

# Disturbances in Influence of a Shepherding Agent is More Impactful than Sensorial Noise During Swarm Guidance

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May 7, 2021

## 1 Background

The guidance of a large swarm is a challenging control problem. Shepherding offers one approach to guide a large swarm using a few shepherding agents. While noise is an inherent characteristic in many real-world problems, the impact of noise on shepherding is not a well-studied problem.

## 2 Topic

The authors extract generalized noise into two forms. First, they evaluate noise in the ability of the sheepdog to influence sheep due to disturbance forces occurring during actuation. Second, they evaluate noise in the sensorial information received by the shepherd about the location of sheep. They study both types of noise and investigate the performance based on notorious model of Strohmer's[2] approach under these actuation and perception noises.

## 3 Explanation

The actuation noise appears when the sheep move randomly around the location they are supposed to move to. Meanwhile, the perception noise happens when there is deviation between the sheep's actual position and the position that the shepherd observes. The perception noise values need to be larger than actuation noise in order to assess its impact on performance.

## 4 Aim

The size of actuation noises are based on position of sheep, speed of shepherds, forces of sheep and parameter  $\lambda$ . The size of perception noises are based on actuation noises and parameter  $\alpha$ . In Strohmer's approach, there are two main behaviours: collecting and driving. They aim to identify appropriate thresholds  $f(N)$  of switching frequency between two behaviours, informed by the estimates of noise levels, in order to improve the performance of the shepherds.

## 5 Evaluation

For both noises, they set seven noise levels from zero to extreme degree. They also divide values above and below the threshold of triggering. When the threshold value increases, the collecting frequency will decrease, and the shepherd focuses on the driving behaviour. They investigate the effects of the actuation and perception noises on the performance of the shepherds, then conduct additional evaluation between the changes of the collecting frequency and the performance under noises. The illustration of the environment is shown in Figure 1.

## 6 Results

The robustness of the shepherding model against both sources of noise shows when the testing scenarios at  $\alpha 2$ ,  $\alpha 3$ , and  $\lambda 4$  could still have a 20% minimum success rate. Additionally, when the perception noise increases, the larger threshold leads to higher success rate. In contrast, when the actuation noise is higher,

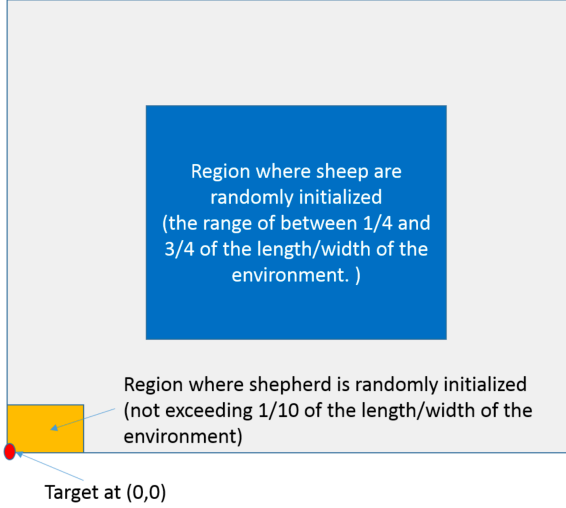


Figure 1: The experiment environment

the smaller threshold contributes to higher success rate. Figure 2 shows the evidences of obtaining these appropriate thresholds.

## 7 Discussion

The actuation noise has a higher impact on the performance of the shepherd than perception, although this noise is less than one tens of the perception noise. The performance of the shepherd deteriorates earlier at higher level of both noises.

Regarding the changes of the threshold  $f(N)$ , when the noises increase, it is logical that this threshold should be increased to prefer the driving behaviour and reduce the collecting behaviour. Under much larger noises, there appears more sheep going out of the mass, and the shepherd might perform the collecting behaviour continuously, and then there is no chance to drive the sheep towards the target.

These interesting results show promising evidences in order to design an adaptive behaviour controller to improve the performance of the shepherd under these noises.

## 8 Analysis From Speecher

They only raise additional noise indexes based on the exact former model, which is interesting but can not be called a large improvement. Some elaboration in this paper is not clear like threshold of collecting frequency and the evaluation metrics. Anyway, the results of threshold change is totally surprising.

## References

- [1] H. T. Nguyen, M. Garratt, L. T. Bui, and H. Abbass, "Disturbances in influence of a shepherding agent is more impactful than sensorial noise during swarm guidance," in *2020 IEEE Symposium Series on Computational Intelligence (SSCI)*. IEEE, 2020, pp. 2257–2264.
- [2] D. Strömbom, R. P. Mann, A. M. Wilson, S. Hailes, A. J. Morton, D. J. T. Sumpter, and A. J. King, "Solving the shepherding problem: heuristics for herding autonomous, interacting agents," *Journal of The Royal Society Interface*, vol. 11, p. 20140719, 2014.

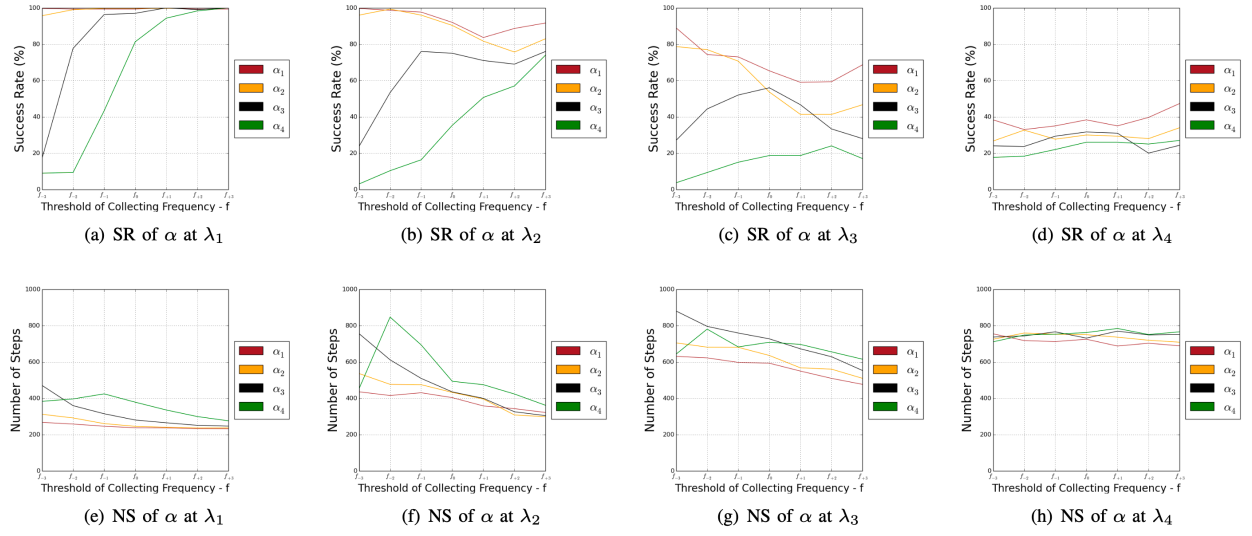


Figure 2: The Effects of Lamda ( $\lambda$ ) and Alpha ( $\alpha$ ) on Different Thresholds or Collecting Frequency ( $f$ ) in 300 Episodes