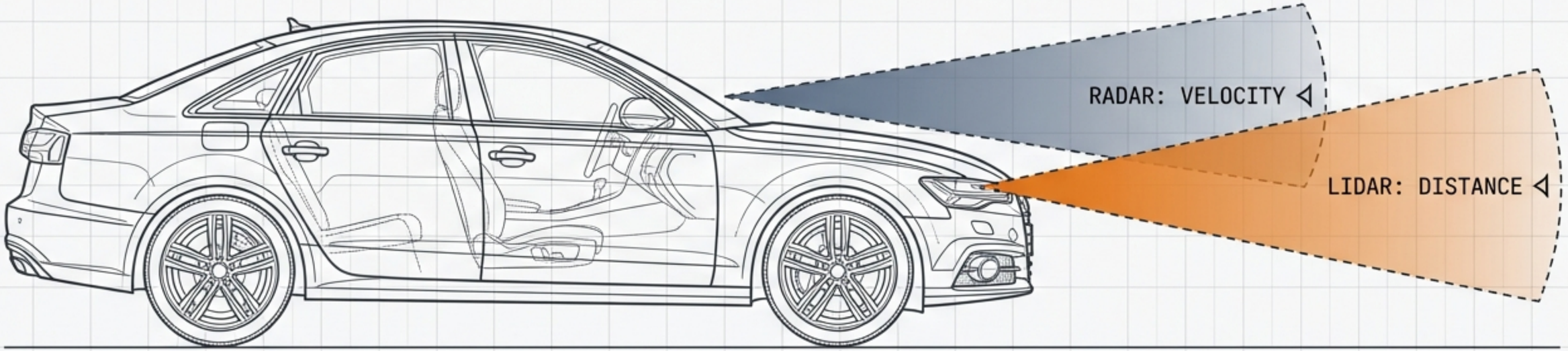
Anatomy of an Autonomous Stop

Deconstructing the fuzzy logic that turns vague sensor data into precise life-saving action.



The Scenario: 65 km/h, 20 Meters, One Decision

INPUT A: VELOCITY

65 km/h

Approaching
Fast Threshold

INPUT B: DISTANCE

20 m

OBSTACLE
DETECTED

OUTPUT: BRAKE PRESSURE

? PSI

CALCULATING...

THE CHALLENGE: The world is not binary. The car is ‘moderately fast’ and ‘dangerously close.’ How do we translate ambiguity into a precise mechanical force?

The Logic Architecture

YOU ARE HERE

PHASE 1: FUZZIFICATION

Translate crisp numbers to linguistic concepts.

65 km/h → MEDIUM

20 m → CLOSE

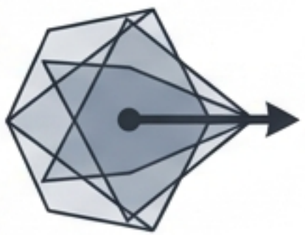
PHASE 2: INFERENCE

Apply expert rules to the situation.

IF SPEED=MEDIUM & DISTANCE=CLOSE
THEN BRAKE=HIGH

PHASE 3: DEFUZZIFICATION

Convert consensus back to mechanical command.



