Developing Software for Fully Automatic Creation of Accessible SVG Diagrams

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Background

- Diagrams are an important teaching means in STEM
- Accessibility is key to inclusive education
- Avoid additional hurdles for both authors and readers
- Fully automatic to reduce need for human intervention

- Technology fully functional for Chemistry diagrams
- Current work involves
  - Physics diagrams (with John Gardner and ViewPlus)
  - Statistics Graphs (with J. Godfrey and D. Fitzpatrick)

Pathways to Accessibility

- Web Accessibility (Volker)
  - Access via Screen Reader and Browser
  - Exploration with keyboard or mouse interaction
- Audio Tactile Diagrams (John)
  - Combination of embossed diagrams and audio feedback
  - Using IVEO Reader

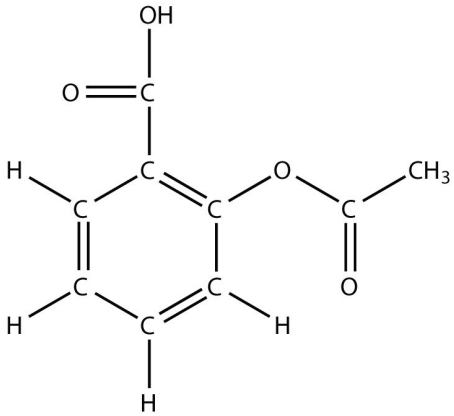
Automatic Generation of Accessible SVG

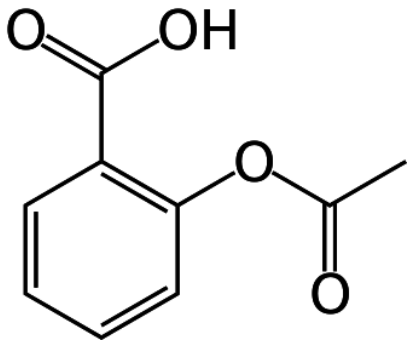
- Start with (bitmap) images of diagrams
- Understand their content
- Enrich information specifically for teaching
- Generate "content-heavy" SVG

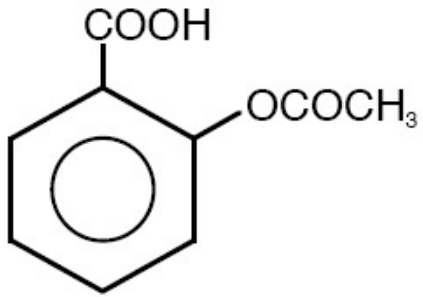
Do all this fully automatically without user interaction

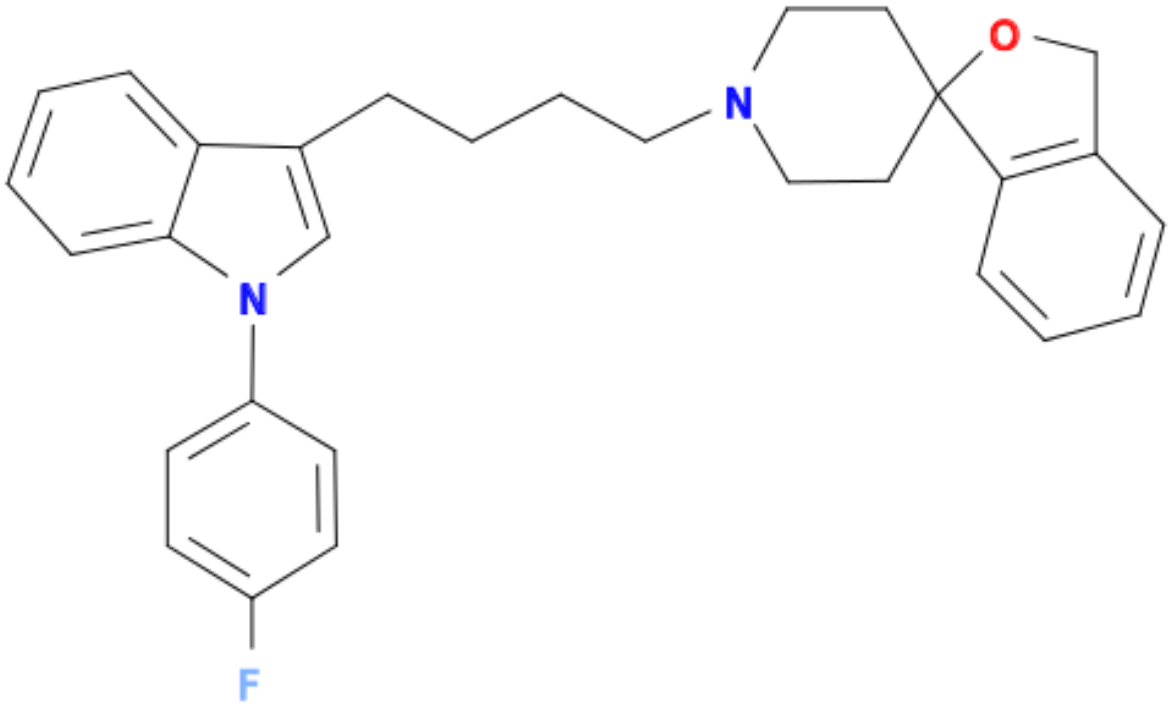
- Source independence
  - Do not rely on the benevolent, educated author
- Tool Independence
  - Do not force readers to use a specialist software tool
- Platform independence
  - Accessible with all browsers, screen readers, on all platforms

