Towards Fully Accessible Data Visualisation

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Introduction

- Data visualisation is increasingly important
- Statistics thrives on visualisation, diagrams are everywhere
  - starting in elementary school
  - in everyday publications: newspapers, magazines
  - in the workplace
- People with visual impairments are often excluded from accessing crucial information
- Allow VI users to become creators not just consumers of visualisations

Motivation and Aims

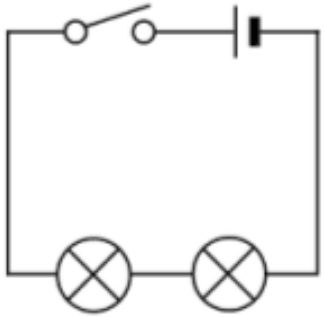
Bring together

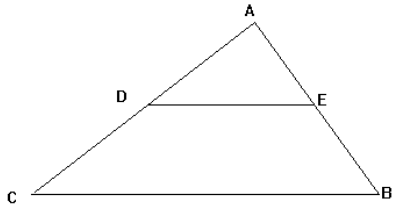
- Jonathan's work on tactile graphics in R
  - Jonathan is blind and a statistics professor x
  - Needs to create meaningful diagrams himself
- My work on web accessible STEM diagrams
  - End-to-end workflow for (some) STEM diagrams, using image analysis, semantic enrichment and a web interaction model
- Can we generate web accessible data visualisations?
- Can we support working VI statisticians/students directly?

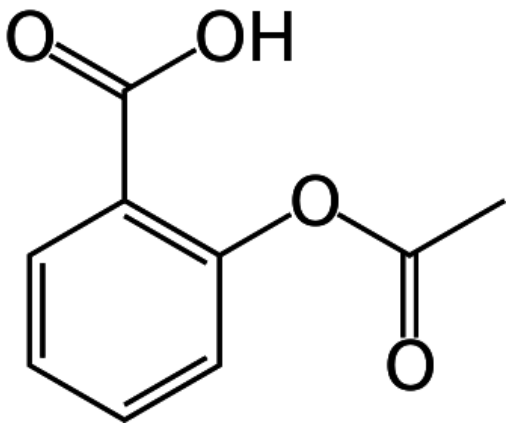
Overview

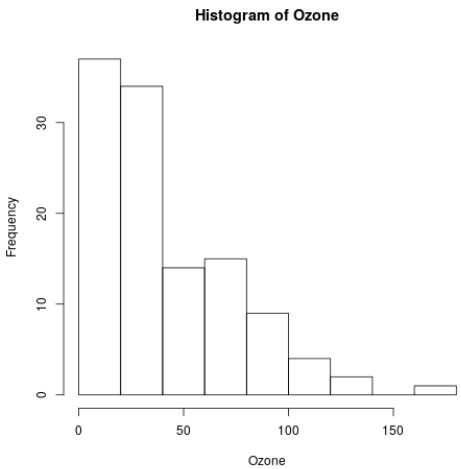
- Accessible diagram problem
- Type of data visualisations
- General navigation model
- Workflow interaction model
- Demo
- Conclusions