850 PSI

BRAKE PRESSURE

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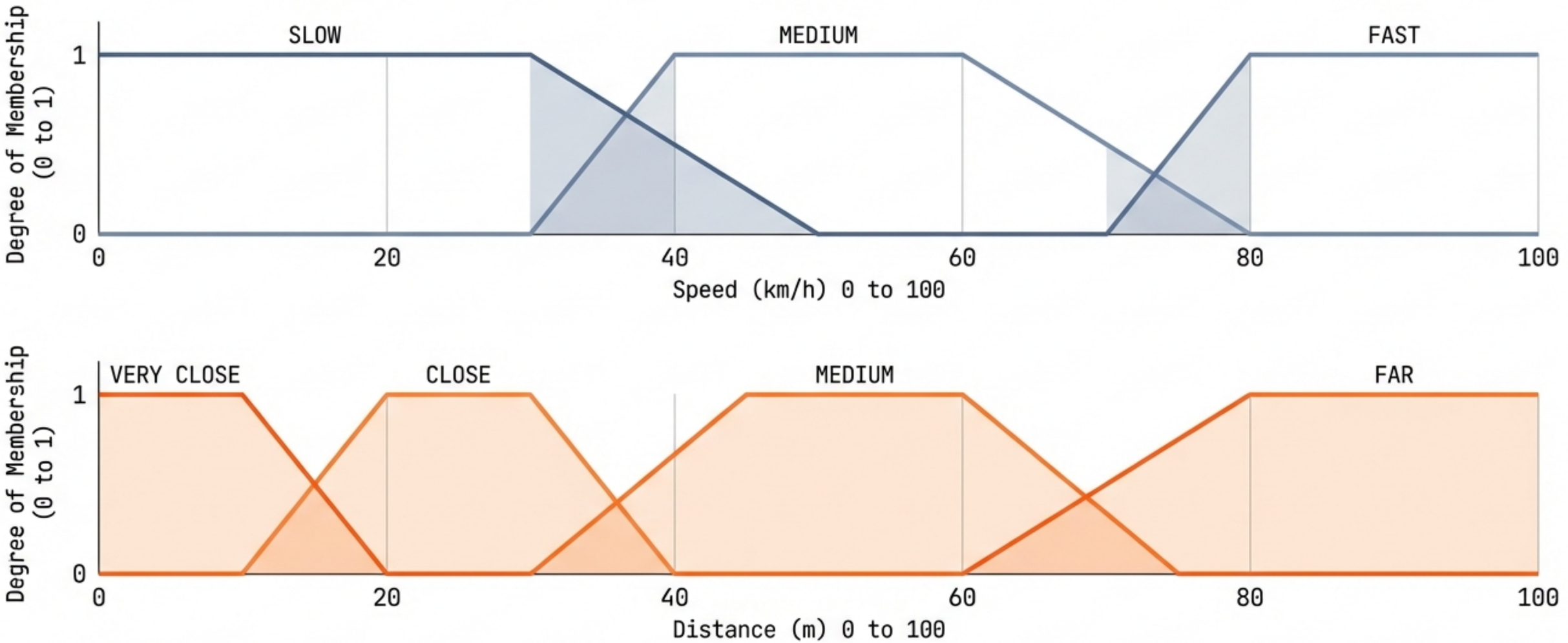
Mapping the Territory: Defining Input Sets



Unlike binary logic, fuzzy boundaries allow a value to belong to multiple sets simultaneously.

The Rulebook: Encoding Human Intuition

	FAR	MEDIUM DIST	CLOSE	VERY CLOSE
SLOW	Gentle	Gentle	Moderate	Firm
MEDIUM SPEED	Gentle	Moderate	Firm	Emergency
FAST	Moderate	Firm	Emergency	Emergency

Braking Output Legend

- Gentle: ~15 PSI
- Moderate: ~40 PSI
- Firm: ~65 PSI
- Emergency: ~90 PSI

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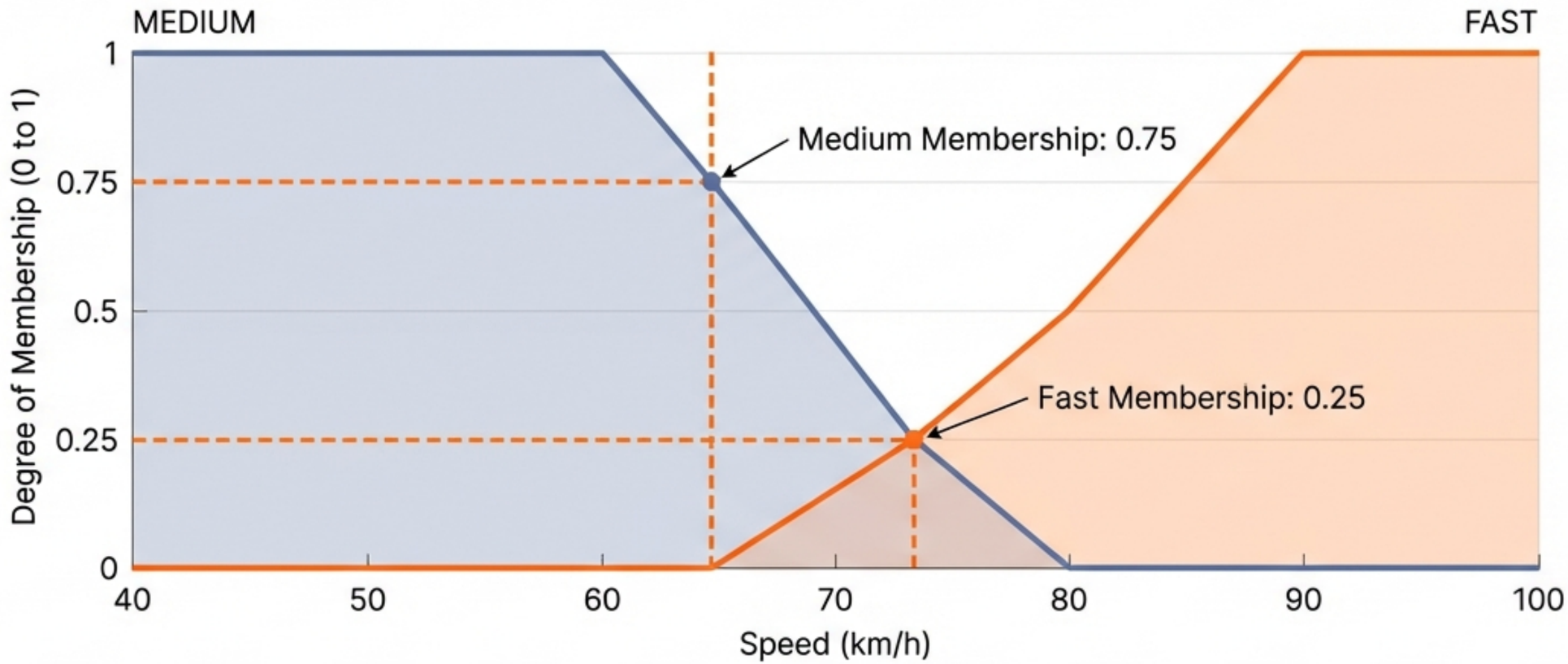
Step 1: Fuzzifying Speed



