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# Detection of Diabetic Neuropathy – Can Visual Analytics Methods Really Help in Practice?

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**Abstract**

*Visual analytics (VA) methods are valuable means for supporting the detection of diabetic neuropathy, the most common long-term complication of diabetes mellitus. We suggest two strategies for strengthening reliability, reproducibility, and applicability of dedicated VA methods in practice. First, we introduce a novel workflow visualization that shows activities together with meta-data and produced output, facilitating a guided step-wise analysis. Second, we present a tailored user interface that integrates various VA tools, unifying access to their functionality and enabling free exploration for further assisting the medical diagnosis. By applying both strategies, we effectively enhance the practical utility of our VA approach for detecting diabetic neuropathy.*

Categories and Subject Descriptors (according to ACM CCS): Human-centered computing – Visualization – Visualization application domains – Visual analytics

## 1. Introduction

Diabetes mellitus is a widely spread and costly disease [?]. The most common long-term complication is diabetic neuropathy. To reduce or even avoid such implications, it is essential to detect nerve fiber abnormalities as early as possible. Recently, corneal confocal microscopy has enabled advances in the recognition of nerve damage as an indicator for diabetic neuropathy [Efr11, ZPZ*14]. Nonetheless, a definite diagnosis is still a challenging problem. In [LRK*14] we introduced a visual analytics (VA) approach, which supports this task. The domain experts acknowledged our work. We were invited to publish in their journal and at their conference [RLK*14, RLTS15]. However, the awareness of novel solutions does not necessarily lead to applying them. In our opinion, the following important problems need to be solved to bridge this gap: i) ensuring reliability & reproducibility and ii) enhancing the applicability.

We tackle the first problem by communicating analysis steps and data in concert. The second problem is addressed by providing a well-designed user interface (UI), which allows to access different analysis tools and data sources under the same umbrella. In the following we describe our approach in more detail.

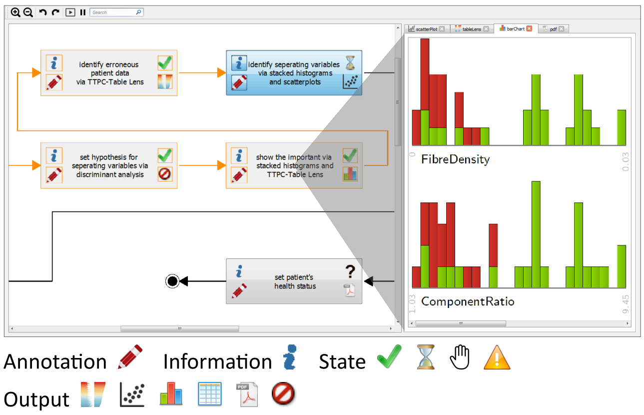


**Figure 1:** *Visualizing the analysis workflow together with meta-data and produced output. The left panel shows completed (orange), current (blue), and outstanding (black) activities as well as various meta-data via icons and tooltips. The right panel depicts step-wise produced output for selected activities, e.g., patient data for two picked ophthalmic variables via stacked histograms.*

## 2. Ensuring Reliability and Reproducibility

Most VA systems assume that users explore their data by selecting or merging arbitrary data subsets, by initiating computations on demand, and by creating diverse visualizations. In order to perform these steps, a user must have knowledge of both; the underlying application domain and the visual analysis. This is hardly the case. On the other hand, in many domains well-established workflows exist that define a sequence or network of activities and thus, can guide the user through the required analysis steps (e.g., [SSL*12]). We decided for this option as well. With our partners, we speci-

