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Workshop on
Life Cycle Management
27-29 October Rotterdam

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Optimal bridge maintenance cost calculation algorithms considering members correlation using genetic algorithms

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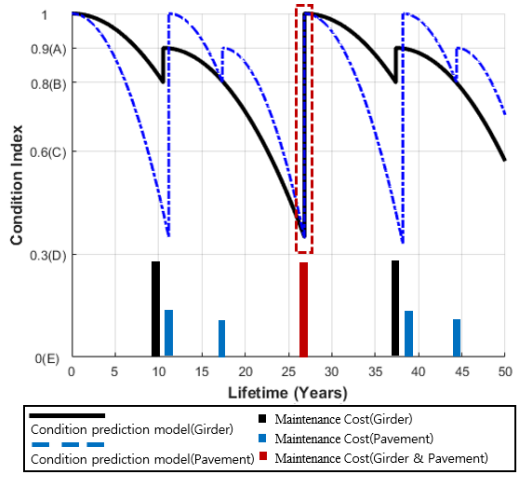
ABSTRACT:

Recently, social interest in the deteriorated bridges and infrastructure has been increasing. Also, studies on per formance prediction and maintenance decision making of structures are underway. In this study, it was propose d an algorithm to create an "optimal maintenance scenario" that takes into consideration the relationship betwe en the members of bridge that affect each other, rather than the “traditional maintenance” that is focused on sin gle member of the bridge.
Since maintenance scenario creation is discrete in terms of time and cost. So in this study, it is used a genetic algorithm. Each member of bridge has a correlation that takes into account member damage transitions effect and the elimination of duplication cost, which was established through the Korean bridge maintenance manual and expert opinion. In order to predict the performance change of each member, the algorithm used the conditi on prediction model of each member of the bridge, which was created by multiple regression analysis based on the actual bridge case. Also, it used the maintenance cost model of members for cost estimation, it has create d and applied it through actual maintenance case analysis. The constraint of the algorithm is set to the minimu m maintenance level of the bridge by the bridge administrator. And, it was conducted the case study about real bridge model using the optimal maintenance model, analyzed the cost-effect and made maintenance scenario.



No.	Member	Condition Index	Lifetime (Years)	Deterioration rate	Maintenance cost (KRW)	Remarks
1	girder	0.8	10.54	0.0018	66,667,000	
2	pavement	0.35	11.18	0.0052	21,666,000	
3	pavement	0.8	17.38	0.0052	6,667,000	
4	**pavement**	**0.35**	**26.84**	**0.006188**	**21,666,600**	**Eliminate duplicate costs**
5	**girder**	**0.35**	**26.84**	**0.00207**	**216,667,000**	
6	girder	0.8	37.38	0.0018	66,667,000	
7	pavement	0.33	38.19	0.0052	22,333,300	
8	pavement	0.8	44.39	0.0052	6,667,000	
9	pavement	0.71	50	0.006188	-	Demolition
10	girder	0.57	50	0.00207	-	Demolition
				Total	347,334,300	

Fig. 1. *Optimal maintenance scenario for girder and pavement*

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Application of Recurrent Neural Network on Structural Health Monitoring

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ABSTRACT:

To monitor the status of a dynamical system from its vibration responses is one way to manage the system's health. In this study, a vibration-based intelligent system is developed to monitor and diagnose structure and machine health. A machine working in different conditions is always accompanied with different vibration patterns. At first, let the engineer of a machine confirm the historical vibration data which is normal condition, and then, apply the normal condition data as input to train the recurrent neural network (RNN) model, the output layer of which is the next time step vibration data. Because the model was only trained by the data of normal conditions, the prediction will match to the training conditions. According to the root-mean-square error (RMSE) between instantaneous vibration and forecast result, one can monitor and diagnose the structure health by the difference. The feasibility of the AI-based monitoring and diagnosis system is verified through the NASA's run-to-failure test bearing data which is from 4th March 2004 to 18th April 2004.

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Rotating machinery health diagnosis using discrete wavelet transform and denoising autoencoder networks

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ABSTRACT:

Rotating machine faults are always accompanied by abnormal signals.The vibration signal processing is an important task for the rotating machine diagnosis. In this study, through the artificial neural network analysis the health status of monitoring and diagnosis of bearing. At first, the professional confirms the normal modes of the machine and acquires normal acceleration signals. And then, by applying discrete wavelet transform decomposed the acceleration signal into the low frequency sub-band and high frequency sub-band as the bearing features. Then combining nonlinearities of neurons into de-noising autoencoder reduce the dimension and increase the robustness of the features. Finally, all the features aiming to detecting faults of bearing extracted from the vibration measurements are merged using Self-organizing map (SOM) . Whether the bearing systems is healthy can be determined by calculating the Mahalanobis distance according to the Minimum quantization error (MQE) from the SOM.The feasibility of the AI-based vibration analysis technique is verified through the NASA's test-to-failure data which's duration was from 12th February 2004 to 19th February 2004.

