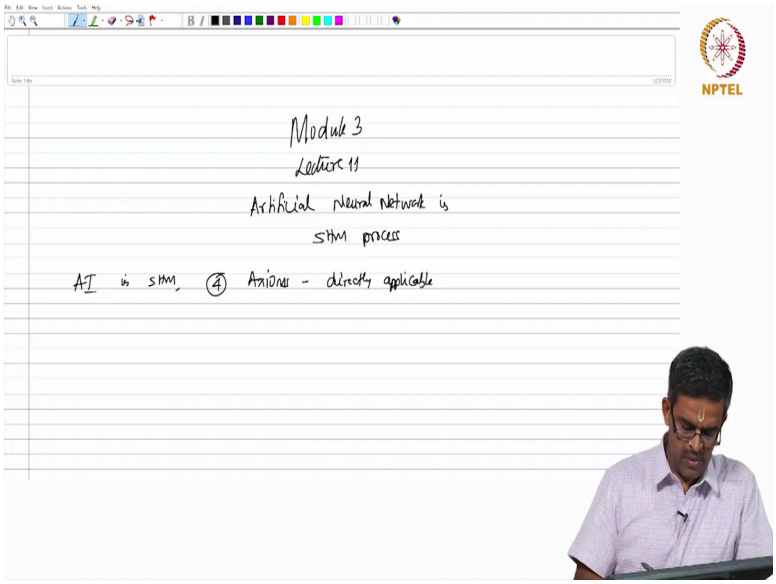
Structural Health Monitoring (SHM)
Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Lecture - 63
Part - 1: Artificial Neural Network (ANN) in SHM process

Friends, welcome to the 11th lecture in module 3.

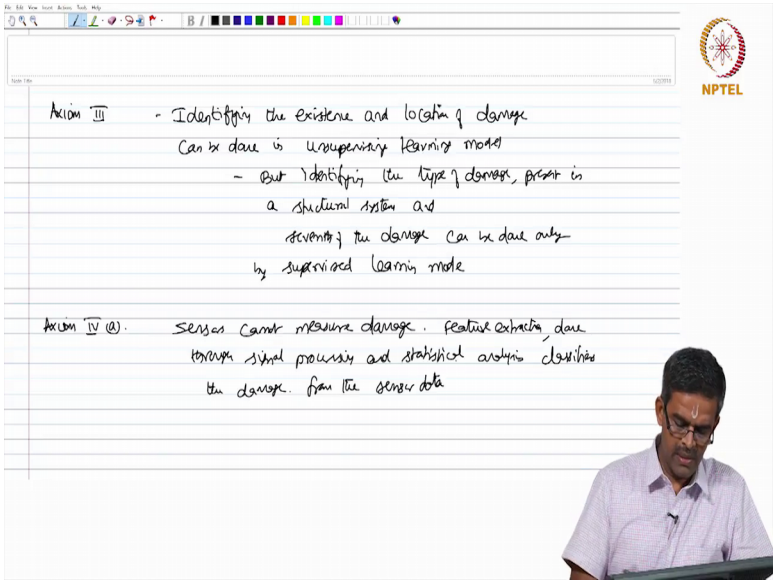
(Refer Slide Time: 00:21)



In this lecture we will talk about the use of artificial neural network in structural health monitoring processes. In the last lecture we discussed about the use of artificial intelligence in general compared to the computation intelligence, and how the interference helps us to improve upon the intelligent sensing, and decision making processes which are very vital and important in structural health monitoring scheme or a network.

So, in this lecture we will extend that artificial intelligence source of information to a neural network. And see how this can be useful in simple applications as far as SHM is concerned, when we talk about use of artificial intelligence in structural health monitoring. There are about four axioms which are very useful and directly applicable axiom one.

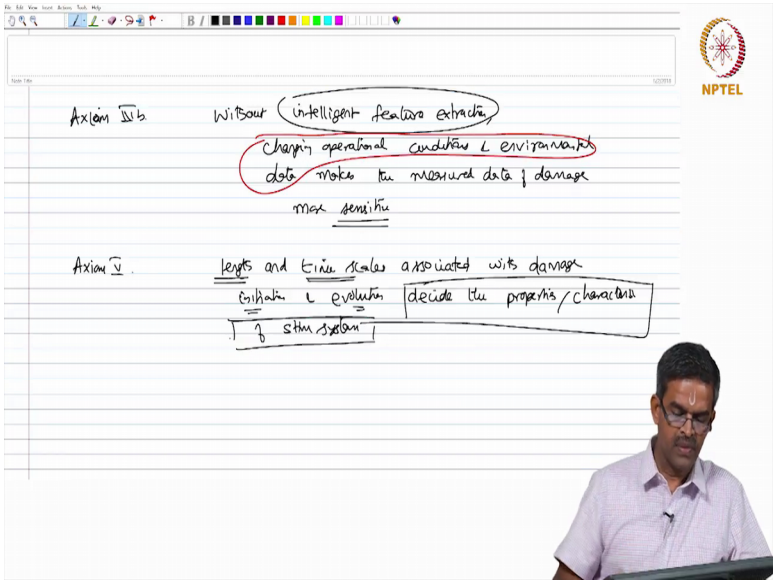
(Refer Slide Time: 01:47)



