Gizual User Interface

Browser-Based Visualisation for Git Repositories

Master's Examination – Andreas Steinkellner

29 Jan 2025

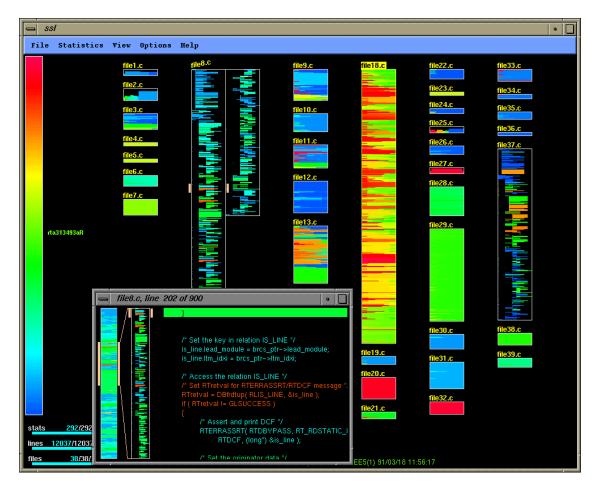


SCIENCE PASSION TECHNOLOGY



Seesoft [1992]

- Visualisation tool for software repositories.
- Published by Eick et. al¹.
- Analyse up to 50,000 lines of code simultaneously.
- Interactive analysis.



Seesoft.

[Image extracted from Eick et al.¹ and used under §42f of Austrian copyright law.]

[1] Eick, Stephen G., Joseph L. Steffen and Eric E. Sumner Jr [1992]: Seesoft: A Tool for Visualizing Line Oriented Software Statistics; IEEE Transactions on Software Engineering 18.11 (Nov 1992) | doi: 10.1109/32.177365

Git

- Version control system.
- Free and open source¹.
- Industry standard.
- Powerful command line interface.
- Integrated in many native development tools.

[1] Git: https://git-scm.com/

Git Blame

> git blame package.json

a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	1) {
a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	2) "name": "gizual",
b217b886	(Andreas Steinkellner	2024-09-06 12:23:24 +0200	3) "version": "1.0.0-alpha.24",
a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	4) "packageManager": "yarn@3.5.0",
a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	5) "license": "Apache-2.0",
a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	6) "private": true,
a9ab27c8	(Stefan Schintler	2023-03-21 17:24:44 +0100	7) "workspaces": [
680994dc	(Stefan Schintler	2023-03-30 02:48:39 +0200	8) "./apps/*",
680994dc	(Stefan Schintler	2023-03-30 02:48:39 +0200	9) "./packages/*",
aacd5989	(Andreas Steinkellner	2023-07-17 08:27:40 +0200	10) "./tools/*",
aacd5989	(Andreas Steinkellner	2023-07-17 08:27:40 +0200	11) "./apps/gizual-app/src/*"
Commit ID	Author	Timestamp	Content

🔲 package.json

Output from a Git blame command on the command line – sections annotated. [Image created by the author of this presentation.]

Git Blame vs. Gizual

> git bla	> git blame package.json				<pre>package.json</pre>	33
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Commit ID	Author	Timestamp	Content			

Comparison of Git blame output (left) vs. Gizual (right, coloured by age of line of code). [Image created by the author of this presentation.]

Overview: Gizual

Gizual [2022 \rightarrow]

- Interactive visualisation tool for software repositories.
- Fast and easy to use web application¹.
- Local data processing.
- Custom queries for detailed analysis.
- Stack: React, TypeScript, MobX, Mantine, Libgit2, Rust.



Gizual: Main interface. [Image created by the author of this presentation.]

