Structural Health Monitoring (SHM)
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Lecture – 11
Components of Structural Health Monitoring Process- Part 1

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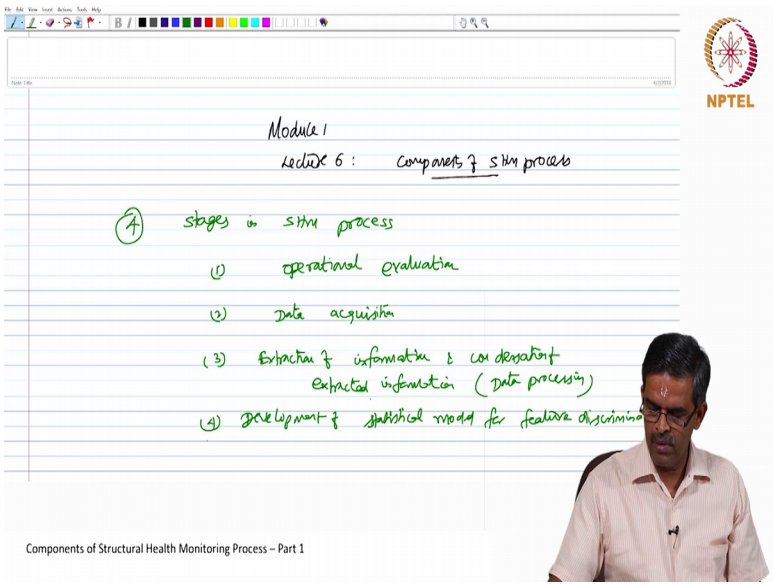

Let us continue to discuss the next lecture in module 1, where we are going to talk about more details on components of SHM process, and what are their significant role in deploying SHM successfully. So, we will talk about various components in SHM process and their role.

As we have already seen, there are 4 stages in SHM process. Namely, operational evaluation, data acquisition, extraction of information and condensation of extracted information what we can say data processing. And the fourth one is development of appropriate statistical model for feature discrimination.

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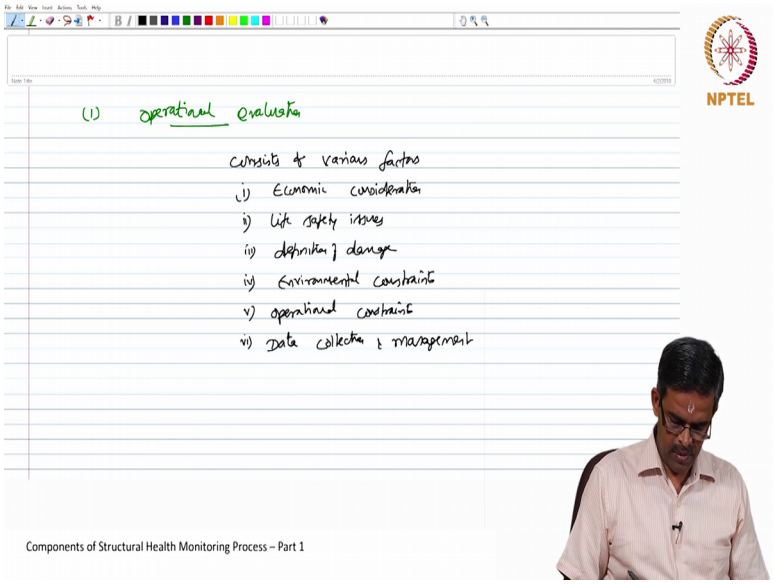

Let us talk about the first stage, which is operational evaluation. This essentially consists of various factors, namely economic consideration, life safety issues, definition of damage, because the sensor choice depends on the type of damage; Then details about environmental constraints, operational constraints and of course, data collection and management.

