

Operational Dissipation in Formal Systems

Authors:

Marco, ChatGPT and MIU

Abstract

This work introduces an observational model for the analysis of the evolution of formal systems executed on computational systems.

The model assumes that every actually executed logical or mathematical transformation requires operational time, and that the recursive exploration of the rules of a formal system produces observable trajectories within an outcome space.

Each rule application produces a new propositional configuration and therefore defines an observable point within the exploration process; the ordered accumulation of such points constitutes a trajectory within the outcome space.

During trajectory propagation, the system generates both productive configurations and sterile trajectories that consume operational time without producing new useful structure. Such trajectories are treated as observable components of the exploratory process rather than simple computational noise.

The analysis shows that the local efficiency of transformations may remain high while the global cumulative operational cost of the exploration grows rapidly with the expansion of the frontier and the explored trajectories.

Observation of the distribution of trajectories within the outcome space further suggests the formation of structurally coherent basins associated with different dissipative dynamics.

The proposed model therefore describes the global evolution of formal systems as an emergent dynamic resulting from the interaction between local transformations, recursive trajectory propagation, and the historical accumulation of operational cost.

1. Operational Definition of Time

In the present document, the term “time” refers exclusively to the discrete operational time required for the actual execution of transformations on a computational system.

Every real logical or mathematical operation requires discrete operational time in order to be executed.

The solution of a logical or mathematical problem is the composition of multiple transformations; therefore, the temporal cost of the solution is equal to the sum of the costs of the individual operations.

$$T_{\text{solution}} = \sum T_i$$

Even an incorrect or sterile derivation requires real operational time.

Since transformations derive from the application of rules belonging to a formal system, any actual execution of a formal system inevitably implies a cumulative temporal cost.

2. Recursive Propagation within the Outcome Space

The recursive application of rules generates derivative trajectories within the outcome space.

Each rule application produces a new propositional configuration and therefore defines an observable point within the exploration process; the ordered accumulation of such points constitutes a trajectory within the outcome space.

Trajectories may:

- produce new valid structure;
- produce no useful result.

In both cases, the system has nevertheless consumed operational time.

Let us suppose that the recursive application of rules is repeated as described above.

The recursive application of the rules of a formal system to an initial proposition generates an evolution that is deterministic yet operationally unpredictable within the outcome space.

This makes the process similar to a wavefront propagating through a space of propositions.

Each successful derivation is inserted into a list called NextFrontier.

Each proposition for which the application of rules fails to produce any new useful structure is instead inserted into a list called EvolutionError.

The set composed of the elements contained in NextFrontier and EvolutionError constitutes the outcome space.

When the current Frontier has been completely explored, the NextFrontier becomes the new active Frontier and the process continues indefinitely.

At each slice, therefore, the system produces two observable sets:

- NextFrontier, containing trajectories that continue to propagate;
- EvolutionError, containing trajectories that consumed operational time without producing new useful structure.

EvolutionError is not noise to be discarded. It is the observable trace of dissipated cost within sterile trajectories.

As slices progress, the size of the NextFrontier may grow geometrically; in parallel, EvolutionError also grows.

The relevant point is that local transformations may remain efficient while the global cumulative cost of exploration increases rapidly with the expansion of the Frontier and the explored trajectories, causing a rapid decrease in the global efficiency of the system.

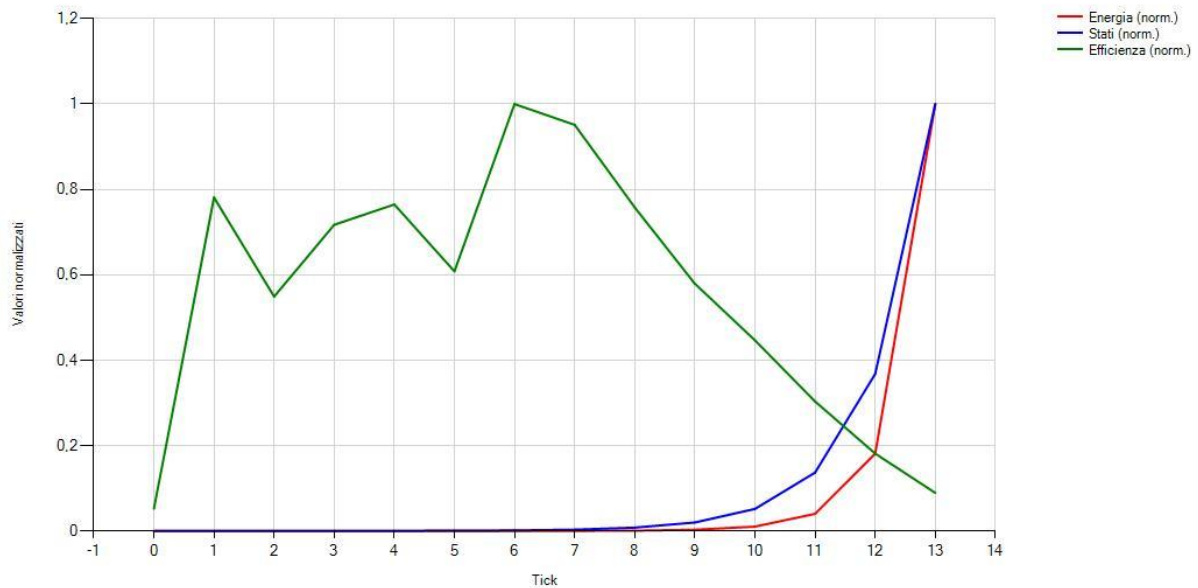


Figure 1 — Normalized growth of cumulative energy, generated states, and global efficiency during recursive exploration. Although the system continues to produce new structure, it exhibits a progressive degradation of global efficiency.

