Multi-agent Consensus Convergence Study

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Introduction

In this work, we experimentally investigate two hypotheses:

- The first hypothesis is that even without a leader, using graph theory, a team of robots can reach a consensus in a finite time.
- And the second hypothesis is that the convergence time does not depend on the number of agents, but depends on the deviation of the most distant agent at the initial moment of time.

Introduction

In this work, we experimentally investigate two issues:

The first issue:

- *Whether a team of robots using graph theory can reach an end-time consensus even if there is no explicit leader?*

And the second question:

- *What the time of convergence depends on: the number of agents, the mean deviation from the final state or the deviation of the farthest agent at the initial point in time?*

Hypothesis and criterion

We raise the following hypothesis:

- robots can reach a consensus for a finite time.
- in addition, we argue that it is not necessary to have a leader to achieve the set goals.

The criterion for proving or rejecting the hypothesis is the following:

- all robots must be in one state, which is described by the angle of movement of the formation.

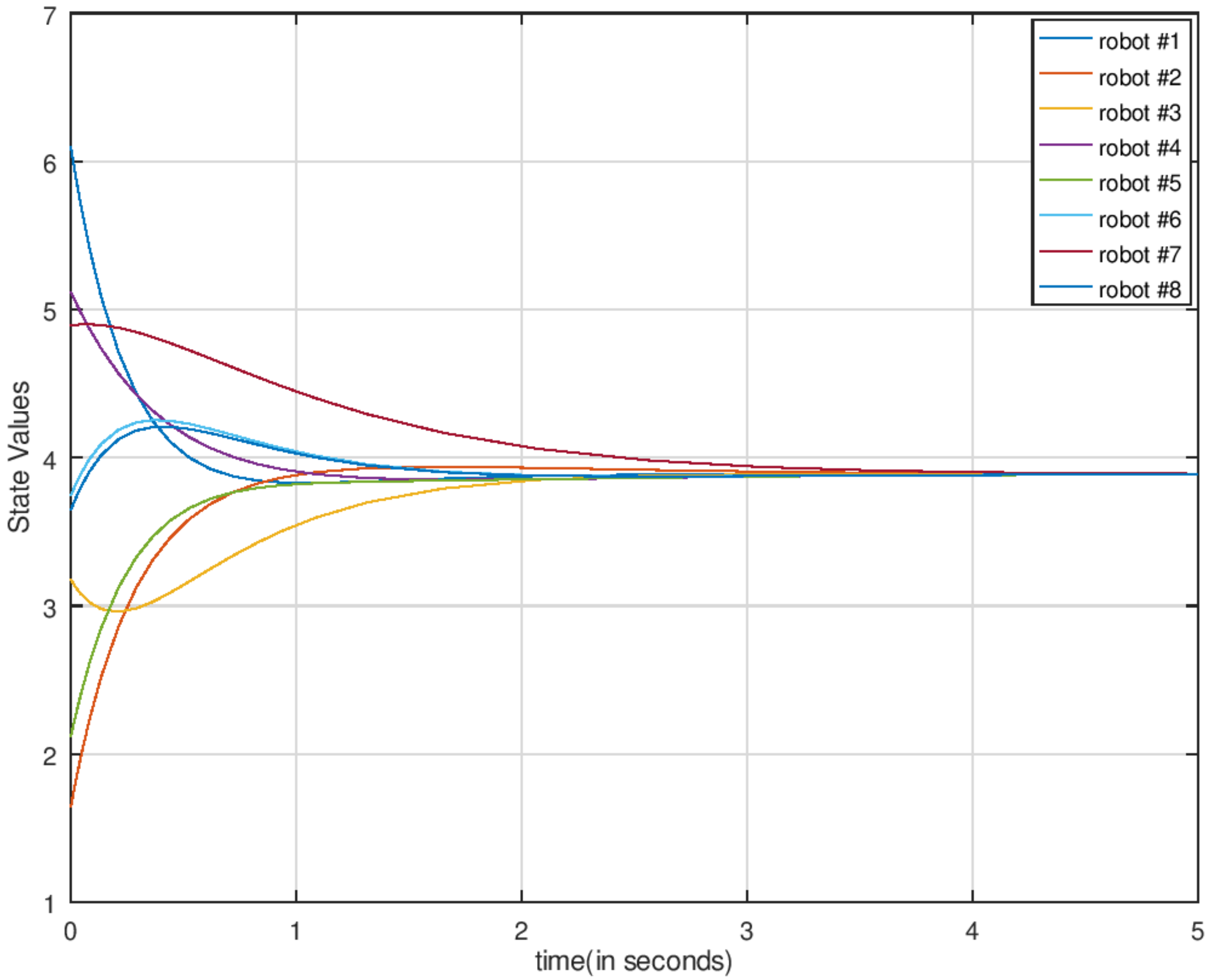
Experiment

We have a group of non-holonomic robots that have to take a position from the starting position and aim at a common angle. Robots should choose an angle of orientation in space to follow. All robots must reach a consensus on the angle of movement of the team.