Chemistry: Molecule Diagrams

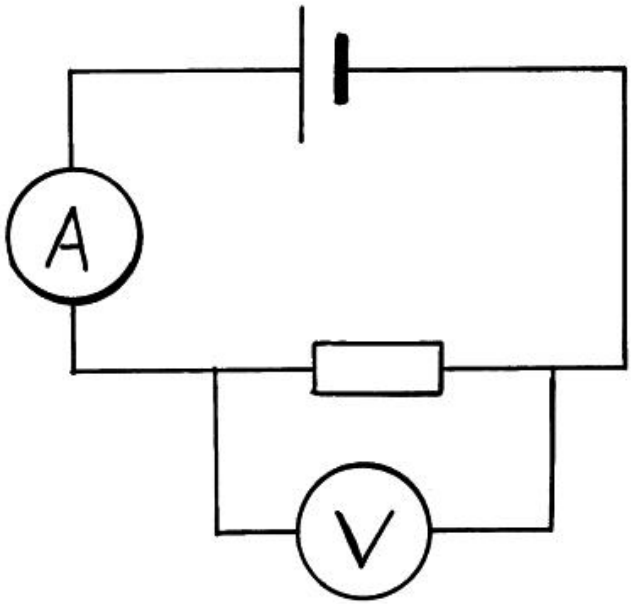


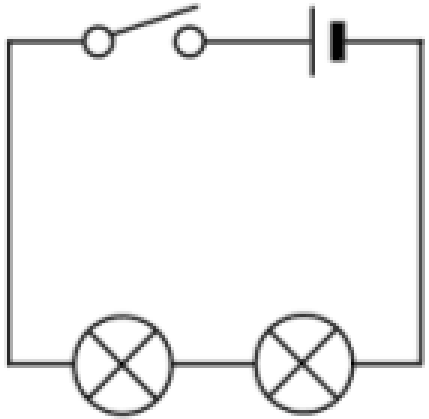


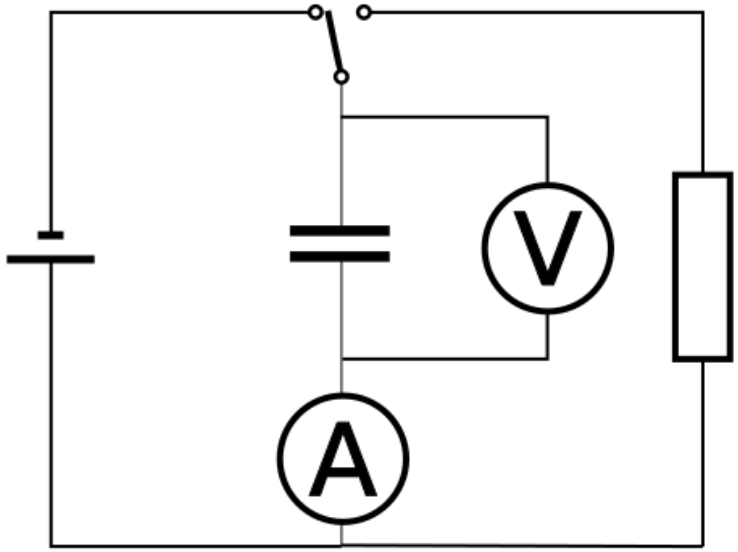




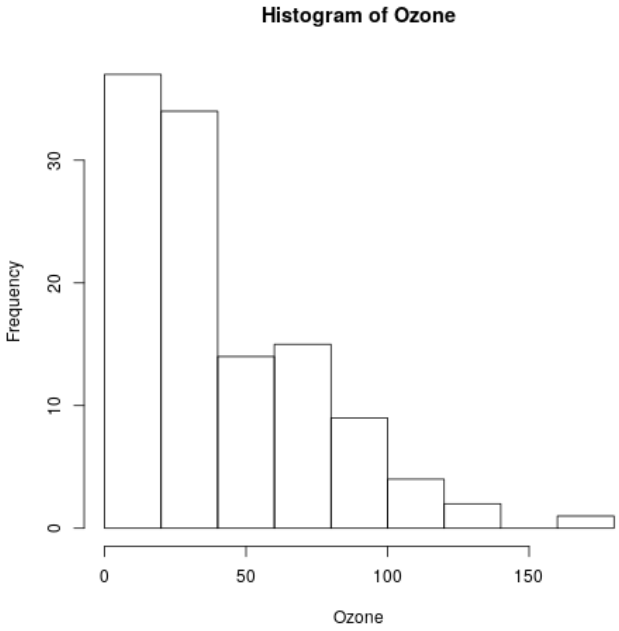
Physics: Circuit Diagrams

