

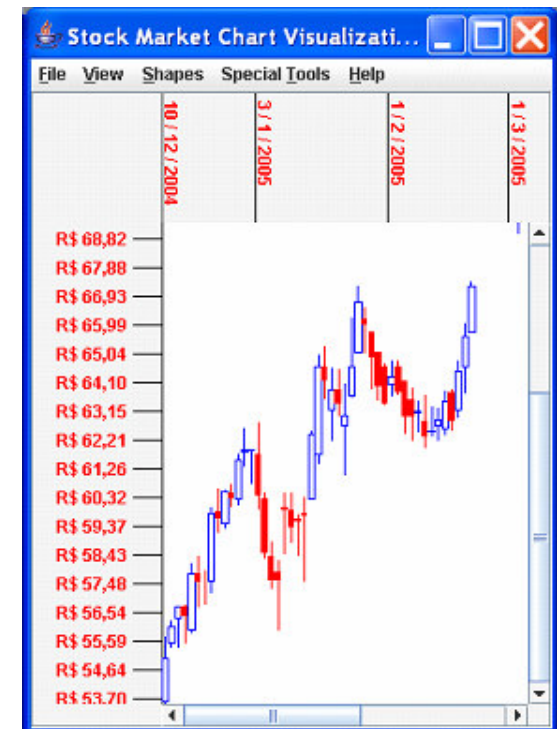
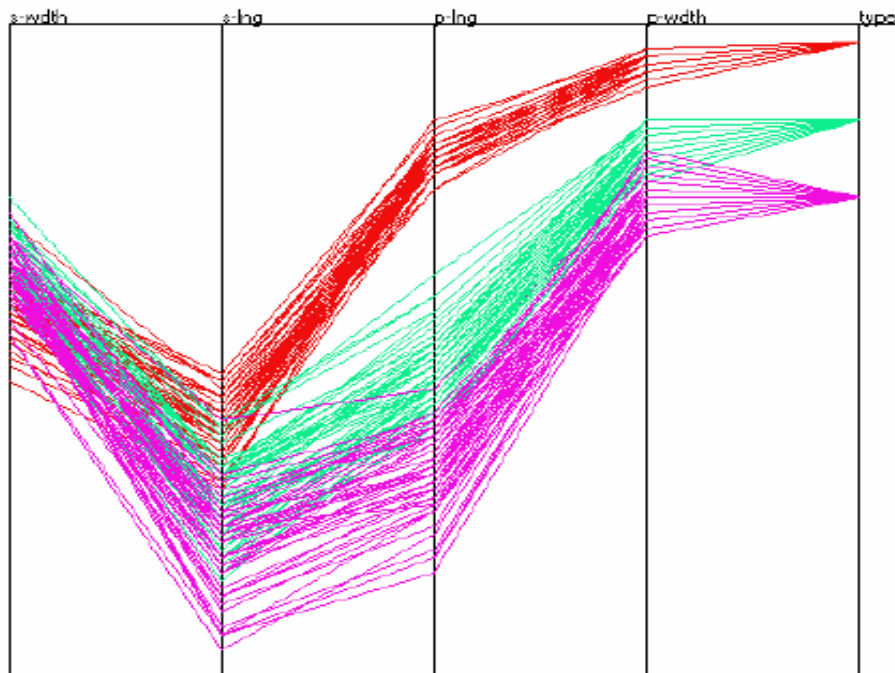


Experimental Evaluation of a Taxonomy of Tasks in Multidimensional Information Visualization

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Interactive visualization of nD data

- Representations of multidimensional data “reduce” working space dimension



- Interaction in 2D/3D replaces nD interaction
 - Cognitive effort
- **Both should support users' tasks**

Evaluating nD visualizations

- Visual representations + interaction techniques
- Users' goals
- Experiments
 - users' tasks
 - which tasks?

Inight Table Lens - [foremost.txt]

	Year	Quarter	Product	Channel	Region	Salesperson	Units	Revenue	Profits
126	1993	2	ForeCode Pro	Direct Sales	Southwest	Kevin Polen	1029	439898	171561
444	1993	4	ForeCode Pro	VAR	West	Tom Tuttle	302	122310	51371
445	1993	4	ForeCode Pro	VAR	West	Ann Thomas	302	122310	51371
446	1993	3	ForeMost S...	Direct Sales	Midwest	Sal Vitatone	301	2.8595e+006	929338
447	1993	3	ForeMost S...	VAR	South	Gary Copper	301	2.709e+006	948150

