User Interface Development for Interactive Multiobjective Optimization Software

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Outline

- Research Goals
- Backgrounds
  - Multiobjective Optimization
  - Complex Systems
  - Visual Analytics
- Ongoing Software Development Projects
  - Nautilus
  - Pareto Navigator (+ sketching example)
- Future Work

Research Goals

- To find methods for developing and evaluating complex decision support systems including *multiple criteria decision making (MCDM)*
- To obtain intuitive and easy-to-use user interface and interaction techniques for *interactive multiobjective optimization (IMO)* software
- Examination and utilization of techniques provided by the research field of *Visual Analytics (VA)*
- To construct a theoretical framework of MCDM in *engineering / industrial domains* and supporting IT

Backgrounds: Multiobjective Optimization

- Multiple *conflicting* (competing) *objectives* to be minimized or maximized simultaneously
  - E.g., maximize quality and minimize costs
- A set of feasible mathematically equivalent *compromise solutions* is formed (= Pareto optimal solutions)
- For the *decision maker (DM)*, the goal is to find the *most preferred compromise*

(Miettinen 1999)

Backgrounds: Complex Systems

- DMs are typically *domain experts*
- *Incomplete* or even *unreliable* information
- *Open-ended* problems: No implicit stopping rules
- Data analysis and recursive decision making are *cognitively burdensome*
- Solution may be *good/bad* but never true/false
- *Visualizations* are often a critical presentation method

(Redish 2007, Mysiak 2005)

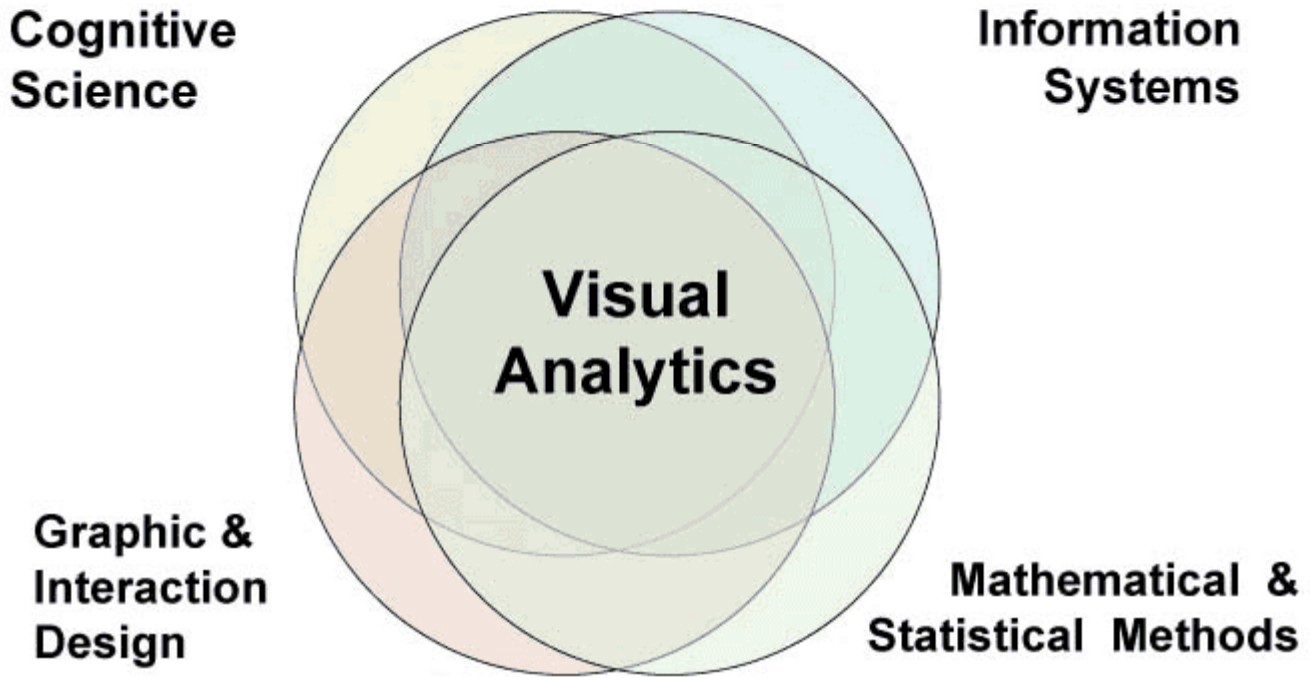
Backgrounds: Visual Analytics (1/3)

