

# A Geometric Measure of Polysemy in Hindi Language

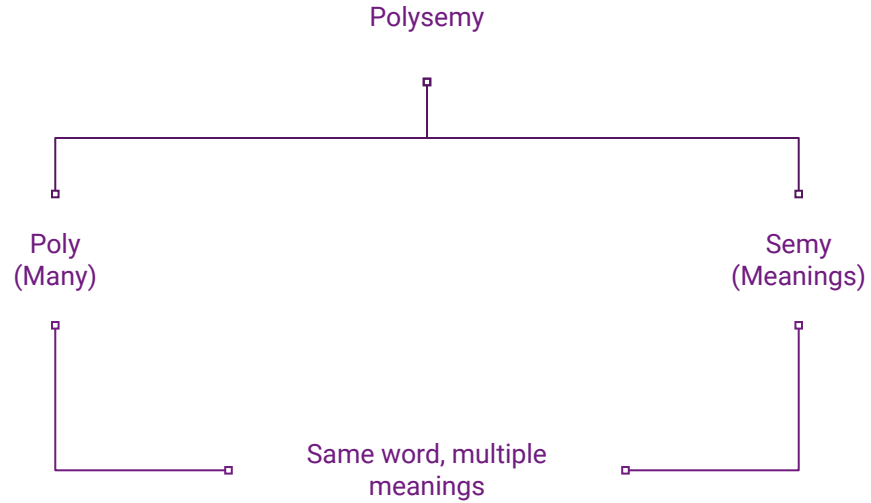
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# What is polysemy?



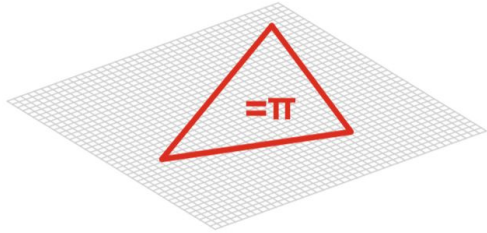
# What is polysemy?

- Polysemy is the ability of a word to possess more than one meanings.
- **Monosemantic** words: hydrogen, molecule
- **Polysemantic** words: bright means shining and intelligent.
- *Applications:*
  - *Used in linguistics to study language.*
  - *Improve POS and WSD tasks using polysemy information. [1]*

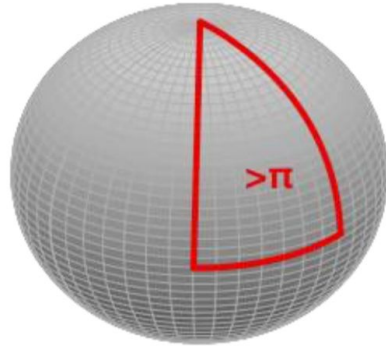
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[1]: <https://link.springer.com/article/10.1007/s10462-019-09725-4#citeas>

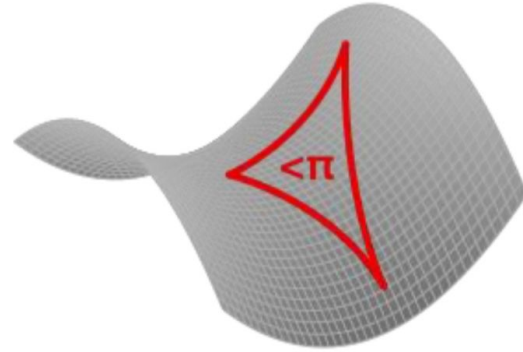
# What is curvature?



2D Plane  
Zero Curvature



3D Sphere  
Positive Curvature



3D Saddle  
Negative Curvature

# What is curvature?

- A geometric property describing flatness of an object
  - Types of curvature -
    - Global
      - One value for whole network
      - No edge/vertex specific information
    - Local
      - Edge/vertex specific information
      - Higher granularity
-

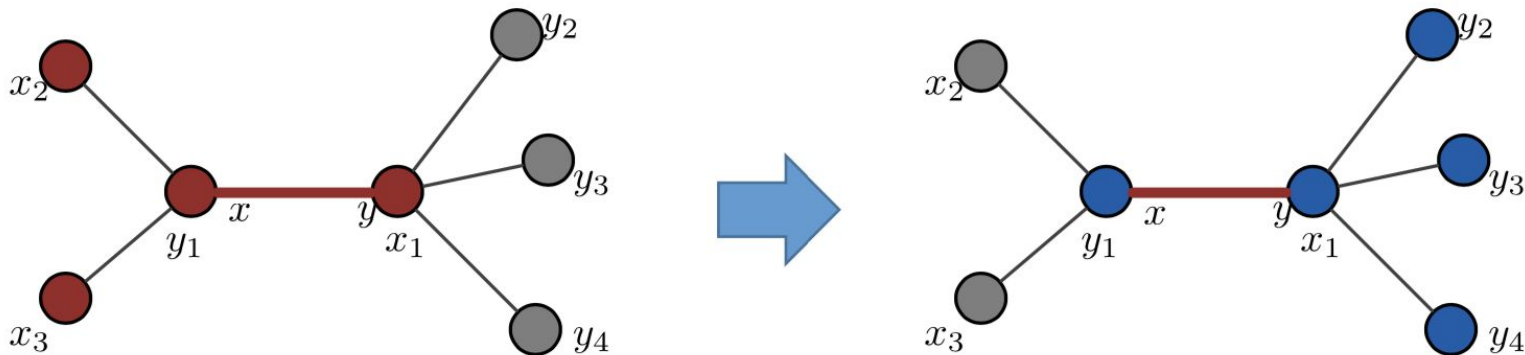
# What is Ricci curvature?

