A tour through the zoo of scented widgets

V. Ciorna[1,2] [ID], N. Médoc[3] [ID], G. Melançon[2] [ID], F. Petry[1] [ID], and M. Ghoniem[3] [ID]

[1]Goodyear Innovation Center, Luxembourg
[2]University of Bordeaux, France
[3]Luxembourg Institute of Science and Technology, Luxembourg

Abstract

Software developers can choose among many popular widget toolkits to build graphical user interfaces quickly. Widgets like sliders, buttons and scrollbars are widespread and well-understood by the public. They allow users to interact with the software, to trigger operations or to set parameters. It is also recognized that widgets could be enhanced to provide a better user experience. Embedded visualizations, also known as scents, could be added to standard widgets to enhance their capabilities. In this work, we survey the literature concerning scented widgets. We propose a two-level taxonomy structured around four main dimensions: Purpose, Widget Type, Number of Scents and Scent Type, with examples of scented widgets. We also discuss our current thoughts about the scope of this survey, and call for feedback to further improve and extend the proposed taxonomy.

CCS Concepts

• *Human-centered computing → Graphical user interfaces; User interface programming; Interface design prototyping; Visualization techniques; Visualization systems and tools;*

1. Introduction

Widgets like buttons, sliders and text fields are essential building blocks of graphical user interfaces. They are used to trigger actions, e.g. with buttons and menus, to input data with text fields, checkboxes, and sliders, and to navigate through data, e.g. using scrollbars. Besides standard widgets, enhanced widgets are needed to support more elaborate tasks, like range sliders for dynamic queries in data visualization, and zoom and pan widgets for maps. One type of enhancements to widgets consists in showing additional information, also called *scent* [WHA07], to support what-if questions [CLV*19], or to contextualize an input value, e.g. relative to the underlying data distribution. This helps to anticipate the future state of the widget, or the outcome of the related operation, at the system level. While setting a value with a vanilla slider requires the user to apply implicit knowledge, a *scented slider* [Eic94] may provide visual guidance, e.g. through an embedded histogram.

Data-driven decision making, in particular what-if analyses, can easily turn into a tedious trial-and-error process, unless the interface is designed to help the user anticipate the outcome of his actions, for example by augmenting widgets with visual feedforward information [CLV*19]. The seminal work of Willett *et al.* [WHA07] provides guidance for the design of scented widgets as well as many examples. In this work, we initiate a reflection on *scented widgets*, attempt to classify them and provide a preliminary visual browser to help navigate existing literature on this topic. We hope that this will evolve into an established taxonomy of scented widgets, motivate further research and guide visualization designers.

2. Search Methodology and Data Collection

We collected relevant papers based on the PRISMA methodology for systematic literature reviews [PMB*21]. For the sake of reproducibility, the search strategy, including detailed query specification, website filters, query formulation and data extraction methods is documented in the supplementary material. We searched in IEEE Xplore, ACM digital library, Wiley online library, Springer, Science Direct and Sage Journals. The search resulted in 5,428 distinct papers and was iteratively reduced to 76 papers. We used a two-step screening process: 1) an automatic screening, matching query phrases in the title, abstract and author-provided keywords, resulting in 392 papers; 2) a manual screening by two coders, completed by peer debriefing [Jan15] with a third coder to resolve disagreements, finally keeping 23 papers. We added 37 papers based on a partial snowballing search, and another 16 papers based on a Google Scholar search. The final corpus of 76 papers was analyzed one by one to elicit the proposed preliminary taxonomy.

3. Preliminary Dimensions

We propose to organize widgets as an inverted 2-level tree [Ras05]. In the first level, we categorize widgets according to their *purpose*, their *type*, the *number of scents* and the *type of scent* they carry.

3.1. Purpose of Scented Widgets

Often starting from a standard widget, the visualization researcher wants to display an additional piece of information in the form
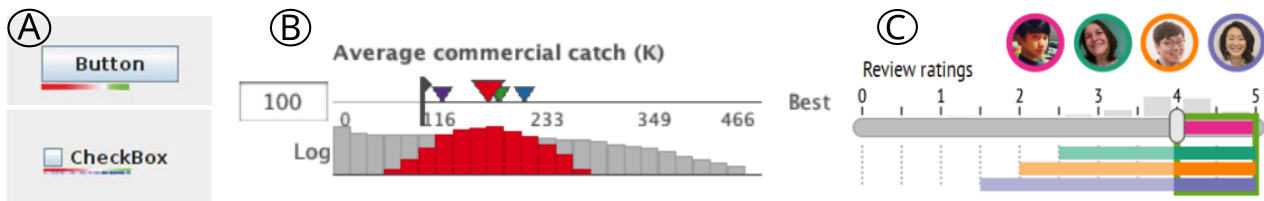
Figure 1: *A) a button & a checkbox scented with a heatmap representing user emotions based on EEG readings [CWEK13]; B) a slider scented with glyphs and a histogram [BMPM12]; C) a slider scented with images and a bar chart [HSR*18]. Images reused with permission.*

