How Do HCI Researchers Describe Their Software Tools? Insights From a Synopsis Survey of Tools for Multimodal Interaction

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Providing tools to support design and engineering of interactive computing systems has been encouraged in the HCI community. However, little is known about the practices adopted by HCI researchers to describe their software tools in academic publications. To address this aspect, we implemented a simplified literature survey procedure combining principles of population sampling and systematic literature reviews to enable rapid access to insights from a vast body of published academic work. Our findings show that screenshots and diagrams are among the most widely used descriptive elements by HCI researchers to present their software tools, a finding that we capitalize on to reflect about the dissemination of tools for the design and engineering of multimodal interaction at the intersection of software engineering and HCI.

CCS Concepts: • **Human-centered computing → Systems and tools for interaction design**; **Human computer interaction (HCI)**.

Additional Key Words and Phrases: Multimodal interaction, tools, platforms, literature survey.

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1 INTRODUCTION

Tools are important in the HCI research and practice to support design and implementation of user interface software [23], rapid prototyping of interactive systems [4], encourage creativity [26], inform design options [32,35], analyze user input [34], manage user-elicited data [18], and support research to understand users [1,36] with evaluations, studies, and experiments [33]. Consequently, "tool contributions," as a specific type of an artifact contribution in HCI research [37], are particularly welcomed at HCI venues. For example, tools are explicitly encouraged by several subcommittees of CHI, e.g., the User Experience and Usability subcommittee "is suitable for papers that extend the knowledge, practices, methods, components, and *tools* that make technology more useful, usable, and desirable," while the Design subcommittee of CHI specifies that "papers submitted here include [...] evaluation of new design *tools*, processes, methods, or principles,

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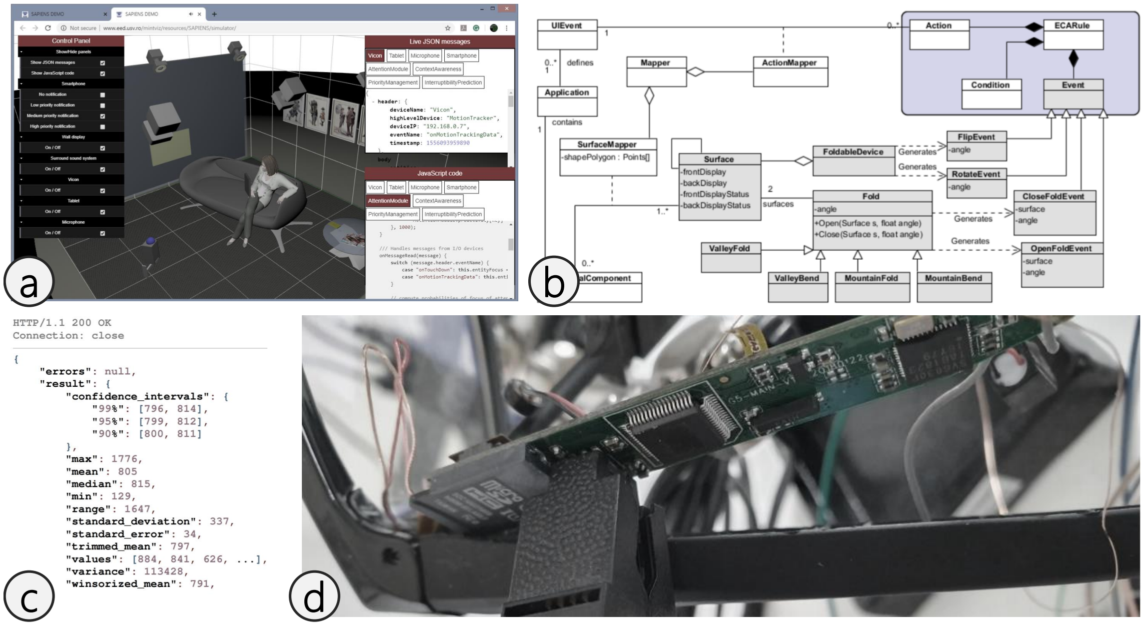

Fig. 1. Documenting software tools with screenshots, diagrams, code, and photographs: (a) screenshot of SAPIENS [28], a software architecture for peripheral interaction, from EICS '19; (b) UML class diagram of Flecto [14], a rapid prototyping tool for foldable UIs, from ISS '20; (c) API response of KeyTime [16], a web-based tool for estimating gesture production time, from CHI '18; and (d) photographs from using a C++ software library to test attacks on smartglasses [24], from IMWUT 2020.

including those that explore alternatives to scientistic ways of knowing"[1] (emphasis ours). Similarly, other HCI venues encourage tools, including "engineering design and evaluation *tools*" at EICS,[2] "multimodal platforms" at ICMI,[3] "*tools* for evaluating interactive systems" at INTERACT,[4] and "new methodologies and *tools*" at IMWUT[5] (emphasis ours); see Figure 1 for examples extracted from papers published in these subcommunities of HCI.

