Delta-Localized Semantics for Intransitive Verb Modeling in Neuronova

Supplementary Note

Abstract

This supplementary document presents the delta-localized versions of seven event constructions involving the intransitive verb *run* in the Neuronova framework. We formally define spatial, temporal, and spatiotemporal Dirac-like localizations, explain their semantic contribution, and place them within the Minkowski-Hilbert hybrid geometry adopted in the main paper. All formulas are implemented using smooth Gaussian approximations to Dirac deltas, ensuring full numerical stability.

1 Introduction

In Neuronova, nouns are modeled as spatiotemporal fields $S(x,t)$ and verbs as differential operators acting on these fields. Adverbs correspond to integration windows over spatial or temporal domains. Delta-localized adverbs, such as "here", "now", and "here and now", correspond to sharply concentrated windows that collapse (in the limit) into Dirac distributions. In practice, numerical realizations use smooth Gaussian approximations.

This supplement formalizes the delta versions of seven canonical constructions:

1. **Juan.**
2. **Juan runs.**
3. **Juan runs here.**
4. **Juan runs now.**
5. **Juan runs quickly.**
6. **Juan runs slowly.**
7. **Juan runs here and now.**

2 Gaussian Approximations to Dirac Deltas

A one-dimensional delta is approximated by the Gaussian

$$\delta_\sigma(x-x_0) = \frac{1}{\sqrt{2\pi}\sigma}\exp\Big(-\frac{(x-x_0)^2}{2\sigma^2}\Big),$$

with $\sigma > 0$ controlling the width. As $\sigma \to 0$, the approximation converges to δ in the distributional sense. For two dimensions we use

$$\delta_{\sigma_r,\sigma_t}(x-x_0, t-t_0) = \delta_{\sigma_r}(x-x_0)\,\delta_{\sigma_t}(t-t_0).$$

All delta-localized operators in this document use Gaussian approximations, so no singularities or numerical instabilities arise in implementation.

3 Case 1: Collapsed Noun-Field (“Juan.”)

Juan’s noun-field is collapsed to a single spacetime point (x_0, t_0):

$$S^{(\delta)}_{\text{Juan}}(x,t) = S_{\text{Juan}}(x_0,t_0)\,\delta(x-x_0)\,\delta(t-t_0).$$

Interpretation. Pure referential presence with no spatial or temporal extension; the worldline collapses to a single event.

4 Case 2: Localized Running Event (“Juan runs.”)

A dynamic event localized along Juan’s worldline $\gamma_{\text{Juan}}(t)$:

$$v^{(\delta)}_{\text{run}}(x,t) = v_{\text{run}}\big(x_{\text{Juan}}(t),t\big)\,\delta\big(x-x_{\text{Juan}}(t)\big).$$

Interpretation. The event is dynamic in time but thin in space—Juan occupies only his trajectory.

5 Case 3: Spatial Delta (“Juan runs here.”)

The spatial indexical “here” anchors the event at x_0:

$$v^{(\delta)}_{\text{here}}(x,t) = v_{\text{run}}(x_0,t)\,\delta(x-x_0).$$

Interpretation. Running is fully evaluated at one spatial coordinate across time. The event becomes a vertical line in spacetime.

6 Case 4: Temporal Delta (“Juan runs now.”)

The temporal indexical “now” anchors the event at t_0:

$$v^{(\delta)}_{\text{now}}(x,t) = v_{\text{run}}(x,t_0)\,\delta(t-t_0).$$

Interpretation. The event is constrained to a single moment; the diagram shows a horizontal line in spacetime.

7 Case 5: Narrow Temporal Delta (“Juan runs quickly.”)

Manner adverb “quickly” corresponds to a compressed temporal support:

$$v^{(\delta)}_{\text{fast}}(x,t) \approx v_{\text{run}}(x,t_0)\,\delta_{\text{narrow}}(t-t_0).$$

Interpretation. High dynamic intensity concentrated in a short interval.

8 Case 6: Wide Temporal Bump (“Juan runs slowly.”)

“Slowly” widens the temporal integration window:

$$v^{(\delta)}_{\text{slow}}(x,t) \approx v_{\text{run}}(x,t_0)\,\delta_{\text{wide}}(t-t_0).$$

Interpretation. Lower rate of change spread over a longer time interval.

9 Case 7: Spatiotemporal Delta ("Juan runs here and now.")

Maximum deictic alignment:

$$v^{(\delta)}_{\text{here-now}}(x,t) = v_{\text{run}}(x_0,t_0)\,\delta(x-x_0)\,\delta(t-t_0).$$

Interpretation. The event collapses to a single spacetime point. Semantically, this represents perfect alignment with the observer's Minkowski origin: a point-like instantiation of the running event.

10 Computational Note

In all practical implementations, ideal Dirac deltas are replaced with Gaussian δ_σ approximations. This guarantees:

- finite values everywhere,
- numerical stability,
- smooth gradients,
- and compatibility with differential operators.

Thus, delta-localized semantics is realized as a stable limit of increasingly sharp but smooth and finite adverbial windows.