

FUNDAMENTALS OF AI-AUGMENTED ENGINEERING: A CONVERSATIONAL APPROACH

Taner Onsay, Ph.D. & Sebnem Onsay
Authors
August 2026 · Revision 1.0

© 2026 AI First Engineering



The engineering workflow you will use throughout this book

CHAPTER - 6

PART 2 · ≈ 30 MIN

Build It, Fill It

The straight line you sketched is a model — yours, not the spreadsheet's. Derive its equation from a slope, compute one missing value by hand, let Excel do the other three, and then try the same trick on y.

2

Problem



Model



Compute



Analyze



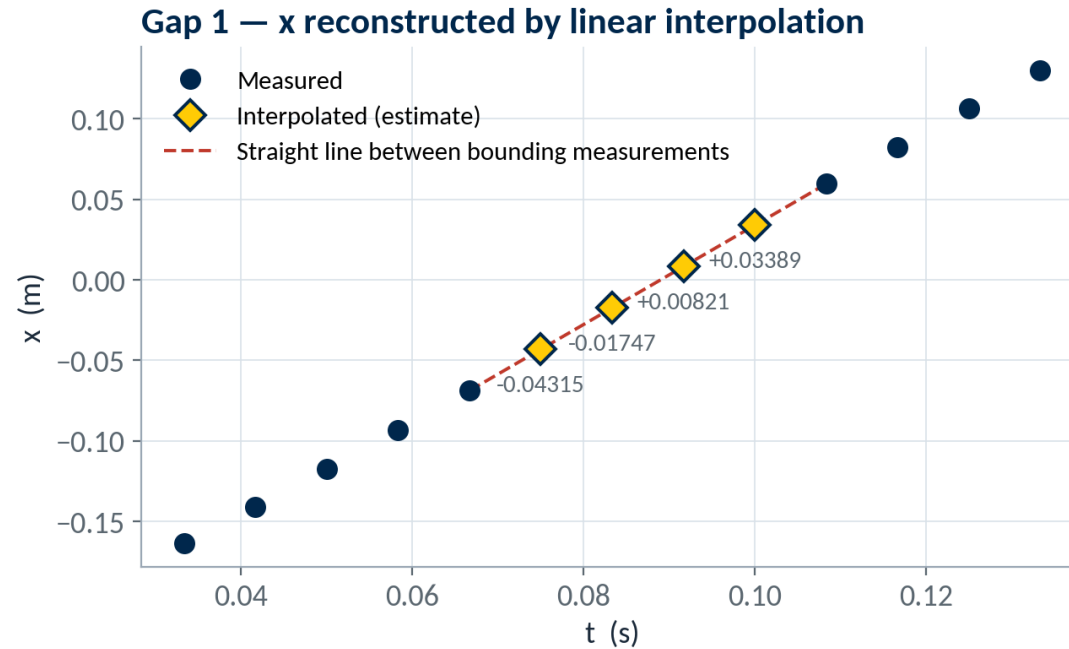
Validate



Improve



You just proposed a model



THE ASSUMPTION IN THE SKETCH

Connecting the two bounding measurements with a straight line says: "while nobody could see it, x changed at a constant rate." That is a statement about the physics, not about the data.

IT IS NOT A PROPERTY OF THE TOOL

Excel did not decide this. Python will not decide this. The missing data certainly did not decide it. A straight line is the simplest LOCAL model that agrees with the neighbours — and the engineer chose it.

CHAPTER 6 · PRINCIPLE No. 2

THE MODEL IS YOURS, NOT THE TOOL'S.

Problem

**Model**

Compute



Analyze



Validate



Improve



From slope to interpolation — derive it, do not memorize it

1 · THE SLOPE

$$m = \frac{x_2 - x_1}{t_2 - t_1}$$

Two measurements bound the gap: (t_1, x_1) before it and (t_2, x_2) after it. Their rise over run is the constant rate the straight-line model assumes.

2 · POINT-SLOPE

$$x(t) - x_1 = m(t - t_1)$$

Chapter 2 arithmetic, nothing new: start at the point you know, (t_1, x_1) , and move along the slope for a time $(t - t_1)$.

