IN PARTNERSHIP WITH:
CNRS

Université Paris-Sud (Paris 11)

Activity Report 2018

Project-Team ILDA

Interacting with Large Data

IN COLLABORATION WITH: Laboratoire de recherche en informatique (LRI)

RESEARCH CENTER
Saclay - Île-de-France

THEME
Interaction and visualization

Table of contents

Project-Team ILDA

Creation of the Team: 2015 January 01, updated into Project-Team: 2016 December 01

Keywords:

Computer Science and Digital Science:

A3.1.7. - Open data
A3.1.10. - Heterogeneous data
A3.2.4. - Semantic Web
A3.2.5. - Ontologies
A3.2.6. - Linked data
A5.1. - Human-Computer Interaction
A5.2. - Data visualization
A5.5.4. - Animation
A5.6.1. - Virtual reality
A5.6.2. - Augmented reality

Other Research Topics and Application Domains:

B9.5.3. - Physics
B9.5.6. - Data science
B9.6.7. - Geography
B9.7.2. - Open data
B9.11. - Risk management

1. Team, Visitors, External Collaborators

Research Scientists

Emmanuel Pietriga [Team leader, Inria, Senior Researcher, HDR]
Caroline Appert [CNRS, Senior Researcher, HDR]
Olivier Chapuis [CNRS, Researcher]

Faculty Member

Anastasia Bezerianos [Univ Paris-Sud, Associate Professor]

Post-Doctoral Fellow

Vanessa Peña Araya [Inria, from Dec 2018]

PhD Students

Eugénie Brasier [Univ Paris-Sud, from Oct 2018 (intern from Apr 2018 to Sep 2018)]
Marie Destandau [Inria]
Anna Gogolou [Inria]
Raphaël James [Univ Paris-Sud, from Oct 2018 (intern from Apr 2018 to Sep 2018)]
Hugo Romat [TKM (CIFRE)]
Tong Xue [Inria, from Oct 2018]

Technical staff

Hande Gözükan [Inria, SED, until Sep 2018]
Léo Colombaro [Inria, from Sep 2018]
Adhitya Kamakshidasan [Inria, from Jun 2018]
Dylan Lebout [Inria]

Interns

Nicole Barbosa Sultanum [Visiting PhD student, Univ. Toronto, from Oct 2018]
Robin Duraz [M1, Univ. Paris-Sud, from May 2018 until Jul 2018]
Clément Sauvard [M1, Inria, from May 2018 until Jul 2018]

Administrative Assistant

Alexandra Merlin [Inria]

External Collaborator

Bruno Fruchard [PhD student, Telecom ParisTech]

2. Overall Objectives

2.1. Overall Objectives

In an increasing number of domains, computer users are faced with large datasets, that are often interlinked and organized according to elaborate structures thanks to new data models such as those that are arising with the development of, *e.g.*, the Web of Data. Rather than seeing the inherent complexity of those data models as a hindrance, we aim at leveraging it to design new interactive systems that can better assist users in their data understanding and processing tasks.

These "Data-centric Interactive Systems" aim at providing users with the right information at the right time, presenting it in the most meaningful manner, and letting users efficiently manipulate, edit and share these data with others. This entails minimizing the effort required to retrieve and relate data from relevant sources; displaying data using visual presentation techniques that match the data's characteristics and the users' tasks; and providing users with means of interacting with the data that effectively support their train of thought.

Our approach is based on the idea of bringing the fields of Web data management [35] and Human-computer interaction [59], [81] closer together, based on the strong belief that they have the potential to cross-fertilize one another. User interface design is essential to the management and understanding of large, interlinked datasets. Interlinked datasets enriched with even a small amount of semantics have the potential to help create interfaces that let users analyze and manipulate data in a more efficient manner by providing them with, *e.g.*, more relevant query results and giving them efficient means to navigate and relate those results. Our ultimate, long-term goal is to design interactive systems that make it as straightforward to manipulate large webs of data as spreadsheets do for tabular data.

3. Research Program

3.1. Introduction

Our ability to acquire or generate, store, process, interlink and query data has increased spectacularly over the last few years. The corresponding advances are commonly grouped under the umbrella of so called *Big Data*. Even if the latter has become a buzzword, these advances are real, and they are having a profound impact in domains as varied as scientific research, commerce, social media, industrial processes or e-government. Yet, looking ahead, emerging technologies related to what we now call the *Web of Data* (a.k.a the Semantic Web) have the potential to create an even larger revolution in data-driven activities, by making information accessible to machines as semistructured data [34] that eventually becomes actionable knowledge. Indeed, novel Web data models considerably ease the interlinking of semi-structured data originating from multiple independent sources. They make it possible to associate machine-processable semantics with the data. This in turn means that heterogeneous systems can exchange data, infer new data using reasoning engines, and that software agents can cross data sources, resolving ambiguities and conflicts between them [79]. Datasets are becoming very rich and very large. They are gradually being made even larger and more heterogeneous, but also much more useful, by interlinking them, as exemplified by the Linked Data initiative [54].

These advances raise research questions and technological challenges that span numerous fields of computer science research: databases, communication networks, security and trust, data mining, as well as human-computer interaction. Our research is based on the conviction that interactive systems play a central role in many data-driven activity domains. Indeed, no matter how elaborate the data acquisition, processing and storage pipelines are, data eventually get processed or consumed one way or another by users. The latter are faced with large, increasingly interlinked heterogeneous datasets (see, *e.g.*, Figure 1) that are organized according to complex structures, resulting in overwhelming amounts of both raw data and structured information. Users thus require effective tools to make sense of their data and manipulate them.

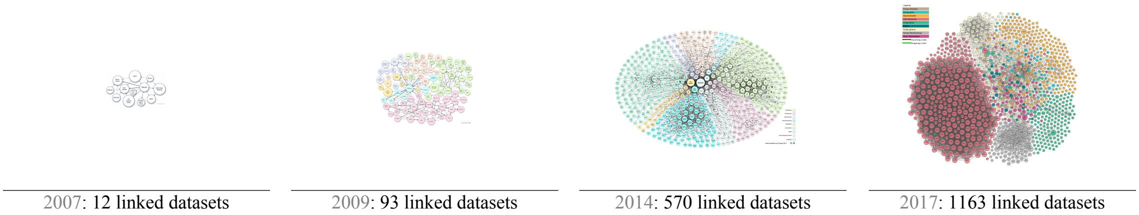

Figure 1. Linking Open Data cloud diagram from 2007 to 2017 – http://lod-cloud.net

We approach this problem from the perspective of the Human-Computer Interaction (HCI) field of research, whose goal is to study how humans interact with computers and inspire novel hardware and software designs aimed at optimizing properties such as efficiency, ease of use and learnability, in single-user or cooperative work contexts. More formally, HCI is about designing systems that lower the barrier between users' cognitive model of what they want to accomplish, and computers' understanding of this model. HCI is about the design, implementation and evaluation of computing systems that humans interact with [59], [81]. It is a highly multidisciplinary field, with experts from computer science, cognitive psychology, design, engineering, ethnography, human factors and sociology.

In this broad context, ILDA aims at designing interactive systems that display [43], [66], [88] the data and let users interact with them, aiming to help users better *navigate* and *comprehend* large webs of data represented visually, as well as *relate* and *manipulate* them.

Our research agenda consists of the three complementary axes detailed in the following subsections. Designing systems that consider interaction in close conjunction with data semantics is pivotal to all three axes. Those semantics will help drive navigation in, and manipulation of, the data, so as to optimize the communication bandwidth between users and data.

3.2. Semantics-driven Data Manipulation

Participants: Emmanuel Pietriga, Caroline Appert, Anastasia Bezerianos, Marie Destandau, Hugo Romat, Tong Xue, Léo Colombaro, Hande Gözükan.

The Web of Data has been maturing for the last fifteen years and is starting to gain adoption across numerous application domains (Figure 1). Now that most foundational building blocks are in place, from knowledge representation, inference mechanisms and query languages [55], all the way up to the expression of data presentation knowledge [74] and to mechanisms like look-up services [87] or spreading activation [50], we need to pay significant attention to how human beings are going to interact with this new Web, if it is to *"reach its full potential"* [51].

Most efforts in terms of user interface design and development for the Web of data have essentially focused on tools for software developers or subject-matter experts who create ontologies and populate them [61], [48]. Tools more oriented towards end-users are starting to appear [40], [42], [56], [57], [60], [69], including the so-called *linked data browsers* [54]. However, those browsers are in most cases based on quite conventional point-and-click hypertext interfaces that present data to users in a very page-centric, web-of-documents manner that is ill-suited to navigating in, and manipulating, webs of data.

To be successful, interaction paradigms that let users navigate and manipulate data on the Web have to be tailored to the radically different way of browsing information enabled by it, where users directly interact with the data rather than with monolithic documents. The general research question addressed in this part of our research program is how to design novel interaction techniques that help users manipulate their data more efficiently. By data manipulation, we mean all low-level tasks related to manually creating new content, modifying and cleaning existing content, merging data from different sources, establishing connections between datasets, categorizing data, and eventually sharing the end results with other users; tasks that are currently considered quite tedious because of the sheer complexity of the concepts, data models and syntax, and the interplay between all of them.

Our approach is based on the conviction that there is a strong potential for cross-fertilization, as mentioned earlier: on the one hand, user interface design is essential to the management and understanding of webs of data; on the other hand, interlinked datasets enriched with even a small amount of semantics can help create more powerful user interfaces, that provide users with the right information at the right time.

We envision systems that focus on the data themselves, exploiting the underlying *semantics and structure* in the background rather than exposing them – which is what current user interfaces for the Web of Data often do. We envision interactive systems in which the semantics and structure are not exposed directly to users, but serve as input to the system to generate interactive representations that convey information relevant to the task at hand and best afford the possible manipulation actions.

Relevant publications by team members this year: [22], [29], [28].

3.3. Generalized Multi-scale Navigation

Participants: Caroline Appert, Anastasia Bezerianos, Olivier Chapuis, Emmanuel Pietriga, Vanessa Peña Araya, Marie Destandau, Anna Gogolou, Hugo Romat, Adhitya Kamakshidasan, Dylan Lebout.

The foundational question addressed here is what to display when, where and how, so as to provide effective support to users in their data understanding and manipulation tasks. ILDA targets contexts in which workers have to interact with complementary views on the same data, or with views on different-but-related datasets, possibly at different levels of abstraction. Being able to combine or switch between representations of the data at different levels of detail and merge data from multiple sources in a single representation is central to many scenarios. This is especially true in both of the application domains we consider: mission-critical systems (e.g., natural disaster crisis management) and the exploratory analysis of scientific data (e.g., correlate theories and heterogeneous observational data for an analysis of a given celestial body in Astrophysics).

