COPPALINI ARCHITECTURE

Horizon Silence

Viability boundary and zero residual

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Abstract

A horizon is the boundary of a physically viable region. Silence is the zero residual relation at a completed address. A present occurrence has a carrier, a constraint, a read, a calibration, and a measured difference. Time orders occurrences into history; future differences remain individually addressable. The eight-address field is partitioned into seven matchings. Its triangular residual condition reconstructs an edge potential exactly. The resulting equations type survival, boundary, observation, completion, and continuation inside one physical field.

1. Viability, horizon, and silence

Let X be the state carrier of a living physical system and let $\mathcal{V} \subset X$ be its viable region. Its survival condition is

$$\theta(x) = 1 \iff x \in \mathcal{V}, \tag{HS.0}$$

and its horizon is the boundary

$$\mathcal{H}_{\text{hor}} = \partial\mathcal{V}. \tag{HS.1}$$

For a time-dependent state, regulation carries the system by

$$\dot{x} = f(x, u, d), \qquad \theta(x(t)) = 1. \tag{HS.2}$$

The control u and disturbance d change the trajectory. The viable set and its boundary determine which changes remain survivable.

2. Energy and regulation

For a thermodynamic state with internal energy U_{th}, entropy S_{th}, volume V, pressure p, chemical potentials μ_i, particle counts N_i, and generalized coordinate–force pairs (X_a, Y_a),

$$dU_{\text{th}} = T_{\text{th}}\, dS_{\text{th}} - p\, dV + \sum_i \mu_i\, dN_i + \sum_a Y_a\, dX_a. \tag{HS.3}$$

For an irreversible process,

$$dS_{\text{th}} = d_e S_{\text{th}} + d_i S_{\text{th}}, \qquad d_i S_{\text{th}} \geq 0. \tag{HS.4}$$

Energy, matter, work, and entropy therefore enter the viable trajectory as measurable state relations. Regulation changes their flows while preserving the survival condition in HS.0.

3. Constraint and type

Fix a jurisdiction J and its active context

$$\Gamma_J = (\text{Condition}, \text{Constraint}, \text{SourceAuthority}, \text{Namespace}). \tag{HS.5}$$

The namespace reserves

$$\varnothing = \mathsf{UNTYPEABLE}. \tag{HS.6}$$

A candidate belongs to the typed domain only when it has a type in the active context:

$$D_{\Gamma_J} = \{\sigma : \exists \tau \ (\Gamma_J \vdash \sigma : \tau)\}. \tag{HS.7}$$

The gate acts after type:

$$\text{Gate}_{\Gamma_J} : D_{\Gamma_J} \to \{\mathsf{can}, \mathbf{2}\}. \tag{HS.8}$$

Here **2** is the declared fold/refusal value. Set-theoretic emptiness, when needed, is written $\emptyset_{\text{set}}$.

4. Occurrence, history, and future difference

A physical field has an interface

$$\begin{aligned}\mathfrak{I}_J := (J, \Gamma_J, \text{Src}_J; A_J, X_J, Y_J, T_J, \Sigma_J, \text{Con}_J,\\ \rho_J, O_J, K_J, B_J, \theta_J), \qquad \rho_J : X_J \to Y_J, \quad O_J : X_J \to \mathcal{O}_J, \quad \theta_J : X_J \to \{0,1\}.\end{aligned} \tag{HS.9}$$

Its occurrence type is

$$\begin{aligned}\mathsf{Occ}_J := \{(\mathfrak{I}_J; \Theta, x, \rho_J(x), \kappa, \boldsymbol{\varepsilon}, \theta_J(x)) :\\ \Theta \in A_J, \ x \in X_J, \ \kappa \in K_J, \ \boldsymbol{\varepsilon} \in \mathbb{R}^3_{\geq 0}\}.\end{aligned} \tag{HS.10}$$

An indexed occurrence $\mathsf{Occ}_{J,n}$ is an element of Occ_J.

The lower-case $\theta_J(x)$ is the survival condition; the upper-case Θ is the occurrence timing/address. The calibration κ and residual $\boldsymbol{\varepsilon}$ fix the resolution of the read. Put

$$\mathscr{O} := \bigsqcup_J \mathsf{Occ}_J, \qquad \mathscr{L}_n := \mathscr{O}^n, \qquad \mathcal{L}_n = (\mathsf{Occ}_1, \ldots, \mathsf{Occ}_n) \in \mathscr{L}_n. \tag{HS.11}$$

Let $\mathcal{P}_n$ be a candidate subset of $\mathscr{O}$, and put

$$\mathcal{P}_n^{\text{typed}} := \{p \in \mathcal{P}_n : \text{Typed}_{\Gamma_{J(p)}}(p)\}, \qquad \mathbf{F}_n := \{\text{future}(p) : p \in \mathcal{P}_n^{\text{typed}}\}. \tag{HS.12}$$