of a scent, as explained by Willet *et al.* [WHA07]. Inspired by the interaction taxonomy of Yi et al. [YKSJ07] and the task taxonomy of Brehmer et al. [BM13], we identify various purposes for scenting a widget. A scent may be used for **enhanced filtering** [Eic94] or **enhanced selection** [HAW08]. Displaying a histogram on top of a slider is a case in point [LBS*03]. Scented widgets may also aim to provide a **state preview** [DMB22], typically by displaying feedforward information to anticipate the future state of the system [CLV*19]. Scented widgets can also support **collaborative decision making**, for example by decorating widgets with awareness cues [HG03] or by using custom visualizations to indicate the interface state for other team members [HSR*18]. Scented widgets are also used to **mitigate bias** [GSC16], where the scent helps to contextualize user actions, thus preventing bias. Multiple scented sliders can also help to solve multi-objective **optimization** problems, for example by allowing the user to specify preferences [LNC*18, AT11]. Finally, scents can support **query formulation**. Examples include previews of search query results [QGDA13], selection via query relaxation [HAW08] and partial satisfaction of queries [OCSF12].

3.2. Type of Widget

Categorizing widgets by type can help designers to narrow down the search space to a specific kind of widgets. While there are more complete taxonomies related to widget types [WSI06], we extract only the ones which are more commonly scented. Typically, **sliders** are often scented with a histogram on top, depicting the underlying data distribution [NZSG03, DCCW08, TBJ15]. **Buttons** [CWEK13], **lists** [STM17], **textual inputs** [SHKC20] are also scented frequently. When classical widgets are not enough, or the need is specific, **custom widgets** need to be created such as concentric sliders [OCSF12], interactive legends [RLP10], widgets to query temporal data [HR97] or responsive matrix cells [HBS*21].

3.3. Number of Scents

When user action may be guided by multiple considerations, the designer may be tempted to display multiple scents on the same widget, without harming the usability of the widget. For example, this may arise in the context of multi-criteria decision making or multi-objective optimization. Categorizing widgets by the number of scents will help the interested designer to identify possible design strategies in prior work. We distinguish widgets enhanced with **one scent** [Eic94] from those having **2+ scents** [LNC*18, HSR*18].

3.4. Type of Scent

Scents come in various forms depending on the type of information needed by the user. Widgets have been scented with **images** [DMB22], **histograms** [Eic94], **line plots**, **scatterplots** [CK03] and **heatmaps** [SDMT16] (see examples in Figure 1). **Glyphs** are also common. For instance, Vismon [BMPM12] uses small triangles as landmarks for saved scenarios along the range of a slider. Scenting a widget with **custom visualizations** may also be necessary. In Weightlifter [PSTW*17] for instance, sliders are augmented with a custom-built visualizations showing multiple scents in order to visualize and manipulate weights in a ranking problem. Finally, some work use **dynamic scents**. For instance, Sneak Pique [SHKC20] displays different scents next to a textual input based on the text that is entered: a textual input such as "Show me cases in" will display a map and a calendar as possible scents. Refining the text will further narrow down the options.

4. Visual Literature Browser

To ease the access to papers related to scented widgets, we provide an online visual browser, adapted from the SentimentVis Browser [KPK18], and structured according to the proposed categorization. https://vis-surveys.list.lu/scented-widgets .

5. Discussion and Future Work

While screening the literature, determining inclusion and exclusion criteria is a non-trivial iterative process. We also revisited some papers several times. Drawing the line between a scented widget, especially the custom-built ones, and a standard interactive visualization is sometimes difficult. Even standard widgets are in principle a form of visualization. Color choosers, for instance, meet the common definition of a scented widget [WHA07]. But, we decided to exclude them as they are part of standard widget toolkits. Also, we limited the scope of this preliminary work to standard personal computer environments. Widgets have been explored in other environments, e.g. Augmented and Virtual Reality, on touch-enabled wall-sized displays and phidgets for physical user interfaces. These can possibly be scented too. We also excluded solutions using non-visual perception channels, e.g., audio-based feedforward. In the future, we plan to extend the proposed taxonomy and survey of scented widgets, based on community feedback.

