Laboratory Course Matlab WS23/24

Measurement Data Analysis

Submitted to
Chair of Manufacturing Metrology

Submitted by,
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1 Questions:

1.1 Task 1:

In this task, we investigated signal processing approaches with the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT). The primary goal was to gain insight into the underlying features of the Fourier transform and use these notions to analyze a vibration measurement on a crane boom.

Three sinusoidal signals are generated and visualized with frequencies (2 Hz, 10 Hz, and 20 Hz) with an amplitude of 0.9, and are plotted in the time domain (sec).

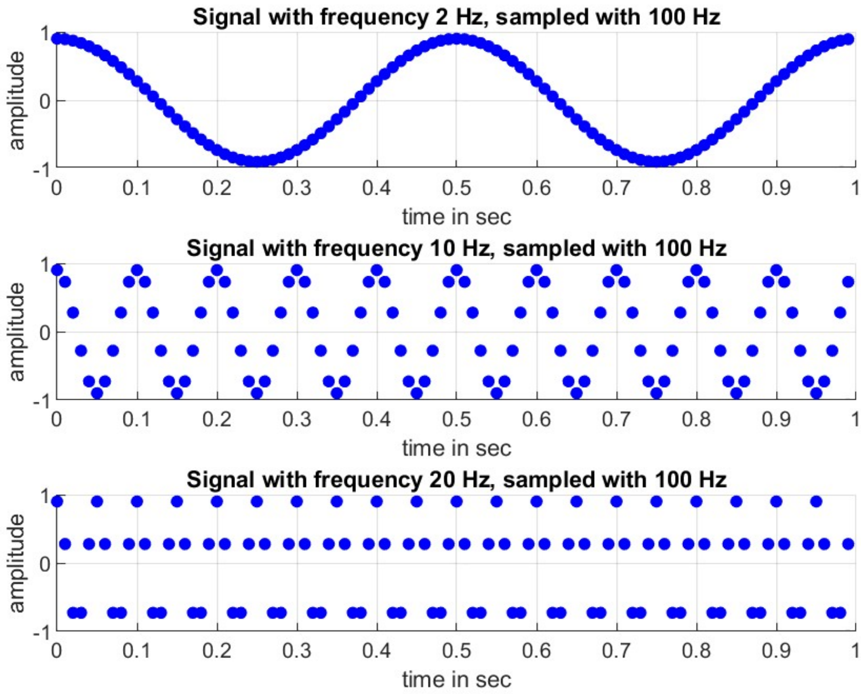


Figure 1: Amplitude Vs Time (sec)

Next step, we analyzed vibration measurement data stored in the DatenSchwingungssensor.xlsx file. Check for Equidistance and number of unique values of x is carried out to perform Fourier transformation which is a crucial step for accurate frequency analysis and the identification of natural frequencies.

Estimated sampling frequency using the time difference between subsequent samples. Using Fourier transformation (FFT), we got double-sided spectra displayed versus frequency, the script explores frequency domain analysis. Logical indexing is used to identify the main frequencies, which results in a cleaned frequency vector that highlights just these important elements. Later, performed FFT on the yValues and plotted the frequency domain.

Finally, Fig.(2) reconstructed the time-domain signal from the cleaned frequency vector using inverse FFT (ifft). This shows a clear picture of the frequency components that have been

