Flock Inspired Area Coverage Using Wireless Boid-like Sensor Agents

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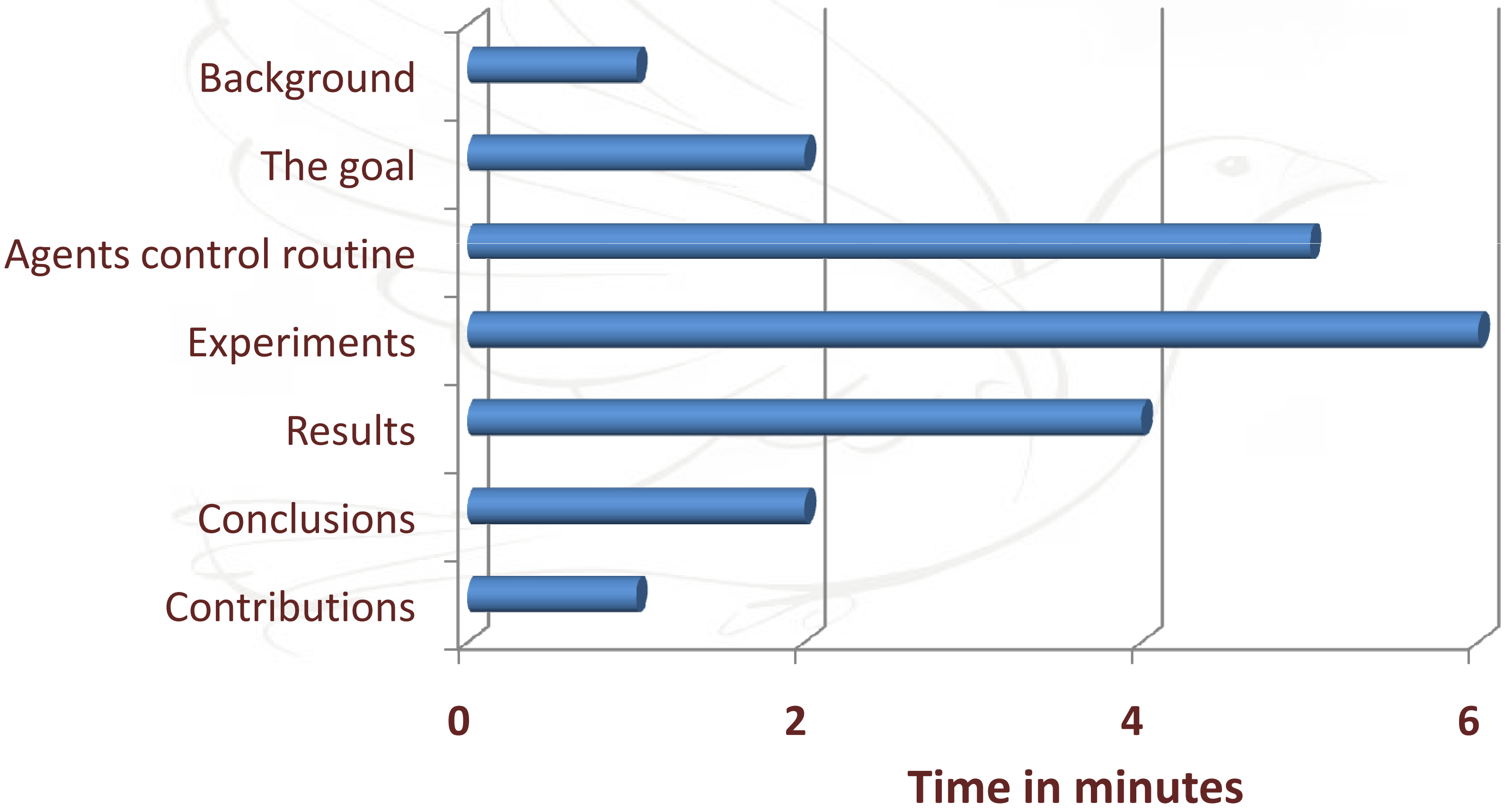
Outline


