Structural Health Monitoring (SHM)
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Lecture - 64
Part - 2: Damage detection

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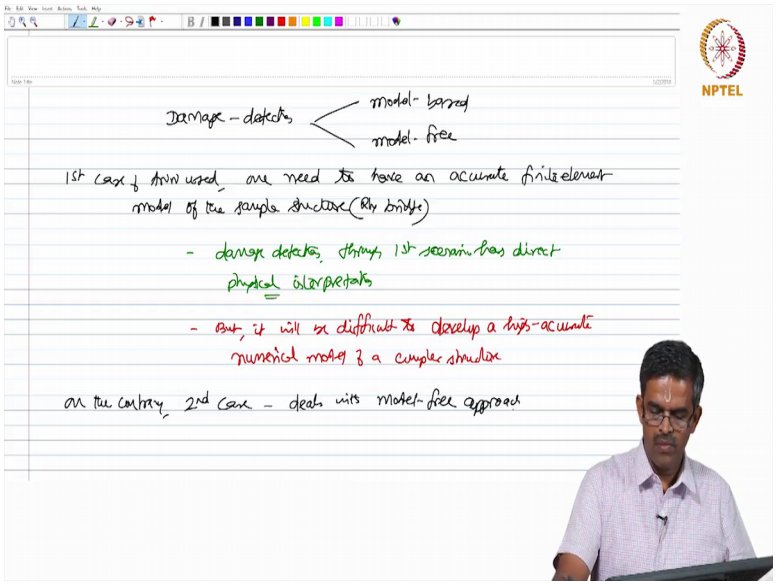

If you talk about damage detection as seen the above example, there can be of two ways: one is model based other is model free. In the first case of ANN used one need to have a computational model. In fact, have an accurate finite element model of the sample structure; in our case it is a railway bridge.

The damage detection through this first scenario will have a direct physical interpretation, because you have a detailed numerical model of the bridge depending upon the location, nature, size and extent of damage you can physically interpret what would be the loss or degradation on the deck of the railway bridge; you have that advantage. It will be difficult to develop a high accurate numerical model of a complex structure; if it is simple one can think about it, but if it is intricate it is very difficult to even develop a numerical model of the structure.

If you look at the second case, the second case actually deals with a model free approach by means of artificial intelligence.

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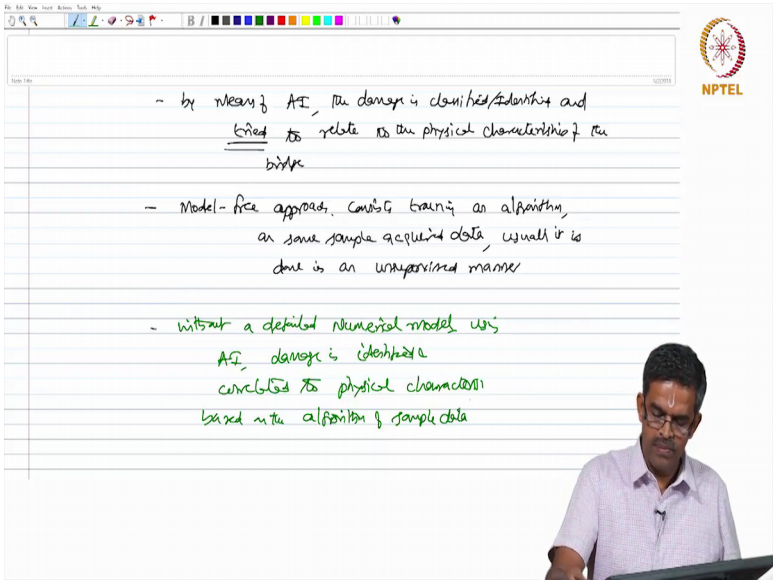

The damage is classified and identified as well, and I should say tried to relate to the physical characteristics of the bridge. The model free approach, training an algorithm on some sample acquire data not on the numerical model, but on some other acquired data similar to this usually it is done in an unsupervised manner. So, the advantage in this case is without a detail numerical model, using artificial intelligence damage is identified and correlated to physical characteristics based on the algorithm of sample data.

