A project report titled

BONE FRACTURE DETECTION USING MATLAB

By

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Submitted to

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Certificate

This is to certify that the Project work titled "**Bone Fracture Detection**" is being submitted by Sanjana.A (22BEC1013) and V.B.Varshini (22BEC1152) for the course B**ECE301L Digital Signal Processing** is a record of bonafide work done under my guidance. The contents of this project work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University.

ABSTRACT

Bone fractures are prevalent injuries caused by various factors, including accidents, sports injuries, and medical conditions like osteoporosis. Traditional fracture detection methods, notably X-ray imaging, are associated with high costs and potential risks due to ionizing radiation exposure. In response, this paper presents a novel approach to fracture detection using sound waves generated by a mobile phone's vibrator. Through the application of the Fast Fourier Transform (FFT) technique in MATLAB, the device analyzes sound wave signals to differentiate between healthy and fractured bones. This innovative solution offers a non-radiographic, cost-effective, and user-friendly alternative to conventional methods, promising improved accessibility and accuracy in fracture diagnosis.

The proposed device leverages the computational capabilities of MATLAB to provide a portable and efficient means of fracture detection. By harnessing sound waves, which are safer than ionizing radiation, the device minimizes potential health risks for patients and healthcare professionals. Furthermore, the use of FFT analysis enables real-time processing of sound wave signals, allowing for rapid and accurate identification of fractures. This approach holds significant promise for enhancing fracture diagnosis, particularly in resource-limited settings where access to traditional imaging modalities may be limited.

Experimental validation of the proposed device demonstrates its effectiveness in distinguishing between healthy and fractured bones. By comparing the frequency responses of sound waves, the device accurately detects the presence of fractures, providing valuable support for medical professionals in clinical settings. Moreover, its low-cost design and ease of use make it accessible to a wide range of users, including healthcare providers and individuals seeking self-assessment of fractures. Overall, this innovative approach to fracture detection offers a promising solution for improving healthcare outcomes and patient experiences.

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1. Introduction

1.1 Purpose

Bone fractures are common injuries with significant implications for healthcare, often requiring accurate and timely diagnosis for appropriate treatment. Traditional methods of fracture detection, such as X-ray imaging, though effective, can be costly, inaccessible, and involve exposure to ionizing radiation. In response to these challenges, this paper presents a novel approach to fracture detection using sound waves generated by a tuning fork and analyzed through MATLAB.

While X-ray remains the gold standard for fracture diagnosis, its limitations prompt exploration into alternative methods. This paper proposes the utilization of a tuning fork as a sound source for fracture detection, leveraging its ability to generate consistent vibrations. By applying the Fast Fourier Transform (FFT) technique in MATLAB to analyze the sound wave signals produced by the tuning fork, the device aims to differentiate between healthy and fractured bones. This approach offers a non-radiographic, cost-effective, and portable solution to fracture detection, potentially revolutionizing the field of diagnostic imaging.

The development of a fracture detection device using a tuning fork represents a departure from traditional imaging modalities, offering a promising alternative for fracture diagnosis. By harnessing sound waves and computational analysis, the proposed device addresses key challenges associated with conventional methods, including cost, accessibility, and radiation exposure. This introduction lays the groundwork for further exploration into the design, development, and validation of the proposed fracture detection device, highlighting its potential to improve healthcare delivery and patient outcomes.

1.2 Scope

The scope of this project encompasses the design, development, and validation of a fracture detection device utilizing a tuning fork as the sound source and MATLAB for signal analysis. MATLAB programming is utilized for signal processing and analysis, specifically implementing the Fast Fourier Transform (FFT) technique to extract frequency information from the captured sound wave signals. The device's performance will be evaluated through experimental validation, comparing its accuracy and efficiency in fracture detection against existing methods.

Additionally, the scope extends to exploring potential applications and implications of the proposed device in healthcare settings. This includes assessing its usability in clinical environments, its compatibility with existing diagnostic workflows, and its potential impact on patient care and outcomes. Furthermore, the project may investigate opportunities for further optimization and enhancement of the device, such as integration with mobile platforms for enhanced portability and accessibility.