At 65 km/h, the input is 75% Medium and 25% Fast.

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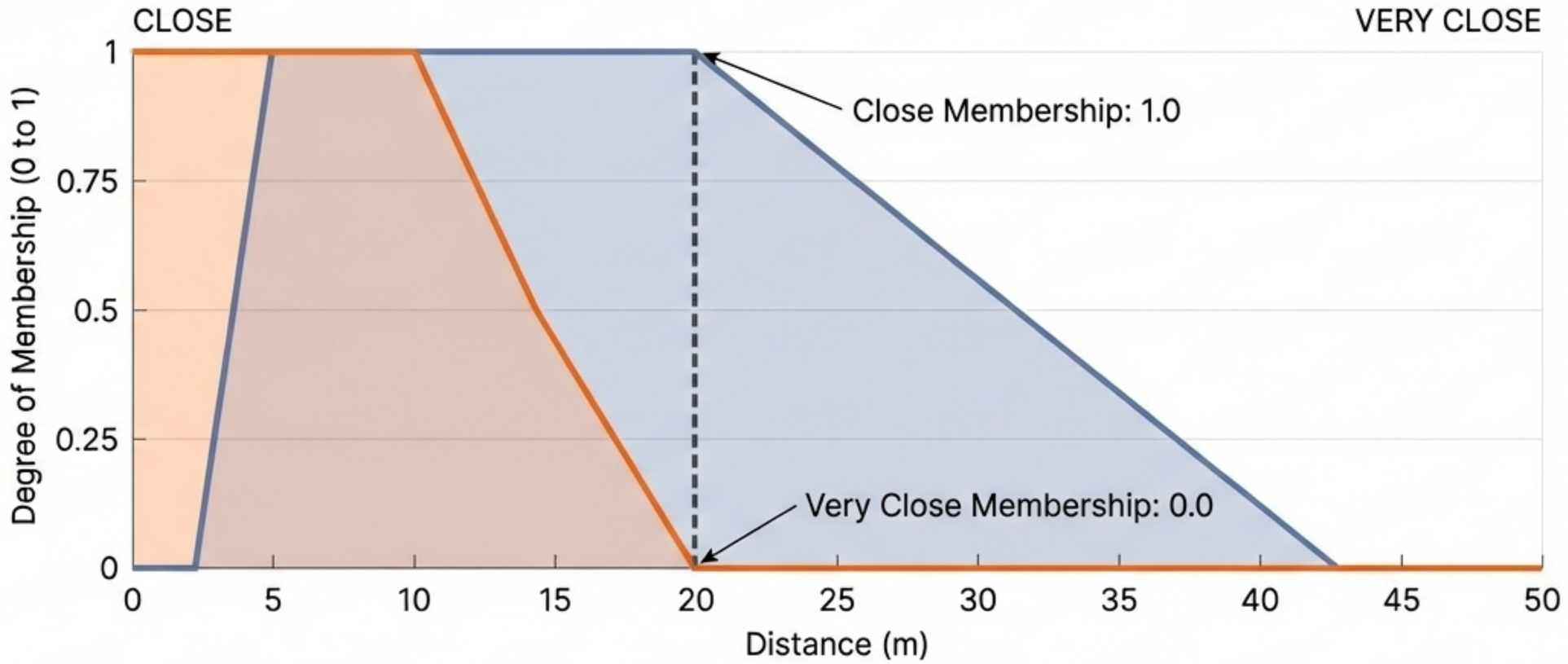
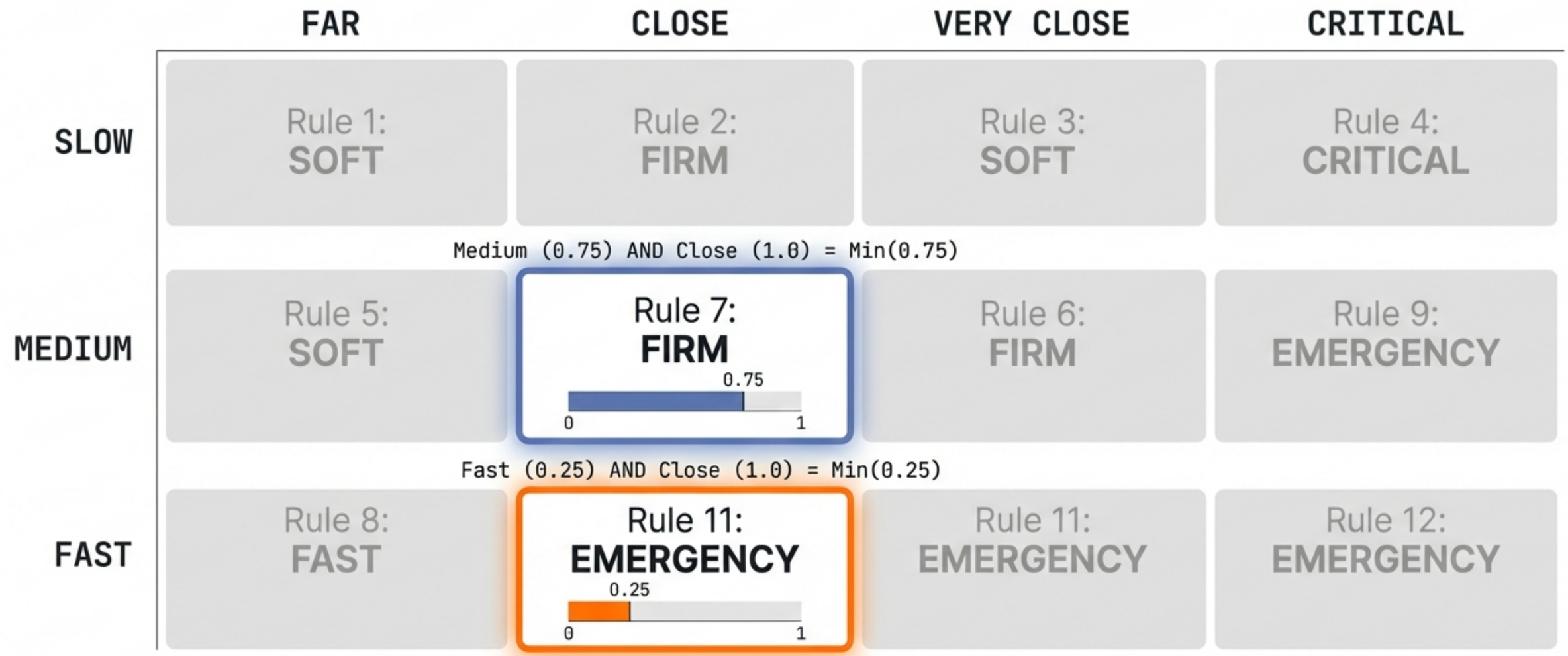
Step 1: Fuzzifying Distance



