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An adaptive agent-based model of homing pigeons: a GA approach

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Big data is here

Traditional tracking

- 3D Accelerometer showing behavior and energy use
- Remote sensing weather data
- Remote sensing habitat data
- Interactions with other tagged animals

Kays, Roland, et al. "Terrestrial animal tracking as an eye on life and planet." Science 348.6240 (2015)

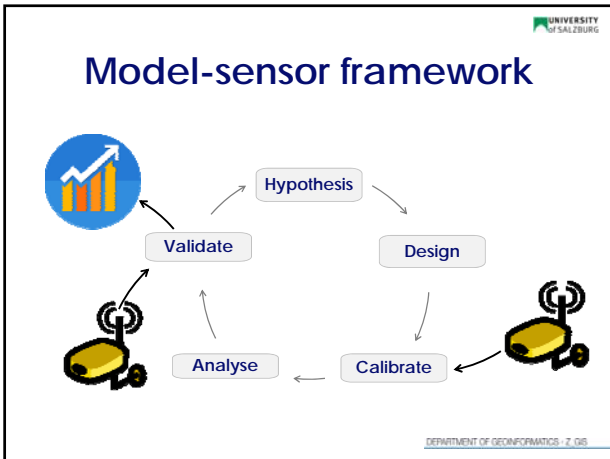
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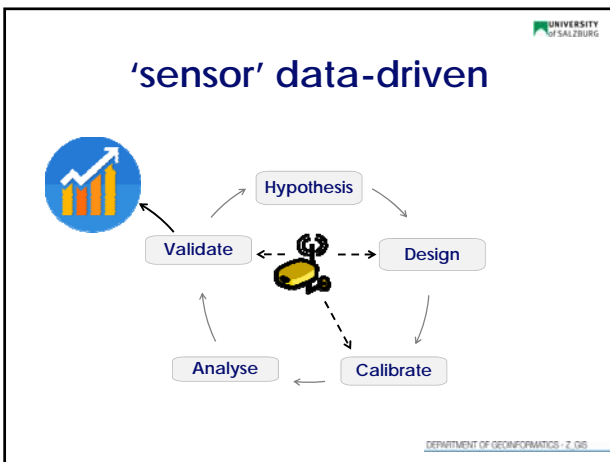
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Conventional model cycle

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graph TD; Hypothesis --> Design; Design --> Calibrate; Calibrate --> Analyse; Analyse --> Validate; Validate --> Hypothesis; DATA --> Calibrate; DATA --> Analyse;
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Research

- **sensor observations** : are dynamic, granular, real-time, 'ubiquitous'
- can sensor streams augment **dynamic model specification (robust)**, calibration and validation? what about accuracy?
- which methods can we employ?
- what are implications to ABM in GIScience?

The University of Salzburg logo is in the top right, and the Department of Geoinformatics - Z_GIS is in the bottom right.

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Approach

- **sensor observations** : emulated GPS trajectories
- **dynamic model specification (robust)** : by optimisation, dynamic evaluation and refinement of model parameters
- **methods?** **Evolutionary (genetic) algorithms**

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Use case

- Optimization of parameters to simulate adaptive **navigation behavior of homing pigeons**

A cartoon illustration of a pigeon holding a newspaper titled "ROAD MAP". The pigeon is looking at the map with a focused expression.

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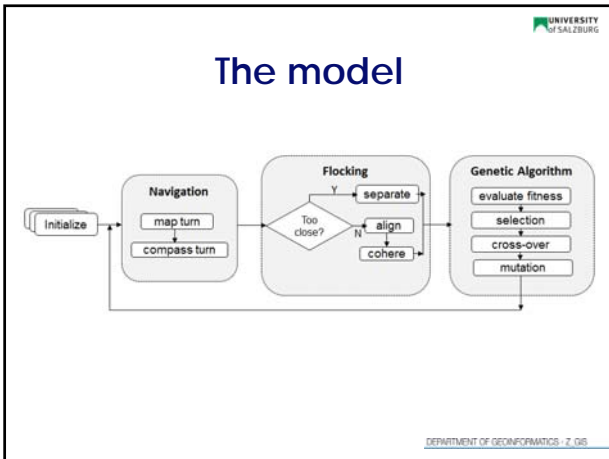
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GPS trajectories

A map titled "Flight paths of pigeon flocks" showing multiple colored lines representing the flight paths of different pigeon flocks. The paths start from a "Home loft" on the left and end at a "Release site" on the right. A scale bar at the bottom left indicates distances from 0 to 5 km. An inset map shows a zoomed-in view of the flight paths near the release site.

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Santos, C.D., et al., Temporal and contextual consistency of leadership in homing pigeon flocks. PLoS one, 2014.

