

Training with Internet

URSI, AP-RASC

August 18, 2025

Demetrios Matsakis

and

Parameswar Banerjee

Talk Outline

- Metrology training with AI, hallucinations and all
 - All but one are free, with \$20/month upgrades
 - Profit drives innovation
 - Google Search often uses AI
 - ChatGBT
 - Claude
 - NotebookLM
 - ResearchRabbit
- Metrology training on BIPM web pages
- An example: n-cornered hat
- Inspirational Training
 - Science Fiction

Using AI to rate AI for electromagnetic metrology

ChatGBT says:

🧠 AI Tools for Training in Electromagnetic Metrology (EMM)				
Tool/Platform	Primary Use in EMM	Strengths	Weaknesses / Limitations	Example Use
ChatGPT (OpenAI)	General-purpose tutor; standards interpretation	Fast, interactive, good at explaining theory, math	No EM-specific database or real-time simulation	Explain traceability or uncertainty
Claude (Anthropic)	Document summarization, Q&A on long standards	Handles long-form content, fast, accurate reasoning	Less context on technical metrology edge cases	Summarize ISO 17025 or calibration SOPs
Socratic (Microsoft Copilot)	In-app, working in Excel or Word for training documentation	Embedded in Office, good for worksheets and logs	Limited knowledge of specialized EM topics	Check uncertainty calculations
Google Notebook LM	Personalized study assistant using uploaded material	Great for organizing and querying technical PDFs	Currently limited access; not interactive	Study NIST/IEC documents on EMC
LabMate / Synaptek (custom LLMs)	Virtual lab assistant in RF and time/frequency labs	Custom-trained on metrology datasets	Not publicly available yet	Step-by-step guidance with instrument use
AIVA / Jupyter w/ SciPy + AI tutor	Interactive notebooks for EM simulation	Reproducible workflows, visualizations	Requires technical setup	Simulate antenna calibration or impedance matching
Digital Twins + AI (e.g., Keysight, NI, Rohde)	Realistic virtual labs with AI tutors	Hands-on practice without real hardware	Costly, proprietary, usually institution-licensed	VNA calibration training

Claude says:

Tool/Platform	Primary Purpose	EM Metrology Strengths	Key Features	Limitations	Best Use Case
Claude (Anthropic)	General-purpose conversational AI	Deep analytical reasoning, complex electromagnetic theory explanation, mathematical derivations	Long-form technical discussions, structured explanations, safety-focused responses	Limited multimodal capabilities, no real-time data access	Conceptual learning, theoretical understanding, technical documentation
ChatGPT (OpenAI)	General-purpose conversational AI	Code generation for simulations, practical problem-solving, visual analysis of circuits/setups	Image analysis, plugin ecosystem, code execution, broad knowledge base	Can be overconfident, requires fact-checking for specialized topics	Practical applications, coding assistance, measurement calculations
Google NotebookLM	AI-powered research assistant	Document analysis for research papers, automatic summarization of metrology literature	Source-grounded responses, document synthesis, audio overviews, citation tracking	Limited to uploaded documents, no real-time calculations	Literature review, research synthesis, academic paper analysis
Socratic (Google)	Educational AI tutor	Step-by-step problem solving for electromagnetic concepts	Educational focus, step-by-step guidance, interactive simulations	Primarily K-12 focused, limited advanced topics	Basic electromagnetic concepts, student self-paced learning

How about music?

ChatGBT:

🎵 Classical vs. Jazz: Which is Easier for AI?

Feature	Classical	Jazz
Structure	Highly rule-based, formalized (e.g., sonata form)	Looser structure, improvisation-heavy
Harmony	Tonal, predictable progressions	Extended chords, modulations, blue notes
Rhythm	Often rigid, tempo-controlled	Swing feel, syncopation, rubato
AI Advantage	Good at rule-following and long structure	Good at capturing stylistic "feel" via training data

✅ Verdict:

- **AI tends to do relatively better at classical composition** (especially Baroque and Romantic styles), because it fits well with algorithmic patterns and formal structure
- **Jazz is harder**, especially the improvisational, human-expressive side—but **AI can still mimic jazz styles** convincingly if trained well.

