구조물 손상 예측 향상을 위한 순환신경망 방법론의 적용

Application of Recurrent Neural Network for Enhancing Damage Detection of Structures

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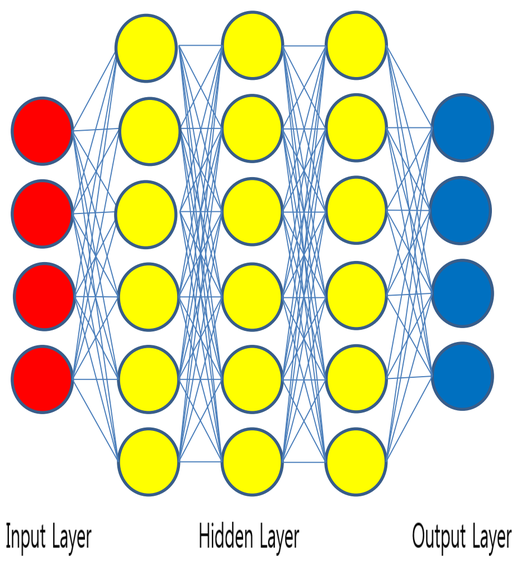
Research Objectives

- Propose a framework to build a deep neural networks that can predict the damage of a structural systems based on the Structure Health Monitoring data and reaction model.
- Introduce structure of Long short-term memory to transform the information of hysteretic behavior of system.
- Verify the efficiency and applicability of the proposed deep neural network model using a detection database.

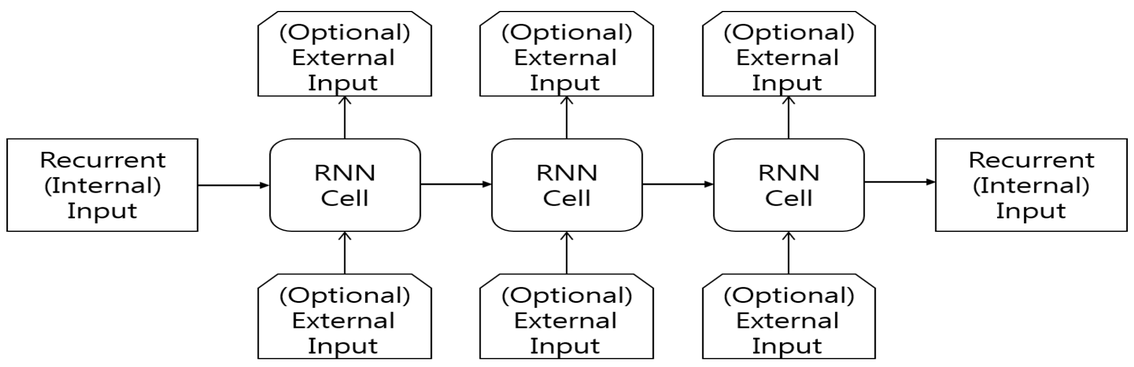
Deep Learning

- Learning multiple levels of representation and abstraction that help to make sense of data such as images, sound, and text.
- Deep learning is the application of the artificial neural network that utilizes multiple layers of nonlinear processing units to extract features of input data and find patterns.



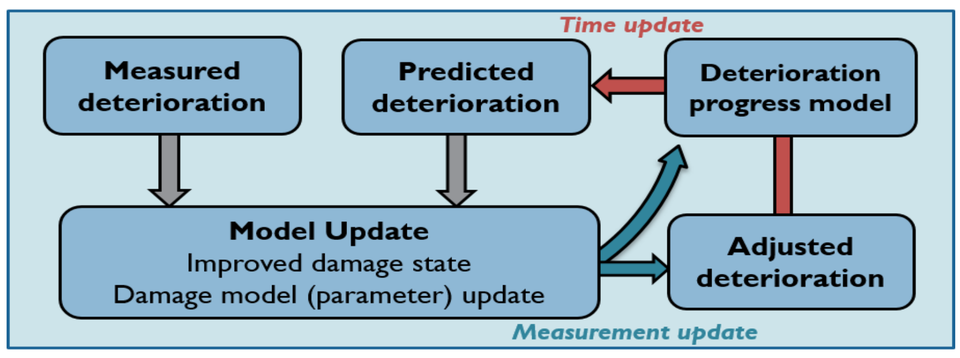
Recurrent Neural Network (RNN)

- Desinged to make use of sequential information.
- Have a 'memory' which captures information about what ha s been calculated so far. Can make use of information in arbitrarily long sequences.