In this context, where tools are both needed and encouraged, it is useful to understand how HCI researchers describe their tool contributions when disseminating their results in order to document and understand this practice in our community. To this end, we perform a characterization of the ways in which HCI researchers describe their software tools in academic publications, and report results of a case study in multimodal interaction, an active area with a long tradition in HCI [8] and, hence, with established practices for providing tools. We use our findings to reflect on the dissemination of tools at the intersection of software engineering and HCI [17].

2 RELATED WORK

We discuss practices for documenting software applications in the software engineering community, and present an overview of prior surveys conducted on the topic of multimodal interaction related to the case study implemented in this work.

[1] https://chi2021.acm.org/for-authors/presenting/papers/selecting-a-subcommittee
[2] https://eics.acm.org/eics2021/submission_fullpapers.html
[3] https://icmi.acm.org/2021/index.php?id=cfp
[4] https://www.interact2021.org/tracks/full_papers.php
[5] https://dl.acm.org/journal/imwut

2.1 Documenting Software Applications

Presenting a software application or tool to others implies employing effective methods to document features and modes of operation to demonstrate the usefulness of the software for the target audience. Thus, software documentation for classes, libraries, frameworks, and platforms takes a variety of forms [20]. In formal projects, documentation is *outside the source code*, e.g., it takes the form of unit development folders containing the developers' notes or detailed-design documents describing class-level and routine-level design decisions. Internal documentation lies *within the source code,* and takes the form of comments inserted by programmers, but especially is the result of a good programming style [20]. A widespread practice among software developers is the use of the "readme" file, usually written in markdown, that provides a short description of the software, how to compile and install it, and how to use it. More detailed technical documentations employ wiki systems.[6] At community level, "get started" and "docs" sections and FAQ sections [10] of web pages and blogs [5,25] are common. In the context of HCI, Mehlenbacher [22] discussed the resistance or lack of interest in documentation development and evaluation, and identified five critical dimensions of all support documentation: audience, task types, information goals, physical and rhetorical differences of media, and genre or information type being developed. Earle et al. [9] examined user preferences of software documentation genres (product help, tutorials, samples, videos, articles, tech notes, forums, and blogs), and reported a strong preference for product help and tech notes.

Several standards exist to provide valuable information to providers of software applications, tools, and platforms. For instance, the ISO/IEC/IEEE 26515:2018 standard on developing user documentation in an agile environment[7] acknowledges that "the documentation may be the first tangible item that the user sees, and so influences the first impressions the users have of the product" and "well designed documentation not only assists the users and helps to reduce the cost of training and support, but also enhances the reputation of the product, its producer, and its suppliers." The standard focuses on specific concepts, such as the burndown chart (a document for recording project status), system feature (a distinguishing characteristic of a system), persona (the archetypal user of a system), scrum report (documenting the daily activities of a scrum team), use case (behavioral requirements of a system and interaction with the user), user story (narrative illustrating user goals), and technical writer (person in charge of the user documentation). The IEEE Standard for Software User Documentation[8] provides "requirements for the structure, information content, and format of user documentation, to include both paper and electronic documentation used in the work environment by users of systems containing software." The standard focuses on concepts such as the user, action, illustration, tutorial, usage mode, and critical information, and identifies fourteen components of software user documentation, from identification data and table of contents to navigational features, indexes, and search capability.

2.2 Surveys of Multimodal Interaction

In this work, we choose to implement a case study in multimodal interaction. Our motivation is driven by the fact that multimodal interaction has a long tradition in HCI [8] and, consequently, more established practices are likely to exist for disseminating tools.