In that case we should name this as per the order explained in the literature. So, we should say axiom three, which says identifying the existence and location of damage can be done in unsupervising learning mode, identifying the damage or to be very precise identifying the type of damage, present in a system severity of the damage. Only by supervised learning mode, axiom of four a it says that sensors cannot measure damage.

They only record the data they do not know really, whether the data recorded the tentative damage or not sensors cannot measure the damage. It is only through the feature extraction done through signal processing and statistical analysis, classifies the damage from the sensor data it is very important axiom.

(Refer Slide Time: 04:24)

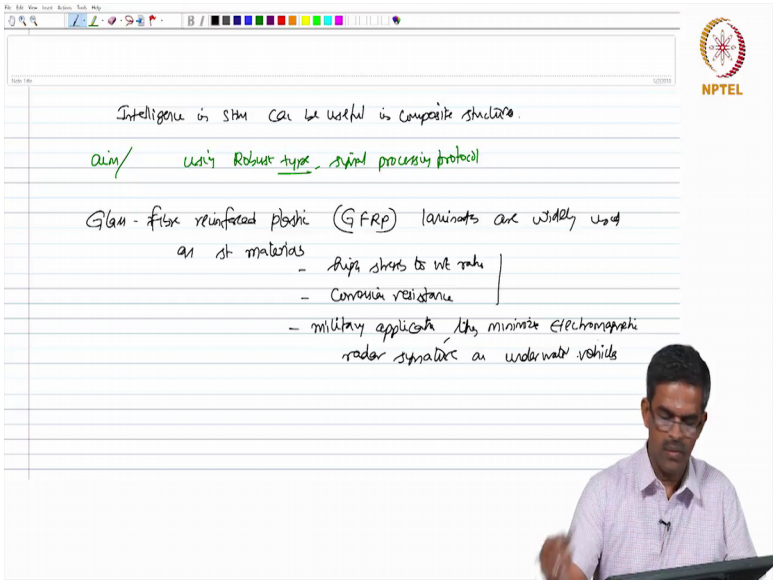


The next axiom is an subset of this so I call this as axiom four b, without intelligent feature extraction, changing operational conditions and environmental data, makes the measure data of damage more sensitive.

It means any change in data related to operational condition or environmental conditions may always give a false implication that it is relevant to a damage, you have to confirm that it is a damage only through intelligent feature extraction. So, without feature intelligent feature extraction the sensitivity of these two parameters will become very dominant. Axiom five the length and time scales associated, with damage initiation and evolution, decide the properties and characteristics of the health monitoring system they govern ok. How long you want to and how and what interval you want to measure the damage parameters.

To really identify the damage initiation and evolution it decides, what is your characteristic of a health monitoring system ok?

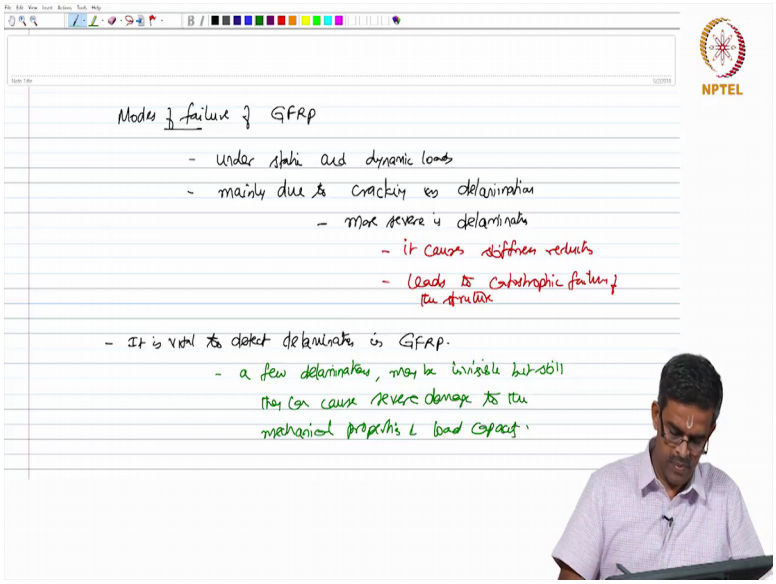
(Refer Slide Time: 07:07)



That is very important the intelligence in structural health monitoring can be useful in composite structures. So, the main aim or the hidden agenda here is using robust type signal processing protocol. Let us take an example where the composites are subjected to damage very often, one classical example is glass fiber reinforced plastic.

