

# Spike Features for Machine Learning

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5:04 PM

## 1. Firing Rate (How many spikes per second)

This is the simplest and most powerful feature.

### Formula (for understanding)

$$\text{Firing Rate} = \text{Number of spikes} / \text{Time duration}$$

Meanings:

- High firing rate  $\rightarrow$  stress / anxiety
- Low firing rate  $\rightarrow$  calm
- Burst firing rate  $\rightarrow$  fear
- Stable firing rate  $\rightarrow$  focus / excitement

## 2. Inter-Spike Interval (SSI)

SSI = the time gap between two spikes.

$$SSI = t_2 - t_1$$

Meanings:

- Short SSI  $\rightarrow$  very fast spiking  $\rightarrow$  stress / anxiety
- Long SSI  $\rightarrow$  slow spiking  $\rightarrow$  calm
- Mixed SSI (short + long)  $\rightarrow$  unstable  $\rightarrow$  emotional shock

## 3. SSI Variance (stability of timing)

This tells how consistent or chaotic the neuron timing is.

• Low Variance = very stable  $\rightarrow$  focused, excited state

• High Variance = chaotic  $\rightarrow$  stress, fear

\* If SSI jumps around too much  $\rightarrow$  indicates instability.

## 4. Burstiness Index

Burst = sudden cluster of spikes:



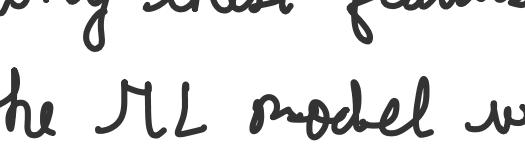
Meanings:

• High Burstiness  $\rightarrow$  fear, panic, sudden stress

• Low burstiness  $\rightarrow$  calm / steady state

## 5. Rhythmicity (How regular the spike timing is)

If spikes appear at consistent intervals:



Meanings:

• High rhythmicity  $\rightarrow$  focus, routine processing, excitement

• Low rhythmicity  $\rightarrow$  chaos  $\rightarrow$  stress / anxiety

It shows whether the emotional state is stable or unstable

## 6. Spike Entropy (Randomness of firing)

Entropy = how predictable the spikes are

Meanings:

• High entropy  $\rightarrow$  stress, anxiety, confusion

• Low entropy  $\rightarrow$  calm, stable emotional state

## 7. Why these features matter (ML POV)?

The ML model will not "look at spike directly." ☺

It will look at **NUMBERS** extracted from spikes:

Example feature vector for one emotion:

[ firing\_rate = 12.4,

mean\_SSI = 5.2,

SSI\_Variance = 3.1,

burstiness = 0.7,

entropy = 0.45,

rhythmicity = 0.82 ]

This vector represents the emotional fingerprint.

This ML model will learn:

• Calm = slow, regular, low burst

• Fear = bursts, high entropy

• Stress = high firing rate + chaotic pattern

• Excitement = rhythmic + moderately fast

## \* Summary

• Firing Rate  $\rightarrow$  activity level

• SSI  $\rightarrow$  timing

• SSI Variance  $\rightarrow$  stability

• Burstiness  $\rightarrow$  sudden emotional reactions

• Rhythmicity  $\rightarrow$  pattern regularity

• Entropy  $\rightarrow$  randomness

• Features turn spike trains  $\rightarrow$  ML Ready data