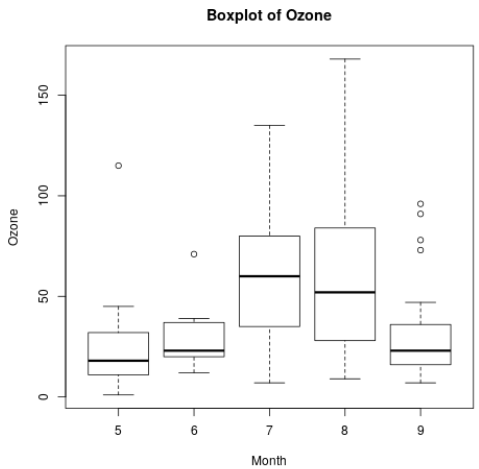
Scientific Diagrams











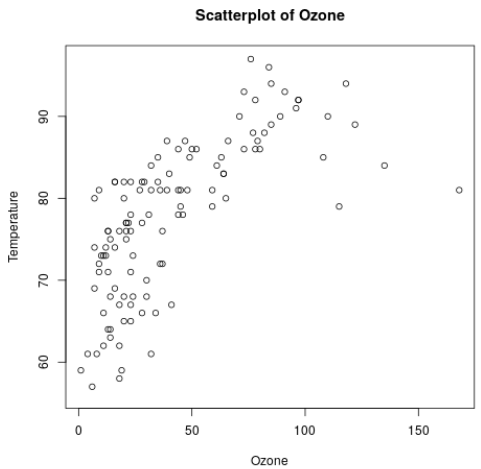


Diagram Accessibility: The Past

- Learning and reading material in Braille, tactile graphics, . . .
- Textbooks audio recorded by expert readers, allowed for independent study
- Use of models, tactile prints, swell paper, etc. in class

- All this is already gives VI readers a considerable disadvantage
- But it gets worth with modern material

Diagram Accessibility: The Future

- Most content is in electronic form
- Anyone can prepare material
- Information is ephemeral
- More and more moving to the web
- Content is more an more geared towards impressive visualisations

- Thread: Danger that the accessibility gap widens
- Opportunity: The Web is ubiquitous

Web Accessible Diagrams

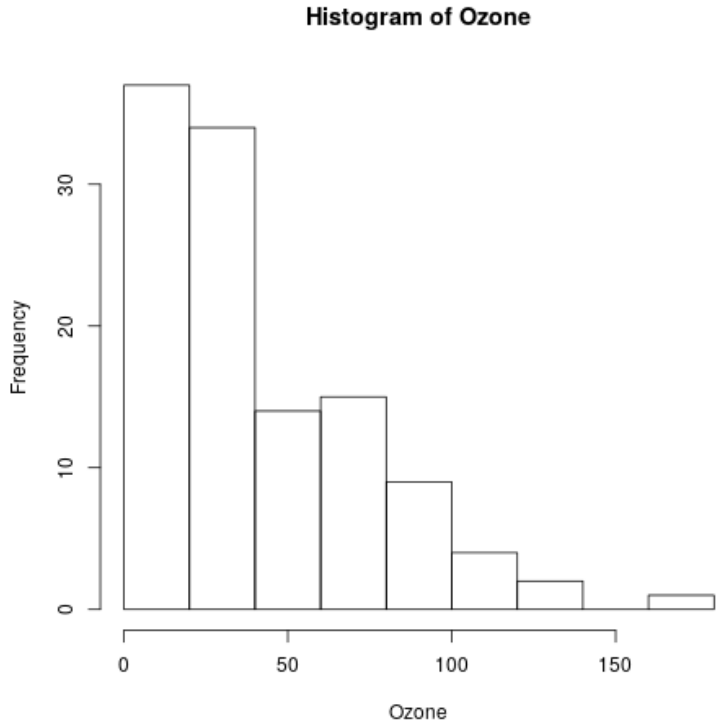
Leverage power of web applications and assistive technology

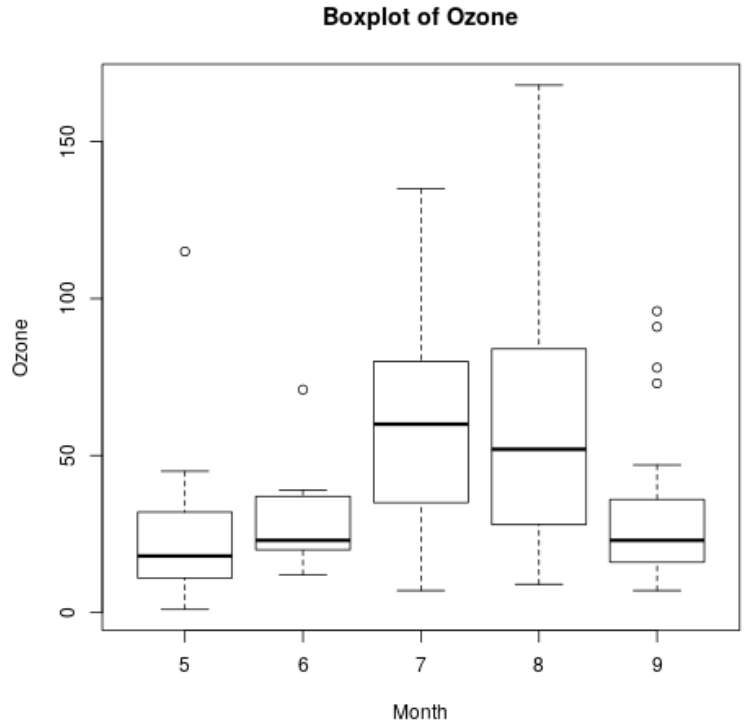
- Embed information and data into a diagram
- Interactive exploration of content
- Speech generation for Screen readers
- Synchronised highlighting and magnification