289 Key: 1992 Col: Profits Median: 30813.00000 Row: 1967, Col: 9



Outline

- Goal
 - Evaluate a taxonomy of user tasks which guides the design of evaluation experiments
- Related work
- Taxonomy of tasks
- Experimental evaluation
 - Three experiments
- Conclusions



Present goal and related work

- Evaluate a taxonomy of users tasks which guides the design of evaluation experiments
- Previous work
 - Wehrend and Lewis, 1990
 - Springmeyer, 1990
 - Shneiderman, 1996
 - Zhou and Feiner, 1998
 - Morse et al., 2000
 - Amar and Stasko, 2004
 - Amar et al., 2005



Related work

- Taxonomy of users tasks to guide the design of evaluation experiments
- Previous work
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Matrix of techniques relating object type with *cognitive operations*



Related work

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Task-by-data type:
7 data types x 7 tasks:
**Overview, zoom,
fliter, details-on-demand,
relate, history and
extract**
(1D, 2D, 3D, temporal,
nD, tree, network)



Related work

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Low-level analytic tasks:
*Retrieve value, filter,
compute derived value,
find extremum, sort,
determine range,
characterize distribution,
find anomalies, cluster,
correlate*



Our taxonomy

- Integrates tasks at different abstractions levels
 - Analytic, (low-level) cognitive and operational
- ***Identify, determine, compare, locate, infer, configure and display***



Our taxonomy

- Identify
- Determine
- Compare
- Infer
- Locate
- Configure
- Display
- *Clusters*
- *Correlations*
- *Categories*
- *Properties/ Characteristics*
- *Patterns*
- *Thresholds*
- *Similarities / Differences*
- *Dependencies*
- *Uncertainties*
- *Variations*



Our taxonomy

- Identify
- Determine
- Compare
- Infer
- Locate
- Configure
- Display
- *Statistical measures*
- *Ranges*
- *Proportions, percentiles*
- *Differences*
- *Correlation coefficients*
- *Probabilities*



Our taxonomy

- Identify
- Determine
- Compare
- Infer
- Locate
- Configure
- Display
- *Dimensions*
- *Items*
- *Data values*
- *Clusters*
- *Properties*
- *Proportions*
- *Position / Location*
- *Distances*
- *Shapes*



Our taxonomy

- Identify
 - Determine
 - Compare
 - **Infer**
 - Locate
 - Configure
 - Display
- *Hypotheses*
 - *Rules*
 - *Trends*
 - *Probabilities*
 - *Cause / Effect*



Our taxonomy

- Identify
 - Determine
 - Compare
 - Infer
 - **Locate**
 - Configure
 - Display
- *Items*
 - *Data values*
 - *Clusters*
 - *Properties*
 - *Positions / Locations*
 - *Distances*
 - *Shapes*



Our taxonomy

- Identify
- Determine
- Compare
- Infer
- Locate
- Configure
- Display
- *Normalization*
- *Classification*
- *Filtering*
- *Zoom*
- *Order of dimensions*
- *Derived attributes*
- *Visual attributes*