3 · LINEAR INTERPOLATION

$$x(t) = x_1 + \frac{x_2 - x_1}{t_2 - t_1} (t - t_1)$$
$$x(t) = x_1 + m(\Delta t)$$

Solve for $x(t)$. Every symbol on the right is a measurement or the time you are asking about. This is the whole method.

One equation, three ingredients: a known point, a slope from two known points, and a requested time BETWEEN them. Keep "between" in view — it returns in Part 4.

Problem

**Model**

Compute



Analyze



Validate



Improve



Real numbers: estimate x at $t = 0.075$ s

	t (s)	x (m)
before the gap (t_1, x_1)	0.066667	-0.068832
after the gap (t_2, x_2)	0.108333	+0.059576
first missing frame t	0.075000	?

WHAT AGREEMENT WILL MEAN

Your number and your neighbour's number should agree to four decimals. Agreement validates the ARITHMETIC. It says nothing yet about whether a straight line was the right model.

SUBSTITUTE THE MEASUREMENTS

$$x(0.075) = -0.068832 + \frac{0.059576 - (-0.068832)}{0.108333 - 0.066667} (0.075 - 0.066667)$$

$$\text{slope} = 0.128408 \text{ m} \div 0.041667 \text{ s} = 3.0818 \text{ m/s}$$

$$\text{elapsed} = 0.075000 - 0.066667 \text{ s} = 0.008333 \text{ s}$$

$$x(0.075) \approx -0.068832 + (3.0818 \text{ m/s})(0.008333 \text{ s}) = -0.04315 \text{ m}$$

Use the raw spreadsheet values when you compute; report to sensible precision: $x(0.075 \text{ s}) \approx -0.0432 \text{ m}$, an estimate.

PREDICT first: is the answer closer to -0.069 (the point before) or to $+0.060$ (the point after)? Why? Then compute.

Problem



Model

**Compute**

Analyze



Validate



Improve



Four missing frames — four estimates

t (s)	x (m)	status
0.066667	-0.068832	MEASURED
0.075000	-0.04315	INTERPOLATED — NOT MEASURED
0.083333	-0.01747	INTERPOLATED — NOT MEASURED
0.091667	+0.00821	INTERPOLATED — NOT MEASURED
0.100000	+0.03389	INTERPOLATED — NOT MEASURED
0.108333	+0.059576	MEASURED

READ THE COLUMN

The measured values carry six decimals because Tracker reported six. The estimates are shown to five: a straight-line guess does not deserve the instrument's precision.

THE LABEL IS PART OF THE NUMBER

Strip the label and these four rows look exactly like measurements. Nobody downstream could tell. That is the danger.

CHAPTER 6 · PRINCIPLE No. 1

AN ESTIMATE IS NOT A MEASUREMENT — LABEL IT.

Verified from the raw spreadsheet values: -0.043151, -0.017469, +0.008213, +0.033895 m.

