University of Zurich

# Snakes: a technique for line smoothing and displacement in map generalisation

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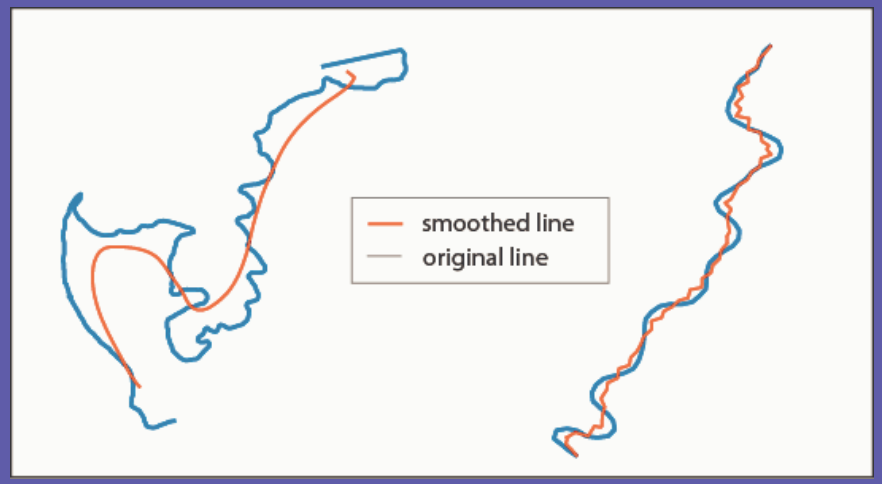
**foundation**:

Snakes for **line** smoothing developed by Burghardt (2002)
(conventional snakes model by Kass et al. 1987)

**results of evaluation**:

already good results, but refinement needed..

- knowledge of parameters / smoothing control
- observation of cartographic constraints




bad parametrisation

**further aims:**

- other approach using TAFUS (Borkowski et al. 1999)
- combination with known displacement model

**tools:** Matlab R12

**Snakes** – an energy minimzing spline function

- developed in graphics domain for image recognition
- smooths „signals“ (lines) like a spline
- speciality: smoothing can be controled locally
- snakes energy integral defined by two terms

$$E_{ges} = \int_0^1 (E_{ext} + E_{\text{int}}) ds \Rightarrow Min$$

  - internal energy : describing the line „shape“ itself
  - external energy : describing external forces

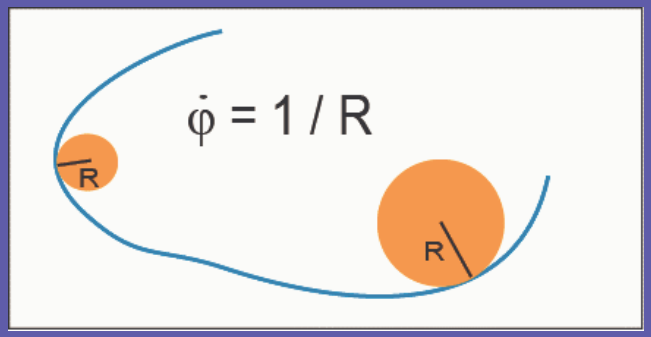
- the overall energy will be minimized
- solution in an iterational process

# models

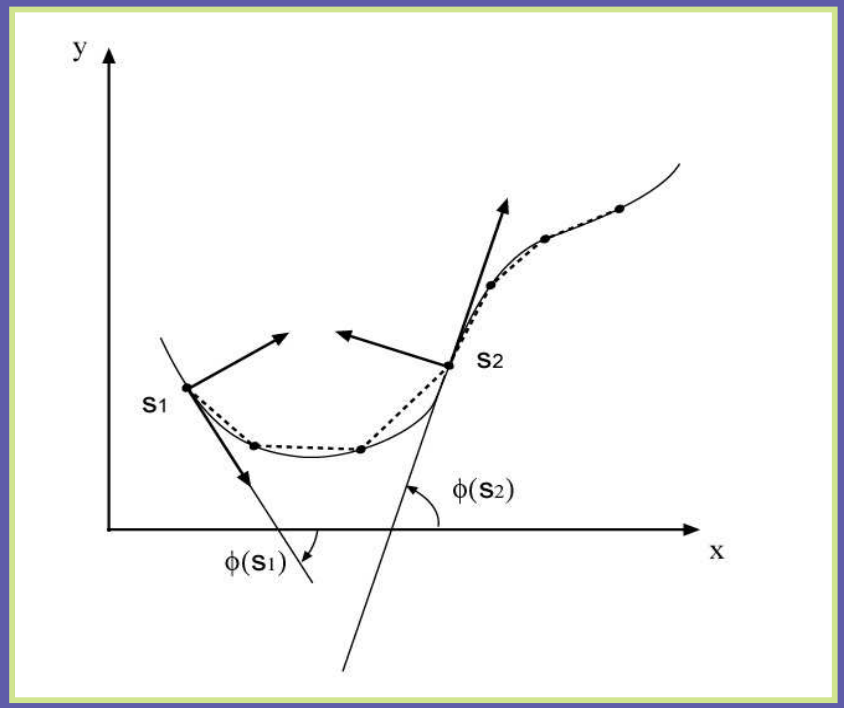
## conventional snakes
(based on x,y coordinate represenatation)