The tagged elements of $\mathbf{F}_n$ remain distinct by their occurrence addresses. With $\text{Past}(\mathcal{L}_n) := \{\mathsf{Occ}_1, \ldots, \mathsf{Occ}_n\}$, the ordered carrier is

$$\widehat{K}_n = \text{Past}(\mathcal{L}_n) \sqcup \mathbf{F}_n. \tag{HS.13}$$

Definition 1 (Occurrence)**.** The next occurrence enters history through the partial map

$$\text{Admit}_n : \mathbf{F}_n \rightharpoonup \mathscr{L}_{n+1}, \tag{HS.14}$$

For $p \in \mathscr{O}$, let $x(p)$ denote its state coordinate. with

$$\text{Admit}_n(\text{future}(p)) = \text{snoc}(\mathcal{L}_n, p) \iff \text{Gate}_{\Gamma_{J(p)}}(p) = \mathsf{can} \wedge \mathsf{Complete}(p) \wedge \theta_{J(p)}(x(p)) = 1. \tag{HS.15}$$

The map carries one completed occurrence into history and preserves the order of every prior occurrence.

5. Completion and silence

For $p \in \mathscr{O}$, define its residual vector by

$$\boldsymbol{\varepsilon}(p) := \big(\varepsilon_{\mathrm{drop}}(p), \varepsilon_{\mathrm{add}}(p), \varepsilon_{\mathrm{strength}}(p)\big) \in \mathbb{R}^3_{\geq 0}. \tag{HS.16}$$

For $p = \mathsf{Occ}_{J,n}$, the residual slot in HS.10 is $\boldsymbol{\varepsilon}_n = \boldsymbol{\varepsilon}(p)$. For an occurrence p, the completion condition is

$$\mathsf{Complete}(p) \iff \mathrm{Typed}_{\Gamma_{J(p)}}(p) \wedge \boldsymbol{\varepsilon}(p) = 0. \tag{HS.17}$$

If Out_n is the physical output set, the local stopping condition is

$$\mathsf{Enough}_n \iff \mathsf{Complete}(\mathsf{Occ}_n) \wedge \mathrm{Out}_n = \{y_n\}. \tag{HS.18}$$

Silence is the local fit reading

$$\mathsf{Silence}_{\mathrm{fit}}(p) = 1 \iff \mathsf{Complete}(p) \qquad (p \in \mathcal{P}_n^{\mathrm{typed}}). \tag{HS.19}$$

The condition states that the required relation is complete at its present address and reader resolution.

6. Eight-address field

Let

$$\mathcal{A}_8 := \{\infty\} \sqcup \mathbb{Z}_7, \qquad (\infty, 0, 1, 2, 3, 4, 5, 6) = (\mathsf{Gr}, \mathsf{Li}, \mathsf{Me}, \mathsf{Ti}, \mathsf{Hz}, \mathsf{Si}, \mathsf{Sc}, \mathsf{Mo}).$$

For $r \in \mathbb{Z}_7$, set

$$\mathsf{M}_r = \{\{\infty, r\}\} \cup \{\{r + j, r - j\} : j = 1, 2, 3\}.$$

Then $E(K_8) = \bigsqcup_{r \in \mathbb{Z}_7} \mathsf{M}_r$, and the canonical matching is

$$\mathsf{M}_0 = \{\mathsf{Gravity}-\mathsf{Light},\ \mathsf{Memory}-\mathsf{Motion},\ \mathsf{Time}-\mathsf{Scope},\ \mathsf{Horizon}-\mathsf{Silence}\}.$$

The canonical matching gives each office one paired relation. The complete K_8 field carries all 28 unordered pair-relations across seven disjoint matchings.

M_0	Gr–Li, Me–Mo, Ti–Sc, Hz–Si
M_1	Gr–Me, Ti–Li, Hz–Mo, Si–Sc
M_2	Gr–Ti, Hz–Me, Si–Li, Sc–Mo
M_3	Gr–Hz, Si–Ti, Sc–Me, Mo–Li
M_4	Gr–Si, Sc–Hz, Mo–Ti, Li–Me
M_5	Gr–Sc, Mo–Si, Li–Hz, Me–Ti
M_6	Gr–Mo, Li–Sc, Me–Si, Ti–Hz

Let $d_{ij} \in \mathbb{R}$ be antisymmetric edge values, $d_{ji} = -d_{ij}$, and define the triangular residual by

$$h_{ijk} := d_{ij} + d_{jk} + d_{ki}. \tag{HS.20}$$

Each layer is a four-edge restriction of the complete edge field:

$$d^{(r)} := d|_{\mathsf{M}_r}, \qquad d = (d^{(0)}, \ldots, d^{(6)}). \tag{HS.21}$$

Theorem 2 (Potential reconstruction)**.** *For an antisymmetric edge field on K_8,*

$$\big(\forall\, i, j, k \in \mathcal{A}_8 \text{ distinct} \quad h_{ijk} = 0\big) \iff \big(\forall\, 0 \leq i < j \leq 6 \quad h_{\infty ij} = 0\big) \iff \big(\exists s : \mathcal{A}_8 \to \mathbb{R} \quad d_{ij} = s_j - s_i\big). \tag{HS.22}$$

The potential s is unique up to addition of one constant.