Background
The goal
Agents control routine
Experiments
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Contributions
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2
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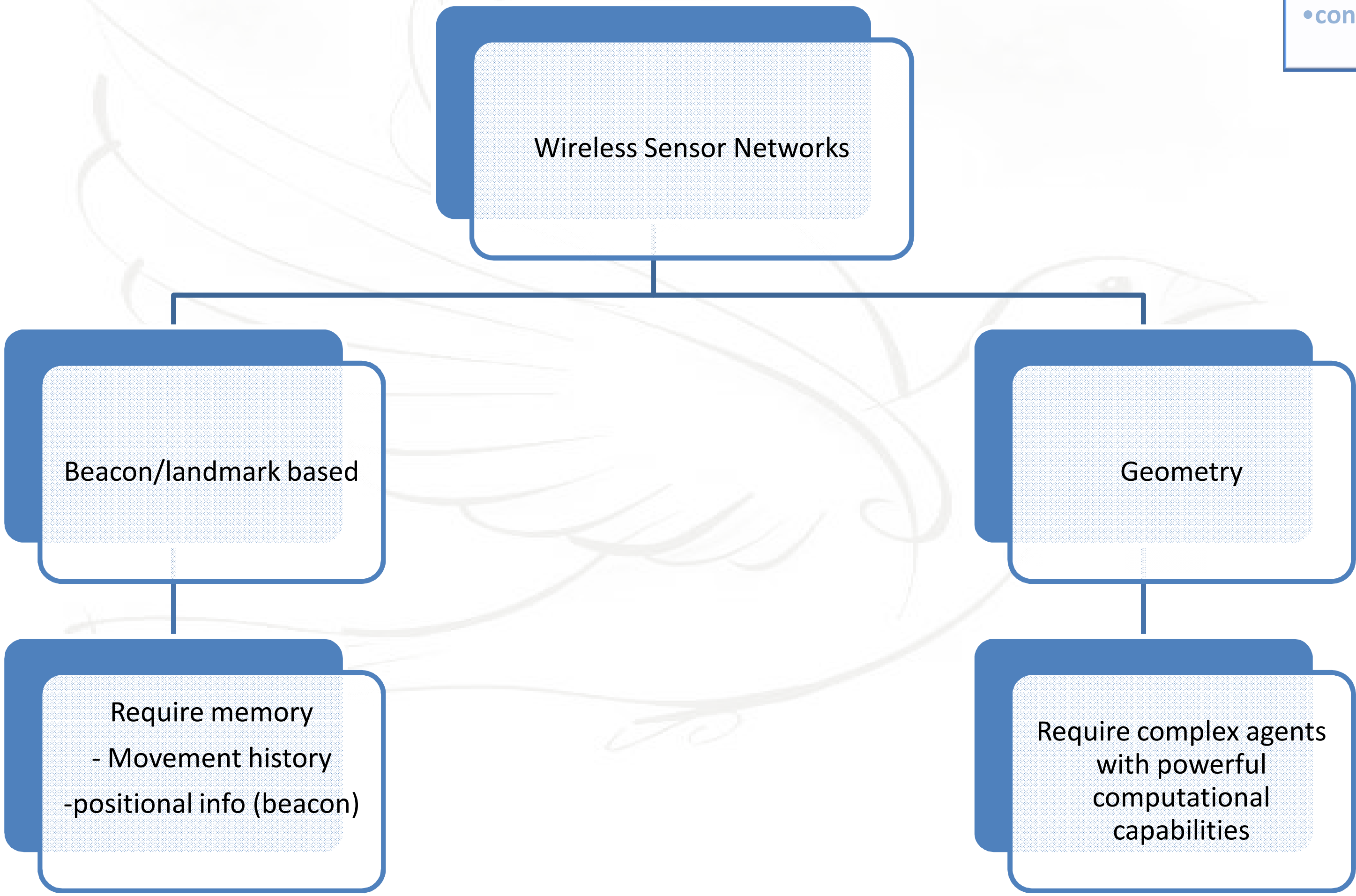
6
Time in minutes

