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# Designing for Uncertainty in HCI: When Does Uncertainty Help?

**Miriam Greis**

University of Stuttgart  
Pfaffenwaldring 5a,  
70569 Stuttgart, Germany  
miriam.greis@vis.uni-  
stuttgart.de

**Michael Correll**

University of Washington  
PO Box 352350 Seattle, WA,  
USA 98195-2350  
mcorrell@cs.washington.edu

**Orit Shaer**

Wellesley College  
106 Central st. Wellesley, MA,  
USA 02481  
oshaer@wellesley.edu

**Jessica Hullman**

University of Washington  
PO Box 352840 Seattle, WA,  
USA 98195-234  
jhullman@uw.edu

**Matthew Kay**

University of Michigan  
105 S. State St. Ann Arbor, MI,  
USA 48109-1285  
mjskay@umich.edu

**Abstract**

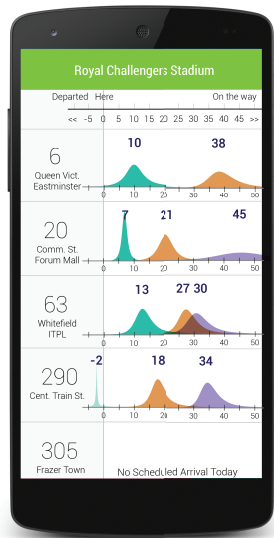
End-users are often exposed to uncertain data in interactive systems such as personal health apps, intelligent navigation systems, and systems driven by machine learning. On one hand, communicating uncertainty may improve the understanding of data and predictions. On the other hand, communicating uncertainty can greatly confuse users and decrease trust. While some specialized guidelines for dealing with uncertainty exist within particular fields such as information visualization or context-aware computing, HCI lacks general design guidelines around the more basic question of “will communicating uncertainty rather help or confuse my users?” The goal of this workshop is to bring together researchers and practitioners from across HCI and related fields to establish a better understanding of when and how to design for uncertainty. The outcome of the workshop will be a set of real-world application scenarios with descriptions of the impact of presenting uncertainty in that scenario. Additionally, we will create a set of design guidelines that supports designers and researchers in this emerging space in evaluating whether and how to present uncertainty.

**Author Keywords**

Uncertainty; Data Modeling & Analysis; Design; Multidisciplinary

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**Figure 1:** Distributions of predicted bus arrival times in a mobile transit application [13].

## ACM Classification Keywords

H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

## Background

People are often exposed to predictions in everyday life, for example, when checking the weather forecast or planning a trip through heavy traffic. These predictions inherently involve uncertainty. Current research in ubiquitous computing and human-computer interaction (HCI) has provided new sources of uncertainty, e.g. by developing devices for counting steps to track exercise [3], more intelligent mapping and navigation systems [15], and interaction techniques driven by machine learning [21].

Throughout disciplines such as natural sciences, psychology, HCI, information visualization, and meteorology [8, 11, 20], it is generally agreed that presenting uncertainty in an interface or visualization can increase trust and help people make better decisions. While evidence from some applications indicates that not including uncertainty information can decrease trust in the application [12, 14], uncertainty can also overwhelm and confuse users. For example, when quick decisions are needed from an application, such as determining when to leave for the airport based on reported traffic, uncertainty can increase the cognitive load on the user without clear benefits. In other situations, displaying uncertainty has been found to decrease people's perceptions of the appropriateness of a prediction [15]. Designing for uncertainty therefore requires a balance between presenting the full picture of the information, and managing the complexity of uncertain data.