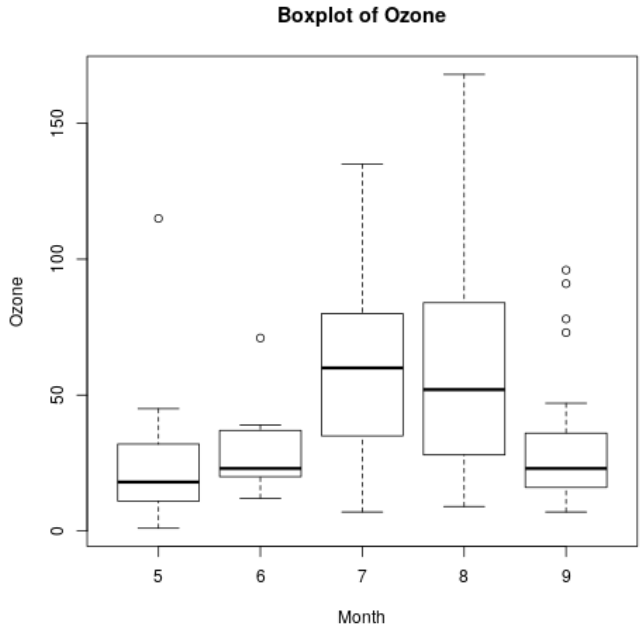


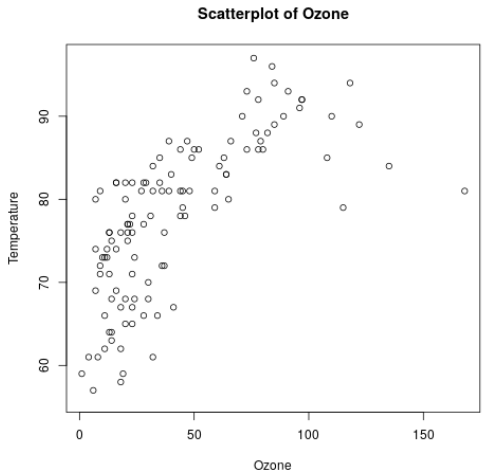


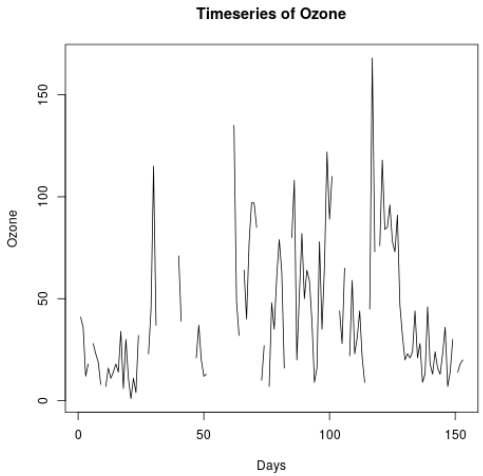


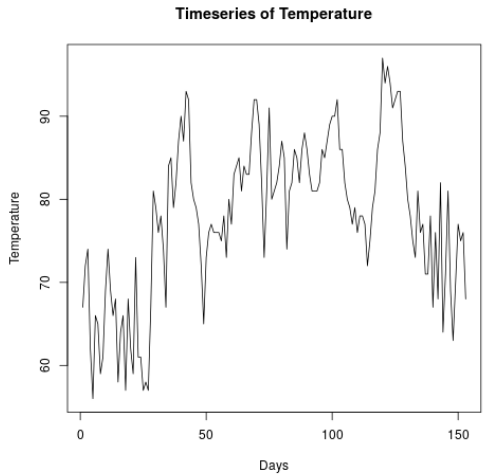
Statistics: Discrete and Continuous Data