[1] Gizual: https://gizual.com

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Gizual: Live Demo

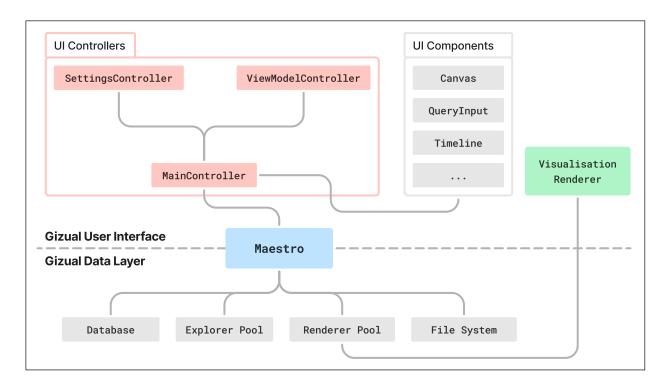


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Architecture

 This work: User interface, visualisation, interactivity, user experience and accessibility.

 Data Layer (Stefan Schintler)¹: Git exploration, Web Worker parallelisation, file management.



Gizual architecture and project split. [Image created by the author of this presentation.]

[1] Schintler, Stefan [2024]: Gizual Data Layer: Enabling Browser-Based Exploration of Git Repositories | url: https://ftp.isds.tugraz.at/pub/theses/sschintler-2024-msc.pdf

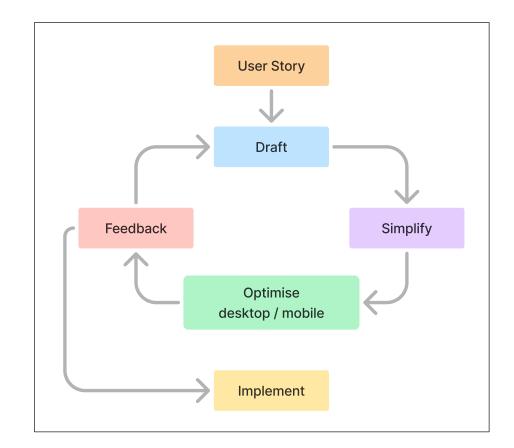
User Experience Goals

- Ease of use and simplicity.
- High performance.
- Minimise required interactions to desired output.
- Guide user focus on main content.
- Multiple input methods.
- Accessible where possible.
- Optimised for desktop and mobile.
- Export functionality.

Methods: Architecture & Goals

UI Components: Thought Process

- Start with user story.
- Draft design for possible user interface.
- Simplify the concept.
- Consider narrow viewports and touch devices.
- Test on desktop and mobile.
- Gather feedback and iterate.



User interface design process. [Image created by the author of this presentation.]

Welcome Screen

Why?

- Support for different browsers and file loaders.
- Performance differences between loaders.
- Address privacy concerns of users.
- Provide users with a choice.

How?

- Separate screen before main application.
- Multiple designs and user flows were tested.

Welcome Screen: Iterative UX Improvements

 Copen Repository From local directory From zip file From URL Copen from local directory Copen a folder from your local file system. None of your files will be uploaded anywhere, all your data is processed locally on your our our device. You can pick a custom loader configuration below, or leave it default to choose the best loader for your current browser context. V tagaz-ids/diamoni 2 state 6 forth hotspir/github.com/super states/diamoni 2 state 6 forth hotspir/github.com/super states/diamoni 2 state 7 forths for hotspir/github.com/super states 7 forthotspir/github.com/super states 7	\rightarrow C (i) localhost:5173		★ 立 4 :
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Gizual's welcome screen [Mar 2024]. [Image created by the author of this presentation.]

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	No need - all data is processed locally and never leaves your device. Read our Privacy Notice to learn more.			
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Gizual's welcome screen [current]. [Image created by the author of this presentation.]