- This talk is about statistics
- But we also have other STEM diagrams, e.g., chemistry, physics, ...

Discrete Data Graphs

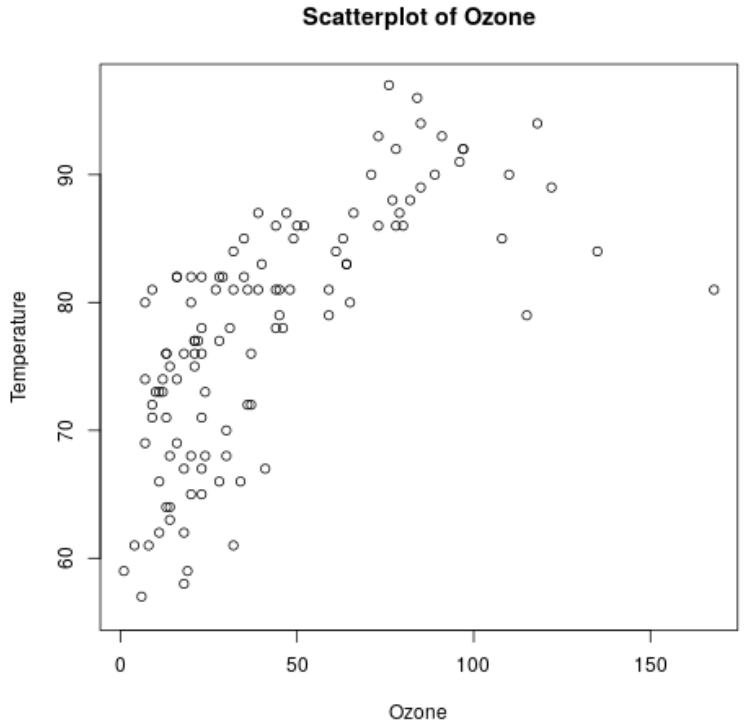
- Not necessarily Discrete Data!
- But a "discrete" presentation of data
- Examples: Histograms, Boxplots

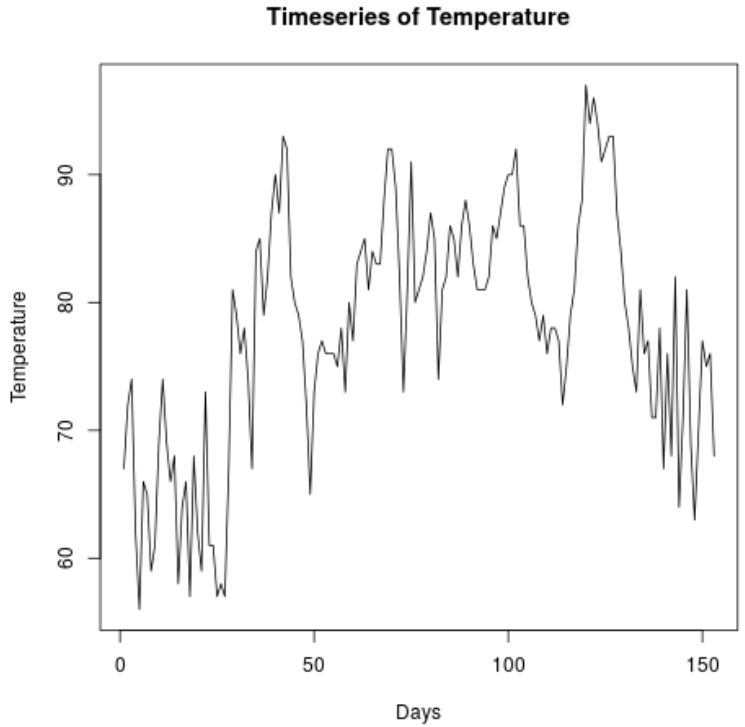




Continuous Data Graphs

- Not necessarily Continuous Data!
- But a "continuous" presentation of data
- Examples: Time series, scatter plots





