

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A CONVERSATIONAL APPROACH

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Problem

›

Model

›

Compute

›

Analyze

›

Validate

›

Improve

The engineering workflow you will use throughout this book

by Taner & Sebnem Onsay,

CHAPTER - 4

PART 2 · ≈ 35 MIN

Trap It — The Bracket & the Sign Change

Before hunting an answer, guarantee it cannot escape. You have already built one trap with a WHILE loop — and one with a thermometer.

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You already own the bracket

CHAPTER 2's SEARCH — ITS FINAL PAIR

20.0 ✓ stops short 20.5 ✗ overruns

The last safe speed and the first unsafe one. Every run of your search ended on such a pair — and the true crossing always lay between them. Chapter 3's grid picture drew it; you never lost this pair once you had it.

That pair IS a bracket. It always was.

LAB 3 — TWO THERMOMETER READINGS

one reading above 40 °C · the next below

Your measured crossing bracket: the drinkable-temperature crossing, trapped between two one-minute checks. You reported its midpoint as the estimate and kept the measured bracket interval as part of the timing uncertainty.

You bracketed a root with a thermometer.

AND HOMEWORK 3 DID IT WITH A SIMULATION

The basin's depth crossed zero between two time steps — depth positive at one step, gone at the next. A bracket in time, built by a loop.

A bracket is not a new tool — it is what your evidence already looked like. Today it becomes a definition, with a guarantee attached.

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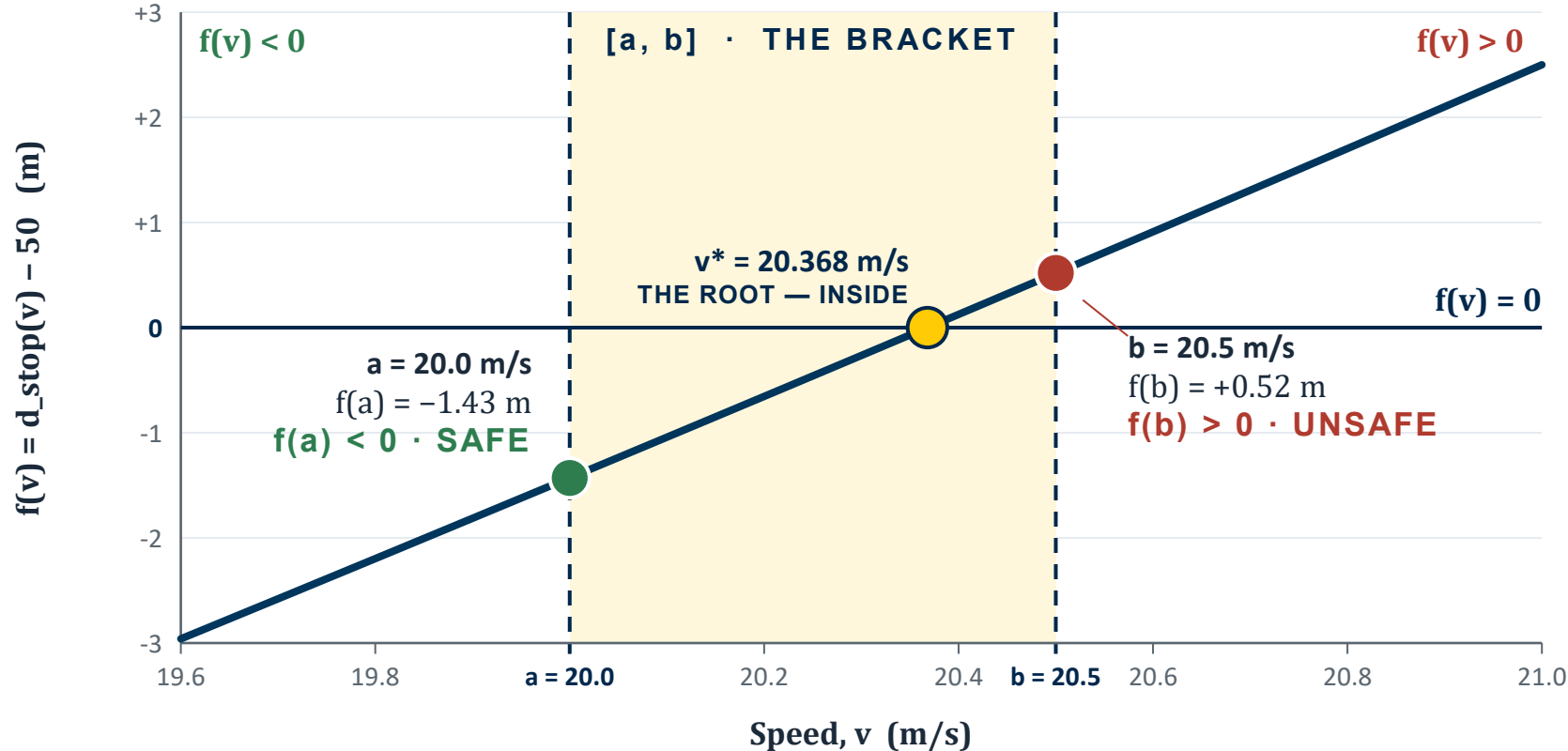
Validate



