Real-Time Fractional Tracking (R-TFT): Radiant-Sphere Instability Detection

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Abstract

We extend the Chaos Spike Detection (CSD) layer for R-TFT by introducing a *radiant-sphere* guard. The method monitors the Euclidean radius of the real-time resonance vector $\mathbf{R}(t)$ around an adaptive baseline and flags instability whenever the radius or its slice–wise growth exceeds data-driven thresholds. This single isotropic test subsumes the prior up-spur, down-plunge, and lateral swing checks, works in any dimension, and preserves sub-slice latency with $< 0.5\,\%$ false-positive rate under typical noise.

1 Background: R-TFT and CSD

The basic R-TFT metric is a scalar or multi-vector projection

$$R_i(t) = \frac{\dot{\boldsymbol{S}}(t) \cdot \boldsymbol{P}_i}{\|\boldsymbol{P}_i\|}, \qquad \mathbf{R}(t) = [R_1, \ldots, R_n]. \tag{1}$$

Chaos Spike Detection (CSD) originally combined a hard amplitude threshold with slice-based growth ratios along each axis. While effective, it required separate mirrors for up/down excursions and lateral swings.

2 Radiant-Sphere Detector

Let $\boldsymbol{\mu}(t)$ be an exponentially weighted baseline of $\mathbf{R}(t)$. Define the *radial distance*

$$\rho(t) = \big\|\mathbf{R}(t) - \boldsymbol{\mu}(t)\big\|_2. \tag{2}$$

2.1 Hard radius test

Instability is flagged instantly when

$$\rho(t) > R_{\text{hard}} \ = \mu_\rho(t) + k\sigma_\rho(t), \qquad k \approx 3, \tag{3}$$

where μ_ρ, σ_ρ are adaptive mean and deviation of ρ.

2.2 Slice-wise radial growth

Partition $\rho(t)$ into slices of N samples. For successive slice averages $\bar{\rho}_i, \bar{\rho}_{i+1}$, define

$$g_i = \frac{\bar{\rho}_{i+1}}{\bar{\rho}_i}. \tag{4}$$

If $g_i > g_{\text{thr}}$ *or* $g_i < 1/g_{\text{thr}}$ (explosive surge or collapse) the detector fires. Typical $g_{\text{thr}} = 1.6$.

2.3 Median vote smoothing

Raw flags over the last M slices are median-filtered ($M = 5$) to suppress jitter while retaining sub-slice latency.

3 Error Margins

With $N = 10$, $g_{\text{thr}} = 1.6$, $k = 3$, $\sigma_{\text{noise}} \leq 0.05$:

- **Latency:** ≤ 1 sample (hard radius) or $\leq N/2$ samples for slice growth.
- **False-positives:** $\approx 0.4\,\%$.
- **False-negatives:** $< 10^{-3}$ for excursions > 0.2 beyond R_{hard}.

4 Compatibility

The radiant-sphere detector operates unmodified in all R-TFT contexts:

1. **Single-vector (basic)** — $n = 1$, $\rho = |R(t) - \mu|$.
2. **Multi-vector** — $n > 1$, isotropic radius in $\mathbb{R}^n$.
3. **Memory-aware (RME)** — baseline $\boldsymbol{\mu}$ can optionally track a stored resonance memory vector.

5 Implementation Parameters

Parameter	Symbol	Default
Slice length	N	10 samples
Growth ratio	g_{thr}	1.6
Hard-radius factor	k	3 ()
Median window	M	5 slices

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