341 | Visualization of the Image Set Recognition Based on Grassmann Manifold

Tianci Liu[1,2,3,4,5]; Zelin Shi[1,2,4,5]; Yunpeng Liu[1,2,4,5]; Zhongyu Zhang[1,2,3,4,5]

[1]*Shenyang Institute of Automation, Chinese Academy of Sciences, Shenyang, China;* [2]*Institutes for Robotics and Intelligent Manufacturing, Chinese Academy of Sciences, Shenyang, China;* [3]*University of Chinese Academy of Sciences, Beijing, China;* [4]*Key Laboratory of Opto-Electronic Information Processing, Chinese Academy of Sciences, Shenyang, China;* [5]*The Key Laboratory of Image Understanding and Computer Vision, Liaoning Province, Shenyang, China*

Objectives: In computer vision, it attracts more and more attention to represent image sets and videos of objects as linear subspaces which lie in the special Riemannian space, the Grassmann manifold. This geometry-aware approach is prevalent in visual tasks of image set recognition due to its robust performances under variabilities arising from changes in pose, lighting, expression, and other physical parameters. Moreover, we always directly measure the recognition performance depending on the numerical values. However, the reasons for differences of recognition results are not naturally clear. Because the Grassmann manifolds are abstract, it will make significant sense if the points on Grassmannian can be visualized from the geometric perspective. This paper aims to propose a novel method to solve this issue.

Methods: We constructed our visualization framework based on the Grassmann manifold. For the purpose of visualizing the circumstances of classification on the manifold, we should compute the set of coordinates corresponding to Grassmannian points in the non-Euclidean space. First, we choose the arc length as the essential distance metric for our framework. The arc length is the geodesic distance on the Grassmann manifold, which measures the intrinsic true distance between points on the manifold. Second, because we want to visualize the geometric distribution of classification, we should obtain coordinates in two-dimensional or three-dimensional Euclidean space, which preserves the pairwise patterns of data points. For the optimization of our model, we iteratively get the solution by t-distributed Stochastic Neighbor Embedding(t-SNE) [5] method. Finally, we conducted our experiments on the ETH-80 dataset to visualize the recognition performance on the Grassmann manifold.

Results: The ETH-80 dataset [6] contains 3280 images of eight object categories in total. All images are rescaled to the size of 20 by 20 for visualization purpose. Then, we produce 80 points on G(3,400) based on the intensity feature. In this case, we obtain 10 Grassmannian points for each class. Based on our novel approach, the visualization results of the image sets are exhibited as follows:

1. The visualization results of the image sets of each category in the two-dimensional space based on the geodesic length on Grassmannian are exclusively shown in Figure 1.

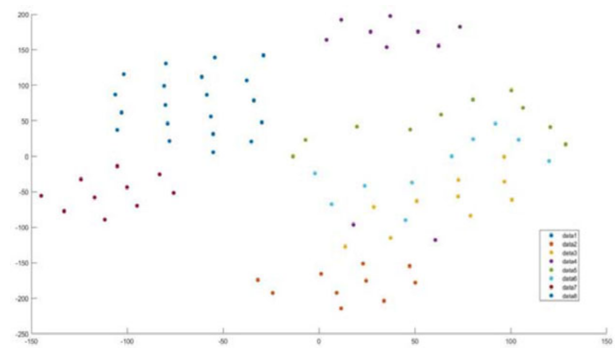

Figure 1

2. The visualization results of the image sets of each category in three-dimensional space based on the geodesic length on Grassmannian are respectively shown in Figure 2 and Figure

