CNIT: Complex Network Image Tranform

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This work aims to utilize complex network modeling techniques to represent the input image. In this approach, the image is modeled as a complex graph where each pixel is represented as a vertex, and the edges are defined based on the r-radius neighborhood connectivity.

Let I be an image composed of pixels $i = (x_i, y_i)$. To model the image, each pixel i is mapped as a vertex $v_i \in V$ and two vertices are connected by an edge if the Euclidean distance between them is less than the radius r. That is, $E = \{\{v_i, v_j\} | v_i, v_j \in V, i \neq j, \text{ and } (x_i - x_j)^2 + (y_i - y_j)^2 < r^2\}$. The weight of the edge is given by the absolute difference in the gray levels of the corresponding pixels, i.e., the weight of an edge connecting v_i and v_j is $w_{ij} = |I(x_i, y_i) - I(x_j, y_j)|$, where $I(x_i, y_i)$ and $I(x_j, y_j)$ are the gray scale intensity values of pixels i and j, respectively.

Unlike previous works in the literature that extract network topological measures directly, the proposed method introduces a novel transformation approach. This approach consists of transforming the modeled complex network into new images that emphasize different textural patterns of the original image encoded within the network topology. An example is shown in Figure 1.

The transformation process involves mapping vertex measures, such as degree and force, to pixel intensity values, resulting in images that encapsulate the underlying textural patterns. The degree of a vertex represents the num-

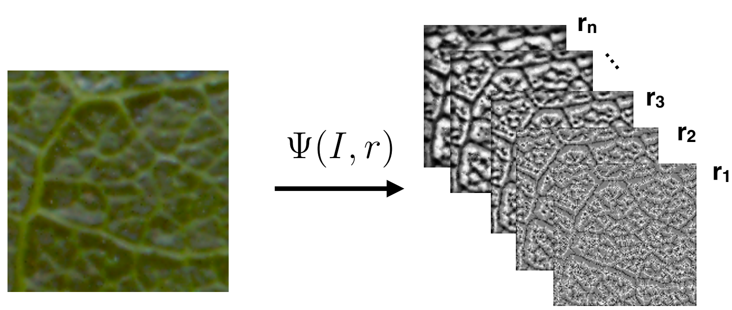

Figure 1: Resulting images of the application of a complex network image transform.

ber of connections it has with other vertices, while the force at a vertex v_i is calculated as a combination of two factors: the normalized difference in gray scale intensity between v_i and all other connected vertices, and the Euclidean distance between them. Specifically, the force F_i for a vertex v_i is defined by the following formula:

$$F_i = \frac{1}{2} \times \left(\frac{\sum_{\{v_i,v_j\}\in E} |I(x_i, y_i) - I(x_j, y_j)|}{255} + \frac{d_{ij}}{r}\right)$$

, where d_{ij} is the Euclidean distance between the pixels (x_i, y_i) and (x_j, y_j), and r is the radius used to define the neighborhood.

The resulting texture patterns are influenced by the modeling parameter r (connection radius), which controls the network's structural representation. By varying r, the method captures different scales of textural information, allowing for an analysis of both micro- and macro-textural patterns.