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Supporting Visual Analysis in Smart Meeting Rooms

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Abstract

Smart meeting rooms as a specific form of multi-display environments (MDE) feature ad-hoc ensembles of heterogeneous devices and software tools to facilitate collective work and information sharing between multiple users. This makes them excellent environments for supporting visual analytics sessions. Effective use of MDE requires not only appropriate visual representations of the information needed by each user for her current task but also the efficient utilization of available display space by means of suitable view management. In this paper, we propose a task-driven approach to Smart View Management that combines automated task-based view configuration with interactive user specification of selected analysis task aspects. It is based on a general task typology capable of expressing the role of individual data views with respect to a given, possibly compound analysis task. The feasibility of the proposed approach is discussed by virtue of a use case from the climate impact research domain.

Categories and Subject Descriptors (according to ACM CCS): H.5.0 [Information interfaces and presentation]: General—; I.3.0 [Computer graphics]: General—

1. Motivation and Problem Description

Smart meeting rooms are physical spaces featuring heterogeneous ad-hoc ensembles that integrate personal devices (laptops, smart phones etc.) and software of multiple users. In particular, they can be considered a specific form of multi-display environments (MDE) with highly dynamic display configurations. MDE in general are well-suited to support users in sharing and jointly discussing information to reach a common analysis goal [VDVKW*07]. By collecting and processing information about users and their environment smart meeting rooms further strive to react to the current situation in a "smart" way by adapting their configuration and behavior automatically [YHHC05]. Thus, smart meeting rooms provide an excellent environment in terms of supporting collaborative Visual Analytics sessions.

The challenges to be solved here are two-fold. The primary objective to show each user the information needed by a visual representation of arbitrary applications appropriate for her current task. This challenge is addressed through the different existing designs for scalable, interactive visual analysis tools that are capable of adapting information presentations to support various tasks (e.g., [KKEM10]).

Here, we focus on an important additional objective within MDE: the proper utilization of displays available in the environment. Shared information should be displayed on large public displays (e.g., projectors, large monitors or display walls) while private information is simultaneously presented on smaller personal displays. A smart meeting room ideally provides support to attain corresponding display layout configurations automatically. Yet it must also allow users to interactively fine-tune or override the system's decisions as to not patronize them [HK07].

A recent approach towards this goal is the Smart View Management (SVM) proposed in [RLS11]. It specifically aims to increase the utility of multiple shared views on different displays. The general idea of SVM is to combine the visual outputs of applications rather than postulating their interoperability on the data or functional level. This means that instead of attempting to create a Visual Analytics framework capable of integrating different tools, the visual outputs of these tools are collected and assigned to available displays using a uniform user interface. Using the SVM the user specifies what should be displayed. This is achieved by defining *Views* representing arbitrary content (visualization, video, document, slides, etc.). By interactively grouping views into *view packages* the user may describe if and how view contents are related. Indicating by whom content is consumed (single user, or presentation to group) facilitates optimized view assignment to available displays by the SVM.

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Figure 1: *A typical collaborative analysis working situation in our smart meeting room providing multiple displays. Output from independent software tools is assigned to available displays using proposed SVM.*

However, to provide appropriate information presentation for the current analysis task(s) to be solved a re-assignment of views, and thus, a task-based adaptation of the SVM's parametrization is needed.

In this paper we propose a task-driven approach to Visual Analytics support in smart meeting rooms. This objective improves on both the configuration of individual views as well as the layout and presentation of views on displays of the room, compared to the original SVM [RLS11].

2. Smart View Management

The SVM was developed to configure the information display in heterogeneous multi-display environments. The general idea of SVM is to combine the visual outputs of the applications instead of intertwining the applications itself. Therefore, the term "view" was defined, describing everything displayable (visualizations, slides, documents, ...). To generate these views, two options have been developed: the 'ad-hoc' and the 'prepared' option. With the ad-hoc option, views from unmodified applications are grabbed. On the other hand, the prepared option provides an API that is integrated in the applications to generate the views on demand. The SVM consists of three functional parts realizing the combination of visual outputs of different applications - (1) the view package generation, (2) the smart display mapping and (3) the smart view layout.

Interactive View Package Generation
The *view packages* are assemblies of semantically related views. They are defined interactively via a lightweight GUI enabling the user to specify characteristics of the views and their view packages. The characteristics are specified by selecting semantic aspects. A first suggestion for these semantic aspects has been made in [RLS11].

Smart Display Mapping
The SDM automatically assigns views of the view packages to the displays available. Based on the properties of the users (e.g., position, view direction), the environmental properties (e.g., position of the display surfaces) and the semantic aspects of the view packages a mapping is calculated that guarantees good visibility of the views for all users. For this, an evolutionary algorithm evaluates possible display mappings by maximizing a quality function.