System Background

R programming language and software environment for statistical computing

- efficient manipulation of statistical data
- plethora of visualisation options

BrailleR Extension to turn R graphics into tactile diagrams

- Tactile graph components
- Braille translation of text

DIAGcess Javascript library for screen reading and interactive exploration of SVG diagrams in any browser

- combines annotated SVG with an XML navigation structure

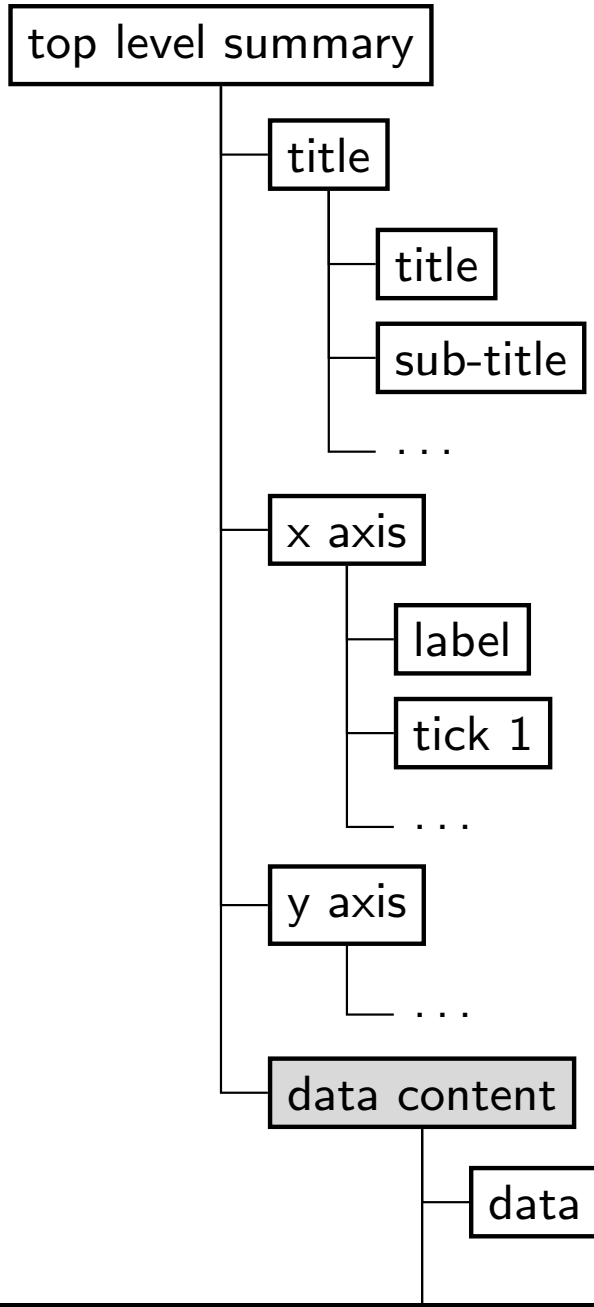
Creating Accessible Diagrams

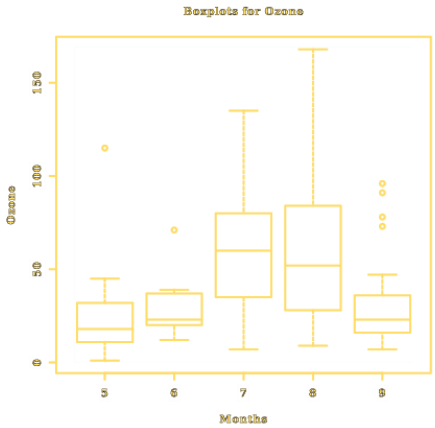
- R offers a number of different renderers
  - many produce SVG, some even good SVG
  - we chose gridSVG which generates highly structured SVG
  - already provides considerable semantic grouping
- Compute semantic information to explain the diagram
  - Start with R model that contains all statistical data
  - Generate speech annotations for diagram elements

