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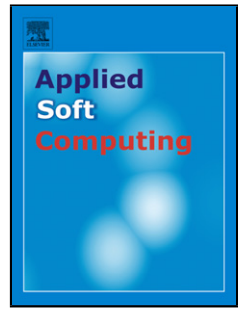

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Convex Polygon Fitting in Robot-Based Neurorehabilitation

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Abstract

Fitting a polygon to a set of points is a task that finds application in many scientific fields. In particular, in robot-based neurorehabilitation, it would be interesting to retrieve the shape that best fits with the path followed by a patient, and evaluate the performance based on the accuracy of the drawing. However, when dealing with a dataset sampled by a drawn trajectory, the methods proposed by the literature may not be exhaustive.

In this work we propose a method to define the distance between a set of points and a polygon, which is used as cost function of a Genetic Algorithm to solve the polygon fitting problem. This method involves a novel space separation metrics to retrieve the correct polygon edge to be compared with each point of the set, featuring linear time complexity.

We compared the proposed approach with the metrics known in the literature, finding that our method performs significantly better in retrieving the original polygon. Finally, we present a robot-based rehabilitation application in which the proposed method is used to evaluate the performance of a group of subjects. The achievements of twenty healthy subjects were compared with three stroke patients. Results emphasize significant differences between the two categories of subjects, proving that the proposed algorithm can quantitatively determine the degree of impairment of a stroke survivor and be used in the future as reference for monitoring and enhancing the efficiency of robot-based therapies.

Keywords: Polygon Fitting, Genetic Algorithms, Geometry Codes, Medical Treatment

1. Introduction

The problem of *shape fitting* from scattered data is a common geometric problem exploited in several applications. In particular, when the data describes a trajectory, like a set of points traced by a human being, the approaches proposed in the literature might be insufficient.

This problem finds interesting application in the area of robot-based neurorehabilitation [1, 2, 3], considering a scenario where a patient with high arm disability is asked to perform a circular or polygonal trajectory following a target with a wearable exoskeleton [4]. Assuming that the device is transparent, the accuracy of the final performance is directly correlated to the subject's degree of impairment. At the end of the task, the overall performance can be evaluated based on the differences between the reference trajectory and the one traced by the patient. In this case, the patient's movements are described by a collection of scattered points sampled during the exercise. However, dealing with single points might create some confusion

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