Smart View Layout
With the smart view layout multiple views are arranged on one display surface. A spring force based layout algorithm is used in combination with a pressure based resizing model to effectively utilize the display space available. These force and pressure based algorithms are dynamically recalculated to guarantee a dynamic adaptation of the layout.

Finally, the views are rendered on a specific display surface by the meta-renderer. It establishes a connection to the view generating application and gets a stream of the views via network. This views are then rendered in a size and position determined by the smart view layout.

Task Specification
Within SVM so far two different tasks are supported specifically considering a presentation scenario: presenting information, and comparison of information. However, Visual Analytics sessions are typically not limited to presentations, but rather heavily feature exploratory analysis scenarios as well. Therefore, it is imperative that presented views properly support analysis tasks occurring in either scenario type.

Andrienko & Andrienko [AA05] introduce a task model with formal task descriptions that allows for a comprehensive support for Visual Analytics sessions. Here, the tasks are divided into two classes: elementary and synoptic tasks. Elementary tasks consider individual elements, whereas synoptic tasks address a set of values. In case of smart view management, a view represents a single element. Thus, here we use *elementary task* when a *single view* is considered, and *synoptic task* if a *set of views* is addressed.

Elementary tasks are further divided into search and comparison tasks as conducted in [TFS08]. Search tasks are further distinguished between direct search (also referred to as

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identification) and inverse search (also referred to as *localization*). In terms of views, identification refers to the extraction of information from a single view. Localization means to find a certain view displaying information the user is looking for, and elementary comparison means to compare single views displaying information.

Synoptic tasks can be divided in the same manner. However, the semantics of the tasks are related to a set of elements – views in the context of SVM – instead of a single one. Here, *identification* means to extract information form a set of views displaying related information. *Localization* means to find views displaying related information, whereas *comparison* means to compare sets of views.

3. General Approach

To support users in exploratory visual analysis sessions, the current task of the users has to be determined. Depending on the result the contributing views have to be configured and the presentation behavior has to be specified. In this section we first present three types of tasks settings and then how the SVM is configured based on the task model described in Section 2. We further describe enhancements of the SVM to achieve a task specific view presentation.

3.1. Task setting

The first step in creating a suitable configuration of views presented within the Smart Meeting Room is to determine the analysis task(s) at hand. Here, three principal strategies can be distinguished.

Automatic SVM is the most extensive approach in terms of automated user support: current tasks are determined without the need for user intervention, and the views are subsequently configured automatically as well. However, it also postulates the availability of suitable workflow descriptions that capture sequences of analysis steps. In [GFF*07] and [BWB*11] it is shown that the current task at hand can indeed be inferred from workflow models by utilizing the ability to track user positions in the smart meeting room. A serious drawback of this strategy is that not only such workflow models/descriptions must be available for the users' visual analysis session; current inference approaches are limited to mostly linear workflows where tasks are executed step-by-step [BWB*11]. Moreover, [HK07] observe that for some users and specific situations, a fully automatic view configuration is perceived as too intrusive.

Semi-automatic view management instead relies on the user(s) to specify the task at hand interactively. SVM then automatically configures the views without further need for interaction. This strategy is thus applicable in situations where automatic task inference is not possible or unwanted, while still offering a reasonable level of automated configuration support. Here, the user selects from a list of available tasks those that best match her current intents, respectively the roles of the views she is interested in with respect to the task at hand. The SVM then configures the presentation of the views as with the fully automatic approach.

Interactive view management leaves the user in control of almost all aspects of configuration. While not offering any noteworthy level of automated task determination this mode of operations does not necessitate workflow descriptions. The view packages are created interactively by assigning tasks to views using a drag-n-drop interface. Even such an interactive specification of the task at hand is beneficial: it allows the SVM to automatically adapt view configuration and presentation within manually created view packages.

By selecting the most appropriate of these three strategies depending on the availability of workflow descriptions, sensory input from the environment and user preferences a comprehensive, smart view management support can be achieved for this particular type of MDE. Furthermore, the permanent availability of the interactive mode ensures the user always has full control and can fine-tune or override any automatic configuration proposed by the SVM – the current view configuration is shown in the interactive mode's interface; single views or packages can again be re-arranged by simple drag-n-drop gestures.

3.2. Task-driven view configuration

This section addresses the configuration of views regarding the tasks described in Section 2. In particular we discuss what support should be provided to users when performing these tasks. Furthermore, we describe the changes made to the smart view management to realize this task-driven support.

