Coding #02: Convolutions and Impulse Responses

10 Points Possible

2025/9/10

Attempt 1

In Progress

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Unlimited Attempts Allowed

2025/9/3 to 2025/9/17

Details

📦 Case File #2: *The Voice in the Static*

Agents, surveillance recordings have arrived from an intercepted transmission. Headquarters has provided you with the following function:

```
[z1, z2, z3, h1, h2, h3, fs] = get_surveillance('########');
```

Replace `########` with your **UFID** to retrieve your mission data:

- `z1` → Surveillance recording #1
- `z2` → Surveillance recording #2

- `z3` → Surveillance recording #3
- `h1` → Template signal (a known audio snippet) for recording #1
- `h2` → Template signal (a known audio snippet) for recording #2
- `h3` → Template signal (a known audio snippet) for recording #3
- `fs` → Sampling frequency

Your task is to use **signal processing techniques** (inner products, correlation, convolution, etc.) to analyze these recordings.

Required Tools

`get_surveillance` function: **get_surveillance.p (https://ufl.instructure.com/courses/540008/files/99666503?wrap=1)** **(https://ufl.instructure.com/courses/540008/files/99666503/download?download_frd=1)**

audio files (unzip into same location as `get_surveillance.p`: **audio.zip (https://ufl.instructure.com/courses/540008/files/98989403?wrap=1)** **(https://ufl.instructure.com/courses/540008/files/98989403/download?download_frd=1)**

I recommend you use the standard `conv` function in MATLAB

The standard `fliplr` or `flipud` functions in MATLAB might help create a time reversal

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🔎 Problem 1: Amplitude & Delay in `z1`

The template signal `h1` has been embedded into the recording `z1`. It has been:

- Scaled by an **amplitude factor** `A1`
- Shifted by a **time delay** `delay1` (in samples)

Your mission: identify both `A1` and `delay1`.

Save your results as:

```
save('case2_problem1.mat','A1','delay1')
```

🔎 Problem 2: Amplitude & Delay in `z2`

The second recording `z2` also contains the template signal `h2`. This time, it has been:

- Scaled by an **amplitude factor** `A2`
- Shifted by a **time delay** `delay2` (in samples)
- **Corrupted with additive noise**

Your mission: extract `A2` and `delay2` despite the interference.

Save your results as:

```
save('case2_problem2.mat','A2','delay2')
```

🔎 Problem 3: Counting Occurrences in `z3`

The final recording `z3` is a much longer surveillance signal containing multiple digits (spoken numbers). Somewhere inside, the template signal `h3` has been repeated several times.

Your mission: determine the **number of times** the template occurs in `z3`. Call this result `signalCount`. In addition, send an array (with length equal to `signalCount`) listing the time delay (in samples) for each template occurrence `delay3`.

Save your results as:

```
save('case2_problem3.mat','signalCount','delay3')
```

This recording has a challenge, though. Every spoken number has a random amplitude. The stronger spoken numbers will always dominate the cross-correlation, hiding the weaker template signals. Perhaps if you could *normalize* the energy of each spoken number, you may able to address this.

Hints from HQ 

- **Cross-correlation** is your most valuable tool for detecting hidden copies of the template.
- In `z2`, the presence of noise will test your ability to distinguish signal from clutter.
- In `z3`, think carefully about normalization. There are many different ways to do it.
- In `z3`, you can identify all of the delays by plotting the cross-correlation (or make a more complex automated threshold process).

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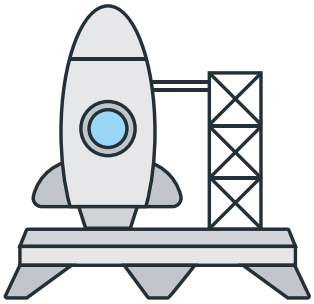

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