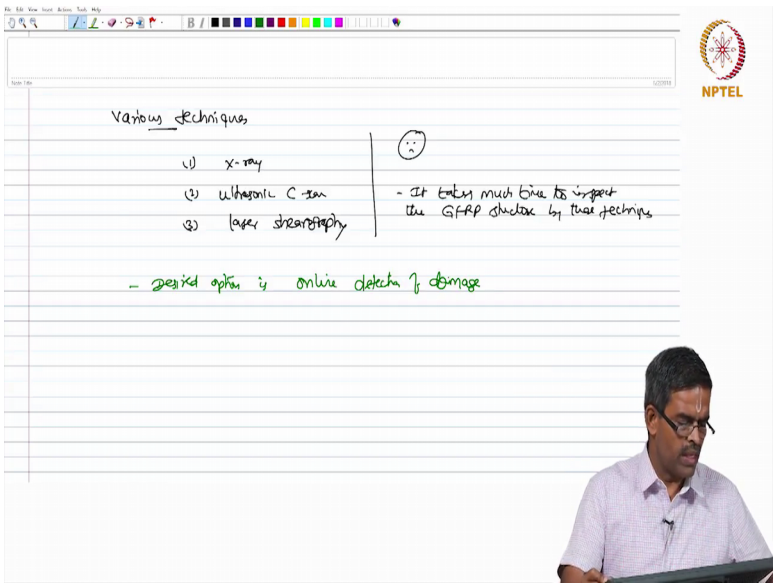
What is GFRP laminates or generally or let us say widely used as structural materials, because they have high strength to weight ratio and good corrosion resistance, they are also useful in military applications, because they minimize electromagnetic radar signature or underwater vehicles of GFRP.

(Refer Slide Time: 09:22)



They fail mainly due to cracking or delamination, delamination is more severe because it causes stiffness reduction and leads to catastrophic failure of the structure. So therefore friends, it is vital to detect delamination in GFRP. The more vital part is a few delamination's maybe, but still they can cause severe damage to the mechanical properties and load carrying capacity of the structure.

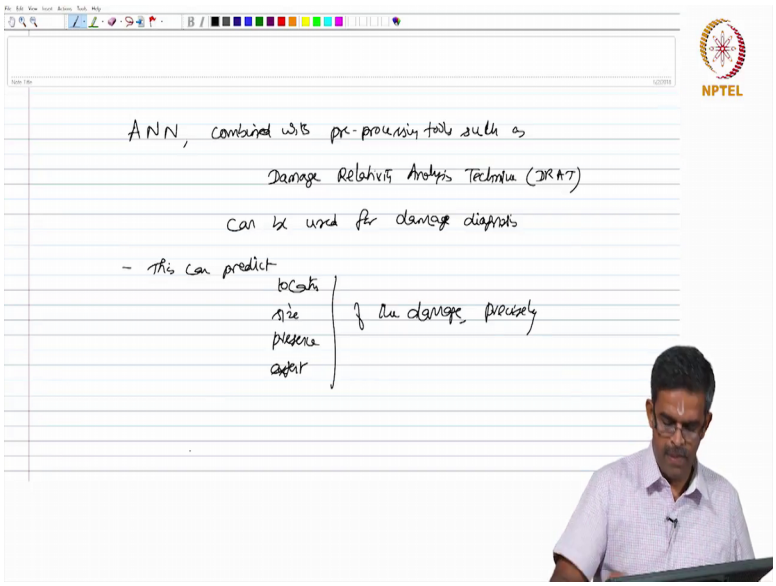
(Refer Slide Time: 11:24)



There are various techniques which are applied to check this delamination, one is X-ray, two is ultrasonic C scan, third could be laser shearography.

