

# 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 (ISI)

ISI = the time gap between two spikes.

$$\text{ISI} = t_2 - t_1$$

Meanings:

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

## 3. ISI 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 ISI jumps around too much  $\rightarrow$  indicates instability.

## 4. Burstiness Index

Burst = sudden cluster of spikes:

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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:

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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\_isi = 5.2,  
isi\_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
- ISI  $\rightarrow$  timing
- ISI Variance  $\rightarrow$  stability
- Burstiness  $\rightarrow$  sudden emotional reactions
- Rhythmicity  $\rightarrow$  pattern regularity
- Entropy  $\rightarrow$  randomness
- Features turn spike trains  $\rightarrow$  ML Ready data