A significant part of our research over the last ten years has focused on multi-scale interfaces. We designed and evaluated novel interaction techniques, but also worked actively on the development of open-source UI toolkits for multi-scale interfaces (http://zvtm.sf.net). These interfaces let users navigate large but relatively homogeneous datasets at different levels of detail, on both workstations [77], [37], [73], [72], [71], [38], [76], [36], [78] and wall-sized displays [68], [63], [75], [67], [39], [45], [44]. This part of the ILDA research program is about extending multi-scale navigation in two directions: 1. Enabling the representation of multiple, spatially-registered but widely varying, multi-scale data layers in Geographical Information Systems (GIS); 2. Generalizing the multi-scale navigation paradigm to interconnected, heterogeneous datasets as found on the Web of Data.

The first research problem has been mainly investigated in collaboration with IGN in the context of ANR project MapMuxing (Section 8.1.1), which stands for *multi-dimensional map multiplexing*. Project MapMuxing aims at going beyond the traditional pan & zoom and overview+detail interface schemes, and at designing and evaluating novel cartographic visualizations that rely on high-quality generalization, *i.e.*, the simplification of geographic data to make it legible at a given map scale [84], [85], and symbol specification. Beyond project MapMuxing, we are also investigating multi-scale multiplexing techniques for geo-localized data in the specific context of ultra-high-resolution wall-sized displays, where the combination of a very high pixel density and large physical surface (Figure 3) enable us to explore designs that involve collaborative interaction and physical navigation in front of the workspace. This is work done in cooperation with team Massive Data at Inria Chile.

The second research problem is about the extension of multi-scale navigation to interconnected, heterogeneous datasets. Generalization has a rather straightforward definition in the specific domain of geographical information systems, where data items are geographical entities that naturally aggregate as scale increases. But it is unclear how generalization could work for representations of the more heterogeneous webs of data that we consider in the first axis of our research program. Those data form complex networks of resources with multiple and quite varied relationships between them, that cannot rely on a single, unified type of representation (a role played by maps in GIS applications).

Addressing the limits of current generalization processes is a longer-term, more exploratory endeavor. Here again, the machine-processable semantics and structure of the data give us an opportunity to rethink how users navigate interconnected heterogeneous datasets. Using these additional data, we investigate ways to generalize the multi-scale navigation paradigm to datasets whose layout and spatial relationships can be much richer and much more diverse than what can be encoded with static linear hierarchies as typically found today in interfaces for browsing maps or large imagery. Our goal is thus to design and develop highly dynamic and versatile multi-scale information spaces for heterogeneous data whose structure and semantics are not known in advance, but discovered incrementally.

Relevant publications by team members this year: [4], [25], [24], [15], [13], [12], [31], [11], [14].

3.4. Novel Forms of Input for Groups and Individuals

Participants: Caroline Appert, Anastasia Bezerianos, Olivier Chapuis, Emmanuel Pietriga, Eugénie Brasier, Bruno Fruchard, Raphaël James.

Analyzing and manipulating large datasets can involve multiple users working together in a coordinated manner in multi-display environments: workstations, handheld devices, wall-sized displays [39]. Those users work towards a common goal, navigating and manipulating data displayed on various hardware surfaces in a coordinated manner. Group awareness [53], [33] is central in these situations, as users, who may or may not be co-located in the same room, can have an optimal individual behavior only if they have a clear picture of what their collaborators have done and are currently doing in the global context. We work on the design and implementation of interactive systems that improve group awareness in co-located situations [62], making individual users able to figure out what other users are doing without breaking the flow of their own actions.

In addition, users need a rich interaction vocabulary to handle large, structured datasets in a flexible and powerful way, regardless of the context of work. Input devices such as mice and trackpads provide a limited number of input actions, thus requiring users to switch between modes to perform different types of data manipulation and navigation actions. The action semantics of these input devices are also often too much dependent on the display output. For instance, a mouse movement and click can only be interpreted according to the graphical controller (widget) above which it is moved. We focus on designing powerful input techniques based upon technologies such as tactile surfaces (supported by UI toolkits developed in-house), 3D motion tracking systems, or custom-built controllers [65] *to complement (rather than replace) traditional input devices* such as keyboards, that remain the best method so far for text entry, and indirect input devices such as mice or trackpads for pixel-precise pointing actions.

The input vocabularies we investigate enable users to navigate and manipulate large and structured datasets in environments that involve multiple users and displays that vary in their size, position and orientation [39], [52], each having their own characteristics and affordances: wall displays [68], [90], workstations, tabletops [70], [47], tablets [7], [86], smartphones [89], [46], [82], [83], and combinations thereof [2], [10], [67], [39].

We aim at designing rich interaction vocabularies that go far beyond what current touch interfaces offer, which rarely exceeds five gestures such as simple slides and pinches. Designing larger gesture vocabularies requires identifying discriminating dimensions (e.g., the presence or absence of anchor points and the distinction between internal and external frames of reference [7]) in order to structure a space of gestures that interface designers can use as a dictionary for choosing a coherent set of controls. These dimensions should be few and simple, so as to provide users with gestures that are easy to memorize and execute. Beyond gesture complexity, the scalability of vocabularies also depends on our ability to design robust gesture recognizers that will allow users to fluidly chain simple gestures that make it possible to interlace navigation and manipulation actions.

We also study how to further extend input vocabularies by combining touch [7], [89], [70] and mid-air gestures [68] with physical objects [58], [80], [65] and classical input devices such as keyboards to enable users to input commands to the system or to involve other users in their workflow (request for help, delegation, communication of personal findings, etc.) [41], [64]. Gestures and objects encode a lot of information in their shape, dynamics and direction, that can be directly interpreted in relation with the user, independently from the display output. Physical objects can also greatly improve coordination among actors for, e.g., handling priorities or assigning specific roles.

Relevant publications by team members this year: [25], [21], [17], [23], [20], [19], [27].

4. Application Domains

4.1. Mission-critical systems

Mission-critical contexts of use include emergency response & management, and critical infrastructure operations, such as public transportation systems, communications and power distribution networks, or the operations of large scientific instruments such as particle accelerators and astronomical observatories. Central to these contexts of work is the notion of situation awareness [33], i.e., how workers perceive and understand elements of the environment with respect to time and space, such as maps and geolocated data feeds from the field, and how they form mental models that help them predict future states of those elements. One of the main challenges is how to best assist subject-matter experts in constructing correct mental models and making informed decisions, often under time pressure. This can be achieved by providing them with, or helping them efficiently identify and correlate, relevant and timely information extracted from large amounts of raw data, taking into account the often cooperative nature of their work and the need for task coordination. With this application area, our goal is to investigate novel ways of interacting with computing systems that improve collaborative data analysis capabilities and decision support assistance in a mission-critical, often time-constrained, work context.

Relevant publications by team members this year: [25], [31], [16], [21], [23], [28], [13].

4.2. Exploratory analysis of scientific data

Many scientific disciplines are increasingly data-driven, including astronomy, molecular biology, particle physics, or neuroanatomy. While making the right decision under time pressure is often less of critical issue when analyzing scientific data, at least not on the same temporal scale as truly time-critical systems, scientists are still faced with large-to-huge amounts of data. No matter their origin (experiments, remote observations, large-scale simulations), these data are difficult to understand and analyze in depth because of their sheer size and complexity. Challenges include how to help scientists freely-yet-efficiently explore their data, keep a trace of the multiple data processing paths they considered to verify their hypotheses and make it easy to backtrack, and how to relate observations made on different parts of the data and insights gained at different moments during the exploration process. With this application area, our goal is to investigate how data-centric interactive systems can improve collaborative scientific data exploration, where users' goals are more open-ended, and where roles, collaboration and coordination patterns [53] differ from those observed in mission-critical contexts of work.

Relevant publications by team members last year: [15], [23], [30].

5. New Software and Platforms

5.1. Smarties

FUNCTIONAL DESCRIPTION: The Smarties system provides an easy way to add mobile interactive support to collaborative applications for wall displays.

It consists of (i) a mobile interface that runs on mobile devices for input, (ii) a communication protocol between the mobiles and the wall application, and (iii) libraries that implement the protocol and handle synchronization, locking and input conflicts. The library presents the input as an event loop with callback functions and handles all communication between mobiles and wall application. Developpers can customize the mobile interface from the wall application without modifying the mobile interface code.

On each mobile we find a set of cursor controllers associated with keyboards, widgets and clipboards. These controllers (pucks) can be shared by multiple collaborating users. They can control simple cursors on the wall application, or specific content (objects or groups of them). The developper can decide the types of widgets associated to pucks from the wall application side.

- Contact: Olivier Chapuis
- URL: http://smarties.lri.fr/

5.2. ZVTM

Zoomable Visual Transformation Machine
KEYWORDS: Big data - Visualization - Data visualization - Information visualization - Graph visualization
FUNCTIONAL DESCRIPTION: ZVTM is a toolkit enabling the implementation of multi-scale interfaces for interactively navigating in large datasets displayed as 2D graphics.

ZVTM is used for browsing large databases in multiple domains: geographical information systems, control rooms of complex facilitites, astronomy, power distribution systems.

The toolkit also enables the development of applications running on ultra-high-resolution wall-sized displays.

- Participants: Caroline Appert, Olivier Chapuis and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: Rapid Development of User Interfaces on Cluster-Driven Wall Displays with jBricks - A Toolkit for Addressing HCI Issues in Visual Language Environments
- URL: http://zvtm.sf.net

5.3. MapMosaic

KEYWORDS: Geo-visualization - Data visualization

SCIENTIFIC DESCRIPTION: GIS software applications and other mapping tools enable users to correlate data from multiple layers and gain insight from the resulting visualizations. However, most of these applications only feature basic, monolithic layer compositing techniques. These techniques do not always support users effectively in their tasks, as we observed during interviews with GIS experts. MapMosaic is a novel approach based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers, taking into account the semantics and attribute values of objects and fields in the composit-ing process. We evaluated MapMosaic's interaction model against that of QGIS (a widely-used desktop GIS) and MAPublisher (a professional cartography tool) using the "Cognitive Dimensions" framework and through an analytical comparison, showing that MapMosaic's model is more flexible and can support users more effectively in their tasks.
FUNCTIONAL DESCRIPTION: MapMosaic is a novel approach to combine geographical layers based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers. It takes into account the semantics and attribute values of objects and fields in the compositing process. MapMosaic aims at better supporting GIS users in their tasks such as correlating data from multiple layers and gaining insight from the resulting visualizations.

RELEASE FUNCTIONAL DESCRIPTION: First public release.

- Participants: Maria Jesus Lobo Gunther, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: MapMosaic: Dynamic Layer Compositing for Interactive Geovisualization - An Evaluation of Interactive Map Comparison Techniques
- URL: http://ilda.saclay.inria.fr/mapmuxing/mapmosaic/index.html

5.4. Baia

Before-and-after satellite image animation
KEYWORDS: Geo-visualization - 2D animation
SCIENTIFIC DESCRIPTION: Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner. Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after images. Baia relies on a pixel-based transition model that gives authors much expressive power, while keeping animations for common types of changes easy to create thanks to predefined animation primitives.
FUNCTIONAL DESCRIPTION: Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after satellite images.

Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner.

Baia relies on a pixel-based transition model that gives authors much expressive power. The animation editor enables authors to easily represent common types of changes thanks to predefined animation primitives and to sequence different changes across time.

RELEASE FUNCTIONAL DESCRIPTION: First public release

- Participants: Maria Jesus Lobo Gunther, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: Animation Plans for Before-and-After Satellite Images
- URL: http://ilda.saclay.inria.fr/mapmuxing/baia/index.html

5.5. LODAtlas

KEYWORDS: LOD - Linked open data - Semantic Web

SCIENTIFIC DESCRIPTION: The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs , datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. LODAtlas is a portal that enables users to find datasets of interest. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

FUNCTIONAL DESCRIPTION: The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs, datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. LODAtlas is a portal that enables users to find datasets of interest. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

- Participants: Caroline Appert, Marie Destandau, Ioana Manolescu, François Goasdoué, Sejla Cebiric, Hande Gozukan and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: Browsing Linked Data Catalogs with LODAtlas
- URL: http://lodatlas.lri.fr

5.6. TouchTokens

KEYWORDS: Tangible interface - HCI

SCIENTIFIC DESCRIPTION: TouchTokens make it possible to easily build interfaces that combine tangible and gestural input using passive tokens and a regular multi-touch surface. The tokens constrain users' grasp, and thus, the relative spatial configuration of fingers on the surface, theoretically making it possible to design algorithms that can recognize the resulting touch patterns. See associated scientific articles below.

FUNCTIONAL DESCRIPTION: TouchTokens allow interface designers to build low-cost tangible interfaces. The technique consists in recognizing multi-touch patterns that are associated with specific passive tokens. Those physical tokens can be made out of any material to get tracked on any touch-sensitive surface. Implementations of the recognizer (in both TUIO and Android) and vector descriptions of the tokens ready for 3D-printing or laser-cutting are available

- Participants: Caroline Appert, Rafael Morales Gonzalez, Emmanuel Pietriga and Gilles Bailly
- Contact: Caroline Appert
- Publications: TouchTokens: Guiding Touch Patterns with Passive Tokens - Passive yet Expressive TouchTokens - Custom-made Tangible Interfaces with TouchTokens
- URL: https://www.lri.fr/~appert/touchtokens/

5.7. Platforms

5.7.1. Platform: WILDER

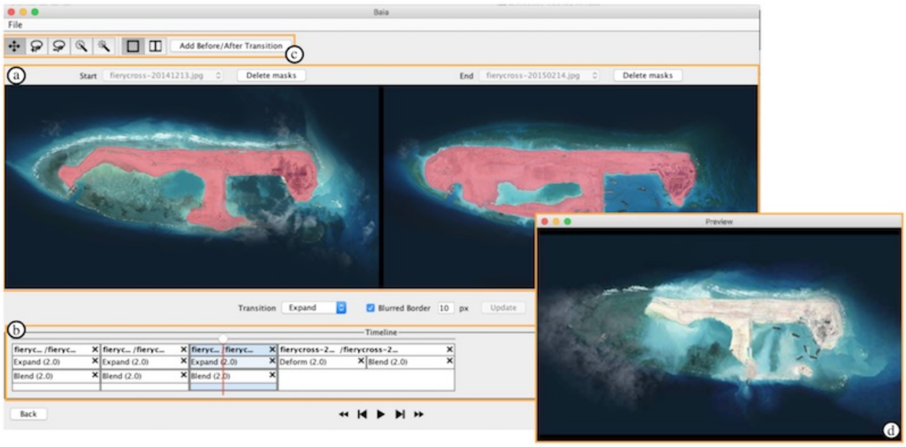

Figure 2. Baia is a framework to create advanced animated transitions between before-and-after satellite images. Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Baia relies on a pixel-based transition model to convey the underlying phenomenon that caused this evolution in a meaningful manner. The animation editor pictured here enables authors to easily represent common types of changes thanks to predefined animation primitives and to sequence different changes across time.

Figure 3. Multiple asteroid-generated tsunami simulations running simultaneously on the WILDER ultra-wall. The high display capacity of this interactive surface makes it possible to show, for each of the simulations: a planet-wide view showing the propagation of the tsunami on the globe, a close-up on the region of impact, showing a simulation of one or more scalar fields, parameters of the simulation.

Ultra-high-resolution wall-sized displays [39] feature a very high pixel density over a large physical surface. Such platforms have properties that make them well-suited to the visualization of very large datasets. They can represent the data with a high level of detail while at the same time retaining context: users can transition from an overview of the data to a detailed view simply by physically moving in front of the wall display. Wall displays also offer good support for collaborative work, enabling multiple users to simultaneously visualize and interact with the displayed data. To make them interactive, wall-sized displays are increasingly coupled with input devices such as touch frames, motion-tracking systems and wireless multitouch devices, in order to enable multi-device and multi-user interaction with the displayed data. Application areas for such visualization platforms range from the monitoring of complex infrastructures and crisis management situations to tools for the exploratory visualization of scientific data.

WILDER is the latest ultra-high-resolution wall-sized display set up at Inria Saclay, and is one of the nodes of the Digiscope EquipEx. We use this platform for multiple projects, both fundamental HCI research, and research and development activities for specific application areas such as geographical informations systems (Figure 3) and astronomy.

WILDER was used in the projects that led to the following publications this year: [23], [31].

6. New Results

6.1. Gestures and Tangibles

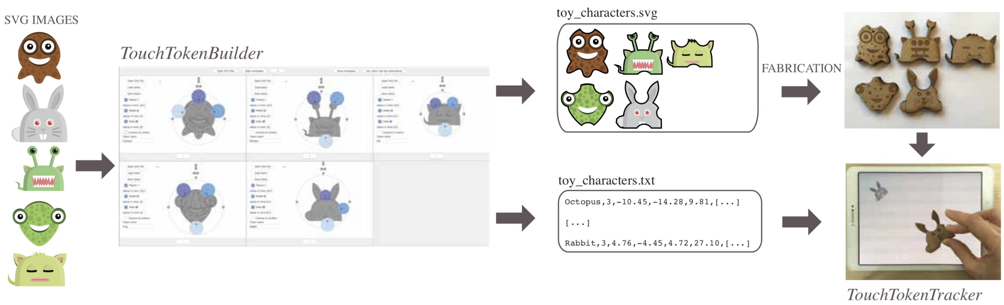

Figure 4. TouchToken-Builder (left) assists users in placing grasping notches on arbitrarily-shaped tokens, warning them about spatial configurations that could generate recognition conflicts or that might be uncomfortable to manipulate. It outputs both a vector and a numerical description of the tokens' geometry (middle). Those are used respectively to build the tokens (top-right), and to track them on any touchscreen using TouchToklen-Tracker (bottom-right).

6.1.1. Custom-made Tangible Interfaces with TouchTokens

One of our main results in this area is the design, development and evaluation of TouchTokens, a new way of prototyping and implementing low-cost tangible interfaces [6]. The approach requires only passive tokens and a regular multi-touch surface. The tokens constrain users' grasp, and thus, the relative spatial configuration of fingers on the surface, theoretically making it possible to design algorithms that can recognize the resulting touch patterns. Our latest project on TouchTokens [17] has been about tailoring tokens, going beyond the limited set of geometrical shapes studied in [6], as illustrated in Figure 4.

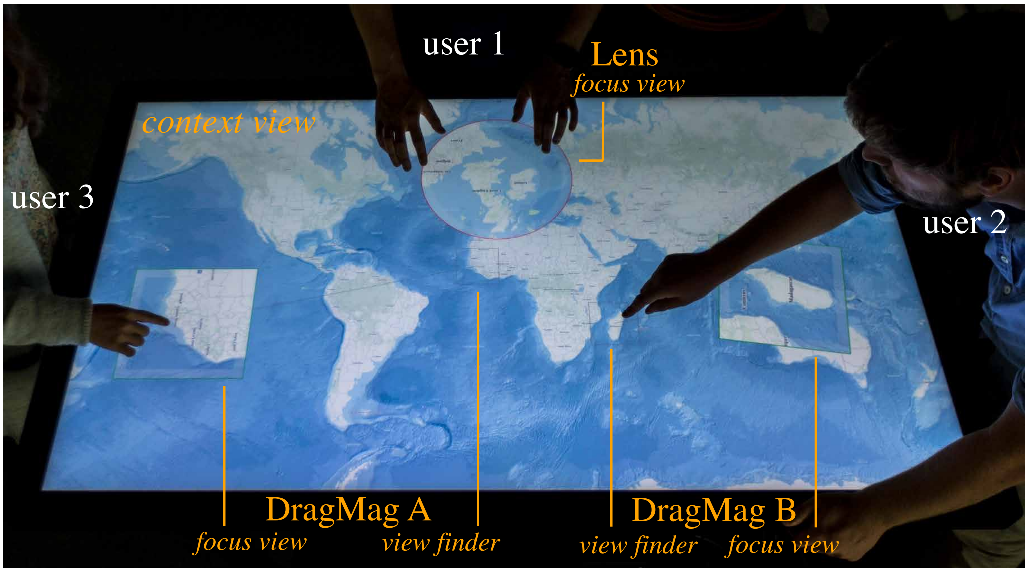

Figure 5. Our framework for the study of multi-scale navigation on tabletops enables users to both pan & zoom the context view and to create independent focus views, either DragMags or lenses.

6.1.2. Designing Coherent Gesture Sets for Multi-scale Navigation on Tabletops

We designed a framework for the study of multi-scale navigation (Figure 5) and conducted a controlled experiment of multi-scale navigation on tabletops [25]. We first conducted a guessability study in which we elicited user-defined gestures for triggering a coherent set of navigation actions, and then proposed two interface designs that combine the now-ubiquitous slide, pinch and turn gestures with either two-hand variations on these gestures, or with widgets. In a comparative study, we observed that users can easily learn both designs, and that the gesture-based, visually-minimalist design is a viable option, that saves display space for other controls.

6.1.3. Command Memorization, Gestures and other Triggering Methods

In collaboration with Telecom ParisTech, we studied the impact of semantic aids on command memorization when using either on-body interaction or directional gestures [21]. Previous studies had shown that spatial memory and semantic aids can help users learn and remember gestural commands. Using the body as a support to combine both dimensions had therefore been proposed, but no formal evaluations had been reported. We compared, with or without semantic aids, a new on-body interaction technique (BodyLoci) to mid-air Marking menus in a virtual reality context, considering three levels of semantic aids: no aid, story-making, and story-making with background images.