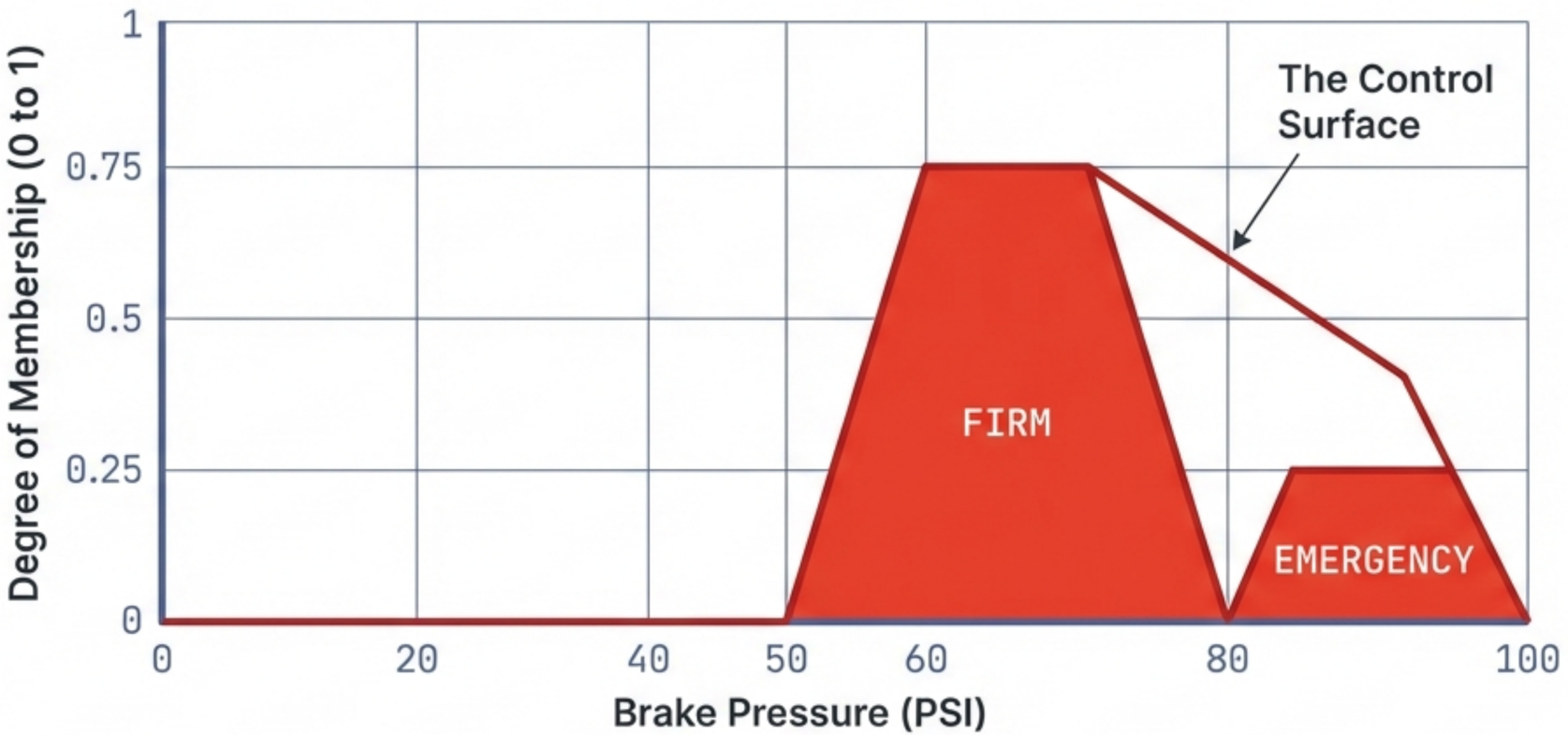
At 20 meters, the car is unequivocally ‘Close’.
It has just exited the ‘Very Close’ zone.

Step 2: Inference (Evaluating the Rules)