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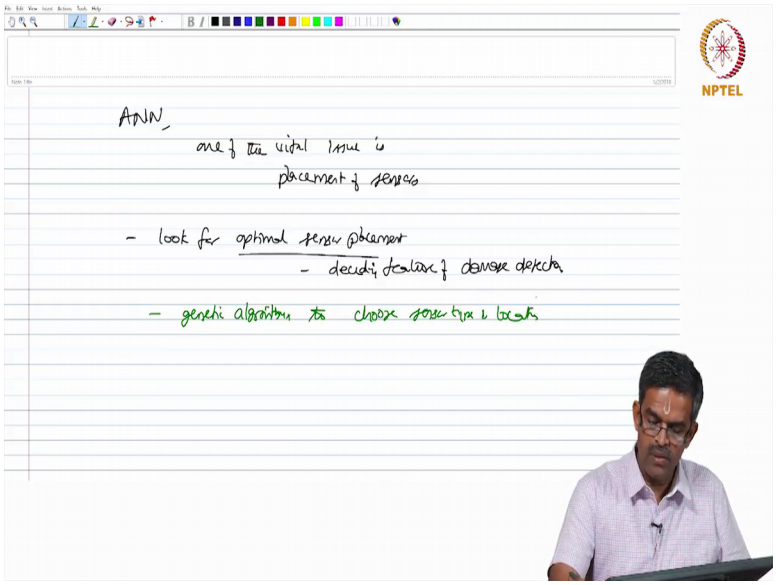

In artificial neural network one of the vital issue is placement of sensors. So, one need to actually look for an optimal sensor placement because that is deciding feature of successful damage detection, is it not that is very important it is a crucial part.

People generally use genetic algorithms to choose the sensor type and their location.

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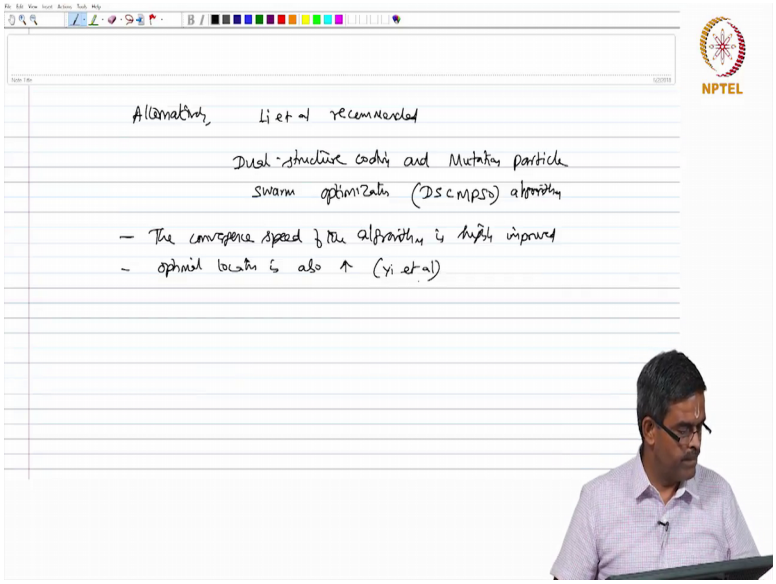

Li et al recommended dual structure coding and mutation particle swarm optimization that is DSCMPSO so algorithm. Now in this case the convergence speed of the algorithm highly improved, optimal location is also highly improved as stated by Yi et al in the paper.

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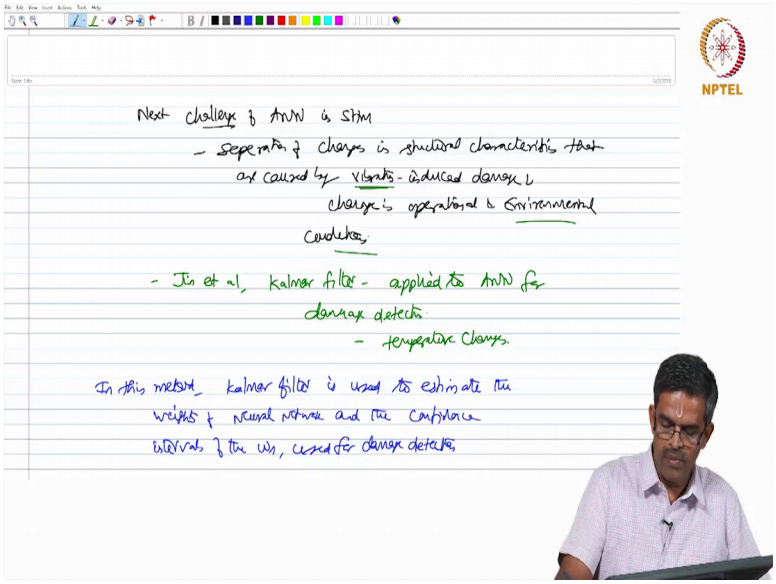

The next challenge of using ANN in SHM could be separation of changes in structural characteristics, that are cost by vibration induced damage and changes in operational and environmental conditions.