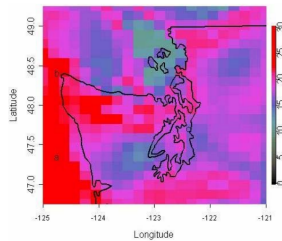
Current applications rarely communicate the uncertainty in the data, despite its ubiquity and its utility for supporting decision-making. One reason for failing to communi-

cate uncertainty is that only specialized guidelines on how to present uncertainty in specific contexts exist [15, 16]. Few cross-cutting and general design guidelines exist to help designers tackle more basic questions such as: Will presenting uncertainty rather help or confuse my users? The lack of clear guidelines around when to show uncertainty is problematic given the complexity of the reactions that uncertainty may entail. The goal of our workshop is to aid designers who may be hesitant to consider presenting uncertainty due to its complexity. As more and more applications rely on and present data that is subject to uncertainty, it is important to develop 1) clear examples of scenarios where uncertainty is modeled and presented to end-users in HCI, along with the impacts that presenting uncertainty had on usage and satisfaction, and 2) guidelines for when to communicate uncertainty, and how to do so without confusing.

In discussing and formulating example scenarios and guidelines for uncertainty in HCI, this workshop will extend existing taxonomies communicating uncertainty (e.g., [16, 19, 22, 23]). Although these taxonomies provide rich descriptions of sources of uncertainty and visual presentation techniques, they typically overlook a basic question about designing for uncertainty: Does presenting uncertainty help in a given interactive application scenario? A second goal is to address the question of how uncertainty can be presented in the most direct and least confusing way for end-users of applications. Cognitive biases in how humans reason about uncertain data [24] can constrain designers that seek to present uncertainty without misleading users – “de-biasing” users often requires novel and occasionally counterintuitive designs [4, 9, 10, 17].

### Workshop Aims

This workshop aims to bring together researchers and practitioners from diverse subdomains in HCI and topic-



**Figure 2:** Display of the margin of error in predicted wind speeds [18].



**Figure 3:** Display of estimated range of electric car, with uncertainty [12].

related fields to develop application scenarios and design guidelines of how to design for and with uncertainty in HCI. We expect our participants to be researchers and practitioners working with uncertainty in diverse fields such as visualization (e.g., [4, 9]), psychology (e.g., [11]), simulation (e.g., [2]), personal informatics (e.g., [14]), healthcare (e.g., [7]), big data analytics (e.g., [5, 6]), and end-user machine learning (e.g., [1]). Informed by prior research across domains, we take a broad view of uncertainty, encompassing myriad related phenomena (e.g., error, variance, evolving interpretation of the data, etc.).

Specifically, our goals are:

- Provide a forum for researchers and practitioners to share their experiences around the challenges and impacts of presenting uncertain data in applications spanning HCI subdomains (personal informatics, big data analytics, health and wellbeing, machine learning, etc.) and topic-related domains (e.g., visualization, simulation). This workshop will provide a platform for knowledge transfer and an exchange of methods currently used.
- Identify common challenges that researchers and practitioners experience when deciding whether to expose uncertainty in interactive systems.
- Develop a set of cross-cutting application scenarios that involve uncertainty presentation and its impacts.
- Identify design considerations and guidelines building a framework for designers that help answer common questions related to uncertainty, including:
  - When should we show uncertainty, if at all?
  - How should we model, frame, and present the uncertainty so as not to confuse?

- How should we evaluate the impact of showing uncertainty on satisfaction or use?

The guidelines will be grounded on the application scenarios collected and identified by participants.

- Develop a research agenda that highlights research questions related to presenting uncertainty that span subfields of HCI, and identify gaps in our understanding to develop a more complete understanding of how to evaluate design decisions about when to communicate uncertainty. The set of example scenarios produced by the workshop will ground these contributions, resulting in a guide for researchers and practitioners interested in the topic.

## Organizers

The five workshop organizers bring diverse backgrounds and knowledge in different subfields of HCI to the discussion of uncertainty.

**Miriam Greis** is a Ph.D. candidate and a member of the HCI group at the University of Stuttgart. Her research mainly concentrates on how to communicate uncertain data (e.g., health and weather data) to laymen in everyday life and the handling of uncertain input in interactive systems. She is also part of the interdisciplinary research cluster Simulation Technology, where she works together with sociologists, engineers, and mathematicians who represent diverse views on the topic of uncertainty.