Claude:

Jazz vs Classical for AI

AI tends to be relatively better at jazz for several practical reasons:

Why jazz works well for AI:

- Jazz relies heavily on pattern recognition and chord progressions that AI can learn effectively
- Improvisation, while creative, follows established harmonic rules and scales
- Jazz has a more modular structure (head-solos-head) that AI can handle
- The genre embraces a controlled randomness that aligns with how AI generates variations

Why classical is more challenging for AI:

- Requires deep structural understanding across long-form compositions
- Classical development and motivic transformation need sophisticated musical reasoning
- Orchestration requires understanding complex instrument interactions
- The emotional arc and formal development in classical works is highly sophisticated

However, Spotify has already replaced jazz played by real players with AI stuff, with most casual listeners unable to tell the difference. [V.com weekend vote: Does ...](#), suggesting AI jazz has reached a convincing level for many applications.

How to treat AI?

a friendly collaborator, not a genie

AI is the first technology I've seen where machines actually behave, think, and—dare I say it?—even *feel* in a way that is recognizably *human*. And that means that, to get the best results, you have to *work with it like you would work with a human*. And that means it is going to be fallible.

The good news is, if you do this, what you get is an intelligent, thoughtful *collaborator*. And that is actually *really great*.

To quote the Stones:

“You can’t always get what you want, but if you try sometimes, you just might find – you get what you need”.

<https://smallcultfollowing.com/babysteps/blog/2025/07/24/collaborative-ai-prompting/>

It's hard not to treat AI as human



BUSINESS

Claude Fans Threw a Funeral for Anthropic's Retired AI Model

BY KYLIE ROBISON | 4-MINUTE READ

Roughly 200 people gathered in San Francisco on Saturday to mourn the loss of Claude 3 Sonnet, an older AI model that Anthropic recently killed.

The BIPM's growing presence (e-learning.bipm.org)

Browser tabs: Current Directory Co..., fred folsom artist - G..., Just make it scale: An..., Frankfurt (Main) Cent..., Confirmation, Stay in Frankfurt | Hot..., Hotels.com - Deals &..., Stay in Frankfurt | Ho...

Browser address bar: e-learning.bipm.org/local/explore/?field%5B0%5D=ta&value%5B0%5D=12&field%5B1%5D=ta&value%

Browser bookmarks: Wiki, Editorial Manager®, 2023 Tempera...oogle Drive, CDDIS | | Dat...s | IERS EOPs, InRaSS training, Index of /ftp/pub/tai, BSJ paper, ChatGPT, Daphne

CBKT

HOME DASHBOARD MY COURSES COURSE CATALOGUE ABOUT US YOUTUBE

Filter by Provider

- ☐ BIPM
- ☐ AFRIMETS
- ☐ APMP
- ☐ COOMET
- ☐ EURAMET
- ☐ GULFMET
- ☐ SIM

Filter by Topic Area

- ☐ Quality Infrastructure
- ☐ CIPM MRA
- ☐ Miscellaneous
- ☐ Mass and Related Quantities
- ☐ Chemistry and Biology
- ☐ Ionizing Radiation
- ☐ Thermometry
- ☒ Time and Frequency
- ☒ Measurement uncertainty
- ☐ JCTLM

Filter by Course Access

- ☐ Open
- ☐ Restricted

Sort by Popularity New A...Z Z...A

Search

EMUE
Examples of Measurement Uncertainty Evaluation

GOOD PRACTICE IN EVALUATING MEASUREMENT UNCERTAINTY; EMPIR PROJECT EMUE 17NRM05

Measurement uncertainty evaluation is at the heart of science and industry as a cross-cutting discipline, impacting ...

VIEW

CCTF TECHNICAL EXCHANGES ON TIME AND FREQUENCY BEST PRACTICE IN NMIS

These online technical exchange meetings are organized by different Working Groups of CCTF to share b...