End-to-end procedure from images to accessible diagrams

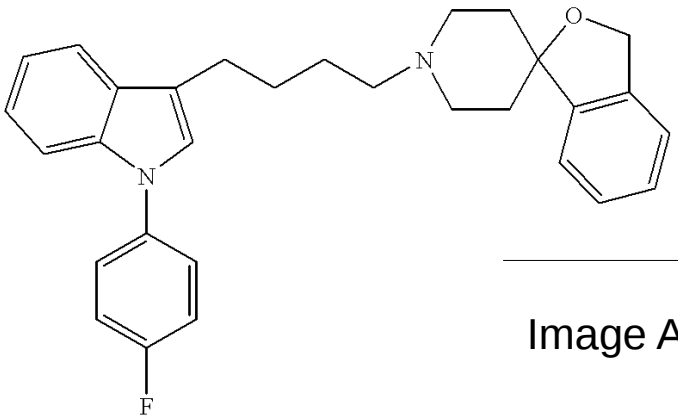


Image Analysis

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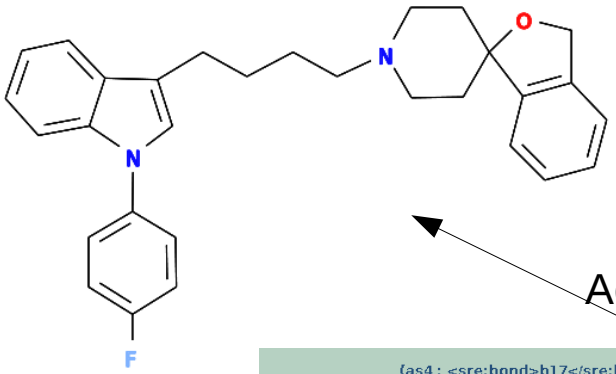
Image Recognition



Accessible Rendering

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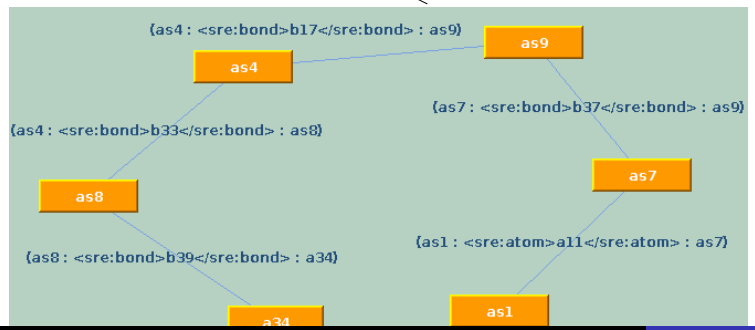
Semantic Enrichment



Workflow

Input: A bitmap image of a molecule diagram

1. Image analysis
2. Image recognition
3. Semantic enrichment
4. Generation of annotated SVG
5. Accessible diagram via browser front-end

Modularity

Steps are modular

- and we can start/stop in any stage,
- depending what information we initially have
- or what output we want to produce

For example,

- Chemistry: from image or with chemical identifiers (e.g., from Database)
- Physics: from image only
- Statistics: from the R package using the full statistical model

Image Analysis and Recognition

Analysis: Generic procedure to extract geometric primitives

- Preprocessing: Binarisation, noise reduction...
- Connected component extraction and OCR
- Result is a set of geometric primitives:
  Character groups, lines, circles, triangles

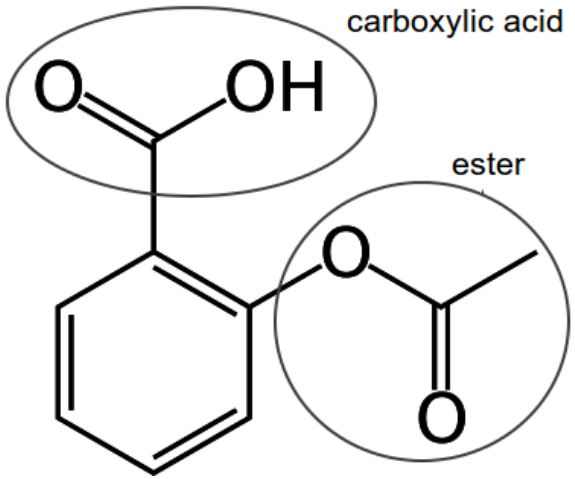
Recognition: Domain specific rewriting system

- Rule based rewriting of primitives into XML representation.
  E.g.,
- Chemistry: Molecule in Chemical Markup (CML or MOL)
- Physics: Circuit in bespoke XML

Semantic Enrichment

- Recognition phase can only generate basic information
- For teaching/learning more detail is needed
- Detect semantically interesting substructures
- Describe them and order them by importance following expert rules.