- *"Is the science of analytical reasoning facilitated by interactive visual interfaces"*
- VA techniques:
  - let users *synthesize information into knowledge* and *derive insight* from massive, dynamic, and often conflicting data
  - support insight-gaining: *discovery, decision making, explanation, analysis, exploration, learning*
  - directly support *assessment*, *planning*, and ***decision making***

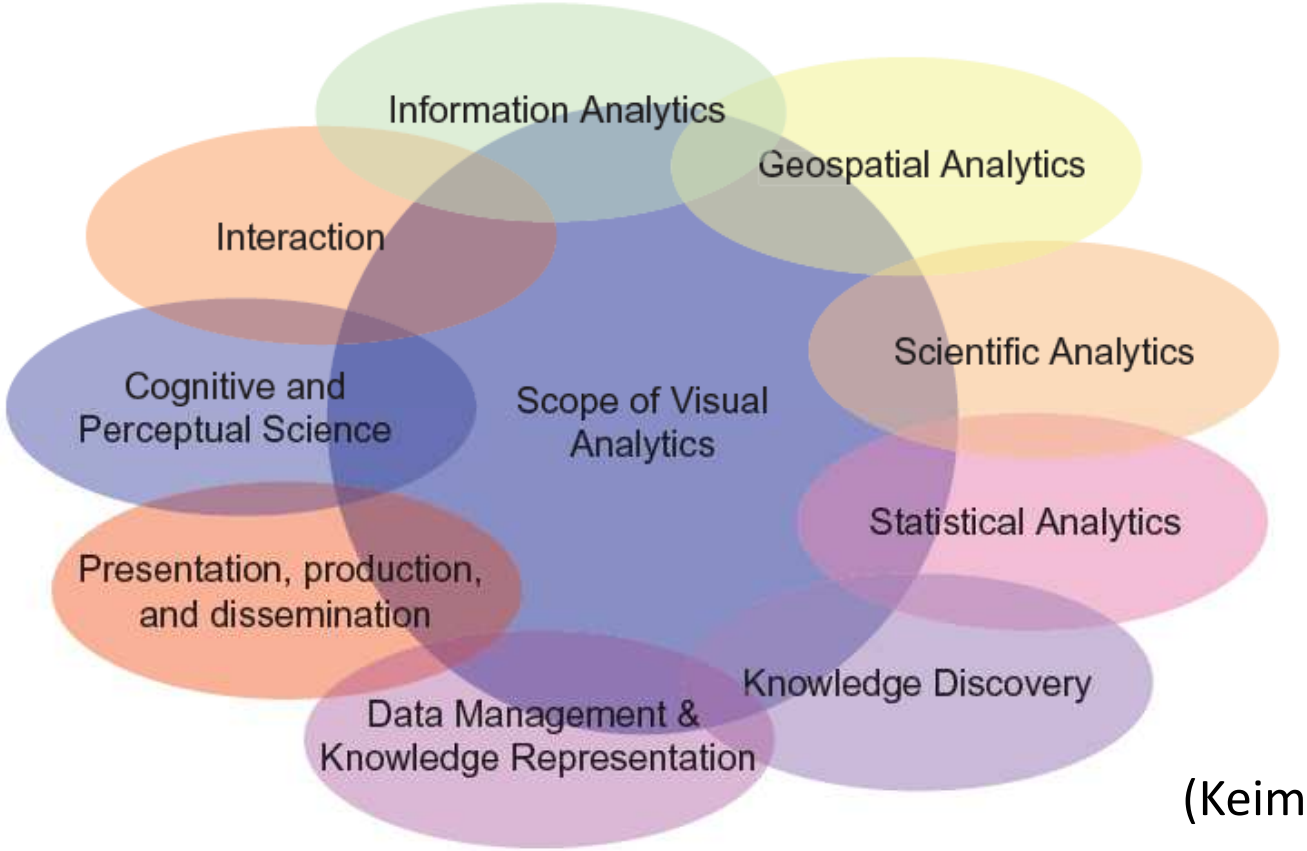
(Thomas & Cook 2005, Stasko 2008)

