Collective Estimation

Basis

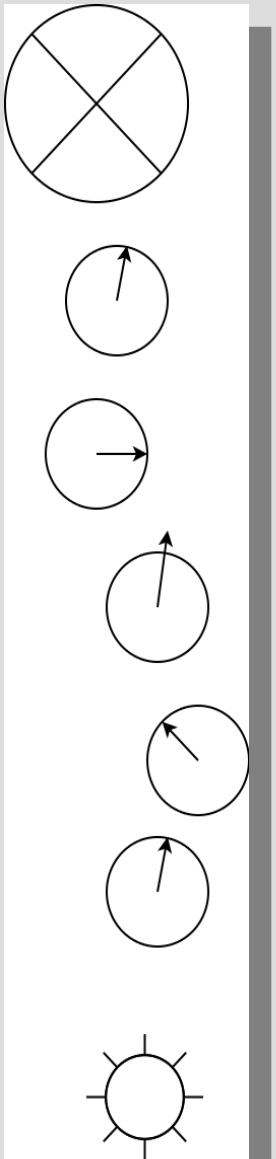
- Following the work of Shervin & Rodi
- The scenario was split in 2 parts
  - find the prey using chains of robots
  - retrieve collectively the prey to the nest

Problem

- Chains might not be long enough

Solution

- Explore the environment using a random walk



Collective Estimation

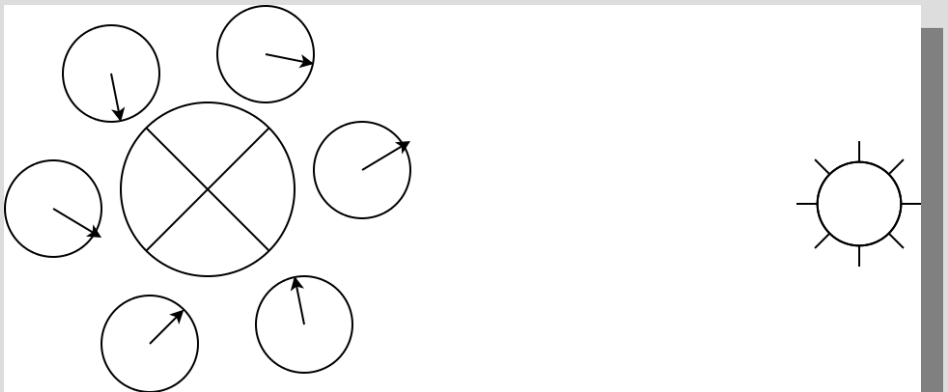
Challenge

- Robots find the prey, but don't perceive the nest anymore
- How to go back to the nest ?
- Odometry on a single robot is not efficient
- Is it possible to have an improved estimation of the direction of the nest using several robots ?

Mechanism proposed

Hypothesis

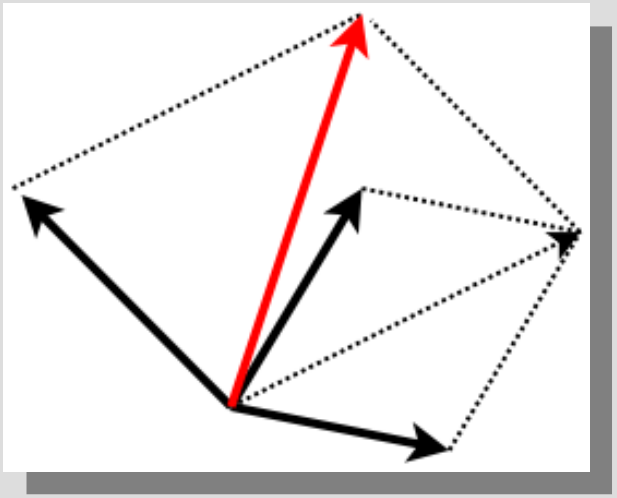
- The distribution of odometry errors is symetric (gaussian)
- Robots can communicate with some local neighbours using their LEDs and cameras
- Robots are disposed in circle around the prey
- The communications are noisy (gaussian perturbation)



Mechanism proposed

Rules

- For each robot
  - Estimate the direction *di* pointed by the **n*2** neighbours
  - Update it's own pointed direction using the formula
    - desiredDir = (oldDir + di) / (n*2 + 1)
    - newDir = oldDir + delta (desiredDir - oldDir)

