**Grokking Artificial intelligence Algorithms**
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## Section 7 Swarm Intelligence Particles

Particle swarm optimization is another swarm algorithm. Swarm intelligence relies on emergent behavior of many individuals to solve difficult problems as a collective. We saw in chapter 6 how ants can find the shortest paths between destinations through their use of pheromones

### What is it?

Birds are a good example since birds flock to save energy and they can change leaders if they change directions or if the leader gets tired. When a bird moves out of formation it has a harder time flying and will quickly move back into formation. 3 main rules used to guide the group are understood: Alignment or an individual should steer in the average heading of its neighbors to ensure that the group travels in a similar direction. Cohesion, an individual should move toward the average position of its neighbors to maintain the formation of the group. Separation, an individual should avoid crowding or colliding with its neighbors to ensure that individuals do not collide, disrupting the group. Particle swarm optimization involves a group of individuals at different points in the solution space, all using real-life swarm concepts to find an optimal solution in the Space. Particle swarm optimization algorithms are particularly useful in the following Scenarios: Large search spaces where there are many data points and possibilities of Combinations. Search spaces with high dimensions where there is complexity in high dimensions. Many dimensions of a problem are required to find a good solution.

### Applicable problems

If we were creating a drone with different materials for its many components we can try to find the combination that gives it an optimal performance. We can judge good performance by seeing less drag and less wobble in the wind.

### Representing State

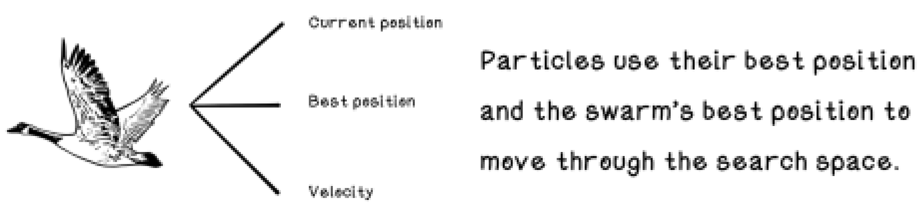
Particles can be represented with position, best position, and velocity. A particle optimization algorithm has a general life cycle of initializing the population of particles, calculate the fitness of particles, update the position of each particle, and determining the stopping criteria. Updating the particles position is a very important step and it is what encompasses the swarm intelligence. They update their position given a cognitive ability and factors in the environment around them, such as inertia and what the swarm is doing. Three components are used to calculate the new velocity of each particle: inertia, cognitive, and social. Here inertia represents the resistance to movement or change in direction for a specific particle that influences its velocity. The cognitive component represents the internal cognitive ability of a specific particle. The cognitive ability is a sense of a particle knowing its best position and using that position to influence its movement. The social component represents the ability of a particle to interact with the swarm. A particle knows the best position in the swarm and uses this information to influence its movement. Social acceleration is determined by using a constant and scaling it with a random number. The social constant remains the same for the lifetime of the algorithm, and the random factor encourages diversity in favoring the social factor. It is important to note that the greater the social constant the more exploration since it will favor its social component the most. The velocity is the sum of the inertia, cognitive and social component. Position is updated by added the velocity to the current position. The number of iterations the algorithms performs exploration, exploring the search space for a better solution and exploitation which is that particles should converge to a desirable solution. A strategy to stop the algorithm is to examine the best solution in the swarm and determine whether it is stagnating. Stagnation occurs when the value of the best solution doesn’t change or doesn’t change by a significant amount.

**Use Cases**

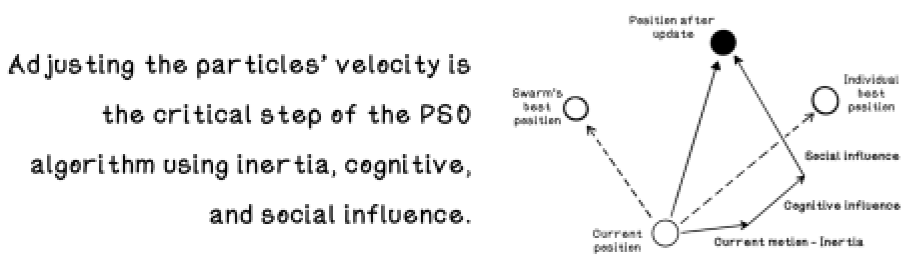
One interesting application of a particle swarm optimization algorithm is deep brain stimulation. The concept involves installing probes with electrodes into the human brain to stimulate it to treat conditions such as Parkinson’s disease.

**Important Firgures**

**Particle Properties**




**Particle velocity**



## New velocity formula

New velocity:

inertia component + social component + cognitive component

(inertia * current velocity)

(social acceleration * (swarm best position - current position))

(cognitive acceleration * (particle best position - current position))