Using Visual Analytics to Support Defence Investment Planning

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Outline

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  - Decision Support

- Design Requirements
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  - Visualization Tasks

- Visual Investment Plan Optimization and Revision (VIPOR) Interface

- Challenges

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Defence Investment Planning

- **The Problem**: Determine the portfolio of investments that provide the best value for money given resource constraints, including:
  - Financial constraints – available funding limitations
  - Organizational capacity constraints – project implementers have limited capacity to execute projects each year
  - Interdependency constraints – inclusion of some projects in the portfolio requires inclusion of other projects

- **Decision Support**
  - Value model that enables comparison of different projects
  - Mathematical model to construct a project portfolio
  - Interactive information visualizations to characterize projects and portfolios, facilitate reasoning about portfolio construction, and make adjustments

- Latter two elements are encapsulated in a visual analytics software package called VIPOR – Visual Investment Plan Optimization and Revision
Design Requirements – High-Level Domain Tasks

- **Portfolio Construction**
  - Enable the construction of a portfolio of projects that respects resource, organization capacity, and project interdependency constraints over time.

- **Portfolio Characterization**
  - Enable the characterization of a portfolio by its aggregate attributes. In addition, enable the assessment of marginal differences between portfolios.

- **Portfolio Adjustment**
  - Enable the adjustment of a portfolio’s composition in alignment with changing user preferences. In addition, enabling reoptimization of the portfolio based on new and altered user preferences.

High-Level Process
Design Requirements - Visualization Tasks

- Visualization tasks described using the Brehmer and Munzner typology (2013)
  - Why? How? What?
- 7 tasks to perform portfolio characterization
- 2 tasks to perform portfolio adjustment
VIPOR Interface - Portfolio View

- Each disc is a project – size can depict total cost, value, etc.
- Projects are clustered by sponsor (i.e., Air Force, Navy, Army, etc.)
- Projects are assigned keys (i.e., 1, 2, 3, etc.)
- Projects ‘in’ the portfolio
- Projects ‘out’ of the portfolio
- Projects can be moved from ‘in’ to ‘out’, and vice-versa, by dragging and dropping a project
VIPOR Interface – Data View

- High scores are shown in red lines, low scores are shown in blue lines.
- Each line represents a project.
- Project data table, sortable by clicking on each column heading.
- Line colouring is attribute dependent – click on attribute to set focus.
- ‘Brushing’ the parallel coordinates plot provides filtering, and plot linked to the project data table (table shows filtered projects).
VIPOR Interface – Decisions View

Each column (1, 2, etc.) represents a single optimization run.

Each square represents a project with project key shown.

Green squares are projects ‘in’ the portfolio, black squares are projects ‘out’ of the portfolio.

Projects that change colour (black to green, green to black) show the impacts of decision makers changes to the model.

Projects with red outlines are modifications made by decision makers.

Sort projects.
VIPOR Interface - Diagnostics

Optimization Diagnostics

This visualization shows the optimized portfolio's value as a function of run for the given set of weights. Two points are shown for each run: first, the black point shows the theoretical best portfolio value; and second, the red point shows the portfolio value that was found given the time limit. Mouse over each point to see the values. The theoretical best value is found by making the yes/no decision for each project to be a continuous decision; that is, the relaxation allows 0.3, 0.7, etc. of a project can be selected rather than a 0 (no) or 1 (yes). This type of relaxation is called an LP Relaxation. The dashed line is a reference to the maximum portfolio value that can be achieved for the given set of weights.

Return Code: Solution is feasible, but not proven optimal
Gap between LP and Integer solutions = 4.7% 
Percent of total project value = 63.63%

- Black dots are LP relaxations for each run
- Red dots are best integer solution found in time limit
- Maximum potential portfolio value (no constraints)
- Linear Programing (LP) relaxation (e.g., you can buy 0.5 of a project, in value and cost)
- Optimization diagnostics give decision makers confidence that the optimization time limit (e.g., 10 sec) does not significantly impact the quality, from a portfolio viewpoint, of the portfolio generated

Optimizer return code and gap percentage
Challenges with Meeting the Requirements

- **Technology**
  - VIPOR’s implementation uses D3 (visualization), R (statistical computing), GLPK (mathematical programming), and a variety of JavaScript libraries
  - **Challenge**: Integrating these to work together in a seamless way to the user

- **Decision-Making Process**
  - VIPOR supports the Canadian Department of National Defence and Canadian Armed Forces transition from a ranked-list investment planning approach to a portfolio-based approach
  - **Challenge**: Integrating VIPOR into a new decision-making for investment planning

- **Data**
  - VIPOR requires data about projects, constraints, and decision-maker preferences
  - **Challenge**: Data exists in a variety of formats that requires manipulation/integration
Future Directions

- **Visualization Tasks**
  - Expand the task list to include a complete set of project management high-level domain tasks

- **Mathematical Model**
  - Stochastic costs rather than deterministic project costs - Stochastic programming
  - Enhanced constraints – i.e., human resources model for organizational capacity
  - Project/capability matching – i.e., balancing investments by capability needs

- **Information Visualization**
  - Further implemented multiple coordinated views
  - Additional visualizations to enable a user to adjust project attributes (e.g. cost profile)
  - Additional visualizations to present the interdependencies between projects