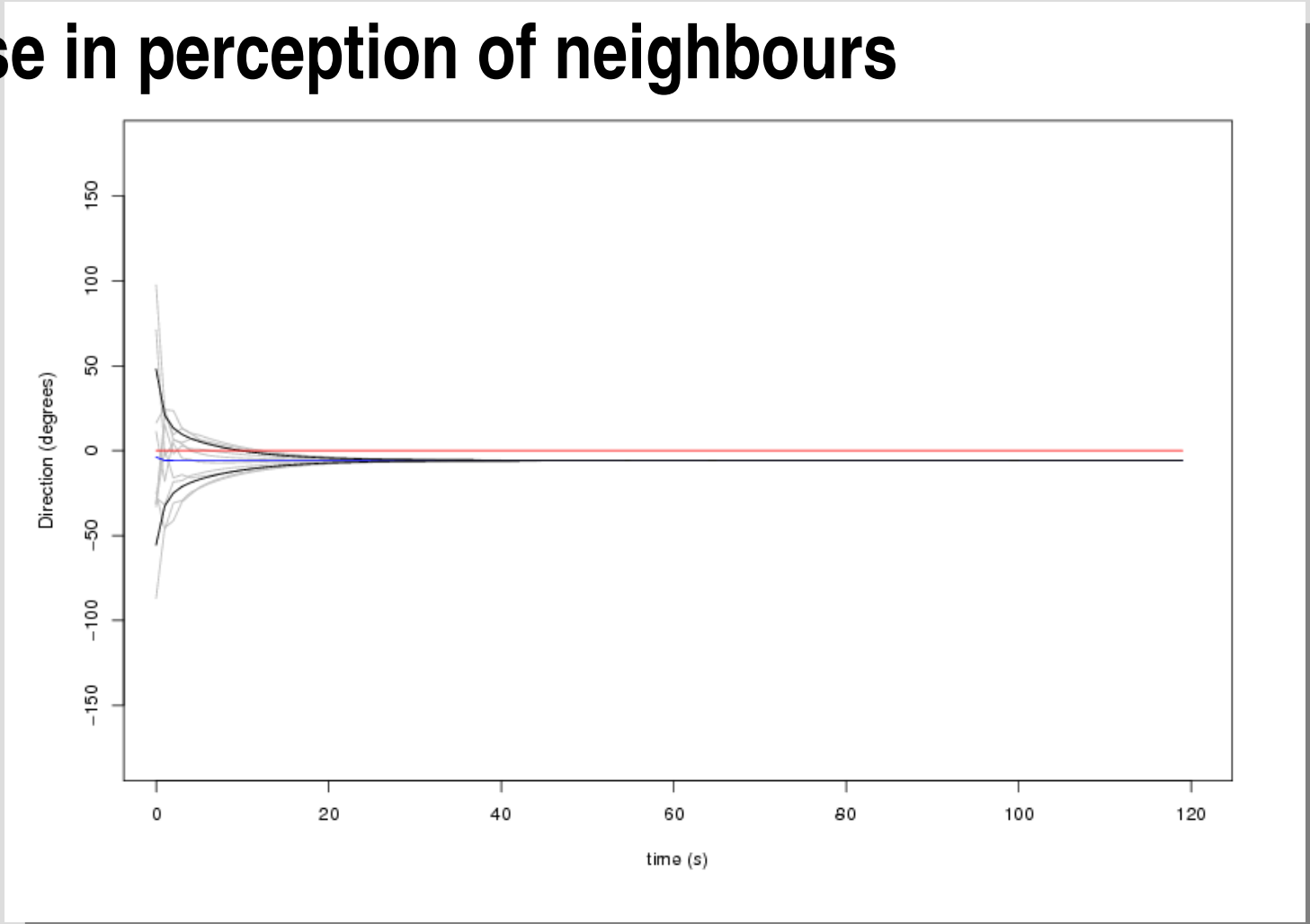


Method & Measures

- Within one experiment of fixed duration *d*
- There are r robots that perceive n*2 neighbours
- We measure the mean direction of the group
- We measure the standard deviation of directions
- Over 10000 replications we have
  - an averaged experiment in time
  - the distribution of mean directions at the end
  - the distribution of standard deviations at the end

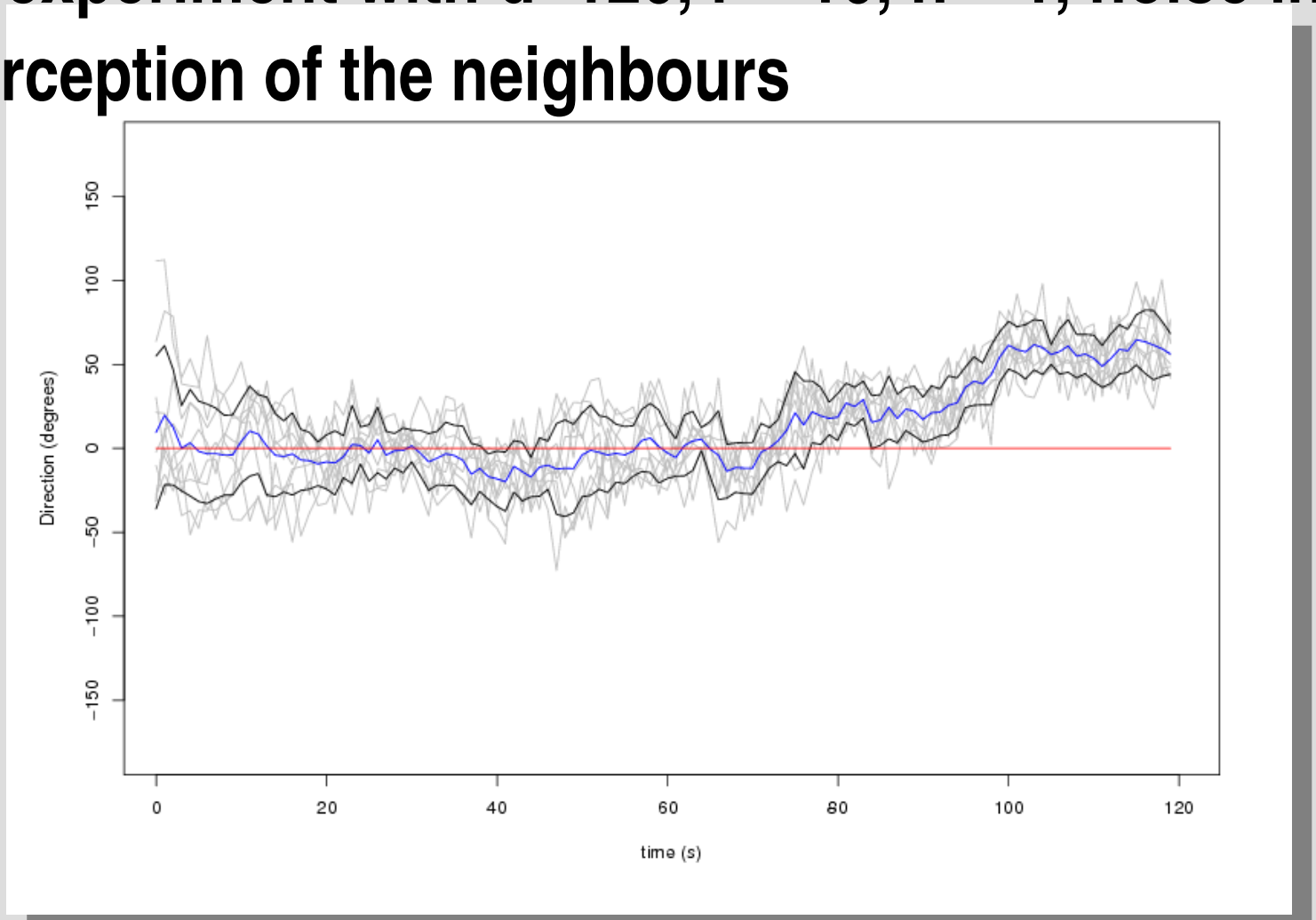
Measures

One experiment with d=120, r = 10, n = 1, and no noise in perception of neighbours