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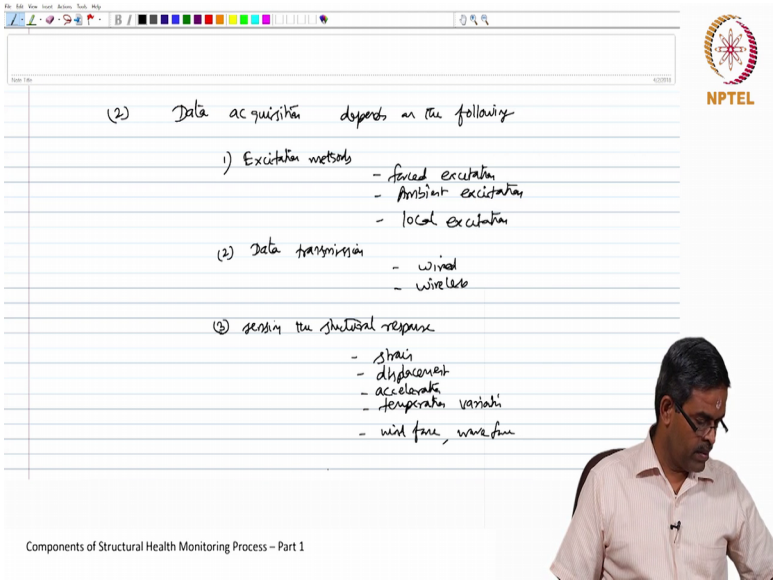

The second stage which is data acquisition depends on the following. It depends on the excitation methods, because the choice of data acquisition system also depends on

whether you are using your force excitation because the number of channels, the frequency and bandwidth all depends on the type of excitation is it an ambient excitation, because in that case the frequency can be relatively low, and is it a local or a global excitation.

Because excitation if it is local the forces will be of a lower level, if it is global it may require larger forces. Second could be the problem with data transmission. Is it essentially wired or wireless? Third item is related to sensing the structural responses. I mean what kind of response are we actually measuring from the structure is it strain? Is it displacement? Is it acceleration? Is it temperature variation is it wind force, wave force etcetera.

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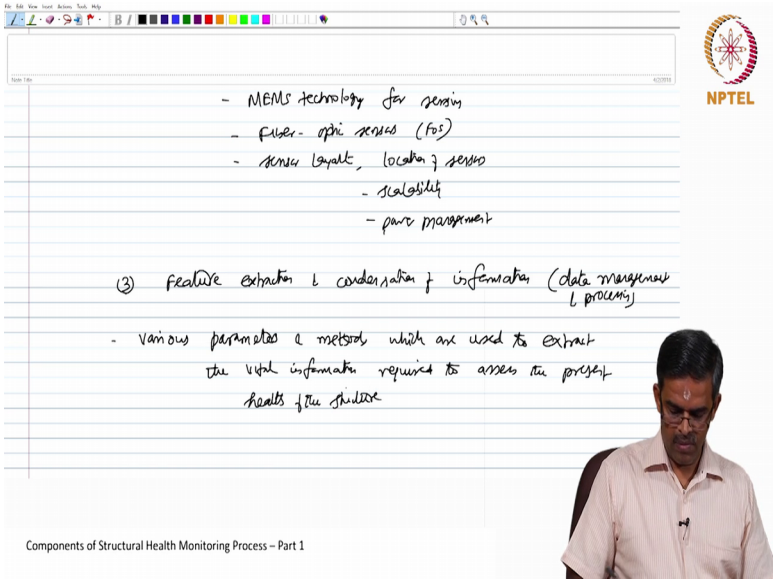

Is it deploying MEMS technology for sensing? Or we really using fibre optic sensors? Then of course, the sensor layout and location of sensors, scalability power management, etcetera.

The third important issue related to the SHM application is feature extraction, and condensation of information; what is other way is called data management and processing.

There are various parameters and methods, which are used to extract information. I should say the vital information, which are required to assess the present health of the structure.

