

Research Associate for the ASIMUT project

Chaotic attractors, Drones and Ants

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SnT - Interdisciplinary Centre for Security, Reliability and Trust, University of Luxembourg

Joint work with [@Pascal](#) and [@Grégoire](#)

ASIMUT project

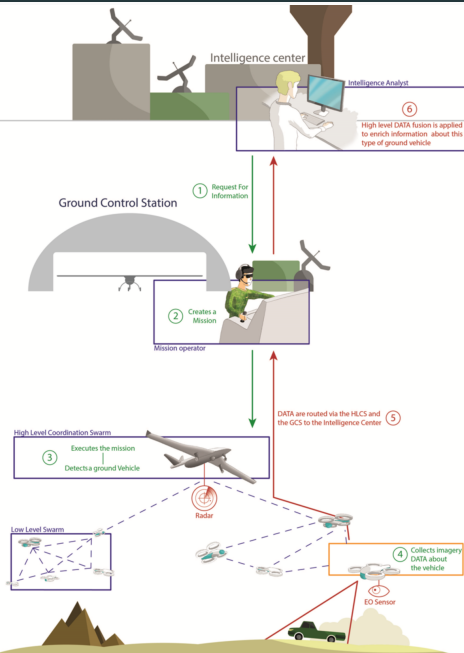


EUROPEAN
DEFENCE
AGENCY

*Aid to Situation
Management based on
MULTimodal, MultiUAVs,
MULTilevel acquisition
Techniques*

- target detection
- data fusion
- swarms of UAVs
autonomy

→ innovative algorithms



Random-based and Pheromone-based mobility models

[Kui06] E. Kuiper & S. Nadjm-Tehrani. **Mobility models for UAV group reconnaissance applications**, in *2006 International Conference on Wireless and Mobile Communications (ICWMC'06)*. Institute of Electrical & Electronics Engineers (IEEE), 2006.

Random-based

Model	Probability of action		
Last action	Left	Ahead	Right
Left	0.70	0.30	0
Ahead	0.10	0.80	0.10
Right	0	0.70	0.30

Table 1 – Random action table

- 10 non equal flight altitude for the UAVs
- Symmetric behavior
- Probabilistic approach

Pheromones-based

- Nature-inspired model based on stigmergy
 - Indirect communication of UAVs using repulsive pheromones spread in the environment
- Geographical area is split in different cells
 - Each cell is characterised by a repulsive pheromone level that evaporates in time
- Each UAV chooses its direction: ahead **A**, left **L** or right **R**
 - Probability inversely proportional to the amount of pheromones in these locations

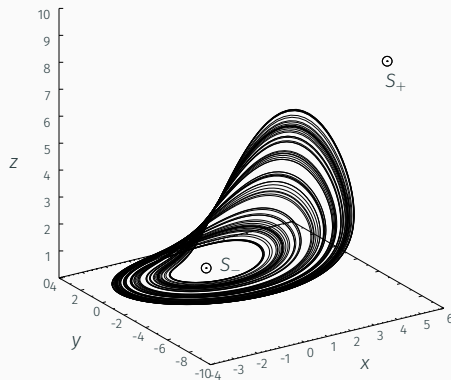
Chaos, what is it?

- A something unpredictable
- B a myth describing the butterfly effect
- C it comes from a deterministic process
- la réponse D a cluster

An attractor solution of the Rössler system [Ros76]

$$\begin{cases} \dot{x} = -y - z \\ \dot{y} = x + ay \\ \dot{z} = b + z(x - c) \end{cases}$$

Chaotic attractor solution of
deterministic process
($a = 0,398$, $b = 2$, $c = 4$)



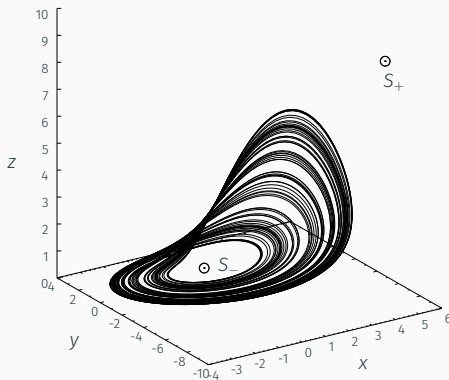
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Properties