- Geometric curvature measure used in Differential Geometry.
- In Riemannian geometry, curvature measures how a smooth object deviates from being flat, or being straight in the case of a line.
- Measured as average over all directions of a tangent vector transported to be a tangent vector at another point.



# Discrete Ricci Curvature

- *Ollivier generalized Ricci curvature to discrete problems like graphs.*
- *Assign uniform distribution  $\mu_1, \mu_2$  on neighbours of 2 nodes.*
- *Use optimal transport distance (Wasserstein) from  $\mu_1$  to  $\mu_2$*
- *Minimize the total transport distance between two probability measures.*



# Discrete Ricci Curvature

- *+ve curvature == edge is within a cluster.*
- *-ve curvature == edge acts as a bridge between 2 distinct clusters*

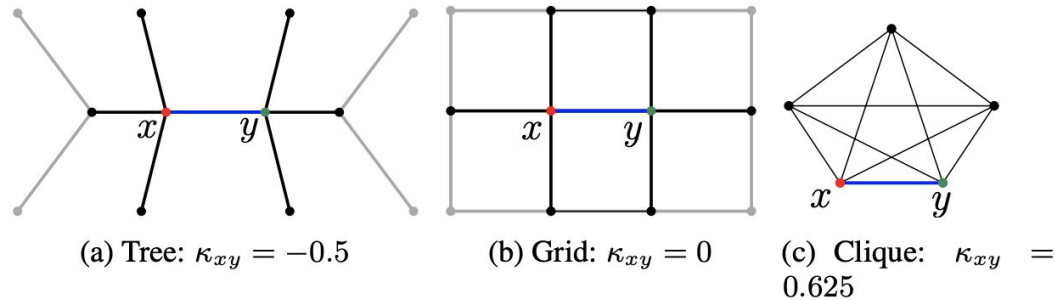


Figure 1: Illustration of structural information. In all three graphs, the degrees of  $x$  and  $y$  are the same. However, the Ricci curvature of the edge  $(x, y)$  is negative, zero, and positive, respectively. All edges have weight 1.  $\alpha = 0.5$  so each node keeps 50% of the probability mass to itself.



# Data

- *We construct a graph of synonyms by accessing the Hindi WordNet*
- *Words = Nodes*
- *Edge between two words if they occur in the same synset of the WordNet.*

<b>Nodes</b>	<b>Edges</b>	<b>Average Degree</b>
9224	34335	7.44

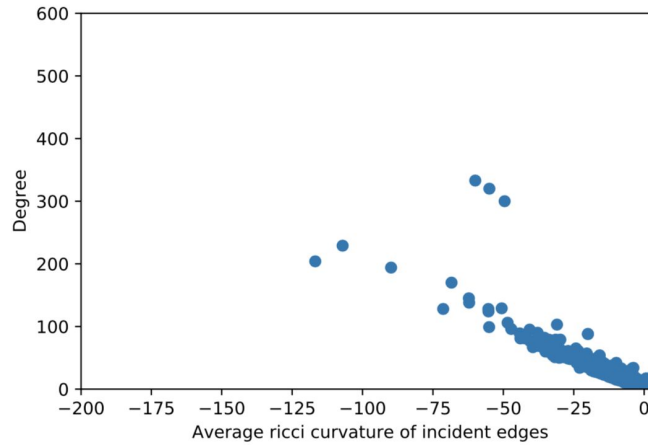
**Table 1: Details of the graph of synonyms**

# Algorithm

- *Construct graph of synonyms from Hindi WordNet.*
- *Calculate Ricci curvature of each edge.*
- *Calculate average Ricci curvature of all incident edges on a node.*
  
- ★ *Negative edge on a node(word) == acts as bridge between distinct clusters of meanings of this word.*
- ★ *Higher negative measure == higher polysemy!*

# Observations

- *Zipf's Law: Words with higher frequency tend to be more polysemous. [1]*
- *In our experiments, we found **-0.84** correlation between word degree and word polysemy.*



# Conclusion & Future Work

- *We propose a novel geometric measure of polysemy.*
- *We measure the degree of polysemy instead of just detecting the presence of polysemous words.*
- *We plan to extend this approach to synsets of other languages and conduct more in-depth experiments.*

Thank You