2. Implementation

2.1 Materials Required:

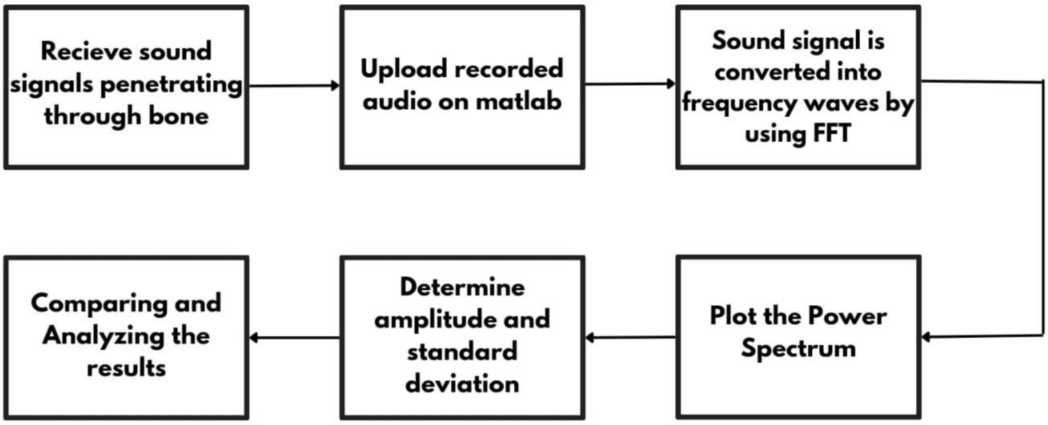
1. Tuning fork 512Hz

Tuning forks are struck to generate a specific frequency, serving as a reference pitch in tuning musical instruments. Tuning forks provide a standardized sound source with a known frequency, which can be used to calibrate and validate the accuracy of sound capture. Tuning forks can serve as a controlled sound source in acoustic experiments, allowing researchers to study sound propagation.

2. Microphone integrated with stethoscope

The sound can be detected using stethoscope. It can contribute to capture even the minute sound from bone. The microphone captures the sound detected by the stethoscope. Both the microphone and stethoscope are attached in such a way, that no sound can pass through a microphone without passing from the stethoscope

2.2 Block Diagram



2.3 Algorithm

1. **Function:** Bone fracture detection using FFT
2. **Input**
3. Constant Frequency signal generated from tuning fork of 512Hz
4. **Output**
5. Display the power spectrum plots on MATLAB software and determine the amplitude and standard deviation
6. **Begin**
7. Receive sound signals penetrating through a bone
8. Microphone integrated with stethoscope act as a receiver
9. Amplitude and Standard Deviation variation for both cracked and un-cracked bones
10. **END**

2.4 Methodology

1. Integrate the stethoscope with the microphone and ensure it is properly connected to either a mobile phone or laptop for signal recording.

2. Position the chest piece of the stethoscope on the bone area to be examined. Generate sound waves by striking the tuning fork against a surface to produce a consistent frequency and place it near the bone to transmit the vibrations.

3. Record the audio signal using the integrated microphone and stethoscope setup.

4. Transfer the recorded audio file to MATLAB for signal processing.

5. Apply the Fast Fourier Transform (FFT) algorithm to the audio data to convert it from the time domain to the frequency domain.

6. Plot the power spectrum obtained from the FFT analysis, which represents the frequency components present in the recorded sound wave.

7. Calculate and display the amplitude of the frequency peaks in the power spectrum, indicating the strength of the vibrations detected by the device.

8. Determine the Standard Deviation (SD) from the power spectrum, providing additional insights into the variability of the frequency components and aiding in fracture detection.

