Continuous mapping of Rey-Osterrieth complex figure test using Variational Autoencoders

Matías Grinberg

January 2019

Abstract

Deep neural networks were used to develop a scoring system for the Rey-Osterrieth complex figure test. Empirical results are contrasted with patient data to account for external validity. The mapping of each observation to the generated latent vector space allows for new kinds of analysis which were previously unreacheable using traditional methodology, with the added benefit of automation.

1 Introduction

The advent of neural networks has conveyed previously unimagined possibilities in most of human intellectual endeavours. This method's capacity is increasing exponentially, demonstrating new state of the art advancements every few weeks. In health, it will in many cases cause the evolution from categorical classifications systems to ones of continuous or dimensional representation as has been suggested in .This linking of nosologic entities in an abstract space allows for applications in both diagnosis and rehabilitation.

The Rey–Osterrieth complex figure test (ROCF) is a widely used neuropsychological assessment in which subjects are asked to copy a line drawing under three conditions: Copy, Immediate Recall and Delayed Recall. The performance depends on many distinct cognitive capacities, serving as an evaluation of visuospatial abilities, memory, attention, and executive functions.

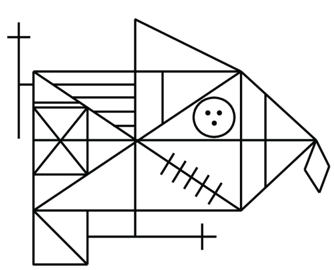

Figure 1: Rey-Osterrieth Complex Figure

or shown to measure various cognitive dimensions, including problem and planning solving strategies [2] attention and concentration levels, fine-motor coordination, and organizational skills [6].

2.2 Neurobiological correlates

The ROCF is considered to be a useful tool for the evaluation of frontal lobe function, which is required for strategic planning and organizing [3]

2.3 Current usage

There are characteristic ways to perform the task associated with different types of brain injury. ROCF has been used to assess visual memory disturbance and recall deficits in individuals with schizophrenia [4, 5] and in patients with traumatic brain injury and individuals with aneurysms of the anterior communicating artery [6]. Patients with right-hemisphere damage tend to do more poorly than do left hemisphere-damaged patients, even though both groups present significant numbers of errors. Poor performance on this test has been found in patients with different localization of focal damage. Also, individuals with Alzheimer's disease (AD), Huntington's disease (HD), and Korsakoff's syndrome have shown poorer copy and recognition on the ROCF than controls [2].

timization of some objective function. In contrast with "shallow" machine learning, neural networks rely on layers of unitary parts or "neurons" that, most generally, apply a linear combination on the input and a non-linearity. This allows for discrete transformations of the input manifold that, if successful, render the problem linearly approximable. Differentiating the loss function with respect to each coefficient of the network with a *backpropagating* fashion, gradient descent is used to *train* the weights of network using batches of data.

3.1 Data

From a small group of example drawings, we construct a ROCF generator that provides unlimited samples to build an initial latent space. Direct manipulation of the variability of the training dataset is useful to approximate the expected generative distribution, and it permits non-random training schemes such as curriculum or skill-specific training. To generate the data, we first sample drawn polygons from ROCF examples. To detect polygons, the process consists of:

- Filtering

  Scharr filter

- Contour finding

  Thresh otsu

- Polygon Approximation

  Remove redundant

- Thresholding

  Otsu

A generator function was used to sample from that set, feeding the neural network after a data augmentation pipeline. To account for possible variability, many augmentation layers where applied to each polygon group sampled.

Algorithm 1 Data Generation Pipeline

Initialize blank image
for random layers **do**
  Sample p polygons
  Add augmentations(polygons) to image
end for

3.2 VAEs

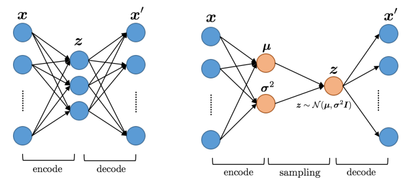

Figure 2: Autoencoders. Left: regular, right: variational

4 Results

4.1 External Validation

4.2 Discussion

References

[1] Somervile, J., Tremont, G. Stern, R.A. (2000). The Boston Qualitative Scoring System as a measure of executive functioning in Rey–Osterrieth Complex Figure performance. Journal of Clinical and Experimental Neuropsychology, 22(5), 613-621.

[2] Lezak, M. D., Howieson, D. B., Loring, D. W. (2012). Neuropsychological assessment (5th ed.). New York: Oxford University Press

[3] Shin, M.-S., Kim, Y.-H., Cho, S.-C., Kim, B.-N. (2003). Neuropsychologic Characteristics of Children with Attention-Deficit Hyperactivity Disorder (ADHD), Learning Disorder, and Tic Disorder on the Rey-Osterreith Complex Figure. Journal of Child Neurology, 18(12), 835–844.

[4] Calev, A., Edelist, S., Kugelmass, S., Lerer, B. (1991). Performance of long-stay schizophrenics on matched verbal and visuospatial recall tasks. Psychological Medicine, 21(3), 655-660

[5] Silverstein S. M., Osborn L. M., Palumbo D. R. (1998). ReyOsterrieth Complex Figure test Perfomance in Acute, Chronic, and Remitted Schizophrenia Patients. Journal of Clinical Psychology, 54(7), 985-994.

[6] Rivera D, Perrin PB, Morlett-Paredes A, Galarza-Del-Angel J, Martínez C, Garza MT, Saracho CP, Rodríguez W, Rodríguez-Agudelo Y, Rábago B, Aliaga A, Schebela S, Luna M, Longoni M, Ocampo-Barba N, Fernández E, Esenarro L, García-Egan P,Arango-Lasprilla JC (2015). Rey-Osterrieth Complex Figure - copy and immediate recall: Normative data for the Latin American Spanish speaking adult population. NeuroRehabilitation. 2015;37(4):677-98

[7] Roselli, M. Ardila, A. (1991). Effects of age, education, and gender on the Rey-Osterrieth Complex Figure. The Clinical Neuropsychologist, 5(4), 371-376.

[8] Stern, R. A., Singer, E. A., Duke, L. M., Singer, N. G., Morey, C. E., Daughtrey, E. W., Kaplan, E. (1994). The Boston qualitative scoring system for the Rey-Osterrieth complex figure: description and interrater reliability. The Clinical Neuropsychologist, 8(3), 309-322.