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Artificial intelligence application to bridge painting assessment

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Abstract

Digital image recognition has been experimented for steel bridge painting assessment by the Indiana Department of Transportation (INDOT) in September 1999. Although the application was successfully carried out as a whole, there are still some minor problems left to be improved. Nonuniform illumination is one of the problems that affect the accuracy of recognition results. To address this problem, the neuro-fuzzy recognition approach (NFRA) is proposed, which segments an image into three areas based on illumination and conducts area-based thresholding with the help of an artificial neural network (ANN) and a fuzzy adjustment system. In this paper, the framework of NFRA will be presented, followed by the application of NFRA to steel bridge painting assessment and its performance comparison with the multiresolution pattern classification (MPC) method and the iterated conditional modes (ICM) algorithm. The conclusions will be presented last.

Keywords: Neuro-fuzzy recognition approach (NFRA); Artificial neural network (ANN); Fuzzy adjustment; Multiresolution pattern classification (MPC); Iterated conditional modes (ICM)

1. Introduction

Image processing has been utilized in a wide range of areas because of its ability to distinguish millions of shades of colors, which is difficult to accomplish by human eyes. In the field of civil engineering, image recognition has been experimented on steel bridge coating assessment, monitoring of underground sewer systems, and some other areas [1–5].

Although image recognition is a capable technique, there are still some drawbacks that need to be resolved. Nonuniform illumination is a frequent problem associated with a poor-quality image. To obtain better recognition results while conducting image processing, methods that can diminish the problems of nonuniform illumination are needed.

The neuro-fuzzy recognition approach (NFRA), which was initially developed for infrastructure surface coating assessment, can be applied to steel bridge painting assessment by training the artificial neural network (ANN) with proper steel bridge paint images. NFRA segments an image into three areas based on illumination and conducts illumination-based image thresholding. The average illumination values of the three areas will be calculated and sent to a pretrained artificial neural network to obtain three corresponding threshold values, which will be used for area-based image thresholding later. A fuzzy adjustment system is utilized to adjust the gray level values of the pixels

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along the boundaries between different areas. Finally, area-based image thresholding will be performed to get a binary image containing only the background pixels and the defect pixels [5,6].

In order to justify the performance of the proposed approach, NFRA will be compared to the multiresolution pattern classification (MPC) method and the iterated conditional modes (ICM) algorithm using steel bridge rust images. MPC, which contains two resolution levels (the fine resolution level and the coarse resolution level) and clusters image information in a high-dimensional feature space, was proposed by Chang [7] in 2000 and by Chen et al. [8]. ICM, which is one of the frequently adopted image recognition algorithms, was proposed by Besag in 1986. ICM has the characteristics of fast convergence and robustness [9].

2. Neuro-fuzzy recognition approach

In this section, the neuro-fuzzy recognition approach will be introduced in detail. The training of the artificial neural network, the procedure of the fuzzy adjustment, and the framework of NFRA will all be presented.

2.1. Training of artificial neural network

The artificial neural network plays an important role in the neuro-fuzzy recognition approach. It automatically generates three optimal threshold values for later image thresholding. In this subsection, the rationale of how the artificial neural network is trained and how to obtain the required training pairs (an input and a target output are called a training pair) is presented [5,6].

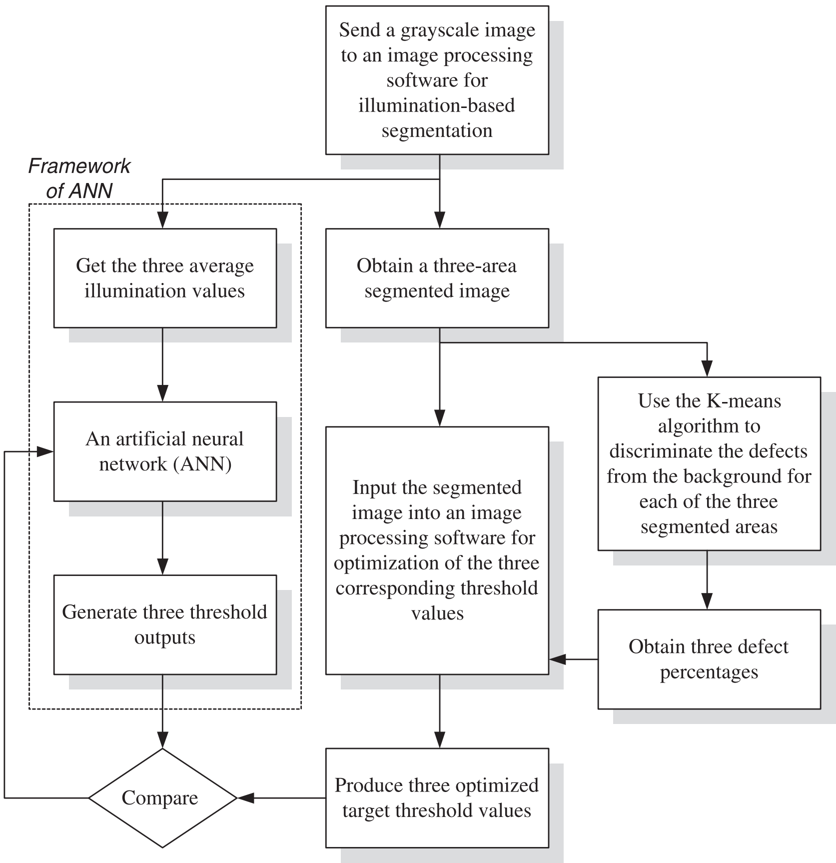

Fig. 1. Training process of artificial neural network.