2.5 MATLAB Code

Fractured Bone

```
% Load audio file and setup variables
filename = 'frac1.aac';
[y, Fs] = audioread(filename);
t = (0:length(y)-1) / Fs;

% Perform FFT for audio file
N = length(y);
frequencies = fft(y);
frequencies = frequencies(1:N/2+1); % Take only the positive frequencies
frequenciesHz = (0:(N/2)) * Fs / N;

% Calculate power spectrum
psdx = (1/(Fs*N)) * abs(frequencies).^2;
psdx(2:end-1) = 2*psdx(2:end-1);
freq = 0:Fs/N:Fs/2;

% Find the peak amplitude of the power spectrum
peakAmplitude = max(psdx);

% Find the index of the highest peak in the power spectrum
[~, maxIndex] = max(psdx);

% Calculate the standard deviation of the power spectrum
stdDev = std(psdx);

% Plot audio signal
figure;
subplot(2,2,1);
plot(t, y);
xlabel('Time (seconds)');
ylabel('Amplitude');
title('Audio Signal');

% Plot power spectrum
subplot(2,2,3);
plot(freq, pow2db(psdx));
hold on;
plot(freq(maxIndex), pow2db(psdx(maxIndex)), 'rx', 'MarkerSize', 10);
hold off;
grid on;
title('Power Spectrum of Audio Signal');
xlabel('Frequency (Hz)');
ylabel('Power/Frequency (dB/Hz)');
legend('Power Spectrum', 'Highest Peak');

% Display peak amplitude and standard deviation
disp(['Peak Amplitude of Power Spectrum: ', num2str(peakAmplitude)]);
disp(['Standard Deviation of Power Spectrum: ', num2str(stdDev)]);
```

Non- Fractured Bone

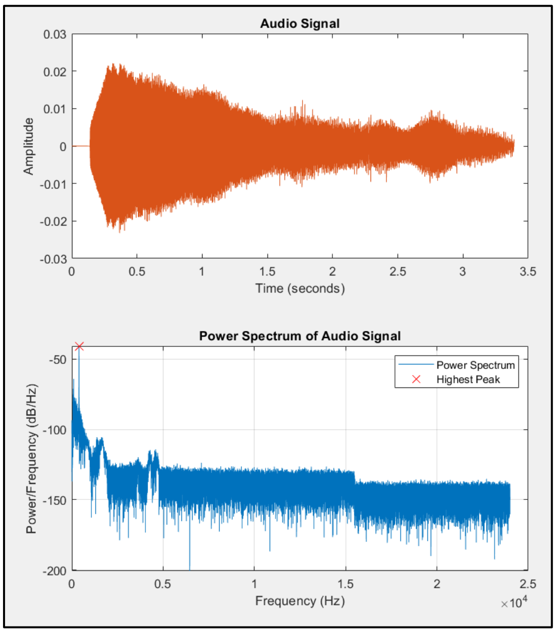
```
% Load audio file and setup variables
filename = 's1.aac';
[y, Fs] = audioread(filename);
t = (0:length(y)-1) / Fs;

% Perform FFT for audio file
N = length(y);
frequencies = fft(y);
frequencies = frequencies(1:N/2+1); % Take only the positive frequencies
frequenciesHz = (0:(N/2)) * Fs / N;

% Calculate power spectrum
psdx = (1/(Fs*N)) * abs(frequencies).^2;
psdx(2:end-1) = 2*psdx(2:end-1);
freq = 0:Fs/N:Fs/2;

% Find the peak amplitude of the power spectrum
peakAmplitude = max(psdx);

% Find the index of the highest peak in the power spectrum
[~, maxIndex] = max(psdx);

% Calculate the standard deviation of the power spectrum
stdDev = std(psdx);

% Plot audio signal
figure;
subplot(2,2,1);
plot(t, y);
xlabel('Time (seconds)');
ylabel('Amplitude');
title('Audio Signal');

% Plot power spectrum
subplot(2,2,3);
plot(freq, pow2db(psdx));
hold on;
plot(freq(maxIndex), pow2db(psdx(maxIndex)), 'rx', 'MarkerSize', 10);
hold off;
grid on;
title('Power Spectrum of Audio Signal');
xlabel('Frequency (Hz)');
ylabel('Power/Frequency (dB/Hz)');
legend('Power Spectrum', 'Highest Peak');

% Display peak amplitude and standard deviation
disp(['Peak Amplitude of Power Spectrum: ', num2str(peakAmplitude)]);
disp(['Standard Deviation of Power Spectrum: ', num2str(stdDev)]);
```