There is a wide literature on the topic of multimodal interaction, including many surveys that have adopted various approaches to describe design, implementation, evaluation, and application of multimodal interactions [3,8,12,13,19,31]. For example, the goal of Jaimes and Sebe's [13] survey was to present an overview of open issues in multimodal

[6]Compare them all | WikiMatrix, https://www.wikimatrix.org
[7]https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:26515:ed-2:v1:en
[8]https://ieeexplore.ieee.org/document/974401

HCI by relating to computer vision approaches, the affective part of human-computer interaction (e.g., emotion processing to make multimodal systems more natural and empathic), and system architecture to support multimodal interactions. Dumas et al. [8] focused on principles, models, and programming frameworks for multimodal user interfaces, highlighting the potential of machine learning for this area. A survey of the state-of-the-art of the role played by and the benefits of multimodality in Virtual Reality was provided by Martin et al. [19] that focused on the potential of multimodal interactions to contribute to compelling experiences in virtual environments. Gürkök and Nijholt [12] surveyed Brain-Computer Interfaces for multimodal interactions, stressing how they can significantly improve error handling, task performance, and user experience. Baig and Kavakli [3] focused on evaluation, input and output modalities, and data collection and fusion as challenges for multimodal systems, and concluded that multimodal application developers focus mostly on input, while the most widely employed input modalities are speech and gesture. Similar conclusions were drawn by Turk's [31] survey on designing multimodal interfaces, including input and output, biological sensory integration, and multimodal integration.

The research question addressed in our work—*how do HCI researchers document their software tools to support design and engineering of multimodal interaction systems?*—can be seen as a complementary survey to the existing literature [3,8,12,17,19,31], yet limited in depth (see the next section introducing synopsis surveys) reporting on how researchers have chosen to describe their prototypes, tools, libraries, frameworks, and applications designed to support multimodal interaction systems.

3 METHOD

To understand existing practices in describing tools for multimodal interaction, we conducted a guided, targeted search of the scientific literature by adopting the procedure of Systematic Literature Reviews (SLR) [6], but without running a comprehensive and extensive search of the literature as SLRs do. This approach is justified for our specific case study in multimodal interaction, as would be in other cases where a huge amount of work exists, that prevents a complete analysis of all the available work in reasonable time.[9] Our simplified approach employs the method of SLRs, while adopting the rationale of conducting scientific experiments, where a sample is used for the analysis instead of the entire population. From this perspective, we follow the sound procedure of SLRs and keep their desirable characteristics [29], while arriving at rapid insights from a vast literature by exploring a sample of that literature, similar to how experimental research methods [15] lead to findings by extrapolating the results obtained on a sample to the large population. We call this procedure a *synopsis survey*,[10] with several convenient characteristics: synopsis surveys are methodical, transparent, replicable, empirical, and rapid. The first three characteristics emerge from adopting the procedure of SLRs [29] (described next), while the last two from the fact that we work with a sample of the literature.

To implement our survey, we ran the following query:

```
"query": Title:(multimodal AND (tool* OR platform*) AND (interaction* OR interface* OR input))
"filter": NOT VirtualContent: true, ACM Content: DL
```

on the titles of papers from the ACM Full-Text Collection and found 49 results. We searched our combination of keywords just in the titles to limit the large number of results corresponding to papers that used "'multimodal," "interaction,"

[9] Many variants exist for conducting surveys, such as *rapid reviews* that employ the method of SLRs, but for which the completeness of searching is determined by time constraints, or *systematized reviews,* that attempt to include elements of the SLR process, while they stop short of a systematic review and are typically narrative; see Grant and Booth [11] for an analysis of fourteen types of reviews and associated methodologies.
[10] According to Merriam-Webster, a synopsis is "a condensed statement or outline (as of a narrative or treatise)," https://www.merriam-webster.com/dictionary/synopsis.