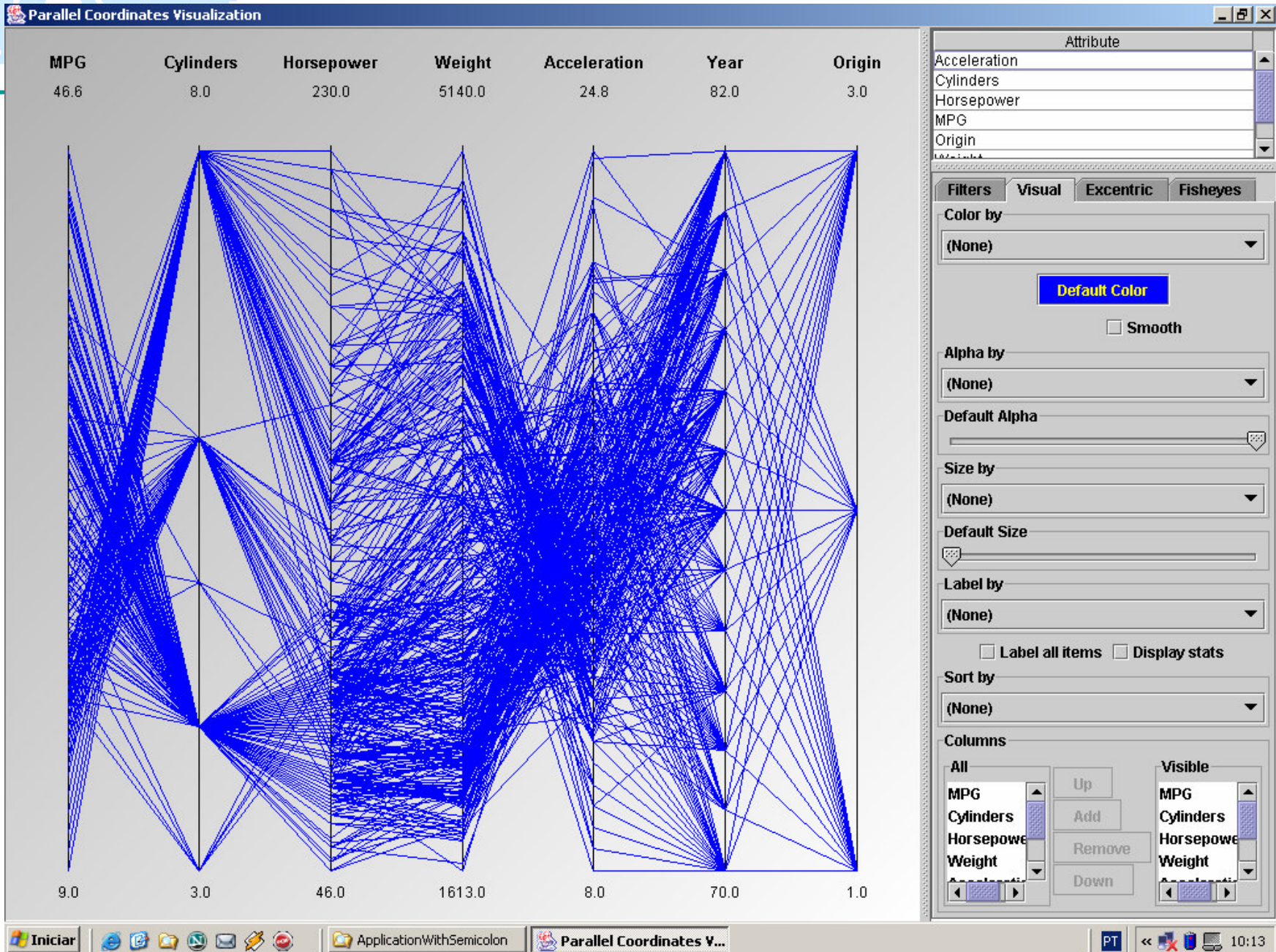
Our taxonomy

- Identify
 - Determine
 - Compare
 - Infer
 - Locate
 - Configure
 - Display
- *Dimensions*
 - *Data items*
 - *Metadata*

