

GSPS: Geometric Semantic Positioning System

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Abstract

I present the Geometric Semantic Positioning System (GSPS), a framework that reveals semantic structure by projecting high-dimensional embeddings onto constrained 2D geometric templates. Using 1024-dimension Alibaba-NLP/gte-large-en-v1.5 embeddings of Wikipedia articles, the GSPS system uses relative positioning to place inner nodes according to relative semantic-similarity to fixed anchor nodes.

I introduce four primitive types: point (1-anchor), edge (2-anchor), triangle (3-anchor), and square (4-anchor).

The protocol enables deterministic, framework-agnostic semantic positioning where any system with the same anchor configuration will compute identical coordinates for a given concept.

1 Core Principles

1.1 Anchor-Defined Spaces

Semantic space is bounded by 1–4 fixed anchor nodes positioned at predetermined coordinates:

- **4-Anchor:** Square configuration $[(-1, 0), (1, 0), (0, 1), (0, -1)]$
- **3-Anchor:** Triangle configuration $[(-1, 0), (1, 0), (0, 1)]$
- **2-Anchor:** Edge configuration $[(-1, 0), (1, 0)]$
- **1-Anchor:** Point configuration $[(0, 0)]$

1.2 Force-Based Positioning

Inner nodes (non-anchors) are positioned through:

- Gravitational attraction when cosine similarity to an anchor exceeds the dynamic pivot
- Electromagnetic repulsion when cosine similarity falls below the dynamic pivot

The dynamic pivot is calculated as the mean cosine similarity across all anchors, enabling manifold-dependent relative positioning.

1.3 Protocol Invariance

Two systems implementing GSPS with identical:

- Anchor node vectors
- Anchor coordinates
- Force parameters (α, γ, β)

will produce identical coordinates for any given inner node vector.

2 Mathematical Framework

2.1 Dynamic Pivot Calculation

The dynamic pivot μ is the mean cosine similarity between the center node and all anchors:

$$\mu = \frac{1}{n} \sum_{i=1}^n \cos(v_c, v_{a_i})$$

where v_c is the center vector, v_{a_i} is anchor i 's vector, and $\cos(a, b) = \frac{a \cdot b}{\|a\| \|b\|}$.

2.2 Force Computation

For each anchor i , compute the deviation from pivot:

$$\delta_i = \cos(v_c, v_{a_i}) - \mu$$

The polarity determines attraction ($\delta_i \geq 0$) or repulsion ($\delta_i < 0$):

$$\rho_i = \text{sgn}(\delta_i)$$

Force magnitude scales with deviation:

$$m_i = \beta + \gamma |\delta_i|^\alpha$$

Force vector:

$$\mathbf{F}_i = \mathbf{p}_i \cdot m_i \cdot \rho_i$$

where $\mathbf{p}_i = (x_i, y_i)$ is the anchor's fixed coordinate.

2.3 Position Resolution

$$\mathbf{r} = \frac{1}{n} \sum_{i=1}^n \mathbf{F}_i$$

Final coordinates are normalized:

$$\mathbf{r}_{\text{final}} = \tanh(\kappa \cdot \mathbf{r})$$

with $\kappa = 1.2$ (stiffness), ensuring $r_j \in [-1, 1]$ for $j \in \{x, y\}$.

Default parameters: $\alpha = 2.0$, $\gamma = 300.0$, $\beta = 0.5$.

3 Visual Examples

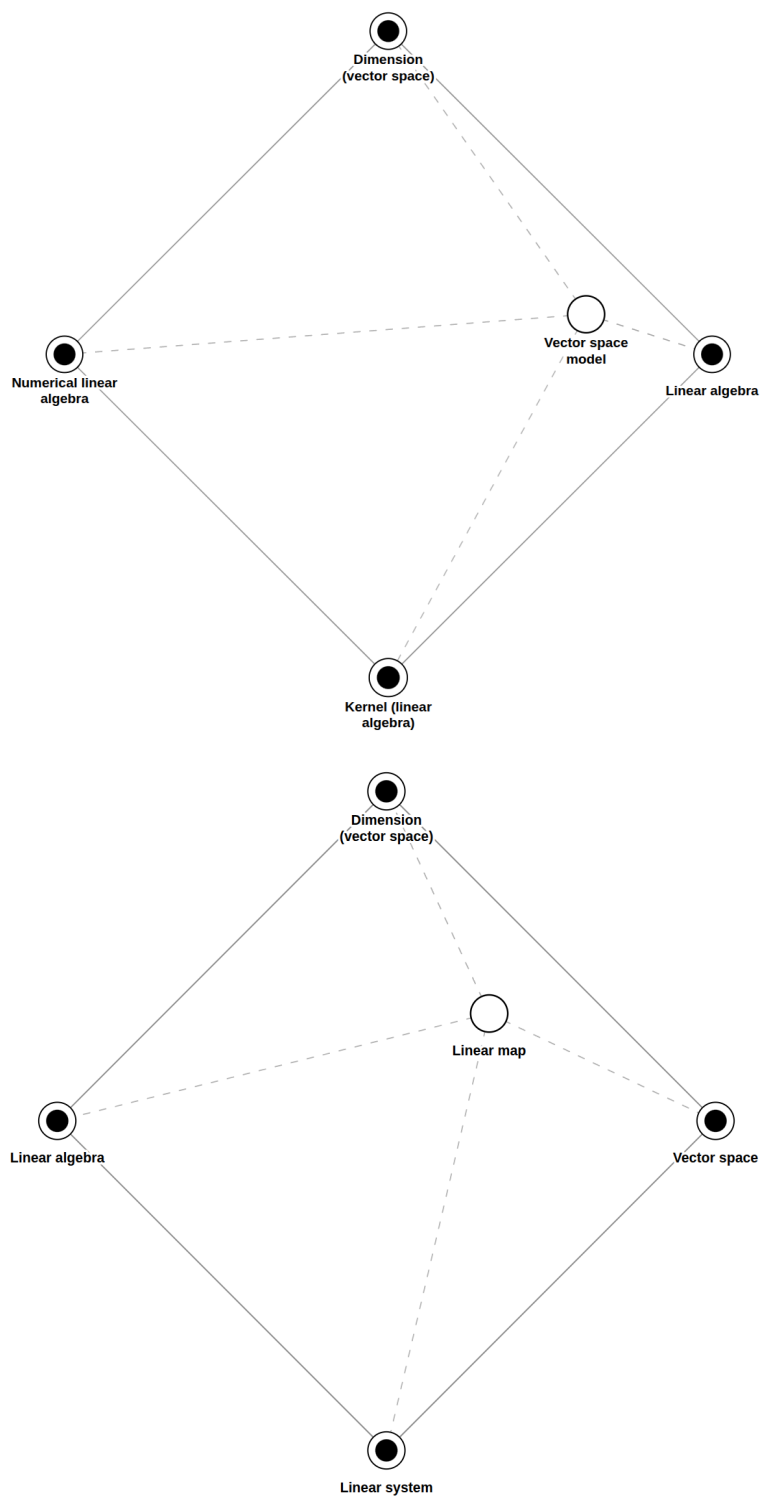


Figure 1: Two 4-anchor GSPS primitive objects