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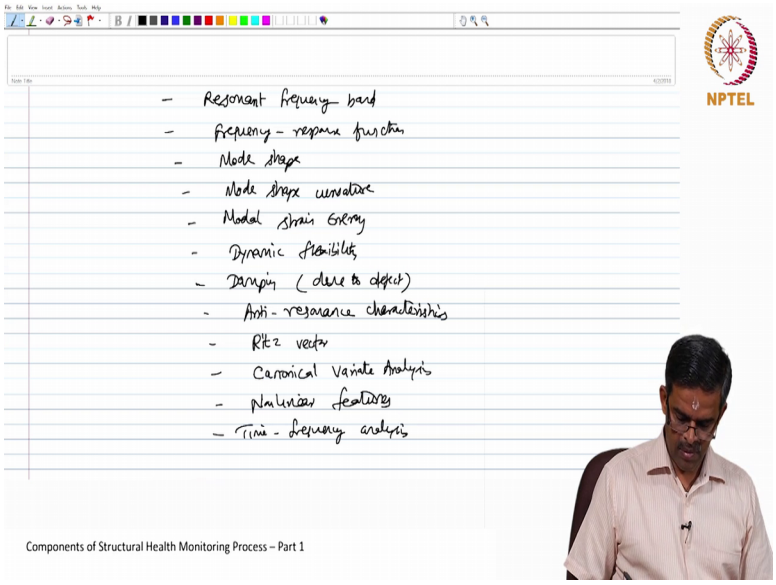

A few of them are listed here, the resonant frequency band of the structure, frequency response function of the structural system, mode shape, mode shape curvature, modal strain energy, dynamic flexibility, damping introduced in the structure because of defect, is there any anti resonance characteristic of the structure Ritz vector, canonical variate analysis, non-linear features, time frequency analysis.

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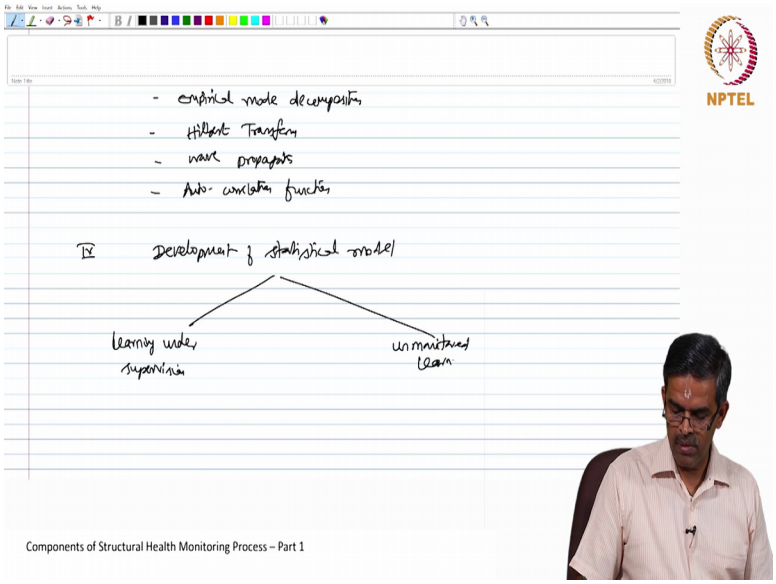

Empirical more decomposition to really know the higher order contributions, Hilbert transform, way propagation and autocorrelation functions.

The 4th level of the compensation process is related to development of statistical model, which is able to identify the vital parameters which are used for assessing the structural health. Now, this can be subdivided into 2, one could be learning under supervision, other could be unmonitored learning.

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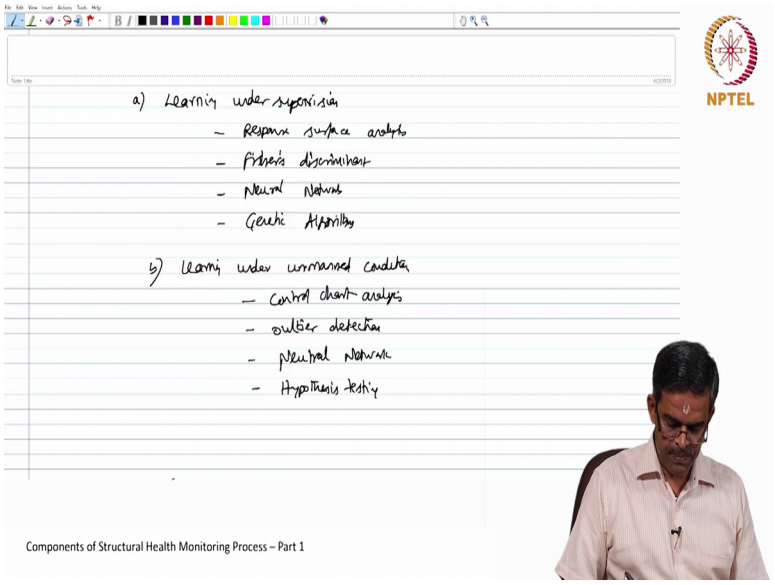