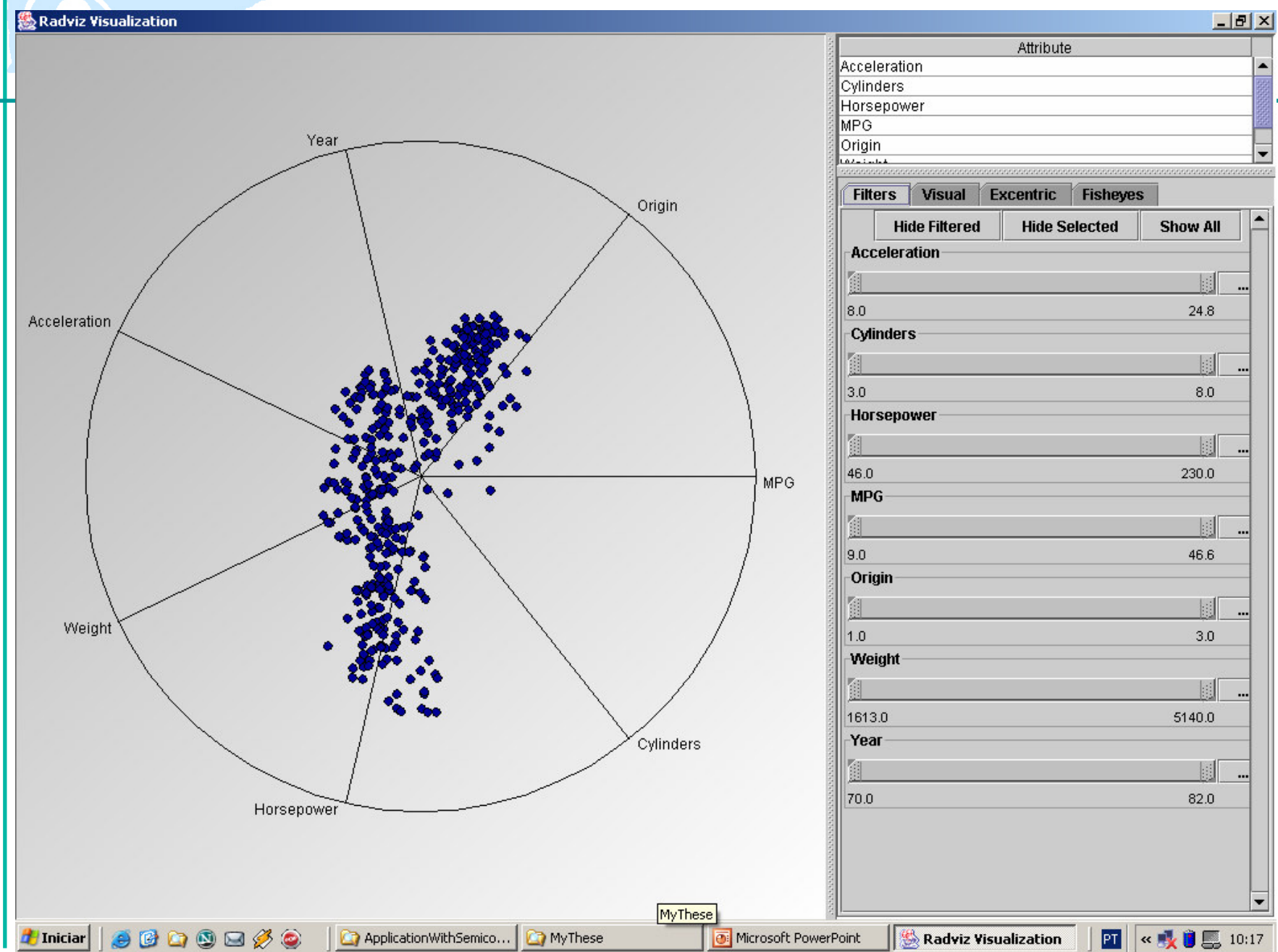


Experimental evaluation

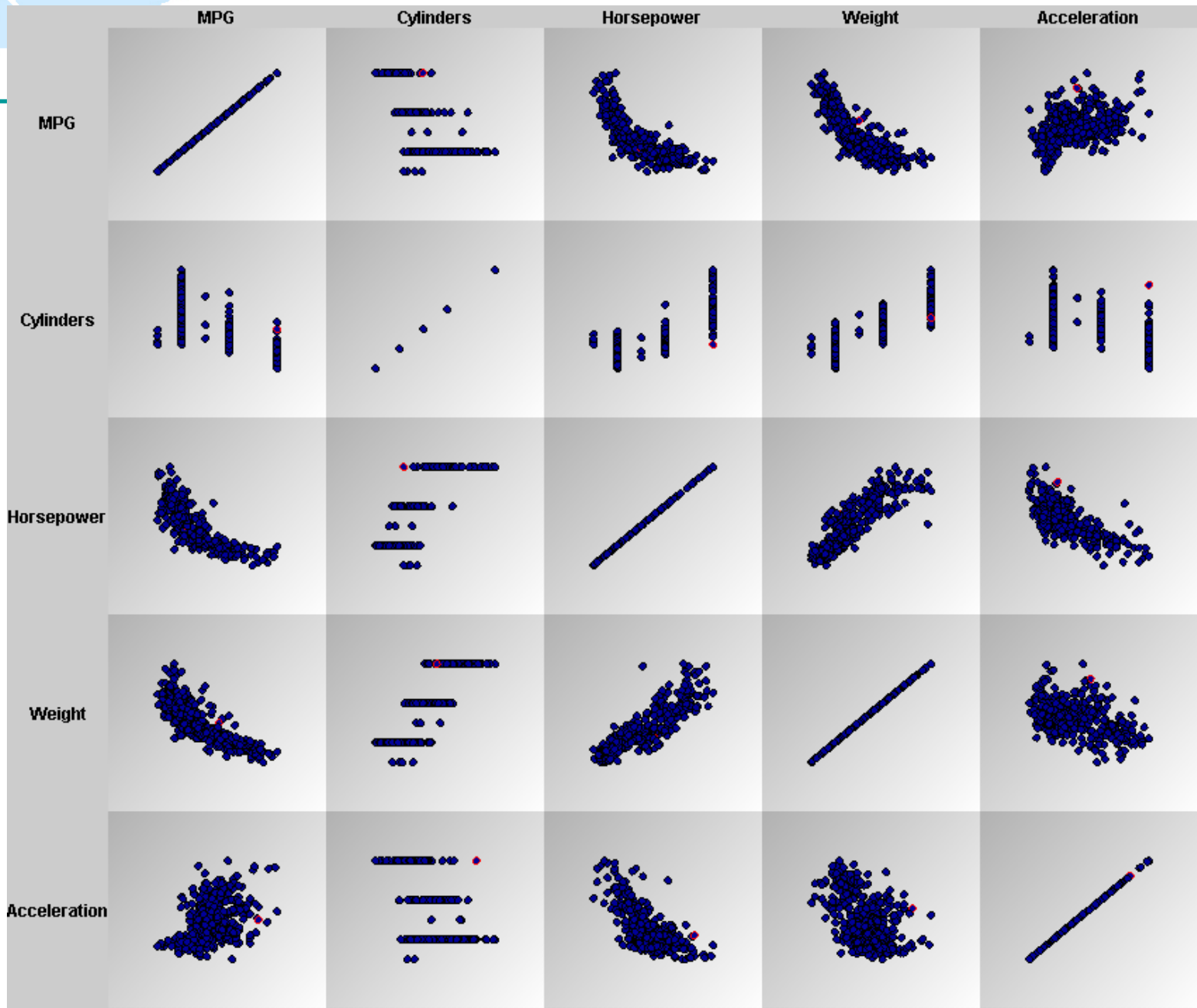
- Experiments with CS students
 - Simple tasks on a known database
 - Comparison of estimated and real scenarios
- Case study with a researcher
 - Data analysis tasks selected by the user
- Case study with biologists
 - Data analysis tasks selected by the users



