Structural Health Monitoring (SHM)
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Lecture - 37
Part - 1: Structural Health Monitoring (SHM) & Statistical Pattern Recognition (SPR)

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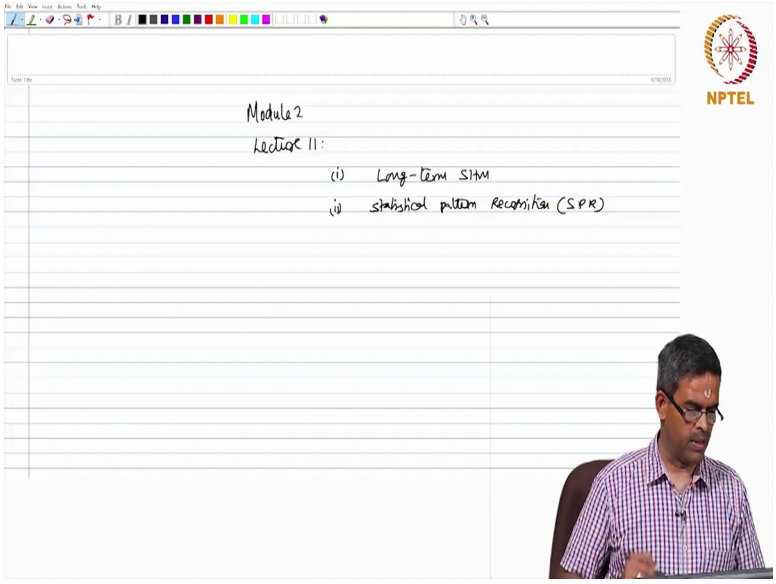

Friends welcome to the next Lecture in Module 2, which is the 11th lecture in this we will talk about 2 things one is long term Structural Health Monitoring, we will also talk about Statistical Pattern Recognition which is abbreviated as SPR.

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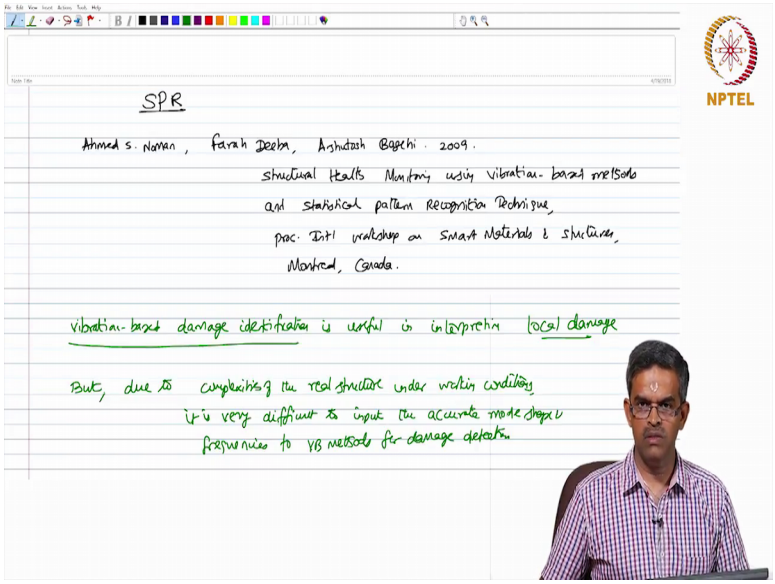

To start with let us discuss about SPR one can see more details about SPR in this paper, this is actually proceedings of an international workshop on smart materials and structures held in Montreal Canada in the year 2009. We will talk about the brief introduction to statistical pattern recognition test and it is application to vibration based methods in structural health monitoring in this lecture, along with that we will discuss details about what are the implications of long term structural health monitoring? Ok.

We have already seen and accepted a fact that vibration based damage identification useful in interpreting the local damage. Let me emphasize this fact repeatedly in different lectures, local damage detection is very easily and conveniently done using vibration based methods, but unfortunately due to the high complexities of the real structure under working conditions, it is very difficult to input the accurate mode shapes and frequencies, to vibration based methods for damage detection.