**Jessica Hullman** is an Assistant Professor in Information and adjunct Assistant Professor in Computer Science & Engineering at University of Washington. Her research aims to develop techniques and tools that make inherent, yet difficult, aspects of data more understandable to non-analysts, often using information visualization. She has worked on

topics including automated generation of visualizations to support news understanding, on-demand analogies to make unfamiliar measurements more understandable, and depiction of uncertainty as a finite set of data samples rather than a more conventional model representation (e.g., confidence interval). Jessica Hullman is the main contact person for this workshop.

**Michael Correll** is a postdoctoral Research Associate at the Interactive Data Lab, Computer Science & Engineering Department at the University of Washington. His research focus is on the interplay between statistics and information visualization as sources of knowledge, as well as the rhetoric of visualization. He has conducted numerous crowdsourced experimental studies to examine how the general audience perceives uncertainty in visualizations, and has deployed uncertainty-aware visualization tools for collaborators in fields from genomics to the humanities.

**Matthew Kay** is an Assistant Professor in the School of Information at the University of Michigan. His research centers on usable statistics and communicating uncertainty in everyday predictive systems. He has studied the expectations people have for data accuracy in personal informatics applications including sleep and weight tracking, and designed and tested novel ways of communicating uncertainty in predictive systems such as real-time bus arrival. He has also developed methods for assessing users' desired trade-offs in types of errors in predictive systems, allowing for machine learning systems to be tuned to users' expectations.

**Orit Shaer** is an associate professor of Computer Science and Media Arts and Sciences at Wellesley College. Her research focuses on the application of tangible and embodied interaction to scientific discovery, collaborative learning, and health informatics. She is a primary investigator on NSF funded projects, which explore the role of HCI in personal

genomics and in synthetic biology. She has developed and evaluated interactive tools that visualize uncertainty in domains including genomics, bio-design, and strategic planning.

### Website

We will build a workshop website for advertising, communicating with potential attendees, and sharing position papers of accepted participants. We have already created the website on [http://visualization.ischool.uw.edu/hci\\_uncertainty](http://visualization.ischool.uw.edu/hci_uncertainty). As soon as the position papers are accepted, they will be made available on the website. Upon completion of the workshop, we will transition the website to capture a report about the outcome of the workshop and to collect resources for designing for uncertainty. This will allow the website to serve as a more permanent base of knowledge about uncertainty in HCI and related fields and offer possibilities for networking.

### Pre-Workshop Plans

Our team is well-suited to recruit workshop participants across diverse fields that deal with uncertainty, including simulation, medical risk communication, personal informatics, ubiquitous computing, interactive systems, machine learning, big data analytics, and information visualization. We will distribute the CFP through leading HCI mailing lists (e.g., SIGCHI Announcements, British HCI, infovis.org, etc.) and our personal networks that span far beyond the HCI community. Participants will be encouraged to ground their position papers in specific application examples to facilitate the transfer of knowledge across subfields. Before the workshop, we will make all position papers available on the workshop website and encourage participants to read the position papers of participants associated to the same panel discussion. We will also invite participants to share links to videos, pictures, or project pages in order to share

best practices, designs, and lessons learned with other participants via e-mail. Participants will also be asked to propose topics for group discussions in the afternoon sessions by sending a challenge, research question, or a design provocation to the workshop organizers that occurred to them when designing for uncertainty.

### Workshop Structure

We plan a one-day workshop consisting of two parts. For the morning session, we invited Susan Joslyn, a psychologist who studies questions related to adding uncertainty to weather and other climate-based reports, as a keynote speaker. Afterwards, we will conduct a series of panel discussions grouping attendees into panels of 3-5 participants each based on the topics of their proposals. Participants will introduce themselves with a presentations of at most 3 minutes in length about their position paper. After each panel, we plan up to 15 minutes for discussion. During the panel discussions, we will provide post-its and markers that allow attendees to write down key points of the discussion for further use in the afternoon activity. We will steer the discussions towards common challenges and experiences that cut across subfields.

The afternoon session will include activities in small groups - developing a set of application scenarios, a design framework and a research agenda about designing for uncertainty in HCI. Participants will form smaller discussion groups, each focusing on one specific application scenario, answering the following questions:

- Should we show uncertainty in this application scenario?
- How can we model, frame, and present the uncertainty so as not to confuse?