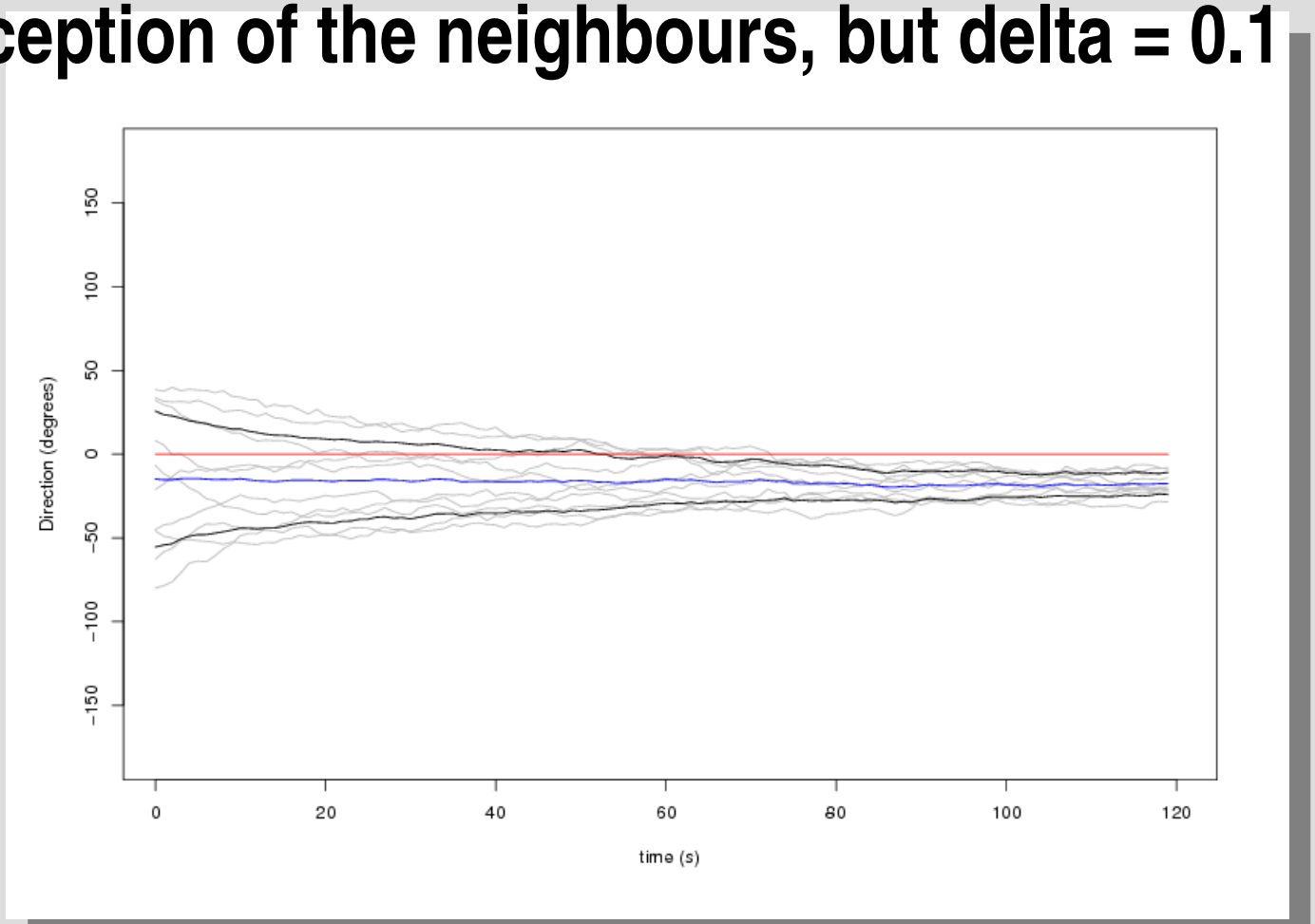
Measures

One experiment with d=120, r = 10, n = 1, noise in perception of the neighbours



Measures

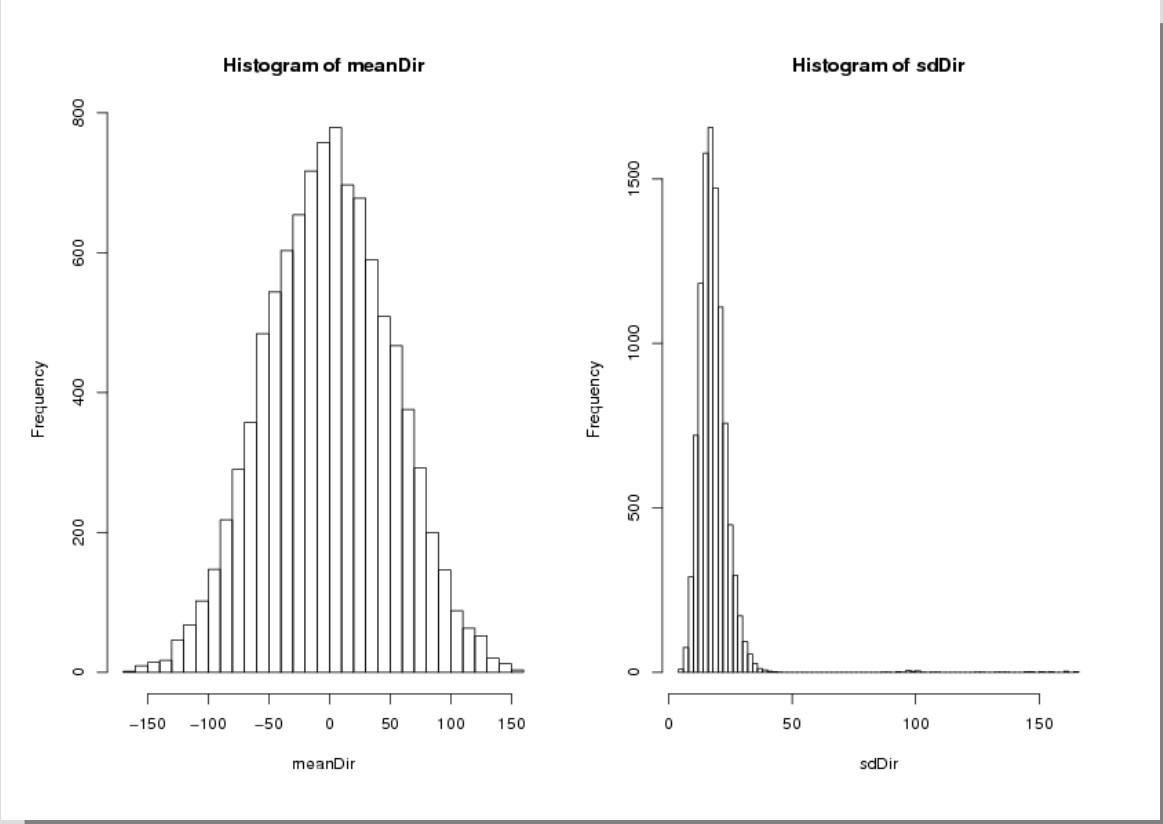
One experiment with d=120, r = 10, n = 1, noise in perception of the neighbours, but delta = 0.1



Measures