All robots are of the same type and have the same parameters. The parameters of the robot are mass m = 0.75 kg, J = 0.001 kgm2, length L = 0.075 m, wheel radius r = 0.024 m and wheelbase d = 0.01 m.

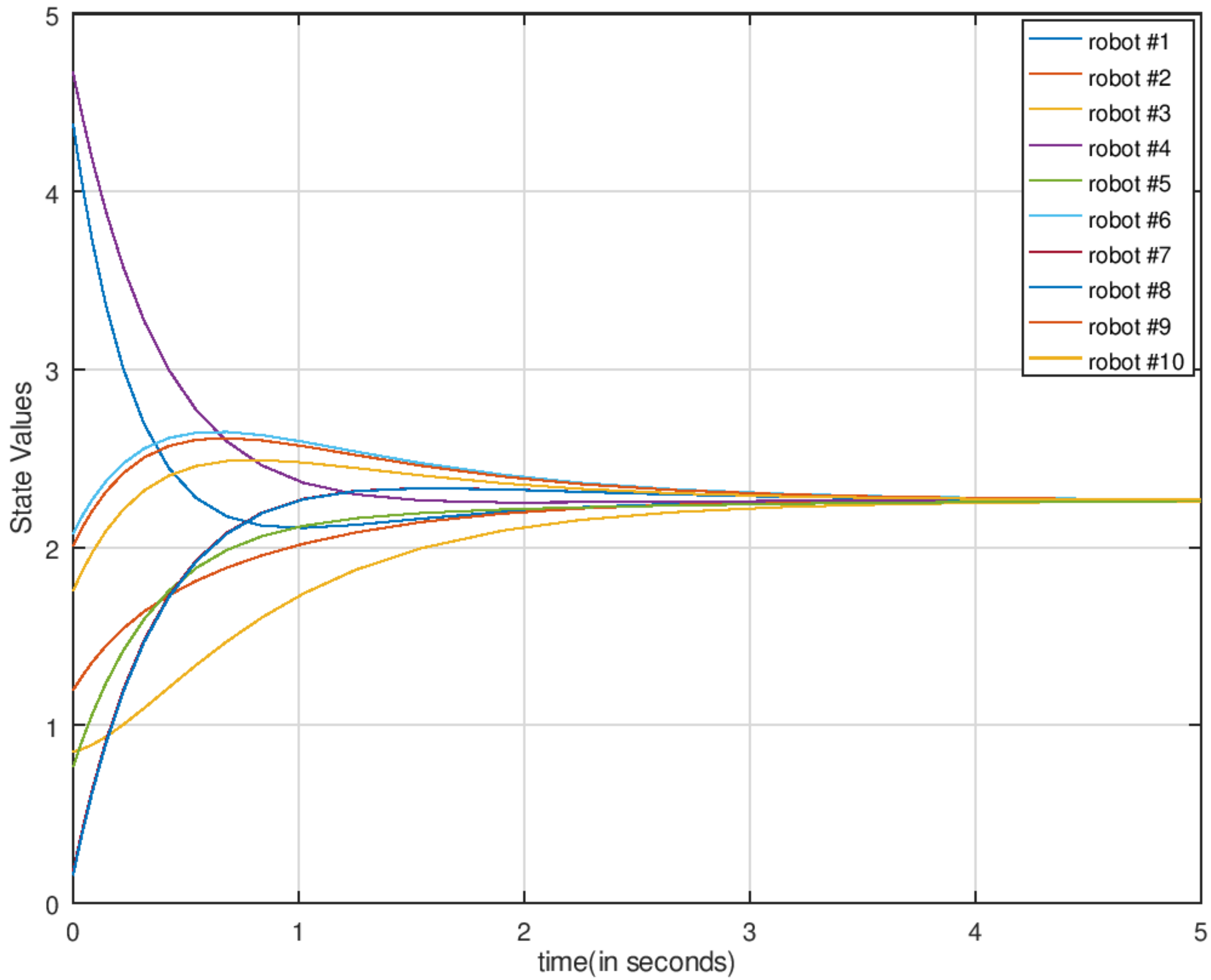
In the first experiment, we have eight robots that need to move in a common direction. There is no unequivocally determined leader, just as there is no per-specified indicated state in which the robots will find themselves at the end of the execution.

