The Dimensionality of Episodic Images
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BACKGROUND

What is context?
- What constitutes a context? Unspecified outside of an experimental setting.
- Models of episodic memory commonly employ a context cue that specifies the context of interest, but they do not describe the process by which this cue is reinstated at the time of test.
- The ultimate goal is to model this as a search over episodic networks.

The Dimensionality of Discourse:
- Discourse is two-scaled (Doxas, Dennis & Oliver, 2010).
- Semantic spaces of five text corpora of different genres in four languages studied. Two-scaled structure found consistently with low dimension at small distances and higher dimension at large distances.
- Is this dimensionality structural or environmental?

Correlation dimension:
- High tolerance to large changes in appearance and shape caused due to changes in viewing angle, camera zoom, etc.
- A color correlogram is a three-dimensional table indexed by color and distance between pixels which expresses how the spatial correlation of color changes with distance in a stored image.
- Superior to color histograms in retrieval performance. Demonstrated by previous studies (Huang, Kumar, Mitra, Zhu & Zabih, 1997).

COLOR CORRELOGRAM

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EXPERIMENTAL METHODOLOGY

Subjects used a Microsoft SenseCam™ device to capture images over a period of about a week.
- The device captures images approximately once every 10 seconds. Each subject provided 5000-8000 images.
- Image representations are explored: The traditional color histogram (HSV) and a more recently developed color correlogram representation.
- Proper distance measures are defined on these representations. The Jensen-Shannon divergence distances are calculated for the color histogram method.
- A correlation dimension analysis is done to study the structure of human episodic experience and to understand the source (structural vs environmental) of the dimensionality constraints that were found to be present in natural language discourse structures.

HSV COLOR HISTOGRAM

- HSV (hue, saturation, value) space used.
- Separates out the luminance from the chromaticity.
- 30X10X3 = 900 bins. More sensitive to color differences than variations in brightness and depth.
- Jensen-Shannon divergences calculated between probability distributions. The square root of this is a metric which is used as the distance measure for the correlation dimension analysis.

RESULTS

Figure 1 (A) The number of points within a distance r scales as r^p, (B) Correlation function for 100,000 points randomly distributed such that they form a hollow tube of wall thickness 10^-1, radius of 10^-2 and length unity. The slopes give dimensions of 3.0, 2.0 and 1.0 at length scales that are smaller than the wall thickness, between the wall thickness and tube diameter, and longer than the diameter, respectively.

Figure 2 Query image and retrieved images using the color correlogram method. The distances from the query image are printed on top of each image.

To compare the two representations, we defined the “common neighbor ratio”.

\[ \text{common neighbor ratio} = \frac{\sum_{i=1}^{n} |I_i \cap T_i|}{n \times k} \]

where n is the total number of images. If k equals to n, then the ratio is 1. \( D_I = \{d_{I1}, d_{I2}, \ldots, d_{Ik}\} \) are image I's k nearest neighbors in the distance space and \( T_I = \{t_{I1}, t_{I2}, \ldots, t_{Ik}\} \) are image I's k nearest neighbors in the time space. A higher ratio would mean that more images that are close in time are correctly recognized as close in space by the method.

The correlogram method outperforms the color histogram method as seen from fig. 3.

Figure 3 The common neighbor ratio as a function of number of nearest neighbors for image sets of subject 1 (on the left) and subject 2 (on the right). The correlogram method has a higher ratio than the color histogram method.

Figure 4 The correlation dimension plots using the sqrt(Jensen-Shannon divergence) distances between color histogram probability distributions for subject 1 (on the left) and subject 2 (on the right).

Figure 5 The correlation dimension plots using the color correlogram method for subject 1 (on the left) and subject 2 (on the right).

CONCLUSIONS

- The color correlogram representation seems to capture episodic experience better than the traditional color histogram representation based on our definition of the “common neighbor ratio”.
- There are hints of a two-scaled structure in the image correlation dimension plots. Since there is one plot that doesn’t exhibit this behavior, analysis from more data is awaited before anything conclusive can be said.
- If a two-scaled structure is found consistently in the image sets across subjects, it is plausible that the source of the dimensionality constraints observed in discourse is environmental and external in nature rather than a constraint that the cognitive system imposes.

REFERENCES
