

Structural Health Monitoring (SHM)
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Lecture - 62
Part - 2: Plausibility of errors in SHM

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plausibility | Errors

- The acquired (measured) data may have inconsistency
- They may not be compatible with the pre-set threshold values

It is necessary to assess the errors in the data using micro-controller based sensing units

Special task? compare the acquired data with the previous set of data

- if no significant change (no change) is seen for a long period of observation, then sensors will interpret this as wrong

When you talk about plausibility of errors may have inconsistency they may not be compatible with the preset, threshold values. So, at this stage when such errors occur it is necessary to assess the errors in the data using microcontroller based sensing units. Now interestingly what special these units will do, what special task these units will perform? These units will compare the acquired data with the previous set of data, if no significant change or let us say no change is seen for a long period of observation then the sensors will interpret this as wrong data.

So, it takes a decision that the corresponding feed unit is idle maybe not working, maybe disconnected, maybe battery down; what are maybe the reason for the sensing unit not working, but somebody in the network or in the loop has to recognize this. This intelligent intervention is done possibly using artificial intelligence in structural health monitoring.

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The whiteboard contains the following text:

- If equal values are reported from a particular sensor location repeatedly for n times, then this is marked as inconsistency
- Further, errors of this nature can also be identified by performing regression analysis (sensor level)
- This detects plausible errors in the acquired data

Important step (AI) different from SHM (conventional)

Is it expensive? It is feasible!

- simple micro-controller with limited computational power

The presenter is a man with glasses, wearing a light-colored shirt, looking at a tablet.

For example: if equal values are reported from a particular sensor location repeatedly for let us say n times this is marked as inconsistency, errors of this nature can also be identified by performing regression analysis which is also done by the sensor. So, this detects plausible errors in the acquired data. So, that is a very important step which makes artificial intelligence different from the conventional SHM.

Now is it expensive; is it expensive, is this process feasible? The answer is very simple: one can use a simple microcontroller with limited computational power to do this job.

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The whiteboard contains the following text:

- If the response measurement (y) of a structure @ a particular sensor location is recorded as y_i predicted values lead to (y_p)
- By comparing the predicted values (y_p) with acquired values (y_i) plausible error can be detected

If $|y - y_p| > \delta_{yp}$, then

permissible range $\delta_{yp} = \delta_{yp}(t, y_p)$

- depends on the property of SHM,

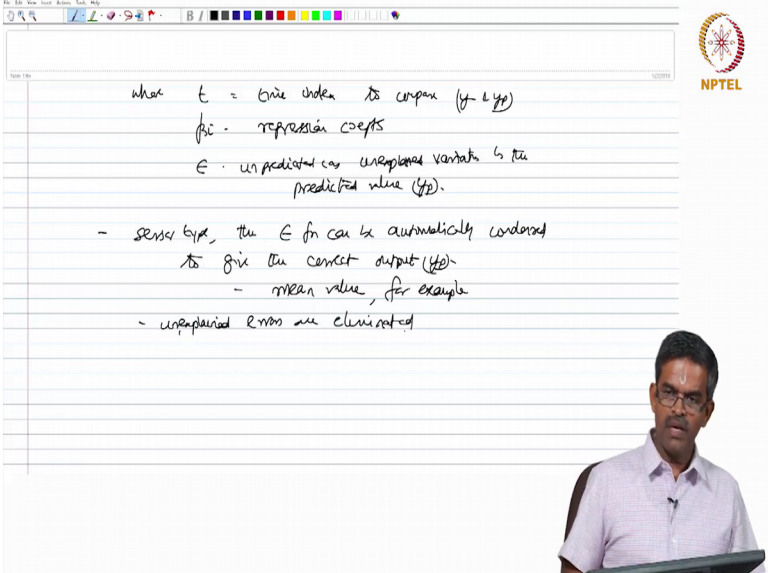
$$y_p = \beta_0 + t \beta_1 + \epsilon$$

The presenter is a man with glasses, wearing a light-colored shirt, looking at a tablet.