Experiments



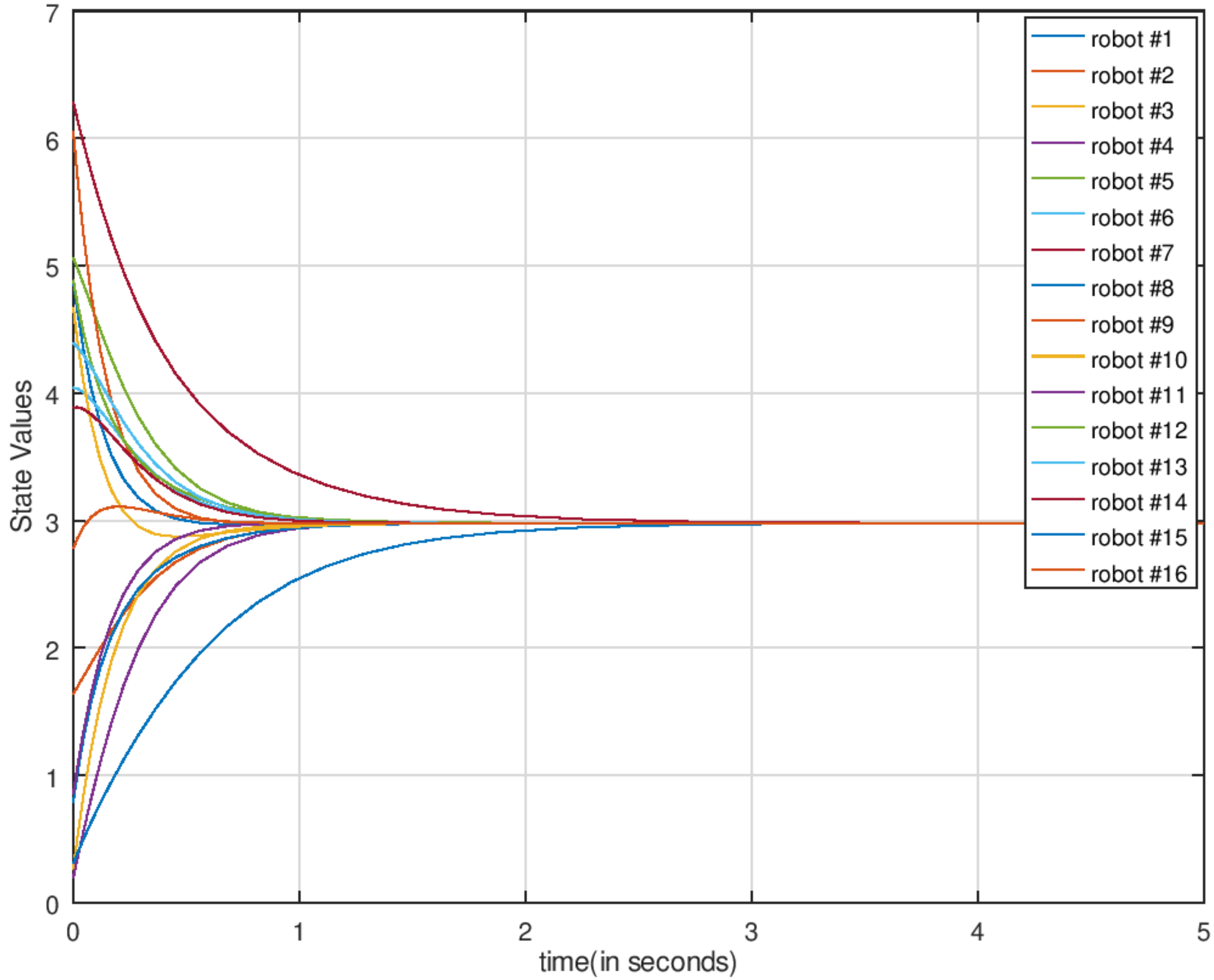
Eight WMRs motion on the X-Y plane

Experiments



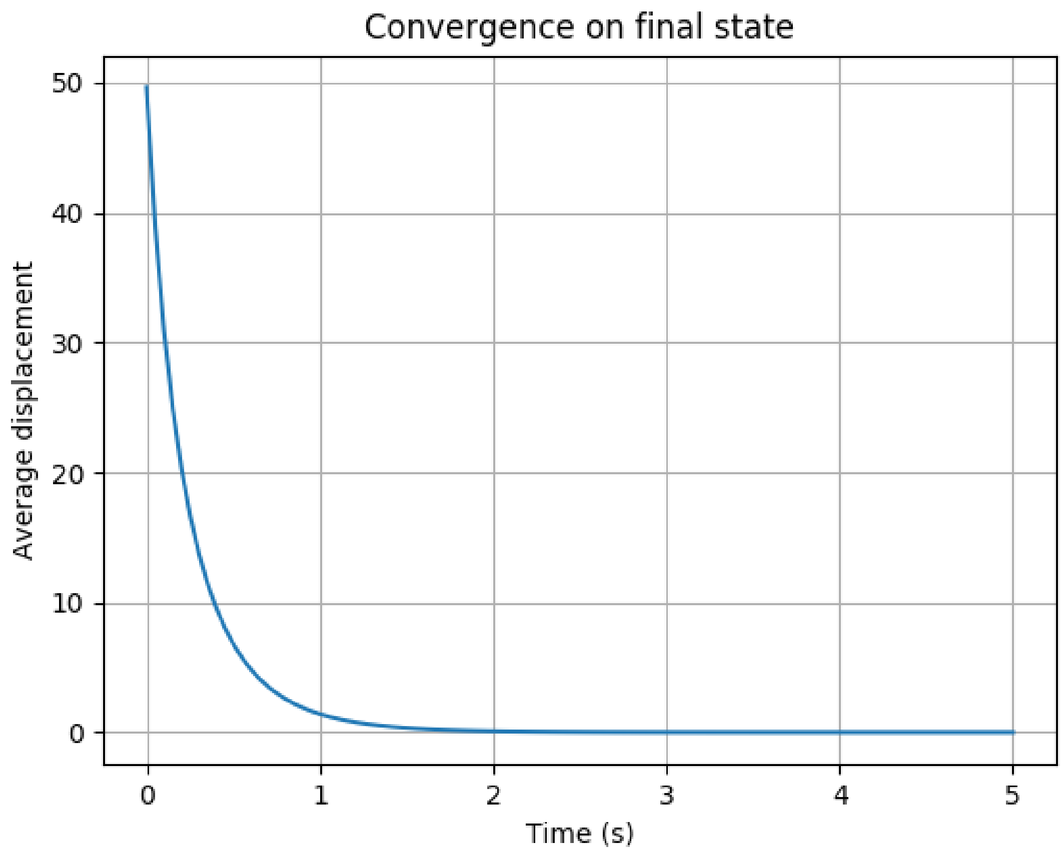
Ten WMRs motion on the X-Y plane

Experiments



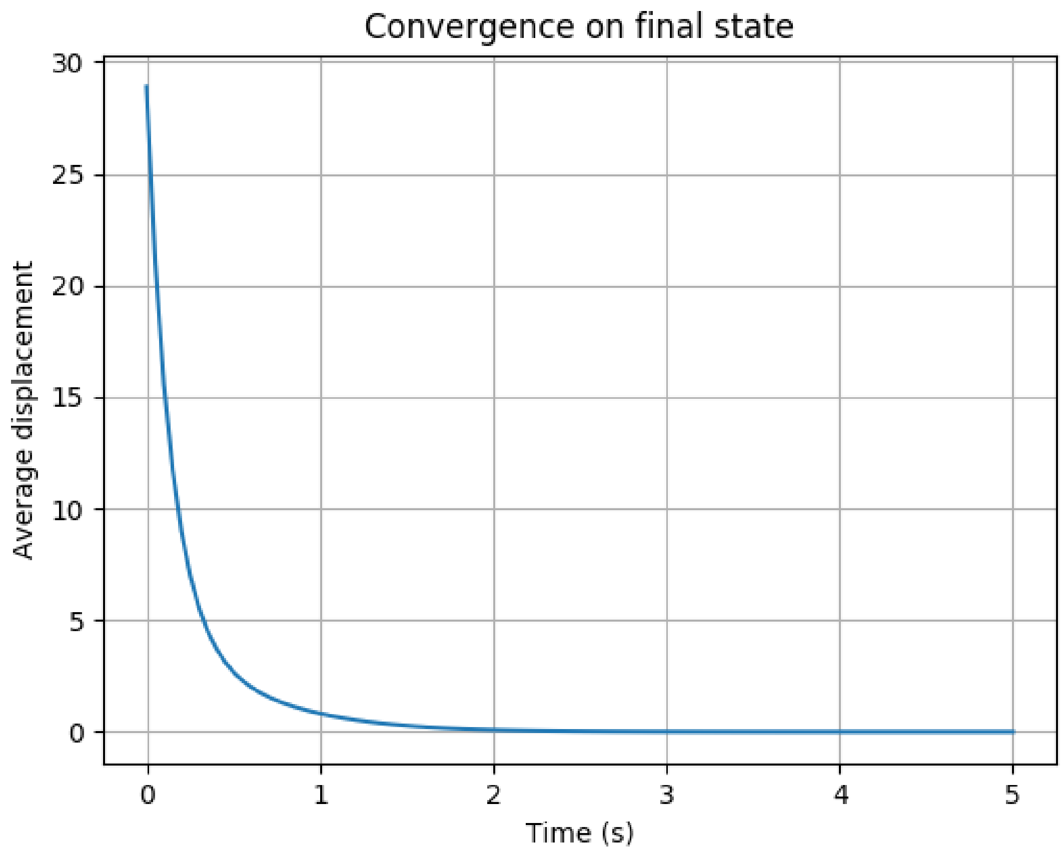
Sixteen WMRs motion on the X-Y plane

Experiments