Backgrounds: Visual Analytics (2/3)

- Multidisciplinary research field



Backgrounds: Visual Analytics (3/3)



(Keim et al. 2006)

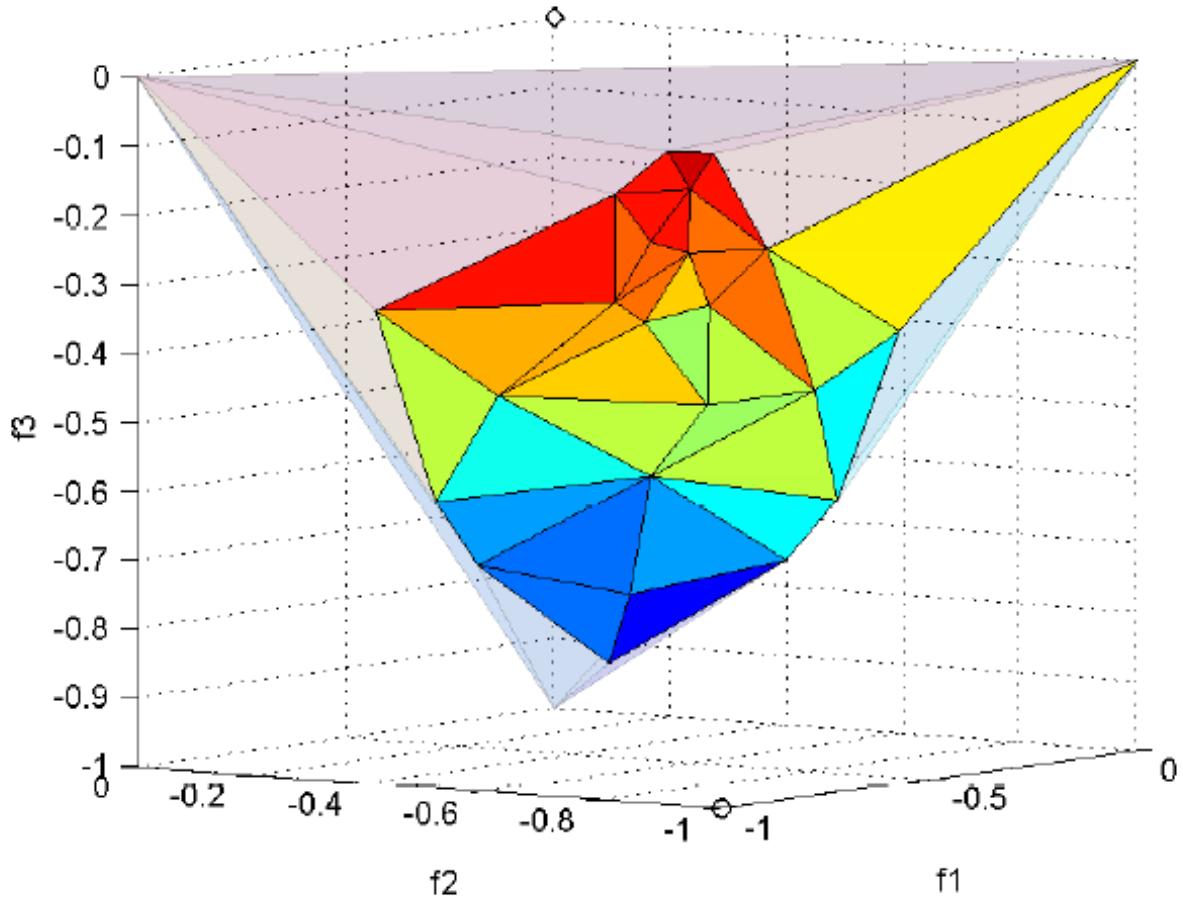
- Further information e.g. http://www.infovis-wiki.net/index.php/Visual_Analytics