VIEW

TIME TRANSFER THROUGH GNSS PSEUDORANGE MEASUREMENTS

This course aims at providing knowledge and processing capacity to obtain time transfer through GNSS...

VIEW

TIME & FREQUENCY CAPACITY BUILDING BY RESOURCE SHARING

According to the Recommendation CCTF 3 (2022) "On the establishment of a UTC capacity building programm...

CLOCK DATA CHECKING

This course aims at providing the knowledge of preliminary inspection of the Clocks Data which is the primar...

▾ Overview of the course "Time Transfer Through GNSS Pseudo-range Measurements"

The objective of this course is to provide concepts and a software tool to obtain Time Transfer using GNSS Pseudo Range Measurements using CGGTTS files. It is arranged in 8 sections as follows:

1. **Tutorial** on Time Transfer by GNSS Common-View and All-in-View Methods
2. CGGTTS data format description in an Interactive webpage "**CGGTTS format**"
3. A software tool "**CGGTTS Data Analyser**" was developed for the analysis of CGGTTS data which can also perform the Common View and All-in-View time transfer
4. **User Manual** of the Software "CGGTTS Data Analyser"
5. Video demonstrating the usage of the "**CGGTTS Data Analyser**"
6. **Git Repository** of the source code of the software
7. **Quiz** on GNSS time Transfer through CV and AV methods
8. **Sample** CGGTTS Data Set
9. **References** for the GNSS Pseudo Range Measurements

It is recommended to attempt the quiz to test your understanding of the topic.

The preparation of this course was co-sponsored by **IEEE-UFFC society**.



Forum for discussion

▾ Tutorial on GNSS time transfer by Common-view and All-in-view methods

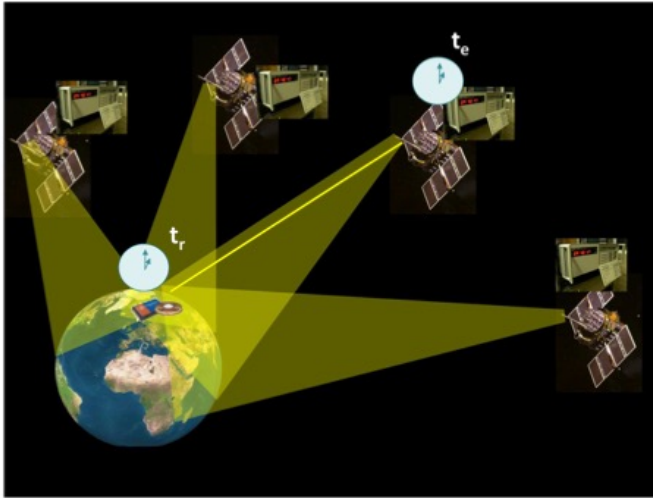
* Course summary

This course aims at providing knowledge and processing capacity to obtain time transfer through GNSS measurements using CGGTTS data.

It offers the following content to the user:

1. A domain expert presentation about common-view and all-in-view methods of GNSS time transfer,
2. Description of the CGGTTS data format version 2E.
3. A general-purpose software "CGGTTS Data Analyser" to perform CV and AV of your own data.
4. The user manual, source code, and demonstrative video of the software.
5. Reference material about the GNSS time transfer methods

The preparation of this course was co-sponsored by **IEEE-UFFC society**.



t_e : emission time (in the satellite clock)
 t_r : reception time (in the receiver clock)

Receiver measures the travel time ($t_r - t_e$),
 which gives a pseudo-distance:
 $P = c (t_r(\text{rec}) - t_e(\text{sat}))$

This measured pseudo-distance contains:

- the true distance satellite-to-receiver
- the desynchronization error between the satellite clock and the receiver clock
- the errors on the measure (atmosphere, multipath...)