Because, we know these methods want or demand input of mode shape and frequency to obtain the mode shape and frequency of a real structure under working condition is very complex.

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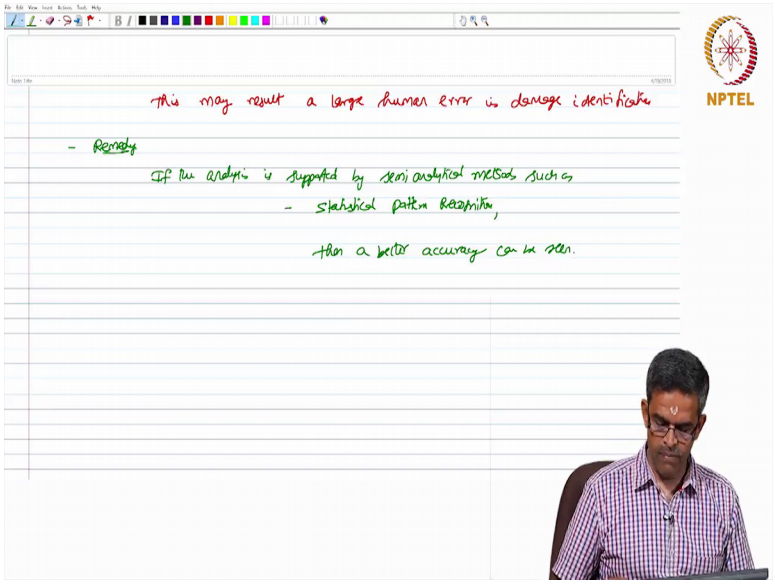

So, this may result this may result a large human error in damage identification, but there is a remedy for this the remedy is if the analysis is supported by semi analytical methods such as statistical pattern recognition, then a better accuracy can be seen.

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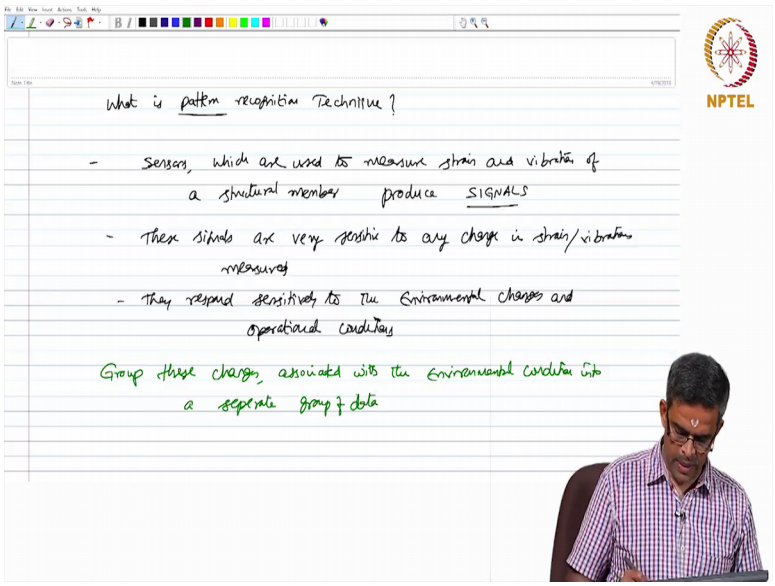

So, the question asked is what is pattern recognition testing more technique. So, the basis is sensors, which are used to measure string and vibrations of a structural member ok, produce signals. These signals are very sensitive to any change in strain or vibrations

measured, they respond sensitively to the environmental changes and operational conditions.

So, what do we actually do is we try to group these changes, associated with the environmental conditions into a separate group of data.