Background

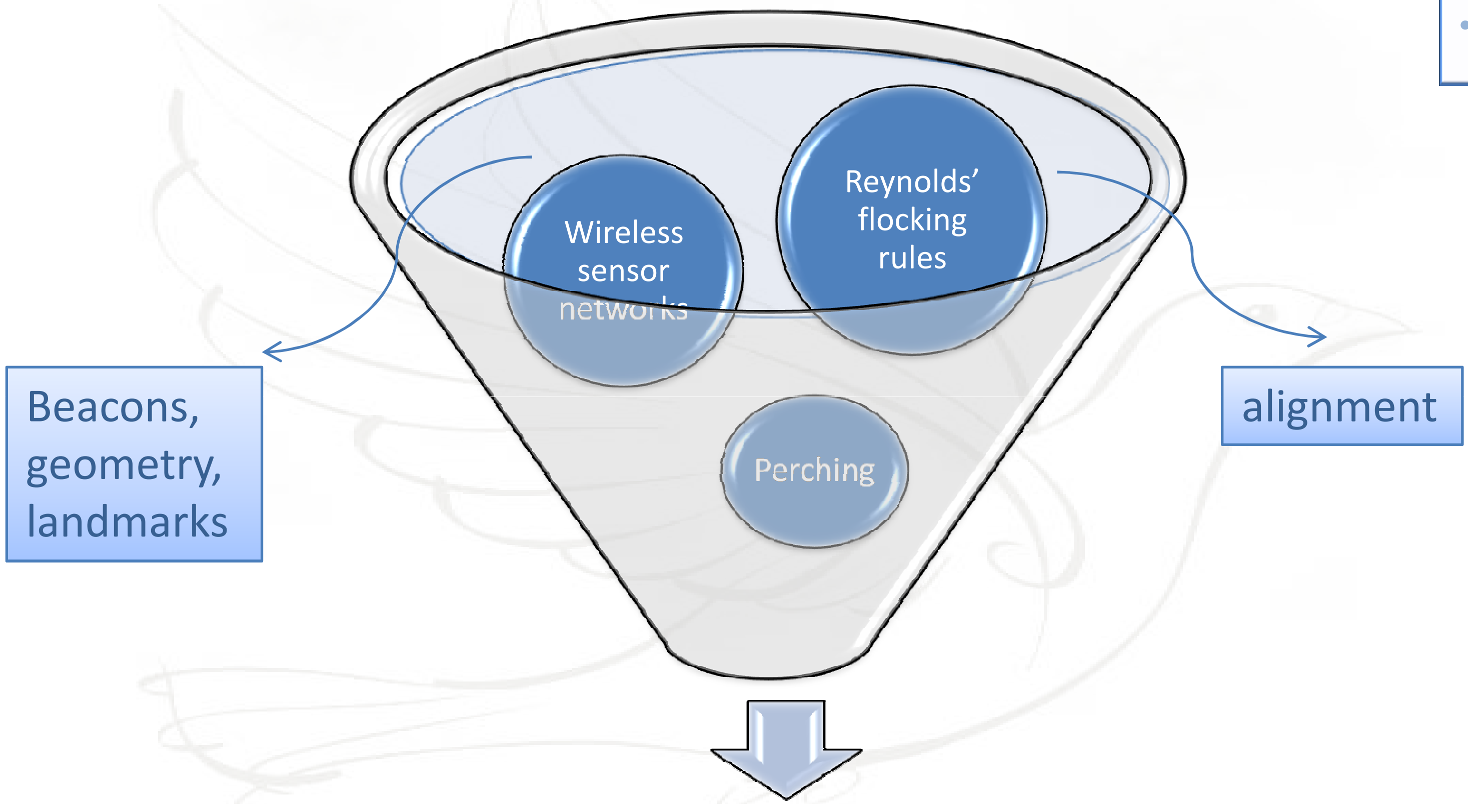


Wireless Sensor Networks
Beacon/landmark based
Geometry
Require memory
- Movement history
-positional info (beacon)
Require complex agents with powerful computational capabilities

Background

- Reynolds' simulated flocks
  - Separation
    - Move to avoid overcrowding
  - Cohesion
    - Attempt to stay close to neighbours
  - Alignment
    - Move towards the average direction of flock mates

