DETECTION OF DIABETIC NEUROPATHY

CAN VISUAL ANALYTICS METHODS REALLY HELP IN PRACTICE?

*Martin Röhlig*¹, *Oliver Stachs*², and *Heidrun Schumann*¹

¹Institute for Computer Science and ²Department of Ophthalmology

University of Rostock, Germany
• Diabetes is costly and widespread disease [WHO 16]
• Diabetic neuropathy (DN): most common long-term complication (pain, amputations, mortality)
• Early detection is important, but right now complicated
• Patient feedbacks and invasive methods are time-consuming and unpleasant
NEUROPATHY DETECTION

• Non-invasive early detection using ophthalmic markers
• Confocal laser scanning microscopy of cornea to identify nerve fiber damage [Allgeier 11]
• Autom. image analysis to quantify nerve fibers based on morphological and topological features [Winter 10]
Visual analytics methods [Luboschik 14]:
- Find markers to separate DN patients from healthy people
- Separate groups in clinical meaningful ways
- Understand existing separability measures
- Data cleansing
- Detect influencing factors [Röhlig 15]
PROBLEM

- Work [Röhlig 14, Röhlig 15] acknowledged by domain experts
  - But, only limited application in practice so far

GOALS

1) Ensure *reliability* and *reproducibility*
2) Enhance *applicability*
ENSURING RELIABILITY AND REPRODUCIBILITY

Workflow definition:

- Specify network of activities that support detection of DN
- Develop required VA steps together with domain experts

► Compensate limited VA knowledge
► Guide users through analysis
ENSURING RELIABILITY AND REPRODUCIBILITY

Workflow visualization:
- Show activities together with meta-data and produced output
  - Activities: selections, computations, assessments
  - Meta-data: states of activities, annotations, additional information
  - Produced output: generated visualizations, documents, images

- Inspect and reproduce whole workflows and individual activities
- Understand and document provenance of diagnosis results
ENSURING RELIABILITY AND REPRODUCIBILITY

Workflow visualization – activities:

Analysis steps

- Activity / Step
- Step 1
- Step 2
- Step 3

Alternatives

- Activity
- Option 1
- Option 2

Conditions

- Option 1
- Option 2
- [Condition 1] → Activity
- [Condition 2]
ENSURING RELIABILITY AND REPRODUCIBILITY

Workflow visualization – meta-data:

State of activities and workflow

- Activity [✓]
- ✔ completed
- ⚠ halted
- ⚠ outstanding
- ⚠ failed

Step 1 ➔ Step 2 ➔ Step 3 ➔ Step 4

(processed, current, unprocessed)

Additional information

- Tool tip
- Instructions
- Annotation
- Output
ENSURING RELIABILITY AND REPRODUCIBILITY

Workflow visualization – produced output:

Visualizations

Documents
ENSURING RELIABILITY AND REPRODUCIBILITY
ENHANCING APPLICABILITY

**Visual analysis via three VA tools** [Luboschik 14]:
1) Two-tone pseudo coloring table lens
2) Scatterplot matrix
3) Parallel coordinates enhanced with stacked bars

- But, switching increases effort and hinders application of different tools
  - *Unified user interface* and *unified access* to functionality
ENHANCING APPLICABILITY

Synchronization of VA tools:
• On view-level: different visualizations are displayed simultaneously
• On data-level: integrate data from one tool into other tools

► Assists diagnosis through visual exploration
► Allows for comparing patient records and examining details on-demand
ENHANCING APPLICABILITY

Synchronization on view-level:
- Show controls and visualization panels of individual tools side-by-side
- **One** control panel:
  - Incorporates common and specific functionality of all tools
  - Switching between tools by clicking on respective controls
- **Multiple** visualization panels:
  - One or more panels for each visualization technique of each tool
  - Vis. panels can be freely arranged, opened/closed, and resized

► UI easily expandable, e.g., adding visualizations or controls elements
ENHANCING APPLICABILITY

Synchronization on data-level:
• Data and state are distributed among individual tools
• Modifications are injected into respective data models
• Event-based loose coupling of functionality
  o Selections and visibility of attributes and patient records
  o Computations, grouping, and ordering
  o Coloring

► Updated data or state is automatically reflected in all views of different tools
► Facilitates coordinating views, e.g., brushing & linking
ENHANCING APPLICABILITY
SUMMARY

Ensure reliability and reproducibility:
• Specify VA workflow for supporting detection of DN
• Visualize activities together with meta-data and produced output
  ► Guided step-wise analysis
  ► Supports understanding the analysis process

Enhance applicability:
• Unify access to different data and tools via combined UI
  ► Free exploration and details on-demand through different tools
  ► Supports understanding the data
FUTURE WORK

• Integrate workflow into combined UI
  o Support entire workflow in unified way
  o Incorporate further tools (statistics, corneal image assessment)
    ▶ Seamless switch between guided and free visual analysis
• Extend testing of UI for clinical practice
Thank you for your attention!
Comments or questions?

martin.roehlig@uni-rostock.de
REFERENCES


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