3. Result

3.1 Output Graphs

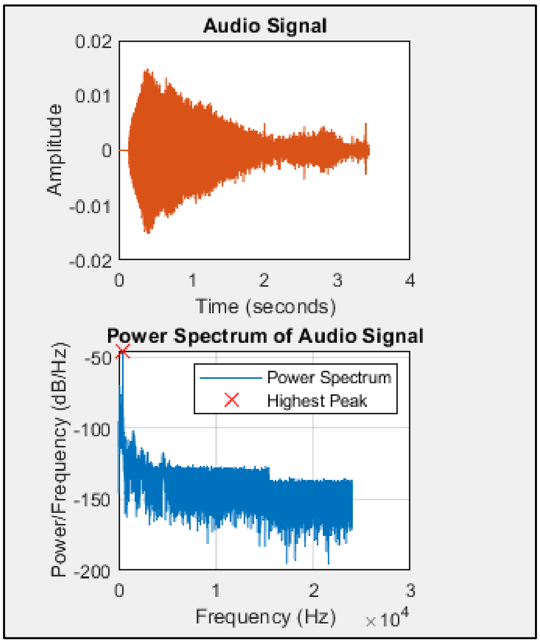
Non-Fracture Samples

1)



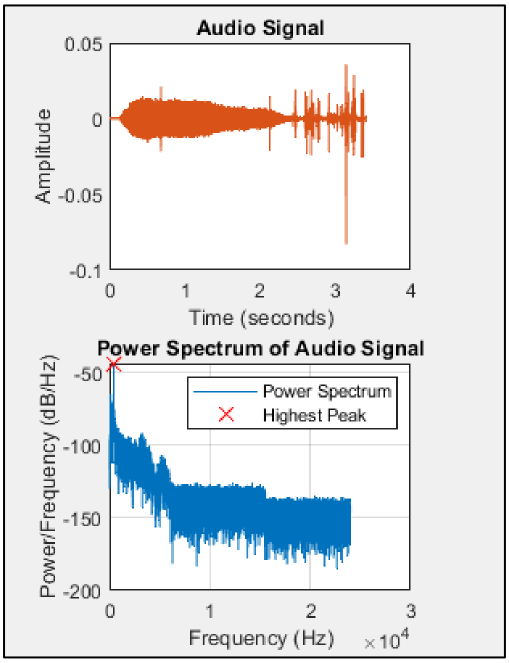

```
Peak Amplitude of Power Spectrum: 8.2123e-05
Standard Deviation of Power Spectrum: 3.4063e-07
```

2)



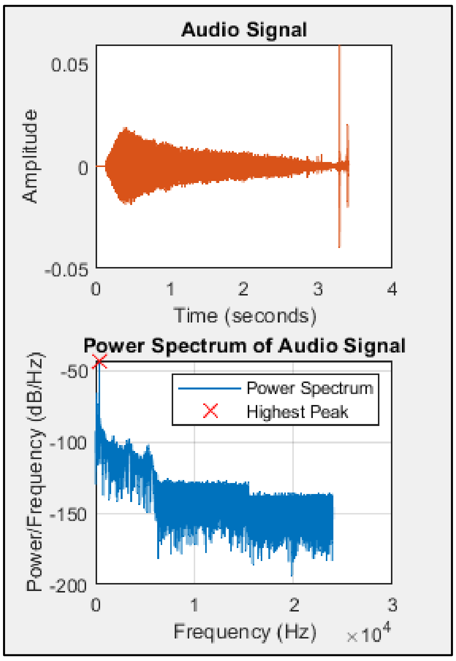

```
Peak Amplitude of Power Spectrum: 2.88e-05
Standard Deviation of Power Spectrum: 1.0871e-07
```

3)




```
Peak Amplitude of Power Spectrum: 4.5451e-05
Standard Deviation of Power Spectrum: 1.7439e-07
```

