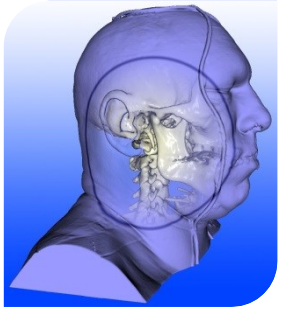
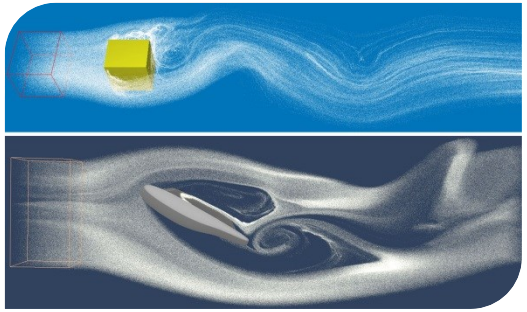
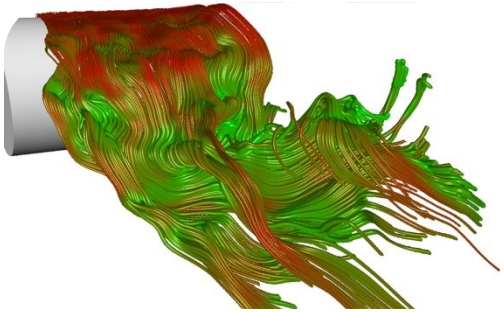
Master Practical Course