Ongoing Software Development Projects

- Implementations of IMO methods for simulation-based, numerical, nonlinear data
- **Nautilus**
  - The main idea in short:
    Solution process is started from the worst possible objective values. The values are improved step by step according to the decision makers preferences.
- **Pareto Navigator**
  - Interactive learning-oriented decision support tool for nonlinear multiobjective optimization
  - For computationally demanding problems

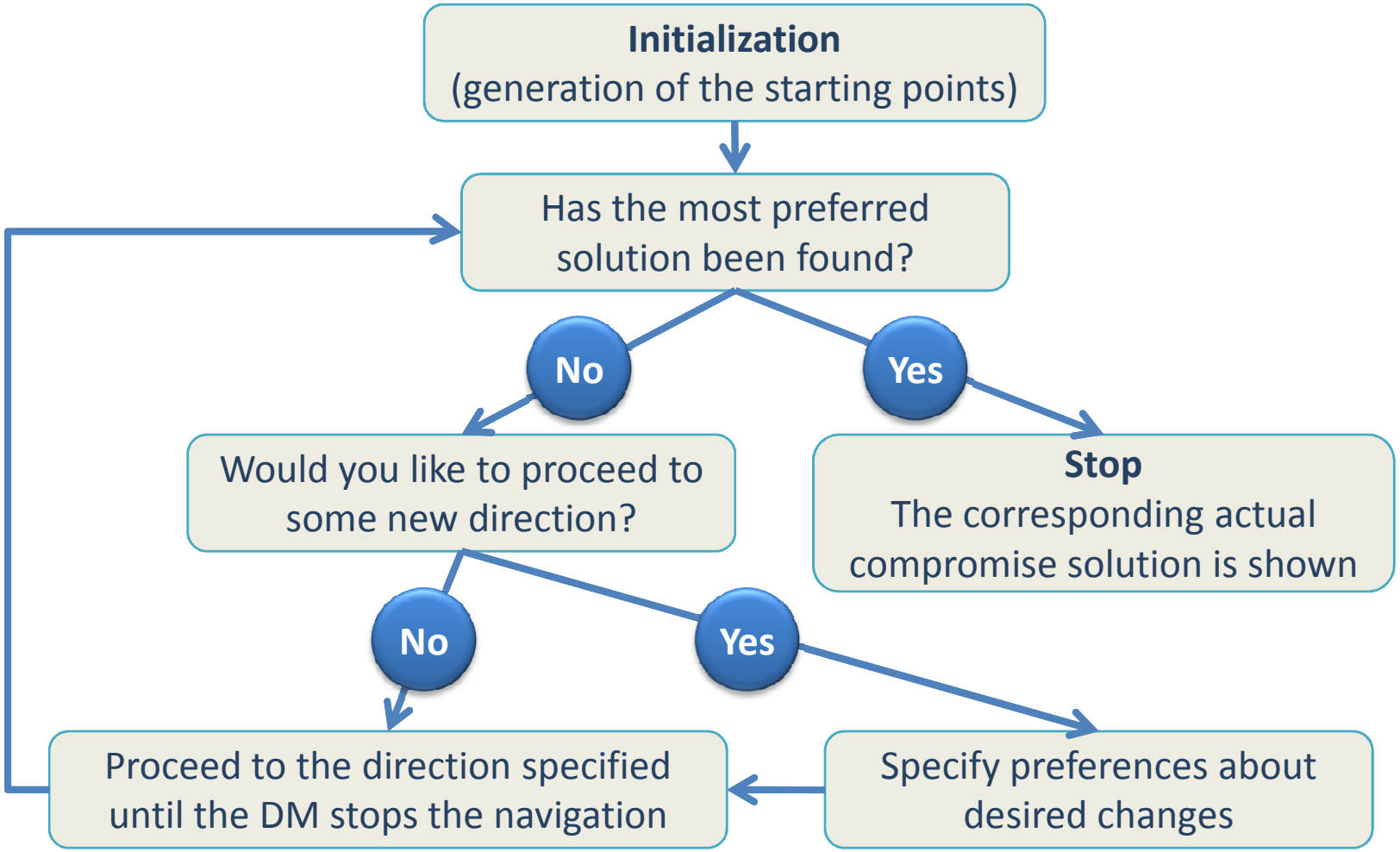
Pareto Navigator: Method (1/2)

