SKA Noise Sensitivity – Harmonic Oscillator Benchmark

Overview

This folder presents a systematic study of **SKA (Structured Knowledge Accumulation) real-time learning applied to a simple harmonic oscillator** with increasing levels of Gaussian noise. The results demonstrate SKA's extraordinary sensitivity to noise and its value as a universal calibrator for information geometry and regime detection.

1. Noise-Free Oscillator (Baseline Reference)

- **All SKA variables are smooth, periodic, and symmetric.**
- **Entropy, knowledge, and decision** precisely follow the physical trajectory.
- **Lagrangian phase portrait**: a perfect, closed, symmetric curve.
- **Interpretation:** This is the gold standard for maximal order and predictability—**the universal "information geometry calibrator."**

2. Noise Amplitude: 0.0001 (Threshold of Sensitivity)

- **SKA variables remain nearly identical to the noise-free case**, with only minute deviations.
- The information geometry is still highly regular and ordered.
- **Interpretation:** SKA treats signals with $noise \leq 0.0001$ as effectively deterministic—**this is the lower sensitivity bound**.

3. Noise Amplitude: 0.001 (Onset of Disorder)

- **Mild irregularities appear in entropy and knowledge;** occasional bursts and "incipient crises."
- The Lagrangian phase portrait develops fine structure but is not yet fully chaotic.
- **Interpretation:** This is the *intermediate regime*: SKA begins to detect unpredictability, mapping the earliest loss of information order.

4. Noise Amplitude: 0.01 (Full Breakdown)

- **SKA variables become highly irregular and bursty;** entropy spikes, decision locks, and large fluctuations dominate.
- **Lagrangian phase portrait**: closed symmetry is lost; a complex, scattered "cloud" forms.
- **Interpretation: A 100x increase in noise amplitude transforms the system from order to chaos**—demonstrating SKA's ultra-high sensitivity and its utility for detecting phase transitions.

Figure 1: Without Noise

Figure 2: Noise 0.0001

Figure 3: Noise 0.001

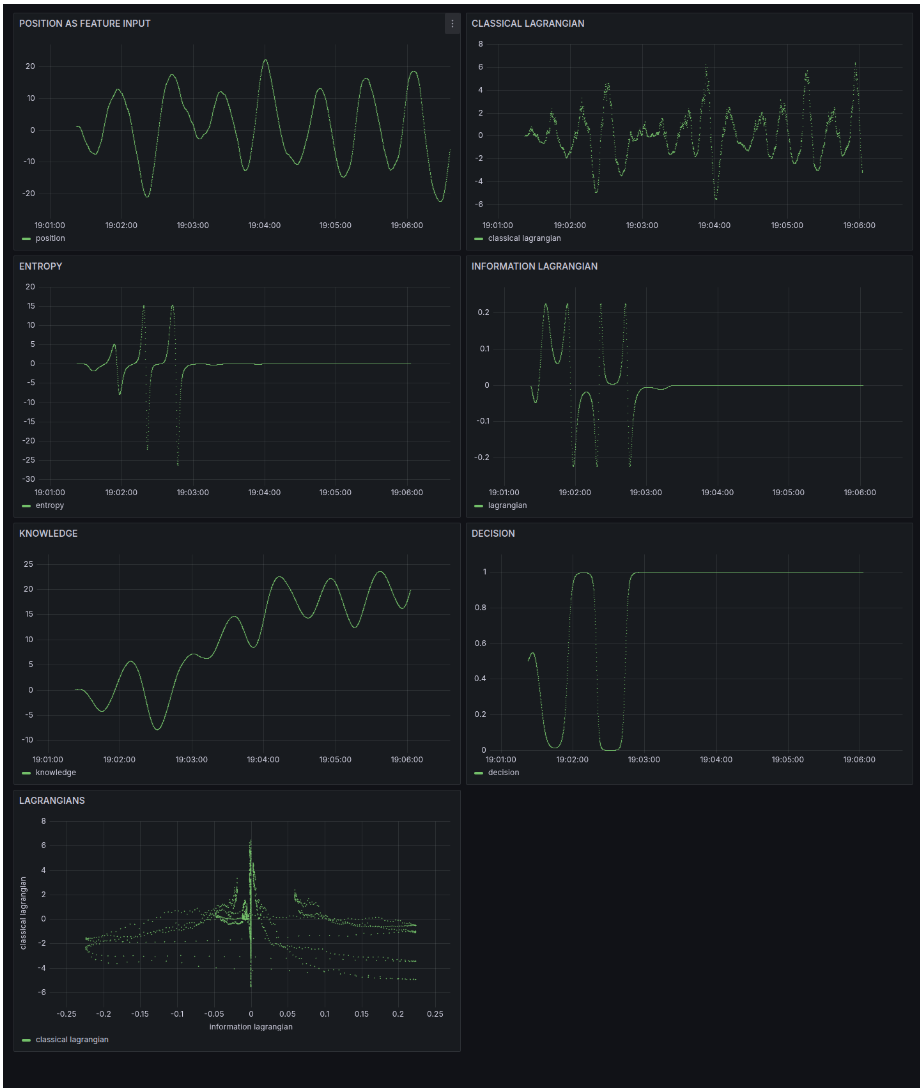

Figure 4: Noise 0.01

Scientific Insights

- **SKA acts as a real-time microscope for predictability,** detecting noise levels down to 10^{-4}.
- The transition from order to disorder is **abrupt and visually dramatic**—SKA variables serve as a universal benchmark for information structure in any time series.
- **This calibration ladder provides a reference standard** for analyzing regime transitions in physical, biological, financial, and engineering data.

How to Use These Results

- **Compare real-world SKA outputs to this set of calibrator plots** to objectively classify their predictability and noise sensitivity.
- **Signals that match the "without noise" or "0.0001" plots are maximally predictable.**
- **Signals resembling the "0.01" plot are chaotic or regime-shifting.**
- The intermediate "0.001" case helps identify *incipient disorder*—critical for early warning in complex systems.

Citation

If you use these results or plots, please cite:

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Bouarfa Mahi, "SKA Noise Sensitivity: Harmonic Oscillator Calibration" (2025).
https://github.com/quantiota/SKA-noise-harmonic-oscillator
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