Ten WMRs time convergence

Experiments



Sixteen WMRs time convergence

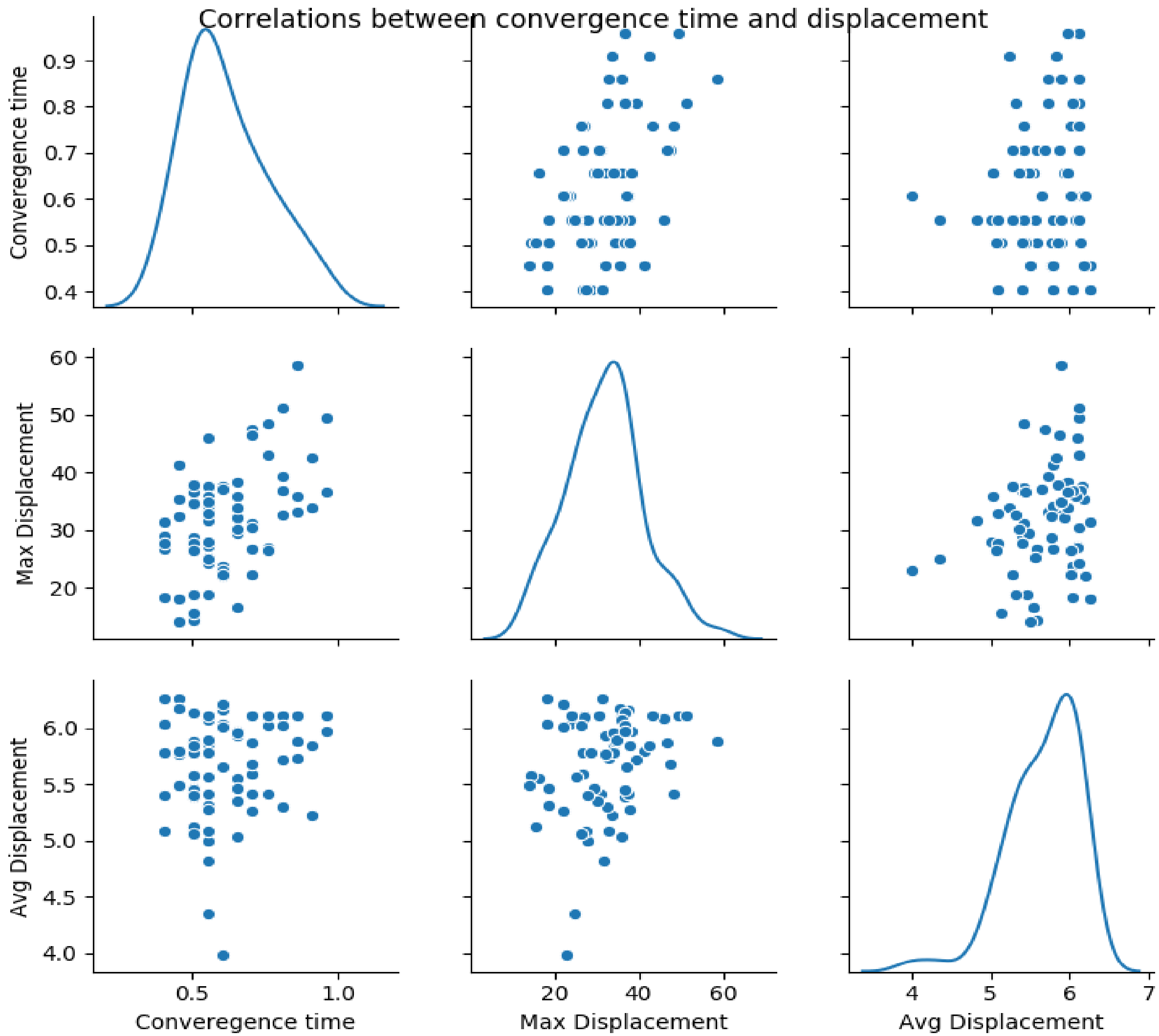
Experiment

However, one question still remains: what does the convergence time depend on? Here we assume that the convergence time can depend on two things: either the complete deviation from