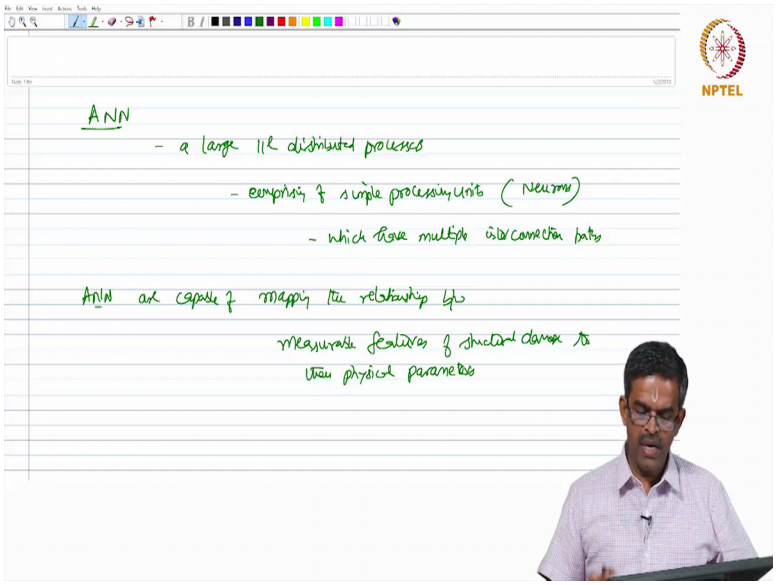
Now, with these methods there are some difficulties the difficulties are it takes much time to inspect the laminate or the GFRP structure, by these techniques. Therefore, what is desire the desired option could be online detection of damage, what is online detection how it is done artificial neural networks.

(Refer Slide Time: 12:26)



pre processing tools such as damaged, relativity, analysis, technique, which is damage diagnosis. Now, the advantages this can predict the location, size, presence and extent of the damage precisely.

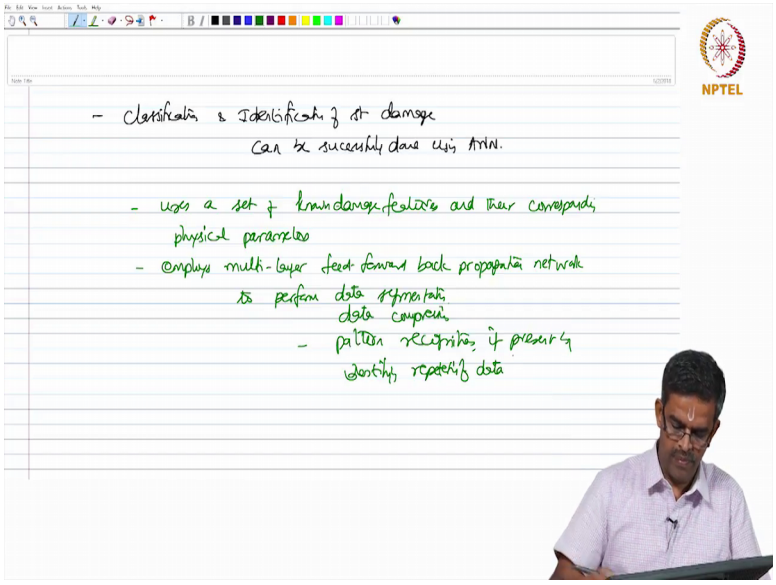
(Refer Slide Time: 13:44)



Now let us see more detail about this artificial neural networks, they are actually large, parallel, distributed, processes comprising of simple processing units. These units are called neurons which has multiple interconnection paths, mapping the relationship between measurable features of structural damage to the physical parameters.

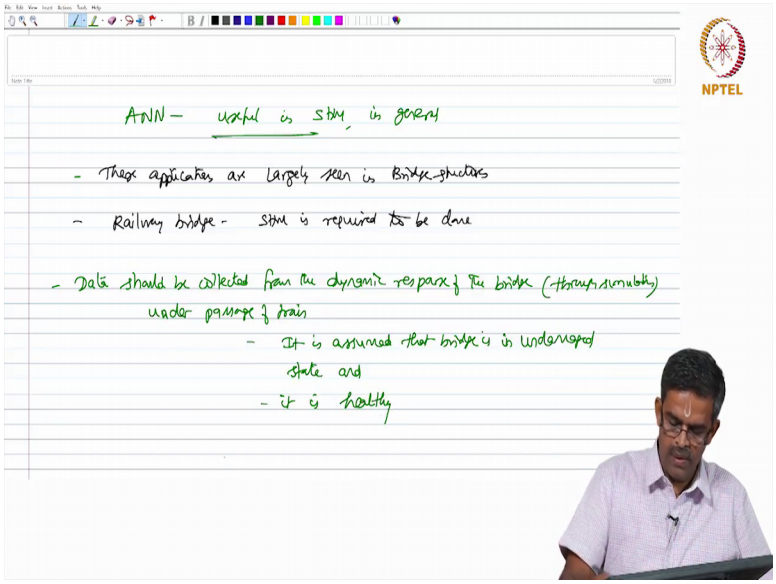
For example what kind of damage would cause what change in the physical parameter of property. This can be identified and established using an artificial neural network.

