Overview

Complex data: families of surfaces
- Meteorology
- Engineering
- Car racing

InfoVis wrap-up

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Meteorology model 1

Climate research at the PIK institute

Multiple runs

Multiple runs:
- two diffusivity parameters
- 10 steps each - 100 runs
- 500 time steps (1 step = 1 year) - per run

35 different results aggregated from the more detailed raw simulation data (temperature, ...)

Common way of storing the data:
- multiply previous table 100 times, 50 000 rows now
- 3 independent variables now timestep, diffh, diffv
Mappings as dimensions - curves

Mapping as a dimension [Konyha et al. 2006]:
- group results for one run
- outputs are not scalar any more
- but functions of time
- 100 rows now

<table>
<thead>
<tr>
<th>Run</th>
<th>Diff_h</th>
<th>Diff_v</th>
<th>Output1(t)</th>
<th>Output2(t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dh1</td>
<td>dv1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>dh1</td>
<td>dv1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>100</td>
<td>dh10</td>
<td>dv10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mappings as dimensions - surfaces

Curves – we are interested about output as f(time)
What if we are interested in outputs as f(x,y)?
Group outputs from all runs in a “surface”
- e.g. temperature = f(diffh, diffv)
- 500 rows now, one for each time step
- Offers new possibilities for analysis

Visualization of family of surfaces

Family of curves
- curve view shows them all
- works great

Family of surfaces
- show them all!
- it does not work!

We can show single surface but
Cannot show whole family at once
If we cannot see it we will grasp it thorough interaction
Analysis of family of surfaces

Look at the data at different levels

Three levels of detail:

- Analysis through single scalar aggregates (overview)
  - reduction by 2 dimensions
- Analysis through aggregated profiles (drill down)
  - reduction by 1 dimensions
- Analysis through surfaces (details on demand)
  - no dimension reduction but selective visualization

Single Scalar Aggregates

Overview, statistics

- First step
- Reduce to
- Use common
- Get the first
- Explore it
- Family – small

Aggregated Profiles

General
  - red
Profile
Analysis
  - adv
  - ven

Surfaces

- Analysis through aggregated profiles (drill down)
  - Advanced analysis
  - Very complex, challenging, and powerful

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EHD bearing

Important part in IC engine

Durability, performance, wear, noise

Two step analysis

225 simulation runs – 4 to 5 days on a standard PC
Analysis snapshot 1

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Race Car Setup

The Open Car Race Simulator - TORCS
Parameters varied
- Wing Angle: 8–18 degrees (six steps)
- Brake Ratio: 0.41–0.50 (five steps)
- Max. Brake Pressure: 6,500–19,000 (six steps)
- Gear Sets: Six different gearbox sets (six steps)
  Front Spring: 1,000–2,000 (three steps)
  Rear Spring: 1,000–2,000 (three steps)

Telemetry data saved

Single run

<table>
<thead>
<tr>
<th>Lap</th>
<th>Sector</th>
<th>Wing Angle</th>
<th>Brake Ratio</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>8</td>
<td>0.41</td>
<td>120</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>8</td>
<td>0.41</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>8</td>
<td>0.41</td>
<td>90</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>20</td>
<td>23</td>
<td>8</td>
<td>0.41</td>
<td>89</td>
</tr>
</tbody>
</table>

Multiple runs

Multiple runs:
- >9000 variations of car parameters
- 20 laps per simulation, 23 sectors

Telemetry data stored
Common way of storing the data:
- multiply previous table 9000 times
- 7 independent variables now lap, sector, car parameters
Mappings as dimensions - surfaces

Group outputs from all runs in a “surface”
- e.g. speed = f(lap, sector)

9000 rows now, one for each simulation run
Offers new possibilities for analysis

<table>
<thead>
<tr>
<th>Run</th>
<th>Wing Angle</th>
<th>Speed(lap,sector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>...</td>
</tr>
</tbody>
</table>

Analysis of family of surfaces

Family of surfaces - conclusion

Projects along x
Projects along y
Wrap-up

In general:
- IVA is one methodology within visualization
- to facilitate insight into large and/or complex data
- via interactive exploration and analysis

Interactive Visual Analysis – main idea

On top level:
- due to the dual-information-knowledge cycle (we need means to abstract insight from data)
- integrating the best from “two worlds”, we combine
data exploration/analysis by the user, based on interactive visualization
and data analysis by the computer, based on statistics, machine learning, etc.
- IVA, in general, is a loop (iterative & interactive),
  1. usually starting with some data visualization first,
  2. followed by user inspection and certain interaction
  3. the user interaction causes a new visualization, (relational information)
  4. user-induced computations lead to visualization, again...
IVA works for engineers, bioinformaticians, climatologists, ...

