ASSESSMENT OF THE SERVICE LIFE OF BUILDINGS AND STRUCTURES USING ARTIFICIAL INTELLIGENCE

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Abstract

This thesis considers the use of artificial intelligence technologies to assess the technical condition of buildings and structures and to determine their remaining service life. During operation, structural elements of buildings may develop cracks, deformations, corrosion, settlement, and other defects. Traditional assessment methods require considerable time and effort to identify and evaluate such defects. The use of artificial intelligence, particularly computer vision and machine learning algorithms, makes it possible to automate structural health monitoring and predict the remaining service life of structures. The study proposes a general model for detecting defects from images, assessing the technical condition of structures, and predicting their remaining service life.

Keywords: buildings and structures, artificial intelligence, machine learning, computer vision, technical condition, cracks, deformation, monitoring, service life, prediction.

Introduction

The safety of buildings and structures is directly related to regular monitoring of their technical condition. During operation, various types of damage may occur in concrete, reinforced concrete, steel, and other structural elements. In particular, the appearance of cracks, deformation of structural elements, concrete deterioration, reinforcement corrosion, and reduction in the strength characteristics of structures can negatively affect the overall condition of a building.

In traditional technical diagnostic methods, specialists conduct visual

inspections, perform measurements, and assess the condition of structures based on the collected data. Although these methods are effective, regular monitoring of large-scale facilities requires considerable time and human resources.

Today, the development of artificial intelligence technologies makes it possible to automate many of these processes. In particular, Computer Vision, Machine Learning, and Deep Learning algorithms can be used to automatically detect defects in building structures and analyze their development over time.

Main Objective of the Research

The main objective of the research is to develop a method for assessing the technical condition of buildings and structures using data obtained from various sensors and images, and for predicting the Remaining Useful Life (RUL) of structural elements using artificial intelligence.

The following tasks are defined to achieve this objective:

Detect defects in building structures.

Identify cracks and deformations from photographic and video images.

Monitor changes in defects over time.

Assess the technical condition of a structure using a numerical indicator.

Predict the remaining service life using an artificial intelligence model.

Compare the obtained results with conventional engineering calculations.

Artificial Intelligence-Based Assessment Model

The proposed system can be divided into several stages:

Data Collection → Image Processing → Defect Detection → Technical Condition Assessment → Prediction → Decision Making

At the first stage, data are collected from buildings and structures. High-resolution cameras, video cameras, deformation sensors, accelerometers, humidity sensors, and temperature sensors can be used for this purpose.

At the second stage, the obtained images are processed for use by artificial intelligence algorithms. Noise is reduced, the required part of the object is extracted, and the image size is standardized.

At the third stage, cracks and other defects in structural elements are detected using Convolutional Neural Networks (CNNs) or other deep learning algorithms.

For example, the relative length of an identified crack can be expressed as:

$$L_r = Lc / L_0$$

where Lc is the detected crack length, L_0 is the total length of the structural element under consideration, and L_r is the relative cracking indicator.

To determine changes in defects over time, the following expression can be used:

$$Vc = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

where C_{t1} and C_{t2} are the defect indicators measured at two different times, while Vc represents the rate of defect development.

Prediction of the Remaining Service Life

Artificial intelligence can be used to predict the future condition of a building structure over time. The following parameters may be provided as inputs to the model:

age of the building;

structural material;

load level;

number and dimensions of cracks;

amount of deformation;

corrosion level;

humidity and temperature;

seismic effects;

previous technical inspection results.

The technical condition of a structural element can, in a simplified form, be represented by the following function:

$H = f(X_1, X_2, \ldots, X_n)$

where H is the technical condition index of the structure and X_i represents parameters affecting the condition of the structure.

At the next stage, a machine learning algorithm is used to predict future values of the technical condition index. For example:

$RUL = f(H, t, D, M, E)$

where RUL is the remaining useful life of the structural element, H is its current technical condition, t is the operating period, D represents detected deformations, M represents material properties, and E represents environmental and operational conditions.

Advantages of Artificial Intelligence

The proposed approach provides several advantages. First, it can automate part of the inspection process for building structures. Second, small cracks and deformations that may be difficult to identify by visual inspection can be detected more effectively through image processing.

In addition, images of the same structure obtained at different times can be compared to determine the rate of defect development. This makes it possible to predict the future condition of the structure and plan maintenance and repair activities in advance.

This approach is particularly important in regions with high seismic risk. An artificial intelligence-based monitoring system can also be used for rapid preliminary assessment and classification of structures after earthquakes and other emergency events.

Conclusion

Assessing the service life of buildings and structures using artificial intelligence is one of the promising areas of modern engineering diagnostics. Computer vision can be used to detect cracks, deformations, and other defects, while machine learning

algorithms can analyze the technical condition of a structure and predict its remaining service life.

In the future, it is advisable to improve such systems using large datasets collected from real buildings and structures and to integrate them with 3D modeling and Digital Twin technologies. This will create an intelligent system capable of continuously monitoring the technical condition of building structures and providing early warnings about potential risks.

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