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Integration of industrial photogrammetry and neuro-fuzzy system for measuring and modeling deformation of industrial product surfaces under external forces

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ABSTRACT

Deformation of surfaces under external loadings greatly is function of physical laws. But according to the impossibility of identifying all effective factors and modeling their interactions parametrically, analytical methods do not provide good performance generally. So, it is necessary to apply practical methods by carrying out field tests and measuring deformations directly. To achieve this purpose it is required to integrate capabilities of an accurate measurement technique and a flexible modeling method. The capabilities such as: high accuracy and speed in measuring 3D coordinates of desired points, ability to perform measurement in a continuous space and no need to contact with the surface of objects at the time of measurement make close range photogrammetry a reliable tool for measuring geometric parameters of an object before and after deformation. The ability to measure geometric parameters of an object before and after deformation in one hand and following the deformation from physical laws on the other hand make neuro-fuzzy system the first choice for modeling the deformation of objects using outputs of close range photogrammetry.

In this paper, a new method has been presented for measuring and modeling deformation of industrial product surfaces under external forces using close range photogrammetry (as an image-based measurement tool) and neuro-fuzzy network (as a behavior modeling tool).

1. Introduction

Measuring 3D coordinates of object points is one of the main needs for many scientific and industrial applications. So, accurate measurement tools are known as principal components for technological development.

According to the limitations of mechanical measurement tools such as: contact with object surface at the time of measurement [1], low speed in measurement [2,3], restriction on the size of the object [4], incompatibility with size and shape of various objects [4] and need to be operated by highly specialized personals in restricted environments [5] the use of optical measurement techniques is increasing.

In recent years, among optical measurement techniques, the imaging technique has become a popular research topic due to its advantages of low cost, easy maintenance, reliability and ability to real time measurement [6]. Many different optical measuring and reconstruction methods have been developed based on the imaging technique [7]. Some of the methods include: stereo or multi view analysis [8–10], projection of structure light [11,12], depth from defocus [13], etc.

With industry advances and need to improve the quality of different products, the practical use of the measuring methods based on the imaging technique has been

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increased in various industrial applications [14]. One of the most common applications is quality control and inspection of industrial products [14–17]. One of the important processes in quality control of an industrial product which can use image-based measurement tools is measuring deformation of the product surface and modeling its behavior under external loadings. Deformation of surfaces under external loadings and forces greatly is function of physical laws. But according to the impossibility of identifying all effective factors and modeling their interactions, analytical methods do not provide good performance generally. So, it is necessary to apply practical methods by carrying out field tests and measuring deformations directly.

In this paper, a new method has been presented for modeling deformation of industrial product surfaces under external forces using close range photogrammetry (as an image-based measurement tool) and neuro-fuzzy networks (as a behavior modeling tool).

2. Methodology

Neuro-fuzzy network is known as integration of artificial neural networks and fuzzy logic. In neuro-fuzzy systems, the human-like reasoning style of fuzzy systems is combined with the learning ability of artificial neural networks. The main advantage of the models developed based on neuro-fuzzy systems is their high accuracy and describability. Neuro-fuzzy network is used when both the knowledge about the phenomenon behavior and the measurable data are required for modeling the phenomenon. One of the phenomena which have such conditions is deformation of surfaces under external loadings and forces. So, in this

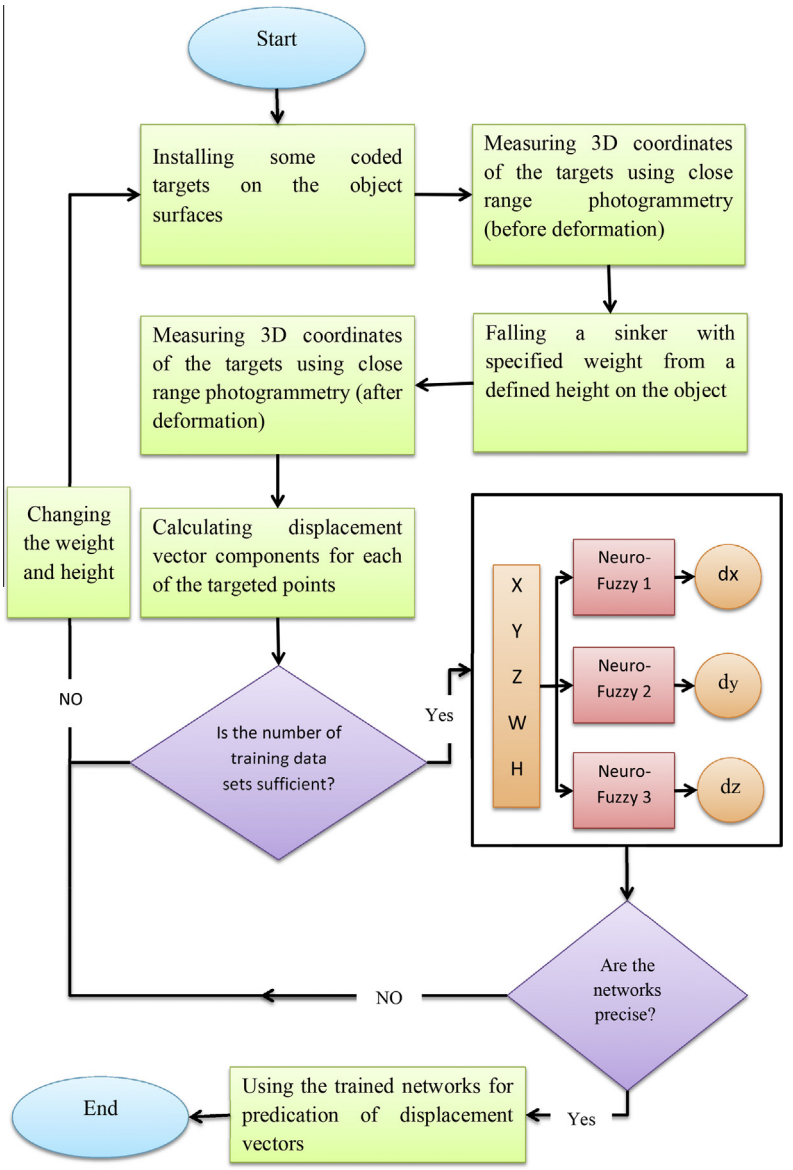

Fig. 1. The flowchart of the process.