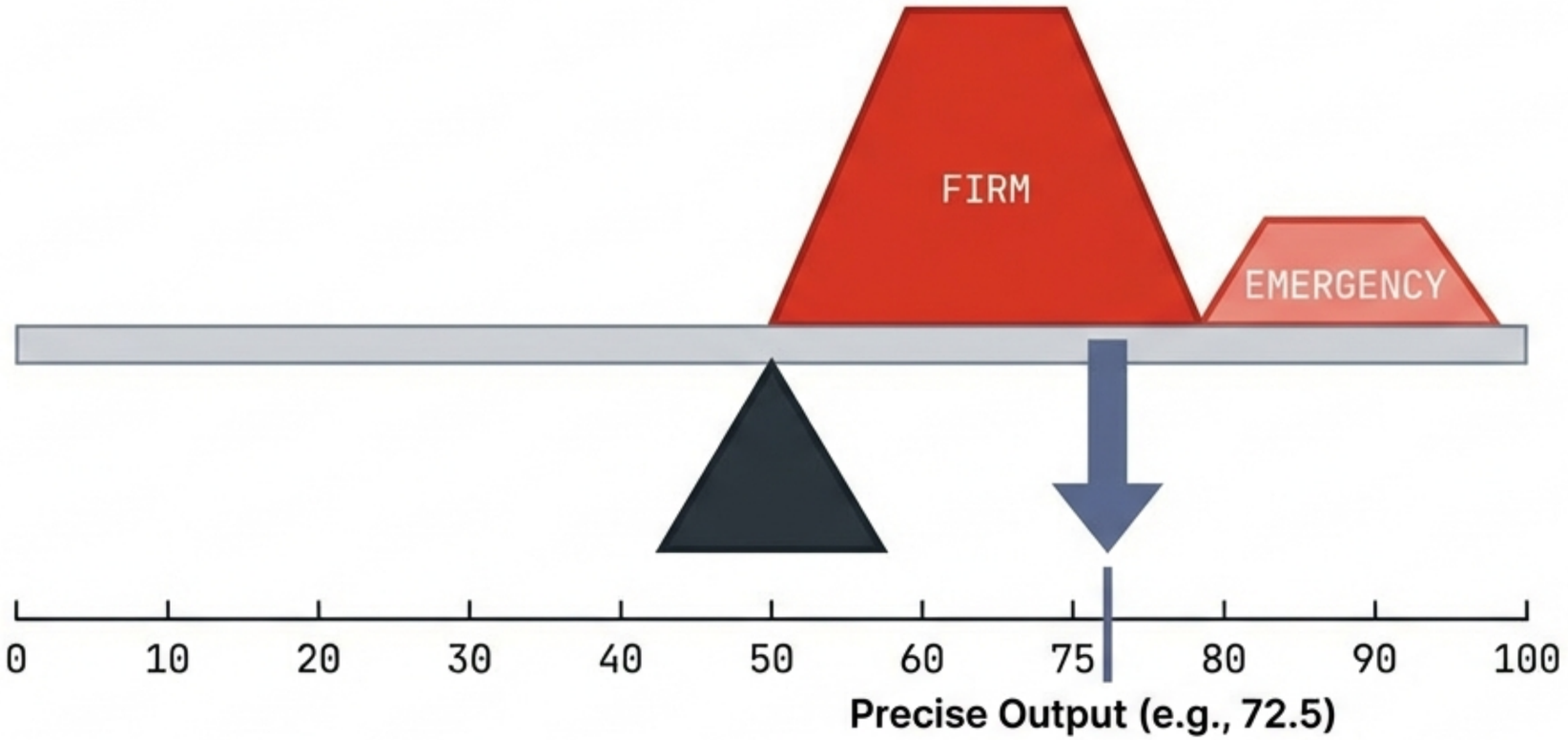
LOGIC CONFLICT: The system believes we need FIRM braking (75% confidence) but also detects an EMERGENCY risk (25% confidence).

Step 3: Aggregation



We don’t choose one rule. We combine the truncated shapes to form a total judgment area.