Problem



Model



Compute



Analyze



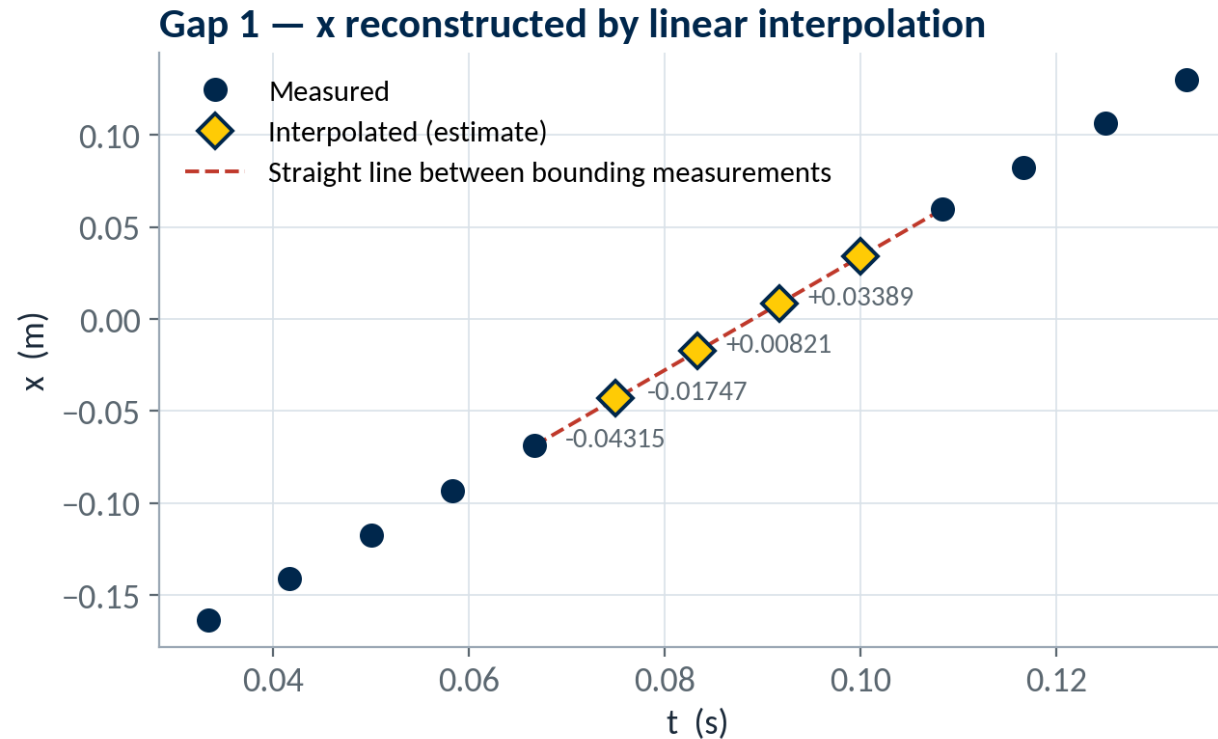
Validate



Improve



Does it look reasonable? And is "it looks smooth" enough?



WHAT THE PLOT SUPPORTS

The four diamonds continue the trend of the neighbours. Nothing jumps. A reviewer glancing at this would accept it.

WHAT THE PLOT CANNOT SUPPORT

Of course it looks smooth — we DREW a straight line between two points and then plotted the line. The plot is the assumption, redrawn. It cannot be evidence for itself.

Smoothness is evidence, not proof. Chapter 3 said it about convergence; it is just as true about a reconstruction. To test the model we need something the model did not produce.

Problem



Model



Compute



Analyze



Validate



Improve



Ten rows, four blanks — the data exactly as Tracker left them

t (s)	x (m)	y (m)	Data Type
0.050000	-0.117594	-0.293563	MEASURED
0.058333	-0.093531	-0.301857	MEASURED
0.066667	-0.068832	-0.308022	MEASURED
0.075000			MISSING
0.083333			MISSING
0.091667			MISSING
0.100000			MISSING
0.108333	0.059576	-0.307425	MEASURED
0.116667	0.082395	-0.301627	MEASURED
0.125000	0.106590	-0.293238	MEASURED

FOUR COLUMNS, ONE RULE

Time | x | y | Data Type. The blanks stay blank until YOU fill them. The Data Type column is not decoration: it will drive two separate plot series — MEASURED and INTERPOLATED — so the provenance of every number survives the plot.

WHY EXCEL FIRST

Every intermediate value is visible in its own cell. When something is wrong, you can point at it. That transparency is why the course puts Excel before Python for every new method.

Open the workbook. Sheet "Gap1" holds the excerpt with raw values; nothing has been filled. Do not type a formula yet — the next slide asks for a prediction first.

Problem



Model

**Compute**

Analyze



Validate



Improve



Predict, then build the formula yourself

1 · PREDICT

Make the $x(t)$ scatter from the MEASURED rows only. Look at the empty band. Sketch what belongs there — you did this on paper in Part 1; now do it on the chart.