As part of the same collaboration, we also studied how memorizing positions or directions affects gesture learning for command selection. Many selection techniques either rely on directional gestures (e.g. Marking menus) or pointing gestures using a spatially-stable arrangement of items (e.g. FastTap). Both types of techniques are known to leverage memorization, but not necessarily for the same reasons. We investigated whether using directions or positions affects gesture learning [20].

6.2. Interacting with the Semantic Web of Linked Data

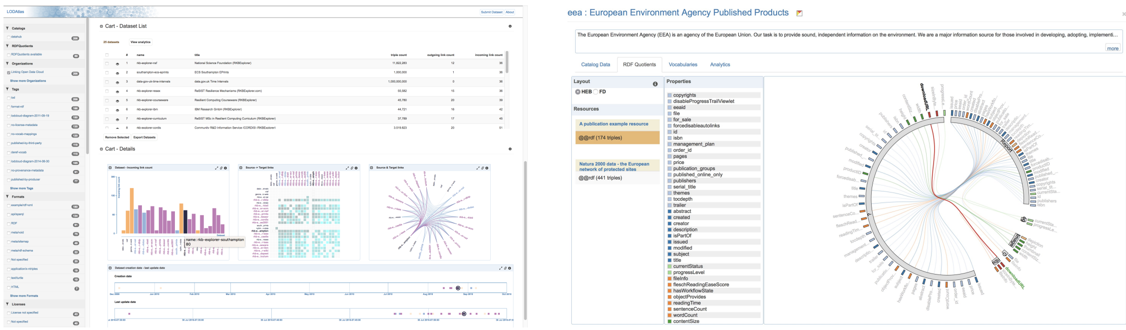

Figure 6. Browsing Linked Data Catalogs with LODAtlas [22]. Left: Visualization of the characteristics of, and links between, datasets selected by the user. Right: RDFQuotients-derived visual summary of a dataset. The summary shows how properties relate instances of the different classes.

The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs, datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. We started working on a platform called LODAtlas in 2016. LODAtlas [22] is a portal that enables users to find datasets of interest (see Figure 6) . Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to summary visualizations of their general metadata, connections and contents. The latter has been developed in collaboration with project-team CEDAR, based on their recent work on RDF Quotients.

Linked Data is structured as a directed labeled graph, or more precisely as a multitude of such graphs, that can be interlinked and distributed over the World Wide Web. Graph structures play an essential role at different scales in the Web of Data, and while it is now clear that basic approaches based on node-link diagram representations are only useful for small datasets, such visualizations remain meaningful for the representation of subsets of these multi-variate data. As part of a larger effort that started in the summer of 2016 to investigate novel interactive visual exploration techniques for multi-variate graphs, we introduced a design space and Web-based framework for generating what we call *animated edge textures*. Network edge data attributes are usually encoded using color, opacity, stroke thickness and stroke pattern, or some combination thereof. But in addition to these static variables, it is also possible to animate dynamic particles flowing along the edges. These can be seen as animated edge textures, that offer additional visual encodings that have potential not only in terms of visual mapping capacity but also playfulness and aesthetics. While such particle-based visual encodings have been featured in several commercial and design-oriented visualizations, this has to our knowledge almost always been done in a relatively ad hoc manner. Beyond the design space and Web framework, we also conducted an initial evaluation of particle properties – particle speed, pattern and frequency – in terms of visual perception. This work [24] was performed in collaboration with Nathalie Henry-Riche from Microsoft Research and Benjamin Bach from Edimburgh University.

6.3. Visualization

A significant part of our activity in this axis has been dedicated to geovisualization for various surfaces, including desktop workstations, tabletops and wall displays, in the context of ANR project MapMuxing. We investigated the representation of time in geovisualizations, more particularly how to convey changes in satellite images. Before-and-after images show how entities in a given region have evolved over a specific

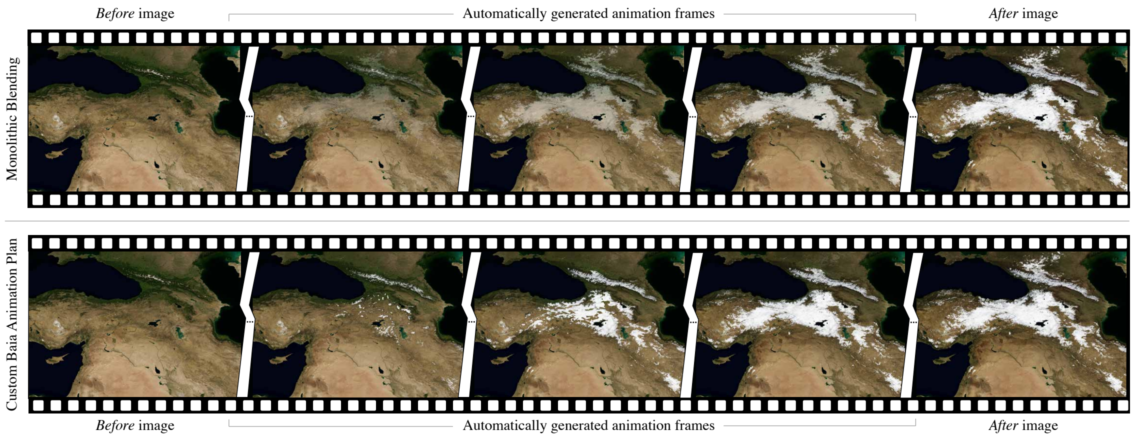

Figure 7. Animated transitions [4] based on one single before-and-after image pair showing seasonal snow cover over northern Middle East. The top row shows keyframes generated using basic monolithic blending. Snow fades in gradually but uniformly, regardless of altitude. The bottom row shows keyframes generated using a Baia animation plan derived from a Digital Elevation Model. Snow fades in gradually, but this time spreading from high-altitude to low-altitude areas.

period of time. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. We introduced Baia [4], a framework to create advanced animated transitions, called animation plans, between before-and-after images. Baia relies on a pixel-based transition model that gives authors much expressive power, while keeping animations for common types of changes easy to create thanks to predefined animation primitives (Figures 7 and 2).

Still in the area of geovisualization, in the context of ADT project Seawall, conducted in collaboration with project-team Lemon at Inria SAM / Montpellier and with Inria Chile, we have participated to the 2018 SciVis contest, which this year was about the visualization of data related to tsunamis generated by the impact of asteroids in deep water [31]. We used the WILDER ultra-high-resolution wall display to make it easier for analysts to visually compare and contrast different simulations from a deep water asteroid impact ensemble dataset. See Section 5.7.1 and Figure 3.

In the area of scientific data analysis, we have been collaborating with neuroscientists that explore large quantities of EEG data at different temporal scales. As a first step, we explored if automated algorithmic processes, that aid in the search for similar patterns in large datasets, actually match human intuition. We studied if we perceive as similar the results of these automatic measures, using three time-series visualizations: line charts, horizon graphs and colorfields. Our findings [15], [30] indicate that the notion of similarity is visualization-dependent, and that the best visual encoding varies depending on the automatic similarity measure considered.

Anstasia Bezerianos co-advised the PhD work of Evanthia Dimara in project-team Aviz together with P. Dragicevic. Last year, they had already confirmed that the cognitive bias known as the *attraction effect* does exist in visualizations [49]. This was followed-up this year by an exploration of different ways to mitigate this bias [12] (in collaboration with Northwestern University and Sorbonne Université). It was observed that the approach that consists of deleting all unwanted alternatives interactively removed the bias, a result that previous research has shown to be extremely hard to achieve. They also explored how different interactive visualizations of multidimensional datasets can affect decision making [13], and created a task-based taxonomy of cognitive biases for information visualization [14].

Our collaboration with INRA researchers has focused on mixed-initiative systems that combine human learning, machine learning and evolution. Results in this area for this year include an interactive evolutionary algorithm to learn from user interactions and steer the exploration of multidimensional datasets towards two-dimensional projections that are interesting to the analyst, and guidelines on how to evaluate such mixed initiative systems [29].

6.4. Collaboration, Multi-display environments, Large and Small Displays

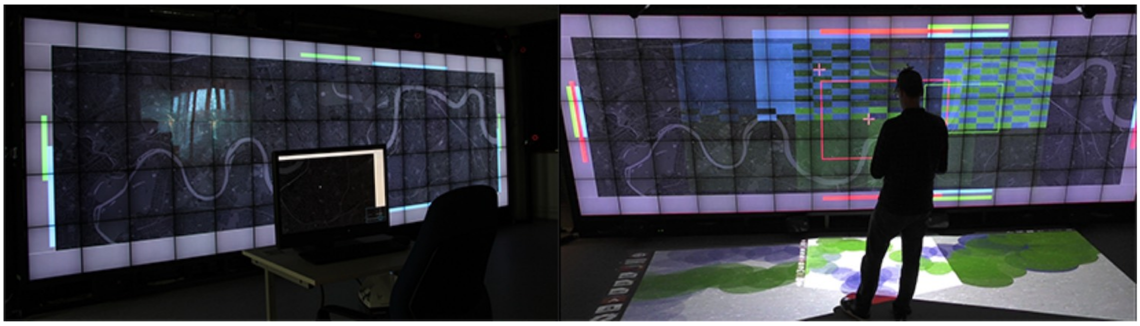

Figure 8. (left) Multi-Display Environment composed of a wall display and two workstations (one visible in the photo). (right) Three workspace awareness techniques: Awareness Bars at the edges of the wall, Focus Map on the wall display, and Step Map projected on the ground.

We studied awareness techniques to aid transitions between personal and shared workspaces in multi-display environments, that include large shared displays and desktops (Figure 8). In such contexts, including crisis management and control rooms, users can engage in both close collaboration and parallel or personal work. Transitioning between different displays can be challenging. To provide workspace awareness and to facilitate these transitions, we designed and implemented three interactions techniques that display users' activities. We explored how and where to display this activity: briefly on the shared display, or more persistently on a peripheral floor display. In a user study motivated by the context of a crisis room where multiple operators with different roles need to cooperate, we tested the usability of the techniques and provided insights on such transitions in systems running on MDEs [23]. We also contributed on a book chapter discussing how to best support collaboration in immersive environments that can range from MDE to mixed reality ones [28].

We collaborated with members from Inria project-team Aviz on the topic of small-scale visualization. This year, new results include a study about the perception of visualizations on smartwatches, performed together with Microsoft Research [11], [26]. The study was designed to assess how quickly people can perform a simple data comparison task for small-scale visualizations on a smartwatch. The goal was to extend our understanding of design constraints for smartwatch visualizations. We tested three chart types common on smartwatches: bar charts, donut charts, and radial bar charts with three different data sizes: 7, 12, and 24 data values. Results show that bar and donut charts should be preferred on smartwatch displays when quick data comparisons are necessary.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- Tecknowmetrix (TKM): ANRT/CIFRE PhD (Hugo Romat), 3 years, started June 2016.

