Random Loads and Processes D

Short learning diary

for this learning diary, it is more about a reflection for previous studies and summary.

In first week, the main topic is to define the random process around an engineering project. So, after the meeting, we decide to choose the topic about semi-active suspension system of vehicles. On the one hand, that's more related to vehicle mechatronics. On the other hand, there are more materials to search and cite. We know that on the road, when we are in vehicle's internal space, there are continuous elevation. So semi-active suspension system, which consists of adjustable damper, suspension spring and connected spring(tyre), body and wheel, could have a better consideration in cost and realization of stability. Next, we defined the random road profile, which is explained with data for its fluctuation in vertical direction. But, how to acquire those data to be used to describe a random road profile? Here, we adopt some sensors, such as accelerometer, displacement sensor, and tilt angle sensor. In order to apply these measured dynamic responses, we could build a system with measurement of vertical displacement of road profile as input and get the vertical displacement of vehicle's body as output. Then when getting output after inputting data, we could analyse them although there is no real data or estimated. But here there is a problem about what is the short-term and long-term probability distribution? Mainly, we derived those answers from published articles, such as road profile of analysis or its estimation. Some matched and we know they are Gaussian distribution and Rayleigh distribution respectively. Next week, the main discussion is around what is transient and stationary part for single degree and how to use FFT (fast Fourier Transform) in MATLAB?

In second week, the main topic is the analysis of single-degree-of-freedom linear system and multiple artificial sinusoidal signals with technical aids of narrow band and broad band, signal filtering as well as using window function to decrease the mixture of disturbance after virtual sampling with compound signals. Window functions, such as rectangular, hanning, flattop are interesting, actually, because I didn't understand its theorem from the start of this week. However, after discussion and reading literature and teaching materials, I understand that it is actually also a filtering function, which could extract centralized sections with less noise signal source and extend it in time domain. Another question is what is the difference between narrow band and broad band? What are their features. This question I asked jani for some helps since I still didn't really understand that during our group discussion. Actually, there is an obvious difference and for narrow band it is simple to make a distinction between signals in time domain. Also, the interval of frequency in frequency domain is larger than in time domain. Instead, for broad band, it is difficult to differentiate mixed signals and the signals seems continuous at the same level.

Band type	Characteristics
Narrow band	signal is clear to differentiate in time domain; Larger interval in frequency domain;
Broad band	signal is vague since mixed many waves in time domain; smaller interval;

When it comes to talk about transient part or stationary part, it seems a composition in natural process. It is because like our model, the transient part is the bump or hollow, cavity in the road happening in the flat road surface which is regarded as steady sections. And for the 1-DoF linear system, I think it is more like a simplified version of our model. There are transient part and stationary part and for transient part, they are represented by harmonic force excitation with the multiply of trigonometric and exponential function. Transient part will disappear after some seconds and steady part will oscillate for some time. So for the stationary part, it will oscillate with irregularity and later with regularity when transient signal is disappear. Apart from that, with the help of window function, here with hanning, the signal in time domain will recreate, and it is more clear in frequency domain since the corresponding frequency is only limited to several frequencies rather than cover many frequencies at the bottom. Finally, for freak event, it is only an odd event in engineering field, simply sum of multiple signals to get several amplitudes, such as three sisters or one huge amplitude when phase of different signals is matching.

In third week, the main topic is road spectrum and its characteristics. Besides, we also discussed with road profile relevant to specific engineering and its analysis with a mathematic model. For the road profile, normally, it is in steady state with steady road elevation. For its distribution, we estimate its vertical displacement as root mean square (RMS) for each measurement. Further, we found that the acceleration of a steady road surface is subordinated to gaussian distribution. In order to intuitively understand the concept, we also search for a paper which describe experiments of acceleration data of vehicle at different velocity with sampling frequencies of 500Hz and 1000Hz. Later, we put forward PSD formula of road profile and simplify our model with mathematic equations to get the RAO formula, and finally get the response of road profile with multiplication of the square of transfer function. But here, we didn't understand how to simplify our model with assumptions although we have known that our model is in the steady state. Also, the parameters are input in the MATLAB to estimate. Actually, here I didn't understand how to simulate signal from time domain, and then with FFT to frequency domain, and then with conjugate to represent the real part and imaginary part to ensure the whole signal because the signal will lose reality when there is only real part only using F^2 (square of transfer function). It is really important, and it is our prerequisite to estimate the signal using mathematic equation(spectra) but not a numerical form.

In fourth week, the main topic is to put forward assumptions for the mathematic model and input data into MATLAB to estimate time average, standard deviation and autocorrelation function. I think the difficulty is how to correctly create the artificial signal and use corresponding MATLAB equation to compute it.

For time average, we could use: mean(data);

For standard deviation, we could use: std(data);

For autocorrelation function, we could use: autocorr(sumL,'NumLags',10000);

For probability expression with histogram we can use istogram(data,'Normalization','pdf'). Actually, for mathematic analysis method, I think it could be mastered, but for numeric one, especially, for rainflow analysis, I need more time to comprehense.

In fivth week, along the analysis of week4, the analysis method of rainflow is applied to get the Rayleigh distribution. For the most of contents, such as codes, theory, mathematic model,

we have discussed on previous week. So when we understood what to do in long-term road profile, how to get the probability distribution of peak value in various road situations. Apart form that, we also define the comfort and fatigue, which is totally different from other groups, it's much interesting, from those steel or metal buckle or sth else. The fatigue here is more related to a feeling of comfort when travelling. Finally, the correlation of probability distribution between road profile and those peak values either in short-term or long-term is discussed. And after week5, I think I should take some time to prepare the exam. More emphasis should be put on materials (mathematic formula) and our assignments' submissions.