(Refer Slide Time: 15:14)



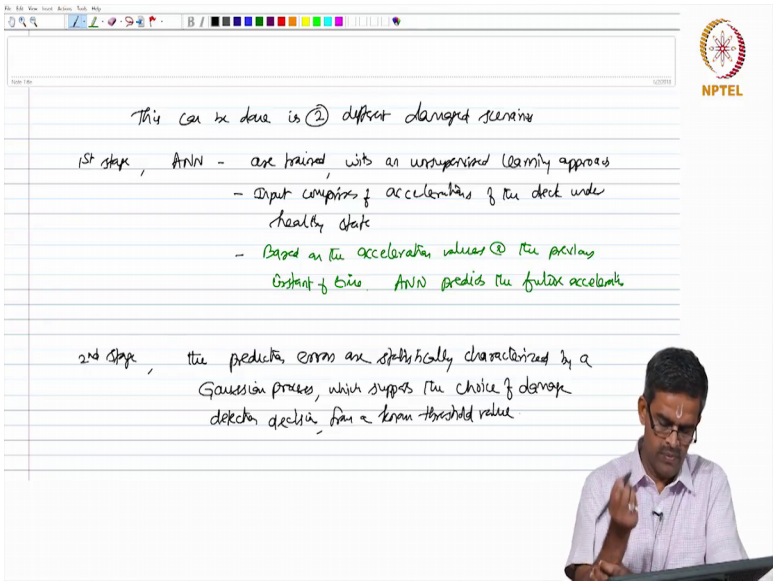
Classification and identification of structural damage can be successfully done using artificial neural network. How does it do it, it uses a set of known damage features and their corresponding physical parameters. It also employs multi layer feed forward back propagation network to perform, data segmentation, data compression and above all most importantly the pattern recognition if present by identifying the repetition of data.

(Refer Slide Time: 17:06)



Let us see how ANN can be useful in structural health monitoring in general are largely seen in bridge structures. For example, let us take a railway bridge whose health monitoring is required to be done ok. So, the steps could be very simple data should be collected from the dynamic response of the bridge, through simulation under passage of train. When this is done, it is assumed that bridge is healthy bridge is in undamaged state and it is therefore considered to be healthy.

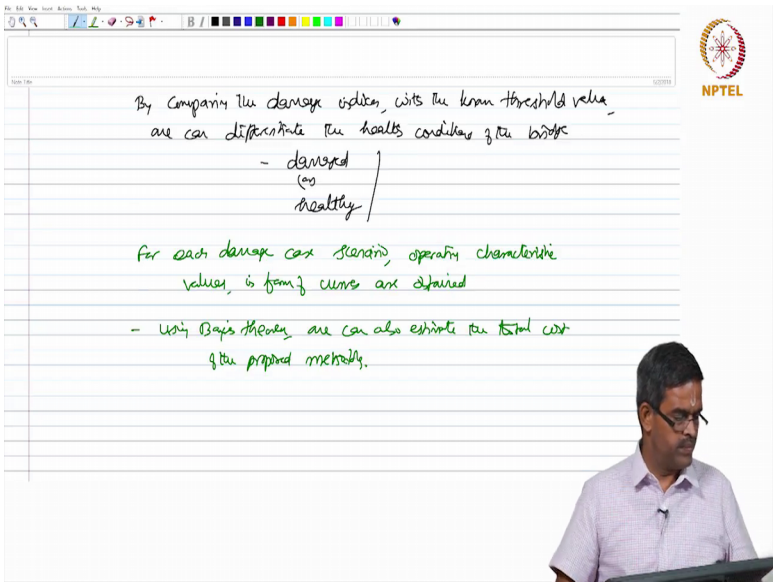
(Refer Slide Time: 19:00)



Which are different damage scenarios in the first stage, I can use artificial neural network which are essentially trained with an unsupervised learning, approach the input comprises of accelerations of the deck under healthy state. Now based on the acceleration values at the previous instant of time, the neural network predicts; the future acceleration in the second stage of damage prediction in the second stage of damage scenario.

The prediction errors are statistically characterized by a Gaussian process which supports, the choice of damage decision the choice of damage detection decision from a known threshold value.

(Refer Slide Time: 21:28)



By comparing the damage indices, with the threshold value one can differentiate the health conditions of the bridge whether it is damaged or healthy ok. One can do decide this for each damage case scenario as seen above, operating characteristic values, in form of curves are obtained then using Bayes theorem one can also estimate the total cost of the proposed methodology.