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

MapMuxing - Multi-dimensional Map Multiplexing. (2014-2018) Funded by the French National Research Agency (ANR). In collaboration with IGN (Institut National de l'Information Géographique et Forestière): **208Keuros**/499Keuros. Participants: Emmanuel Pietriga (PI), Caroline Appert, Olivier Chapuis. http://mapmuxing.ign.fr

The project explores novel ways of combining different maps and data layers into a single cartographic representation, and investigates novel interaction techniques for navigating in it. The project aims at going beyond the traditional pan & zoom and overview+detail interface schemes, and at designing and evaluating novel cartographic visualizations that rely on high-quality generalization, *i.e.*, the simplification of geographic data to make it legible at a given map scale, and symbol specification.

8.1.2. Inria - Ministère de la Culture

Visual Exploration of Linked Data on BnF's data portal (2017-2018) Funded by the French Ministère de la Culture and Inria. **65Keuros**. Participants: Emmanuel Pietriga (PI), Caroline Appert, Hande Gözükan, Marie Destandau, Léo Colombaro.

The project explores novel ways of visually navigating the data exposed by the Bibliothèque Nationale de France as linked data on http://data.bnf.fr.

8.1.3. Inria Project Lab (IPL)

ILDA participates to Inria Project Lab iCODA : Data Journalism : knowledge-mediated Content and Data Interactive Analytics, that started in 2017. A key issue in data science is the design of algorithms that enable analysts to infer information and knowledge by exploring heterogeneous information sources, structured data, or unstructured content. With journalism data as a landmark use-case, iCODA aims to develop the scientific and technological foundation for collaborative, heterogeneous data analysis, guided by formalized, user-centric knowledge. The project relies on realistic scenarios in data-journalism to assess the contribution of the project to this area. iCODA is at the crossroads of several research areas (content analysis, data management, knowledge representation, visualization) and is part of a club of partners of the world of the press. Equipes-projets Inria : Graphik, Ilda, Linkmedia, Cedar. Press partners: Le Monde, OuestFrance, AFP. Participants: Anastasia Bezerianos (PI), Emmanuel Pietriga, Tong Xue, Nicole Barbosa Sultanum.

8.1.4. CNRS - PEPS

VizGest. (2018) Funded by CNRS. In collaboration with LIMSI. **17Keuros**. Participants: C. Appert (PI).

Interacting with multi-display environments often involves using mid-air gestures that do not require any proximity between users and displays. However, mid-air gestures are not *visible* to users. VizGest aims at giving some visibility to mid-air gestures by means of annotations put in the physical environment thanks to augmented reality glasses.

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

Deutsches Elektronen-Synchrotron (DESY): Scientific collaboration on the design and implementation of user interfaces for array operations monitoring and control for the Cherenkov Telescope Array (CTA) project, to be built in the Canary Islands (Spain) and in the Atacama desert (Chile), 2 years, contract started May 2018

8.3. International Initiatives

8.3.1. Inria International Labs

Inria Chile. From 2012 to 2015, Emmanuel Pietriga was the scientific leader of the Massive Data team at Inria Chile, working on projects in collaboration with the ALMA radio-telescope and the Millenium Institute of Astrophysics. He is now scientific advisor to Inria Chile's visualization projects, and is actively involved in the collaboration between Inria Chile and the LSST on the design and development of user interfaces for operations monitoring and control (see below), and the project between ESO and Inria Chile about the design and implementation of user interfaces for ALMA's Integrated Alarm System.

8.3.2. Inria International Partners

Association of Universities for Research in Astronomy (AURA): contract, jointly with Inria Chile, on the design and implementation of user interfaces for telescope operations monitoring and control for the Large Synoptic Survey Telescope (LSST) project, under construction in the Atacama desert (Chile), started 2017. Participants: Emmanuel Pietriga (ILDA), José Galaz (Inria Chile), Sebastian Pereira (Inria Chile), Grazia Prato (Inria Chile).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

- Nicole Barbosa Sultanum, Univ. Toronto, Canada, Oct 2018-Jan 2019.
- José Galaz, María Grazia Prato,Sebastian Pereira, Inria Chile, Dec 2018.

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. General Chair, Scientific Chair

- EICS 2018, 10th ACM SIGCHI Symposium on Engineering Interactive Computing Systems: Emmanuel Pietriga (general co-chair)

9.1.1.2. Member of the Organizing Committees

- VIS 2019, the IEEE Visualization Conference (SciVis, InfoVis, VAST): Anastasia Bezerianos (Workshops co-chair)
- VIS 2018, the IEEE Visualization Conference (SciVis, InfoVis, VAST): Anastasia Bezerianos (Communities co-chair)
- EICS 2018, 10th ACM SIGCHI Symposium on Engineering Interactive Computing Systems: Caroline Appert (Doctoral Consortium co-chair)
- IHM 2018, 30ème Conférence Francophone sur l'Interaction Homme-Machine: Caroline Appert (Doctoral Consortium panel member)

9.1.2. Scientific Events Selection

9.1.2.1. Chair of Conference Program Committees

- CHI 2019, 37th ACM SIGCHI Conference on Human Factors in Computing Systems: Anastasia Bezerianos (SC - subcommittee chair)
- CHI 2018, 36th ACM SIGCHI Conference on Human Factors in Computing Systems: Emmanuel Pietriga (SC - subcommittee chair)

9.1.2.2. Member of the Conference Program Committees

- CHI 2018, 36th ACM SIGCHI Conference on Human Factors in Computing Systems: Anastasia Bezerianos
- TheWebConf (WWW) 2019, 28th Web Conference, research track Web Content Analysis, Semantics, and Knowledge: Emmanuel Pietriga
- ESWC 2019, 16th Extended Semantic Web Conference: Emmanuel Pietriga
- ISWC 2018, 17th International Semantic Web Conference: Emmanuel Pietriga
- EICS 2018, 10th ACM SIGCHI Symposium on Engineering Interactive Computing Systems: Emmanuel Pietriga
- EICS 2018 TechNote, 10th ACM SIGCHI Symposium on Engineering Interactive Computing Systems: Caroline Appert, Olivier Chapuis
- VOILA @ ISWC 2018, Visualizations and User Interfaces for Ontologies and Linked Data, workshop co-located with ISWC 2018: Emmanuel Pietriga
- TheWebConf (WWW) 2018, 27th Web Conference, research track Web Content Analysis, Semantics, and Knowledge: Emmanuel Pietriga
- IHM 2018, 30ème Conférence Francophone sur l'Interaction Homme-Machine: Caroline Appert

9.1.2.3. Reviewer

- ACM CHI 2019, Conference on Human Factors in Computing Systems: Caroline Appert, Olivier Chapuis, Emmanuel Pietriga, Hugo Romat
- ACM UIST 2018, Interface Software and Technologies Symposium: Olivier Chapuis, Caroline Appert
- ACM ISS 2018, International Conference on Interactive Surfaces and Spaces: Olivier Chapuis
- AVI 2018, Advanced Visual Interfaces: Olivier Chapuis
- IEEE VIS 2018, Visualization Conference (InfoVis): Anastasia Bezerianos
- IHM 2018, Conference of the Association Francophone d'Interaction Homme-Machine: Olivier Chapuis, Bruno Fruchard, Marie Destandau

9.1.3. Journal

9.1.3.1. Member of the Editorial Boards

- ACM ToCHI, Transactions on Computer-Human Interaction: Caroline Appert (associate editor and member of EiC search committee)

9.1.3.2. Reviewer - Reviewing Activities

- IEEE TVCG, Transactions on Visualization and Computer Graphics: Emmanuel Pietriga, Anastasia Bezerianos
- Information Visualization Journal: Emmanuel Pietriga
- Journal of Multimodal Interfaces: Caroline Appert
- Interacting with Computers: Caroline Appert

9.1.4. Invited Talks

- Olivier Chapuis: Expressive and multi-user interaction, desktops, wall displays and beyond, Dresden Talks on Interaction & Visualization, Technische Universität Dresden (Germany), May 2018.
- Caroline Appert: Low-cost Tangible Interaction with TouchTokens, Conference FAB' 14, Paris Saclay, July 2018.
- Anastasia Bezerianos: How interactive visualizations can aid us make better or at least more consistent choices, University of Calgary (Canada), Nov 2018.

- Anastasia Bezerianos: Visualization Perception at large and small scales, University of St. Andrews (UK), Dec 2018.

9.1.5. Leadership within the Scientific Community

- ANR, CES chair - Interaction, Robotique: Caroline Appert

9.1.6. Scientific Expertise

- H2020, ERC Advanced Grants (reviewer): Caroline Appert, Emmanuel Pietriga
- ANR, CES chair - Interaction, Robotique: Caroline Appert
- NSERC, Canadian Discovery Grands (reviewer): Anastasia Bezerianos

9.1.7. Research Administration

- Scientific coordinator of Inria's evaluation seminar for period 2015-2018, theme Interaction and visualization: Emmanuel Pietriga
- Deputy Director of the Laboratoire de Recherche en Informatique (LRI): Olivier Chapuis
- President of Inria Saclay - Île de France's Commission for Technological Development (CDT): Emmanuel Pietriga
- Deputy head of Pôle "Données, Connaissances, Apprentissage et Interaction" at École Doctorale Paris Saclay (ED STIC): Caroline Appert

9.1.8. Learned societies

- Association Francophone d'Interaction Homme-Machine (AFIHM), in charge of the relation with the SIF: Olivier Chapuis.
- SigCHI Paris Local Chapter, chair: Anastasia Bezerianos.
- SigCHI Paris Local Chapter, vice chair: Caroline Appert.

9.1.9. Hiring committees

- Univ. Paris-Sud hiring committee, Commission Consultative des Spécialistes de l'Université 27ème section (computer science), members: Caroline Appert, Anastasia Bezerianos.
- Assistant Professor position, Computer Science, Université Paris-Sud, 2018: Caroline Appert, Emmanuel Pietriga.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Master Co-head: Anastasia Bezerianos, M2 Interaction and HCID, Univ. Paris-Saclay (until Aug 2018).

Ingénieur: Emmanuel Pietriga, Data Visualization (INF552), 36h, 3A/M1, École Polytechnique.

Ingénieur: Caroline Appert, Data Visualization (INF552), 18h, 3A/M1, École Polytechnique.

Master: Emmanuel Pietriga, Data Visualization, 24h, M2 Informatique Décisionnelle, Univ. Paris-Dauphine.

Master: Caroline Appert, Evaluation of Interactive Systems - Introduction, 21h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Caroline Appert, Evaluation of Interactive Systems - Advanced, 21h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Introduction to Programming of Interactive Systems, 21h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Career Seminar, 21h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Mixed Reality and Tangible Interaction, 11h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Information Visualization, 10h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, HCI Project, 21h, M2 Interaction and HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Design Project, 21h, M1 HCID, Univ. Paris-Saclay.

