Swarm Intelligence Course—H-414

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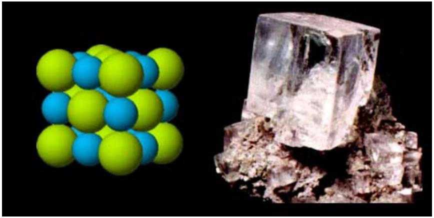
Pattern Formation with Mobile Robots

Working definition: a pattern is an arrangement of objects displaying a mathematical, geometric, or statistic relationship.



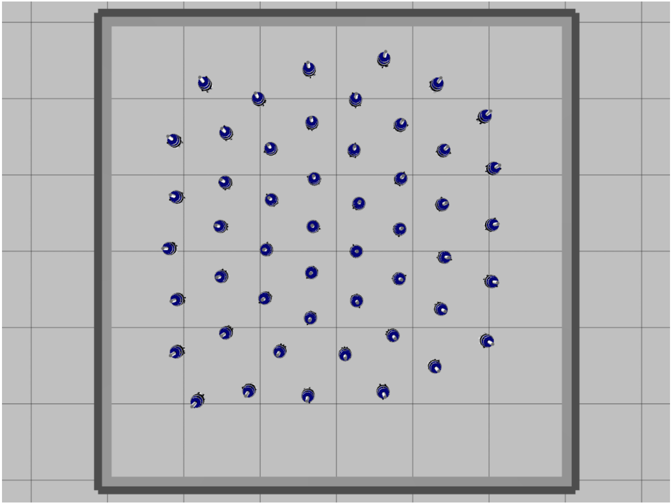


Pattern Formation with Mobile Robots

Pattern formation is useful for:

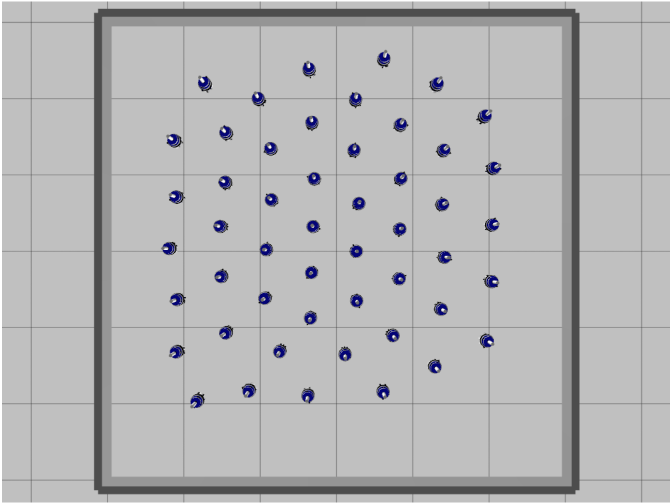
- covering an area with a fixed number of robots;
- flocking
- achieving a certain network topology

Pattern Formation with Mobile Robots



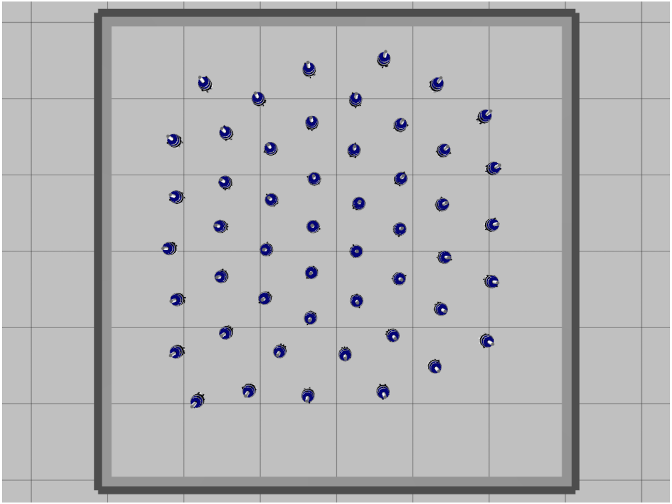
Pattern Formation with Mobile Robots

HOW?