$$\varphi(s) = \arctan \frac{\dot{y}(s)}{\dot{x}(s)}$$

remark on curvature:




## Tangent Angle FUnction Snakes
(based on tangent angle representation s,φ)



## Line smoothing with snakes

| | internal energy (smoothing spline) | *variation* of external energy (interaction, 2nd control) |
|---|---|---|
| snakes | $E_{\text{int}} = \frac{1}{2}\left[\alpha\lvert\dot{\underline{v}}\rvert^2 + \beta\lvert\ddot{\underline{v}}\rvert^2\right]$ | $\frac{\partial E_{ext}}{\partial x} = \frac{\partial E_{ext}}{\partial y} = 0$ |
| tafus | $E_{\text{int}} = \frac{1}{2}\left[\alpha\varphi^2 + \beta\dot{\varphi}^2\right]$ | $\frac{\partial E_{ext}}{\partial \varphi} = -\dot{\varphi}_0$ |

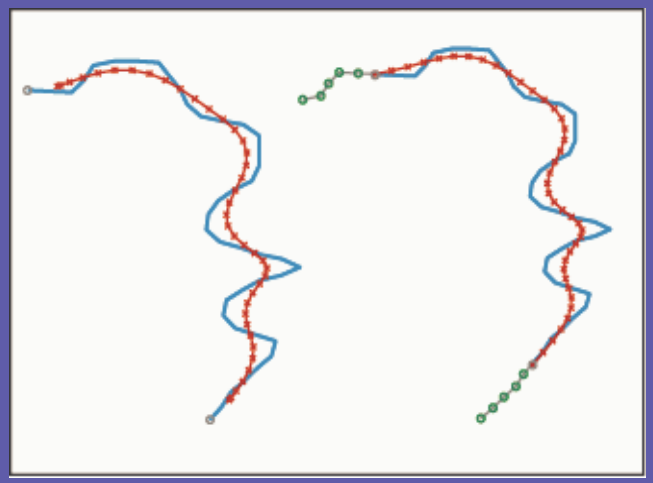
$\dot{\underline{v}} = \begin{bmatrix}\dot{x}\\ \dot{y}\end{bmatrix}$ $\ddot{\underline{v}} = \begin{bmatrix}\ddot{x}\\ \ddot{y}\end{bmatrix}$

$\alpha,\beta$ : control parameters (1st control)
$\varphi$ : tangent angle
dotted : partial differentiation with respect to arc length s

