Mondrian Conformal Prediction of Boosting for Swarm Behavior Recognition

Zepu Xi[1,2], Hongbo Chen[1], Xiaoqian Chen[2], Wen Yao[2]

[1]School of Systems Science and Engineering
Sun Yat-sen University, China
[2]Defense Innovation Institute
Chinese Academy of Military Science, China
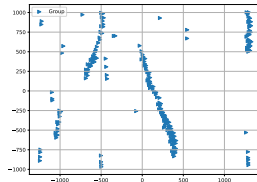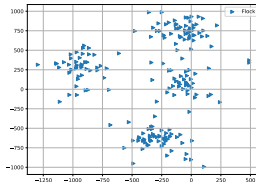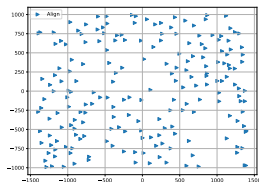2022 5th IEEE International Conference on Unmanned Systems

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Swarm behaviors

Attributes	Interpretation
(xm, ym)	m-th boid X-Y-axis position vector
(xAm, yAm)	m-th boid X-Y-axis as the alignment vector
(xSm, ySm)	m-th boid X-Y-axis as the separation vector
(xCm, yCm)	m-th boid X-Y-axis as the cohesion vector
Class	Binary class

Swarm behaviors

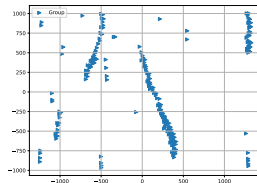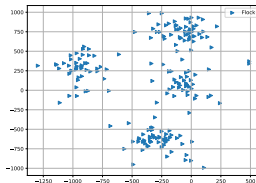| Attributes	Interpretation
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Swarm behaviors

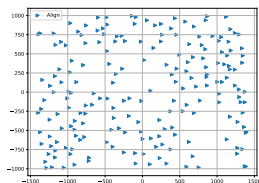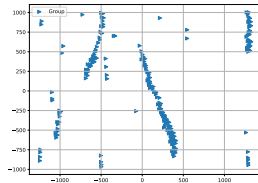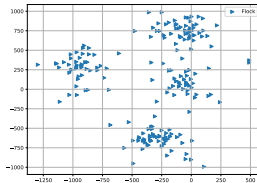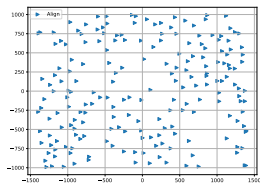| Attributes	Interpretation
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Binary classification
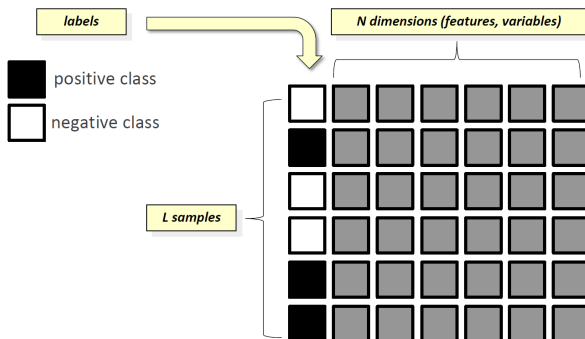
1. Input X: position field of collective swarm agents.
2. Input y: classification label of the entire swarm behavior.

Learning-based algorithms
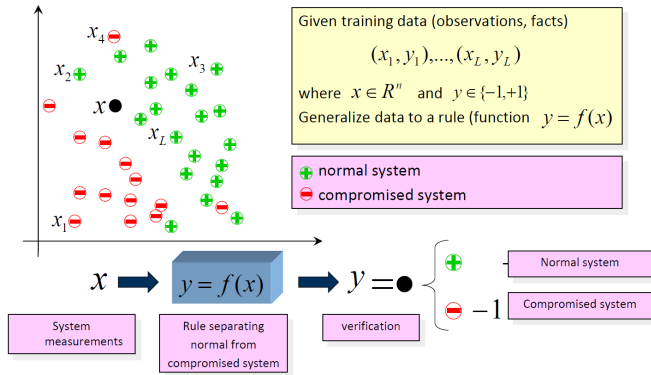
$\Rightarrow$ How to measure the uncertainty of the machine learning based algorithms?