Step 4: Defuzzification (The Concept)



Centroid Method: Imagine balancing the shape on a pin.
The balance point is the precise output number.

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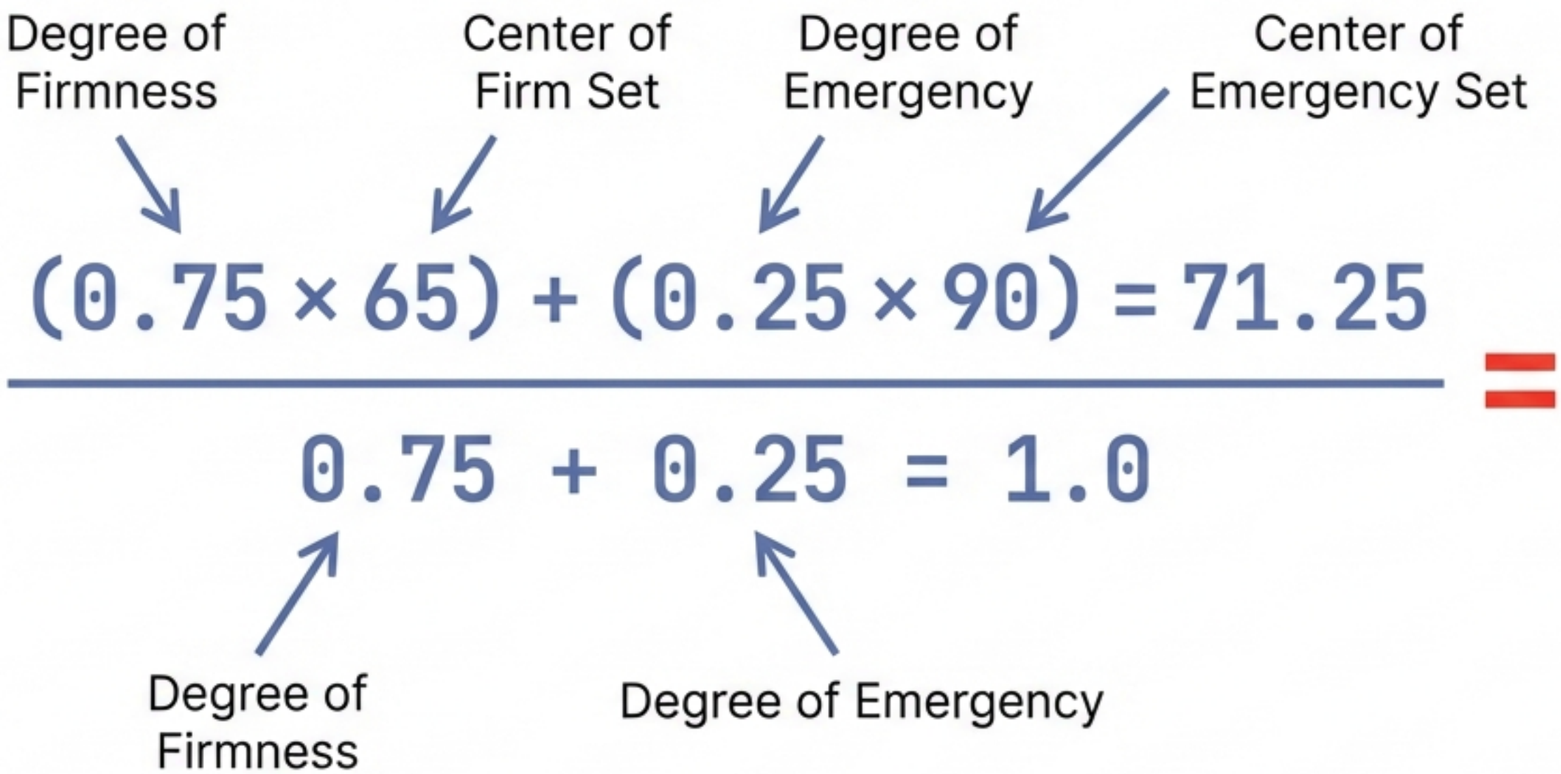
Calculating the Precise Command



