ASSIGNMENT 07

THE THEORY OF FAUCET DRIPPING

A dripping faucet can exhibit a transition from regular to chaotic behavior depending on the flow rate of water. The core idea is that as the flow rate of water through a faucet increases, the timing between consecutive drips shifts from a steady, predictable pattern to an irregular, unpredictable one. This shift illustrates the key principles of chaos theory, where a deterministic system (in this case, the faucet) shows sensitivity to initial conditions, leading to complex behavior.

Transition to Chaos: Bifurcation and Period-Doubling

As the flow rate Q increases:

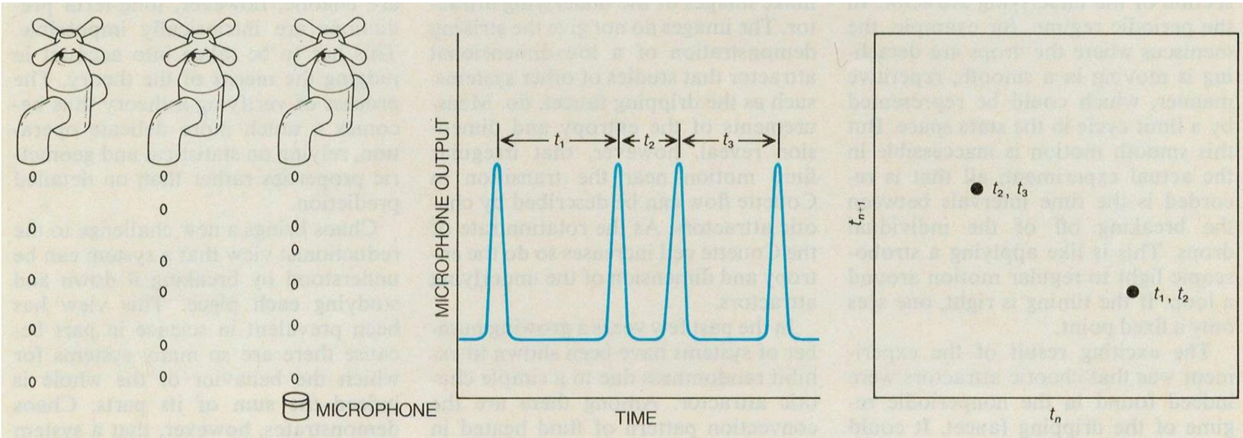
Low Flow Rate: The dripping pattern is regular and periodic. Each droplet detaches after a fixed time interval, resulting in constant time intervals (tn).

Increasing Flow Rate: As the flow rate increases, the system undergoes a **bifurcation**, where the time interval pattern splits:

- Instead of a single constant interval, it alternates between two intervals.
- This is called a **period-doubling bifurcation**, which is a hallmark of systems approaching chaos.

Chaos: At even higher flow rates, the time intervals become aperiodic, meaning there is no discernible pattern between successive drips. This behavior is classified as **chaotic**:

- The system still follows deterministic physical laws, but small variations in conditions lead to vastly different outcomes.
- The intervals between drips are sensitive to initial conditions, making precise prediction nearly impossible.



STEPS TO RECORD THE VIDEO

To record audio of a dripping faucet, use a smartphone or a condenser microphone. Position the microphone about some distance from the drip source in a quiet room, slightly off-axis to avoid splashes. Set the recording format to WAV at 44.1 kHz or 48 kHz for high quality. Ensure the environment is quiet, with minimal background noise and echo. Start recording, keeping the device steady on a stable surface or tripod. Record for at least 1-2 minutes to capture sufficient data for analysis.

Steps for Code and Results

1. Load Audio File:

- Use `scipy.io.wavfile` to read the `.wav` file.
- Convert stereo to mono if necessary and normalize the data.

2. Plot Audio Waveform:

- Use `matplotlib` to display the waveform, showing amplitude over time.