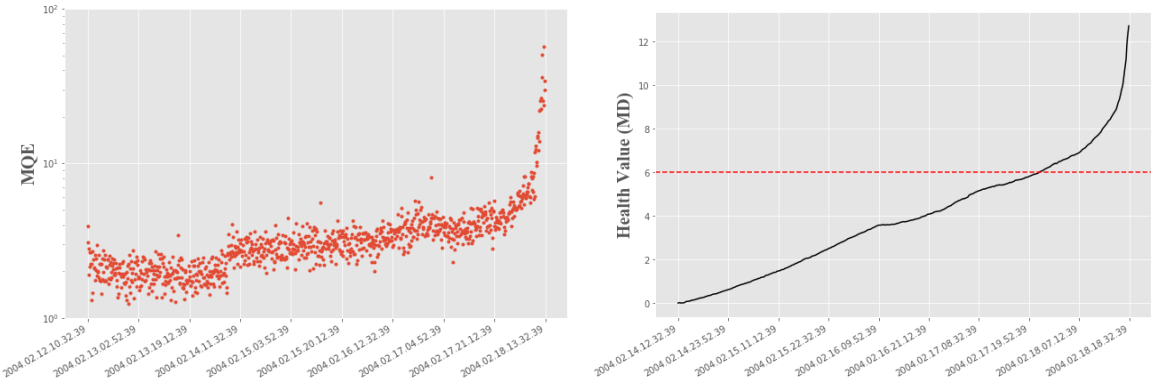

Fig. 1. *Minimum quantization error (left) and an abnormality occurred in Health value = 6 (right).*

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Predictive maintenance planning of road bridges using entity embedding deep neural networks

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ABSTRACT:

Nowadays many infrastructure managers still primary rely on information obtained during visual inspection to subjectively decide on the required maintenance actions. The subjective approach is likely to lack the appropriate use of inspection data and does not promise delivering smart and cost-effective maintenance plans. Data-driven decision support models can significantly improve decision making process for maintenance planning of transport infrastructures. In this work, we show that the historical and operational data, readily available at the agencies, is of vital importance and can be used to develop machine learning models. We have used a large-scale dataset on concrete bridges collected from 2007 to 2017. The dataset is generated as a result of Inspection to Maintenance Advice process, where a decision-maker decides on the condition state and risk level, based on the visual inspection data and finally recommends the maintenance activity, as shown in Figure 1. The decisions are made mainly on decision-makers' technical knowledge and judgments, where the past damage details are not considered due to data accessibility challenges. The objective of this study is to develop predictive models that can provide support in the subjective assessment procedure of bridge maintenance planning.

This work deals with three prediction tasks namely, assessment of condition state, analyses of risk level, and recommendation of maintenance advice, by using the damage details noted during inspection activity. In this work we have developed a machine learning system which is trained on the past asset management data and can provide support to the decision-makers in the condition assessment, risk analysis, and maintenance planning tasks. We have evaluated several traditional learning algorithms as well as the deep neural networks with entity embedding to find the optimal predictive models in terms of prediction accuracy. Additionally, we have explored the multi-task learning framework that has shared representation of related prediction tasks to develop a powerful unified model. The analysis of results shows that a unified multi-task learning model performed best for all considered tasks followed by task-specific neural networks with entity embedding and class weights, which has achieved close to 80% accuracy. The results of models are further evaluated by instance-level explanations, which provide insights about essential features and explains the data attributes that leads to particular predictions. To conclude, the developed models have excellent predictive capabilities, and they can facilitate decision makers in maintenance planning of assets.

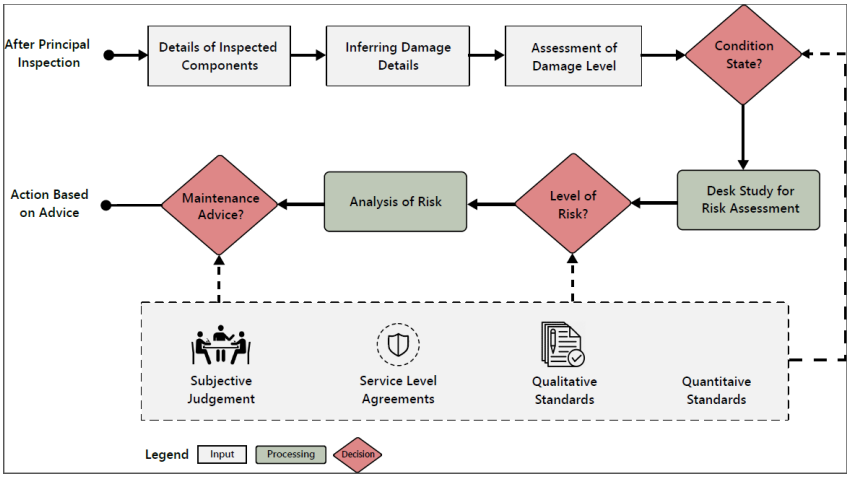

Fig. 1. *Process of Inspection to Maintenance Advice.*