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This interval has a name: THE BRACKET



NAME IT

THIS IS A BRACKET.

$[a, b] = [20.0, 20.5]$
 $f(a) \cdot f(b) < 0$

INTERMEDIATE VALUE THEOREM

PART 1 you SAW the trap. **PART 2** now we NAME it.

BRACKET = an interval $[a, b]$ whose endpoints have opposite signs.

WHY DOES THE TRAP HOLD?

A continuous curve cannot go from $f(a) < 0$ to $f(b) > 0$ without crossing zero.

CONTINUITY IS THE HINGE.

THE BRACKET IS THE GUARANTEE. Opposite endpoint signs + continuity $\rightarrow$ at least one root is trapped inside.

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No sign change, no promise

NO SIGN CHANGE

$f(a)$ and $f(b)$ with the SAME sign promise nothing. There may be no root inside — or two crossings hiding, in and back out, invisible to the endpoint signs.

A JUMP CAN FAKE IT

A discontinuous f can change sign without ever crossing zero — a gap in a lookup table, a hard IF switch. The theorem's hinge is continuity. Know your model.

SEVERAL CROSSINGS

A sign change guarantees AT LEAST one root. If f wiggles, the bracket may hold three. Which crossing the decision needs is engineering, not mathematics.

YOUR $f(v)$, CHECKED — NOT ASSUMED

Continuous (a sum of smooth terms), and climbing the whole way for $v > 0$ — more speed never shortens the stop. One crossing, cleanly trapped in $[20.0, 20.5]$.

CHAPTER 4 · PRINCIPLE No. 2

THE BRACKET IS THE GUARANTEE — NO SIGN CHANGE, NO PROMISE.

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PREDICT

Your bracket: [20.0, 20.5].
Budget: zero further evaluations.



You must report a speed anyway — right now. Which number do you report, and what is the largest error your report could possibly have? Commit both in writing.

Hint: Chapter 3 taught you to report a number WITH its error. This bracket contains everything you know.

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Report the midpoint — the error cannot exceed the half-width

THE ZERO-COST REPORT

report $x \approx (a + b) / 2 \rightarrow E_{\text{abs}} \leq (b - a) / 2$ here: $[20.0, 20.5] \rightarrow 20.25 \pm 0.25 \text{ m/s}$

CHAPTER 3's REPORT, UPGRADED

The incremental search reported the LAST SAFE point: error $\leq$ one step, always on the low side. **The midpoint splits the difference: error $\leq$ half the width** — and you can prove it from the bracket alone. The root has nowhere else to be.

LAB 3 DID EXACTLY THIS

Your crossing-time estimate was the midpoint of the measured bracket — with the measured interval kept as part of the timing uncertainty. **Same move in spirit — different in kind: this certified bracket GUARANTEES its half-width bound; a sampling interval is experimental evidence, not a theorem.**

Midpoint for accuracy — but the DECISION may prefer the safe edge. Reporting 20.0 “guaranteed safe” is also engineering. Know which question you are answering — Chapter 3's sufficiency lesson, again.

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DISCUSS

You may buy exactly ONE more evaluation of f .

One speed, one run of the model, one sign. Where do you spend it — near 20.0? near 20.5? in the middle? And what does each choice buy you AFTER the answer comes back?

Think in worst cases: the evaluation might answer “safe” — or “unsafe.” A good question helps either way. (Break — Part 3 opens with your answer.)

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