One experiment with d=120, r = 10, n = 1, delta = 1.0

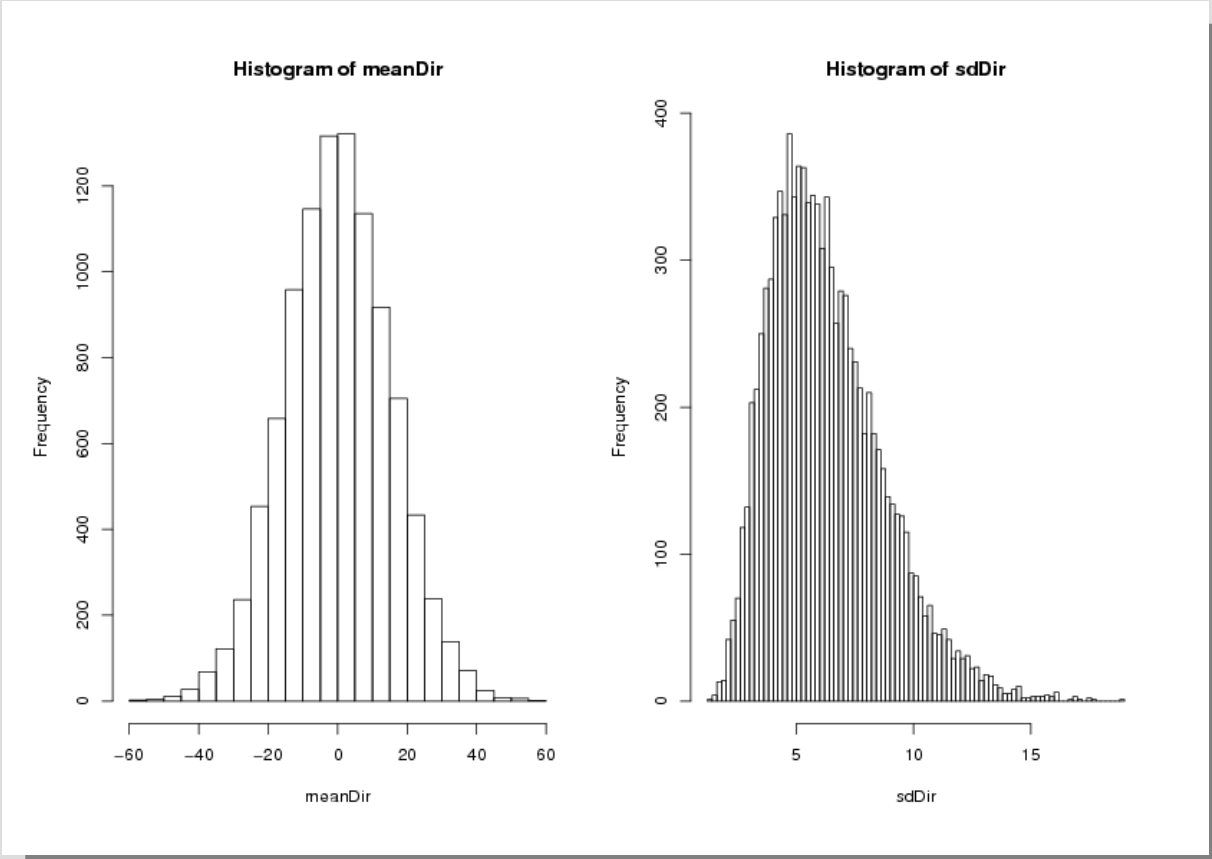
- Distributions of mean directions and standard deviations at the end of the exp.



Measures

One experiment with d=120, r = 10, n = 1, delta = 0.1

- Distributions of mean/sd directions at end of the exp.