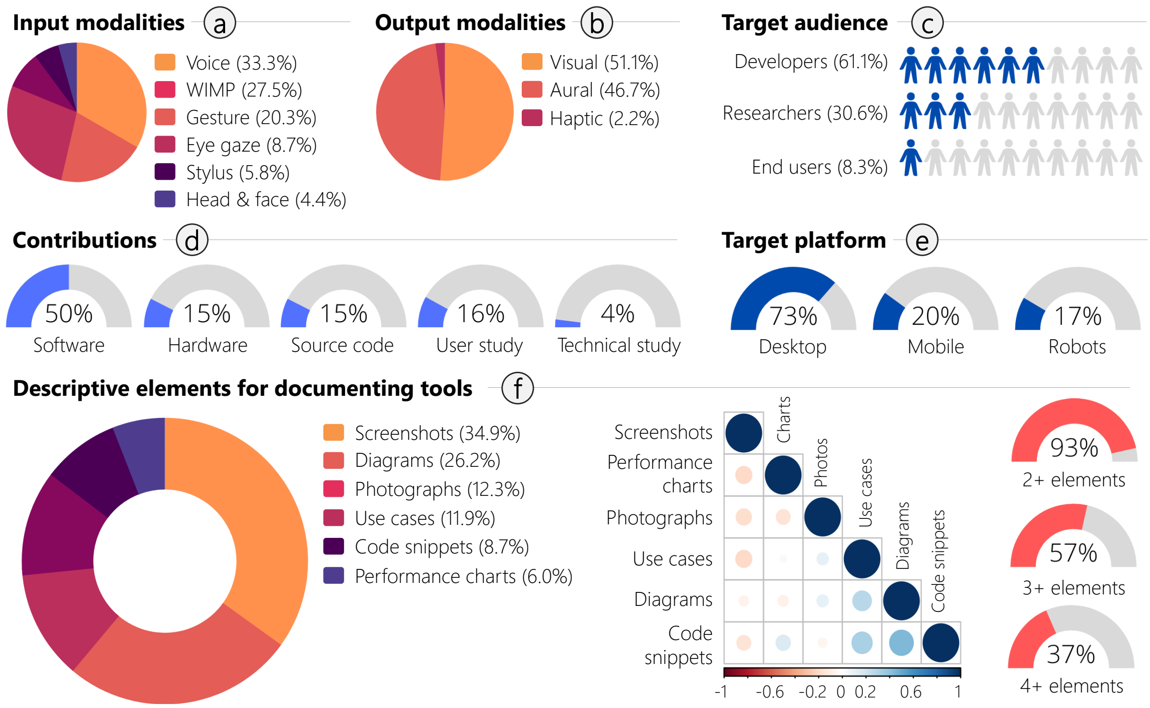

Fig. 2. Input and output modalities (a,b), target audiences (c), contributions (d), target platforms (e), and descriptive elements for documenting tools (f) extracted from the papers that we analyzed in our synopsis survey.

or "interface" as part of their abstracts or full text and that were not relevant to our research question about *tools* for multimodal interaction. We also considered the following eligibility criteria (ECs) to screen these results:

EC_1. *Content availability.* The paper is written in English, the full text is available, and the paper was peer reviewed. Journal articles, conference papers, and other contributions are eligible according to this criterion, while invited keynotes, book abstracts, and white papers are not.

EC_2. *Eligible area.* The paper is about multimodal interaction.

EC_3. *Eligible topic.* The paper presents, evaluates, or surveys tools or platforms to support multimodal interaction.

A number of six results were discarded by not meeting eligibility criterion EC_1, three were excluded by EC_2, and ten did not present tools (EC_3). After the eligibility stage, we arrived at a number of 30 papers for subsequent analysis. During this analysis, we extracted the following characteristics and coded[11] the papers accordingly:

(1) *Input modalities.* We used the following categories that emerged from our analysis: *voice*, *gesture*, *WIMP*, *eye gaze*, *stylus input*, and *head & face input.*
(2) *Output modalities: visual*, *aural*, and *haptic.* Just like for input modalities, these categories emerged from our analysis.
(3) *Target users: researchers, developers,* and *other users.*
(4) *Target platform* addressed by the tool, with the following categories: *desktop*, *mobile*, and *embodied* (robots).

[11] The coding was done by the first author of this paper, while the second author cross-checked 20% of the codings.

(5) *Contribution.* We extracted the contributions made by the papers describing tools for multimodal interaction: *software application* (i.e., the tool is a software that developers can use to design and create new systems), *hardware prototype* (the tool relies on a hardware component, e.g., a specific sensor, required for multimodal interaction), *source code* (the authors release source code accompanying the previous two types of contributions), *user study* (a study with users to validate the tool), and *technical study* (results are reported about the technical performance of the tool).

(6) *Descriptive elements* employed to present and document tools, besides the textual description from the paper, with the following categories emerging from our analysis: *diagrams*, *code snippets*, *use cases*, *screenshots*, *photographs*, and *performance charts*, respectively.

4 RESULTS

The papers included in our final set were published between 1998 (Cheyer and Julia's [7] multimodal tools for the video analyst) and 2020 (Sarmah et al.'s [27] Geno tool for authoring multimodal interaction on existing web applications), and the majority (19/30=63.3%) were published at ICMI, the ACM International Conference on Multimodal Interaction (formerly on Multimodal Interfaces).

