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Local LLMs 101: What Really Happens When You Run an AI Model on Your Own Machine

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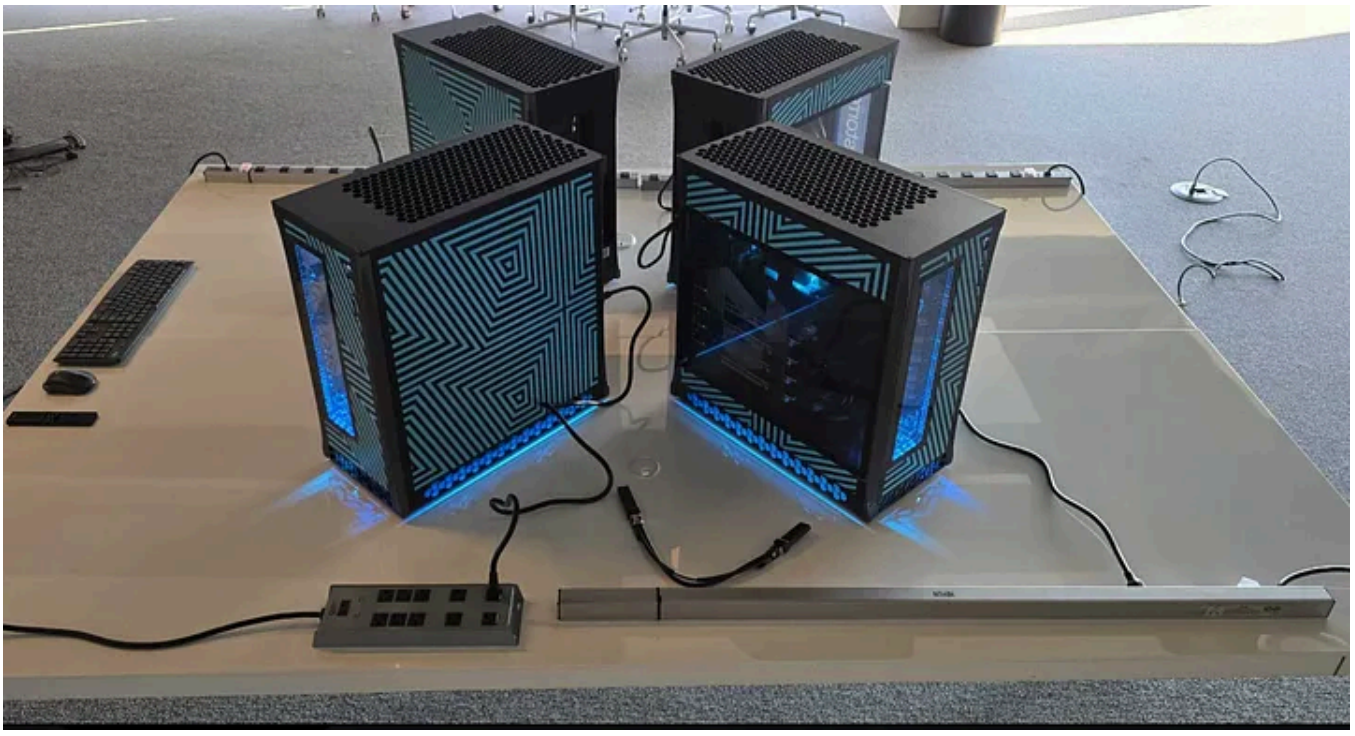
If you've ever tried running a large language model locally — and your GPU fans started screaming — you've probably wondered: *what's really happening behind the scenes?*

Let's explain. No hype, no academic jargon. How these models actually work when you click "Run".



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The Basics: What “Running a Model” Actually Means

When you run a model, you’re performing **inference**. That is simply the technical term for *using the model to make predictions*.

In practice, inference involves the model predicting the **next token** (a segment of text) based on your input and everything it has generated so far.

You can think of it like this small loop:

```
sequence = ["Hello"]
while True:
    next_token = model.predict(sequence)
    sequence.append(next_token)
```

That’s it. The model keeps asking, *“Given all this, what comes next?”* Then it spits out one token at a time. Repeatedly.

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Tokens Aren’t Words

This part confuses many people. Tokens are not the same as words. They are simply the segments of text that the model actually processes.

For example:

- `"hello"` might be one token, or maybe two.
- `"internationalization"` could be five, six, maybe eight tokens.

It depends on the **tokenizer**, which is the tool that breaks up text. Common examples include **BPE (Byte Pair Encoding)** and **SentencePiece**.

So when you hear about a model's **context window** — say 8K or 32K — that's the number of tokens it can "see" at once, not words.
Longer context = more memory, more compute, and slower generation.

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Behind the scenes: It's All Math

At its core, every step is simply this:

```
next_token = f(weights, sequence)
```

- The **weights** are the model's learned knowledge — billions of tiny numbers.
- The **sequence** is what you've typed and what it's generated so far.
- The function `f` is the **transformer architecture**, the brain doing the math.

Every time you produce a new token, the model reanalyzes the full sequence.
That's why it's not blazing fast — it's literally recalculating context at every step.