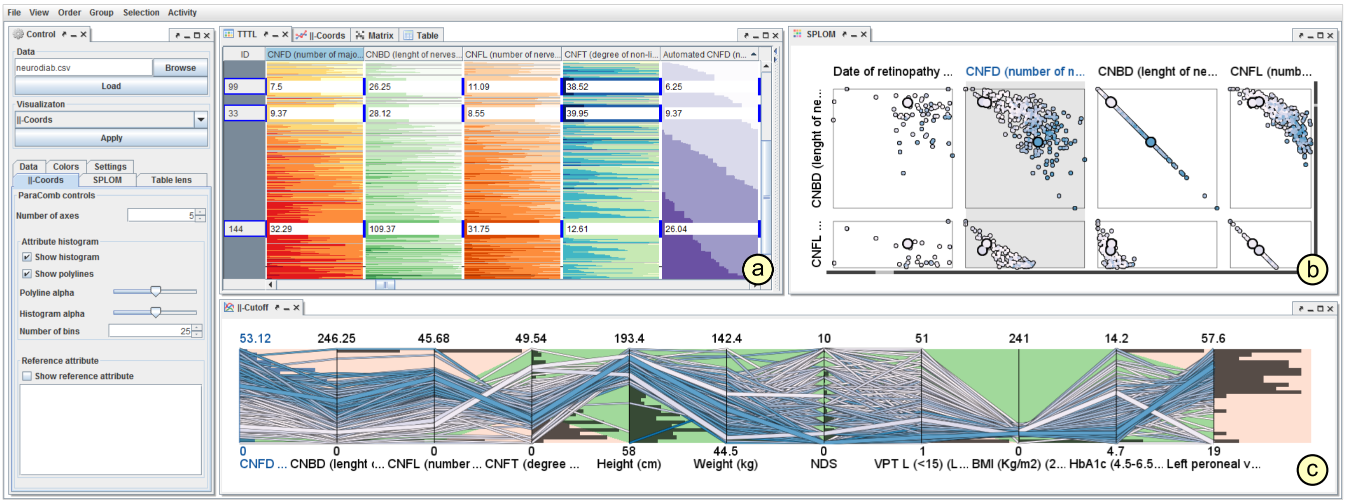


**Figure 2:** *Illustration of our unified interface design. The controls of the individual tools are integrated into one common panel shown on the left. The corresponding visualizations are arranged to the right: (a) table lens, (b) scatterplot matrix, and (c) parallel coordinates. Selected rows of the table lens are highlighted via thick polylines in the parallel coordinates and via large circles in the scatterplots.*

fied a VA workflow that supports the detection of diabetic neuropathy. This workflow is visualized along with meta-data as well as with the produced output. Meta-data encapsulate annotations, the state of the analysis process, as well as other additional information. Linked visual representations show step-wise produced data. This enables the user to examine, which activities already have been completed or should be carried out next to generate a certain result. This definitely enhances the reliability. Moreover, the given workflow might serve as a basis for reproducibility (cf. [SVK*08]). Figure 1 illustrates our design.

## 3. Enhancing the Applicability

One tailored VA system might completely support a particular workflow. However, typically a broader range of tools needs to be applied. In our case, we primarily consider three visualization tools: (i) a two-tone pseudo coloring table lens for overviews, (ii) a scatterplot matrix for showing measures and classifications, and (iii) parallel coordinates enhanced with stacked histograms for examining specific variables (cf. [LRK*14]).

Switching between different systems increases the effort of the user and thus, eventually might hinder the application of additional visualization tools. We tackle this problem by a unified user interface. Our design shows the control and visualization panels of the individual tools side-by-side. Clicking on one panel activates the corresponding tool and enables its functionality. Switching to another system just requires clicking on another view. The tools are synchronized via two mechanisms:

**On View-Level:** This per se is ensured via the unified UI, since the visualization panels of different tools are simultaneously displayed.

**On Data-Level:** This is realized by integrating the computed or selected data from one tool into the data structures of the other tools.

These coupling mechanisms are particularly tailored to our use case. They are simple, but sufficient. For instance, groups of a cluster analysis can be easily shared between the tools and visually compared in the respective views. Moreover, coordinating the views facilitates brushing and linking, e.g., selecting one or multiple rows in the table lens highlights the respective values in the other views as well. Figure 2 shows a screenshot of our unified UI. We are convinced that this unified access to different data and tools definitely increases the applicability of our VA approach.

## 4. Conclusion

VA methods are valuable means for supporting the diagnosis of early diabetic neuropathy. For enhancing reliability, reproducibility, and applicability of our VA tools in practice, we suggested two different strategies: (i) a novel workflow visualization and (ii) a unified UI design. Our workflow visualization allows for a guided stepwise analysis and thus, facilitates understanding and documenting the provenance of diagnosis results. Moreover, our design enables inspecting and reproducing whole workflows as well as individual activities. In fact, currently hardly any other approaches exist that simultaneously show a workflow together with meta-data and stepwise produced output. Our UI design aims at free exploration of data. Particularly for experienced users, the diagnosis can be further assisted through visually comparing patient records or examining details on demand. In sum, the workflow mainly supports understanding the analysis process, whereas the unified UI primarily supports understanding the data.

Currently, our workflow and our unified UI are provided by two uncoupled systems. For future work, we plan to combine both solutions. More precisely, we will tightly integrate the workflow visualization into the unified UI, allowing for seamlessly switching between guided and free visual analysis. This way, the utility of our VA approach will be further strengthened.

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