3. Detect Drips:

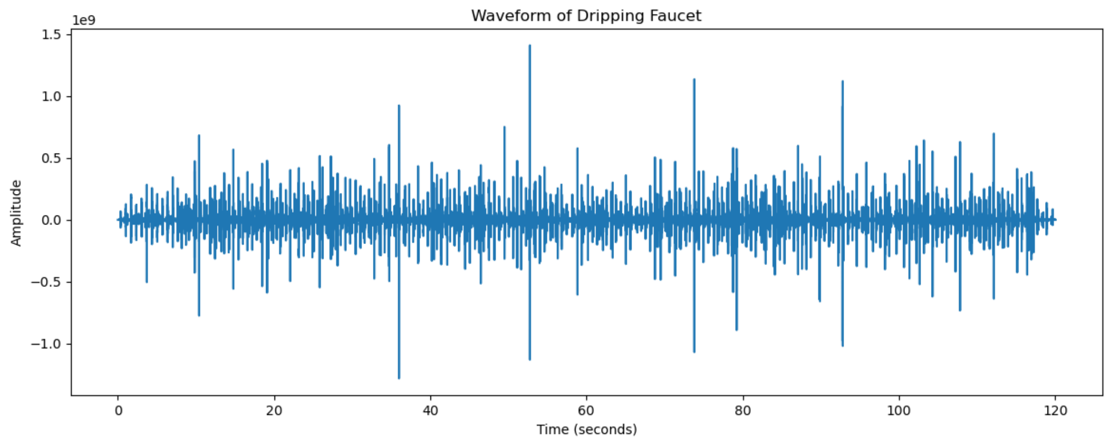
- Apply `scipy.signal.find_peaks` to identify peaks in the waveform, representing drips. Adjust parameters like height and distance for accuracy.

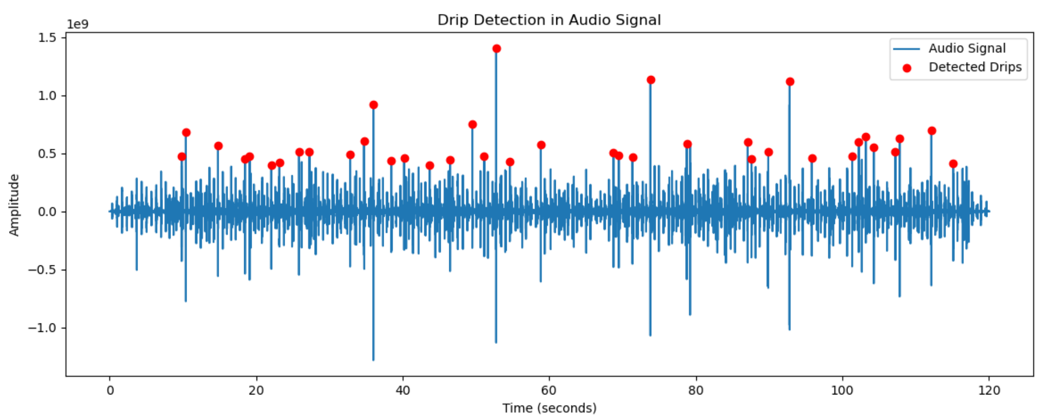
4. Analyze Intervals:

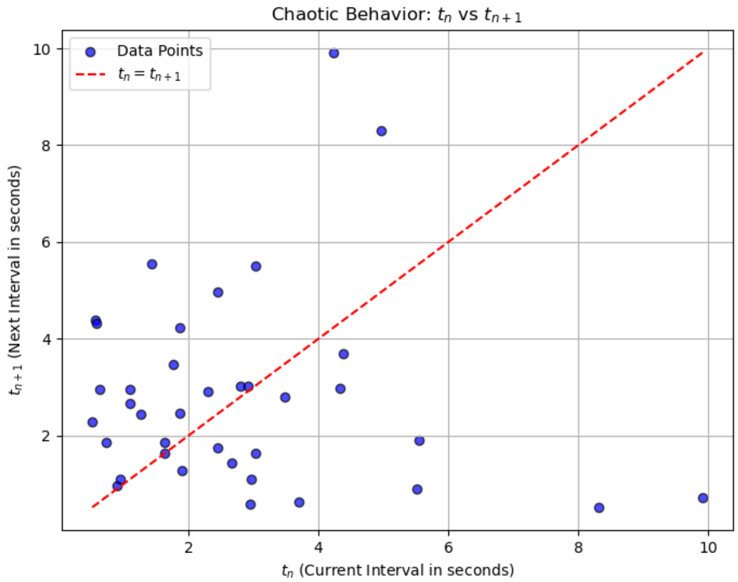
- Compute time intervals between detected drips.
- Plot `$t_n$` (current interval) vs. `$t_{n+1}$` (next interval) to visualize potential chaotic behavior.

Results:

- A clear plot of the audio waveform, with red markers indicating detected drips.
- A scatter plot of `$t_n$` vs. `$t_{n+1}$`, showing the relationship between consecutive intervals, highlighting patterns or chaotic behavior.







Chaotic Behavior: t_n vs t_{n+1}
Data Points
$t_n = t_{n+1}$
t_{n+1} (Next Interval in seconds)
t_n (Current Interval in seconds)
10
8
6
4
2
2
4
6
8
10