Learning under supervision deals with response surface analysis, Fisher's discriminant, neural networks and genetic algorithms. Whereas, learning under unmanned conditions deals with control chart analysis, which is more or less automatic outlier detection, which will filter out the outlier values of the recorded excitations, of course, neural networks which also has the capability of training the system under unmanned conditions and hypothesis testing.

So, friends we have seen different stages in SHM process, which deals with operational evaluation acquisition extract of information a data processing and management and 4th will be the development of statistical model to feature the discrimination.

One can very easily see here that out of all the four components in SHM process. The most difficult task is choice of statistical model which helps us to really extract the important information related to assessment and monitoring. Having said this, let us talk about a few techniques which makes SHM really a state of art application.

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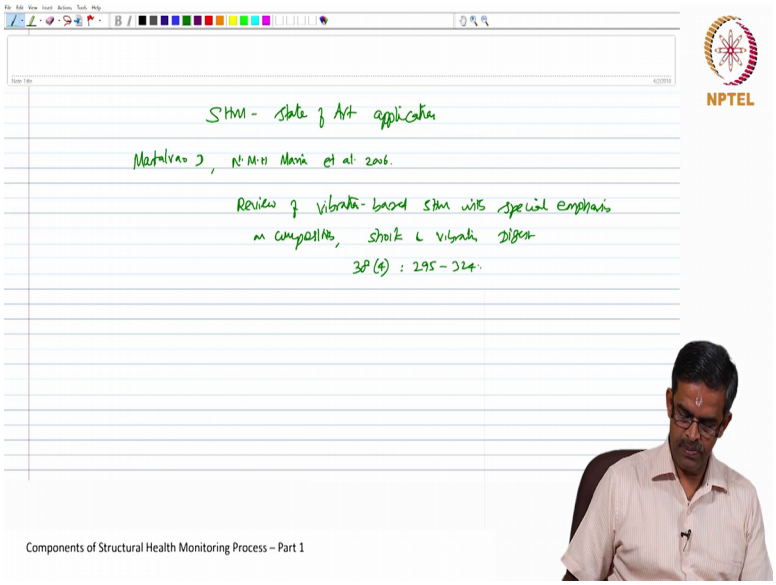

So, this has a specific reference, review of vibration based SHM with special emphasis on composites, shock and vibration digest 295, 324.

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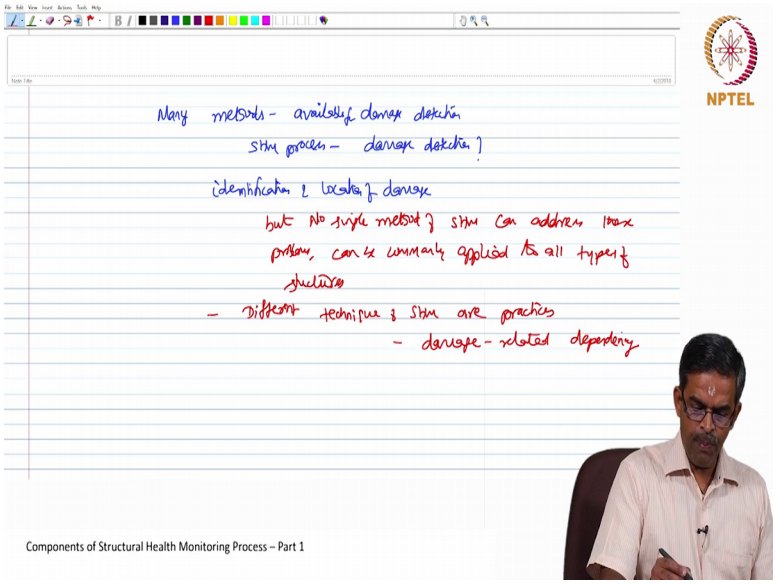

There are many methods available for damage detection. Friends, we all agree that SHM method or the process depends on what is the technique use for damage detection is strongly depends on this process. Therefore, identification and location of damage is very important.