2 · MAP THE SYMBOLS TO CELLS

Which cell is t_1 ? x_1 ? t_2 ? x_2 ? Which cell is the requested t ? Write the mapping before typing anything.

symbol	meaning	cell
t_1	time before the gap	A4
x_1	x before the gap	B4
t_2	time after the gap	A9
x_2	x after the gap	B9
t	the row's own time	A5 ... A8

3 · BUILD IT FROM THE EQUATION

Translate $x(t) = x_1 + [(x_2 - x_1)/(t_2 - t_1)] \cdot (t - t_1)$ into a formula in cell B5 using the mapping.

Anchor the four bounding cells with \$ so the same formula can be copied down. The requested time is the only reference that should move.

There is no "magic formula" on this slide on purpose.

The equation is yours; Excel is only the calculator. A formula you built from the mathematics is a formula you can debug. One you pasted is not.

Problem



Model



Compute



Analyze



Validate



Improve



Compute one cell. Compare with your hand result. Then fill the gap.

t (s)	x (m)	y (m)	Data Type
0.050000	-0.117594	-0.293563	MEASURED
0.058333	-0.093531	-0.301857	MEASURED
0.066667	-0.068832	-0.308022	MEASURED
0.075000	-0.04315		INTERPOLATED
0.083333			MISSING
0.091667			MISSING
0.100000			MISSING
0.108333	0.059576	-0.307425	MEASURED
0.116667	0.082395	-0.301627	MEASURED
0.125000	0.106590	-0.293238	MEASURED

t (s)	x (m)	y (m)	Data Type
0.050000	-0.117594	-0.293563	MEASURED
0.058333	-0.093531	-0.301857	MEASURED
0.066667	-0.068832	-0.308022	MEASURED
0.075000	-0.04315		INTERPOLATED
0.083333	-0.01747		INTERPOLATED
0.091667	0.00821		INTERPOLATED
0.100000	0.03389		INTERPOLATED
0.108333	0.059576	-0.307425	MEASURED
0.116667	0.082395	-0.301627	MEASURED
0.125000	0.106590	-0.293238	MEASURED

HAND ↔ EXCEL: B5 must reproduce -0.04315 m

Copy B5 down to B8 — three more estimates, same model

What agreement validates: the implementation — the formula does the arithmetic you did by hand. **What it does not validate:** the local-linear assumption. Hand and Excel agree because they share the same model; sharing a model is not testing it.

Problem



Model



Compute



Analyze



Validate



Improve



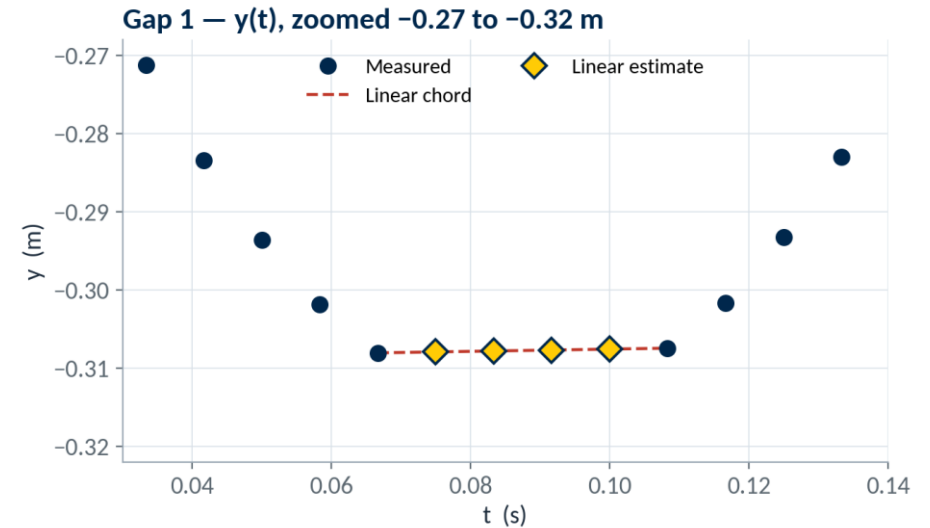
PREDICT

**Same experiment. Same four missing frames.
Same straight-line formula, copied into the y
column in three seconds.**

**Same confidence in the y estimates as in the x estimates? Vote:
yes · no · it depends. Then say what it depends on.**

$$y(t) = y_1 + \frac{y_2 - y_1}{t_2 - t_1} (t - t_1)$$

In the workbook: copy the B-column formula into C5 : C8. The mathematics does not care which column it lives in.



y(t) shown ZOOMED, -0.27 to -0.32 m. At full scale the same picture looks perfectly fine.