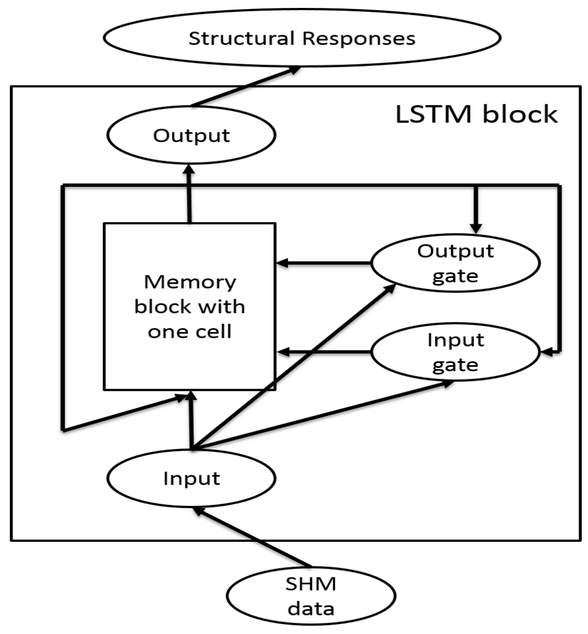
Structure of Long short-term memory(LSTM) model

Behavior of Deterioration progress model



- To identify the characteristic of model, measured deterioration data and its results of model is needed.

Long short-term memory(LSTM)



- To improve efficiency of the predicted data of model, Each time series data should be cycled by input and output data.
- Structural Responses can be known as adjusted measures of existing deterioration model.

Numerical Example

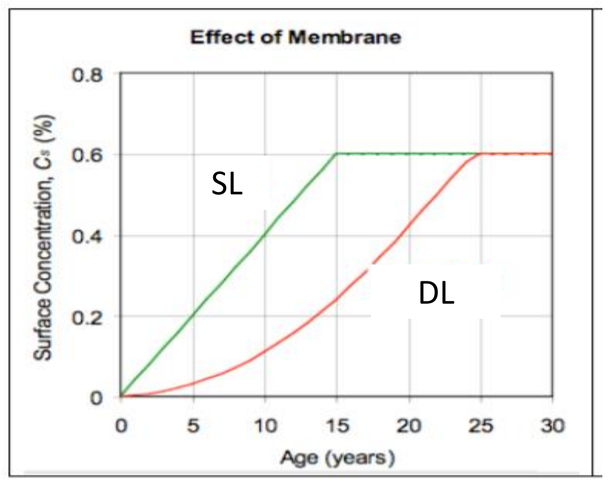
Pilot Study

Service Life Prediction Model

- The corrosion of embedded steel reinforcement in concrete due to the penetration of chlorides from membrane and sealer is the most prevalent form of premature concrete deterioration.
- Costs billions of dollars a year in terms of infrastructure repair and replacement.
- There are several ways in model to determine the Service Life.
- In this paper, only one of prediction method is used.
- $$\mathrm{SC} = c\left(\frac{1+i}{1+r}\right)^{t}$$

$$(SC: surface\ concentration\ c: future\ cost\ \left(\frac{\$}{m}\right)$$

$$i : inflation\ rate \qquad r : real\ discount\ rate)$$



Predicting Structural Responses Based on Deep Learning

- We randomly split the dataset into a training set and a test set to prevent over-fitting of the model by monitioring the loss on the test set.
- As number of epoches increases, both training and test set error start to decrease.
- The Surface Concentration predicted by the deep neural network closely match those by prediction model.

Conclusions

- A new deep-learning-based model is proposed to combine deterioration model and Structure Health Monitoring data.
- Results of numerical examples confirm that the proposed method can predict structural responses accurately and reduce uncertatinty which can be helpful to decision making problem.
- Ongoing research futher developes the applicability of the proposed method to larger datasets and experimental results.

References

- I. Sutskever (2012). Training recurrent neural networks. PhD thesis, University of Toronto.
- S. Hochreiter and J. Schmidhuber (1997). Long short-term memory. *Neural Computation*, vol.9, no.8, 1735-1780.