2

How the GNSS work (2/2)

Observation Equation

$$P = ||x_{sat} - x_{rec}|| + c(t_{rec} - t^{sat}) + errors$$

Pseudorange measured by the receiver

4 unknowns :

3 for position (Longitude, Latitude, Height)
 1 for Clock desynchronization (receiver-satellite)

If the receiver position is known (with sufficient precision) : only one unknown

$$t_{rec} - t^{sat} = \frac{1}{c} (P - ||x_{sat} - x_{rec}||) - errors$$

To get one receiver clock solution combining all the satellites, use GNSStime:

$$t_{rec} - t^{sat} = (t_{rec} - \text{GNSStime}) + (\text{GNSStime} - t^{sat})$$

broadcast

$$t_{rec} - \text{GNSStime} = \frac{1}{c} (P - ||x_{sat} - x_{rec}||) + (t^{sat} - \text{GNSStime}) - errors$$

A quiz

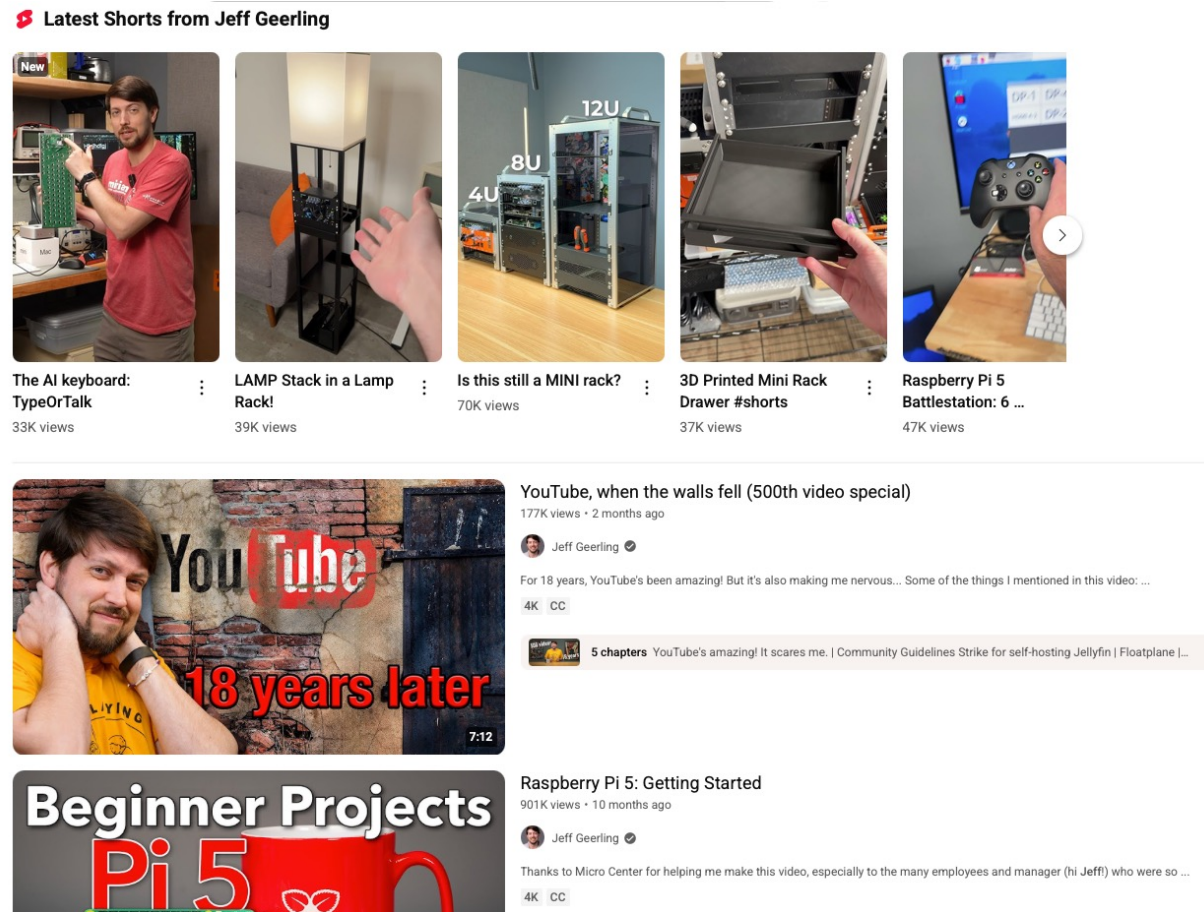
All-in-view method is preferred than common-view method for long baselines as

- ☐ There may not be enough common satellites in common view between the two locations.
- ☐ All-in-View method considers all the satellites in view, but common-view method considers only satellites in common. Hence, the orbital error is better accounted.
- ☐ Ionospheric effects are better compensated in All-in-View method than Common-View method.