Pillat and Freitas 2006



Pillat and Freitas 2006



CLINC – RIO de Janeiro, September 2007

Pillat and Freitas 2006



Experiment with CS students

- Simple tasks with the (7D) Cars dataset
 - 4 analytical tasks
- Comparison of recorded scenarios with estimated ones
- Subjects
 - 15 students
- Visualization techniques
 - Parallel Coordinates and RadViz
 - Implemented using Fekete's InfoVis toolkit (Pillat 2006)



Experiment with CS students

- Procedure
 - One hour training
 - Before the experiment:
 - Re-training
 - List of questions
 - Think aloud method
 - Students used techniques in random order, unlimited time
 - One observer
 - Sequence of tasks
 - Usability problems
- 108 scenarios examined, comparing real scenarios to estimated ones



Experiment with CS students

- More frequent tasks
 - Identify: each user performed it around 10 times
 - Configure (9 times)
 - Display (6 times)

- Confirmed results from a previous work
 - All the users performed basically the same real scenarios
 - All tasks were detected
 - Iterative use of subtasks was not estimated, but recorded as part of the real scenarios
 - Some “subtasks” came out (the operational ones)
 - Execution order varied



Case study with a researcher

- Subjects
 - Agronomist analyzing 4 data sets (24 itens x 12 dimensions, 24x14, 4x34, 6x34)
- Technique
 - Parallel Coordinates
 - User did not use RadViz and Scatterplot matrix
- Tasks and scenarios
 - No estimated scenarios
 - No pre-defined tasks other the high-level analysis



