Exploring Stakeholder Value Models via Interactive Visualization

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Motivation

Perceived needs (mission objectives)
Motivation

Eliciting needs and mapping value to those needs is a challenging process:

- Unknowns, lack of clarity and trust in interviews and statements, and other factors inhibit adequate capturing of the value space
  - Demonstrated by the large amount of requirements change in modern systems (Lane & Boehm 2007)
  - Multiple value constructs are used to address this problem (e.g., requirements statements, utility functions, net present value)
Motivation

Eliciting needs and mapping value to those needs is a challenging process:

...leading to any or all of the following in the early design phases:
- failure to adequately represent the needs/value space
- stakeholder decisions hedged against value models perceived as probably “incorrect” or incomplete
- unjustifiably confident decisions based on inadequate representation of needs/value space
Hypothesis

Visual Interaction + Constructed Value Models → Better Decision Outcomes
Overview

Agenda

– Our context: Systems Design
– Our framework for:
  • Increasing Trust in Constructed Value Models
  • Increasing Truthfulness of Constructed Value Models
– Case Example
Overview

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Also related (but beyond today’s scope):
– Visual Analytics of Scientific Data
– Visualization Techniques
Our Context: Systems Design

The Design-Performance-Value Loop

Perceived needs (mission objectives)
Systems Design: 2 Purposes of Models

The Design-Performance-Value Loop

Perceived needs (mission objectives)
The Design-Performance-Value Loop

Perceived needs (mission objectives)

REALITY

VALUES

“Two things fill the mind with ever-increasing wonder...
the starry heavens above me and the moral law within me.”

– Immanuel Kant, Critique of Practical Reason (1788)
The Design-Performance-Value Loop

Consolidative Model
- Gather facts
- Analyze behavior

(Pielke Jr, 2003)

Exploratory Model
- Question assumptions
- Examine consequences
**Model Purpose**

- **Performance models**
  - Approximate reality
- **Value models**
  - Approximate values
Systems Design Models: Meta-dimensions

- **Model Purpose**
  - Performance models
    - Approximate reality
  - Value models
    - Approximate values

- **Model Type**
  - Mental models
    - “Represents entities and persons, events and processes, and the operations of complex systems”, and reside in the mind (P.N. Johnson-Laird)
  - Constructed models
    - Formalization of (one or more) mental model(s), and it can reside on paper, in a physical model, computer simulation, etc.
Systems Design Models: Coupled Three-Body Problems
Systems Design Models: Knowledge vs. Decision Making

Knowledge Assessment

Consolidative Model
- How big will B9 be?
- How fast will he move?

Decision Making

Exploratory Model
- How to measure “clean”?
- How much do I care?
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Constructed Performance Models: Objective Validation

“A model should be developed for a specific purpose (or application) and its validity determined with respect to that purpose.”
- Sargent (1998)

Classic model **validation**: Reduce $\Delta_3^p$ for a specific purpose

Reference of reality is objective, albeit changing (e.g., geopolitical shifts, technology advancement)
Constructed Value Models: How to Validate?
Baruch Fischhoff discusses a spectrum of philosophies:

Articulated Values

- Values are self-evident
- Common among economists and surveys
- Examples:
  - Demand curves
  - Value of life (Viscusi)

Partial Perspectives

- Some values are self-evident, but many aren’t
- People don’t have answers to all questions, but they also don’t need to start from scratch every time.

Basic Values

- Values aren’t well-differentiated for most evaluation questions
- People must derive valuations from some basic values through an inferential process
- MAU (Keeney and Raiffa)
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**Basic Values**
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**PROBLEM**: since values are not directly observable, $\Delta_3^{V*}$ is also unobservable.