✓ Check



YouTube has more information than I could ever hope to know, in every way



Jeff Geerling has >900,000 followers

What is most important attraction: “the Title and the Introduction”

Navigating through presentations (not always implemented)

<https://support.google.com/youtube/answer/7631406?hl=en>

Shortcut	Action
← / →	Rewind/fast-forward 5 seconds
J / L	Rewind/fast-forward 10 seconds
K	Play/pause
0 to 9	Jump to 0% to 90% of the video
Home / End	Jump to start/end of video
Up / Down	Volume up/down
M	Mute/unmute
F	Toggle full screen
T	Toggle theater mode
I	Toggle mini player
C	Toggle captions
Shift + N / P	Next/previous video (in playlist)
./ ,	Frame-by-frame forward/backward (paused only)

Example: N-Cornered Hat *notorious for negative variances*

$$\begin{aligned}\sigma_{AB}^2 &= \sigma_A^2 + \sigma_B^2 \\ \sigma_{AC}^2 &= \sigma_A^2 + \sigma_C^2 \\ \sigma_{BC}^2 &= \sigma_B^2 + \sigma_C^2\end{aligned}$$



$$\begin{aligned}\sigma_A^2 &= \frac{1}{2}\sigma_{AB}^2 + \frac{1}{2}\sigma_{AC}^2 - \frac{1}{2}\sigma_{BC}^2 \\ \sigma_B^2 &= \frac{1}{2}\sigma_{AB}^2 + \frac{1}{2}\sigma_{BC}^2 - \frac{1}{2}\sigma_{AC}^2 \\ \sigma_C^2 &= \frac{1}{2}\sigma_{AC}^2 + \frac{1}{2}\sigma_{BC}^2 - \frac{1}{2}\sigma_{AB}^2\end{aligned}$$

Example:

$$\sigma_{AB}^2 = 1$$

$$\sigma_{AC}^2 = 2$$

$$\sigma_{BC}^2 = 4$$

Implies

$$\sigma_A^2 = -1$$

$$\sigma_B^2 = +3$$

$$\sigma_C^2 = +3$$

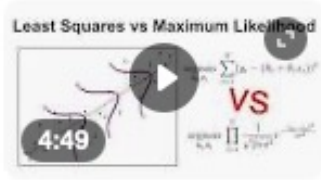
A Great (but brief) Paper, IFCS 2021

Multi-Source Maximum Likelihood Modified Allan Deviation Estimation

James Schatzman
Augustus Aerospace Co
Lone Tree, CO, USA
schatzman@augustusaero.com

Maximum Likelihood

Videos :



Least Squares vs Maximum Likelihood

YouTube · DataMListic

Jul 10, 2024

Least Squares and **Maximum Likelihood** are equivalent in linear regression. The data points are assumed to be drawn from a Gaussian distribution with a mean that lies on the regression line.

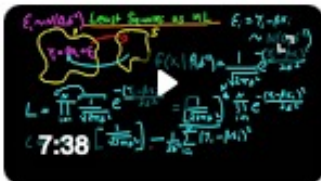


MLE vs OLS | Maximum likelihood vs least squares in linear ...

YouTube · TileStats

Jun 5, 2022

MLE and **OLS** are methods to estimate parameters of a regression line. **MLE** maximizes the **likelihood** function, while **OLS** minimizes the sum of squared residuals.



Least Squares as a Maximum Likelihood estimator

YouTube · Ben Lambert

Oct 30, 2013

Least squares estimators are identical to **maximum likelihood** estimators in linear regression when errors are normally distributed.