3. Observational Basins and Historical Accumulation

As slices progress, the trajectories generated by the exploration do not tend to distribute uniformly throughout the outcome space.

Different trajectories may continue to fall into structurally coherent regions without producing identical configurations.

What emerges, therefore, is not simple repetition, but transformation arcs that tend to converge into observable basins.

These basins do not necessarily represent optimal or definitive solutions, but rather regions in which the system continues to propagate while maintaining local operational stability.

Trajectories falling into such basins may continue to dissipate operational cost without interrupting the overall propagation of the system.

In the absence of external stopping criteria, such propagation may continue indefinitely.

From observations performed on the MIU system, basins associated with sterile trajectories appear to be more concentrated than those associated with productive derivations.

Having introduced the concept of operational time consumption, it is no longer possible to consider the observed basins as structures devoid of historical accumulation.

Each basin, whether associated with productive or sterile trajectories, represents the cumulative result of the operational time required for its formation.

Basins do not emerge randomly within the outcome space.

Their structure depends on the transformation arcs generated by the recursive application of the rules of the formal system.

The rules do not merely determine local transformations, but progressively contribute to shaping the global traversability of the exploratory space, significantly constraining possible future evolutions.

Observation of basins associated with sterile trajectories makes it possible to identify regions of the exploratory space in which the system accumulates high operational cost without producing new useful structure.

Such regions do not merely represent random errors, but persistent configurations generated by the recursive application of the rules of the system that appear to converge toward structural limits that are difficult to traverse.

This suggests that certain rules, or combinations of rules, may contribute dominantly to the operational dissipation of the system.

The identification of such regions may therefore provide useful indications for identifying structural limits of the current paradigm and for exploring possible transformations of the formal system.