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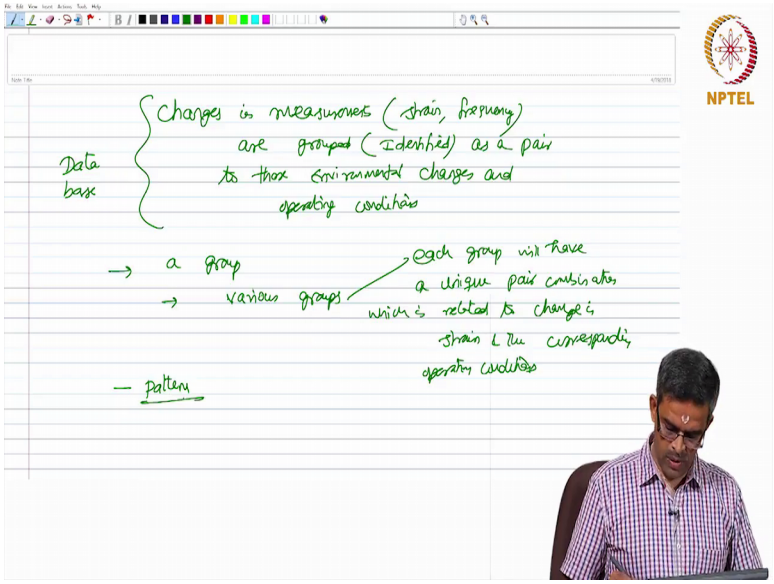

That is changes in measurements what are the measurements used for example, strain, frequency, etcetera are grouped that is identified as a pair to those environmental changes and operating conditions.

So, we a we create a database which is actually a group like this we create various groups, each group will have a unique pair combination, which is related to change in strain and the corresponding operating conditions we call this as a pattern.

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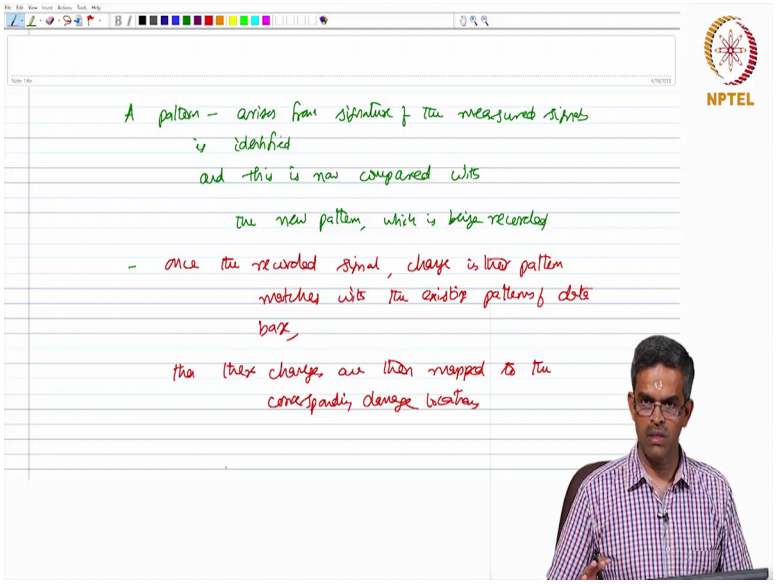

So, now a pattern which essentially arises from signature of the measured signals is identified and this is now compared with the new pattern, which is being recorded. Once the recorded signal, change in their pattern matches with the existing patterns of database. Then these changes are then mapped to the corresponding damaged locations.

So, it is very simple that we do not compare every signal to identify the damage. We try to compare the measured signal signatures with the existing patterns, which are saved, which are grouped in the given database.