We found that the most common input modalities were voice (33.3%), mouse and keyboard for the WIMP interaction paradigm (27.5%), and gesture commands (20.3%), followed by eye gaze, stylus input, and head movements and facial expressions; see Figure 2a. These results match a conclusion from Baig and Kavakli's [3] survey of multimodal systems based on 136 references, according to which the most widely employed input modalities in the literature were found to be speech and gesture—a result that builds confidence in our synopsis approach. Visual and aural modalities were approximately balanced at 51.1% and 46.7%, respectively, while haptics was addressed by just one tool [21]; see Figure 2b.

We identified a total of 48 contributions, of which software applications were the most common (50%), followed by user studies (16%) to validate the tools, and hardware contributions (15%) to enable new input modalities, e.g., the chemistry pod from Anderson et al.'s [2] multimodal tool for the classroom was designed to record audio from various locations in the classroom. The most widely addressed platform was desktop (73%), while mobile platforms and robots were less represented (20% and 17%, respectively). Finally, tools were specifically addressed at developers (61.1%) and researchers (30.6%) and, in a few cases, at end users, such as video analysts [7] and instructors [2]; see Figures 2c to 2e.

Figure 2f shows the distribution of descriptive elements used by the authors of these papers to document and present their tools. We found that *screenshots* and *diagrams* were the most used (34.9% and 26.2%), followed by *photographs* of the tools (12.3%) and descriptions of *use cases* (11.9%). A Pearson correlation analysis showed a significant positive correlation between the number of *diagrams* and *code snippets* ($r_{(N=30)}$=.436, p=.05) employed to describe the tools, and several negative correlations (not reaching statistical significance at α=.05, however) between *screenshots* and *photographs* and *screenshots* and *use cases,* respectively. *Screenshots* and *diagrams* were also used in conjunction in 70% of the papers identified in our synopsis survey, while *diagrams* and *photographs* were used together to present the tools in 43.3% of the papers. A percent of 93% of the tools were described using at least two descriptive elements, and 37% with at least four descriptive elements, e.g., Skantze and Al Moubayed [30] employed *diagrams*, *photographs*, *code snippets*, and a description of an *use case* for IrisTK, their toolkit for multi-party face-to-face interaction; see Figure 2f, right.

Our results show that *screenshots* and *diagrams* have been preferred by HCI researchers and authors to describe their tools designed to support multimodal interaction. These findings make sense since, by definition, a tool implies engineering details that are communicated via platform-independent and programming language-independent *diagrams* showing the operation of the tool, e.g., dataflows or UML classes, while *screenshots* are useful to exemplify directly the end result to the audience. Using more descriptive elements, e.g., *diagrams* and *photographs*, enables authors to describe their tools better as well as corresponding use cases for the tools. However, our results also show a strong technical perspective for presenting tools, with authors insisting more on technical aspects compared to use cases. By connecting this finding to the IEEE/ISO/IEC standards discussed in Section 2, descriptions of *personas* as archetypal users of a tool, narratives illustrating *user goals*, *tutorials*, illustrations of *actions* and *steps* to achieve user goals are missing from tool descriptions. This finding may seem surprising on a first look, but can be interpreted from the perspective that tools for multimodal interaction are situated at the intersection of software engineering and HCI. In this context, the audience is primarily represented by researchers and practitioners that will use the tools to engineer new interactive computing systems (EICS), and that speak the same language of EICS [17], a strongly technically-oriented subcommunity of HCI.

5 CONCLUSION AND FUTURE WORK

We reported results from a synopsis survey to form a preliminary understanding of how HCI researchers and authors describe software tools for multimodal interaction, and found that screenshots and diagrams are representative of the technically-oriented EICS subcommunity of HCI. Future work will examine the description of tools in other areas of HCI, such as tools for fabrication (where more hardware contributions are expected) or tools for conducting user experiments (where use case descriptions and tutorials are likely to be more representative). These new case studies will complete our understanding of how the HCI community presents its tools, and will enable us to reapply synopsis surveys for other areas.

We also acknowledge the limitations of our synopsis survey approach as well as our focus on results from the ACM DL only and running our query on the paper titles alone. Nevertheless, a synopsis survey has useful features, among which being replicable and providing rapid access to insights from areas where a vast amount of literature exists. Comparing synopsis surveys to other types of literature reviews [11] is recommended, along with formalizing synopsis surveys with population sampling methods and the use of inferential statistics to extrapolate the results obtained on a sample of papers to the wider scientific literature.

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