Attack Surface, Threat Models, and Falsifiability Boundaries

Defensive Formalization of Fragmented Evolution Theory

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Abstract

This paper systematically enumerates the major attack vectors against Fragmented Evolution Theory and formalizes them as a set of explicit threat models. By analyzing whether each attack actually touches the core decision structure of the theory, we rigorously distinguish between genuine counterexamples, legitimate boundary cases, and invalid attacks. This allows us to clearly specify the falsifiability conditions, applicability scope, and structurally non-attackable regions of the theory.

1 Methodological Statement

Fragmented Evolution Theory is a **decision-structure theory**, rather than a dynamical law, generative model, or optimization framework. Accordingly, the legitimacy of an attack does not depend on whether the constructed system is "clever" or "complex", but solely on whether it violates at least one of the following core structures:

1. Difference decidability;
2. Scale-induced difference structure;
3. Logical incompatibility between dead loops and evolution;
4. Structural exclusion of terminal absorption by fragmentation.

Any attack that does not compromise at least one of these structures does not constitute a counterexample.

2 Threat Model Classification

All known attacks can be systematically classified into the following six categories.

2.1 TM-1: Pathological Construction of Difference Functions

Description Artificially defining difference functions that have no observational, scale-based, or structural origin, such as:

- fully random difference lookup tables;

- time-dependent arbitrary collapse unrelated to system states;
- difference assignments that do not correspond to any scale operator.

Assessment Once the scale-induced difference assumption is enforced, such constructions are treated as *illegal inputs* and therefore do not constitute counterexamples.

2.2 TM-2: Non-Transitive or Non-Metric Differences

Description Difference functions that violate transitivity or the triangle inequality.

Assessment The theory never assumes differences to be metrics or pseudometrics. All core definitions depend only on whether adjacent-state differences are zero. Therefore, this attack is invalid.

2.3 TM-3: Periodic Systems $\neq$ Dead Loops

Description Attempting to misclassify limit cycles, periodic orbits, or reversible dynamics as dead loops.

Assessment A dead loop is not defined as "returning to a previous state", but as "all future differences being undecidable at the given scale". Periodic but distinguishable systems do not constitute dead loops.

2.4 TM-4: Scale Limit Attacks

Description Using extremely coarse scales (total collapse) or hypothetical infinitely fine scales to force evolution disappearance or difference divergence.

Assessment

- Total collapse scales correctly predict undecidability of evolution;
- Infinitely fine scales are not assumed by the theory;
- Under scale monotonicity, this does not form a counterexample.

2.5 TM-5: Continuous and Stochastic Systems

Description Employing chaotic systems, random walks, Brownian motion, or other continuous or stochastic models.

Assessment Under measurability assumptions:

- chaotic systems provide instances of persistent evolution;
- convergent stochastic processes yield dead-loop examples;
- random walks serve as canonical fragmented systems.

All outcomes are consistent with theoretical predictions.

2.6 TM-6: Self-Reference and Meta-Theoretical Attacks

Description Attempting to construct paradoxes where a system's evolution depends on its own evolutionary□□.

Assessment Evolution is an external decision predicate and does not participate in the system's internal dynamics. No self-referential loop exists.

3 Falsifiability Statement

Fragmented Evolution Theory is **falsifiable**. Its explicit falsifiability condition is:

There exists a system S and a scale σ such that:

- S satisfies the definition of fragmentation under σ;
- S enters a dead loop under the same σ.

No such counterexample has been found among all currently examined finite, continuous, and stochastic models.

4 Non-Attackable Boundaries

The following do not constitute valid refutations:

1. changing linguistic descriptions without altering decision structure;
2. constructing arbitrary difference functions without scale origin;
3. conflating periodicity or reversibility with dead loops;
4. introducing infinite-resolution limits not declared by the theory.

5 Conclusion

Through systematic threat modeling, this paper clarifies the attack surface, falsifiability conditions, and structural defense boundaries of Fragmented Evolution Theory. Within its declared scope, the theory remains formally self-consistent and admits no known counterexamples.