So, the solution for this problem could be as accepted by Jin et al, one can use Kalmar filter which can be applied to the network for damage detection, essentially caused by temperature changes is one of the environmental conditions that causes or induces additional damage other than those induced by vibration on the bridge. So, in this process or in this method the Kalmar filter is used to estimate the weights of the neural network. And the confidence intervals of the natural frequencies, which are used for damage detection the other advantage, where ANN can be successfully used.

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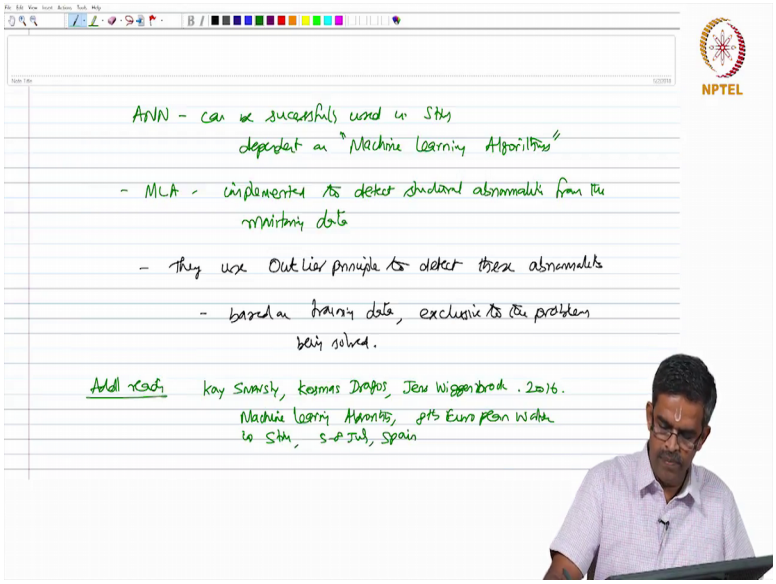

In SHM is dependent on the machine learning algorithms, because ANN has to use certain level decisions at the sensor initiation or at the sensor level to process the data to make it intelligent. So, one need to understand, the machine learning algorithms effectiveness on the neural network, when they are deployed in health monitoring systems generally the machine learning algorithms are implemented to detect structural abnormalities caused from the monitoring data outlier principle to detect these abnormalities.

It is based on the training data which is exclusive to the problem being solved from Kay Smarsly, Kosmas Dragos and Jens Wiggenbrock 2016, machine learning algorithms, proceedings of the eighth European workshop on SHM 5 to 8 July Spain.

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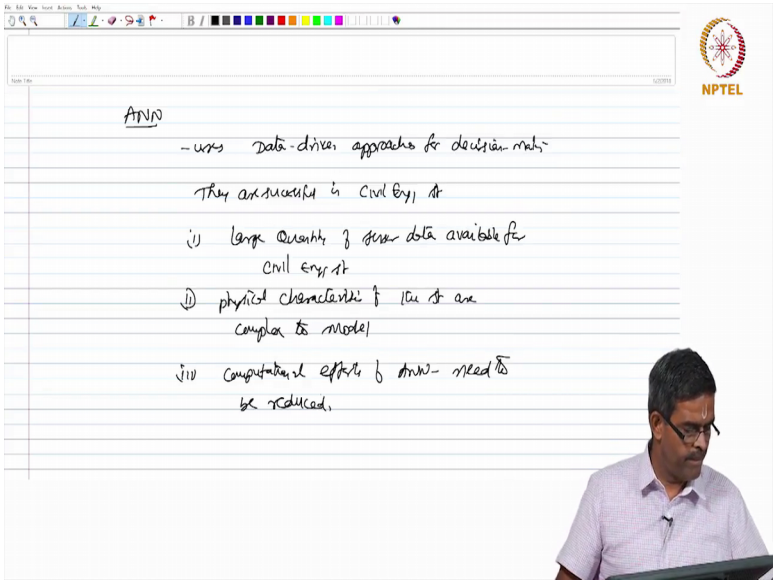

So, the artificial neural network actually uses data driven approaches, for decision making they are successful in civil engineering structures because of the following reasons. You have large quantity of sensor data available for civil engineering structures to the physical characteristics of the structure or complex to model. Thirdly, the computational efforts of ANN need to be reduced in such situation.