Let us say if the response measurement y of a structure at a particular sensor location is recorded as y and predicted values lead to let us say y_p ; p stands for predicted value. Now, by comparing the predicted values y_p with acquired values y plausible errors can be detected if $y - y_p$ mod is greater than Δy_p . Then the permissible range Δy_p will be a function of the measured value and the predicted value. It depends on the kind of project of SHM.

Therefore, I can say the predicted value can be some error function of $\beta_1 \beta_0 \beta_1$ plus some error function.

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The slide contains the following handwritten text:

- where ϵ = Error taken to compare ($y - y_p$)
- β_i = regression coeffs
- ϵ = un-predicted or unexplained variation to the predicted value (y_p).
- sensor type, the ϵ fn can be automatically condensed to give the correct output (y_p)
 - mean value, for example
- unexplained errors are eliminated

The slide also features the NPTEL logo in the top right corner and a video inset of a man in a light blue shirt speaking in the bottom right corner.

Where t is the time index used to compare y and y_p . β_i or the regression coefficients and ϵ represents the un-predicted or unexplained variation in the predicted value y_p . So, depending upon the sensor type the error function can be automatically condensed output y_p , which can be for example a mean value. So, the unexplained errors are eliminated.

So, this can be done by a simple microcontroller.

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Data Analysis $\left\{ \begin{array}{l} \text{short-term} \\ \text{long-term} \end{array} \right.$

short-term - 2 steps

- i) prognosis
- ii) evaluation

Prognosis value (y_p) is computed using simple multiple regression model.

$$\hat{y}_p = \beta_0 + x_1\beta_1 + x_2\beta_2 + \dots + x_k\beta_k + \epsilon$$

Next the parameter x_i - correspondingly, variables independently measured from different sensor locations.

The next issue comes how do you do the data analysis. The data analysis can be done in two forms: one is short term, other is long term. Short term data analysis has two steps: one is the prognosis and second one is the evaluation. The prognosis value let us say y_p of s is computed using simple multiple regression model; y_p of s can be calculated as $\beta_0 + x_1\beta_1 + x_2\beta_2 + \dots + x_k\beta_k + \epsilon$. Where, the parameters x_i or the corresponding variables independently measured from different sensor locations.

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Based on the prognosis (y_p),
measured variable (y_e) can be evaluated by Fuzzy logic approach.

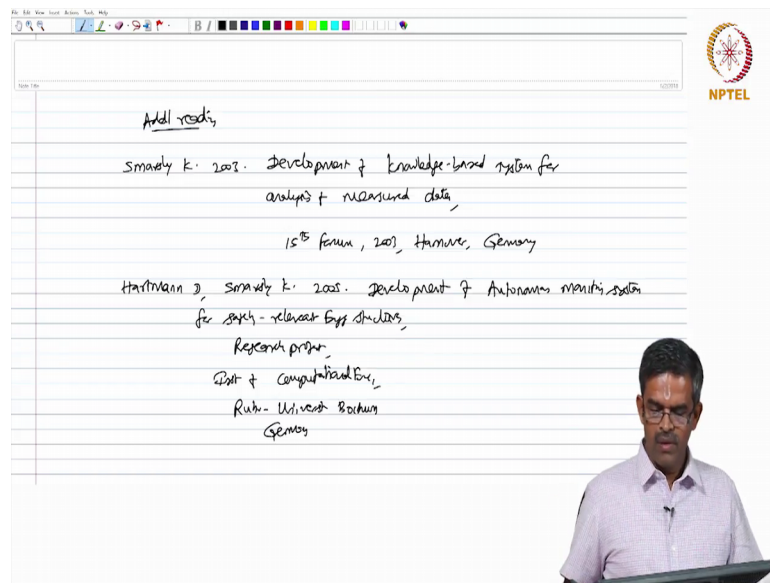
long-term data analysis

- dealt with Data Mining & Machine Learning (DMML) techniques.
- Both the analysis can lead to successful pattern-recognition which make them more a close-fem problem.
- Data trends, can be handled Mann-Kendall test, to check any possible pattern.