Results

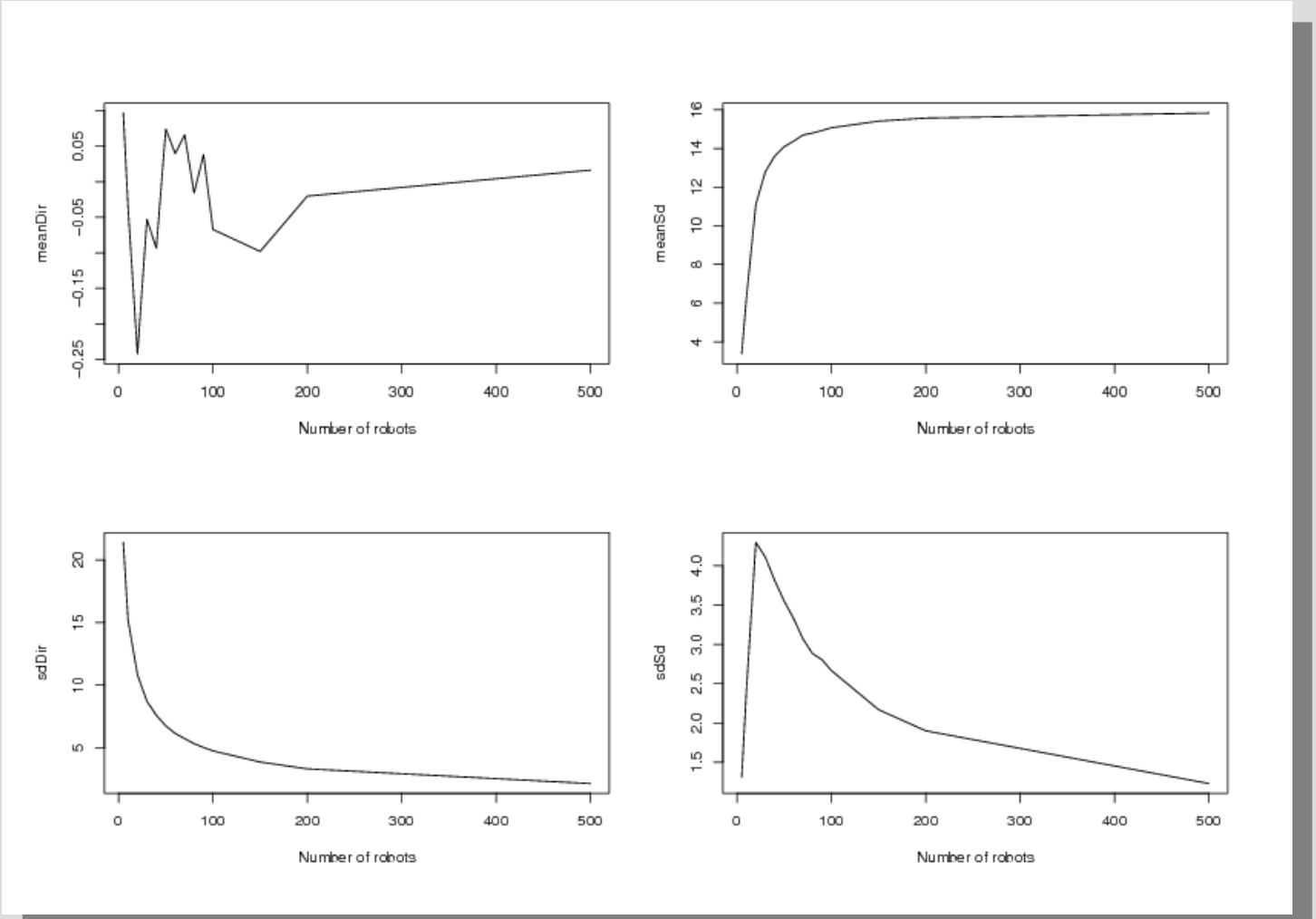
- We focus on a specific case :
  - d = 120 seconds
  - r = 10 robots
  - n = 1 robots
  - odometry noise = 45 degrees
  - perception noise = 25 degrees
  - delta = 0.1

Results

- We study the distributions of mean direction and standard deviations of direction with respect to variations of all parameters