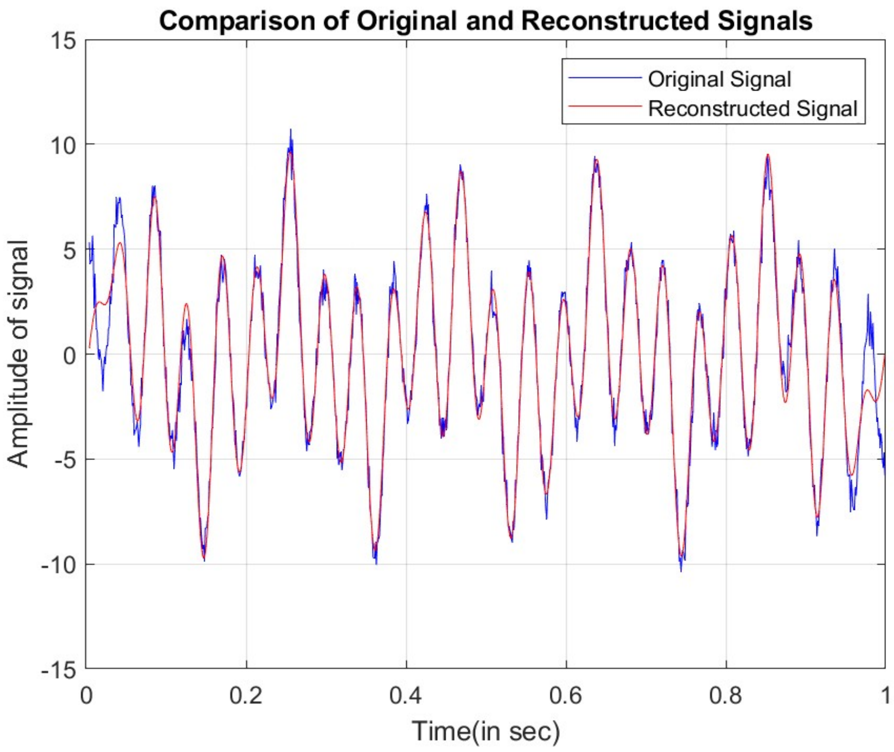
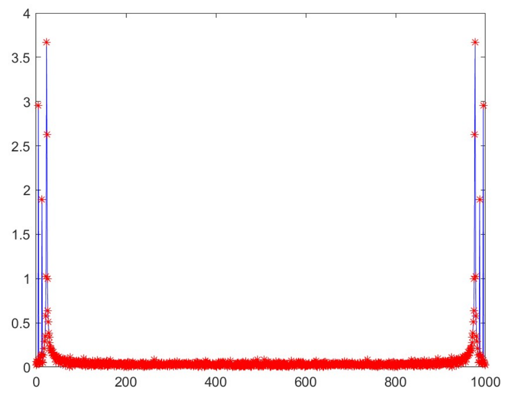
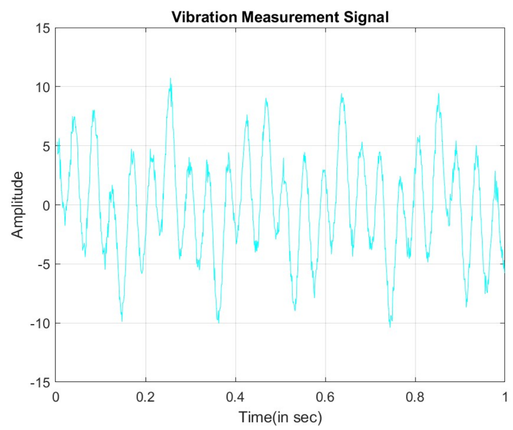


Figure 2: Signal Comparison

maintained and removed while successfully filtering out disruptive elements.



(a) Double-sided spectra



(b) Vibration Analysis

1.2 Task 2:

- Symbolic Representation: Symbolically defines the properties of a simply supported beam, including the moment of inertia, applied force, and beam deflection equation.
- Integration and Boundary Conditions: Utilize symbolic integration to obtain the beam's deflection equation, applying boundary conditions to determine constants of integration.

The surface moment of inertia for the beam, considering a moment about the y-axis is given by Iyy=(bh3)/12. The bending beam is firmly clamped at one end and loaded at the other end with a force F perpendicular to the beam. This leads to the bending moment My(x) = F · (l x). The boundary conditions are evaluated, considering that the beam is firmly clamped on one side, resulting in w (x = 0) = 0 and w(x = 0) = 0. It is emphasized that the dead weight of the beam is neglected.

- Determined the derivative w'(x) by integration with the int() function. Subsequently, the constant of integration C1 is obtained by substituting the boundary condition value in w'(x)s and then using the solve() function to calculate C1.

  For example:

  ```
  w_d = int(w_dd, x) + C1;
  eq1 = subs(w_d, x, 0) == 0;
  solution1 = solve(eq1, C1);
  ```

- Then we replace the constant of integration C1 with a determined expression using subs().

  For example:

  ```
  w_d = subs(w_d, C1, solution1);
  ```

- Then we repeat the same task that we used to determine the function w(x) by integrating w_d using the int function and calculating c2 (constant of integration 2) using the solve function and the boundary condition values.
- Deflection Evaluation: Substitutes numerical values for parameters, such as force, beam height, and material properties, to evaluate the deflection equation at discrete points along the beam.
- Uncertainty Analysis: Quantifies uncertainties in the applied force and beam height, calculates the uncertainty in deflection, and visualizes the deflection profile along with uncertainty bounds.