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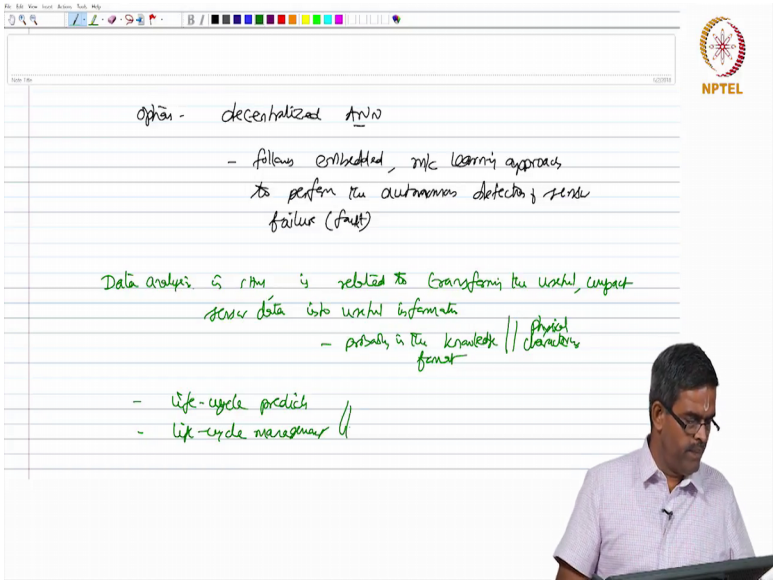

The options used by researchers were decentralized artificial neural network. So, decentralized ANN, follows an embedded machine learning approach to perform the

autonomous detection of sensor failures or let us say the sensor fault. Therefore friends, data analysis in structural health monitoring is related to transforming the useful compact sensor data into useful information, probably in the knowledge format what do you understand by knowledge format.

I should relate this to the physical characteristics of failure ok. What are those physical characteristics which we are interested in one can look for life cycle prediction one can look for lifecycle management etcetera.

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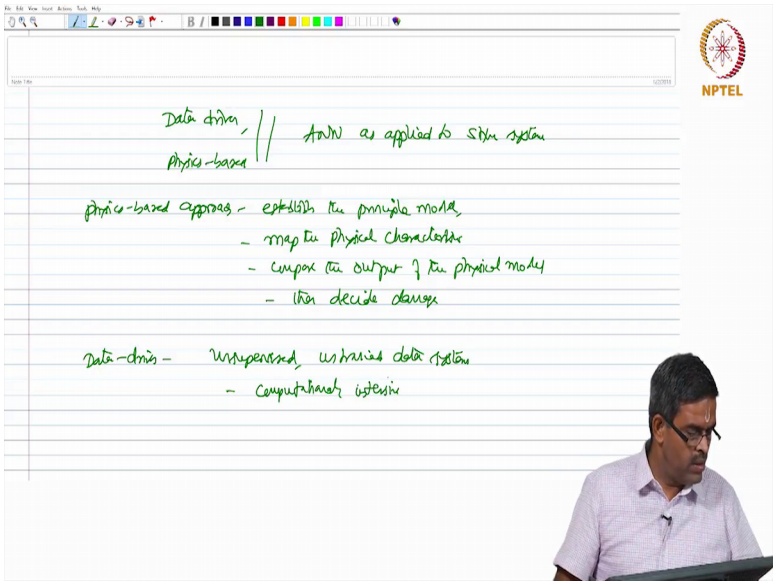

So, you have two approaches one is what we call data driven the other can be physics based. Both can be used in ANN as applied to structural health monitoring systems, the physics based approach establish the principle models. Then, map the physical characteristics and then compare the output of the physical model with the physical characteristics and then decide damage. Whereas, the data driven approach is similar to unsupervised untrained data system which is of course, computationally intensive.

