

Charting Scenarios: A Framework for Uncertainty Visualization in Data Journalism Practice

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ABSTRACT

Like other fields, data journalism faces the fundamental challenge of conveying uncertainty to the audience. However, unlike scientific communication, data journalism must engage a broad audience with highly variable levels of prior topic-related, statistical, and methodological knowledge. To structure examples and develop better strategies for visualizing uncertainty it is useful to distinguish different types of uncertainty that commonly arise in journalistic contexts. For this purpose we propose a framework that identifies seven key scenarios: *Spatial*, *Sampling*, *Forecast*, *Classification*, *Definite Ranges*, *Missing Data*, and *Reconstructed Past*. Each scenario highlights a distinct situation where uncertainty plays a crucial role—whether in mapping environmental risks, interpreting election polls, projecting future outcomes, or reconstructing data about historical events. By systematically examining these uncertainty scenarios, this work seeks to better support data journalists in dealing with uncertainty, encourage transparent reporting and promote critical engagement with data-driven narratives.

Index Terms: Uncertainty Visualization, Data Journalism, Data-driven Storytelling.

1 UNCERTAINTY IN DATA JOURNALISM

Although visualizing uncertainty is considered valuable, it poses significant challenges for practitioners in “calculating, visualizing, and explaining uncertainty to viewers” [2]. Although many of these are not unique to data journalism, the field also faces distinct challenges of its own: editorial workflows in the fast-paced daily news environment may leave limited room to accommodate the additional effort required to visualize uncertainty. In addition, empirical work shows that uncertainty communication, especially in imprecise or verbal forms, can reduce trust, increase confusion, or discourage engagement, all of which are central concerns in journalistic work [5]. This research focuses on a content-centered, not data-centered perspective by observing the scenarios in which uncertainty is already being visualized by data journalists. We propose a conceptual framework that is supposed to enable systematic exchange with data professionals working within journalistic contexts: how is uncertainty currently communicated in practice and in which contexts does it appear to play a relevant role? An exploratory approach, combined with a first evaluation with practitioners, allows us to approach this question. We see this work as a first step toward closer collaboration between academic research and hands-on data journalism.

2 REVIEW OF UNCERTAINTY VISUALIZATIONS IN DATA-DRIVEN JOURNALISM

To address this challenge, we created an overview of published data visualizations that communicate uncertainty in various visual

ways. We compiled a database of examples from online data journalism through a systematic review. Visualizations from 17 different media outlets were selected based on reputation and relevance in (data) journalistic discourses. The scope was limited to German (e.g., *SPIEGEL*) and English (e.g., *The New York Times*) media outlets and only articles published online were included in the review. However, this meant that only media outlets with a dedicated and up-to-date data visualization section or article classification system (e.g., for data journalism or graphics) could be included. Pay-walled content was only partially included due to access limitations. Overall, visualizations from about 900 articles published from January 1, 2024, to April 25, 2025, were examined. A visualization was considered to represent uncertainty if it explicitly depicts visual elements that communicate ambiguity or variability in the data or the topic-related context (e.g., confidence intervals, shaded ranges, blurred areas, dashed lines). Since this process was exploratory and conducted by a single researcher without a formal coding protocol, some degree of bias cannot be ruled out. A total of 75 uncertainty visualizations were identified, documented, and categorized by characteristics such as chart type or description of the represented uncertainty. The graphical representation of uncertainty was then assessed using the systematization of the uncertainty cube proposed by Kinkeldey et al. [3]. All visualizations were categorized along the three dimensions *Dynamic vs. Static* (does the visualization contain animation or interactive elements to represent uncertainty or not?), *Coincident vs. Adjacent* (is uncertainty integrated into the main visualization of the data, or shown in a separate display?) and *Extrinsic vs. Intrinsic* (is uncertainty represented through additional visual elements, or through modifications of existing elements?).

3 DISCUSSION OF FRAMEWORK WITH DATA JOURNALISTS

Based on the analysis and categorization of the collected visualizations, we inductively derived *uncertainty scenarios* that describe journalistic contexts in which uncertainty visualizations were practically applied. These scenarios emerged by identifying thematic and visual patterns and grouping visualizations according to the type, source, and visual strategy of the presented uncertainty. In contrast to existing similar taxonomies that are arranged around data types and visualization techniques [1, 4], we focused on the role of uncertainty visualization when defining the scenarios. We evaluated the scenarios by discussing them during a workshop with eleven journalists from various data teams from German-speaking newsrooms. The participants were asked to bring examples of visualizations from their own work in which they had addressed uncertainty. In group work, these visualizations were then assigned to the predefined scenarios. The discussion showed that a single visualization often involved multiple scenarios. Furthermore, the journalists tended to approach the topic from a strongly data-centered perspective—statistical and model-related uncertainties were frequently mentioned. This suggests that data teams, as an interface between statistical-methodological and content-driven work, place greater emphasis on these technical aspects in their day-to-day practice. In response to these insights, the scenarios were revised to place greater emphasis on content-centered perspectives, and the definitions were refined with application-oriented examples from

