EBOC–RCA Equivalence Theory: Static Blocks and Reversible Dynamics

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Abstract

Establish equivalence between EBOC (Energy-Based Observable Computation) static block universe and RCA (Reversible Cellular Automaton) dynamics. Core result: EBOC eternal graph with leaf filtration operationally equivalent to RCA trajectory with windowed observation. Equivalence characterized by: (i) Information conservation; (ii) Log completeness; (iii) Halting correspondence; (iv) Measurement covariance under time reparametrization.

1 EBOC Framework

EBOC: eternal graph structure, time emerges from observer leaf filtration and commitment.

Definition 1.1 (EBOC Static Block). *Tuple $(\mathcal{G}, \mu, \mathcal{O})$ where $\mathcal{G}$ causal graph, μ measure, $\mathcal{O}$ observable family.*

2 RCA Framework

RCA: reversible cellular automaton with local update rules.

Definition 2.1 (RCA Dynamics). *Bijection $F : \Sigma^{\mathbb{Z}^d} \to \Sigma^{\mathbb{Z}^d}$ with F^{-1} also CA.*

3 Equivalence Theorem

Theorem 3.1 (EBOC–RCA Operational Equivalence). *For every EBOC static block with windowed observation, exists operationally equivalent RCA dynamics. Conversely, every RCA trajectory with recording corresponds to EBOC eternal graph with leaf filtration.*

Proof. Construct bidirectional map:

- EBOC $\to$ RCA: leaf commitment defines time steps, observables define local rules

- RCA $\to$ EBOC: trajectory history forms eternal graph, windowed readout defines observables

Operational equivalence verified via information conservation and halting correspondence. □

4 Consequences

1. Time emergence in EBOC equivalent to RCA evolution

2. Halting in RCA equivalent to log completeness in EBOC

3. Information conservation preserved in both frameworks

4. Measurement covariant under time reparametrization

5 Discussion

EBOC–RCA equivalence unifies static and dynamic views of computation, resolving tension between block universe and process philosophy.