[Feedback](#)

Maximum Likelihood vs. Least Squares

- They give the same answer when
 - Model is Linear
 - Errors are independent
 - Errors are identically distributed, zero mean, and Gaussian
- They do not give the same answer when variance errors are Chi-Squared
- Why?
 - The $\sigma_{x,y}^2$ used are *measured* variates, not the true variances
 - The measured $\sigma_{x,y}^2$ are not evenly distributed around the true values
 - They have a Chi-squared distribution and are never negative
 - Mean > median
 - Probability of measuring a variance of 0 is vanishingly small

Gamma Functions

chi squared = gamma (ndf/2,2)

YouTube

gamma function chisquared

00:33:34

$(1/54)x^2e^{-x/3}$

has been shown to integrate to 1, it can be thought of as being a density for a continuous random variable X .

It is now possible to define the gamma distribution.

Gamma Distribution

Definition 4.3.2 (Gamma distribution). A random variable X with density

$$f(x) = \frac{1}{\Gamma(\alpha)\beta^\alpha} x^{\alpha-1} e^{-x/\beta} \quad \begin{matrix} x > 0 \\ \alpha > 0 \\ \beta > 0 \end{matrix}$$

is said to have a gamma distribution with parameters α and β .

Although the moment generating function of a gamma random variable can be found easily from the definition, (see Exercise 31), we shall use the technique. As you will see later, it is very helpful.

Programming Maximum Likelihood is easy

... with a little help from my friends (Chatgpt)

Sample Data	Least Squares	<i>Max Likelihood</i>
$\sigma_{AB}^2=1$	$\sigma_A^2=-1$	<i>5 degrees of freedom</i>
$\sigma_{AC}^2=2$	$\sigma_B^2=+3$	$\sigma_A^2=10^{-10}$ ($>10^{-10}, <10^{-9}$)
$\sigma_{BC}^2=4$	$\sigma_C^2=+3$	$\sigma_B^2=1.06$ ($>1, <4$)
		$\sigma_C^2=+3$ ($>2.2, <6.8$)

The generalization to N-cornered hat, for real data and the correct number of degrees of freedom, is straightforward ... especially with a little more help from my friends

Inspirational Training

Sean Carroll
Sabine Hossenfelder
Neil DeGrasse Tyson
Roger Penrose



Science Fiction can lead the way

- ~150 CE Space Travel (Lucian of Samosata)
- 1865 Air-locks (Jules Verne; later H.G. Wells)
- **1869 Submarines? NO! (Jules Verne did inspire development)**
- 1872 Artificial Intelligence (Samuel Butler)
- 1909 Internet (E. M. Forster, 1909) – also Room with a View & Howard's End
- 1920 Robots (Karel Capek)
- 1922 Drones (Hugo Gernsback)
- 1935 Autonomous cars (David Keller)
- 1935 Virtual reality (Stanley Weinbaum)
- **1945 Geostationary Satellites (Arthur C. Clarke)**
- 1945 3-D printing (Murray Leinster)
- 1947 Mobile phones (Rene Barjavel)
- 1953 Ear Buds (Ray Bradbury)

In 1816, Organ Transplants were anticipated!

Frankenstein, by Mary Shelley



You should write Sci Fi short-stories

1. Pick any science topic of interest to you
 - Stretch one fact or theory
2. Create tension
3. Resolve it
 - Surprise endings never hurt
 - Especially if there are hints along the way
4. Less is more (reference: *Edgar Allan Poe*)
5. Learn from rejections by publishers
 - Do not share until published (except with your spouse or s.o.)
6. You will learn science by playing with it
 - My topics so far
 - Dinosaurs
 - Dark Matter
 - Global Warming
 - Brain Implants
 - Sun as an intelligent being
 - Stopping light
 - Microbes

Conclusions

- AI is changing the world
 - The Internet has already changed the world
- We can treat it as a supplement
 - The next generation will treat it as a fact
- The best way to learn is to tackle a problem.
- Get with it!