- An approximation of Pareto optimal front:



(Eskelinen 2007, Eskelinen et al. To appear)

Pareto Navigator: Method (2/2)



(Eskelinen et al. To appear)

Pareto Navigator: UI sketching process (1/6)

- A need for easy-to-use software implementation

1. How to select the starting point?
2. How to elicit preference information?
3. How to visualize the navigation progress?
4. How to examine the approximated set of compromises?
5. How to ask for real compromise solutions?
6. How to examine real compromises?

Interaction and visualization techniques needed

Pareto Navigator: UI sketching process (2/6)

Sketch	Prototype
Evocative	Didactic
Suggest	Describe
Question	Answer
Propose	Test
Provoke	Resolve
Tentative	Specific
Noncommittal	Depiction

(Greenberg & Buxton 2008)

Pareto Navigator: UI sketching process (3/6)

1. How to select the starting point?

> *"Combining controls with visual representations can speed access, and improve productivity for the combined human, analytical, and data system"*
>
> (Thomas & Cook 2005)

2. How to elicit preference information?

(Figure censored. Available by request at suvi.p.luoma@jyu.fi)

Pareto Navigator: UI sketching process (4/6)

3. How to visualize the navigation progress?

"Comparing something visible with memories of what was seen before is more difficult than comparing things simultaneously visible side by side"

(Munzner 2008)

(Figure censored. Available by request at suvi.p.luoma@jyu.fi)

Pareto Navigator: UI sketching process (5/6)

4. How to examine approximated set of compromises?

Mirel (2004) encourages *"designing rich representations in single, compressed, multipurpose visualizations instead of several singularly focused graphics."*

5. How to ask for real compromise solutions?

(Figure censored. Available by request at suvi.p.luoma@jyu.fi)

Pareto Navigator: UI sketching process (6/6)

6. How to examine real compromises?

Mirel (2004) encourages *"designing rich representations in single, compressed, multipurpose visualizations instead of several singularly focused graphics."*