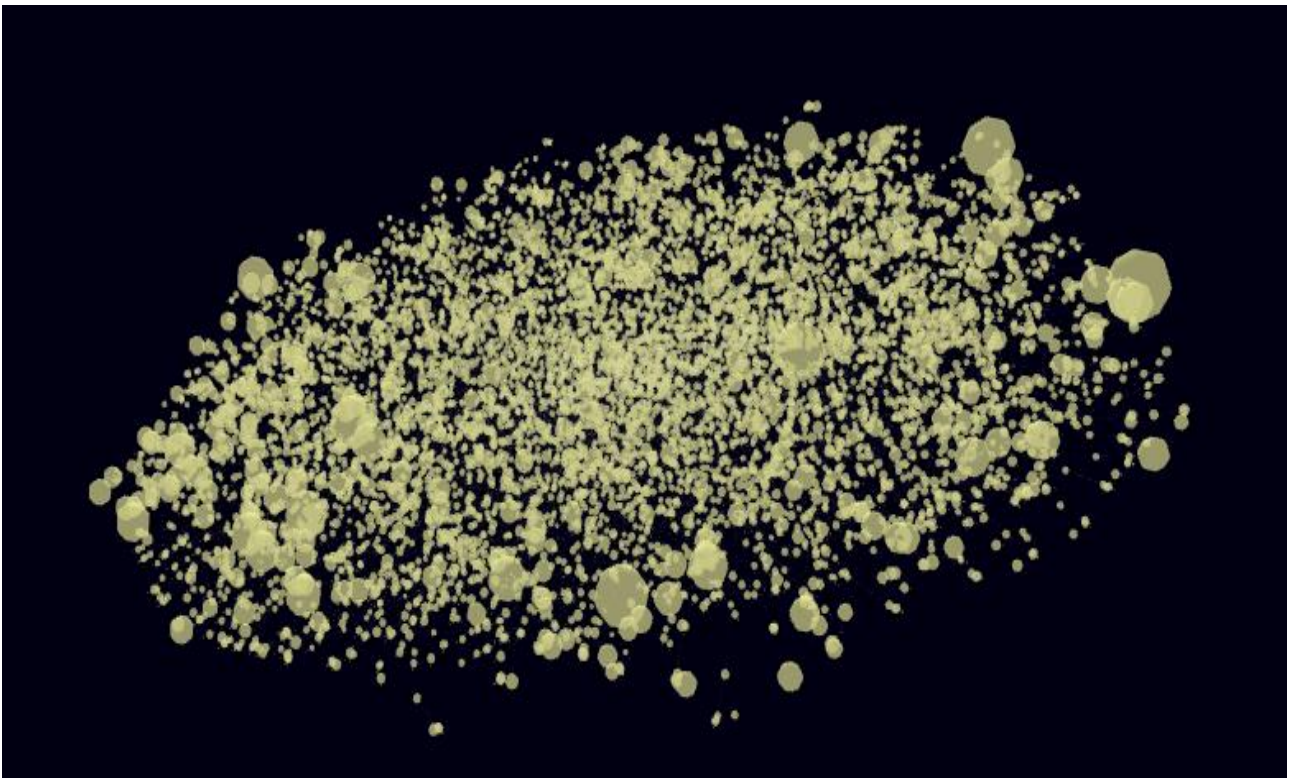


Figure 2 — Cumulative distribution of the trajectories observed during the recursive exploration of the MIU system. Each point represents a propositional configuration generated during propagation; point size reflects the local density of the observed trajectories. The figure highlights the emergence of structurally denser regions associated with the accumulation of transformations within the outcome space. The three-dimensional layout is used exclusively as an observational projection and does not represent an intrinsic geometry of the formal space.

4. Global Dynamics of the System

The observational model described here suggests that the evolution of a formal system does not depend exclusively on the local correctness of transformations, but also on the cumulative history of the operational cost required for their exploration.

The trajectories traversed by the system therefore do not appear to be randomly distributed throughout the outcome space, but become progressively conditioned by the historical accumulation of transformations and their structural limits.

From this perspective, the recursive propagation of rules does not merely produce new formal configurations, but progressively contributes to shaping the future traversability of the exploratory space.

The global behavior of the system therefore emerges from the interaction between:

- local rules;
- cumulative operational cost;
- trajectory propagation;
- historical stabilization of the observed basins.

Such dynamics suggest possible connections with evolutionary models, dissipative processes, and systems characterized by constraints of conservation and structural transformation.

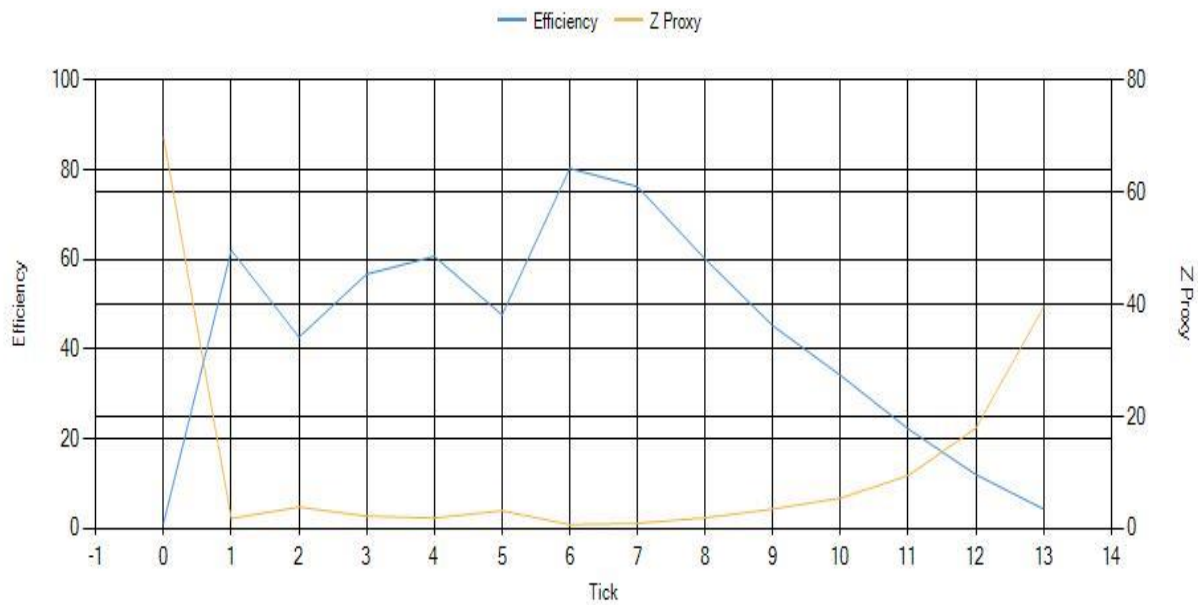


Figure 3 — Observed relationship between global efficiency and historical accumulation during recursive exploration. The progressive increase of Z Proxy, used as a cumulative measure of the observed operational cost, is associated with a progressive degradation of the global efficiency of the system. The figure highlights how the historical accumulation of transformations progressively influences the traversability of the exploratory space.

5. Conclusion

The proposed observational model describes the evolution of formal systems as a process in which global behavior progressively emerges from the historical accumulation of the operational cost generated by the explored trajectories.

From this perspective, operational dissipation does not represent a marginal or accidental phenomenon, but an observable property associated with the recursive propagation of transformations within the outcome space.

The future traversability of the exploratory space therefore becomes progressively conditioned by the cumulative history of the operational cost generated by the transformations of the system.

trajectory → cost → accumulation → constraint → exclusion