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What's Inside a Model

When you download a model like *Mistral 7B* or *LLaMA 3*, you're actually getting a little ecosystem:

1. **The architecture** — the “skeleton” (layers, heads, attention, all that jazz)
2. **The weights** — the learned parameters (the actual knowledge)
3. **The tokenizer** — how text gets split into tokens
4. **The config file** — shapes, limits, and metadata
5. **Chat template** — the hidden formatting that makes chat models behave properly

If you ever loaded a base model and received pure nonsense, you probably missed the chat template.
It's like trying to communicate with a robot in the wrong language.

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Model Sizes and the VRAM Reality Check

You’ll see models labeled like “7B” or “13B”.
That “B” stands for **billion parameters** — basically, how many numbers the model learned.

Each parameter consumes space on your GPU's memory (VRAM).
Here’s the rough math:

```
| Precision | Bytes per Parameter | 7B Model Size |
| --------- | ------------------- | ------------- |
| FP16      | 2 bytes             | ~14 GB        |
| INT8      | 1 byte              | ~7 GB         |
| INT4      | 0.5 byte            | ~3.5 GB       |
```

Add a few gigabytes for overhead and **KV cache** — the memory that stores your conversation context.

So if you have, say, an 8 GB GPU, you’ll want a **4-bit quantized model**. Otherwise, it’s game over (or worse: the model starts swapping to CPU — pure pain).

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Transformers: The Real Engine

At the core, there's the **transformer** — the architecture that powers these models. It's designed for sequences, like sentences or code.

Each layer does a few things:

- **Self-attention**: decides which previous tokens matter most
- **MLPs (neural subnets)**: refine the representation
- **LayerNorms + residuals**: keep everything stable
- **RoPE (rotary position embeddings)**: tell the model where each token sits

It's like a multi-layered thought process — each pass gradually enhances understanding.
Stack enough layers, and you develop reasoning, memory, and even personality.

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How the Model Chooses Words

Once the model calculates probabilities for all possible following tokens, it must *select one*.

That's where **decoding** strategies come in:

- **Greedy**: always choose the highest probability (predictable, robotic)
- **Temperature**: adds randomness; higher = more creative
- **Top-k / Top-p**: limit the pool of choices to make text more natural
- **Repetition penalty**: prevents the "I love cats. I love cats. I love cats." loop

Example:

```
token_probs = model(sequence)
next_token = sample(token_probs, temperature=0.8, top_p=0.9)
```

That little sampling trick is the difference between “meh” and “this actually sounds human.”

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Quantization: The Memory Cheat Code

Quantisation means “store numbers with fewer bits.” It is the most effective trick for fitting large models into smaller GPUs.

```
Type Memory Quality     FP16 High Excellent   INT8 Medium Good   INT4 (NF4/GPTQ
```

For most people, **4-bit** is the ideal choice — low memory use and a barely noticeable drop in quality.
Even the **KV cache** can now be quantized, which greatly benefits long chats.

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Running Locally: The Real Options

Depending on your configuration, you can select how to deploy your model.

- **vLLM** → crazy fast, handles multiple users
- **llama.cpp** → simple and portable, great for quantized models
- **ExLlama V2/V3** → optimized for speed
- **PyTorch / Transformers** → flexible, great for experimentation
- **FastAPI / Flask** → if you want to build your own mini API

Local doesn’t always mean “offline.” You can still serve your model to apps — it just s*tays* under *your* control.

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When Things Go Wrong

Let's be honest. Running models locally isn't always smooth. Here are the typical "oh no" moments:

```
| Issue               | Why It Happens                                        |
| ------------------- | ----------------------------------------------------- |
| OOM (Out of Memory) | Model or context too big; try 4-bit or smaller model |
| Gibberish output    | Wrong chat template or high temperature               |
| Sluggish speed      | CPU offloading, no FlashAttention, bad drivers        |
| Suspicious files    | Avoid `.bin`; use `safetensors` for safety            |
```

. . .

Why Bother Running Locally?

Because once you get it working, it's *yours*.

No API limits.
No cloud fees.
No data is leaving your machine.

You can tweak temperature, context size, quantization — everything — until it behaves exactly how you want.
It's like finally driving the car instead of just being a passenger.

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Quick Setup Checklist

Before you hit "Run," double-check:

1. Model fits in VRAM
2. Precision (4-bit if needed)
3. Runtime (vLLM, llama.cpp, etc.)
4. Correct chat template

5. Decoding tuned (temp, top-p)
6. Tested on your use case
7. Served locally via API or script

That's it. You're officially running your own AI model.

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Final Thoughts

Running LLMs locally isn't some mysterious art. It's mainly about **memory, formatting, and patience**.

Once you understand how tokens, weights, and VRAM work together, you can run almost any modern model — from tiny 3B ones to massive 70B beasts (if your hardware supports it).

It's somewhat like building your own spaceship. You don't need to understand every bolt — just enough to keep it flying.

And once it's running?
You'll see: the "magic" everyone mentions is just math, memory, and one token at a time.

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