6. Acknowledgements

References

[AT11] AITTOKOSKI T., TARKKANEN S.: User preference extraction using dynamic query sliders in conjunction with UPS-EMO algorithm. doi:10.48550/arXiv.1110.5992. 2

[BM13] BREHMER M., MUNZNER T.: A Multi-Level Typology of Abstract Visualization Tasks. *IEEE Trans. Vis. Comp. Graph. 19*, 12 (2013), 2376–2385. doi:10.1109/TVCG.2013.124. 2

[BMPM12] BOOSHEHRIAN M., MÖLLER T., PETERMAN R. M., MUNZNER T.: Vismon: Facilitating analysis of trade-offs, uncertainty, and sensitivity in fisheries management decision making. *Computer Graphics Forum 31* (2012), 1235–1244. doi:10.1111/j.1467-8659.2012.03116.x. 2

[CK03] CRAIG P., KENNEDY J.: Coordinated graph and scatter-plot views for the visual exploration of microarray time-series data. In *Proc. IEEE Symp. Information Visualization, INFO VIS* (2003), pp. 173–180. doi:10.1109/INFVIS.2003.1249023. 2

[CLV*19] COPPERS S., LUYTEN K., VANACKEN D., NAVARRE D., PALANQUE P., GRIS C.: Fortunettes: Feedforward about the future state of gui widgets. *Proc. ACM on Human-Computer Interaction 3*, EICS (Jun 2019), 1–20. doi:10.1145/3331162. 1, 2

[CWEK13] CERNEA D., WEBER C., EBERT A., KERREN A.: Emotion scents: a method of representing user emotions on GUI widgets. In *Visualization and Data Analysis 2013* (2013), vol. 8654, p. 86540F. doi:10.1117/12.2001261. 2

[DCCW08] DÖRK M., CARPENDALE S., COLLINS C., WILLIAMSON C.: VisGets: Coordinated visualizations for web-based information exploration and discovery. In *IEEE Trans. Vis. Comp. Graph.* (2008), vol. 14, pp. 1205–1212. doi:10.1109/TVCG.2008.175. 2

[DMB22] DANG H., MECKE L., BUSCHEK D.: GANSlider: How Users Control Generative Models for Images using Multiple Sliders with and without Feedforward Information. In *ACM Conf. Hum. Fact. Comput. Sys.* (2022), pp. 1–15. doi:10.1145/3491102.3502141. 2

[Eic94] EICK S. G.: Data visualization sliders. In *Proc. ACM Symp. User Interface Software and Technology, UIST 1994* (1994), pp. 119–120. doi:10.1145/192426.192472. 1, 2

[GSC16] GOTZ D., SUN S., CAO N.: Adaptive contextualization: Combating bias during high-dimensional visualization and data selection. In *Proc. Int'l Conf. Intell. User Interf.* (2016), IUI '16, ACM, p. 85–95. doi:10.1145/2856767.2856779. 2

[HAW08] HEER J., AGRAWALA M., WILLETT W.: Generalized selection via interactive query relaxation. In *Proc. Conf. Hum. Fact. Comput. Sys.* (2008), pp. 959–968. doi:10.1145/1357054.1357203. 2

[HBS*21] HORAK T., BERGER P., SCHUMANN H., DACHSELT R., TOMINSKI C.: Responsive Matrix Cells: A Focus+Context Approach for Exploring and Editing Multivariate Graphs. *IEEE Trans. Vis. Comp. Graph. 27*, 2 (2021), 1644–1654. doi:10.1109/TVCG.2020.3030371. 2

[HG03] HILL J., GUTWIN C.: Awareness support in a groupware widget toolkit. In *Proc. Int'l ACM SIGGROUP Conf. Supporting Group Work* (2003), pp. 258–267. doi:10.1145/958200.958201. 2

[HR97] HIBINO S., RUNDENSTEINER E. A.: User interface evaluation of a direct manipulation temporal visual query language. In *Proc. 5th ACM Int'l Conf. Multimedia* (1997), pp. 99–107. doi:10.1145/266180.266342. 2

[HSR*18] HONG S., SUH M., RICHE N. H., LEE J., KIM J., ZACHRY M.: Collaborative dynamic queries: Supporting distributed small group decision-making. In *Proc. Conf. Hum. Fact. Comput. Sys.* (2018), pp. 1–12. doi:10.1145/3173574.3173640. 2

[Jan15] JANESICK V. J.: *Peer Debriefing*. John Wiley & Sons, Ltd, 2015. doi:10.1002/9781405165518.wbeosp014.pub2. 1

[KPK18] KUCHER K., PARADIS C., KERREN A.: The state of the art in sentiment visualization. *Computer Graphics Forum 37*, 1 (2018), 71–96. doi:10.1111/cgf.13217. 2

[LBS*03] LI Q., BAO X., SONG C., ZHANG J., NORTH C.: Dynamic query sliders vs. brushing histograms. In *CHI ext. abs. Hum. Fact. Comput. Sys.* (2003), pp. 834–835. doi:10.1145/765891.766020. 2