But interestingly no single method of SHM can address these problems which can be commonly applied to all structures. In fact, I should say all types of structures, it means different techniques of SHM are practiced and they are all damage related dependency. There is an important factor in SHM identification which is called sensitivity.

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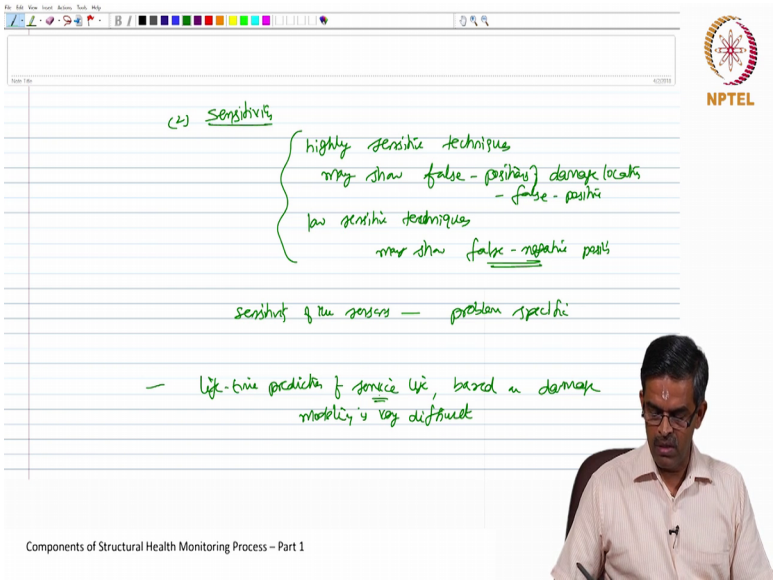

It is very important that highly sensitive techniques may show false positions of damage location. Low sensitive techniques may show falls negative positions.

So, this shows false positive positions, sometimes it shows false negative positions. Therefore, sensitivity of the sensors deployed is again problem specific. Further, lifetime prediction of service life based on damage modelling is actually very difficult to do.

I will show an example later in the next module, where one of the jetties have been assessed for damage modelling and based on which his service life prediction has been made. I will show you the complexity and uncertainty involved in this estimate.

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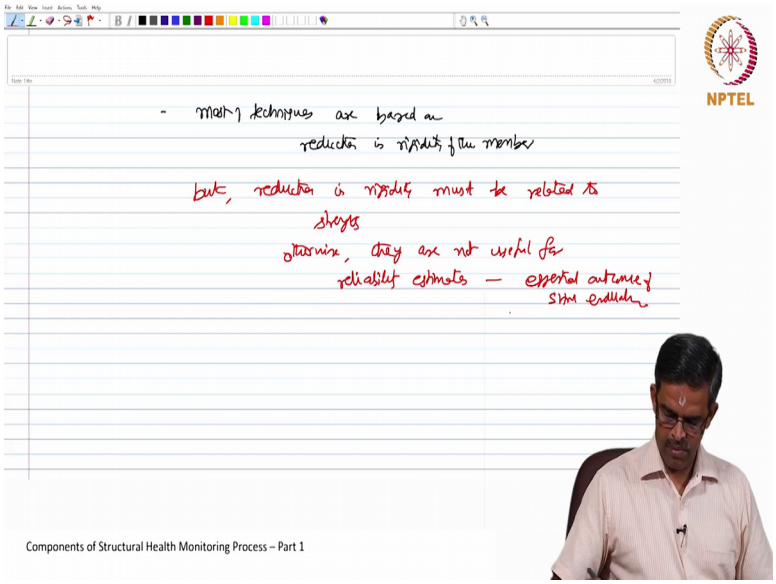

Very importantly, most of the techniques which use the service life prediction based on damage modelling are based on reduction in rigidity of the member. But reduction in rigidity must be related to strength. Otherwise, they are not useful for reliability estimates, which are an essential outcome of SHM evaluation.