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Foundation of a new technique for geometric and non-geometric multi-shapes similarities degrees using boundary unfolding transformation with applications

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ABSTRACT

This paper presents a novel approach for measuring multi-shapes degrees of similarities. A new shape transformation concept is suggested through mapping the closed boundary of the shape using unfolded process into one-to-one equivalent graph (or signal) where ample number of approaches for similarity testing can be applied. The degree of similarity is then measured by calculating the discrepancies between each of the two transformed unfolded-graphs autocorrelation functions. The proposed method is also effective in applying clustering technique for clustering groups of shapes into three hierarchical similarity levels depending on their mutual degree of similarity. The suggested similarity method handles two categories of shapes: geometric and non-geometric. Unlike other well-known techniques in the subject of machine learning and deep learning, the presented method represents a powerful analytical-based technique for similarity analysis of both regular and irregular shapes regardless of size or orientation, and in effectively handling compound or multi-shapes degrees of similarities. The results of testing the approach on selected datasets have successfully demonstrated the great effectiveness of the developed technique in yielding output multi-shape degrees of similarities in new graphical and comprehensive forms. Finally, it is pointed out that the new approach will have many potential real-life applications such as in industry, medicine, biology, security, and authentications.

1. Introduction

The problem of shapes similarity testing is a fundamental task in both machine and human vision systems that must identify or classify objects with less time and effort [1]. Non-geometric shapes' matching is a difficult task as they have irregular shape structures and therefore, a developed algorithm is needed to accurately classify such shapes and determine their degree of similarity. This paper has addressed this problem from a more general view and introduced a new technique based on boundary unfolding transformation concept for multi-shapes degrees of similarities testing. The new proposed concept of mapping the given shape boundary to an equivalent graph (or signal) has simplified the process as there are many signal similarities techniques available in the literature compared to the direct comparison of the shapes. In addition, this method will be an extension to the other sciences, when shape matching(s) is required.

With the development of computing systems and technologies, several machine learning (ML) and deep learning (DL) techniques have been presented in the literature for shape matching [2]. One of the well-known techniques for shape feature description is invariant moments technique. The basic idea of this method is that objects are expressed by a set of measurable quantities called invariants which are insensitive to particular deformations such as scaling and rotation [3]. In this method, the features are identified based on seven different moments calculated around the main principal axes passing by the shape central of gravity. Although this method has many salient merits in real-life applications, only the first two or three moments are sensitive to the shape that makes the approach to be not suitable for a wide range of applications in the area of shapes similarities. Therefore, a new general approach independent on size or orientation is needed for shape description and similarity degree measure. In this study, the dataset is divided into two types: geometric and non-geometric shapes. Geometric

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