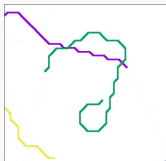
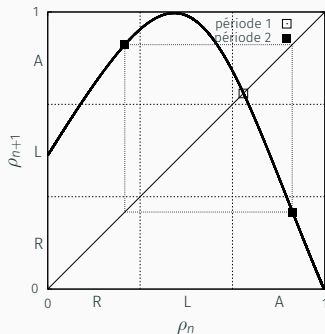
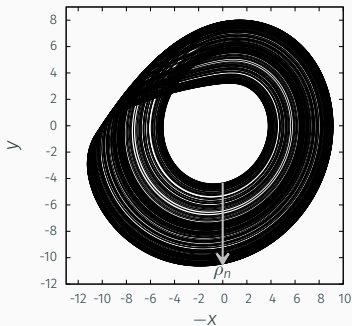
- aperiodic
- globally time-invariant
- sensitive to initial conditions



Saddle-focus points S_+ et S_-
Stretched and fold surface

CROMM - Chaotic Rössler Mobility Model

Based on the Rössler system having a chaotic attractor as solution



Period 1 (AAAAA...): straight forward

Period 2 (ARARA...): large circle on the right

CACOC - Chaotic Ant Colony Optimization for Coverage

Pheromone model where the random parts are replaced by chaos

- Repulsive pheromone deposit
 - If there is no pheromone: use of **CROMM**
 - If there is pheromone, the return map partition (**R**, **L** and **A**) is adapted to encourage the UAV to visit non recently visited area
- ⇒ use of first return map value for each step

CACOC - Chaotic Ant Colony Optimization for Coverage

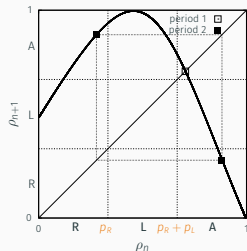
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First return map partition

Left	Ahead	Right
$p_L = \frac{tot-left}{2 \times tot}$	$p_A = \frac{tot-center}{2 \times tot}$	$p_R = \frac{tot-right}{2 \times tot}$

- if $\rho_n < p_R$ then direction is right;
- if $p_R < \rho_n < p_L + p_R$ then direction is left;
- else the direction is ahead.



CACOC - Chaotic Ant Colony Optimization for Coverage

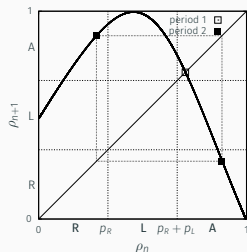
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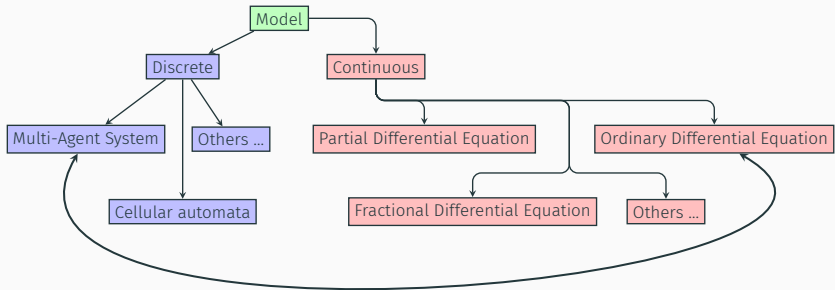
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Video

Current and future works




Links?

- ✓ Chaos used to improve ACO algorithm exploration
- + Joint work with [@Bird](#) on graph traversal problem
- ⇒ Use of chaos in metaheuristics (PSO, firefly algorithm, ...) to increase the exploratory performances
- ? Use of *nonlinear tools* to analyse the dynamics of discrete and distributed system (eg. fractal clustering with [@Matthias](#))

International conferences

-  **M. Rosalie**, G. Danoy, S. Chaumette, and P. Bouvry. “From random process to chaotic behavior in swarms of UAVs”. In: *Proceedings of the 6th ACM Symposium on Development and Analysis of Intelligent Vehicular Networks and Applications*. DIVANet’16. La Valette, Malta: Association for Computing Machinery (ACM), 2016, pp. 9–15.
-  P. Bouvry, S. Chaumette, G. Danoy, G. Guerrini, G. Jurquet, A. Kuwertz, W. Müller, **M. Rosalie**, and J. Sander. “Using heterogeneous multilevel swarms of UAVs and high-level data fusion to support situation management in surveillance scenarios”. In: *Proceedings of the IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems (MFI 2016)*. Baden-Baden, Germany: IEEE, 2016.
-  **M. Rosalie**, G. Danoy, P. Bouvry, and S. Chaumette. “UAV Multilevel Swarms for Situation Management”. In: *Proceedings of the 2nd Workshop on Micro Aerial Vehicle Networks, Systems, and Applications for Civilian Use*. DroNet’16. Singapore, Singapore: ACM, 2016, pp. 49–52.

Journal article

-  **M. Rosalie**. “Templates and subtemplates of Rössler attractors from a bifurcation diagram”. In: *Journal of Physics A: Mathematical and Theoretical* 49.31 (2016), p. 315101.

Questions?

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