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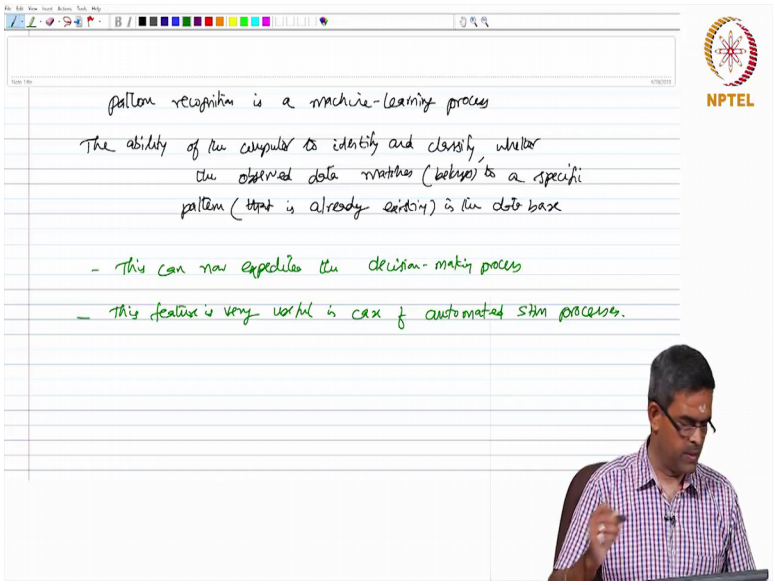

So, we call this as pattern recognition. Therefore, pattern recognition is a machine learning process that is it is the ability of the computer to identify and classify, whether the observed data matches or belongs to a specific pattern that is already existing in the database. So, what is the advantage of this? This can now expedite the decision making process. This feature is very useful in case of automated SHM processes.

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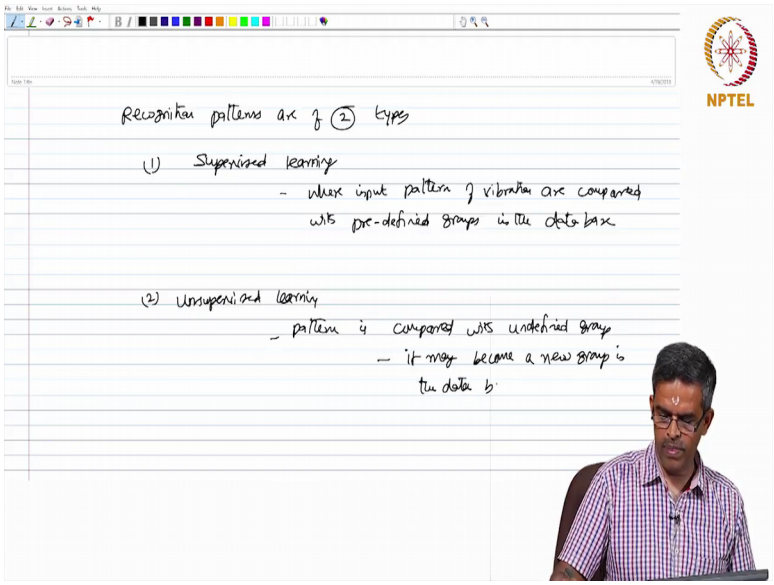

Now, recognition patterns one of 2 types; namely supervised learning which means that where the input patterns of vibration are compared with predefined groups in the database. Alternatively you can also have unsupervised learning. This means that pattern is compared with undefined group possibly it may become a new group in the database.

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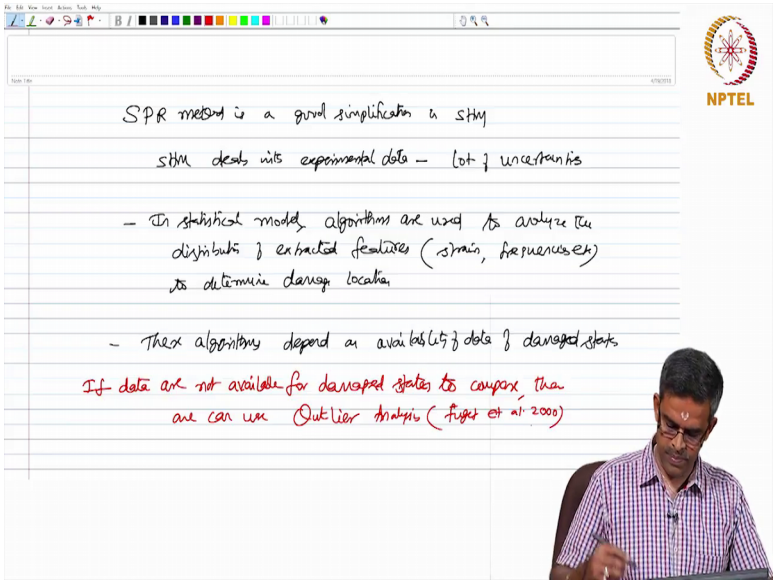