Proof. The first condition contains the 21 triangles through ∞. Conversely, set $s_\infty = 0$ and $s_i = d_{\infty i}$. Then

$$h_{\infty ij} = d_{\infty i} + d_{ij} - d_{\infty j} = 0$$

gives $d_{ij} = s_j - s_i$, and this potential telescopes around every triangle. Adding a constant to all s_i leaves every difference unchanged; equality of all edge differences leaves only that freedom. □

Writing $\mathbf{h}(d) = (h_{ijk})_{\{i,j,k\}\in\binom{\mathcal{A}_8}{3}}$, the 21 residuals through ∞ are independent and exhaust the rank:

$$\operatorname{rank}\mathbf{h} = 21, \qquad \dim\ker\mathbf{h} = 28 - 21 = 7. \tag{HS.23}$$

Each residual $h_{\infty ij}$ contains its own finite edge coordinate d_{ij}, which gives independence. The seven-dimensional kernel is the potential space modulo its additive constant.

7. Cyclic matching transport

The cyclic transport fixes the gravity address and advances every finite address by one:

$$\tau(\infty) = \infty, \qquad \tau(k) = k + 1 \pmod 7. \tag{HS.24}$$

It acts on an edge by its endpoints. For every $r \in \mathbb{Z}_7$,

$$\tau(\mathsf{M}_r) = \mathsf{M}_{r+1}, \qquad \tau^7 = I. \tag{HS.25}$$

Proof. The distinguished edge obeys

$$\tau\{\infty, r\} = \{\infty, r+1\}.$$

For $j = 1, 2, 3$,

$$\tau\{r+j, r-j\} = \{r+1+j, r+1-j\}.$$

Thus every edge of M_r maps to the corresponding edge of M_{r+1}. Seven applications return every finite address to itself. □

8. Cyclic carrier

Let

$$Q = \begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}, \qquad \Omega = \begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}, \qquad C = -\Omega,$$

$$G = [Q, \Omega] = \begin{pmatrix} -2 & 1 \\ 1 & 2 \end{pmatrix}, \qquad H = \frac{G}{\sqrt{5}}, \qquad S = \frac{2Q - I}{\sqrt{5}}.$$

The common exact identities are

$$Q^2 = Q + I, \qquad C^2 = -I, \qquad G^2 = 5I, \qquad H^2 = S^2 = I,$$

$$H = CS, \qquad SG = \sqrt{5}\Omega = -GS, \qquad L_s := e^{sS}, \qquad L_s^{\mathsf{T}} G L_s = G, \qquad HL_sH = L_{-s}.$$

The signed root actions form the order-eight dihedral group of a square:

$$\langle S, H\rangle = \{\pm I, \pm S, \pm H, \pm C\}. \tag{HS.26}$$

The address carrier $\mathcal{A}_8$ and the root action carrier are separately typed. Their common cyclic coordinate is the group element τ^r that advances the matching layer M_r.

Let $E = \mathbb{R}^2$ carry the Euclidean form I_2 and define

$$\widetilde{V} = \mathbb{R}^2 \oplus E, \qquad \widetilde{G} = G \oplus I_2, \qquad \widetilde{C} = C \oplus C, \qquad \operatorname{sig}(\widetilde{G}) = (3, 1). \tag{HS.27}$$

With $D = \mathrm{diag}(1, -1)$, define the extended mirror and cyclic action by

$$\widetilde{H} = H \oplus D, \qquad R_r = e^{(2\pi r/7)C}, \qquad \varrho(\tau^r) = I_2 \oplus R_r \quad (r \in \mathbb{Z}_7). \tag{HS.28}$$

They satisfy

$$\begin{gathered} \varrho(\tau^r)\varrho(\tau^s) = \varrho(\tau^{r+s}), \qquad \varrho(\tau)^7 = I_4, \qquad \varrho(\tau)^{\mathsf{T}}\widetilde{G}\varrho(\tau) = \widetilde{G}, \\ \varrho(\tau)^{-1}\widetilde{C}\varrho(\tau) = \widetilde{C}, \qquad \widetilde{H}\varrho(\tau)\widetilde{H} = \varrho(\tau)^{-1}. \end{gathered} \tag{HS.29}$$

Thus $\mathsf{M}_r \mapsto \varrho(\tau^r)$ carries the common sevenfold layer coordinate between the finite ledger and the Lorentzian operator carrier.