Visualisation within School of Engineering Sciences SCI

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School of Engineering Sciences, SCI

Research groups with interest for visualisations

- **Mechanics**
  Fluids: Dan Henningson
  Solids: Anders Eriksson

- **Physics**
  Bengt Lund-Jensen
  Theoretical Physics: Mats Wallin

- **Vehicle Engineering**
  Gunilla Efraimsson
  Art Rizzi

- **Mathematics/Optimisation**
  Anders Lindquist

- **KCSE**: KTH Computational Science & Engineering Centre, Director: Olof Runborg
Vision/Needs for SCI

- **Applications:**
  - Computational Mechanics (incl. CFD)
  - 4D insight into motion/interaction of structures

- **Status:**
  - Very localised solutions (areas, persons)
  - “unsophisticated” software (Matlab, homegrown, ...)

- **Needs:**
  - more centralised knowledge on visualisation techniques, capabilities, tools etc.
  - dedicated machines, i.e. with large memory, scratch disks, graphic cards
  - software availability, specialised tools e.g. for CFD
  - steep learning curve → specialists? (area-specific)
  - huge amounts of data (1 velocity field ~5GB)

- **Vision:**
  - Introduce Visualisation as a daily tool for students and researchers
  - focus on time-dependent 3D visualisations
Workflow of Visualisation in CFD

1. Theory/Experiments

2. Simulation → Statistics

3. 2D-Visualisation

4. 3D-Visualisation
Detailed Insight through Visualisation: laminar-turbulent Transition

LES Data, ca. 20 Mio. Grid Points, done with OpenDX
Views not obtainable from Experiments...

DNS Data, ca. 40 Mio. Grid Points, done with OpenDX
Thank you!
Comparison: Simulation and Experiment

Experiment
KTH Windtunnel
Matsubara & Alfredsson (2001)

Simulation
LES (ADM-RT)
Schlatter, Brandt & Henningson (2006)
Transition Mechanism: Classical Transition

Low levels of background noise (<1%) → exponential modal growth

2D primary instability (TS waves)

Secondary instability (K- & H-modes)

Turbulent spots

Turbulence

Schlichting (1977)
Transition Mechanism: Bypass Transition

High levels of free-stream turbulence (>1%) → exponential growth of TS waves is “bypassed”

Non-modal growth of 3D streaks

Secondary instability of streaks

Turbulent spots

Turbulence

Matsubara & Alfredsson (2001)
Bypass Transition

High levels of free-stream turbulence (>1%)
→ exponential growth of TS waves is “bypassed”

(high velocity)
(low velocity)
contours of $\lambda_2$

Flow direction $x$

turbulent boundary layer
	n turbulent spots

(outflow)

Decaying freestream turbulence

Flat plate
DNS Results: Streak Breakdown

Low-speed streak  High-speed streak

Vortical structures (negative $\lambda_2$)

✓ horseshoe pattern (symmetric instability)

Visualisation of Bypass Transition

- Streamwise velocity component $u$ obtained from LES with ADM-RT in a wall-parallel $(x, z)$ plane at $y=2\delta^*_0$
  - Red: high velocity, blue: low velocity,
  - Black: spot detection criterion
  - Threshold for spanwise velocity variance
  - Median filters to smoothen boundaries