If $\Delta_3^{V*}$ is unobservable, we cannot validate constructed model w.r.t. values.
Value Models

- The concept of **trust** is inversely related to the magnitude of $\Delta_2^V$
- The concept of **truthfulness** is inversely related to the magnitude of $\Delta_1^V$

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<tr>
<th>Constructed Model (trust)</th>
<th>Mental Model (truthfulness)</th>
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*Flanagan 2012 contains an alternative formulation of this matrix

Simply assuming that a constructed model of values (e.g., requirements, utilities) is **valid**:  
\[ \rightarrow \text{High risk of Type I error} \]

“…to design the wrong value system is to design the wrong system.” (Hall, p. 110).
**Goal: Correct Trust**

→ reduction of both \( \Delta_2^V \) and \( \Delta_1^V \)

- Several methods exist for **reducing \( \Delta_1^V \)** (reducing cognitive biases):
  - Allow Decision Makers (DMs) to *simulate a decision*, noting regrets.
  - Allow DMs to *consider the ramifications of their expressed values* (i.e. mental model) for many different situations and outcomes (e.g., MATE).
  - Directly *discuss and uncover biases* that skew a person’s understanding of his/her actual values (e.g., anchoring, availability).
  - **Introduce new attributes** to DMs, noting any change in preferences.
### Framework Ideas: Increasing Trust

**Goal: Correct Trust**

→ reduction of both $\Delta_2^V$ and $\Delta_1^V$

- Several methods exist for **reducing** $\Delta_2^V$ (i.e., increasing truth and credibility):
  - **Rigorous interview process** for the construction of utility functions, which reduce framing and other biases that may be present in standard requirements-as-value-statements
  - **Comparison of ranked list** of alternatives from stakeholder with a ranked list produced by a constructed value model
  - **Comparison of two or more** constructed value models’ ranked lists

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Hypothesis: Interactive Visualization for $\Delta$ Reductions

Steps in Interactive Visualization:

1. **displaying a constructed value model** alongside its outcomes (e.g., ranked list of design alternatives)
2. **allowing real-time modifications** to the constructed model (simulating different sets of preferences, introduction of new attributes)
3. **providing instant feedback** on the newly changed constructed model, as well as providing comparison of the new results with previous results

Value models $\rightarrow$ SAU and MAU functions
Hypothesis: Interactive Visualization for $\Delta$ Reductions

Each of these steps allows a DM to explore:

- **simulate** making a decision
- **observe** mental model of values **propagating** throughout the design space
- **discover biased regions** of their mental model
- **compare expectations** of preferred designs with the model’s prediction

**Hypothesis:**

*Interactive visualization of constructed value models can facilitate the reduction of $\Delta_2^V$ and $\Delta_1^V$ through an iterative process, enabling better decisions.*
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Interactive Visualization: Case Example

System:
“Space Tug” Satellite
Simplified to 2 attributes:
  Speed and Delta V

Stakeholder:
Involved in creation of the constructed performance and value models for system

Interactive Visualization Step 1:
Allow stakeholder to interact with the intitial tradespace, encouraging exploration of the ramifications of stated preferences on all designs
System:
“Space Tug” Satellite
Simplified to 2 attributes:
   Speed and Delta V

Step 1:
Allow stakeholder to interact with initial tradespace

Interactive Visualization Step 2:
Allow stakeholder to compare expectations of preferred designs with constructed value model’s output.
Display constructed value models alongside their outcomes.
System:
“Space Tug” Satellite
Simplified to 2 attributes:
Speed and Delta V

Step 1:
Allow stakeholder to interact with initial tradespace

Step 2:
Compare expectations with outputs
Display constructed value models

Interactive Visualization Step 3:
Identify misrepresented portions of the value model
Allow stakeholder to change constructed models (i.e., increase truthfulness)
Instantly update the outcomes on the tradespace
System:
“Space Tug” Satellite
Simplified to 2 attributes:
   Speed and Delta V

Step 1:
Allow stakeholder to interact with initial tradespace

Step 2:
Compare expectations with outputs
Display constructed value models

Step 3:
**Build truthfulness**
Instantly update the outcomes

Final Step:
Allow stakeholder to explore the tradespace (return to Step 1), **building trust.**
Interactive Visualization: Hypothesis Revisited

Visual Interaction + Constructed Value Models → Trusted, Truthful Outcomes
Exploring Stakeholder Value Models: Summary/Conclusion

- The System Design Loop:
  - Performance Models (for Reality)
  - Value Models (for Values)
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- Value Models
  - Fall somewhere on Fischhoff’s spectrum
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  - Basic Values and the 3-Body Problem
Exploring Stakeholder Value Models: Summary/Conclusion

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- Value Models
  - Fall somewhere on Fischoff’s spectrum
  - Basic Values and the 3-Body Problem

- Interactive visualization can help
  - Enables trajectory of delta reductions
  - Leading to trusted, truthful decisions
Exploring Stakeholder Value Models through Interactive Visualization

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References

Keeney RL, Raiffa H. *Decisions with multiple objectives: preference and value tradeoffs*. Published by John Wiley & Sons, Inc., Ch. 2, (1976)
WHO CAN DEFINE "VALUES"? ANYONE?