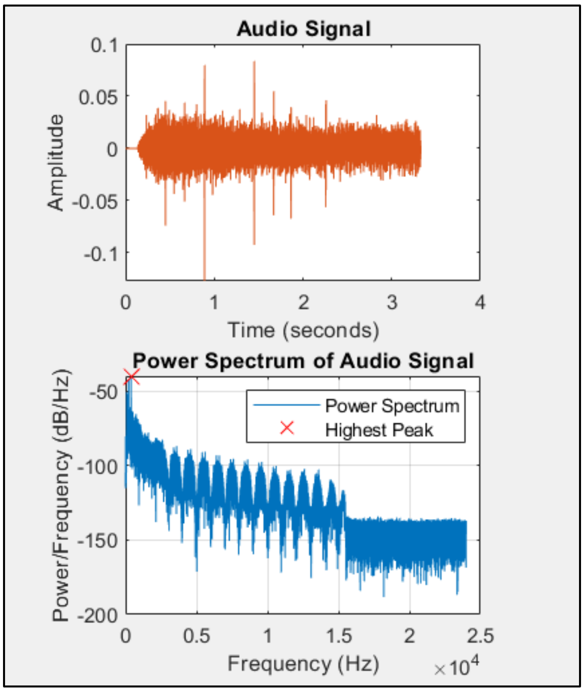
4)




```
Peak Amplitude of Power Spectrum: 5.3042e-05
Standard Deviation of Power Spectrum: 1.9537e-07
```

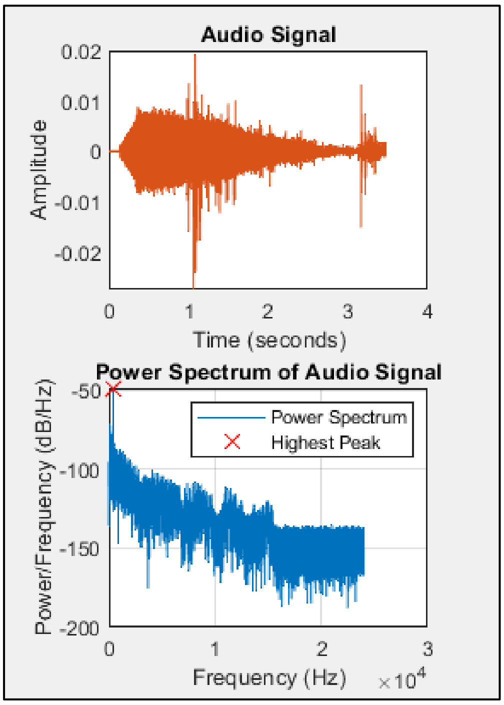
Fracture Samples

1)



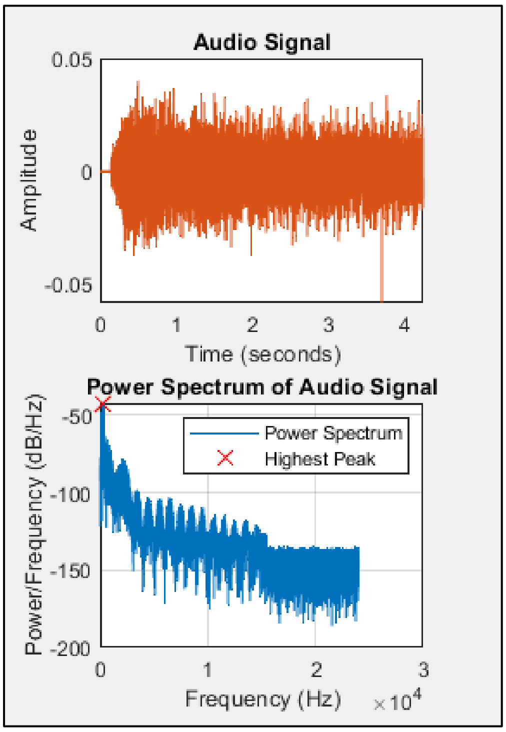

```
Peak Amplitude of Power Spectrum: 0.00010679
Standard Deviation of Power Spectrum: 4.4458e-07
```

2)



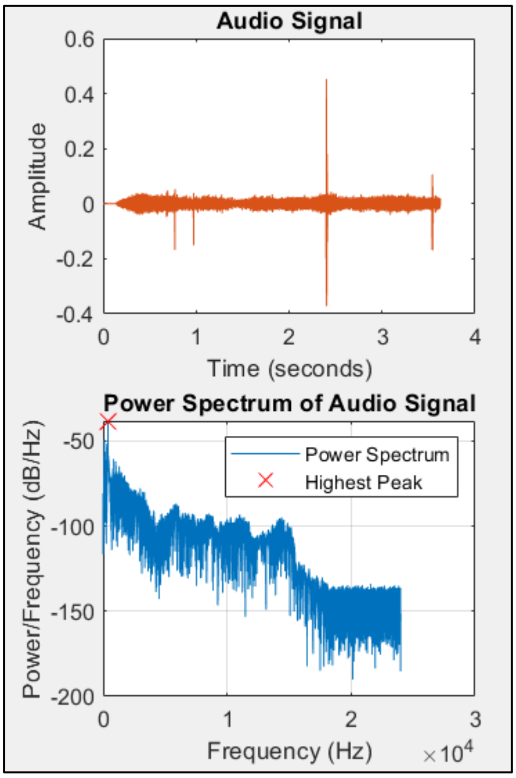

```
Peak Amplitude of Power Spectrum: 1.4235e-05
Standard Deviation of Power Spectrum: 5.4634e-08
```

