Model-Centric Decision Making:
Insights from an Expert Interview Study

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Why is Human-Model Interactivity Important to the Future of Model-Centric Engineering?

Addressing complex systems problems requires human intelligence and use of models

Models are useful for generating data and analytics that can be used in human decision making

Human cognitive limits drive necessity of using models and computational resources

Models can "automatically" perform certain human functions but humans provide context: under which conditions is the model appropriate and useful?

While progress has been made on model-based engineering

… there has been relatively little investigation of the complexities of **human-model interaction**

Interview-Based Study
model-centric decision making

- *MIT and DoD IRB Approved*
- *Investigators: German and Rhodes (PI)*

Exploratory study to gain insight into how various types of decision makers interact with and perceive models (2016 - 2017)

Motivated by increasing need for individuals and teams to **make decisions using models** and model-generated information

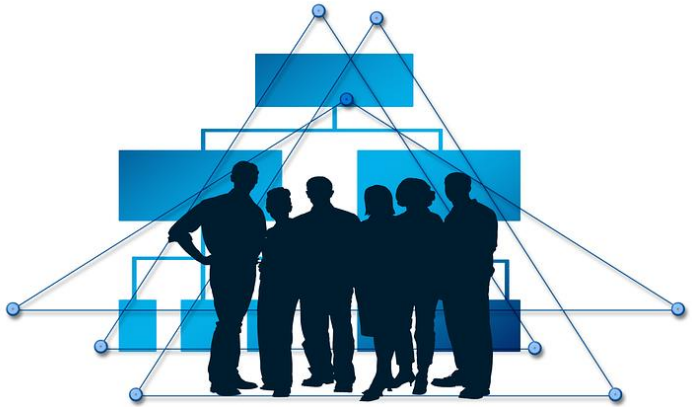
While anecdotal stories of success and failure exist, **empirical studies are needed to truly understand** the many facets of human decision-making in model-centric engineering

Resulted in insights regarding **how decision makers build trust in models and to what degree models are used to make decisions** that may inform current/future practice, and areas for more extensive study

German, E.S. and Rhodes, D.H., "Model-centric decision-making: exploring decision-maker trust and perception of models" 15th Conference on Systems Engineering Research, 2017

Study findings (unordered)

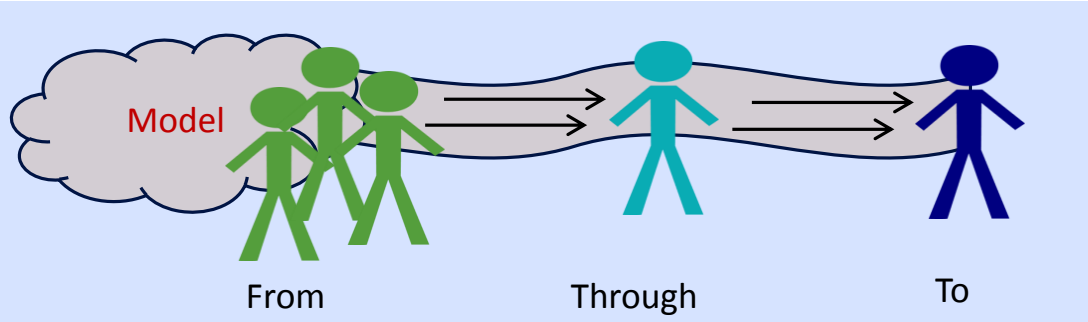
Three actor decision flow
Importance of intercommunication
Understanding of assumptions and uncertainty
Technological and social factors influencing trust
Importance of model-related documentation
Need for model pedigree
Using models as primary versus supplementary
Non-advocate role in reviews
Transparency and trust
Model investment bias and confirmation bias
Factors limiting model-centric decisions
Real-time interaction with models
Viewing humans as endogenous



30 recognized experts

Study Finding

Three actor decision flow



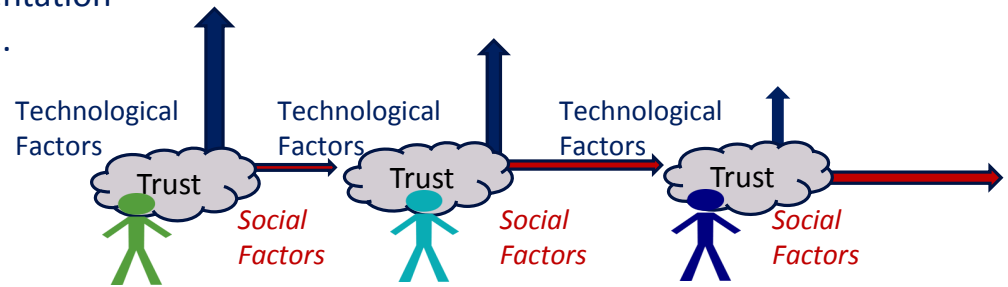
The data suggests that as actors move further along the flow of information and have less time and ability to personally investigate a model and build their own trust in the model, their trust instead shifts more onto their people to investigate the model for them.

… the trust for ultimate decision-maker is “implicitly on the models, but explicitly on the people.”

Study Finding

Technological and social factors influencing trust

Model code
Referent data
Uncertainty
Documentation
….



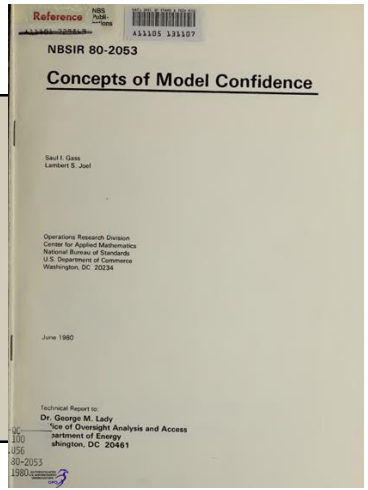
Personal relationships
Experience level
Originator of model
Expert opinions
….