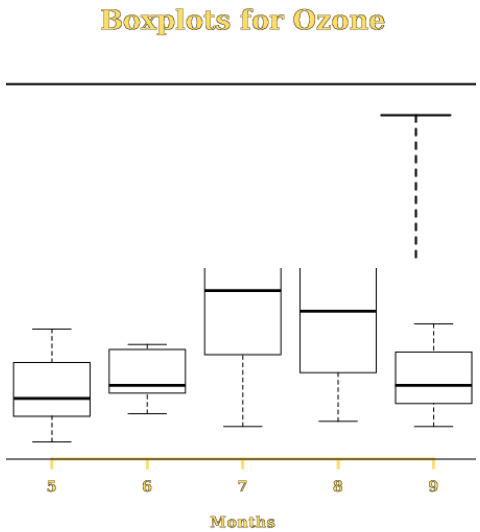
Creating a Navigation Structure

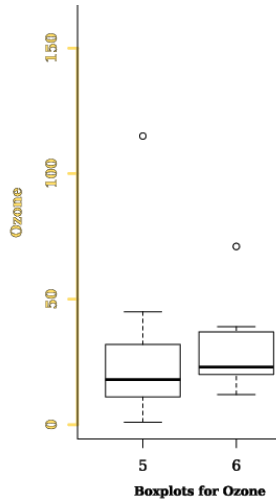
- Generate Abstraction Graph for navigation and explanation
  - Represent diagram as multi-layered graph
  - multiple layers of abstraction
  - "fit" XML to SVG via element ids with three element types: active, passive, grouped
- Graph structure serves as bases for interacting with diagram
- Very simple navigation model: down/up, right/left

Navigation Model (Boxplot Example)

