**cytoNet: description of metrics**

**Global Network Metrics**

(Contained in the file GlobalMetrics.csv)

*Basic Network Parameters*

**Node Count ()**

Number of nodes (objects).

**Edge Count (**

Number of edges (connections).

**Percent Area Cells**

Fraction of total surface area covered by cells.

**Average Degree**

Average number of connections for a node in the network.

*Degree-related Metrics*

**Network Density**

Normalized version of average degree. Network density is a number between 0 and 1, and is the ratio of actual connections in the network to the total number of potential connections. A fully connected clique has a network density of 1.

**Variance in Degree**

Variance of normalized node degree sequence

**Network Heterogeneity**

Reflects tendency of network to contain hub nodes

Where is the degree sequence.

**Clustering Coefficient (normalized)**

Clustering coefficient of a node is the number of connections in the local neighborhood of the node, divided by total possible connections in the neighborhood. The local neighborhood of a node comprises of all the nodes exactly 1 link away.

If the average clustering coefficient across all nodes in the network is and the average clustering coefficient of 100 random graphs (generated through degree-preserving rewiring) is , thenclustering coefficient (normalized)

**Average Neighbor Degree**

Average degree of neighboring nodes, averaged across all nodes.

**Variance in Neighbor Degree**

Variance of the normalized average neighbor degree sequence.

*Motif Counts*

**4-star Motif Count**

Number of occurrences of motif with hub node and 3 spokes, normalized by total possible 4-tuples, *nC4*

**5-star Motif Count**

Number of occurrences of motif with hub node and 4 spokes, normalized by total possible 5-tuples, *nC5*

**6-star Motif Count**

Number of occurrences of motif with hub node and 5 spokes, normalized by total possible 6-tuples, *nC6*

**Triangular Loop Count**

Number of occurrences of motif with 3 connected nodes, normalized by total possible 3-tuples, *nC3*

**Pair Node Count**

Number of occurrences of motif with 2 nodes.

**Isolated Node Count**

Number of nodes with no neighbors.

*Modularity Metrics*

**Number of Connected Components**

A connected component is a collection of nodes in which no node is isolated. A highly connected graph has a small number of connected components.

**Average Component Size (normalized)**

Average number of nodes per connected component, divided by total number of nodes.

**Variance in Component Size**

Variance in normalized component size sequence.

*Geodesics*

**Network Diameter**

The largest distance between two nodes in terms of number of links.

**Network Efficiency (normalized)**

The shortest path between two nodes is the smallest number of links needed to travel from one node to the other. The reciprocal of the shortest path length is the efficiency. The average value of efficiency for the network is called network efficiency.

If network efficiency is and the average network efficiency of 100 random graphs (generated through degree-preserving rewiring) is , thennetwork efficiency (normalized) .

**Local Efficiency**

Network efficiency of local neighborhood of a node, averaged across the network.

**Assortativity**

Pearson correlation coefficient of degrees between pairs of linked nodes. A highly assortative network is one where nodes with high degree tend to connect with other nodes with high degree.

**Local Network Metrics**

(Computed on a per-cell basis)

**Degree**

Number of neighbors one link away.

Illustration of degree in a culture of human umbilical vein endothelial cells

**Average Neighbor Degree**

Average of average degree for all neighboring nodes.

**Clustering Coefficient**

Number of connections in the local neighborhood of a node, divided by total possible connections in the neighborhood.

**Local Efficiency**

Network efficiency of local neighborhood of a node.

**Closeness Centrality**

Sum of the length of shortest paths between a node and all other nodes in the network.

Illustration of closeness centrality in a culture of human umbilical vein endothelial cells (HUVECs). Cells at the center of colonies have high closeness centrality compared to cells at the edge of colonies or isolated cells.

**Betweenness Centrality**

Number of times a node occurs in the shortest path between two other nodes.

Illustration of betweenness centrality in a culture of human umbilical vein endothelial cells. Cells connecting different clusters have high betweenness centrality.

**Single-Cell Metrics**

(Computed on a per-cell basis)

**Object Size**

Total cell area in pixels.

**Circularity**

A metric of cell roundness, measured as the closeness to a perfect circle.

Where = cell area, = cell perimeter

**Elongation**

Shape factor measured as perimeter/area.

**Intensity**

Average grayscale intensity of pixels within the cell, reported as a number between 0 and 1, where 0 indicates complete darkness and 1 indicates complete whiteness.

**Note that the files containing local network metrics and single-cell metrics contain a column labeled ‘Cell Index’, listing the indices overlaid in the processed images. The indices in each of these files match each other.**