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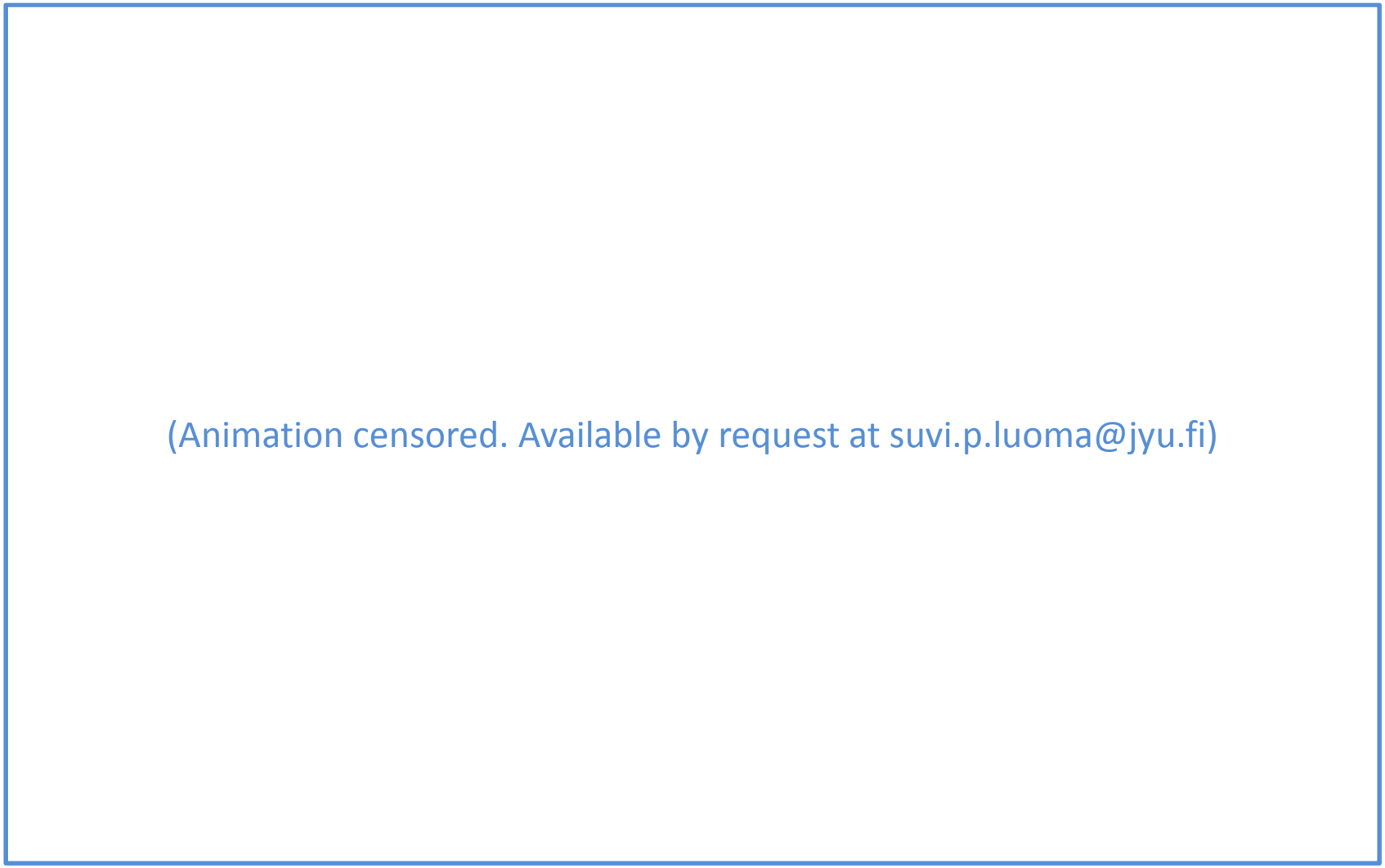
Pareto Navigator:
An Animation Based on the Sketches


(Animation censored. Available by request at suvi.p.luoma@jyu.fi)

Future Work (1/3)

> *"Early sketches are best considered as crude sketches illustrating the essence of the idea, but having many rough and/or undeveloped aspects."*
> *"Usability testing should happen after multiple ideas are generated, critiqued, and considered."*
>
> (Greenberg & Buxton 2008)

→Refining the designs, developing functional prototype(s) for testing

Future Work (2/3)

*"**Usability** of information visualization tools can be measured in a laboratory however, to be convincing, **utility** needs to be demonstrated in a real setting, that is a given application domain and set of users."*

(Plaisant 2004)

*"A primary use of the visualization tool is to **gain insight** into the data. If the participants are unfamiliar with the experimental context of the data used in the study, the data does not mean as much to them" – "…participants are **not self-motivated** to perform data analysis"*

(Saraiya 2006)

It is critical that usability test participants represent the people who will use the system.
"How will we as non-experts even be able to define good tasks unless we work with the domain experts?"
"How do we get the right level of complexity?"
*"How do we set up usability testing with the **time and environment that is realistic**?"*

(Redish 2007)

→Planning and performing tests for usability & utility

Future Work (3/3)

- IMO methods for optimizing simulated data are not suitable in all cases, e.g.
  - no preference information available
  - the DM would rather examine the whole decision space first and at once, then zoom the areas of interest
    - Several techniques for these purposes already exist, see e.g. Visual Analytics Digital Library: http://vadl.cc.gatech.edu/
- Unified user interface adaptable for several methods and for other approaches as well (EMO, statistical methods, etc.) ?
- Wider framework in scope of large-scale industrial environments ?

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Thank you!

- Questions?