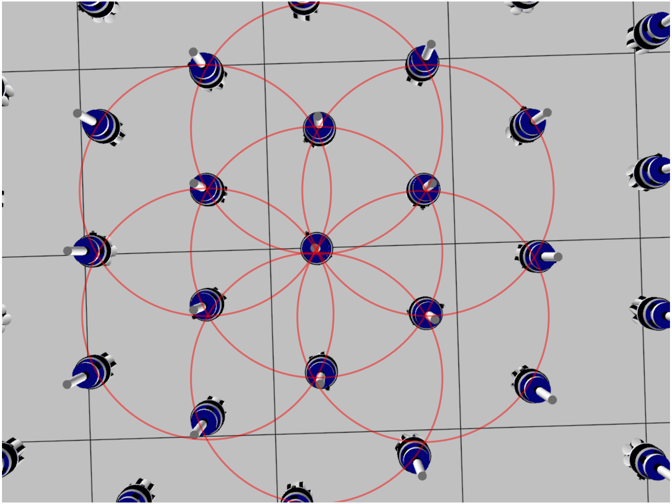


Pattern Formation with Mobile Robots

HOW? **(propose something!)**



Pattern Formation with Mobile Robots



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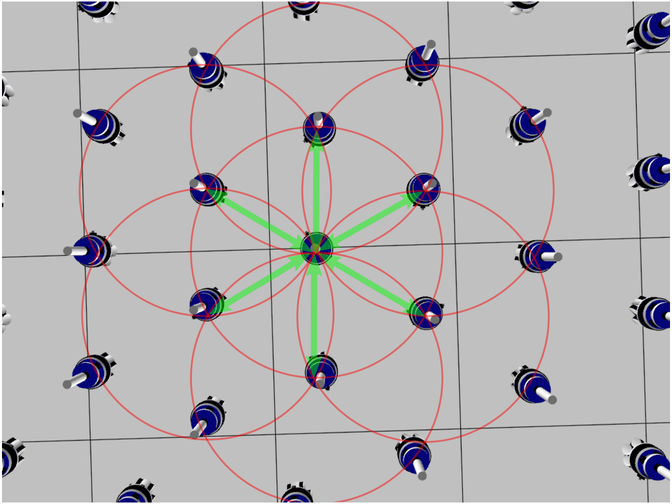

Pattern Formation: idea

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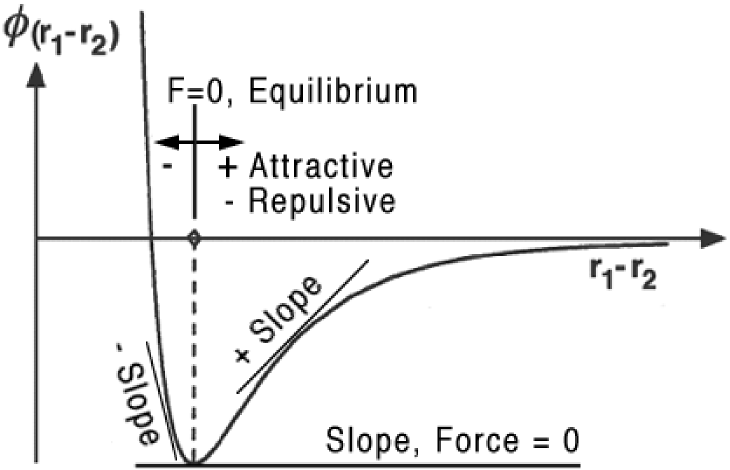
- In physics, the derivative of a potential is a **force**.
- We transform the force into wheels actuation.
- This way, the robots tend to go to the **minimum energy configuration**.