# Interactive Visual Data Analysis

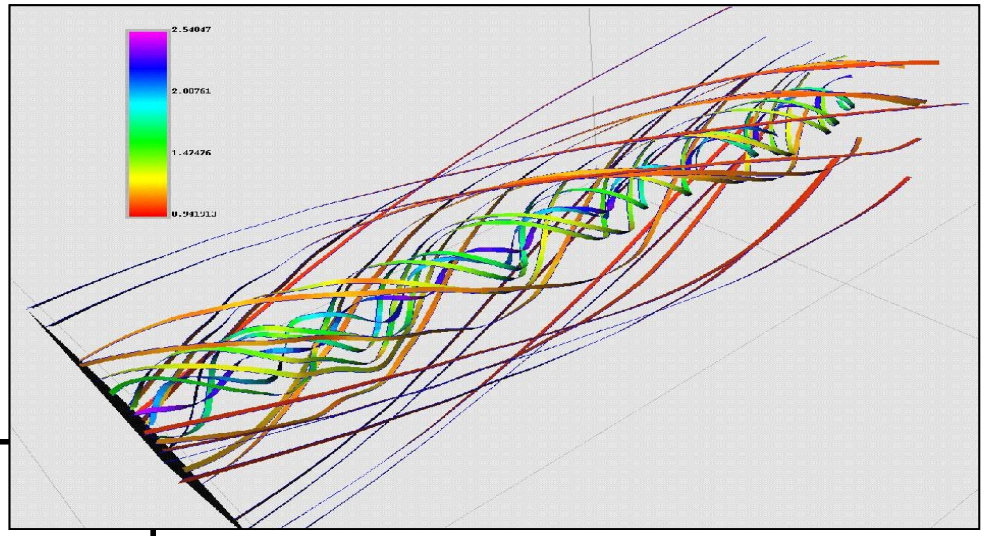





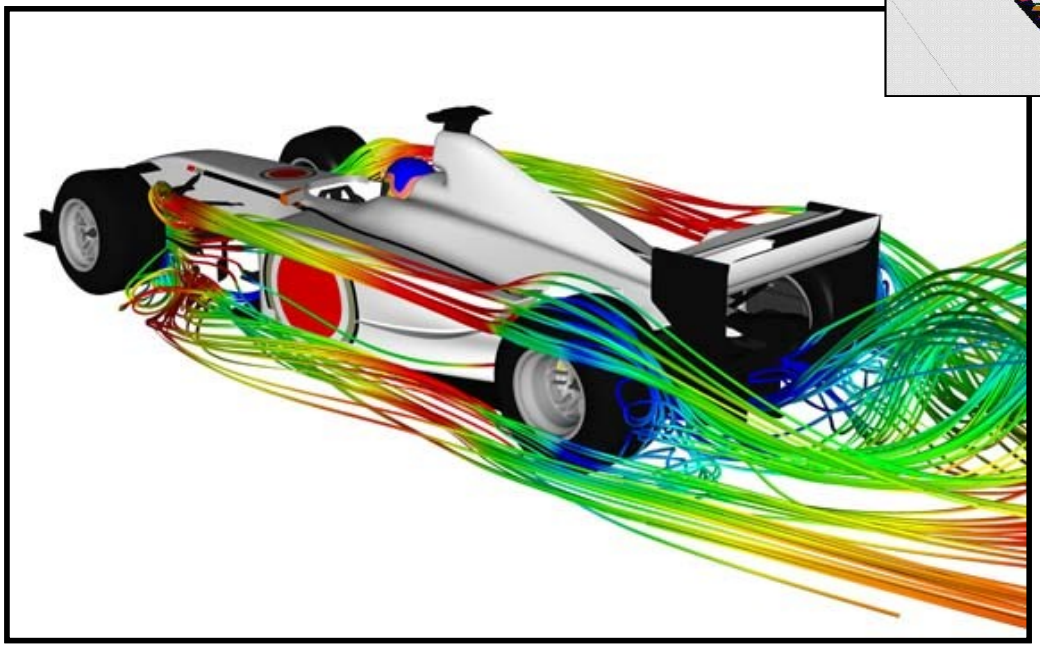
tum.3D

computer graphics & visualization

# This week: Characteristic Lines

Show not only individual particles, but connect them to characteristic lines



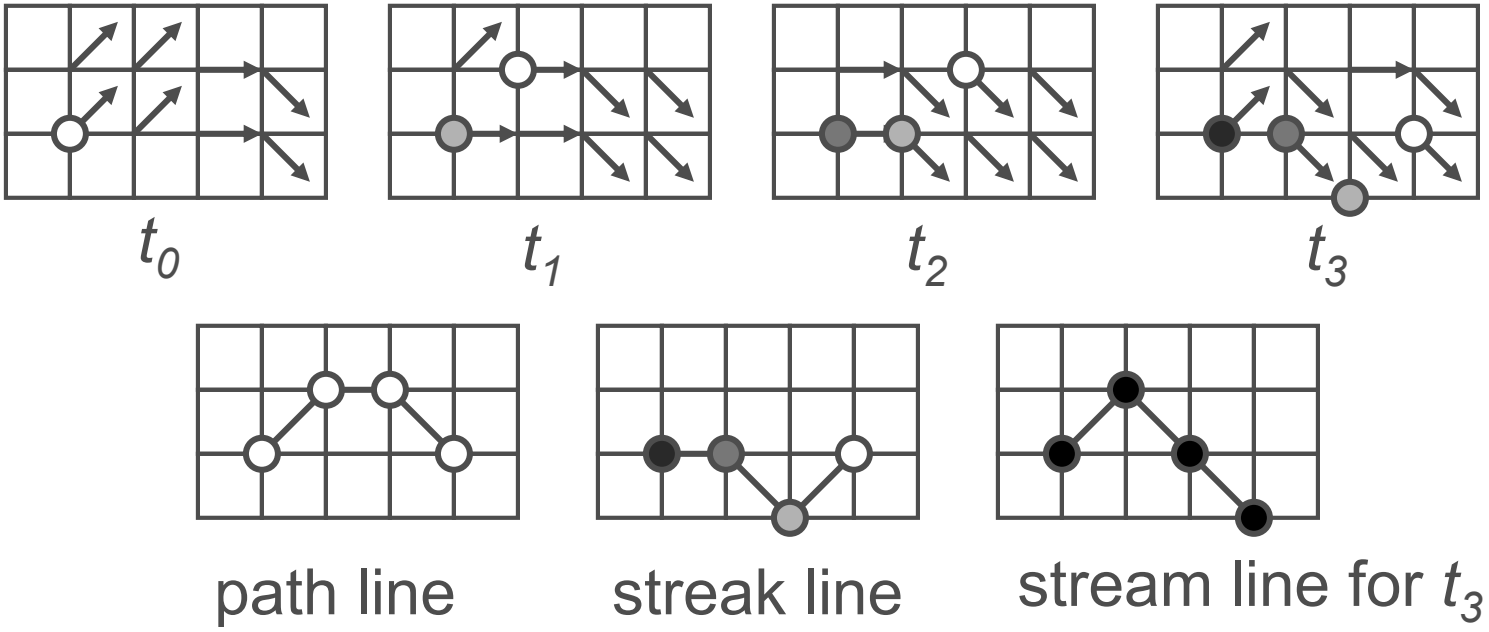



# Characteristic Lines

- Types of characteristic lines in a vector field:
  - Path lines: trajectories of massless particles in the (unsteady) flow
  - Stream lines: trajectories of massless particles in a “frozen” (steady) vector field
  - Streak lines: trace of dye that is released into the (unsteady) flow at a fixed position