Now, based on the prognosis value y_p s the measured variable y_s can be evaluated by fuzzy logic approach. The long term data analysis is generally dealt using data mining and machine learning; this is DMML technique. Further, both the analysis can lead to a successful pattern recognition which makes SHM more a close form problem.

So, data trends which are different can be handled Mann-Kendall test to check any possible pattern.

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The image shows a presentation slide with a white background and a blue border. The slide contains handwritten text in black ink. At the top right, there is a logo for NPTEL (National Programme on Technology Enhanced Learning) featuring a stylized sun or starburst design. The text on the slide is as follows:

Additional reads

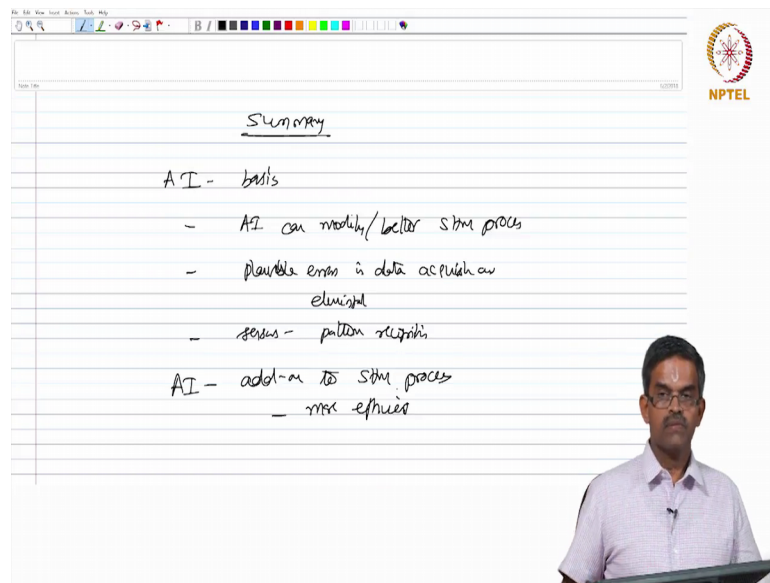
Smarsly K. 2003. Development of knowledge-based system for analysis of measured data,
15th forum, 2003, Hannover, Germany

Hartmann D, Smarsly K. 2005. Development of Autonomous monitoring system for safety-relevant engineering structures,
Research project,
Dept of Computational Eng.,
Ruhr-University Bochum
Germany

In the bottom right corner of the slide, there is a small inset image of a man with glasses, wearing a light-colored shirt, standing behind a podium and speaking.

Friends, this lecture has additional reading which I recommend you can read Smarsly K 2003: development of knowledge based system for analysis of measured data; 15th forum 2003, Harnover, Germany. Hartmann D, and Smarsly K 2005: development of autonomous monitoring safety relevant monitoring system for safety relevant engineering structures; so research project done by Institute of Computational Engineering Ruhr University, Bochum, Germany.

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The image shows a digital whiteboard interface with a toolbar at the top. The whiteboard contains the following handwritten text:

Summary

AI - basis

- AI can modify/better SHM process
- plausible errors in data acquisition eliminated
- sensors - pattern recognition

AI - add-on to SHM process

- more efficient

In the bottom right corner, a man with glasses and a light-colored shirt is visible, standing behind a podium. The NPTEL logo is located in the top right corner of the whiteboard area.

So friends, in this lecture we learnt basics of artificial intelligence, we also saw how AI can modify and make it better SHM process, we have also seen how the plausible errors in data acquisition are eliminated, and how sensors can also be used for pattern recognition. So, we have said that AI is a successful add on to SHM process to make it more efficient.

Thank you very much and bye.