The goal

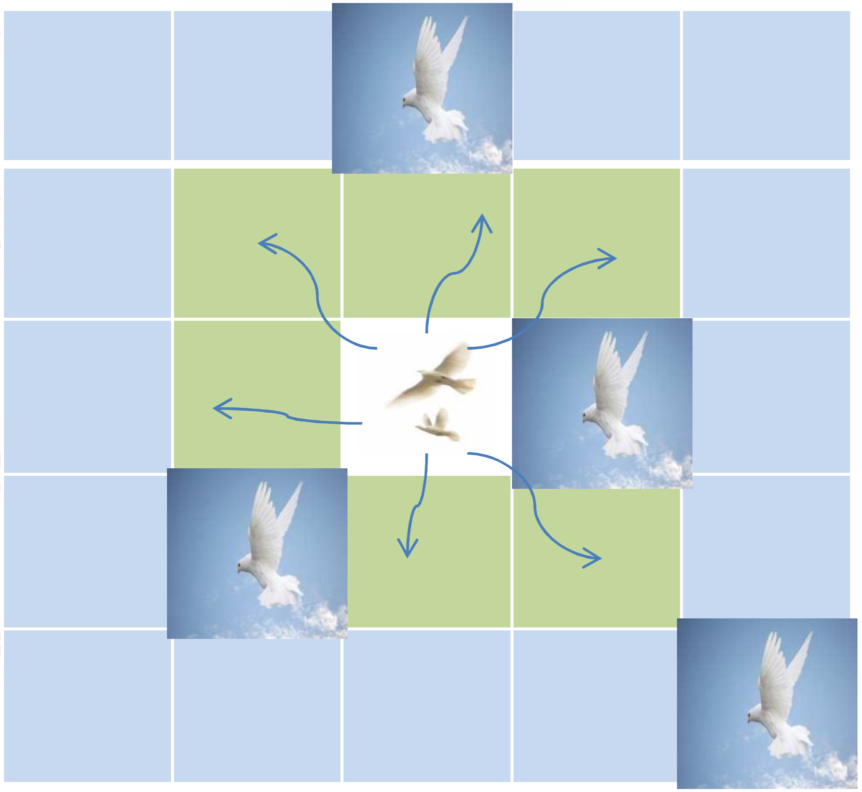


Flock inspired area coverage model

Exemplary scenario

Exemplary scenario

- Free neighbouring locations
- Free locations in sensing range
- The mean free path