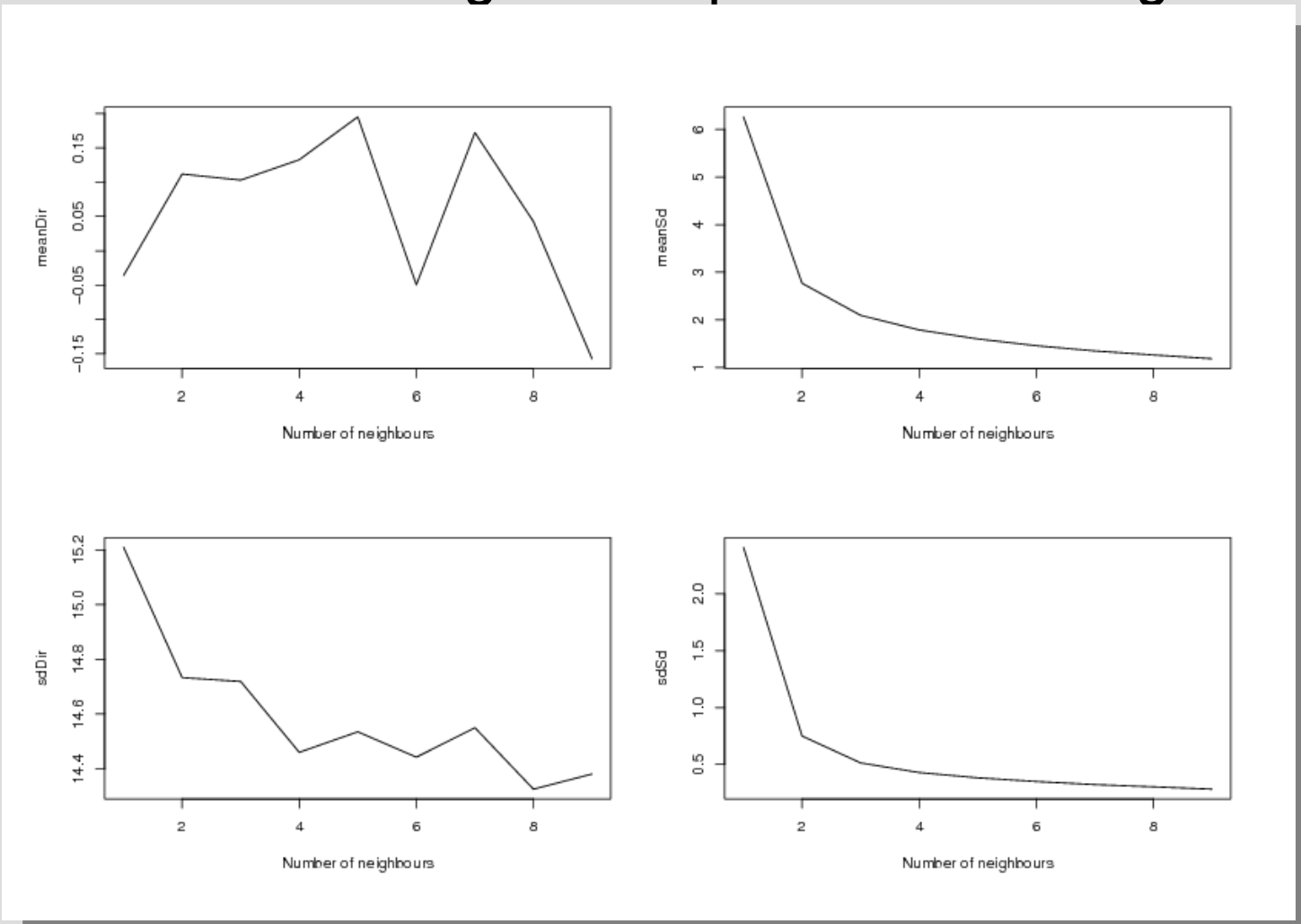
Results

- What happens if the number of robots changes ?



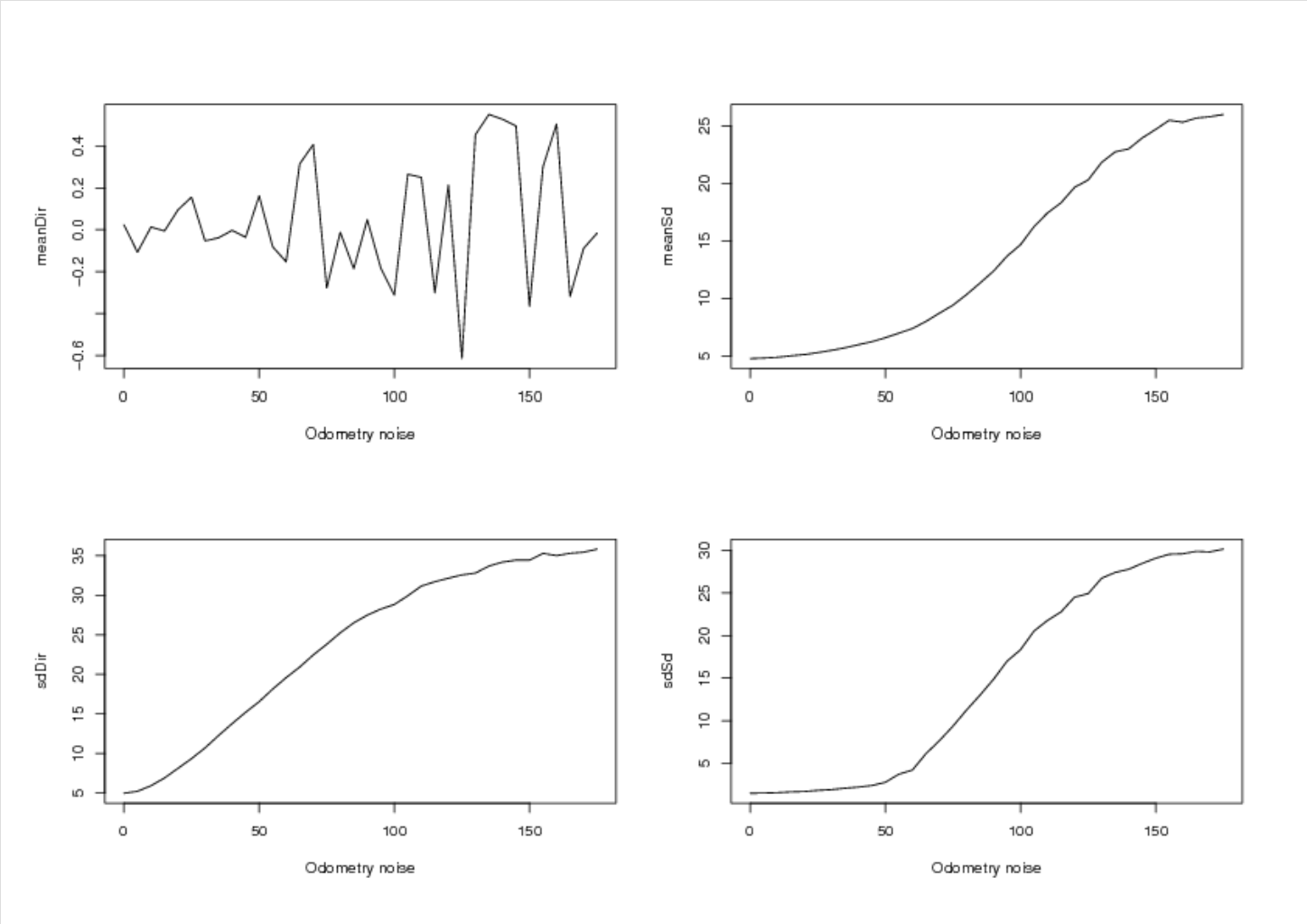
Results

- If the number of neighbours perceived changes ?