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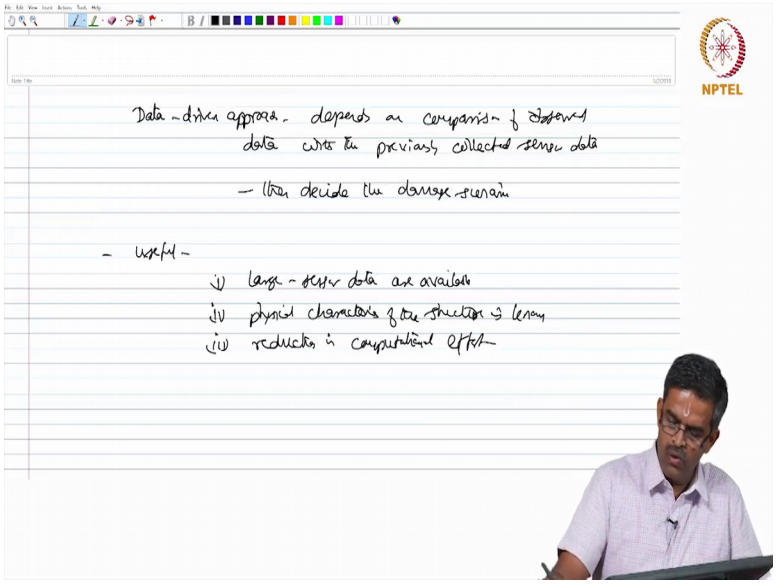

So, the data driven approach depends on comparison of observed data with the previously collected sensor data. And then decide the damage scenario data driven approach are useful when large sensor data are available physical characteristics of the structural model is known three there is a demand of reduction in computational effort.

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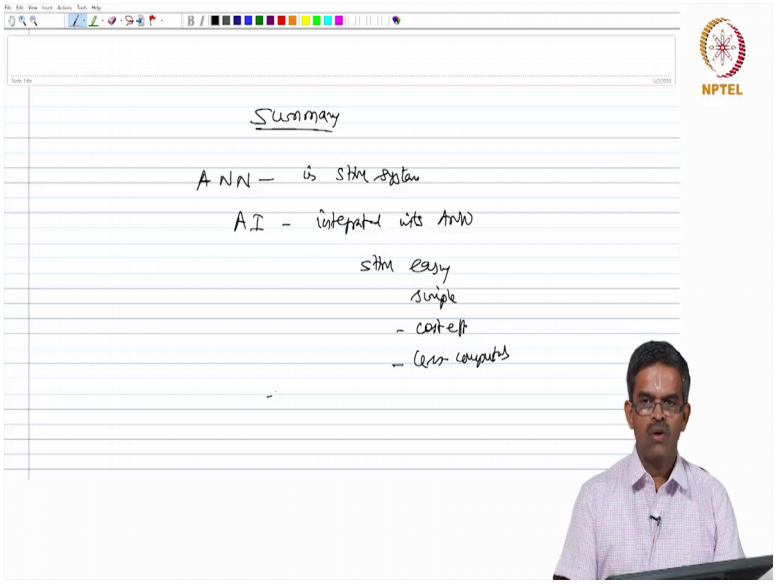

So, friends in this lecture we discussed about application of artificial neural network in SHM system. We have seen how artificial intelligence can be integrated with artificial neural network to make SHM easy, simple cost effective, less computational and so on.

With this we end up with the lectures on module 3, where we discussed about sensor technology, sensor applications, types of sensors, and some application problems related to offshore structures, bridges, etcetera laminates etcetera. I hope the condensed form of all the set of lectures in module 1, 2, and 3 would have given you an exposure about structural health monitoring as a whole from its start to a decent level of understanding in applications.

In the fourth module we are going to discuss about a lab scale application on SHM, which we did on a research basis at IIT Madras in the department of Ocean Engineering, which I will present the results and discuss the anomalies which has been obtained by using wired and wireless sensor networking; where we will also discuss about the layout, design, implementation difficulties, and limitations of wireless sensor networking for various applications in general and very specifically to offshore structures on a lab scale model.

Thank you very much. See you in the fourth set of module lectures.