Basis of IVA

Given some data, e.g.,
- a large bunch of time series,
some (larger) tables of numbers (usually multiple columns),
spatiotemporal data that is multivariate,
etc. (yes, it’s really that general!),
IVA is
- a flexible exploration & analysis methodology
  that utilizes a variety of different views on the data
  and feature extraction (iteratively & computationally)
IVA enables
- interactive information drill-down, while navigating between
  overview & details, seeing the unexpected, e.g., for hypothesis
generation, steering the analysis
- IVA bridges the gap between the data & the user

From Data to Information (Insight)

Whereas data is explicit, information often is implicit
We need to
- interpret data (from numbers to meaning)
- read between the lines (relational information)
- pursue information drill-down (deep search)
Approaches are
- procedural, computational, automatic
- interactive (user in the interaction-feedback-loop)
- hybrid

Level 1: KISS-principle IVA

Base-level IVA (solves many problems, already!)
- bring up at least two different views on the data
- allow to mark up interesting data parts (brushing)
- utilize focus+context visualization to highlight the user selection
  consistently() in all views (linking)
With base-level IVA, you can already do
- feature localization – brush high temperatures in a histogram,
  for ex., and see where they are in spacetime
- local investigation – for ex., select from spacetime and see how
  attributes are there (compared to all the domain)
- multivariate analysis – brushing vorticity values and studying
  related pressure values (selection compared to all)
Getting more out of IVA (advanced IVA)

Starting from base-level IVA, level 2,
- we enable the identification of complex features, for ex., by exploiting a feature definition language
- we realize advanced brushing schemes, e.g., by realizing a similarity brush

With advanced IVA,
- we drill deeper (data \(\rightarrow\) selections \(\rightarrow\) features \(\rightarrow\) ...)
- we read between the lines (semantic relations)
- answer complex questions about the data

Getting more out of IVA (advanced IVA)

Starting from base-level IVA, level 3,
- we facilitate interactive attribute derivation, e.g., by means of a formula editor
- we integrate statistics/ML on demand, e.g., by linking to R

With advanced IVA,
- we drill deeper (data \(\rightarrow\) selections \(\rightarrow\) features \(\rightarrow\) ...)
- we read between the lines (semantic relations)
- answer complex questions about the data

Levels of IVA

Conclusions

IVA helps to integrate the user’s and the computer’s strengths to enable exploration and analysis
IVA is interactive and iterative
An approach to realize semantic abstraction from data (to features, insight)
Enables the joint analysis based on multiple perspectives, e.g., several feature detectors
Helps with questions of different character (physical, geometric, statistical, ...)

Info Vis – what we learned?

What is InfoVis

“The use of computer-supported, interactive, visual representations of abstract data to amplify cognition”

Typical Visualization Tasks

Visualization is (can be) good for:
- exploration
  - find the unknown, unexpected
  - hypothesis generation
- analysis
  - confirm or reject hypotheses
  - information drill-down
- presentation
  - communicate/disseminate results
Visual Analytics – What is it?

James Thomas & Krešimir Matković
NVAC (National Visualization and Analytics Center), Seattle, USA

“Visual Analytics is the science of analytical reasoning facilitated by interactive visual interfaces”

[Thomas & Cook 2005]

Info Vis – what we learned?

A little bit about colors and perception

Info Vis – what we did not learn?

Software Visualisierung
Visualisierung in der Bioinformatik (Andreas Karen)
Graph Drawing (Andreas Karen)
Text Visualization
Casual InfoVis, Many Eyes
InfoVis and Art

Complex data
Some examples from real life
Families of curves, surfaces, sets
- Everywhere
- Many possibilities for analysis
- Very hard to do it in a conventional way
- Multiple simulation runs, image collections, car racing, bio-signals, ECG of pregnant sheep!, questionnaires,

Ideas
Praktikums – Diplomaarbeiten!
Thank you!

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