# Characteristic Lines

- Comparison of path lines, streak lines, and stream lines




- Path lines, streak lines, and stream lines are identical for steady flows

# Math!

- Reminder: Particle $\boldsymbol{x}(t)$ = Path line

$$\boldsymbol{x}(t_0) = \boldsymbol{x}_0\ , \qquad \dot{\boldsymbol{x}}(t) = \frac{\partial \boldsymbol{x}(t)}{\partial t} = \boldsymbol{u}(\boldsymbol{x}(t), t)$$

- Stream line $\boldsymbol{x}(s)$ at fixed time $t$

$$\boldsymbol{x}(0) = \boldsymbol{x}_0\ , \qquad \dot{\boldsymbol{x}}(s) = \frac{\partial \boldsymbol{x}(s)}{\partial s} = \boldsymbol{u}(\boldsymbol{x}(s), t)$$

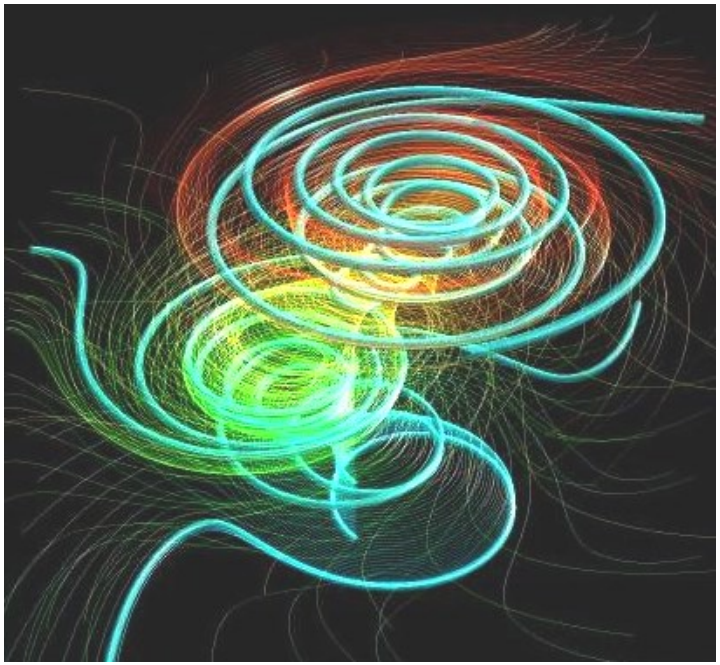
  - Integration variable $s$ not a physical time anymore!
  - Just use a user-defined constant as $\Delta s$ …