Master: Anastasia Bezerianos, Introduction aux Systèmes Interactifs, 21h, M1 Informatique, Univ. Paris-Saclay.

Master: Raphaël James, Programming of Interactive Systems, 12h, Univ. Paris-Saclay

Master: Raphaël James, Fundamentals of HCI, 21h, Univ. Paris-Saclay

Master: Tong Xue, Design of Interactive Systems, 21h, Univ. Paris-Saclay

License: Raphaël James, Algorithm/C/C++, 29h, Polytech

License: Tong Xue, Introduction à l'informatique graphique, 33h, Univ. Paris-Sud

Licence: Bruno Fruchard, Visualisation, 10h, Télécom Paristech.

Licence: Bruno Fruchard, Interaction Homme-Machine, 8h, Télécom Paristech.

Licence: Bruno Fruchard, Paradigmes de programmation, 8h, Télécom Paristech.

Licence: Bruno Fruchard, Projet d'apprentissage collaboratif thématique (student supervision), 6h, Télécom Paristech.

IUT: Marie Destandau, Programmation et administration des bases de données, 32h, Univ. Paris-Sud

IUT: Marie Destandau, Suivi de projet, 27h, Univ. Paris-Sud

IUT: Marie Destandau, Bases de données avancées, 18h, Univ. Paris-Sud

9.2.2. Supervision

PhD in progress : Eugénie Brasier, Interaction techniques for remote manipulation in multi-display environments, since October 2018, Advisors: Caroline Appert

PhD in progress : Raphaël James, Environnements de réalité physique et augmentée utilisés dans l'analyse visuelle collaborative, since October 2018, Advisors: Anastasia Bezerianos, Olivier Chapuis, Tim Dwyer

PhD in progress : Tong Xue, Interactive Visualization for Data Journalism, since October 2018, Advisors: Anastasia Bezerianos, Emmanuel Pietriga

PhD in progress : Marie Destandau, Interactive Visual Exploration of Webs of Data, since October 2017, Advisors: Caroline Appert, Emmanuel Pietriga

PhD in progress : Anna Gogolou, Iterative and expressive querying for big data series, October 2016, Advisors: Anastasia Bezerianos, Themis Palpanas

PhD in progress : Hugo Romat, Visual exploration and interactive manipulation techniques for collections of heterogeneous data and documents, since June 2016, Advisors: Caroline Appert, Emmanuel Pietriga

PhD in progress : Bruno Fruchard, Techniques d'interaction exploitant la mémoire spatiale pour faciliter l'accès rapide aux commandes et aux données, since October 2015 – December 2018, Advisors: Eric Lecolinet, Olivier Chapuis

9.2.3. Juries

PhD: Kashyap Todi, Hasselt University, Belgium: Emmanuel Pietriga (rapporteur)

PhD: Anonymous, University of Swinburne, Australia: Emmanuel Pietriga (rapporteur)

PhD: Ulrich von Zadow PhD, Technische Universität Dresden, Germany: Olivier Chapuis (reviewer)

PhD: Juliette Rambourg, Université de Toulouse, France: Caroline Appert (rapporteur)

PhD: Julien Gori, Université Paris Saclay, France: Caroline Appert (président)
PhD: Marion Dumont, Université Paris-Est, France: Caroline Appert (examinateur)
PhD: Fatemeh Rajabiyazdi, University of Calgary, Canada: Anastasia Bezerianos (rapporteur)
PhD: Amira Chalbi, Université Lille 1, France: Anastasia Bezerianos (examinateur)
HDR: Marcos Serrano, Université de Toulouse, France: Caroline Appert (président)

10. Bibliography

Major publications by the team in recent years

[1] C. APPERT, O. CHAPUIS, E. PIETRIGA, M.-J. LOBO. *Reciprocal Drag-and-Drop*, in "ACM Transactions on Computer-Human Interaction", September 2015, vol. 22, n^{o} 6, pp. 29:1–29:36 [*DOI :* 10.1145/2785670], https://hal.archives-ouvertes.fr/hal-01185805

[2] O. CHAPUIS, A. BEZERIANOS, S. FRANTZESKAKIS. *Smarties: An Input System for Wall Display Development*, in "CHI '14", Toronto, Canada, ACM, April 2014, pp. 2763-2772 [*DOI :* 10.1145/2556288.2556956], https://hal.archives-ouvertes.fr/hal-00979034

[3] C. LIU, O. CHAPUIS, M. BEAUDOUIN-LAFON, E. LECOLINET. *CoReach: Cooperative Gestures for Data Manipulation on Wall-sized Displays*, in "Proceedings of the 35th international conference on Human factors in computing systems", Denver, United States, CHI '17, ACM, May 2017 [*DOI :* 10.1145/3025453.3025594], https://hal.archives-ouvertes.fr/hal-01437091

[4] M.-J. LOBO, C. APPERT, E. PIETRIGA. *Animation Plans for Before-and-After Satellite Images*, in "IEEE Transactions on Visualization and Computer Graphics", January 2018, vol. 24 [*DOI :* 10.1109/TVCG.2018.2796557], https://hal.inria.fr/hal-01773882

[5] M.-J. LOBO, E. PIETRIGA, C. APPERT. *An Evaluation of Interactive Map Comparison Techniques*, in "CHI '15 Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems", Seoul, South Korea, ACM, April 2015, pp. 3573-3582 [*DOI :* 10.1145/2702123.2702130], https://hal.inria.fr/hal-01144163

[6] R. MORALES GONZÁLEZ, C. APPERT, G. BAILLY, E. PIETRIGA. *TouchTokens: Guiding Touch Patterns with Passive Tokens*, in "2016 CHI Conference on Human Factors in Computing Systems", San Jose, CA, United States, May 2016 [*DOI :* 10.1145/2858036.2858041], https://hal.archives-ouvertes.fr/hal-01315130

[7] H. OLAFSDOTTIR, C. APPERT. *Multi-Touch Gestures for Discrete and Continuous Control*, in "International Working Conference on Advanced Visual Interfaces (AVI)", Como, Italy, May 2014, 8 p. [*DOI :* 10.1145/2598153.2598169], https://hal.archives-ouvertes.fr/hal-00998971

[8] E. PIETRIGA, F. DEL CAMPO, A. IBSEN, R. PRIMET, C. APPERT, O. CHAPUIS, M. HEMPEL, R. MUÑOZ, S. EYHERAMENDY, A. JORDAN, H. DOLE. *Exploratory Visualization of Astronomical Data on Ultra-high-resolution Wall Displays*, in "Proceedings SPIE", July 2016, vol. 9913, 15 p. [*DOI :* 10.1117/12.2231191], https://hal.inria.fr/hal-01350722

[9] A. PROUZEAU, A. BEZERIANOS, O. CHAPUIS. *Evaluating Multi-User Selection for Exploring Graph Topology on Wall-Displays*, in "IEEE Transactions on Visualization and Computer Graphics", August 2017, vol. 23, n^{o} 8, pp. 1936–1951 [*DOI :* 10.1109/TVCG.2016.2592906], https://hal.archives-ouvertes.fr/hal-01348578

[10] T. TSANDILAS, A. BEZERIANOS, T. JACOB. *SketchSliders: Sketching Widgets for Visual Exploration on Wall Displays*, in "Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems", Seoul, South Korea, ACM, April 2015, pp. 3255-3264 [*DOI :* 10.1145/2702123.2702129], https://hal.archives-ouvertes.fr/hal-01144312

Publications of the year

Articles in International Peer-Reviewed Journals

[11] T. BLASCHECK, L. BESANÇON, A. BEZERIANOS, B. LEE, P. ISENBERG. *Glanceable Visualization: Studies of Data Comparison Performance on Smartwatches*, in "IEEE Transactions on Visualization and Computer Graphics", January 2019, vol. 25, n^{o} 1, https://hal.inria.fr/hal-01851306

[12] E. DIMARA, G. BAILLY, A. BEZERIANOS, S. FRANCONERI. *Mitigating the Attraction Effect with Visualizations*, in "IEEE Transactions on Visualization and Computer Graphics", October 2018, 11 p. [*DOI :* 10.1109/TVCG.2018.2865233], https://hal.inria.fr/hal-01845004

[13] E. DIMARA, A. BEZERIANOS, P. DRAGICEVIC. *Conceptual and Methodological Issues in Evaluating Multidimensional Visualizations for Decision Support*, in "IEEE Transactions on Visualization and Computer Graphics", 2018, vol. 24 [*DOI :* 10.1109/TVCG.2017.2745138], https://hal.inria.fr/hal-01584729

[14] E. DIMARA, S. FRANCONERI, C. PLAISANT, A. BEZERIANOS, P. DRAGICEVIC. *A Task-based Taxonomy of Cognitive Biases for Information Visualization*, in "IEEE Transactions on Visualization and Computer Graphics", 2019, https://hal.sorbonne-universite.fr/hal-01868738

[15] A. GOGOLOU, T. TSANDILAS, T. PALPANAS, A. BEZERIANOS. *Comparing Similarity Perception in Time Series Visualizations*, in "IEEE Transactions on Visualization and Computer Graphics", October 2018, 11 p. , https://hal.inria.fr/hal-01845008

[16] M.-J. LOBO, C. APPERT, E. PIETRIGA. *Animation Plans for Before-and-After Satellite Images*, in "IEEE Transactions on Visualization and Computer Graphics", January 2018, vol. 24 [*DOI :* 10.1109/TVCG.2018.2796557], https://hal.inria.fr/hal-01773882

International Conferences with Proceedings

[17] C. APPERT, E. PIETRIGA, E. BARTENLIAN, R. MORALES GONZÁLEZ. *Custom-made Tangible Interfaces with TouchTokens*, in "Proceedings of the International Working Conference on Advanced Visual Interfaces", Grosseto, Italy, AVI '18, ACM, May 2018 [*DOI :* 10.1145/3206505.3206509], https://hal.archives-ouvertes.fr/hal-01777599

[18] T. BLASCHECK, A. BEZERIANOS, L. BESANÇON, B. LEE, P. ISENBERG. *Preparing for Perceptual Studies: Position and Orientation of Wrist-worn Smartwatches for Reading Tasks*, in "Proceedings of the Workshop on Data Visualization on Mobile Devices held at ACM CHI", Montréal, Canada, April 2018, https://hal.inria.fr/hal-01744246

[19] B. FRUCHARD, E. LECOLINET, O. CHAPUIS. *Command Memorisation: Spatial Positions versus Directional Gestures*, in "30eme conférence francophone sur l'interaction homme-machine", Brest, France, Articles Scientifiques, AFIHM, October 2018, pp. 92-99, https://hal.archives-ouvertes.fr/hal-01899048