Study Finding

Model pedigree

The models generated by various actors and used in various decision-making situations are vast, and this generation and use of models produces information that may influence decision-maker trust in using these models in other situations

7. Model Demographics--an abstract and description of the model antecedents and developmental process, originators and developers, past users, cost, and current developmental activities. This information should enable the decision maker to determine the model's status with respect to past achievements, theoretical and methodological state-of-the-art, and the expert advice that went into its development.



Study Finding

Model transparency

Varied opinions on how much transparency others need/want

Everyone cares about transparency
…but personally may not need to
"see the code", rely on others to do that

I like to be able to get way down in my code…to see the algorithms doing the calculation.

I never look at the lowest levels…I have associates working on that.

If I have somebody who I trust, as I know their expertise, background … I will trust their model

Study Finding

Factors limiting effective model-centric decisions

MODEL	HUMAN		
Data availability	Talent of people	Time and money	Educated leadership
Data quality	Inertia to change	Team agreement	Lack of desire to understand
Model complexity	Communication barriers	Skill level	Bad past experiences
Inadequate methods	Changing preferences of decision-makers	Ability to socialize models	Generational differences
Lack of transparency and documentation	Unwillingness to share models or information	Lack of trust/fear of the unknown	Organizational differences
Interactivity with models		Lack of understanding	

Study Finding

Viewing humans as endogenous

Understanding the behavior of a model-centric enterprise requires viewing human actors as endogenous constituents

- Models influence decision maker behavior
- Human interaction with models influences how models are conceived and used

Endogenous point of view (J. Forrester)

Formulating a model of a system should start with the question "Where is the boundary, that encompasses the smallest number of components, within which the dynamic behavior under study is generated?" (G.P. Richardson , 2011)

Six categories
Human-model interaction heuristics

1. **designing models for human use**
2. **using models in decision-making**
3. sociotechnical considerations
4. **context and assumptions**
5. transparency and trust
6. **mitigating biases**

Heuristics encapsulate insights and strategies discovered by experts though experience

Experts apply these intuitively

Heuristics can be used to educate and guide practice of novices, as they learn through their own experiences

Validated heuristics inform the development of policy and practices

Selected Heuristic

Designing models for human use

Humans should not be forced to adapt to models, rather, models should be designed for humans

Evolving technology enables more complex and capable models but may not result in increased effectiveness if humans are not appropriately considered

Humans have cognitive and perceptual limitations that limit amount and types of information they can effectively comprehend and use to make decisions

Designing for humans requires understanding their capabilities and limitations so that the model intelligence can extend the overall system intelligence

Selected Heuristic

Using models in decision making

Models do not have agency -- the ultimate responsibility for decisions must be upon humans

Ultimate decision-making authorities are people, and blame cannot be placed upon models for poor decisions

Model developers, users, and decision-makers have the responsibility to ensure that models are properly understood and appropriately used

Individuals should be aware of the potential for improperly diffusing responsibilities for decisions upon models

Policies should clearly establish the responsibilities for which individuals are held accountable in model-centric enterprises

Selected Heuristic

Context and assumptions

Models are created for specific reasons and contexts, and those assumptions fundamentally bound a model's applicability

A model may be insightful and valuable within one problem context, but the assumptions built into the model may not be valid within some other context

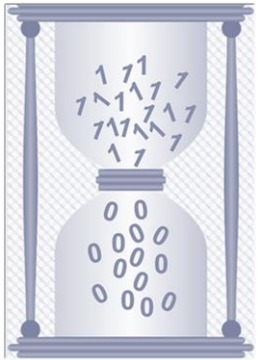
Evaluating a model's applicability should not just consider whether it has been validated, but in what contexts it has been validated

Using a model outside of its inherent bounds may lead to model results that are inappropriate for the problem under consideration

Selected Heuristic

Mitigating biases

Increasing speed of decision-making implies a decrease in time spent analyzing a problem that in turn increases chance of biased judgment



Model-centric environments enable interaction to build intuition and speed decision-making, but may increase bias

Complex problems may require focused time and attention to fully understand and develop an accurate mental model of the situation

While faster decisions are desired if effective, speed itself may set people up for failure by encouraging them to rely upon fast and intuitive, yet bias-susceptible, judgment… rather than more cognitively demanding rational and analytical thought processes

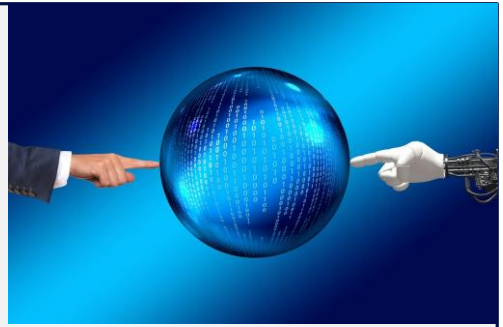
Implications for practice and research

Empirical data (vs anecdotal evidence) on human-model interaction “state of practice” (based on 30 expert interviews)

Heuristics encapsulate human-model interaction strategies for use in education, training and practice guidelines

Confirms need for further investigation ….

- Capture patterns of why, when and how various stakeholders interact with models
- Understand most effective means for interaction
- Determine where human interaction is preferred over augmented intelligence
- Inform model-centric enterprise transformation and new leadership roles



Questions?

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