Case study with a researcher

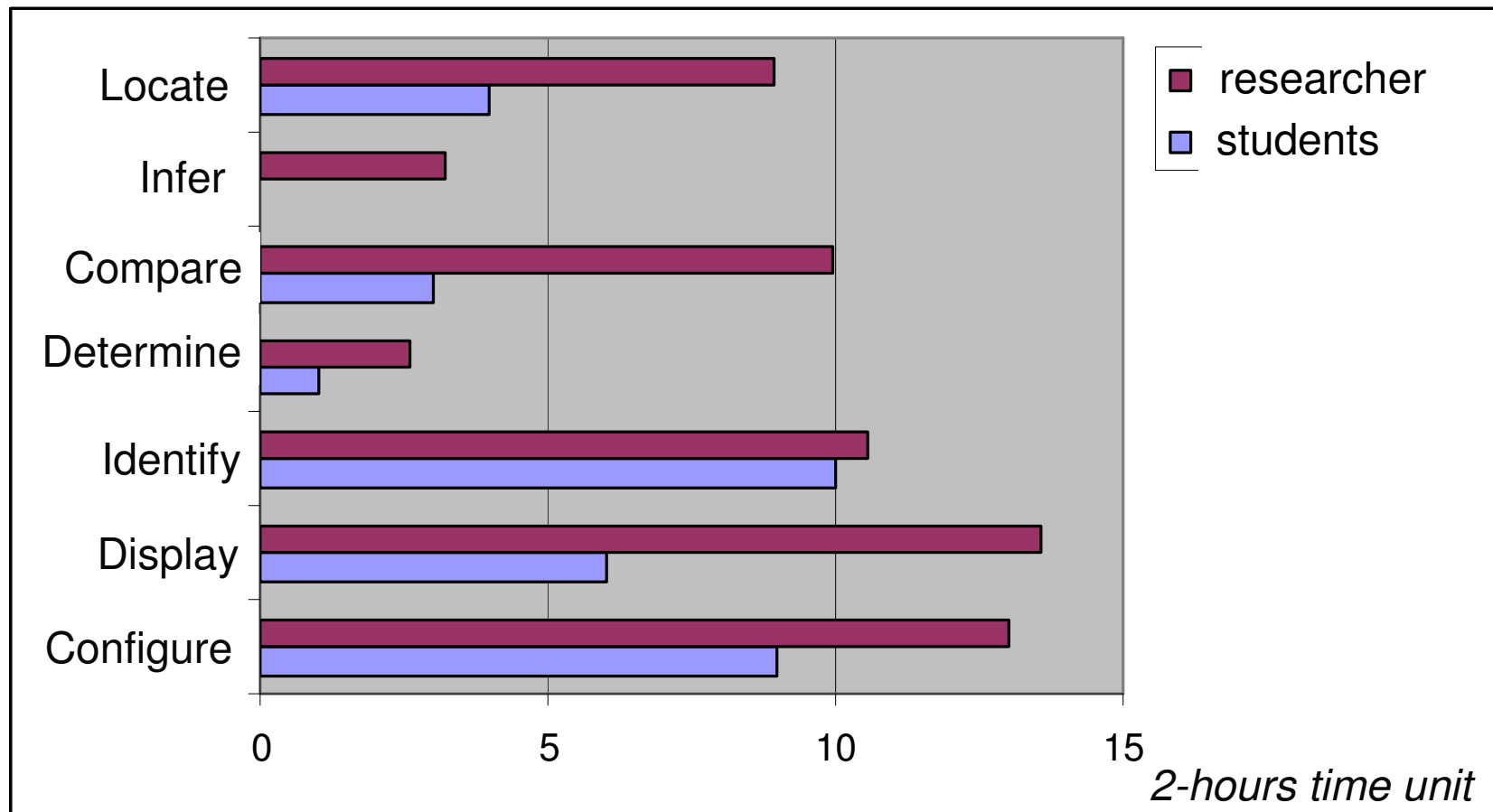
- Procedure
 - Basic training
 - 6 observations
 - ~15 hours
 - Think-aloud method
 - Tasks recorded by the observer
- Results
 - 39 high level analytic questions
 - 19 usability problems
 - No new tasks
 - Occurrences of the same tasks
 - Some of them used as subtasks at a third level



Case study with a researcher

- Display was recorded 105 times
 - Configure: 101 times
 - Identify: 82
 - Compare: 77
 - Locate: 69
- No new tasks detected
 - Display and configure are most frequent
 - Identify and compare come next
 - Locate
 - Then, infer and determine

Comparison





Case study with biologists

- Subjects
 - Two geneticists analyzing their own data set (157 x 20 dimensions)
- Techniques
 - Parallel Coordinates and Scatterplot matrix (Pillat 2006)
 - Users gave up RadViz
- Tasks and scenarios
 - No estimated scenarios
 - No pre-defined task:
 - Just “what can you observe? “Analysis of correlations”



Case study with biologists

- Procedure:
 - Basic training
 - 3 days of free use of the tool
 - Tasks performed and problems detected recorded
 - Users interviewed after the experiment

- Results
 - No new tasks detected
 - Configure
 - Display
 - Identify
 - Locate
 - Compare



Final comments

- About users
 - Real users give more qualified results than students
 - Real users are more difficult to contact and work with
- Usability problems in the visualization system are serious limitation for experiments
- Experiment datasets should have interesting “facts” to allow evaluation
- Taxonomy seems to be wide and deep enough: more testing undergoing within other domains
- Next step
 - Adapt an usability evaluation method like conformity inspection integrating the tasks and specific ergonomic criteria for visualization techniques



Thanks!

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