User Interface Details

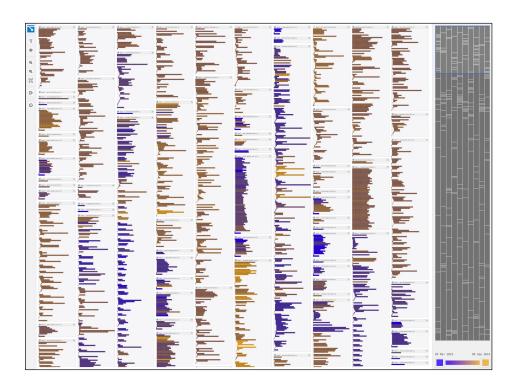


Gizual's main user interface with annotated regions. [Image created by the author of this presentation.]

Canvas

Requirements:

- Interactive, with high performance.
- Display hundreds (thousands) of files.
- Stable layout.
- Easily navigable.
- Good user experience on all viewport sizes and input devices.



Gizual's Canvas component. [Image created by the author of this presentation.]

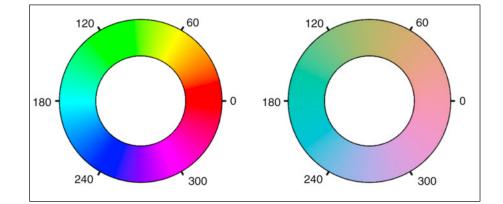
Canvas

Approach:

- Each file rendered into a single image (block).
- Entire Canvas transformed on zoom, pan or pinch \rightarrow CSS for high performance.
- Positioning of images in masonry layout.
 - Not available with pure $CSS \rightarrow Custom JavaScript implementation.$
- Custom Minimap and Legend components support orientation.

Visual Encoding (1)

- Colour lines of code based on age or author.
- Age encoding: Gradient with two userdefined values.
- Author encoding: HCL palette with custom user overrides.
 - RGB colour space not uniformly distributed
 → use HCL colour space.
 - Custom algorithm based on d3-color¹ for stable results.



Comparison of HSV-based (left) and HCLbased (right) colour wheel. [Image extracted from Zeileis et al.² and used under §42f of Austrian copyright law.]

[1] d3-color: https://d3js.org/d3-color

[2] Zeileis, Achim and Hornik, Kurt and Murrell, Paul [2009]: Escaping RGBland: Selecting Colors for Statistical Graphics; Computational Statistics & Data Analysis 53.9 (Jul 2009) | doi: 10.1016/j.csda.2008.11.033

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Visual Encoding (2)

Model	Parameters	Details
RGB	Red, Green, Blue	Non-uniform, device dependent.
HSL	Hue, Saturation, Lightness	Perceptually-oriented, based on RGB.
HSV	Hue, Saturation, Value	Used interchangeably with HSL.
CIE XYZ	Tristimulus response (eye)	Perceptually uniform reference model, based on human vision experiments.
CIE Lab	Lightness, Green-to-red, Blue- to-yellow	Perceptually uniform, device independent.
HCL	Hue, Chroma, Luminance	Perceptually uniform, based on CIE.

Comparison of commonly used colour spaces. [Table created by the author of this presentation, based on data from Noor et. al.¹]



HCL colour band, created in Gizual for a set of ten authors. [Image created by the author of this presentation.]

[1] Ibraheem, Noor & Hasan, Mokhtar & Khan, Rafiqul Zaman & Mishra, Pramod [2012]: Understanding Color Models: A Review; ARPN Journal of Science and Technology url: <u>https://www.researchgate.net/publication/266462481_Understanding_Color_Models_A_Review</u>

Rendering

Requirements:

- Parallelised rendering.
- Distributed workload across web workers.
- Reusable for different visualisations and outputs.

Approach:

- Rendering tasks for each block (file).
- Generalised rendering interface.
- Class-based file and module structure.

Query Bar (1)

Requirements:

- Everything accessible within few clicks.
- Modular setup, easily extendible.
- Consistent look and feel.

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Gizual's Query Bar, with the Timeline component expanded. [Image created by the author of this presentation.]

Query Bar (2)

Approach:

- Generalised base module exposes common functionality.
- Individual modules grouped by category.
- Modules directly attached to query interface via Maestro.