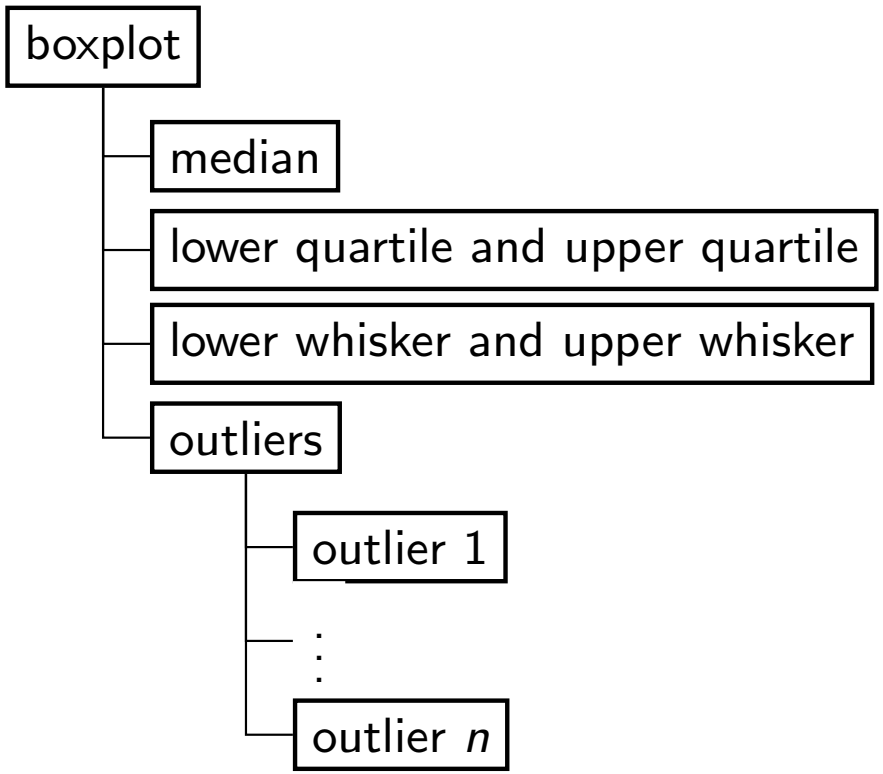


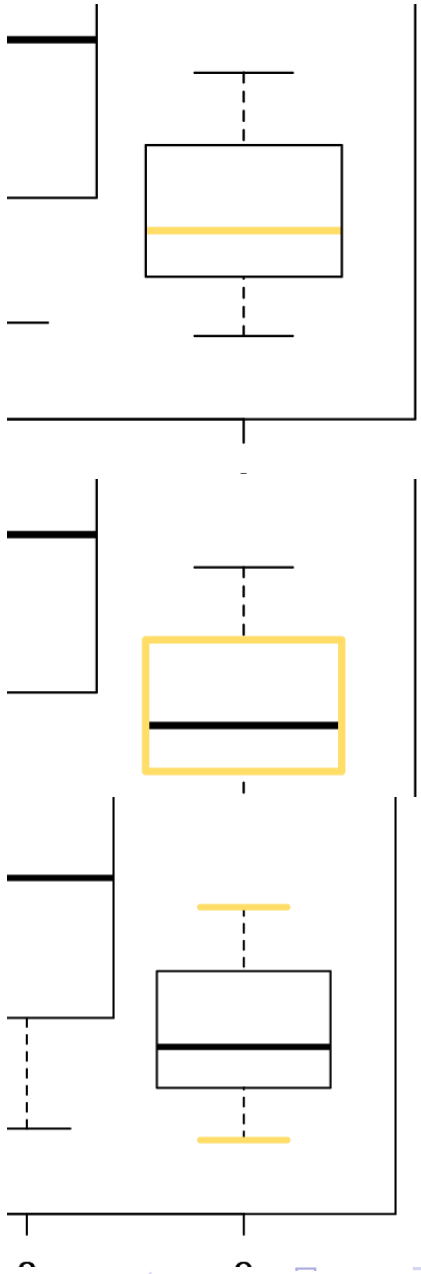






Navigation Example



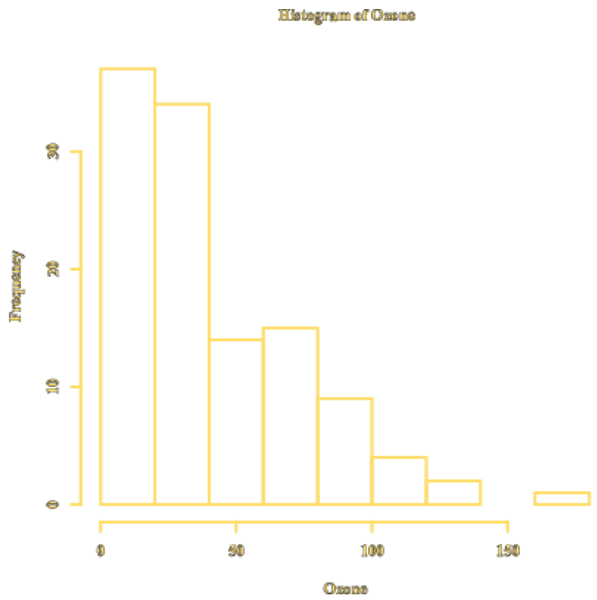


Accessibility Support

- Screen Reader Support:
  - Generate speech output from XML annotations
  - Display of speech output using subtitling
- Low Vision/Learning Disability Support:
  - Highlighting of inspected components
  - Optional zooming and magnification of components
  - Changing contrast, colour configurations