- How can we evaluate the impact of showing uncertainty?

Further challenges and research questions will be added from attendees' position papers and from topics identified during the morning panel discussions.

### *Schedule*

The proposed workshop schedule is outlined in Table 1. We plan to accept up to 15 submissions and therefore have 3 panel sessions with up to 5 participants in each panel session. In the Wrap-Up of the Morning Session, we will select the discussion topics for the afternoon based on the suggestions in this proposal and participants' suggestions.

### *Resources*

Resources required include a projector, preferably in a room with tables that can accommodate small groups discussions. In addition, the workshop organizers will provide post-it notes, and craft supplies for supporting the discussion and group activity.

### Post-Workshop Plans

As a follow-up of the workshop, we plan to reorganize the workshop website to provide an overview in the form of an outline of subtopics related to uncertainty in HCI. This outline will offer interested researchers and practitioners an easy point of access to the topic and ability to gain familiarity even before the workshop date by curating details and references from different disciplines. The outcome of the workshop, which will be a set of example scenarios, design framework and a research agenda, will not only be outlined on the website, but also summarized for a report in the ACM Interactions Magazine. To make it easier to connect and share experiences with other people dealing with uncertainty in HCI, we will maintain an e-mail list that allows to

9.00 - 9.05	Welcome and Introduction
9.05 - 9.30	Keynote
9.30 - 10.00	Thematic Group A Talks (approx. 5 x 3 mins) + Discussion
10.00 - 10.30	Thematic Group B Talks (approx. 5 x 3 mins) + Discussion
10.30 - 11.00	Coffee Break
11.00 - 11.30	Thematic Group C Talks (approx. 5 x 3 mins) + Discussion
11.30 - 12.00	Wrap-Up of Morning Session/ Preparation for Afternoon Session
12.00 - 13.30	Lunch
13.30 - 14.00	Introduction and Group Forming
14.00 - 15.00	Group Activity - Application Scenarios
15.00 - 15.30	Coffee Break
15.30 - 15.50	Discussion on Group Activity
15.50 - 16.50	Group Activity - Design Guidelines
16.50 - 17.15	Report Back from Discussion Groups
17.15 - 17.30	Conclusions + Wrap-Up
20.00 (approx.)	Workshop Dinner

**Table 1:** Proposed Workshop Schedule

network and follow-up on the developed research agenda.

### Call for Participation

Across its many subfields (e.g., personal informatics, information visualization, machine learning, big data analytics), HCI increasingly deals with uncertainty. The goal of this workshop is to address common challenges that occur in designing for uncertainty across HCI-related domains, such as when and how to communicate uncertainty to users without confusing them. The workshop will include a keynote and panel and group discussions, with the goal of developing a set of application scenarios demonstrating

successful and unsuccessful examples of presenting uncertainty, and resulting design guidelines. Attendees from all backgrounds dealing with uncertainty (inside and outside of HCI) are invited to submit 2-4 page position papers in extended abstract format explaining their interest in uncertainty and the challenges that they experience. Participants are encouraged to ground their positions in real application scenarios. Suggested contribution types include, but are not limited to:

- Critical reflections about the choice of when to present or support interaction with uncertain data
- Implementation, development, and evaluation of systems which communicate uncertainty
- Design recommendations for interfaces handling uncertain data
- Future scenarios for designing for uncertainty

Papers should be sent to [designingforuncertainty@gmail.com](mailto:designingforuncertainty@gmail.com) before January 20th and will be reviewed by two organizers of the workshop on how well they fit to the topic, describe concrete scenarios, and contribute to the overall discussion. An early acceptance round will be completed by December 21st. Up to 15 papers will be accepted. At least one author of each accepted position paper must attend the workshop. All attendees must register for the workshop and at least one day of the CHI conference. More details are on the workshop website: [http://visualization.ischool.uw.edu/hci\\_uncertainty](http://visualization.ischool.uw.edu/hci_uncertainty).

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