

Synth-Fuse v0.1.0

A Modular Fusion Engine for Hybrid Intelligence
(v0.1.0)

System Architecture & Computational Principles

Core Axiom

Every algorithm is a plugin; every fusion is a pipeline; every pipeline is a JAX transform.

Plugin Contract

Requirements: Pure, JIT-compatible, PyTree-structured.

```
def step(key: jax.Array, state: PyTree, params: PyTree) -> PyTree:  
    ...
```

- **Failure Mode:** Side effects lead to non-deterministic behavior under `vmap`.
- **Control Mechanism:** Static analysis combined with `chex.dataclass` enforcement of immutability.

Fusion Calculus

Higher-order, closed under JIT.

Combinator	Semantics	Failure Mode	Control
<code>fuse_seq</code>	$(f \circ g)(x) = g(f(x))$	Exploding gradient	Gradient-norm clipping inside each primitive
<code>fuse_loop</code>	$f^n(x)$	Infinite recursion	Max-iter hard-cap + cos-distance early-stop
<code>fuse_cond</code>	$1_c(x) \cdot f(x)$	Condition never true	Entropy monitor triggers default branch
<code>fuse_parallel</code>	$f(x) + g(x)$	Tree-shape mismatch	Compile-time PyTree structural check
<code>fuse_meta</code>	$M(f)$	Meta-overfitting	β -divergence threshold on Λ drift

Recipes (Pre-fused, JIT-ready)

Recipe	Core Idea	Failure Mode	Control
FQL-RIME	Flow-guided Lévy escape	Flow collapse ($\sigma \rightarrow 0$)	Minimum-entropy latch on latent space
MRBMO-PPO	Siege-elite buffer	Elite set empty	Fallback to full-population update
ISO-VNS	Chaotic perturb	Chaos diverges ($\lambda > 4$)	Logistic-map clamp at $\lambda_{max} = 3.9$
CA-SVD-UKF	Rank-collapse	$\kappa(A) > \kappa_{max}$	Trigger full-rank refresh

Solver: W-Orion (Weierstrass Field Solver)

Claim: Smooth surrogate over discrete architectures via heat-kernel:

$$U(x) = \sum_i \exp\left(-\frac{\|x - \tau_i\|^2}{4\sigma^2}\right)$$

- **Failure Mode:** σ too large \rightarrow landscape flattens, search stalls.
- **Control:** Adaptive σ schedule driven by $\frac{\Delta U}{\Delta x}$ gradient magnitude.

Algorithm: STCL (Semantic–Thermodynamic Loop)

Free-energy functional:

$$\mathcal{F}(\ell) = \Lambda(\ell) - \beta \cdot C(\ell)$$

- **Failure Mode:** β too high \rightarrow compression destroys concept ($\Lambda < \tau$).
- **Control:** β -divergence detector triggers rollback to last $\Lambda \geq \tau$ checkpoint.

Emergent Behaviours (Observed & Bounded)

Behaviour	Mechanism	Failure Mode	Control
Spontaneous Decentralisation	Consensus dominance	Partition imbalance	Monitor modularity Q ; inject global coupling if $Q < 0.3$

Behaviour	Mechanism	Failure Mode	Control
Crosstalk Avoidance	Zeta pole separation	Over-separation (bandwidth waste)	Adaptive σ_{zeta} via gradient of constraint density
Thermal Self-Balancing	Hamiltonian heat term	Runaway diffusion	Quadratic coeff κ capped by max current density
Topology Preservation	Semantic load $\Lambda(\ell)$ guide	Λ drops below τ	Truncation rejected; fallback to lossless codec
Single-shot Convergence	Weierstrass smoothing	Oversmooth \rightarrow sub-optimum	σ_{min} clamped to preserve constraint gradient

NTEP (Neural Tool-Embedding Protocol)

Pipeline: Tool \rightarrow Vector \rightarrow Impulse \rightarrow Execution

- **Claim:** Continuous operator, no schema, no RPC latency.
- **Failure Mode:** Impulse misfire ($\cos\text{-sim} < \theta$).
- **Control:** Phase-locking quorum ≥ 3 tools; discard outlier impulses.

NS²UO Field Equation

$$\dot{S} = -\nabla H(S) + \xi(t)$$

Where $\xi(t)$ is drawn from a Λ -weighted Ornstein-Uhlenbeck process.

- **Failure Mode:** ξ magnitude too large \rightarrow instability.
- **Control:** Spectral norm of Jacobian ≤ 1.02 for > 5 steps, else reject update.

Security & Safety Posture

- **Sandboxing:** All inputs treated as hostile; sandboxed in JAX-compiled environment.
- **Meta-Updates:** Must pass differentiable QP trust-region check.
- **Persistence:** Checkpoint every 15 minutes (async); rollback cost < 30 s.
- **Verification:** Formal verification hooks exported for external provers.