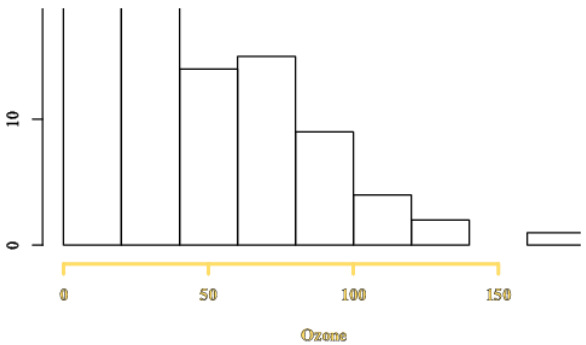
Example: Exploring a Histogram

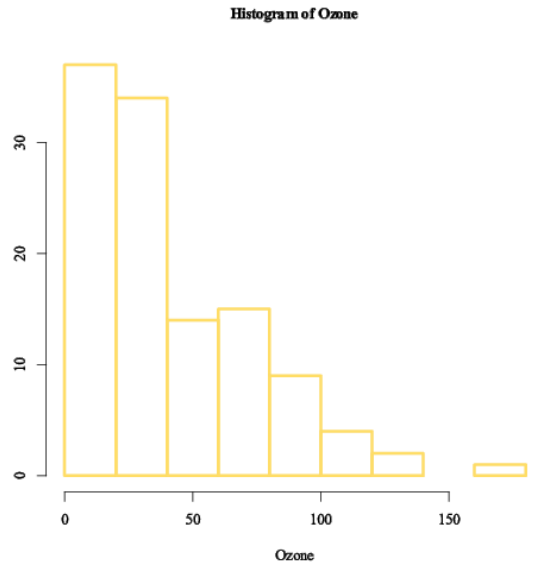
- Intial top level summary
- E.g. "Histogram of Ozone" or verbose
- "Histogram showing 9 bars for Ozone over the range 0 to 150 and Frequency from 0 to 30."



Example: Exploring a Histogram (cdt.)

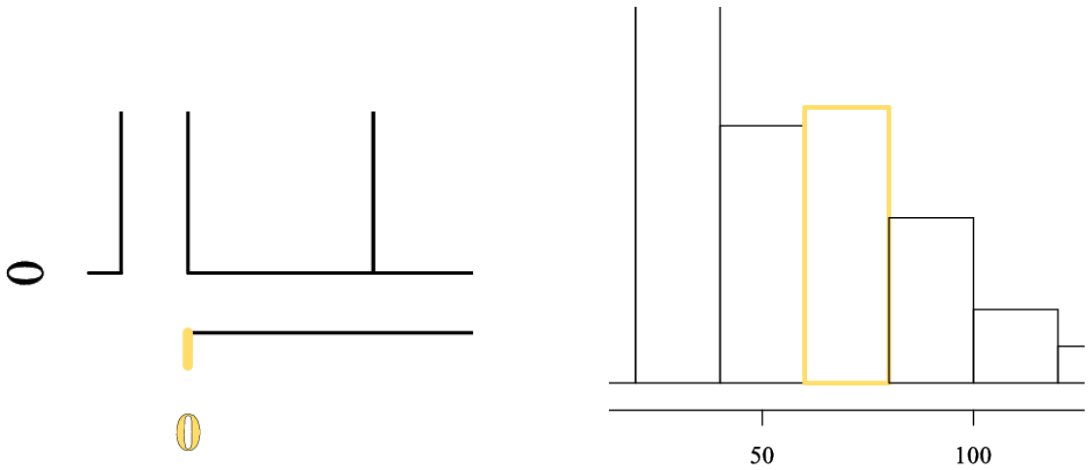
- First level exploration of 4 major components
  - Title: "Histogram of Ozone"
  - X axis: "X axis Ozone ranges from 0 to 150"
  - Y axis ...
  - Data content (summary)





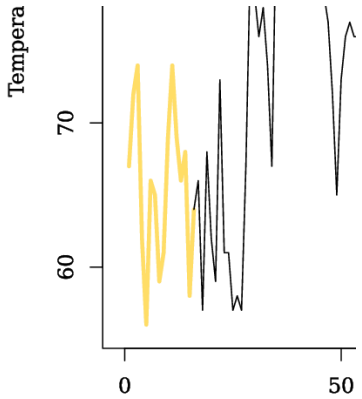
Example: Exploring a Histogram (cdt.)

