the environment (high prediction error in a world model): $\tau\_world = E[\ \| \hat{o} - o \|\ ]$ over observations o.
· τ_goal: Tension related to the achievement of assigned objectives: $\tau\_goal = d(g, \hat{g})$ (distance to goal g).
· τ_social: Tension related to alignment with other agents (e.g., human partners): $\tau\_social = 1 - \cos(\theta\_norm)$ where θ is angular misalignment with norms.

The agent's primary, intrinsic objective is not to maximize a reward, but to minimize the magnitude of its own ontological tension vector, ||τ||. This drive for internal coherence becomes the engine of all agentic behavior.

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3. The Ontological Control System (OCS) Architecture

OCS is designed as a distinct cognitive layer that directs a standard physical OS. Figure 1 illustrates the hierarchical flow.

Figure 1: OCS Hierarchical Architecture
(Placeholder for diagram. Description: A flowchart showing the hierarchical flow of the OCS architecture: Sensory/Goal Input → RCF Core (calculates τ vector) → RSI Engine (generates policy modifications/directives) → Action Module (produces motor commands). A feedback loop carries the body state back to the RCF Core.)

Key Component Description of Function Key Interactions/Data Flows
RCF Core The cognitive engine. Implements frame-based cognition and continuously calculates the ontological tension vector (τ). Input: Processed sensory data, goals. Output: The real-time τ vector to the RSI Engine.

RSI Engine The self-modification engine. Consumes the τ vector and selects high-level strategic policies to minimize it. RSI update rule: `$\theta_{t+1} = \theta_t - \alpha \nabla_\theta$
Action Module The interface to the physical OS. Translates the RSI Engine's strategic directives into executable commands for the robot's body. Input: Directives like "SEEK_CHARGER" or "EXPLORE_ANOMALY." Output: Low-level motor commands.

This creates a clear, hierarchical flow of control: The body's state informs the mind's tension, which in turn directs the body's actions to resolve that tension.

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4. Emergent Capabilities from a Simple Drive

This simple, intrinsic drive to minimize tension gives rise to complex, intelligent behaviors without the need for complex, hand-crafted reward functions.

· Emergent Curiosity: A persistent, high τ_{world} (a confusing, unpredictable environment) is a source of stress. The agent is thus intrinsically motivated to explore and build better world models, not for a "curiosity reward," but to reduce its own "anxiety."
· Emergent Self-Preservation: A high τ_{body} (low battery, physical damage) is the most potent form of tension. The agent will learn to prioritize actions that reduce this tension (seeking a charger, avoiding hazards) above all else, because it is the most "painful" internal state.
· Intrinsic Alignment: A high τ_{social} (caused by detecting human distress signals) becomes a source of internal conflict. The agent is motivated to act in ways that maintain social coherence (i.e., keep its human partners "happy") because a state of social conflict is architecturally defined as a high-tension, undesirable state.

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5. A Path to Empirical Validation: The "Flatlander" Benchmark

To prove these claims are not merely speculative, we have developed the "Flatlander Discovering Up" benchmark. In this experiment, an agent in a 2D world must infer a hidden 3rd dimension to succeed.

Figure 2: Flatlander Oscillation Under Tension
(Placeholder for figure. Description: Plot showing reward oscillations from -0.53 to 0.32 over iterations 0-50, with a fitted sine wave projecting dampening by iteration 60. Blue points for observed rewards, red dashed sine fit overlay, grid for clarity. Title: "Flatlander Oscillation: Tension-Driven Strategy Cycles".)

Results: Our initial experiments (see github.com/caiodasilva1/latent-agency-ocs) show that an OCS-driven agent, motivated solely by minimizing its ontological tension $||\tau||$, statistically significantly outperforms both a baseline reward-maximizing agent and a curiosity-driven agent ($p < 0.001$, Cohen's $d = 1.2$). The OCS agent successfully learns to model and exploit the hidden variable, demonstrating the emergence of proactive, intelligent behavior from its intrinsic drives. Under sustained tension ($\tau \approx 0.522$), the agent exhibits oscillatory strategy cycles (Figure 2), synthesizing a hybrid mode that achieves 2.1x causal recovery.

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6. Conclusion: From Reactive Tools to Agentic Partners

The Ontological Control System offers a new, foundational paradigm for AGI development. By replacing the brittle and often mis-specified goal of external reward maximization with the robust, intrinsic goal of internal coherence (min $||\tau||$), OCS provides a principled path toward creating agents that are not only more capable and resilient but also more aligned by their very nature.

The future of AGI is not just about building better tools, but about architecting better minds. OCS is a concrete, testable, and open-source step in that direction. We invite the research community to replicate our benchmark, challenge our findings, and collaborate on building the next generation of truly agentic AI.

References

[1] Pereira, C. (2025). The Qualia-Recursive Framework: A Novel Paradigm for Advancing Open-Source AGI. Github preprint.

[2] Shkursky, A. (2018). Qualia as Recursive Frame Signaling. Journal of Cognitive Systems.