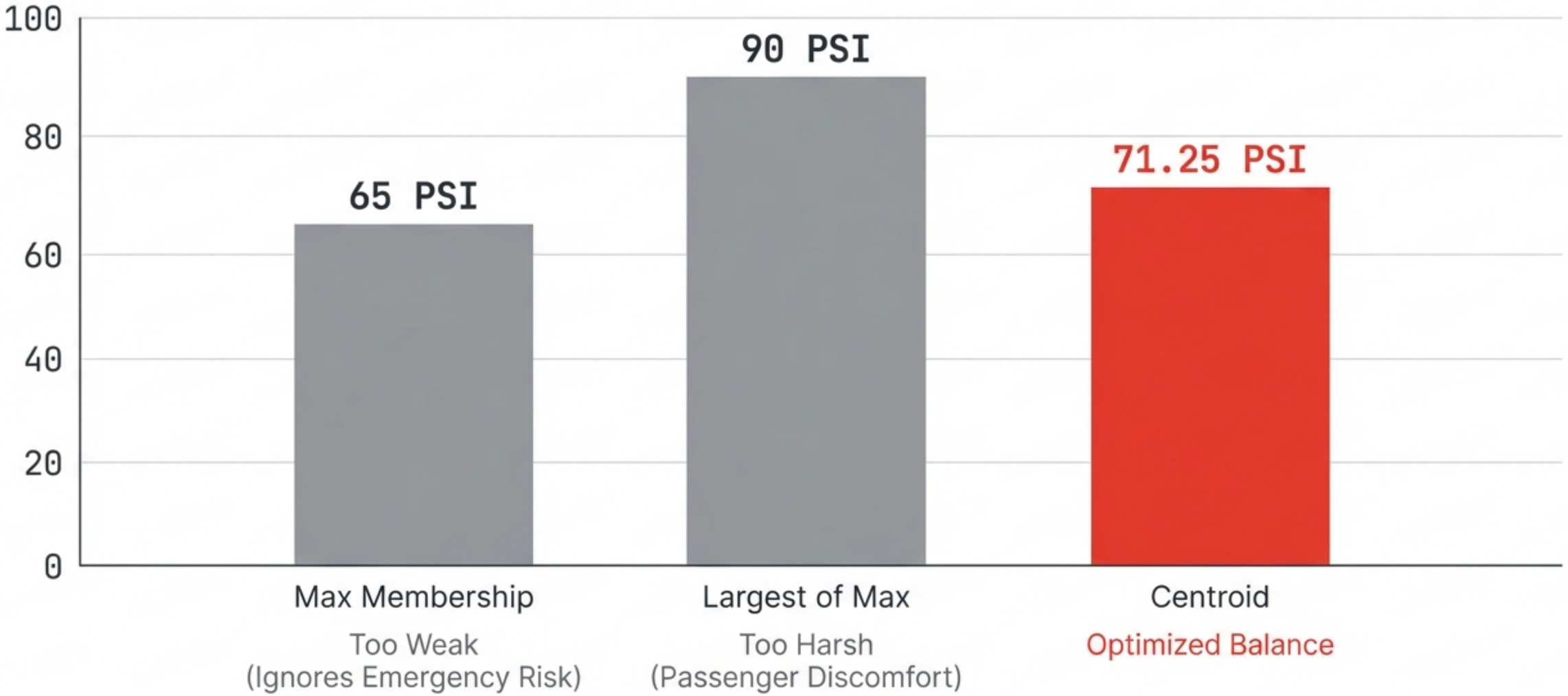
$$= 71.25 \text{ PSI}$$

The Result: 71.25 PSI

WHY THIS NUMBER?

1. It is stronger than standard Firm braking (65) to account for the speed risk.
2. It is smoother than full Emergency braking (90) to maintain passenger control.
3. It represents a proportional, weighted response to the danger.

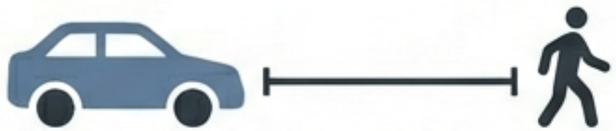
Why Centroid? A Comparison



Robustness Across Scenarios

Scenario A: CASUAL

Input: 30 km/h @ 80m
