

Subconscious Motion Field Reconstruction: An Interpretable Dynamical Framework for Sleep-State Visualization

Dream Engine Whitepaper
Interlace Systems / Dream Team
Methods preprint - synthetic implementation

Abstract

Subconscious Motion Field Reconstruction is a signal-driven method for visualizing sleep-state dynamics through interpretable dynamical systems. The approach maps multi-modal physiological signals - including EEG-like rhythms, HRV volatility, breath irregularity, and sleep-stage transitions - into spatial vector fields that reveal flow, turbulence, stability, and attractor behavior across time. Unlike latent generative models or opaque neural embeddings, the method is explicitly interpretable: each motion parameter is derived from transparent feature extraction pipelines and modality-gated mappings. The current implementation uses synthetic, seeded signals to establish reproducibility and conceptual validity, with planned integration of real EEG/HRV data for empirical evaluation. This framework aims to provide researchers and institutions with a structured, interactive tool for exploring subconscious dynamics without resorting to speculative or non-scientific representations.

1. Introduction

Sleep-state dynamics represent one of the most complex and least accessible domains of human physiology. While EEG, HRV, respiration, and hypnogram transitions provide measurable proxies for internal state changes, these signals are rarely visualized in ways that reveal underlying dynamical structure. Traditional approaches rely on spectrograms, hypnogram charts, or statistical summaries that fail to capture the spatial and temporal relationships between modalities.

Recent advances in computational neuroscience and neurotechnology have emphasized interpretability, transparency, and multi-modal integration. However, most visualization frameworks remain either too abstract or too tied to clinical metrics to support exploratory research into subconscious dynamics.

Subconscious Motion Field Reconstruction introduces a new perspective: treating sleep-state signals as components of a dynamical system and visualizing them as spatial vector fields. This approach enables researchers to inspect subconscious behavior through flow, turbulence, attractors, and transitions - concepts familiar in dynamical systems theory but underutilized in sleep research.

The method is not intended to decode dream content. Instead, it provides a structured, interpretable representation of subconscious dynamics that can support hypothesis generation, comparative analysis, and future empirical validation.

2. Method

2.1 Synthetic Signal Generation

To establish reproducibility and conceptual clarity, the current implementation uses synthetic,

seeded signals that emulate:

- EEG-like band activity (delta, theta, alpha, beta)
- HRV volatility
- Breath irregularity
- Sleep-stage transitions (N1, N2, N3, REM)

Signals are generated over discrete time steps (e.g., 120-300) using deterministic pseudo-random functions conditioned on a synthetic hypnogram. This ensures consistent behavior across sessions while preserving variability needed for dynamical modeling.

2.2 Feature Extraction

At each time step, a feature vector $F(t)$ is computed:

- Band powers or normalized amplitudes
- HRV volatility (short-term change)
- Breath regularity vs irregularity
- Sleep-stage encoding (one-hot or numeric)

This feature vector forms the basis for motion parameter mapping.

2.3 Motion Parameter Mapping

Features are mapped to motion parameters through interpretable rules:

- Direction: derived from band interactions (e.g., theta dominance -> upward drift)
- Magnitude: tied to autonomic activation (e.g., HRV volatility)
- Turbulence: influenced by breath irregularity and REM transitions
- Attractor Strength: determined by feature clusters (e.g., REM -> strong attractor)

Mappings are modality-gated, allowing researchers to toggle EEG, HRV, breath, or stage influence.

2.4 Motion Field Construction

A 16x16 spatial grid is used to construct a vector field for each time step. Attractor points are placed where feature combinations cluster, such as:

- REM clusters
- Deep-sleep basins
- Autonomic ridges
- N2 transition bridges

Each grid point receives a vector derived from the motion parameters, producing a spatial representation of subconscious dynamics.

2.5 Interactive Visualization

The Dream Engine viewer provides:

- Time scrubbing
- Modality toggles
- Intensity sliders
- Hover-based local inspection
- Attractor labels

- Real-time parameter readouts

This transforms the method from a static model into an exploratory research tool.

3. Discussion

Subconscious Motion Field Reconstruction offers a novel way to visualize sleep-state dynamics. By grounding motion parameters in interpretable features, the method avoids the pitfalls of latent generative models and maintains scientific transparency.

The synthetic implementation demonstrates conceptual validity and provides a foundation for future empirical work. The interactive viewer enables researchers to explore how physiological signals interact to produce subconscious dynamics, potentially revealing patterns not visible through traditional charts.

This method does not attempt to decode dream content. Instead, it provides a structured representation of subconscious behavior that can support:

- hypothesis generation
- comparative analysis
- sleep-stage transition studies
- autonomic dynamics research
- future integration with real data

4. Future Work

Planned extensions include:

- Integration of real EEG/HRV datasets
- Cross-subject comparisons
- Sleep-stage transition modeling
- Attractor stability analysis
- Clinical collaboration for empirical validation
- Institutional pilot programs
- Expansion to 3D vector fields
- Multi-night longitudinal modeling

5. References

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