- Chemistry Example:
  - Aliphatic chains
  - Ring systems: Isolated and fused
  - Functional groups

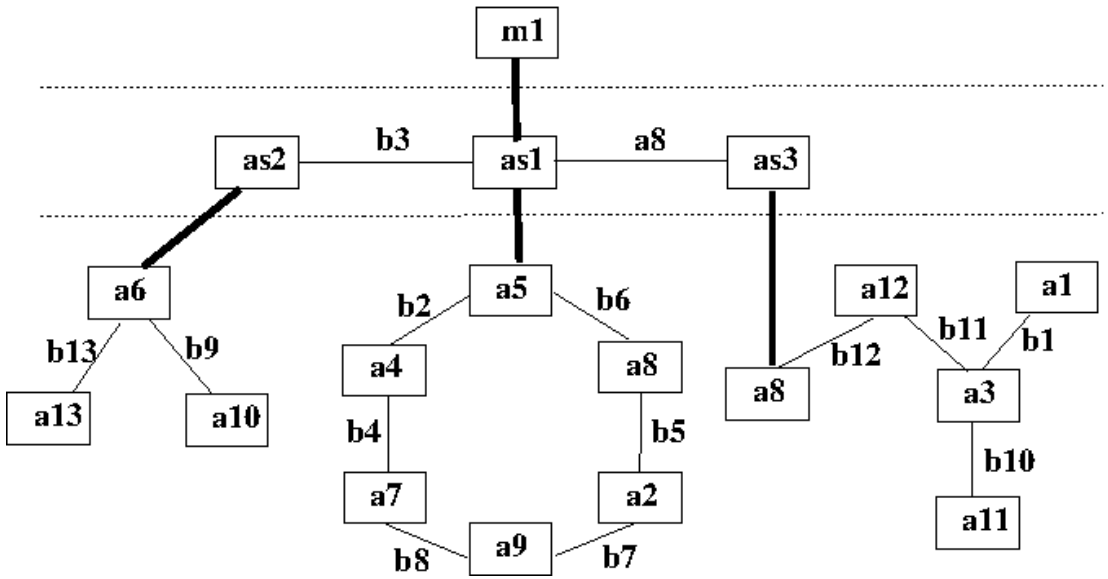


- Order blocks and atoms by chemical conventions

Abstraction and Navigation Model

- Represent diagram as layered graph
- Abstract and summaries subelements via multiple layers
- Distinguish active and passive elements for display and navigation

- Chemistry Example:



- Molecule summary
- Component summary
- Atoms and bonds

Accessibility Support

- Simple navigation model with arrow keys
- Screen Reader Support:
  - Generate speech output on different levels
  - 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
- I18n support

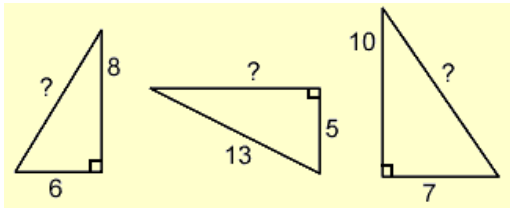
Future Support for Other Disabilities

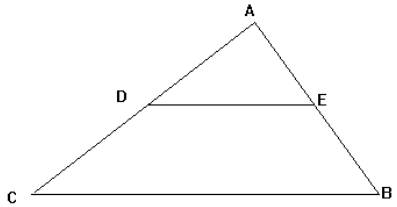
- More low-vision options
- Improved support for students with dyslexia/dysgraphia

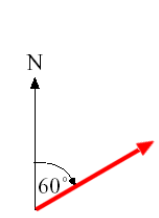
- More mouse interaction
- Automatic reading
- Synchronised shading

Future Subject Areas

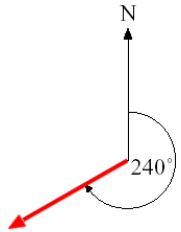
- Other STEM subjects: Maths (geometry, bearings), Biology (systems diagrams), Computer Science (flow charts)



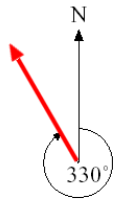




Bearing 060 °



Bearing 240 °



Bearing 330 °