Model integration in SAMT with the focus to fuzzy

Problem: the use of SAMT as modeling framework

- Fuzzy modeling (yield model, habitat models)
- Neuronal network (som, rbf, feed forward)
- Integration of model written in C++
- Modeling toolbox SAMTDESIRE
Structure of SAMT

- GIS interface
- database interface
- spatial data management
- graphical user interface and control unit
- spatial analysis [simple, complex]
- 2D-visualization
- spatial operations [simple, advanced]
- cellular automata control unit
- model interface
- neural network control unit
- fuzzy control unit
- 3D control unit
- model frame control unit
Fuzzy modeling

Problem: many of the modeling tasks are difficult to formalize exactly but the expert can often cope with it.

- Habitat modeling: the habitat quality is a measure of the integrity of an area
  - Habitat quality depends on different properties of an area
  - These properties can be organized as a hierarchy
  - The influence of each property can be modeled using fuzzy

- Yield modeling as an expert system
Simplified example: Lesser Spotted Eagle

Habitat model
Lesser Spotted Eagle

fuzzy model nutrition

soil coverage dynamic model

agricultural management

agricultural plants

soil condition

weather condition

Distance to
forest (eyrie)

Distance to
wind power plants

Landscape structure hedges
Method of habitat modeling using fuzzy

Model development

• Develop an appropriate habitat structure
• Organize all basic maps (from GIS, use additional information for example from remote sensing)
• Build the fuzzy models and the dynamic models
• Check this models using SAMT-Fuzzy

Simulation

• Use this models in SAMT (spatial context)
• Combine all models and make the simulation
• Test the model with other data, other locations
The work with projects in SAMT

A project in SAMT is a bundle of basic maps, models, fuzzy models, neural networks, and points.

• Create a project when you start your work
• Include all basic maps, points in it
• Include the models in it (if you have to change one model it doesn’t matter SAMT include automatically the newest version)
• Use “PROJECT_Open” in stead of “HDF_Open”
Start with SAMT-FUZZY

- Open the project “lse”
- Open the SAMT-Fuzzy toolbox and play with the models (do not save changed models)
- Simulate the nutrition
- Calculate the visibility
- Exchange the cell[i][j]=-1 in the map with the maximum of the map
- Simulate the habitat quality
- Use “splatter” plot with habitat
How does it work?

We use simple triangular and trapezoid function for fuzzification:

triangular function

$$
\mu_A(x) = \begin{cases} 
0 : & x \leq x_1 \\
(x - x_1)/(x_2 - x_1) : & x > x_1 \land x \leq x_2 \\
(x_3 - x)/(x_3 - x_2) : & x > x_2 \land x < x_3 \\
0 : & x \geq x_3
\end{cases}
$$

trapezoid function

$$
\mu_A(x) = \begin{cases} 
0 : & x \leq x_1 \\
(x - x_1)/(x_2 - x_1) : & x > x_1 \land x < x_2 \\
1 : & x \geq x_2 \land x \leq x_3 \\
(x_4 - x)/(x_4 - x_3) : & x > x_3 \land x < x_4 \\
0 : & x \geq x_4
\end{cases}
$$
Output functions are crisp

Why that? Crisp values and fuzzy?

- Crisp values as output function can model linear and nonlinear behavior
- Crisp values leads to very fast calculation
Fuzzy Inference

\[
\begin{align*}
\text{IF } & \mu_{11}(x_1) \land \mu_{21}(x_2) \land \mu_{31}(x_3) \Rightarrow o_1 \\
\text{IF } & \mu_{12}(x_1) \land \mu_{22}(x_2) \land \mu_{32}(x_3) \Rightarrow o_2 \\
& \cdots \cdots \\
\text{IF } & \mu_{1n}(x_1) \land \mu_{2n}(x_2) \land \mu_{3n}(x_3) \Rightarrow o_n
\end{align*}
\]

assign a membership to all rules

\[a_{mk}^m = \min\{\mu_1 j_m(x_1), \mu_2 j_m(x_2), \mu_3 j_m(x_3)\}\] (1)

select the best rule for each different output

\[a_k = \max\{a_1^k, a_2^k, \cdots\}\] (2)
Defuzzification

\[ o = \frac{\sum_k a_k \times o_k}{\sum_k a_k} \]  

(3)

more common:

\[ o = \frac{\int_{x_\alpha}^{x_e} \mu(x) \times x \, dx}{\int_{x_\alpha}^{x_e} \mu(x) \, dx} \]  

(4)
Influence of different “and” operators in fuzzification

AND as minimum operator

AND as product operator
Investigate in fuzzy models

Do not use a fuzzy model without a check!
Please load the “lse” project again.

- Use “Fuzzy Analysis” in SAMT
- Use “Sensitive Fuzzy” (play with the rules and observe the changes)
- Change the fuzzy models using SAMT-Fuzzy and look how it works