snakes approach: spline -- tafus approach: controlled by curvature

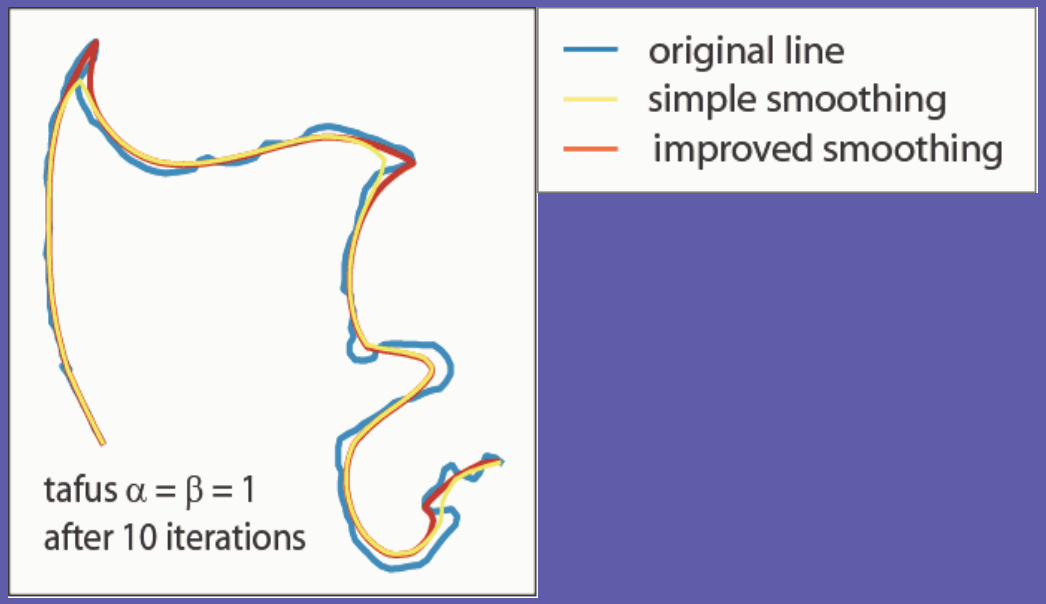
3rd control: number of iterations

# model refinement for use in generalisation



maintain constraint points (landmarks)

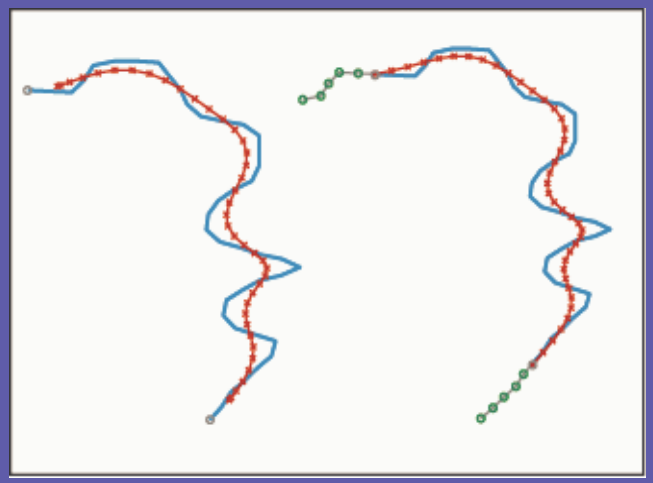
by curvature controled line segmentation




fixing translated border points of a line

by changed weights in the snakes filter matrix and mirror last points (green)

# model refinement for use in generalisation



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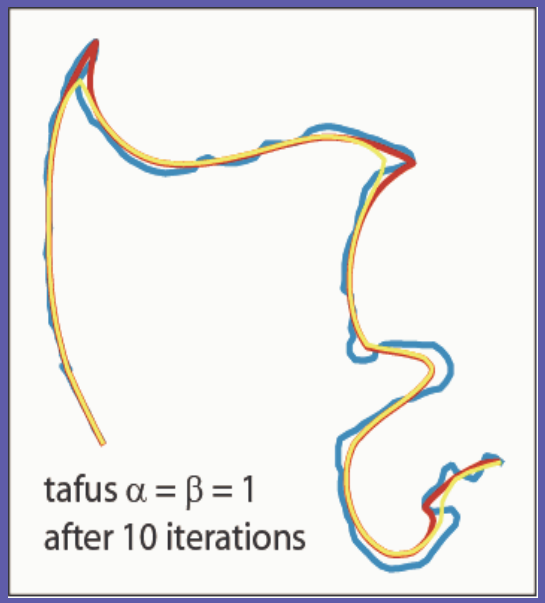
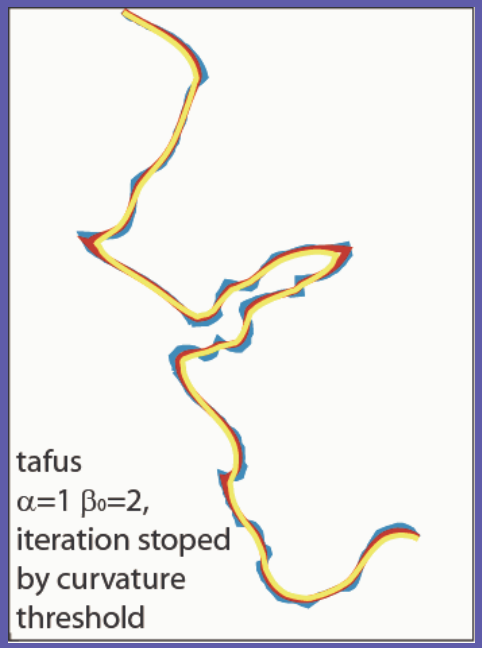