Control routine-1

Mode ← separation

FOR_EVERY agent X at location L_i

  IF (cardinality of $L_i > 1$) **THEN**

    IF (exist free neighbouring spaces (L^*)) **THEN**

      X move to L^*

    ELSE IF (free spaces, L^{**} are in sensing range) **THEN**

      X move to L^* that is closest to L^{**}

    ELSE

      X uses the mean free path

  ELSE

    Mode ← cohesion

Control routine-2

Mode ← cohesion

FOR_EVERY agent X at location L_i

IF (exists a neighbouring location L^* whose cardinality > 0) **THEN**

mode ← perch

ELSE IF (exist some covered locations in sensing range) THEN

X moves to L* closest to the covered locations

ELSE

X uses the mean free path

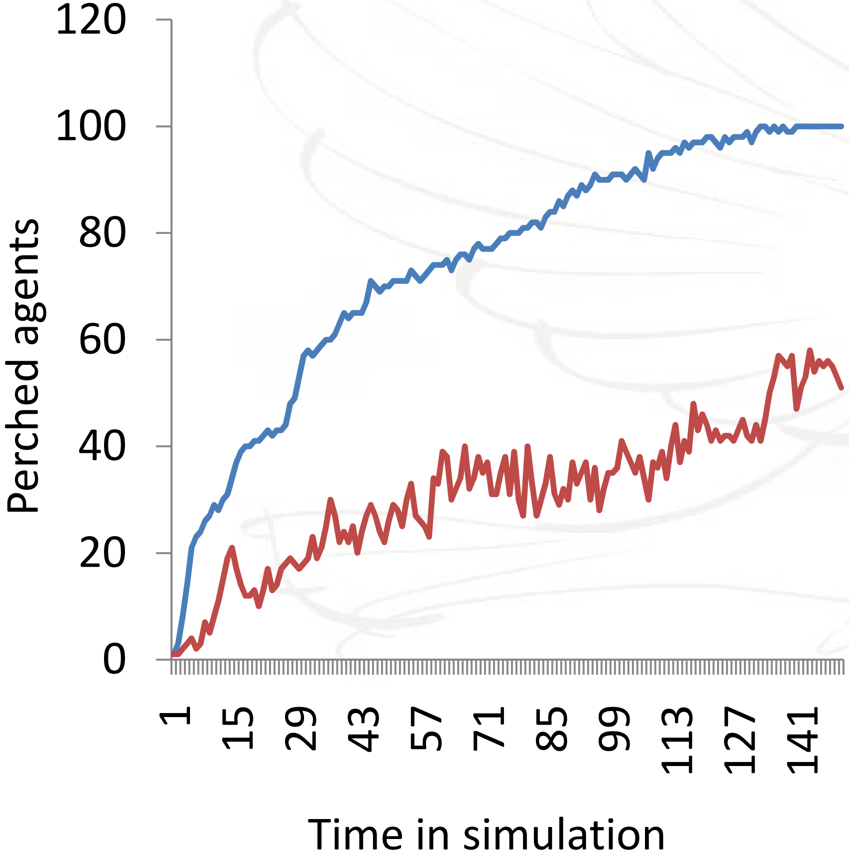
Experiment 1: Separation speed

- How we measure separation speed
  - -number of agents that are successfully perched within a specific time in simulation
- Centrally placed values
  - 10 simulations are averaged
- Results
  - Compared against a random guess.

Result 1: Separation speed

- Literature
- The goal
- Movie
- Control routine
- Experiment
- **Results**
- Conclusion
- contributions

Fig 1: comparison of separation speed



Findings

– 50.57% of agents were perched in 31 iterations, compared to only 19.14% using a random guess

– Our model achieved complete coverage in 135 iterations when a random guessing model was at 65.66%

Experiment 2: Cohesion speed

- How we determine cohesion speed
  - Count iterations from isolation until cohesion
- Procedure
  - Allow coverage to occur in some continuous space
  - Deploy an isolated agent
  - Record the iterations
  - Repeat for 1000 times
- Results
  - Compare with random guessing

Result 2: Cohesion speed

Table 1

	Model	Guess
Mean steps	16	39
Standard deviation	3	14
Entropy levels	0.5%	41.2%

Findings

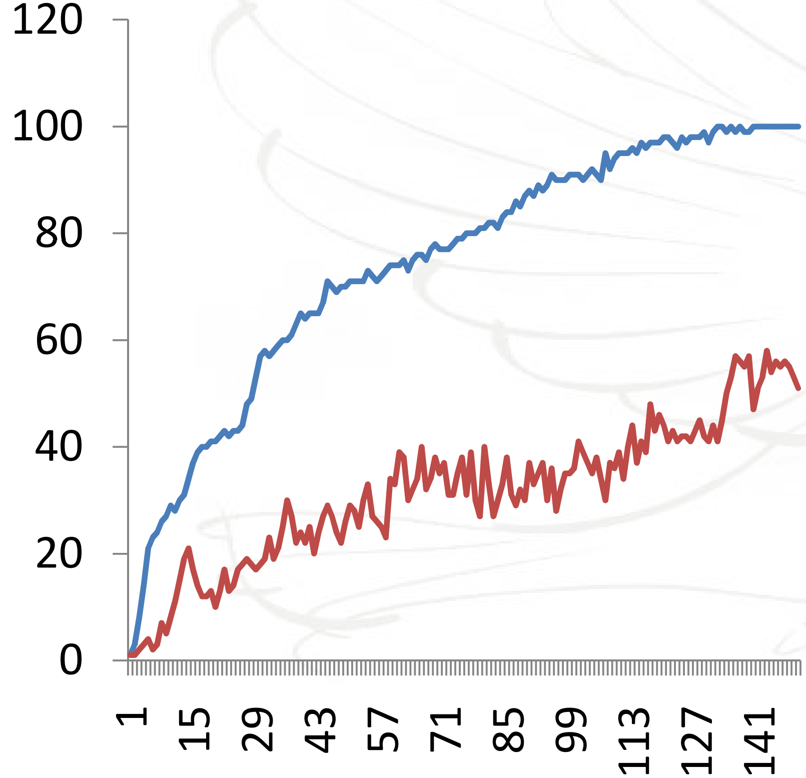
- Agents achieved cohesion in 16 ±3 steps, compared to 39 ±14 steps using random guessing
- Chances that agents fail to perch are 0.5% in our model and 42.2% in random guess model