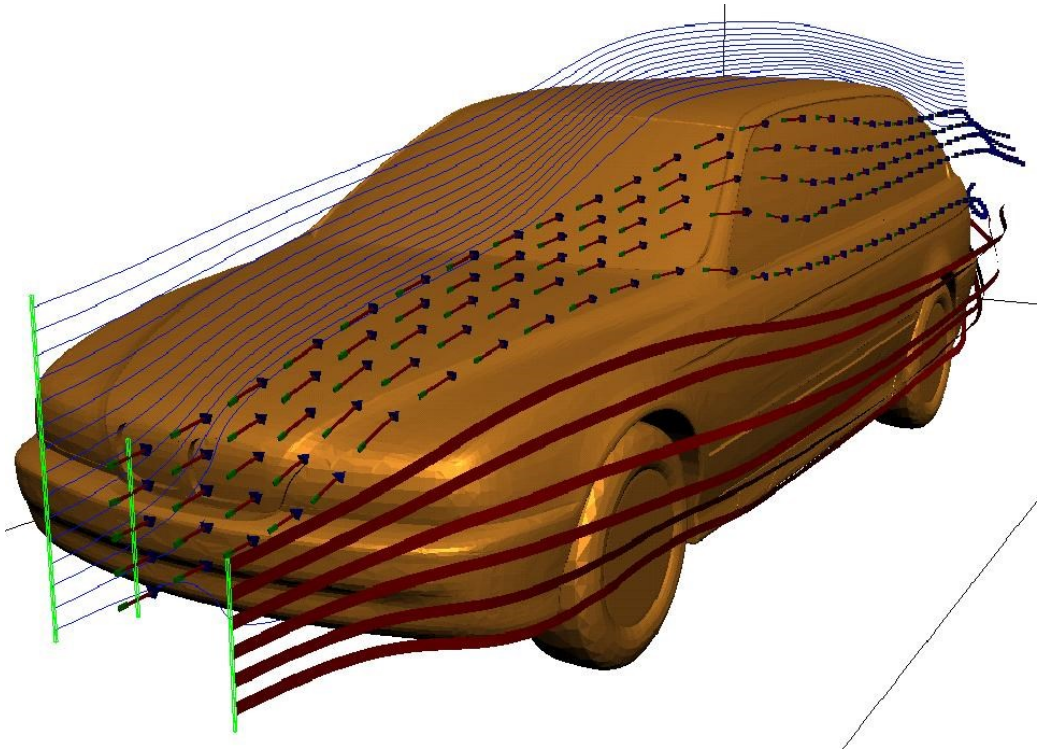
# Implementation

- Create buffer for n*m vertices (n lines, m vertices each)
- Path lines
  - Just store previous particle positions
  - Boring to look at – we won‘t do these!
- Stream lines
  - Need to be recomputed every frame
  - Integrate for (m-1) steps with one CS thread per line
- Streak lines
  - Need to update every vertex once per frame
    - Integrate for a single step with one CS thread per vertex
  - Seeding etc. a bit more complicated → next week!

# Rendering

- (Infinitesimally thin) Lines
- Tubes
- Ribbons / Bands
  - Need orientation!



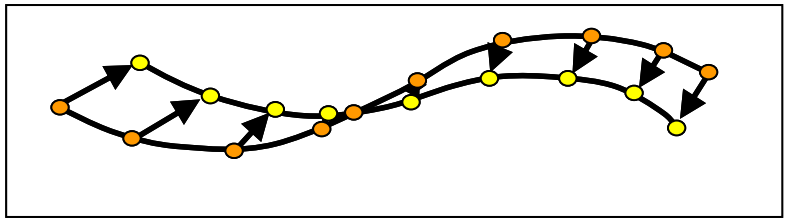


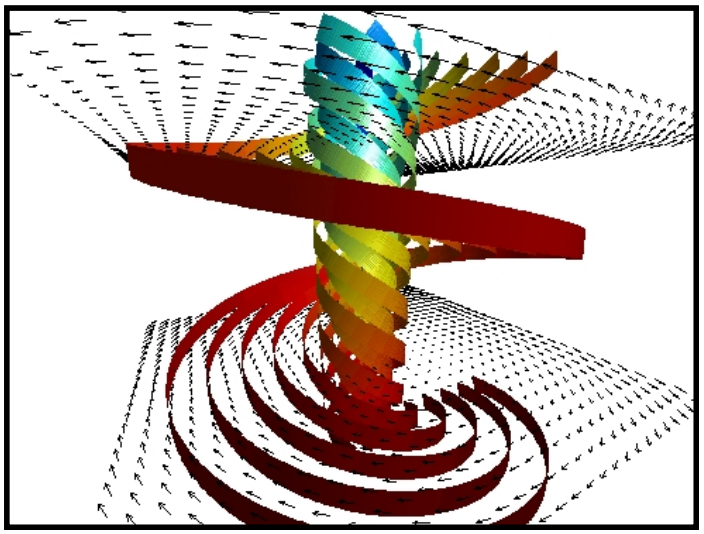
This week: Lines and Ribbons

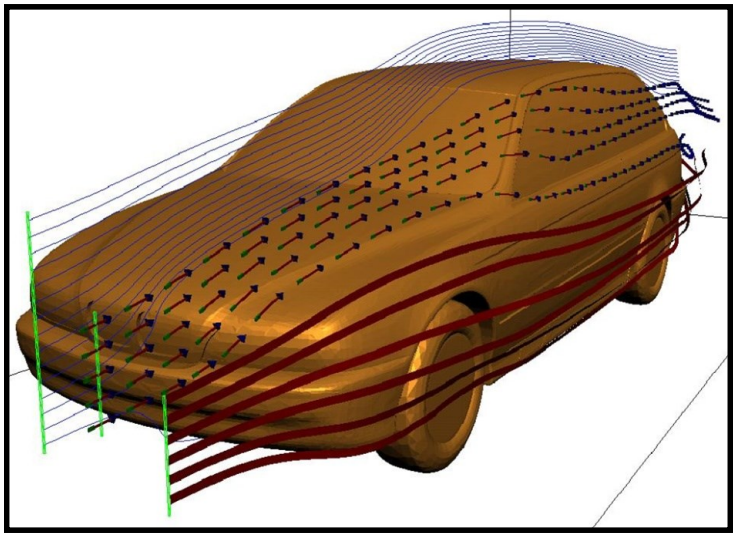
# Stream Ribbons



- Ribbon orientation
  - Trace two close-by particles
    - Keep distance constant
    - Shearing still possible
  - Or trace central particle + left and right “ghost particle”
    - Reset ghost particles after each step to prevent divergence/shearing







# Questions ?