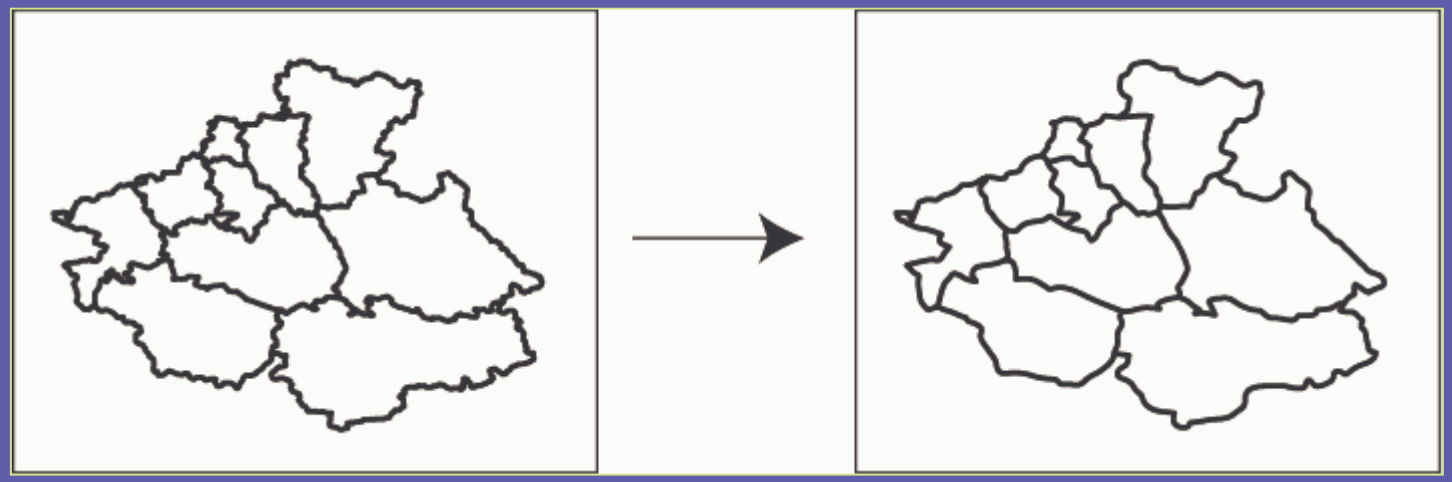




preserve shape caracteristics (meander, serpentines)

by curvature controled param. effect only up to 5 iterations

**Finally we recommend:**

- conventinal snakes (robust + faster than tafus)
- fix parameter $\alpha$=1, only $\beta$ variable
- iteration process to obtain desired smoothing deg.
  stopping criterion: curvature threshold
- segmentation