[20] B. FRUCHARD, E. LECOLINET, O. CHAPUIS. *How Memorizing Positions or Directions Affects Gesture Learning?*, in "Proceedings of the 2018 International Conference on Interactive Surfaces and Spaces", Tokyo, Japan, ISS '18, ACM, November 2018, pp. 107–114 [*DOI :* 10.1145/3279778.3279787], https://hal.archives-ouvertes.fr/hal-01891436

[21] B. FRUCHARD, E. LECOLINET, O. CHAPUIS. *Impact of Semantic Aids on Command Memorization for On-Body Interaction and Directional Gestures*, in "AVI 2018 - International Conference on Advanced Visual Interfaces", Castiglione della Pescaia, Grosseto, Italy, ACM, May 2018 [*DOI :* 10.1145/3206505.3206524], https://hal.archives-ouvertes.fr/hal-01764757

[22] E. PIETRIGA, H. GÖZÜKAN, C. APPERT, M. DESTANDAU, Š. ČEBIRIĆ, F. GOASDOUÉ, I. MANOLESCU. *Browsing Linked Data Catalogs with LODAtlas*, in "ISWC 2018 - 17th International Semantic Web Conference", Monterey, United States, Springer, October 2018, pp. 137-153, https://hal.inria.fr/hal-01827766

[23] A. PROUZEAU, A. BEZERIANOS, O. CHAPUIS. *Awareness Techniques to Aid Transitions between Personal and Shared Workspaces in Multi-Display Environments*, in "Proceedings of the 2018 International Conference on Interactive Surfaces and Spaces", Tokyo, Japan, ISS '18, ACM, November 2018, pp. 291–304 [*DOI :* 10.1145/3279778.3279780], https://hal.archives-ouvertes.fr/hal-01890787

[24] H. ROMAT, C. APPERT, B. BACH, N. HENRY-RICHE, E. PIETRIGA. *Animated Edge Textures in Node-Link Diagrams: a Design Space and Initial Evaluation*, in "Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems", Montréal, Canada, CHI '18, ACM, April 2018, pp. 187:1–187:13 [*DOI :* 10.1145/3173574.3173761], https://hal.inria.fr/hal-01726358

[25] V. RUSŇÁK, C. APPERT, O. CHAPUIS, E. PIETRIGA. *Designing Coherent Gesture Sets for Multi-scale Navigation on Tabletops*, in "Proceedings of the 36th international conference on Human factors in computing systems", Montreal, Canada, CHI '18, ACM, April 2018, pp. 142:1-142:12 [*DOI :* 10.1145/3173574.3173716], https://hal.inria.fr/hal-01722189

Conferences without Proceedings

[26] T. BLASCHECK, L. BESANÇON, A. BEZERIANOS, B. LEE, P. ISENBERG. *Visualization perception on smartwatches*, in "Journée Visu 2018", Palaiseau, France, May 2018, https://hal.inria.fr/hal-01844726

[27] B. FRUCHARD, E. LECOLINET, O. CHAPUIS. *Command Memorization: Spatial Positions versus Directional Gestures*, in "Proceedings of the 30e Confe´rence Francophone sur l'Interaction Homme-Machine", Chauvigny, France, October 2018 [*DOI :* 10.1145/3286689.3286700], https://hal.archives-ouvertes.fr/hal-01898325

Scientific Books (or Scientific Book chapters)

[28] M. BILLINGHURST, M. CORDEIL, A. BEZERIANOS, T. MARGOLIS. *Collaborative Immersive Analytics*, in "Immersive Analytics", Marriott, K., Schreiber, F., Dwyer, T., Klein, K., Riche, N.H., Itoh, T., Stuerzlinger, W., Thomas, B.H., October 2018 [*DOI :* 10.1007/978-3-030-01388-2_8], https://hal.inria.fr/hal-01938529

[29] N. BOUKHELIFA, A. BEZERIANOS, E. LUTTON. *Evaluation of Interactive Machine Learning Systems*, in "Human and Machine LearningVisible, Explainable, Trustworthy and Transparent", J. ZHOU, F. CHEN (editors), Springer, July 2018, pp. 341-360, https://hal.inria.fr/hal-01845018

Research Reports

[30] A. GOGOLOU, T. TSANDILAS, T. PALPANAS, A. BEZERIANOS. *Comparing Time Series Similarity Perception under Different Color Interpolations*, Inria, June 2018, n° RR-9189, https://hal.inria.fr/hal-01844994

Other Publications

[31] A. KAMAKSHIDASAN, J. GALAZ, R. CIENFUEGOS, A. ROUSSEAU, E. PIETRIGA. *Comparative Visualization of Deep Water Asteroid Impacts on Ultra-high-resolution Wall Displays with Seawall*, October 2018, pp. 1-2, IEEE VIS 2018 - IEEE Conference on Visualization, Poster, https://hal.inria.fr/hal-01888112

[32] A. KAMAKSHIDASAN. *Spatial Comparison of Cricketers*, October 2018, pp. 1-2, IEEE VIS 2018 - IEEE Conference on Visualization, Poster, https://hal.inria.fr/hal-01852138

References in notes

[33] M. R. ENDSLEY, D. G. JONES (editors). *Designing for Situation Awareness: an Approach to User-Centered Design*, CRC Press, Taylor & Francis, 2012

[34] S. ABITEBOUL, P. BUNEMAN, D. SUCIU. *Data on the Web: From Relations to Semistructured Data and XML*, Morgan Kaufmann, 1999

[35] S. ABITEBOUL, P. SENELLART, V. VIANU. *The ERC Webdam on Foundations of Web Data Management*, in "Proc. of the 21st International Conference Companion on World Wide Web", WWW '12 Companion, ACM, 2012, pp. 211–214, http://doi.acm.org/10.1145/2187980.2188011

[36] J. ALVINA, C. APPERT, O. CHAPUIS, E. PIETRIGA. *RouteLens: Easy Route Following for Map Applications*, in "Proceedings of the International Working Conference on Advanced Visual Interfaces", AVI '14, ACM, 2014, pp. 125–128 [*DOI :* 10.1145/2598153.2598200]

[37] C. APPERT, O. CHAPUIS, E. PIETRIGA. *High-precision magnification lenses*, in "Proceedings of the 28th international conference on Human factors in computing systems", CHI '10, ACM, 2010, pp. 273–282 [*DOI :* 10.1145/1753326.1753366]

[38] C. APPERT, J.-D. FEKETE. *OrthoZoom Scroller: 1D Multi-scale Navigation*, in "Proceedings of the SIGCHI Conference on Human Factors in Computing Systems", New York, NY, USA, CHI '06, ACM, 2006, pp. 21–30, http://doi.acm.org/10.1145/1124772.1124776

[39] M. BEAUDOUIN-LAFON, S. HUOT, M. NANCEL, W. MACKAY, E. PIETRIGA, R. PRIMET, J. WAGNER, O. CHAPUIS, C. PILLIAS, J. R. EAGAN, T. GJERLUFSEN, C. KLOKMOSE. *Multisurface Interaction in the WILD Room*, in "IEEE Computer", 2012, vol. 45, n° 4, pp. 48-56 [*DOI :* 10.1109/MC.2012.110]

[40] E. BENSON, D. KARGER. *End-users Publishing Structured Information on the Web: An Observational Study of What, Why, and How*, in "Proc. of the SIGCHI Conference on Human Factors in Computing Systems", CHI '14, ACM, 2014, pp. 1265–1274, http://doi.acm.org/10.1145/2556288.2557036

[41] J. BERNDTSSON, M. NORMARK. *The coordinative functions of flight strips: air traffic control work revisited*, in "Proceedings of the international ACM SIGGROUP conference on Supporting group work", GROUP '99, ACM, 1999, pp. 101–110, http://doi.acm.org/10.1145/320297.320308

[42] T. BERNERS-LEE, Y. CHEN, L. CHILTON, D. CONNOLLY, R. DHANARAJ, J. HOLLENBACH, A. LERER, D. SHEETS. *Tabulator: Exploring and Analyzing linked data on the Semantic Web*, in "Proc. of the International Semantic Web User Interaction Workshop", 2006

[43] J. BERTIN. *Semiology of Graphics*, University of Wisconsin Press, 1983

[44] A. BEZERIANOS, R. BALAKRISHNAN. *View and Space Management on Large Displays*, in "IEEE Computer Graphics and Applications", 2005, vol. 25, n^o^ 4, pp. 34-43

[45] A. BEZERIANOS. *Using alternative views for layout, comparison and context switching tasks in wall displays*, in "OZCHI", 2007, pp. 303-310

[46] D. BONNET, C. APPERT, M. BEAUDOUIN-LAFON. *Extending the Vocabulary of Touch Events with ThumbRock*, in "Proceedings of Graphics Interface", GI '13, CIPS, 2013, pp. 221-228, http://dl.acm.org/citation.cfm?id=2532129.2532166

[47] A. COLLINS, A. BEZERIANOS, G. MCEWAN, M. RITTENBRUCH, R. WASINGER, J. KAY. *Understanding File Access Mechanisms for Embedded Ubicomp Collaboration Interfaces*, in "Proceedings of the 11th International Conference on Ubiquitous Computing", New York, NY, USA, UbiComp '09, ACM, 2009, pp. 135–144, http://doi.acm.org/10.1145/1620545.1620567

[48] A.-S. DADZIE, M. ROWE. *Approaches to Visualising Linked Data: A Survey*, in "Semantic Web", 2011, vol. 2, n^o^ 2, http://dx.doi.org/10.3233/SW-2011-0037

[49] E. DIMARA, A. BEZERIANOS, P. DRAGICEVIC. *The Attraction Effect in Information Visualization*, in "IEEE Transactions on Visualization and Computer Graphics", 2017, vol. 23, n^o^ 1 [*DOI :* 10.1109/TVCG.2016.2598594], https://hal.inria.fr/hal-01355750

[50] A. DIX, G. LEPOURAS, A. KATIFORI. *From the web of data to a world of action*, in "Web Semantics", 2010, vol. 8, pp. 394–408, http://dx.doi.org/10.1016/j.websem.2010.04.007

[51] D. FENSEL, J. HENDLER, H. LIEBERMAN, W. WAHLSTER. *Spinning the Semantic Web: Bringing the World Wide Web to Its Full Potential*, MIT Press, 2005

[52] C. FORLINES, A. ESENTHER, C. SHEN, D. WIGDOR, K. RYALL. *Multi-user, Multi-display Interaction with a Single-user, Single-display Geospatial Application*, in "Proceedings of the 19th Annual ACM Symposium on User Interface Software and Technology", UIST '06, ACM, 2006, pp. 273–276, http://doi.acm.org/10.1145/1166253.1166296

[53] J. GRUDIN. *Computer-Supported Cooperative Work: History and Focus*, in "IEEE Computer", May 1994, vol. 27, n^o^ 5, pp. 19–26, http://dx.doi.org/10.1109/2.291294