Look at where the measured points are heading before the gap and where they come from after it. Then look at the chord.

Problem



Model



Compute



Analyze



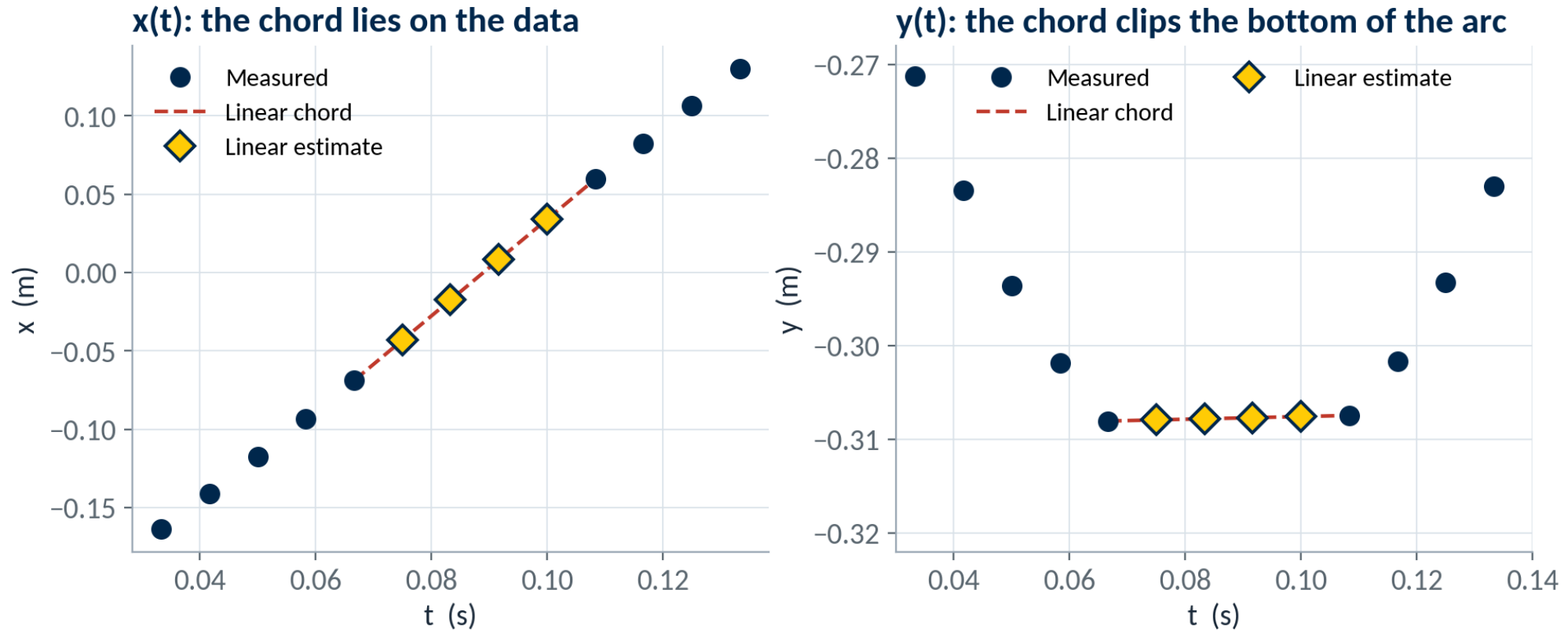
Validate



Improve



Same gap, same algorithm — different confidence



Suitability of linear interpolation depends on LOCAL BEHAVIOUR, not simply on how many frames are missing. x is at its straightest here; y is at the bottom of an arc. A chord never reaches the arc — it always clips an extremum.

Problem



Model



Compute

**Analyze**

Validate



Improve