Experiment 3: Coverage quality

- Metrics of importance
  - Fraction of area covered at any time slot
  - Time it takes to achieve complete coverage
    - Measured in iterations
- Results
  - Compared with results achieved

Result 3: Coverage quality

Figure 2 : Coverage quality



Findings

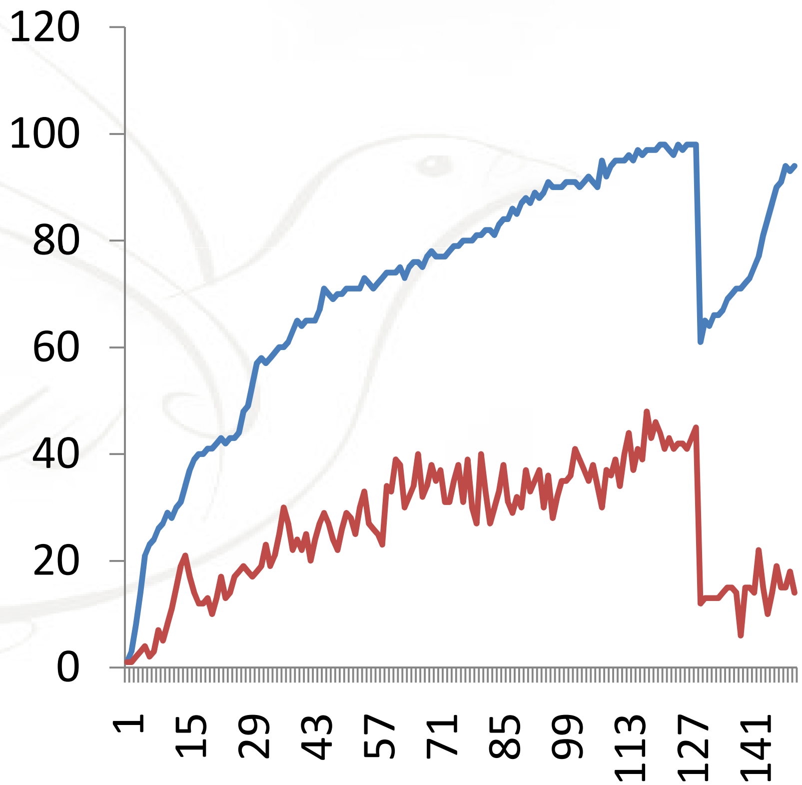
- Our model achieved complete coverage in 135 iterations
- Random guess achieved a maximum of 65.66%

Experiment 4: Fault tolerance

- Purpose of experiment
  - Model performance where agents may fail
- How we conducted the experiment
  - Allow coverage to occur
  - Kill 40 agents
- Results
  - Compare with a random guess

Result 4: Fault tolerance

- Our model self-repaired to 94.35% coverage quality in 34 iterations
- Agents that used the random guessing model could not re-organize.



Conclusions

- We proposed an area coverage model inspired by Reynolds' flocking algorithms.
- The model exhibits good separation speed and cohesion properties of the flocking algorithm
- The model is fault tolerant and adaptive to agents' failures
- The model is fast, achieving high quality coverage in a relatively short period of time

Contributions

- We presented a novel sensor agents control model using simulated flocking rules
- We devised and evaluated a plausible strategy for determining coverage quality as well as fault tolerance
- This work provides a new way of measuring the performance of agent based coverage models