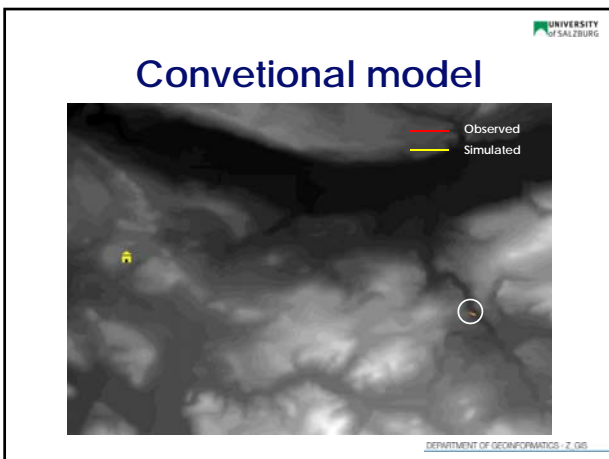


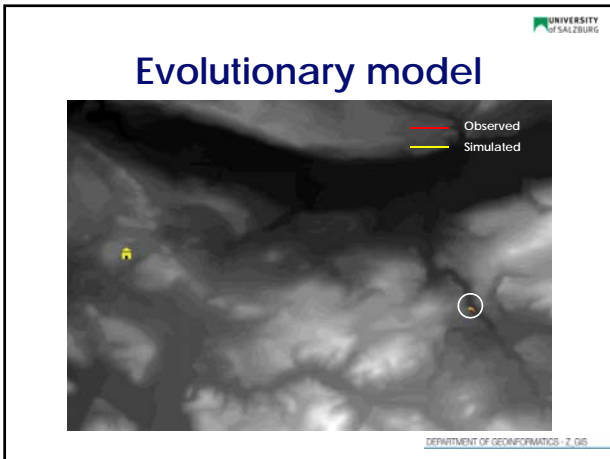
Chromosome of parameters

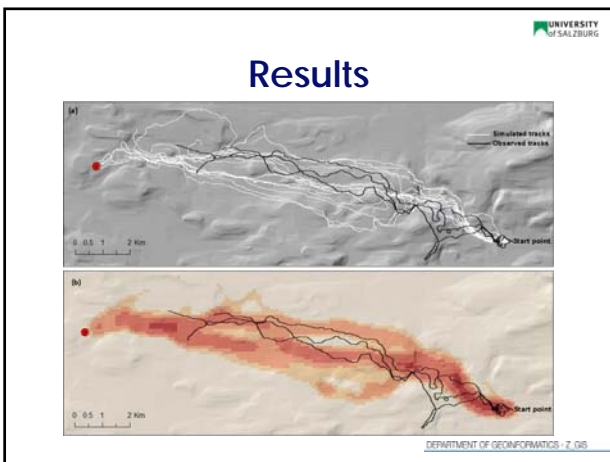
- **A conventional model** : calibrated to provide initial candidate parameters
- **Random noise**: introduced in each parameter to ensure uniqueness (stochasticity)

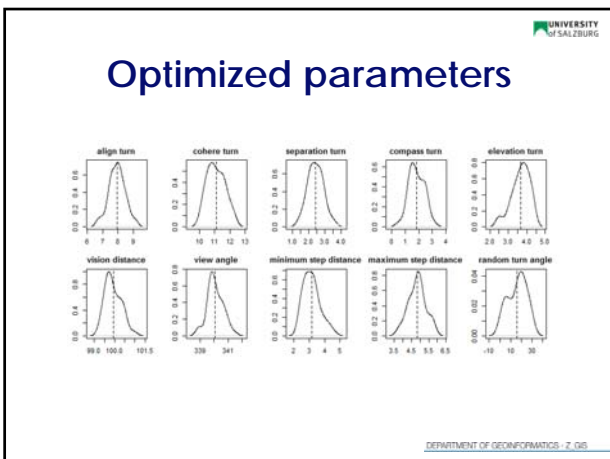
Align turn	Cohere turn	Separate turn	Loft turn	Altitude turn	Elevation turn	Width	View angle	Min step	max step
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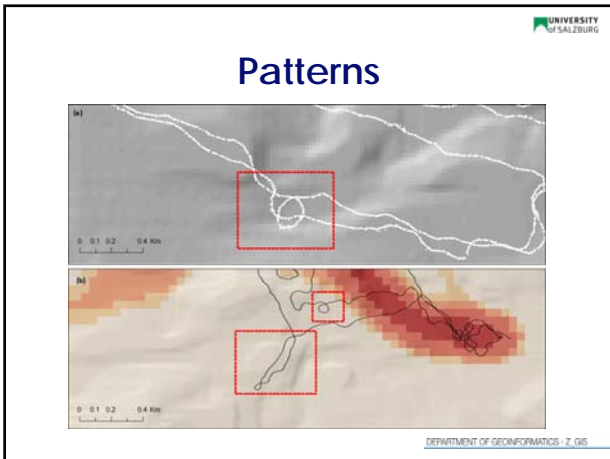
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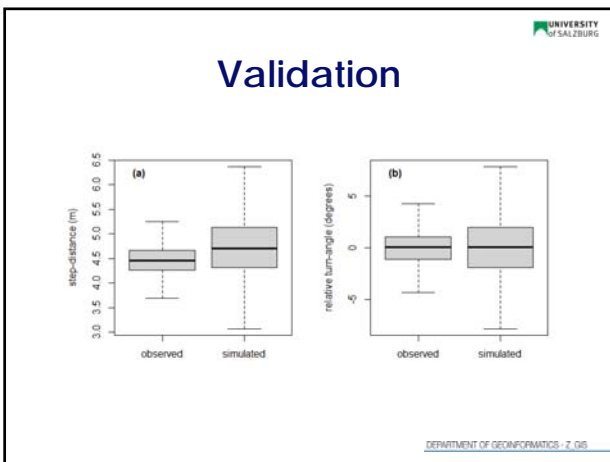












- ### Conclusion
- **Optimization** through evolutionary algorithm results in **robust parameters**
 - Dynamic (sensor)data streams do **improve specification** of agent behavior and **validation** of models
 - **Hybridity**: conventional + evolutionary
 - **Epistemology**: Can data replace hypothesis?
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Research directions

- **Model-sensor interaction** through educational robotics (bi-directional modelling)
- **Dynamic behavior detection** models
- **Automatic rule-set (hypothesis) generation** from sensor data streams

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