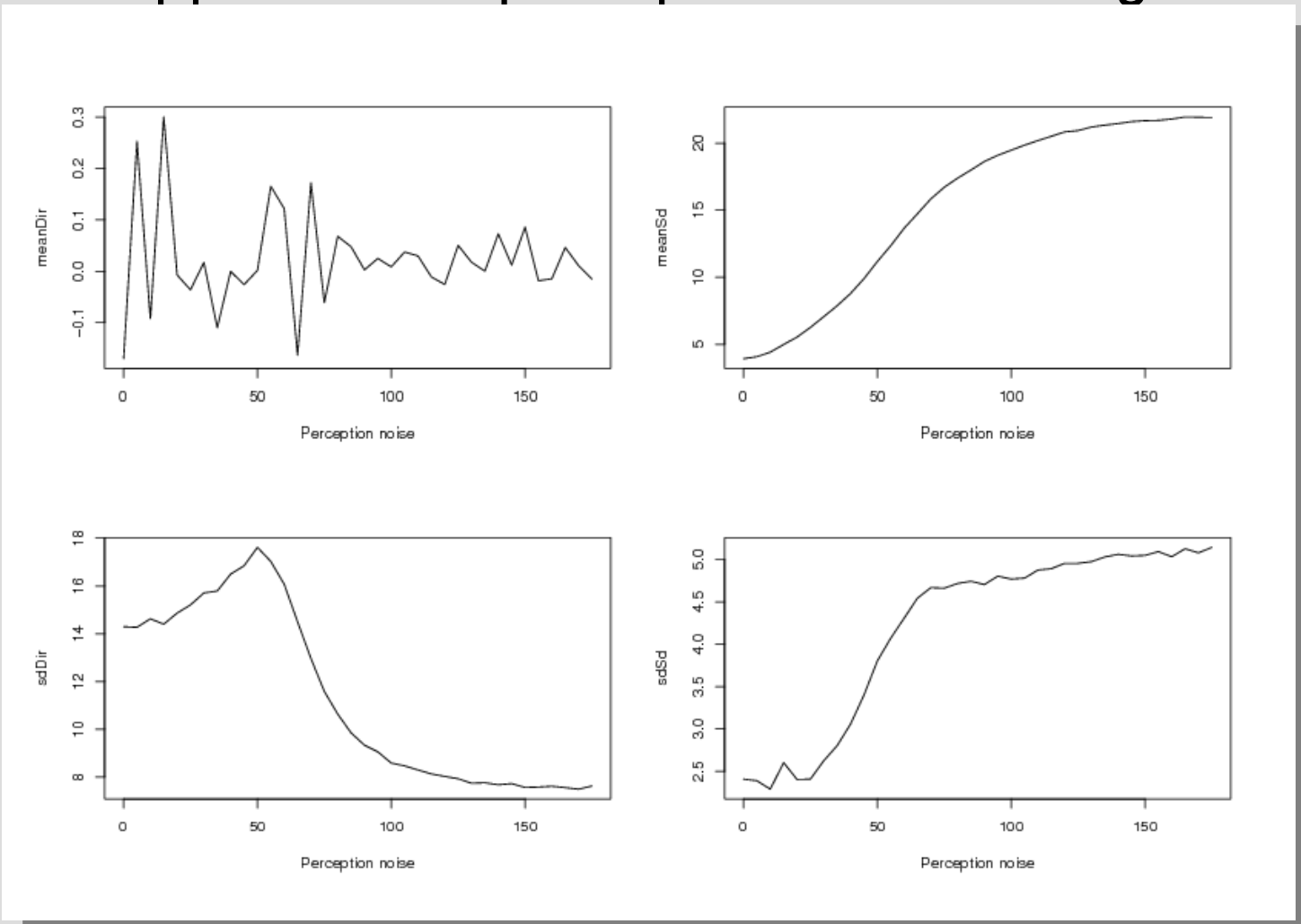
Results

- What happens if the odometry noise changes ?