Now, statistical pattern recognition method is a good simplification in structural health monitoring. We know structural health monitoring deals with experimental data, which anyway has lot of uncertainties. These uncertainties can be handled in statistical model; different algorithms are used to analyze the distribution of extracted features. What are the normal extracted features? Maybe the strain measurements may be frequencies, etcetera to determine the damage location. However, these algorithms depend on availability of data of damaged states.

Now, if the damaged states are not available for damaged states to compare, then one can use outlier analysis. You can see more details about this and Fuget et al 2000.

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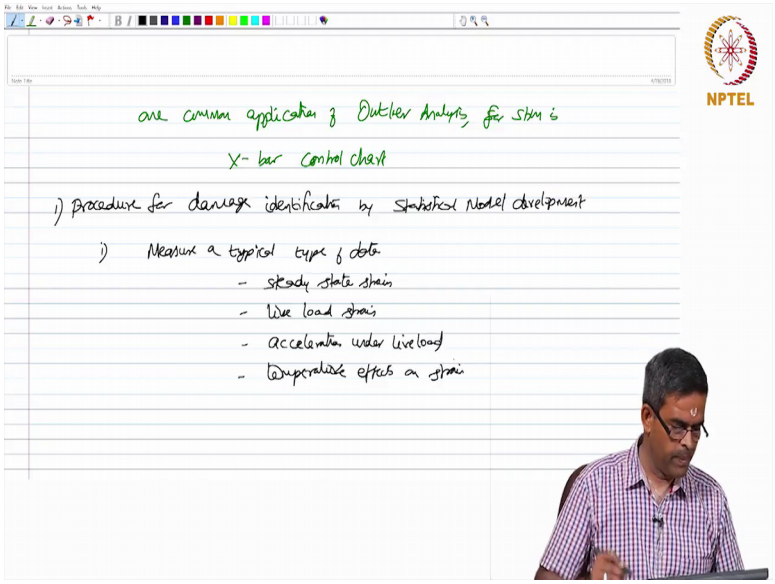

One common application of outlier analysis recommended for structural health monitoring is X-bar control chart. We will not be able to discuss more detail about the specific application (Refer Time: 18:47) Fuget et al 2000 to learn more about the X-bar control chart and it is application as far as SPM is concerned. Now let us look into the procedure for damage identification by statistical model development.

So, first step will be measure a typical set of data. Namely steady state strain live load strain, acceleration under live load, one can also measure temperature effects on strain.

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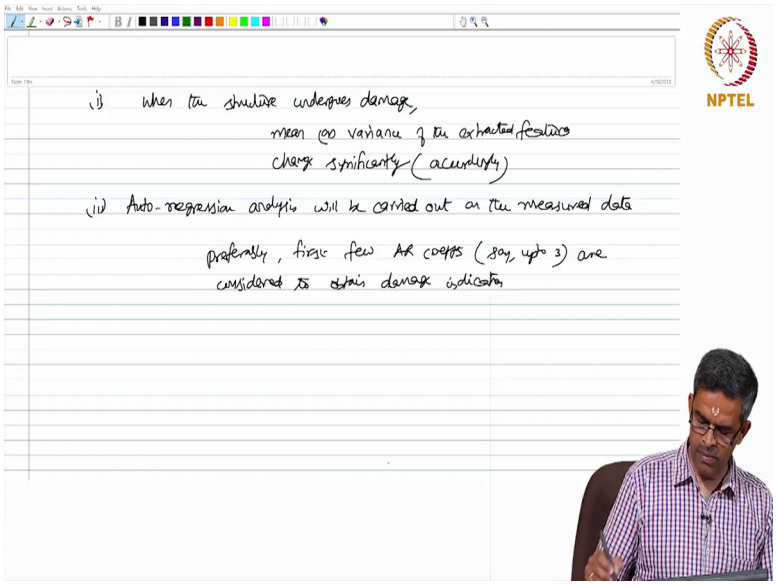

Once they are measured when the structure undergoes damage mean on variance of the extracted features change significantly. In fact, they change accordingly subsequently auto regression analysis will be carried out on the measured data preferably, first few auto correlated regression coefficients. Say up to 3 or considered to obtain damage indications.