Output: 15 PSI (Gentle)



Scenario B: PANIC

Input: 85 km/h @ 8m
Output: 88 PSI (Emergency)

Scenario C: STANDARD

Input: 55 km/h @ 50m
Output: 40 PSI (Moderate)

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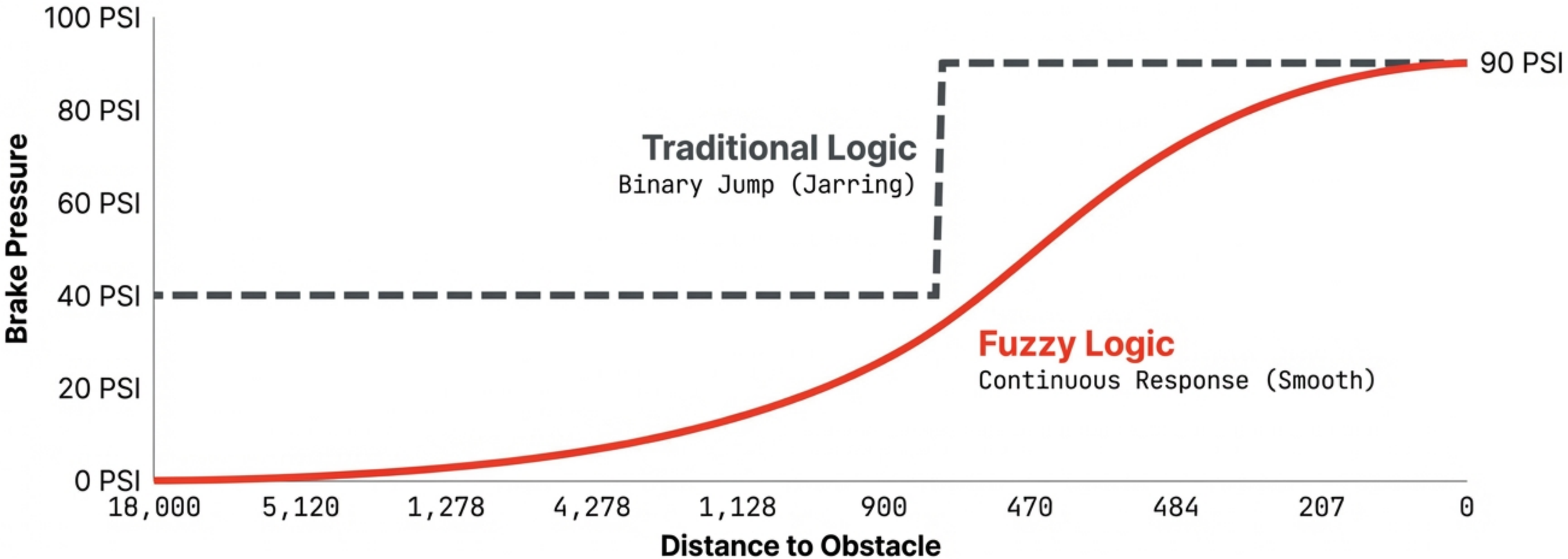
The Human Advantage in Machine Code



Fuzzy logic allows the machine to think like a human: "I'm going pretty fast and getting kind of close," translating vague reality into precise, safe engineering.