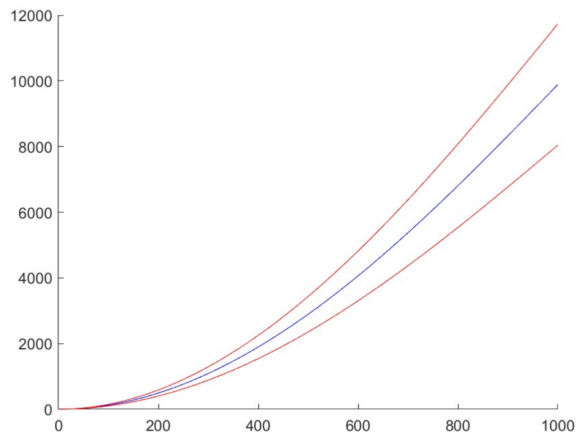


Figure 4: Uncertainty Analysis

- Next, we plot the deflection and the uncertainty graph together. We have three graphs in total: the deflection with uncertainty, the deflection minus uncertainty, and the deflection without uncertainty. We are doing this action to be unable to pinpoint the precise location of the deflection; as a result, we can only determine that it is feasible for the deflection to occur in the zone described above as deflection plus uncertainty and deflection minus uncertainty.
- Random Sampling: to generate random samples for force and beam height to simulate variations, allowing for statistical analysis of their impact on the beam's deflection.
- Histogram Visualization: Created histograms to illustrate the distributions of force, beam height, and deflection, providing insights into the variability of these parameters. For example:

```
subplot(3, 2, 1);
histogram(random_F);
subplot(3, 2, 2);
histogram(random_h);
subplot(3, 2, 3);
histogram(results);
```

  - And then we repeats the procedure with a larger number of random numbers and the histogram is plotted.

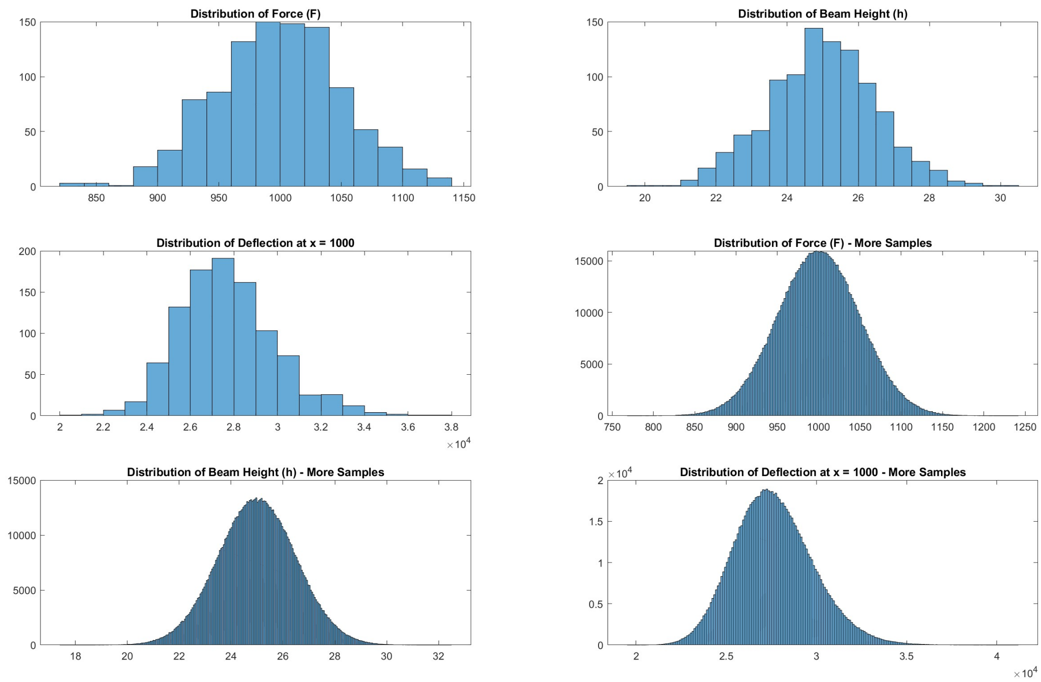


Figure 5: Histogram Visualization