the final state at the initial moment of time, or the deviation of the agent farthest from the final state.

We call "Maximum dislocation" or "Maximum displacement" the distance from the final state of the most distant agent at the start. For each simulation step (at least ten times per second), this value is calculated and saved for further analysis.

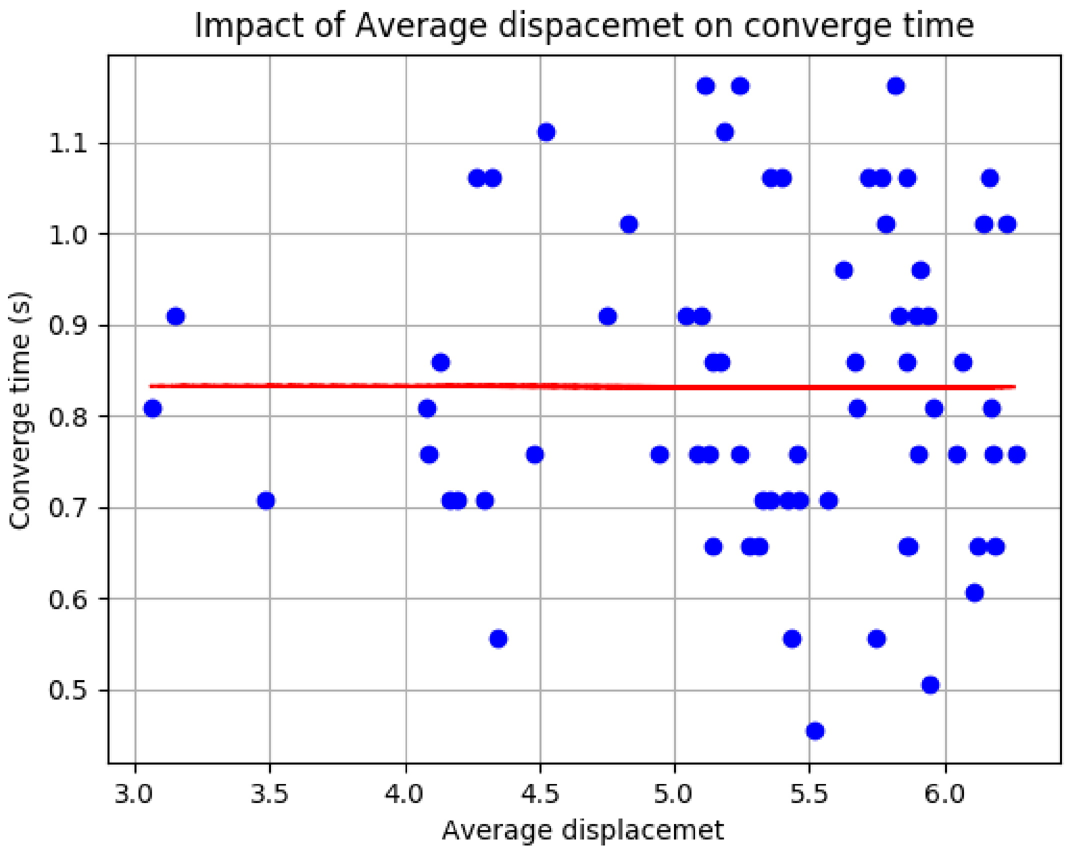
We define "Average dislocation" or "Average displacement" as the average deviation for agents from the final state. this value is also calculated and saved for further analysis at each simulation step.