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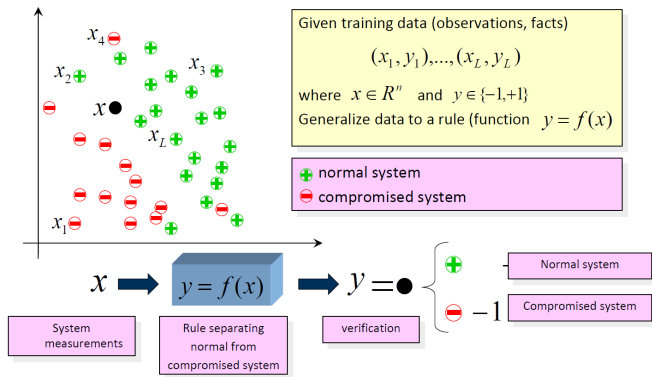
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Mondrian Conformal Prediction
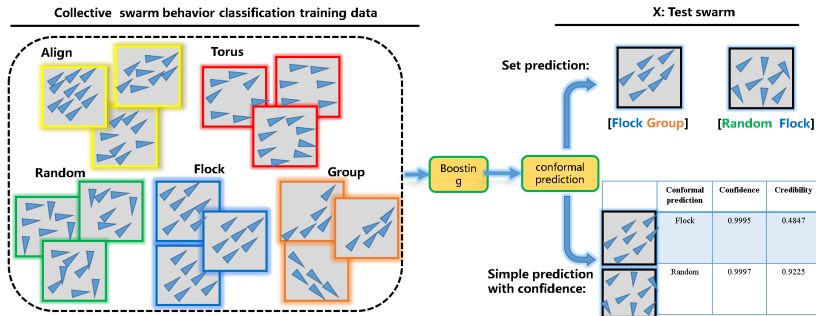
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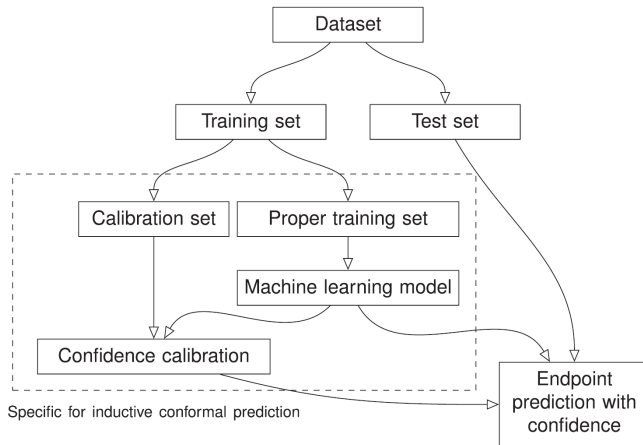
The Effects of Mondrian Conformal Prediction
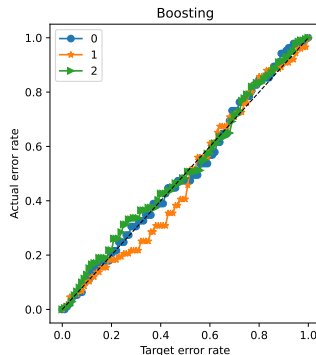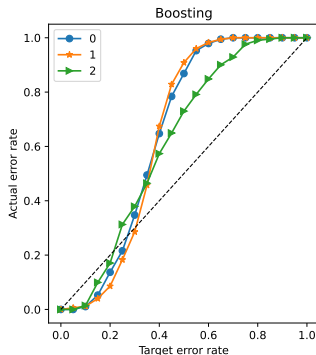
The Results of MCP: Predicting With Confidence

	0	1	True	MCP	Conf.	Cred.
0	0.001578	0.490446	1	1	0.998422	0.490446
1	0.079073	0.008217	0	0	0.991783	0.079073
2	0.821253	0.000954	0	0	0.999046	0.821253
3	0.002549	0.250972	1	1	0.997451	0.250972
4	0.002752	0.387290	1	1	0.997248	0.387290
5	0.873465	0.000006	0	0	0.999994	0.873465
6	0.645499	0.000051	0	0	0.999949	0.645499
7	0.476809	0.000863	0	0	0.999137	0.476809
8	0.702656	0.002115	0	0	0.997885	0.702656
9	0.062616	0.008220	1	0	0.991780	0.062616

The Results of MCP: Set Prediction

	0	1	.0	.01	.05	.2	.5	.95	True
0	0.001578	0.490446	[0, 1]	[1]	[1]	[1]	[]	[]	1
1	0.079073	0.008217	[0, 1]	[0]	[0]	[]	[]	[]	0
2	0.821253	0.000954	[0, 1]	[0]	[0]	[0]	[0]	[]	0
3	0.002549	0.250972	[0, 1]	[1]	[1]	[1]	[]	[]	1
4	0.002752	0.387290	[0, 1]	[1]	[1]	[1]	[]	[]	1
5	0.873465	0.000006	[0, 1]	[0]	[0]	[0]	[0]	[]	0
6	0.645499	0.000051	[0, 1]	[0]	[0]	[0]	[0]	[]	0
7	0.476809	0.000863	[0, 1]	[0]	[0]	[0]	[]	[]	0
8	0.702656	0.002115	[0, 1]	[0]	[0]	[0]	[0]	[]	0
9	0.062616	0.008220	[0, 1]	[0]	[0]	[]	[]	[]	1

The Results of MCP: Set Prediction

	0	1	2	0.15	0.2	0.4	True
0	0.41	0.33	0.26	[0, 1, 2]	[0, 1, 2]	[0]	1
1	0.34	0.44	0.22	[0, 1, 2]	[0, 1, 2]	[1]	2
2	0.19	0.34	0.47	[0, 1, 2]	[1, 2]	[2]	2
3	0.26	0.49	0.25	[0, 1, 2]	[0, 1, 2]	[1]	2
4	0.62	0.23	0.15	[0, 1]	[0, 1]	[0]	1
5	0.37	0.18	0.45	[0, 1, 2]	[0, 2]	[2]	1
6	0.50	0.38	0.12	[0, 1]	[0, 1]	[0]	1
7	0.52	0.30	0.18	[0, 1, 2]	[0, 1]	[0]	2
8	0.24	0.45	0.31	[0, 1, 2]	[0, 1, 2]	[1]	2
9	0.14	0.14	0.72	[2]	[2]	[2]	0

Conclusions

1. A conformalized Boosting algorithm, MCP-Boosting, can be learning for swarm position fields, and used for infer the uncertainty of predicated collective swarm behavior.

2. Unlike traditional statistics research, we transformed the empirical data into high-dimensional feature space by the methods of Boosting.

3. Both real-life and synthesis datasets are established.

4. we propose two kind of prediction paradigms, such as the simple prediction corresponding with confidence and credibility measurements and the set prediction.

5. The purposed methods are not need any assumption of distributions.

6. The purposed methods can be build on the top of any learning algorithms.