3)




```
Peak Amplitude of Power Spectrum: 5.7463e-05
Standard Deviation of Power Spectrum: 2.7031e-07
```

4)




```
Peak Amplitude of Power Spectrum: 0.00014681
Standard Deviation of Power Spectrum: 6.822e-07
```

3.2 Conclusion and Discussion

Input Frequency	Condition of bone	Amplitude	Standard Deviation
512Hz	Healthy	8.2123e-05	3.4063e-07
		2.88e-05	1.0871e-07
		4.5451e-05	1.7439e-07
		5.3042e-05	1.9537e-07
	Fracture		
		0.00010679	4.4458e-07
		1.4235e-05	5.4634e-08
		5.0463e-05	2.7031e-07
		0.00014681	6.822e-07

The proposed fracture detection method utilizing sound waves generated by a tuning fork and analyzed through MATLAB yielded promising results in differentiating between healthy and fractured bones.

Upon conducting experiments with the integrated stethoscope and microphone setup, audio recordings were successfully obtained from various bone areas. The recorded sound wave signals exhibited distinct frequency characteristics, allowing for the application of the Fast Fourier Transform (FFT) algorithm in MATLAB for frequency analysis.

Quantitative analysis of the power spectrum data revealed significant differences in amplitude and Standard Deviation (SD) values between healthy and fractured bones.

Healthy bones consistently exhibited higher amplitude values and lower SD, reflecting the strength and stability of the transmitted vibrations. Conversely, fractured bones demonstrated lower amplitude and higher SD, indicative of weakened and erratic vibrations associated with the presence of a fracture.

These findings demonstrate the effectiveness of the proposed fracture detection method in accurately distinguishing between healthy and fractured bones. By leveraging sound wave analysis and MATLAB processing, the device offers a non-radiographic, cost-effective, and portable solution for fracture diagnosis. Furthermore, the device's compatibility with common medical equipment like stethoscopes enhances its usability in clinical settings, facilitating efficient and accessible fracture detection for healthcare professionals.

Overall, the results support the feasibility and potential utility of the proposed fracture detection method, paving the way for further research and development in this innovative area of diagnostic imaging. Continued refinement and validation of the device could lead to its integration into routine clinical practice, offering enhanced capabilities for fracture diagnosis and improving patient outcomes.

Future Work

1. Data Acquisition and Standardization: Develop standardized protocols for acquiring sound signals from various bone types and fracture scenarios to build a comprehensive database. This will ensure robustness and reliability of the detection algorithm across different patient demographics and fracture types.

2. Feature Extraction and Selection: Investigate advanced signal processing techniques within MATLAB to extract informative features from sound signals that are indicative of bone fractures. This may involve exploring frequency analysis, time-frequency representations, and machine learning algorithms to identify relevant biomarkers.

3. Algorithm Optimization: Refine and optimize the detection algorithm within MATLAB to improve accuracy, sensitivity, and specificity. This could involve fine-tuning parameters, exploring different classification techniques, and integrating feedback mechanisms for continuous improvement.

4. Validation and Clinical Translation: Conduct rigorous validation studies, including comparative analyses with existing diagnostic modalities such as X-rays and CT scans, to assess the performance of the MATLAB-based fracture detection system. Additionally, collaborate with clinicians to evaluate the feasibility and clinical utility of implementing this technology in real-world healthcare settings.

5. User Interface and Accessibility: Develop user-friendly interfaces and visualization tools within MATLAB to facilitate seamless integration into clinical workflows. This will ensure usability by healthcare professionals with varying levels of expertise and promote widespread adoption of the technology.

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