The Lennard-Jones Potential



The Lennard-Jones Potential

From the potential:

$$V(\rho) = \epsilon \left(\left(\frac{\delta}{\rho} \right)^{12} - 2 \left(\frac{\delta}{\rho} \right)^{6} \right)$$

We can derive the force:

$$F(\rho) = -\nabla V(\rho) = -\frac{12\epsilon}{\rho} \left(\left(\frac{\delta}{\rho} \right)^{12} - \left(\frac{\delta}{\rho} \right)^{6} \right)$$

The Lennard-Jones Potential

The same works with smaller exponentials (and it is easier to compute):

$$V(\rho) = \epsilon \left(\left(\frac{\delta}{\rho} \right)^4 - 2 \left(\frac{\delta}{\rho} \right)^2 \right)$$

We can derive the force:

$$F(\rho) = -\nabla V(\rho) = -\frac{4\epsilon}{\rho} \left(\left(\frac{\delta}{\rho} \right)^4 - \left(\frac{\delta}{\rho} \right)^2 \right)$$

Pattern formation: Implementation

1) Calculate the result force due to neighbors

```
for each neighbor i do
   calculate Lennard-Jones[i]
   direction = direction + Lennard-Jones[i]
end
```

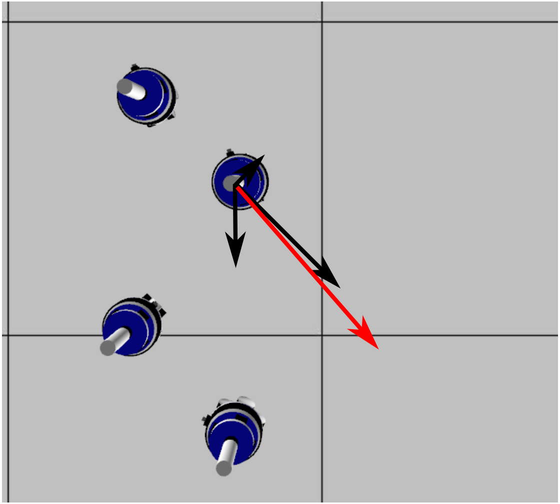
2) Transform **direction** into wheel actuation

Pattern formation: Implementation

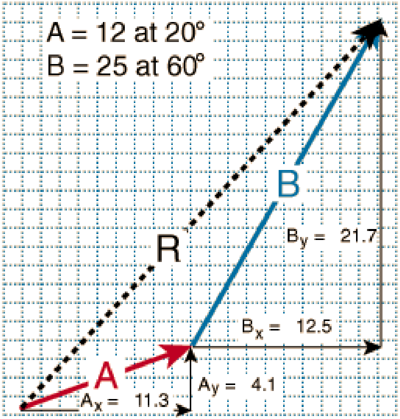
Possible numerical values:

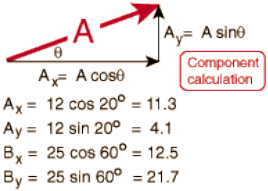
- Target distance: 80 [cm]
- $\epsilon = 50$
- Wheel speed: slow! E.g., 5 [cm/s]

Implementation:



Vectors:

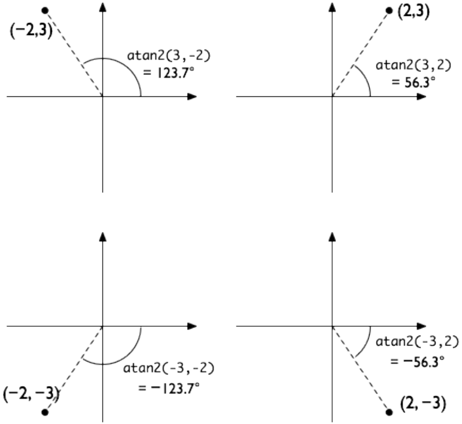




From: http://hyperphysics.phy-astr.gsu.edu/hbase/vect.html

Vectors:

From components [x,y] to angle:



Extra: grid lattice

Grid lattice