Topological implications of negative curvature for biological networks

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In real biological network applications, one frequently encounters phenomena of the following type:

a) Network motifs are often nested.

b) Paths mediating up- or down-regulation of a target node starting from the same regulator node often have many small crosstalk paths.

c) There are central nodes of influential neighborhoods.

Although each of these phenomena can be studied on its own, it is desirable to have a network measure reflecting salient properties of complex large-scale networks that can explain all these phenomena at one shot. In this talk we adapt a combinatorial measure of negative curvature (Gromov hyperbolicity) to parameterized finite networks, and show that a variety of biological networks are hyperbolic. The hyperbolicity property has strong implications on the higher-order connectivity and other topological properties of these networks. Specifically, we derive and prove bounds on the distance among shortest or approximately shortest paths in hyperbolic networks, and explain how implications of these bounds may provide answers to observations such as in a)-c) above [1,2].

REFERENCES

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