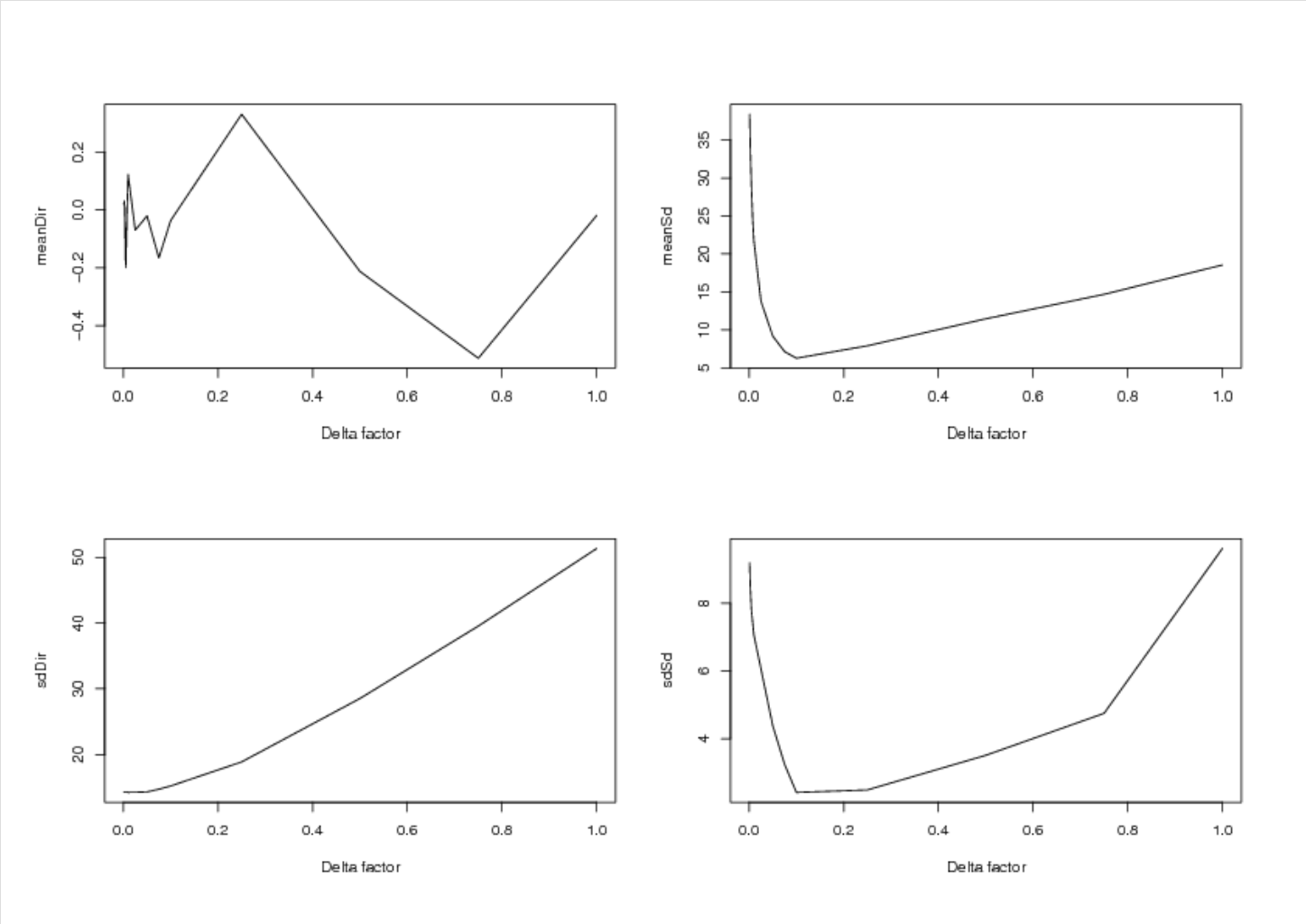
Results

- What happens if the perception noise changes ?



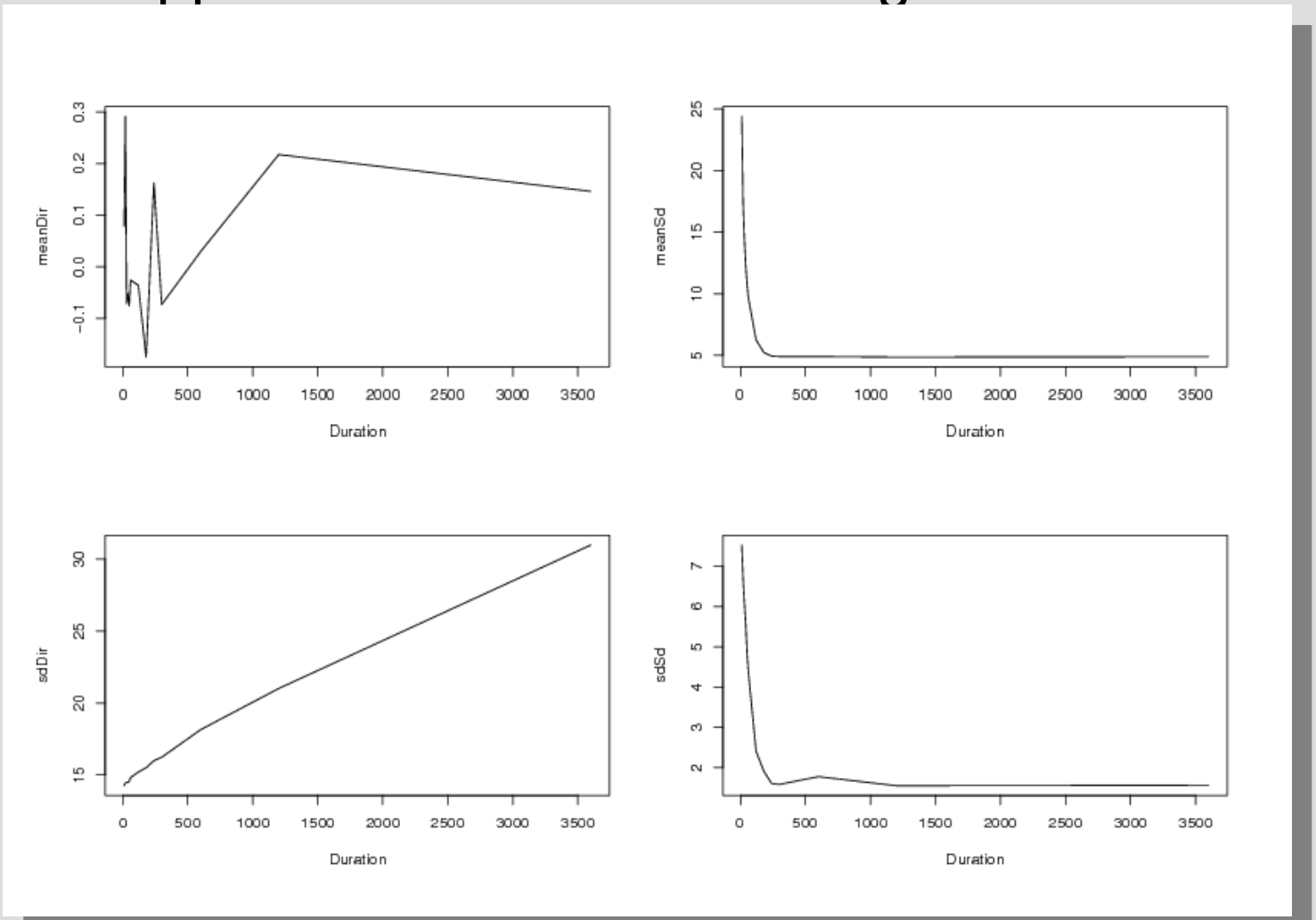
Results

- What happens if the delta changes ?



Results

- What happens if the duration changes ?



Discussion

Tradeoff problem

- Robots estimate better the direction of the nest if they are numerous
- On the other hand they have difficulties to polarize for achieving a collective prey retrieval

Discussion

Scalability and robustness features

- There is a phase transition in the polarization of the robots with respect to the noise in odometry
- That makes the estimation of the direction of the nest by the group more robust in some conditions
- In any case the direction estimated is much better than what a single robot could do

Perspectives

Multi-dimensional analysis

- We didn't study the effect of 2 parameters changing
- Maybe there are some statistical tools that could help to find independent parameters, and relationships among parameters of the system (PCA, MANOVA ?)

Mathematical model

- I love strange and unsolvable equations, could we put some ?

Perspectives

Simulations & real experiments

- We need to simulate the experiment to chack to no relevant parameters was neglected during this work
- We need to design a real experiment to assess the efficiency in real conditions of the system

Thank you for your attention

So long, and thanks for the fish