VALUES ARE A TYPE OF EMOTIONAL ILLUSION COMMON TO CHILDREN, IDIOTS AND NON-ENGINEERS.

CAN WE PRETEND VALUES ARE REAL? ARE WE A CULT NOW?
Backup Slides

Slides included in Backup are not intended to be coherent outside of the original presentation. They are included here only for reference, and only to be used/read at the sole discretion of the viewer.
Artificial Data in the Design Loop

- **Model Purpose**
  - **Performance models**
    - Approximate* reality
  - **Value models**
    - Approximate* values

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*When designing systems of the future, the data used is *artificial*…and that means that there must remain some significant departures from reality.

"Artificiality connotes **perceptual similarity** but **essential difference.**"

- Herbert Simon

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“Trust” related to “Perception”: Regardless of the amount of “essential difference”, it is the “perceived similarity” to reality that leads to model **credibility** (i.e., trust).
Values (Mis)diagnosis

A basic values philosophy is assumed hereafter, as the risk of misdiagnosis is less severe for large-scale systems.

Table 1
Risk of Misdiagnosis

<table>
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<th>Articulated values</th>
<th>Partial perspectives</th>
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<td>Articulated values</td>
<td>—</td>
<td>Get incomplete values</td>
<td>Get meaningless values</td>
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<td></td>
<td></td>
<td>Inadvertently impose perspective</td>
<td>Impose single perspective</td>
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<td>Promote new perspectives</td>
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<td>Distact from sharpening</td>
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<td>Exaggerate resolvability</td>
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<td>Basic values</td>
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Note. Above diagonal: misplaced precision, undue confidence in results, missed opportunity to help. Below diagonal: needless complication, neglect of basic methodology, induced confusion.

Knowledge Assessment

Simon’s “essential difference”
Knowledge Assessment

• Once perceived similarity of the constructed model and reality is enough: Mental model can update from constructed: $\Delta^P_2$ is reduced.

• Leads to reduction of $\Delta^P_1$, the **goal of constructing a model**
Decision Making

- Two kinds of mental models:
  - Fast, automatic, emotional and subconscious (System I)
  - Slow, effortful, logical and conscious (System II)

- Kahneman
Decision Making

For complex decisions:

- **Multiple objectives**, a **variety of decision criteria**, **multitude of alternatives**
- The decision maker can use a **constructed model** of values (e.g. AHP, Pugh, Utility, requirements, etc), constructed with the help of “System II” mental model (Kahneman)
- Constructed model extends decision makers’ **bounded valuation**
Barriers to Delta Reductions

Knowledge assessment delta reductions:
- $\Delta_3^P = \text{lack of }$ experience or existence of appropriate abstractions (e.g., modelling fluid dynamics prior to calculus)
- $\Delta_2^P = \text{lack of }$ trust in the constructed model.
- $\Delta_1^P = \text{bounded rationality}$ of to grasp complex systems.

Decision making delta reductions:
- $\Delta_1^V = \text{cognitive biases}$ (e.g. anchoring, availability), as well as bounded valuation
- $\Delta_2^V = \text{explanation-related biases}$ (e.g., elicit utility functions through interviews); biases present in value model choosing.
- $\Delta_3^V = \text{function of } \Delta_2^V \text{ and } \Delta_1^V$
**Delta Reduction Trajectory**

Iterative process of delta reductions traces a clockwise trajectory

1. If the model is not accurate, *(proper) mistrust* of the models ensues.
2. The model is then changed incrementally to build *truthfulness* (reduce $\Delta_1^V$).
3. The model is confirmed to be a “good” representation of mental model, building *trust*.

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