# Neighborhood Topologies

In the original PSO, two different kinds of neighborhoods were defined for PSO:

- In the gbest swarm, all the particles are neighbors of each other; thus, the position of the best overall particle in the swarm is used in the social term of the velocity update equation. It is assumed that gbest swarms converge fast, as all the particles are attracted simultaneously to the best part of the search space. However, if the global optimum is not close to the best particle, it may be impossible to the swarm to explore other areas; this means that the swarm can be trapped in local optima.
- In the lbest swarm, only a specific number of particles (neighbor count) can affect the velocity of a given particle. The swarm will converge slower but can locate the global optimum with a greater chance.

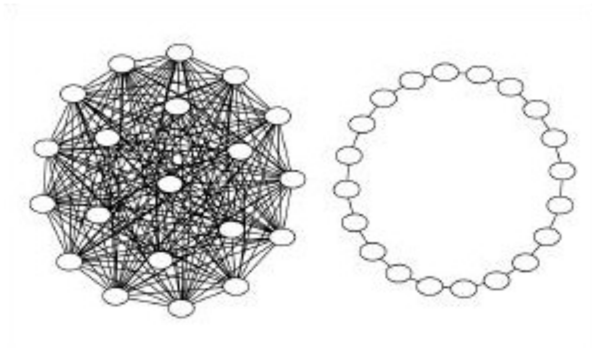

**Figure 1:** Graphical representation of the gbest(left) and lbest(right) neighborhood topologies. In the lbest topology, a number of neighbors is selected from each side of the particle.

Both gbest and lbest can be seen as "social" neighborhoods, as the relations among particles does not depend on their positions in the search space, but on "external" relationships that are not dependent on the problem that is being solved.

In [2] a systematic review of alternative "social" neighborhood topologies was investigated. Different neighborhoods can be characterized in terms of two factors, taken from Watts [3,4]:

- The degree of connectivity, *k*, that measures the number of neighbors of a particle
- The amount of clustering *C*, that measures the number of neighbors of a particle that are also neighbors of each other

The following additional topologies were tested:

- Random
- Von Neumann, a two dimensional grid with neighbors to the N, E, W and S
- Pyramid, a three-dimensional triangular grid
- Star, all the particles connected to a central particle
- Heterogeneous, particles are grouped in several cliques

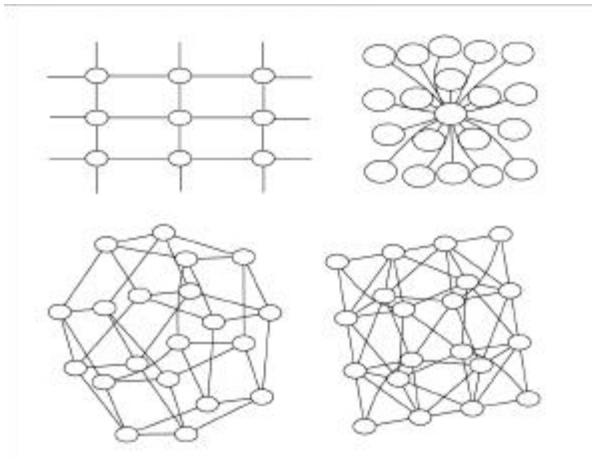

**Figure 2:** A flattened representation of the Von Neumann neighborhood (top left), three-dimensional representation of the Von Neumann neighborhood (bottom left), the star (top right) and the pyramid (bottom right) neighborhoods.

The swarms with the different neighborhoods were used to optimize several known functions and an statistical analysis was carried out over several dependents: best result at 1000 iterations, number of iterations needed to meet the stopping criteria, and whether the stopping criteria was met or not.

The conclusions depended on the variable selected, but a combined measure selected the Von Neumann and Pyramid neighborhoods as the best, and the star and gbest as the worst. Other conclusions were that higher *k* favored performance (good exploration), while lower *k* favored the chance of meeting the criteria (good exploitation).

In [1], the concept of a "dynamic" neighborhood is explored. In this work, neighborhood of a particle changes over time in two senses:

- The number of neighbors of a particle starts as in the lbest swarm, with neighbor count 1; that is, the particle itself is its only neighbor. This neighbor count increases over time, finally becoming a gbest swarm.
- The selection of neighbors for a particle is calculated on each iteration, based on the hamming distance between the potential neighbors and the particle.

The advantage of this topology, however, is not clearly stated in the mentioned paper. The drawbacks are the extra computational cost required to calculate the neighborhood for each particle, and the separation from the original social metaphor.

In [5], a dynamic neighborhood topology is used for multimodal function optimization.

## Bibliography

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