**🔍 What is a Murmur in PCG?**

In **phonocardiogram (PCG)** recordings, a **murmur** is an abnormal heart sound caused by turbulent blood flow. It appears as a **noisy**, irregular segment **between S1 and S2** (systolic murmur) or **after S2** (diastolic murmur).

Visually, murmurs look like **intense or fuzzy** parts of the waveform that are **longer and noisier** than the typical short-duration S1/S2 heart sounds.

**⚡ What is Energy Thresholding?**

**Energy thresholding** is a simple and effective way to detect **abnormal sound regions** (like murmurs) in a signal:

**✅ Steps:**

1. **Divide** the audio into **small windows** (e.g., 200 ms)
2. For each window, compute the **energy**:

E=∑(x[i]2)E = \sum (x[i]^2)E=∑(x[i]2)

1. If energy of the window **exceeds a threshold**, it may contain a murmur
2. Group contiguous high-energy windows to form **murmur segments**

**🎯 What is an Energy Threshold?**

It’s a **cut-off value** used to decide whether a segment is “high-energy” (possible murmur) or not.

**👉 How to choose the threshold:**

* **Empirical**: Start with something like 0.01 or 0.02 (for signals normalized to [-1, 1])
* **Dynamic**: Use a fraction of the **mean or max energy**:

python

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threshold = 0.5 \* np.mean(energy)

**🧠 Example**

Imagine this simplified signal:

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| S1 | silent | MURMURRRRR | silent | S2 |

Energy plot (in windowed segments):

csharp

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[0.005, 0.004, 0.06, 0.07, 0.06, 0.004, 0.003]

With threshold = 0.02, segments 3, 4, 5 would be labeled as **murmur**.

**✅ Why Energy Works for Murmurs:**

* Murmurs are **longer** and **noisier**, so they have higher energy over time.
* S1/S2 are short, **impulsive sounds** → lower energy in longer windows.
* Silent areas or diastole = very low energy.

**🔧 How to Improve Murmur Detection**

| **Method** | **Benefit** |
| --- | --- |
| **Bandpass Filter (20–200 Hz)** | Removes irrelevant noise |
| **Short Window (100–200ms)** | Captures fine time-scale murmur |
| **Dynamic Threshold** | Adapts to signal loudness |
| **Peak envelope analysis** | For S1/S2 exclusion |

**✅ Summary:**

| **Term** | **Meaning** |
| --- | --- |
| **Energy** | Total power in a time segment |
| **Threshold** | Decision cutoff to detect murmur |
| **Window** | Time duration to calculate energy (e.g., 0.2 sec) |
| **Segment** | Group of consecutive high-energy windows |