[54] T. HEATH, C. BIZER. *Linked Data: Evolving the Web into a Global Data Space*, Morgan & Claypool, 2011

[55] J. HEBELER, M. FISHER, R. BLACE, A. PEREZ-LOPEZ. *Semantic web programming*, Wiley & Sons, 2011

[56] M. HILDEBRAND, J. VAN OSSENBRUGGEN, L. HARDMAN. */facet: A Browser for Heterogeneous Semantic Web Repositories*, in "ISWC'06: Proc. of the International Semantic Web Conference", Springer, 2006, pp. 272–285

[57] D. F. HUYNH, R. C. MILLER, D. KARGER. *Potluck: Data Mash-up Tool for Casual Users*, in "Web Semantics", 2008, vol. 6, n^{o} 4, pp. 274–282, http://dx.doi.org/10.1016/j.websem.2008.09.005

[58] H. ISHII, B. ULLMER. *Tangible Bits: Towards Seamless Interfaces Between People, Bits and Atoms*, in "Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems", CHI '97, ACM, 1997, pp. 234–241, http://doi.acm.org/10.1145/258549.258715

[59] J. A. JACKO. *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, 3rd Edition*, 3rd, CRC Press, 2012

[60] D. KARGER, S. OSTLER, R. LEE. *The Web Page As a WYSIWYG End-user Customizable Database-backed Information Management Application*, in "Proc. of the Symposium on User Interface Software and Technology", UIST '09, ACM, 2009, pp. 257–260, http://doi.acm.org/10.1145/1622176.1622223

[61] A. KATIFORI, C. HALATSIS, G. LEPOURAS, C. VASSILAKIS, E. GIANNOPOULOU. *Ontology visualization methods—a survey*, in "ACM Computing Surveys", 2007, vol. 39, n^{o} 4, pp. 10:1-10:42

[62] C. LIU, O. CHAPUIS, M. BEAUDOUIN-LAFON, E. LECOLINET. *Shared Interaction on a Wall-Sized Display in a Data Manipulation Task*, in "Proceedings of the 34th international conference on Human factors in computing systems", San Jose, United States, CHI '16, ACM, May 2016, pp. 1-12 [*DOI :* 10.1145/2858036.2858039], https://hal.inria.fr/hal-01275535

[63] C. LIU, O. CHAPUIS, M. BEAUDOUIN-LAFON, E. LECOLINET, W. MACKAY. *Effects of Display Size and Navigation Type on a Classification Task*, in "Proceedings of the 32nd international conference on Human factors in computing systems", CHI '14, ACM, 2014, pp. 4147-4156, http://doi.acm.org/10.1145/2556288.2557020

[64] W. MACKAY. *Is paper safer? The role of paper flight strips in air traffic control*, in "ACM Trans. Comput.-Hum. Interact.", December 1999, vol. 6, pp. 311–340, http://doi.acm.org/10.1145/331490.331491

[65] R. MORALES GONZÁLEZ, C. APPERT, G. BAILLY, E. PIETRIGA. *TouchTokens: Guiding Touch Patterns with Passive Tokens*, in "Proceedings of the SIGCHI Conference on Human Factors in Computing Systems", New York, NY, USA, CHI '16, ACM, 2016, To appear

[66] T. MUNZNER. *Visualization Analysis and Design*, CRC Press, 2014

[67] M. NANCEL, O. CHAPUIS, E. PIETRIGA, X.-D. YANG, P. P. IRANI, M. BEAUDOUIN-LAFON. *High-precision pointing on large wall displays using small handheld devices*, in "Proceedings of the SIGCHI Conference on Human Factors in Computing Systems", CHI '13, ACM, 2013, pp. 831–840, http://doi.acm.org/10.1145/2470654.2470773

[68] M. NANCEL, E. PIETRIGA, O. CHAPUIS, M. BEAUDOUIN-LAFON. *Mid-air Pointing on Ultra-Walls*, in "ACM Transactions on Computer-Human Interaction", August 2015, vol. 22, n^{o} 5, pp. 21:1–21:62 [*DOI :* 10.1145/2766448], https://hal.inria.fr/hal-01184544

[69] A.-C. NGONGA NGOMO, L. BÜHMANN, C. UNGER, J. LEHMANN, D. GERBER. *Sorry, I Don'T Speak SPARQL: Translating SPARQL Queries into Natural Language*, in "Proc. of the International Conference on World Wide Web", WWW '13, ACM, 2013, pp. 977–988, http://dl.acm.org/citation.cfm?id=2488388.2488473

[70] H. OLAFSDOTTIR, T. TSANDILAS, C. APPERT. *Prospective Motor Control on Tabletops: Planning Grasp for Multitouch Interaction*, in "Proceedings of the 32nd international conference on Human factors in computing systems", CHI '14, ACM, 2014, pp. 2893-2902, http://doi.acm.org/10.1145/2556288.2557029

[71] E. PIETRIGA, C. APPERT, M. BEAUDOUIN-LAFON. *Pointing and beyond: an operationalization and preliminary evaluation of multi-scale searching*, in "CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems", ACM Press, 2007, pp. 1215–1224 [*DOI :* 10.1145/1240624.1240808]

[72] E. PIETRIGA, C. APPERT. *Sigma lenses: focus-context transitions combining space, time and translucence*, in "CHI '08: Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems", ACM, 2008, pp. 1343–1352 [*DOI :* 10.1145/1357054.1357264]

[73] E. PIETRIGA, O. BAU, C. APPERT. *Representation-Independent In-Place Magnification with Sigma Lenses*, in "IEEE Transactions on Visualization and Computer Graphics (TVCG)", 2010, vol. 16, n^o 03, pp. 455-467 [*DOI :* 10.1109/TVCG.2009.98]

[74] E. PIETRIGA, C. BIZER, D. KARGER, R. LEE. *Fresnel - A Browser-Independent Presentation Vocabulary for RDF*, in "Proceedings of the 5th International Semantic Web Conference (ISWC 2006)", Springer, November 2006, pp. 158-171

[75] E. PIETRIGA, S. HUOT, M. NANCEL, R. PRIMET. *Rapid development of user interfaces on cluster-driven wall displays with jBricks*, in "Proceedings of the 3rd ACM SIGCHI symposium on Engineering interactive computing systems", EICS '11, ACM, 2011, pp. 185–190, http://doi.acm.org/10.1145/1996461.1996518

[76] E. PIETRIGA. *A Toolkit for Addressing HCI Issues in Visual Language Environments*, in "IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)", IEEE Computer Society, 2005, pp. 145-152 [*DOI :* 10.1109/VLHCC.2005.11]

[77] C. PINDAT, E. PIETRIGA, O. CHAPUIS, C. PUECH. *JellyLens: Content-Aware Adaptive Lenses*, in "UIST - 25th Symposium on User Interface Software and Technology - 2012", Cambridge, MA, United States, Proceedings of the 25th Symposium on User Interface Software and Technology, ACM, October 2012, pp. 261-270 [*DOI :* 10.1145/2380116.2380150], https://hal.inria.fr/hal-00721574

[78] C. PINDAT, E. PIETRIGA, O. CHAPUIS, C. PUECH. *Drilling into complex 3D models with gimlenses*, in "Proceedings of the 19th ACM Symposium on Virtual Reality Software and Technology", VRST '13, ACM, 2013, pp. 223–230, http://doi.acm.org/10.1145/2503713.2503714

[79] N. SHADBOLT, T. BERNERS-LEE, W. HALL. *The Semantic Web Revisited*, in "IEEE Intelligent Systems", 2006, vol. 21, n^o 3, pp. 96-101, http://doi.ieeecomputersociety.org/10.1109/MIS.2006.62

[80] O. SHAER, E. HORNECKER. *Tangible User Interfaces: Past, Present, and Future Directions*, in "Found. Trends Hum.-Comput. Interact.", January 2010, vol. 3, n^o 1–2, pp. 1–137, http://dx.doi.org/10.1561/1100000026

[81] B. SHNEIDERMAN, C. PLAISANT. *Designing the User Interface, 4th Edition*, Pearson Addison Wesley, 2005

[82] D. SPELMEZAN, C. APPERT, O. CHAPUIS, E. PIETRIGA. *Controlling widgets with one power-up button*, in "Proceedings of the 26th annual ACM symposium on User interface software and technology", UIST '13, ACM, 2013, pp. 71–74, http://doi.acm.org/10.1145/2501988.2502025

[83] D. SPELMEZAN, C. APPERT, O. CHAPUIS, E. PIETRIGA. *Side pressure for bidirectional navigation on small devices*, in "Proceedings of the 15th international conference on Human-computer interaction with mobile devices and services", MobileHCI '13, ACM, 2013, pp. 11–20, http://doi.acm.org/10.1145/2493190.2493199

[84] G. TOUYA, J.-F. GIRRES. *ScaleMaster 2.0: a ScaleMaster extension to monitor automatic multi-scales generalizations*, in "Cartography and Geographic Information Science", 2013, vol. 40, n^o 3, pp. 192–200, http://dx.doi.org/10.1080/15230406.2013.809233

[85] G. TOUYA. *Social Welfare to Assess the Global Legibility of a Generalized Map*, in "International Conference on Geographic Information", Springer, 2012, pp. 198–211, http://dx.doi.org/10.1007/978-3-642-33024-7_15

[86] T. TSANDILAS, C. APPERT, A. BEZERIANOS, D. BONNET. *Coordination of Tilt and Touch in One- and Two-Handed Use*, in "Proceedings of the 32nd international conference on Human factors in computing systems", CHI '14, ACM, 2014, pp. 2001-2004, http://doi.acm.org/10.1145/2556288.2557088

[87] G. TUMMARELLO, R. DELBRU, E. OREN. *Sindice.com: Weaving the Open Linked Data*, in "Proc. of the 6th Int. Semantic Web Conf. (ISWC2007)", Springer-Verlag, 2007, pp. 552–565

[88] C. WARE. *Information visualization: perception for design*, Elsevier, 2012

[89] S. ZHAI, P. O. KRISTENSSON, C. APPERT, T. H. ANDERSEN, X. CAO. *Foundational Issues in Touch-Screen Stroke Gesture Design - An Integrative Review*, in "Foundations and Trends in Human-Computer Interaction", December 2012, vol. 5, n^o 2, pp. 97-205 [*DOI :* 10.1561/1100000012], https://hal.inria.fr/hal-00765046

[90] R. A. DE ALMEIDA, C. PILLIAS, E. PIETRIGA, P. CUBAUD. *Looking behind bezels: french windows for wall displays*, in "Proceedings of the International Working Conference on Advanced Visual Interfaces", AVI '12, ACM, 2012, pp. 124–131, http://doi.acm.org/10.1145/2254556.2254581