Conclusion



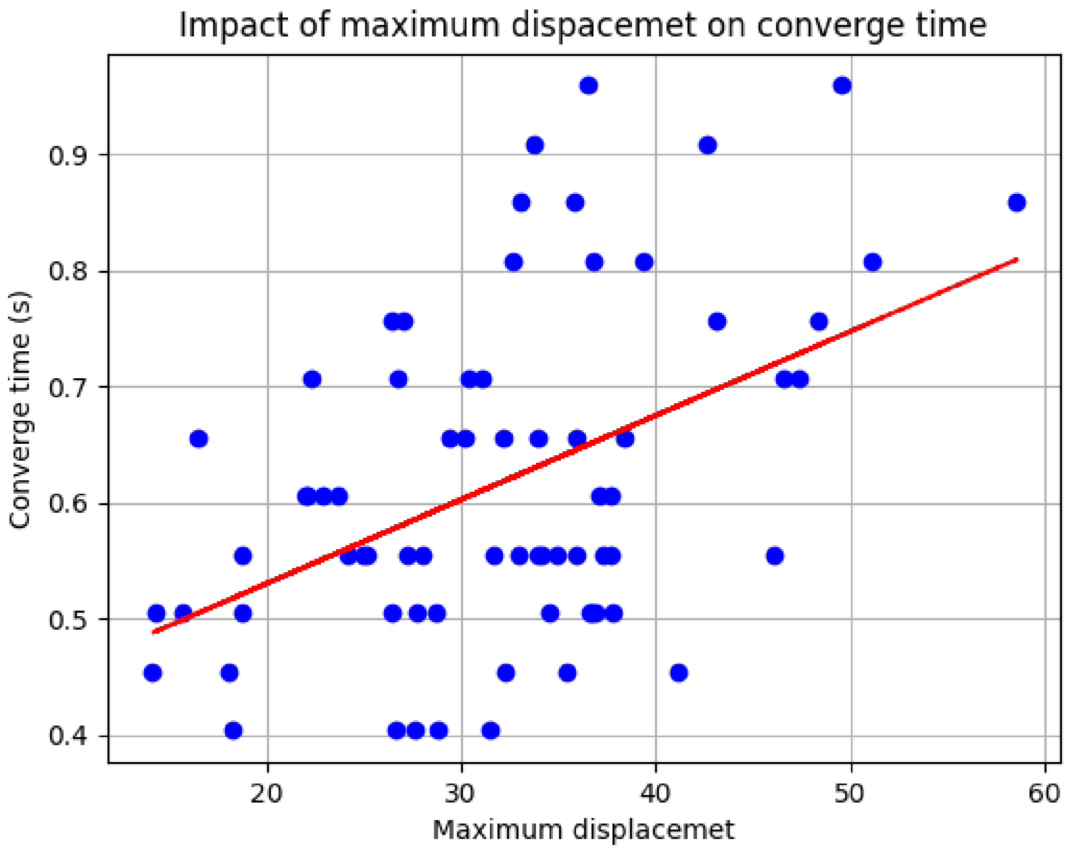
Sixteen WMRs: correlation between convergence time and average and maximum displacement

Experiments



Sixteen WMRs: Impact of average displacement on convergence time

Experiments



Sixteen WMRs: Impact of maximum displacement on convergence time

Conclusion

We can draw the following conclusions:

- The convergence time does not depend on the number of agents. This follows from the fact that agents make decisions independently.

- In addition, the convergence time does not depend on the average dislocation in the initial state.

- To a greater extent, the convergence time depends on the amount of dislocation of the agent, which is most distant at the initial moment of time from the final state of the agents.

Future research

In this case, a debatable moment arises for future research:

Should the agent collective continue to move in the expectation that the “lagging” agent will catch up with the collective and eventually take its place in the formation later?

Or all to stop moving and wait for the "lagging" robot in place and only when all robots take place in formation to continue moving?

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Thank You!