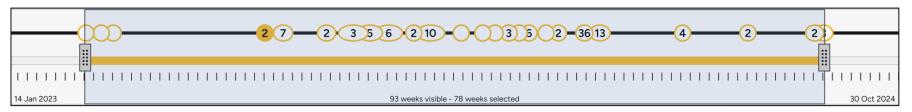
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Gizual's Query Bar, with the Timeline component expanded. [Image created by the author of this presentation.]

Query Bar: Timeline (1)

Requirements:

- Easy selection of time range.
- Visual display of commits.
- High performance.

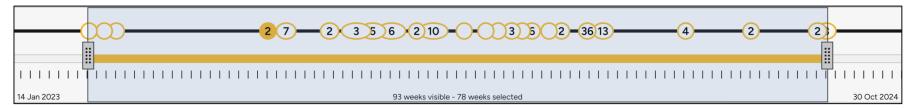


Gizual's Timeline component. [Image created by the author of this presentation.]

Query Bar: Timeline (2)

Approach:

- SVG-based rendering with interactive HTML on top.
- Interactivity for zooming, panning and dragging (mouse and touch).
- Viewport pre-rendered to improve interactivity performance.



Gizual's Timeline component. [Image created by the author of this presentation.]

Query Bar: File Tree

Requirements:

- Support for thousands of files.
- Partial selection for folders.
- File type icons.

Approach:

- Limited recursive pre-rendering (3 levels).
- Internal tree representation in flat structure.

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Gizual's File Tree component. [Image created by the author of this presentation.]

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Thank You!

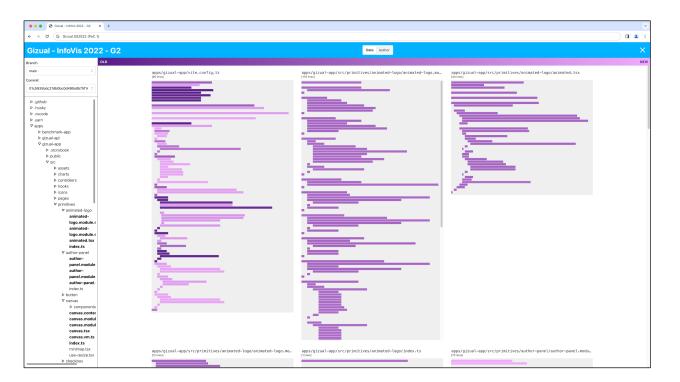
gizual.com

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Gizual Proof of Concept 1 [SS 2022]

- Limited interaction and metrics.
- Frequent UI freezes.
- Slow canvas performance.
- No customisation of results.

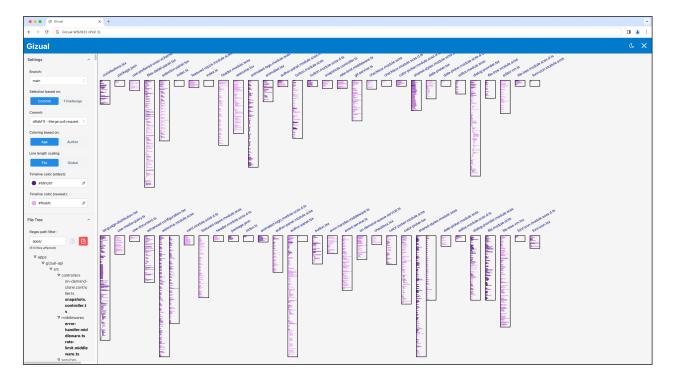


POC1¹: [May 2022 \rightarrow Jun 2022] [Image created by Korduba, Schintler and Steinkellner¹.]

[1] Gizual - Repository Visualization for Git (SS 2022), seminar paper: <u>https://gizual.com/resources/gizual-paper-ss2022.pdf</u>

Gizual Proof of Concept 2 [WS 2022/23]

- Max. 50 files.
- Limited support for Firefox.
- Inefficient blame performance.