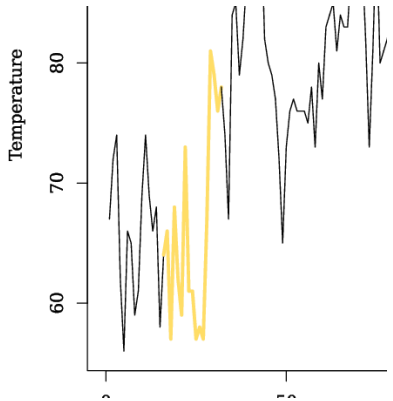
- Next level: Diving deeper into components to get more details
- E.g. for data content:
  - Explore every bar separately
  - E.g., "Bar 4 at 70 with value 15" or verbose
  - "Bar 4 between x values 60 and 80 with y value 15 and density 0.00647"

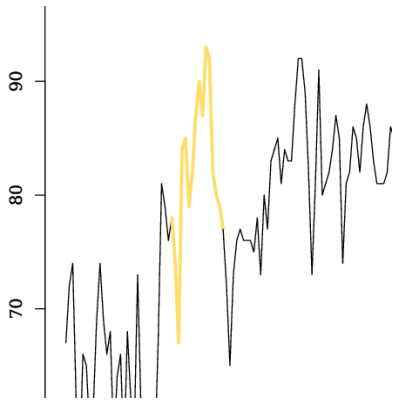


Navigating Continuous Data

- Apply the same navigation model on the data component
- Split continuous curve (recursively) into intervals
- Exploit discontinuities if possible
- Otherwise rewrite SVG diagram to allow navigation of partial curves







Interaction Model for Data Exploration

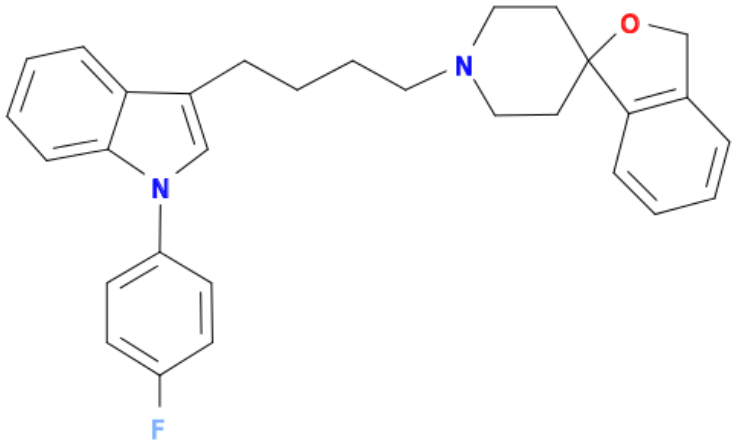
- Support typical workflow for a working statistician in R
- Recurring process of model refinement by
  - data generation and manipulation
  - data inspection and visualisation
  - adaptation of the data and modification of the current statistical model
- Replace canvas based by browser based visualisation
- Automatically open and shift focus to browser tap
- Combined with work in accessible environment like Shell, Emacs, etc.

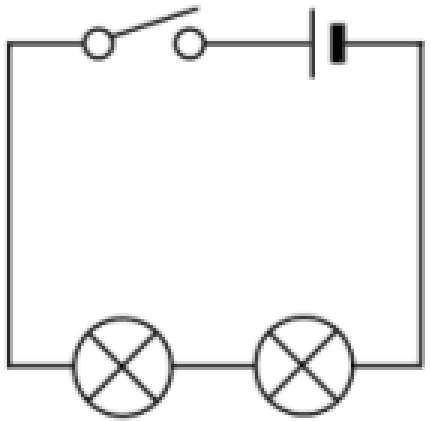
Evaluation

- Expert evaluation
  - Feedback from 10 power users
  - Exclusively positive
  - People want to get involved
- User Study
  - 12 non-expert users
  - Generally very positive
  - Demand for Braille output and sonification
- User study with audio tactile diagrams in July

Conclusions & Future Work

- Work should aid with learning, teaching and employment
- Extending to more types of diagrams
- Adding sonification for recursively exploring continuous curves
- Demonstrates transferability of navigation model
- Fits into ongoing work of making STEM diagrams accessible





References

- BrailleR available via CRAN in R
- Web References
  - Demo:
    - `https://zorkow.github.io/BrailleR/www/`
  - BrailleR package:
    - `https://github.com/ajrgodfrey/BrailleR`
    - `https://www.r-pkg.org/pkg/BrailleR`
- Chemistry examples:
  `https://progressiveaccess.com/chemistry`

Acknowledgements

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