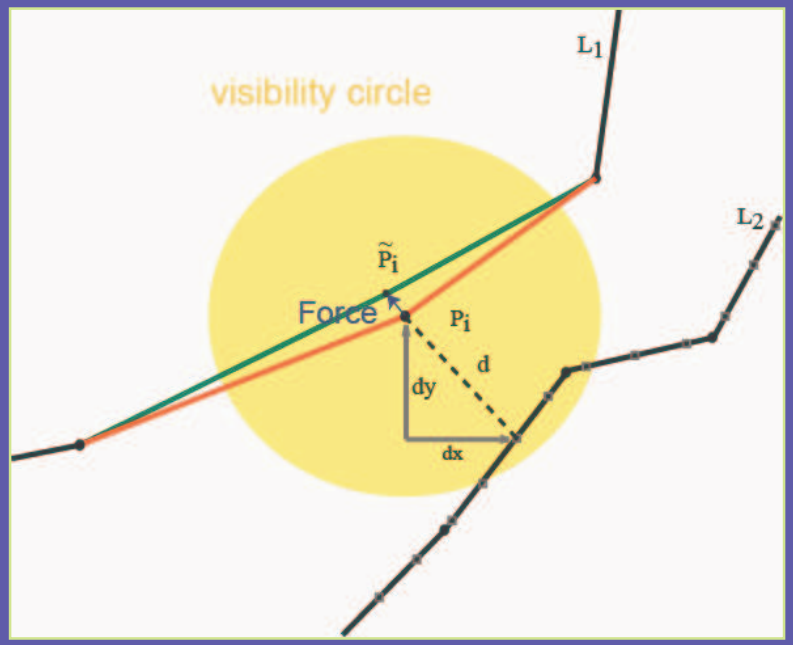


## Combined line smoothing and displacement

- snakes displacement algorithms by Burghardt & Meier 1997
  tafus displacement algorithms by Borkowski et al. 1999

- same structure of energy integral

- differences to smoothing:
  - internal energy usesd to preserve original line shape
  - external energy defined by displacement forces



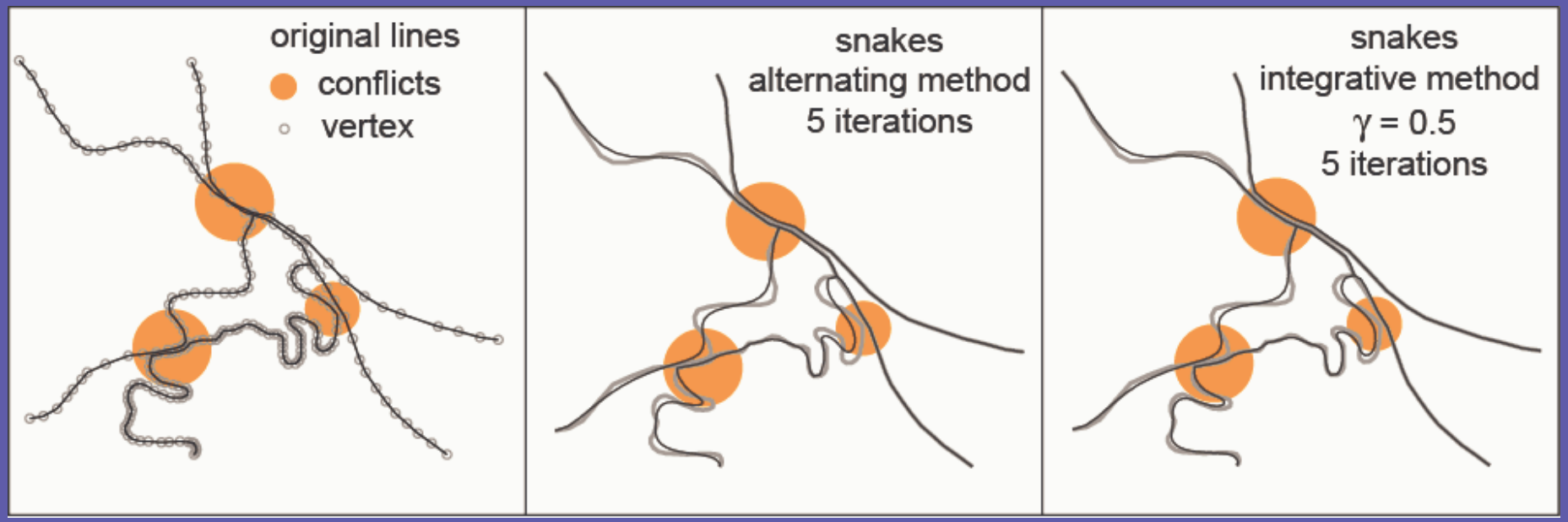
basic methodes of (batch like) combination:

*alternating method*

- **switching** between both algorithms after defined number of steps
- both processes can have different parameter values (variable $\beta$ useful to prevent side effects of smoothing on displacement)

*integrative method*

- combination of formulas in a **linear fashion**
- a new weighting parameter $\gamma$ arises (equal weight: $\gamma = 0.5$)
- only **one system matrix** exists: no local control of $\alpha, \beta$




grey: original lines
black: smoothed and displaced lines
=> only small differences in results

*preliminary* results:

- higher processing time for displacement (reason: conflict evaluation)
- a larger number of iterations does not show big differences among constant and variable parameters $\alpha,\beta$
- snakes ⇔ tafus:negligible time cost differences; snakes are robust
- further tests required: stopping criterion for not solvable displacement situations

Thank you for listening!

..questions are welcome

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# interference of smoothing and displacement