Elementary Identification means that information should be extracted from a single view. To support this task in terms of information presentation the view should be presented so that it is well legible. Therefore, it is presented on the display surface best visible for the users, i.e., in the center of the display surface by default. Here two functional components of the view management are concerned: the smart display mapping for the assignment of the view to an appropriate display surface, and the smart view layout to ensure the preservation of the view's central position within the display.

Elementary Localization refers to finding a specific view on one of the room's displays that displays information the users is looking for. To support this task a highlighting mechanism is employed that accentuates the view to be localized. Elementary localization does not entail changes to view configuration – the targeted view remains on the same display at a fixed position and size. Highlighting is achieved by the SVM rendering a colored border around the relevant view (see Figure 1). This eases spotting the searched view by the users on displays showing several outputs.

Elementary Comparison affects two or more views that

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should be compared. In terms of view configuration this means these views have to be presented in spatial proximity. This is already supported within SVM by utilizing the semantic aspect attribution of view packages. Here, a compare package is defined that includes all views to be compared. Based on this aspect the smart display mapping and the smart view layout arranges the views next to each other.

Synoptic Identification on a set of views means that specific information needs to be extracted from multiple coordinated views showing different aspects of the data. With respect to the individual views the same objectives as for elementary (i.e., single view) identification need to be met here: each view should be displayed at an appropriate position close to the center of the display and as large as possible, given the display is shared between multiple views.

To achieve this *view priorities* are introduced. In the original SVM views are assigned to displays by the display mapper based on their association with a particular view package. However, the views contained within a given view package were considered equally important, with the overall view mapping quality determined by summing up individual view scores. Hence, up to now it has not been possible to handle any individual view preferably, neither during display mapping (finding an appropriate display) nor view layout (ensuring a central position within the display).

With our new approach, weighting the view quality scores with the respective view priorities ensures that views with a higher priority are much more likely to be assigned to the display surface rated as best visible to the user. Note that 'best visible display' is a dynamic property as users move around in the MDE. Likewise, weighting the views' positions within that display by their priorities – whereas positions closer to the display's center are rated higher – evaluates view layouts better where the most important views are placed more centrally, as opposed to layouts that would move those views to the screen's periphery.

Synoptic Localization of a set of views means to find multiple views displayed in the smart meeting room. Here, basically the same support as in elementary localization is needed. Multiple views are highlighted.

Synoptic Comparison a set of views means to display these views next to each other. In terms of smart view management a synoptic comparison means that view packages have to be compared. As described above the SVM already supports the comparison task. Since the synoptic case concerns views already defined in separate view packages, we temporarily compose a temporary 'compound' view package containing all views of the view packages to be compared. After completing the task, the temporary package is disbanded and the original view packages are used.

If the views to be displayed change, by applications adding, removing or updating views, view packages as well as the view configuration are dynamically re-adjusted with regards to the current task, regardless of how tasks are associated with views (i.e., automatic, interactively).

4. Use Case

In this section we briefly discuss a prototypical Visual Analytics scenario – an analysis session of of three climate impact researchers [RNS11]. This scenario assumes the analysis tasks are known to the SVM module by virtue of a workflow description format (e.g., [PMM97, tHvdA05]) so that semi-automatic task specification is possible.

First, user A *presents* the predicted temperature in Europe for the next 50 years. This is an identification task concerning a set of views. Therefore, all views presenting temperature in Europe are presented to be readable for the entire audience (second canvas from the right in Figure 1).

Then, user B *compares* the temperature development with the vegetation development for the same time period; a synoptic comparison task. Therefore, the compare relation is set to the view package holding the temperature views as well as the view package holding the vegetation views generated by user B's visualization tool. As a result both view packages are places on displays next to each other (the two rightmost canvases in Figure 1).

Following this comparison, user C comments on a specific time period where an unusual development might have occurred. To verify this hypothesis, the researchers needs to *locate* the views that present information from this time period. The corresponding views are thus highlighted by the SVM independently of the tools that created their contents (seen in Figure 1 as views with a red border).

5. Conclusion and Future Work

To support users working together in a Visual Analytics session an information presentation is necessary that fits the tasks to be performed. In this paper we presented an approach for a task-driven Visual Analytics support in smart meeting rooms. Based on either an automatic, semi-automatic or interactive task assignment the views are configured by the smart view management for presentation within the multi-display environment.

As future work we currently aim for two enhancements. The integration of an overarching interaction management would allow for unified interaction with any view regardless of which tool generated its contents. However such shared interaction across application boundaries is a separate concern but also a non-trivial problem. In fact, we are currently conceptualizing a "smart interaction management" approach [RLSS12] to complement the view-level integration that is the SVM proposed here. This would ease view adaptation in interactive view management mode. Second, synoptic comparison task support could be further improved by integrating the visual links concept [WPL*10] with the current highlighting strategy.

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