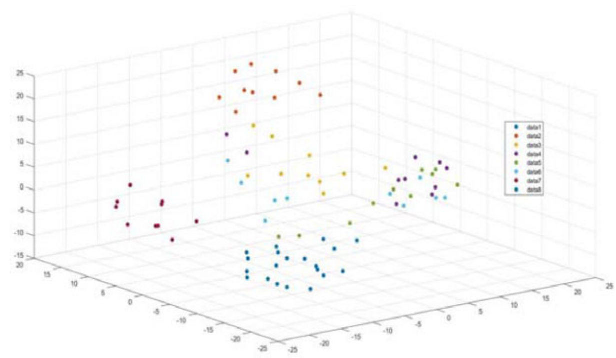

Figure 2

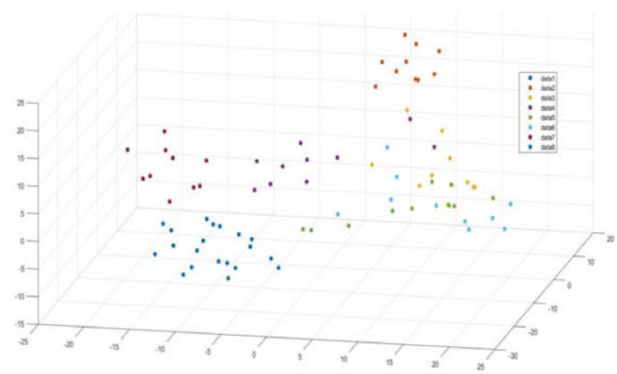

Figure 3

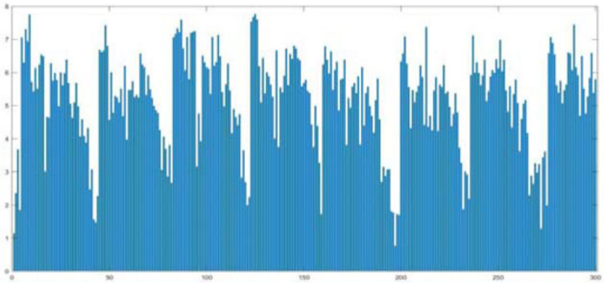

Figure 4

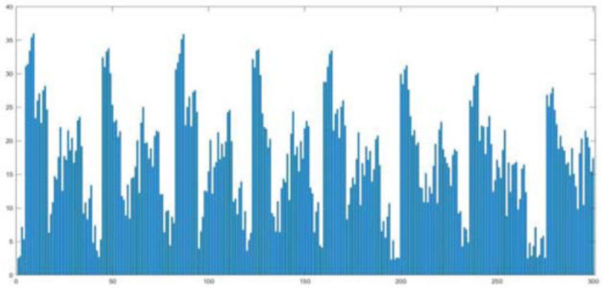

Figure 5

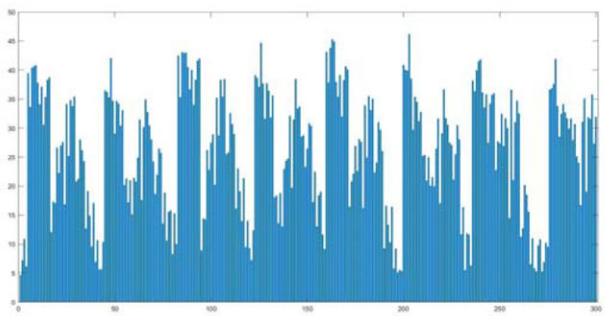

Figure 6

3. The distribution histograms of distances between the image sets based on the Riemannian points on the Grassmann manifold and visualized coordinate-points in the low-dimensional embedding space are shown in Figure 4, Figure 5 and Figure 6 respectively.

Conclusions: We present a novel methodology and framework to visualize the classification results of image sets in the two-dimensional and three-dimensional spaces according to the geodesic length on the Grassmann manifold. The geometric structure of sample points on Grassmannian is visualized to show the distribution of image sets with different classes. From the results, the proposed framework well approximates the pairwise distances of the image sets for recognition and illustrates its results from the geometric perspective instead of only numerical values.

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Correspondence Author: Tianci Liu, No.114, Nanta Street, Shenyang, China.

342 | Correlations between the Improvement-Related Kinematic Changes and Brain Activities Induced by Virtual Reality Based Stroke Rehabilitation

Chun-Chuan Chen[1]; Si-Huei Lee[2,3]; Changwei W. Wu[4,5]; Shih-Ching Yeh[6]; Mu-Chun Su[6]

[1]Department of Biomedical Sciences and Engineering, National Central University, Taoyuan, Taiwan; [2]The Physical medicine and Rehabilitation Department, Taipei Veterans General Hospital, Taipei, Taiwan; [3]Department of Medicine, College of Medicine, National Yang Ming University, Taipei, Taiwan; [4]Graduate Institute of Humanities in Medicine, Taipei Medical University, Taipei, Taiwan; [5]Shuang-Ho Hospital, New Taipei, Taiwan; [6]Department of Computer Science and Information Engineering, National Central University, Taoyuan, Taiwan

Background: Virtual reality-based rehabilitation (VRBR), a type of therapeutic approaches to reduce disability after stroke, enables the monitoring of kinematic parameters during training by using multiple sensory modalities. However, it remains clear how the kinematic changes during VRBR training are related to the changes of the neuronal mechanism underlying improved functional outcomes. Evidence from the neuroimaging and VRBR studies suggested that the neuronal patterns are crucial for functional recovery amongst stroke patients. In this study, we hypothesized that stroke patients at distinct recovery levels have different neuronal patterns associated with the kinematic changes during VRBR.

Methods: Eighteen stroke patients were recruited and underwent a custom-made VRBR during which the kinematic parameters were recorded. Before and after VRBR, stroke patients conduced the electroencephalography (EEG) experiments for measuring the movement-related brain activities and were evaluated with the Fugl-Meyer Assessment of Physical Performance (FMA). The EEG data were processed with the analysis of effective connectivity and by regression analysis, the neuronal correlates of the improvement-related kinematic changes were identified.

Results: The connectivity changes between ipsilesional and contralesional primary motor cortex (M1) were significantly related to the motion efficiency (ME) changes in patients with favorable recovery, while in patients with poor recovery, four additional network changes in the contralesional hemisphere were identified. Furthermore, the connectivity changes between ipsilesional pre-motor areas (iPM) and supplementary motor area (SMA) showed significant associations with the