[LNC*18] LAURILLAU Y., NGUYEN V. B., COUTAZ J., CALVARY G., MANDRAN N., CAMARA F., BALZARINI R.: The TOP-slider for multi-criteria decision making by non-specialists. In *ACM International Conference Proceeding Series* (2018), ACM, pp. 642–653. doi:10.1145/3240167.3240185. 2

[NZSG03] NORMAN K., ZHAO H., SHNEIDERMAN B., GOLUB E.: Dynamic query choropleth maps for information seeking and decision making. *Proc. Human-Computer Interaction International* (2003). 2

[OCSF12] OTJACQUES B., CORNIL M., STEFAS M., FELTZ F.: MCS Filters to Express Partial Satisfaction of Criteria. In *Eurographics Conf. Visualization (EuroVis)* (2012), pp. 49–53. doi:10.2312/PE/EuroVisShort/EuroVisShort2012/049-053. 2

[PMB*21] PAGE M. J., MOHER D., BOSSUYT P. M., BOUTRON I., HOFFMANN T. C., MULROW C. D., SHAMSEER L., TETZLAFF J. M., AKL E. A., BRENNAN S. E., ET AL.: Prisma 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ 372* (2021). doi:10.1136/bmj.n160. 1

[PSTW*17] PAJER S., STREIT M., TORSNEY-WEIR T., SPECHTENHAUSER F., MÖLLER T., PIRINGER H.: WeightLifter: Visual Weight Space Exploration for Multi-Criteria Decision Making. *IEEE Trans. Vis. Comp. Graph. 23*, 1 (2017), 611–620. doi:10.1109/TVCG.2016.2598589. 2

[QGDA13] QVARFORDT P., GOLOVCHINSKY G., DUNNIGAN T., AGAPIE E.: Looking ahead: Query preview in exploratory search. In *Proc. ACM SIGIR Conf. Research and Development in Information Retrieval* (2013), pp. 243–252. doi:10.1145/2484028.2484084. 2

[Ras05] RASCHEN B.: A resilient, evolving resource: How to create a taxonomy. *Business Information Review 22*, 3 (Sep 2005), 199–204. doi:10.1177/0266382105057495. 1

[RLP10] RICHE N. H., LEE B., PLAISANT C.: Understanding interactive legends: A comparative evaluation with standard widgets. *Computer Graphics Forum 29*, 3 (2010), 1193–1202. doi:10.1111/j.1467-8659.2009.01678.x. 2

[SDMT16] STAHNKE J., DÖRK M., MÜLLER B., THOM A.: Probing Projections: Interaction Techniques for Interpreting Arrangements and Errors of Dimensionality Reductions. *IEEE Trans. Vis. Comp. Graph. 22*, 1 (2016), 629–638. doi:10.1109/TVCG.2015.2467717. 2

[SHKC20] SETLUR V., HOQUE E., KIM D. H., CHANG A. X.: Sneak pique: Exploring autocompletion as a data discovery scaffold for supporting visual analysis. In *Proc. ACM Symp. User Interf. Soft. Technol.* (2020), pp. 966–978. doi:10.1145/3379337.3415813. 2

[STM17] SARVGHAD A., TORY M., MAHYAR N.: Visualizing Dimension Coverage to Support Exploratory Analysis. *IEEE Trans. Vis. Comp. Graph. 23*, 1 (2017), 21–30. doi:10.1109/TVCG.2016.2598466. 2

[TBJ15] TSANDILAS T., BEZERIANOS A., JACOB T.: Sketch sliders: Sketching widgets for visual exploration on wall displays. In *Proc. Conf. Hum. Fact. Comput. Sys.* (2015), vol. 2015-April, ACM, pp. 3255–3264. doi:10.1145/2702123.2702129. 2

[WHA07] WILLETT W., HEER J., AGRAWALA M.: Scented widgets: Improving navigation cues with embedded visualizations. *IEEE Trans. Vis. Comp. Graph. 13*, 6 (2007), 1129–1136. doi:10.1109/TVCG.2007.70589. 1, 2

[WSI06] WANG L., SAJEEV A., INCHAIWONG L.: A Formal Specification of Interaction Widgets Hierarchy Framework. In *Proc. Conf. Inf. Technol.: New Gen. (ITNG'06)* (2006), pp. 658–664. doi:10.1109/ITNG.2006.8. 2

[YKSJ07] YI J. S., KANG Y. a., STASKO J., JACKO J.: Toward a Deeper Understanding of the Role of Interaction in Information Visualization. *IEEE Trans. Vis. Comp. Graph. 13*, 6 (2007), 1224–1231. doi:10.1109/TVCG.2007.70515. 2