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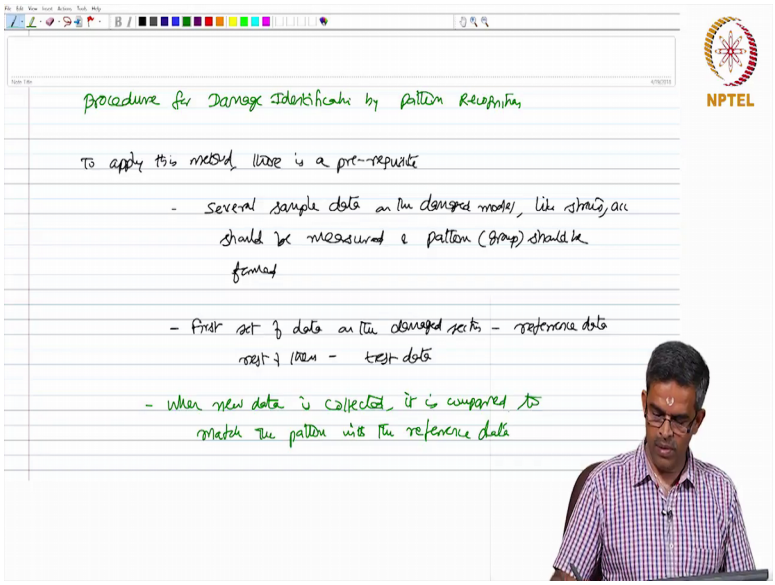

Let us now see the procedure for damage identification by pattern recognition to apply this method there is a prerequisite. The prerequisite is several sample data on the damaged model, like strain acceleration should be measured and pattern let us say group should be formed.

The first set of damaged data that is first set of data on the damaged section can be considered as the reference data. The rest of the data can be considered as the test data. Now, when new data is collected it is compared to identify or let us say to match the pattern with the reference data.

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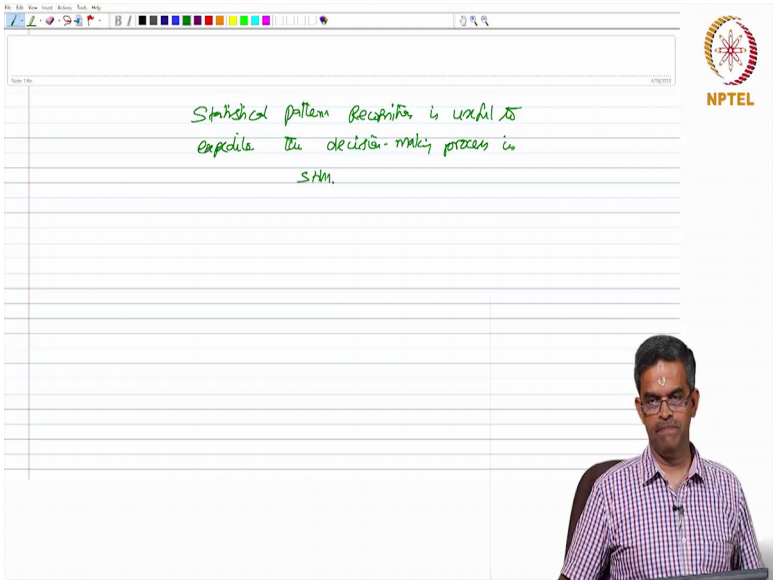

So, friend's statistical pattern recognition is useful to expedite the decision making process in Structural Health Monitoring.