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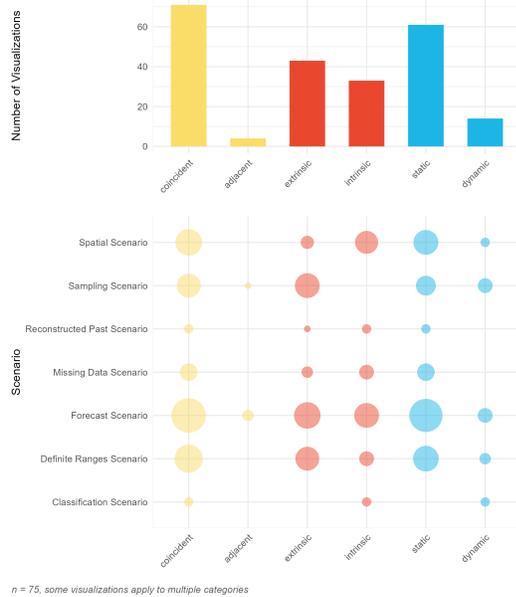


Figure 1: Framework for uncertainty visualizations in data journalism. We identified seven scenarios for their application purpose, with Forecast being the most common. Most visualizations employ coincident and static visualization approaches, regardless of the scenario.

the audience’s point of view. For instance, the previously labeled *Polling* scenario was expanded to include all types of sampling. Feedback from the journalists also indicated that the framework is especially useful as a conceptual tool in the planning phase of visualization work, rather than as a taxonomy for classifying existing visualizations. This supports the notion that a systematic approach is essential to foster a broader awareness of uncertainty within data journalism practice.

4 FRAMEWORK OF UNCERTAINTY VISUALIZATION SCENARIOS IN DATA JOURNALISM PRACTICE

As described, the identified uncertainty visualizations were sorted and grouped based on thematic similarities and the underlying sources of uncertainty and later refined collaboratively with data journalists. The result is a set of typical scenarios in which data journalists communicate uncertainty to the public. The categories are not strictly exclusive; some visualizations fall into more than one category. The resulting classification highlights the diversity of approaches and contextual functions of uncertainty visualization in journalism. Below are the identified categories, listed in descending order of frequency:

1. Forecast - Showing that statements rely on assumptions about an unknown future; uncertainty about future outcomes, based on predictions from models that depend on assumptions and input data. (30 visualizations)

2. Definite Ranges - Estimating the expected reality within a range of possible outcomes; uncertainty introduced when different assumptions, parameter settings, or external conditions change results. (18 visualizations)

3. Spatial - Estimating indeterminate locations, areas, etc.; uncertainty related to geographic data, such as incomplete measurements, interpolation errors, or fuzzy boundaries. (16 visualizations)

4. Sampling - Assessing the results of a sample group and possible differences from reality; uncertainty arising from surveys and polls, including sampling error, response bias, or methodological flaws. (14 visualizations)

5. Missing Data - Assessing the limitations of a statement because certain information is not available; uncertainty caused by absent, incomplete, or selectively reported data, which impacts analysis and interpretation. (7 visualizations)

6. Reconstructed Past - Showing that results cannot be compared because they rely on different historical assumptions; uncertainty involved in reconstructing historical events or states based on incomplete or biased data sources. (2 visualizations)

7. Classification - Estimating the possible border cases of a chosen group; uncertainty in assigning data into discrete categories, including misclassifications by models or ambiguous cases. (2 visualizations)

In addition to developing content-oriented scenarios, we also categorized the examples by their strategy of visually communicating uncertainty following Kinkeldey et al. [3], as presented in Figure 1. In total, there is a notable imbalance in the distribution of visualizations across the scenarios. We also observed that existing uncertainty visualizations mainly focus on static coincident approaches. This suggests a preference for seamless integration of uncertainty into the main visualization. It raises the questions of why dynamic or adjacent approaches are rarely implemented in practice, and why data journalists seem to prioritize the visualization of uncertainty more frequently in certain scenarios.

5 CONCLUSION

In this work, we proposed a framework for systematizing uncertainty visualization scenarios in the realm of data journalism. It is supposed to summarize the current use of uncertainty visualization and inspire new forms of data-driven journalism practices. The findings show that it seems to be more common to visualize uncertainty in specific scenarios while in general only a small minority of visualizations include any visual representation of uncertainty. Depending on the area of application, these categories should be critically examined and adapted. They are intended to serve as a working foundation for ongoing research and to support data journalism through a structured framework. In keeping with the nature of uncertainty research itself, the categories remain inherently uncertain. Rather than offering a definitive classification, they are meant to stimulate discussion and critical engagement. Researchers are encouraged to use this overview to systematically identify gaps and develop new approaches to visualizing uncertainty. Understanding the reasons behind these gaps and exploring their implications remains an important task for future research.

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