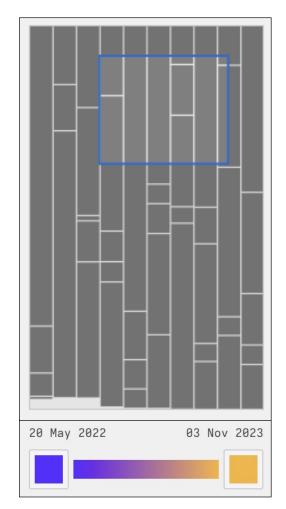


POC2¹: [Dec 2022 \rightarrow Jan 2022] [Image created by Pinheiro de Souza, Schintler and Steinkellner¹.]

[1] Gizual - Repository Visualization for Git (WS 2022), seminar paper: <u>https://gizual.com/resources/gizual-paper-ws2022.pdf</u>

Canvas: Details

- Intuitive interactivity:
 - Zoom
 - Pan
 - Pinch
- Custom minimap implementation for overview in large visualisations.
- Custom legend component.
 - Quick access to gradient colours.
 - Show selected time range.



Gizual's Minimap and Legend components. [Image created by the author of this presentation.]

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Backup

Query Editor

- Replaces Query Bar on devices with narrow viewports.
- Provides a simplified selection of modules.

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Gizual's Query Editor. [Image created by the author of this presentation.]

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Backup

Query Assistant (Draft)

- Easier way for new users to get started.
- Contains a subset of available options.
- Highly focused on selecting a range and files to start immediately.

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Gizual's Query Assistant. [Image created by the author of this presentation.]

Query Bar Modules

- Module groups provide interchangeable modules.
- Visual layout always consistent.
- Modules can be swapped with one button.

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Gizual's Query Bar, annotated with module information. [Image created by the author of this presentation.]

Visualisation Type Dialogue

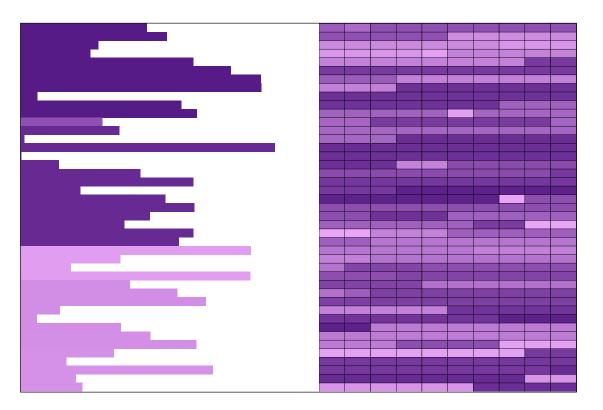
- Deliberate use of dialogue instead of direct display in Query Bar.
- Overview of visualisation types.
- Choice between visual encodings.
- Preview of selected visualisation type in selected encoding with customised colours.

File Lines	File Lines Full Width	
Displays file content as a series of colored lines. Each line represents a line of code.	Displays file content as a series of full-width colored lines. Each line represents a line of code.	
File Mosaic	Author Mosaic Coming soon!	
Displays file content as a mosaic of colored tiles. Each tile represents a line of code.	Displays a mosaic for each author. Each tile represents a file modified by the author.	
Author Contributions Coming soon!	File Bar Coming soon!	
Displays a tiled mosaic for the amount of contributions an author has made over time.	Displays each file as a stacked bar, with individual segments representing different metrics.	
Author Bar Coming soon!		
Displays each author as a stacked bar, with individual segments representing different metrics.		
elect Visual Encoding		
Gradient by Age Colors are assigned based on the age of the line	Palette by Author Colors are assigned based on the author of the	
of code.	line of code.	
Customize Visual Encoding		

Gizual's Visualisation Type Dialogue. [Image created by the author of this presentation.]

Mosaic Mode

- Alternative visualisation mode.
- 10 lines of source code grouped into a single line of tiles.
- Condensed representation.
- No rendered text content.



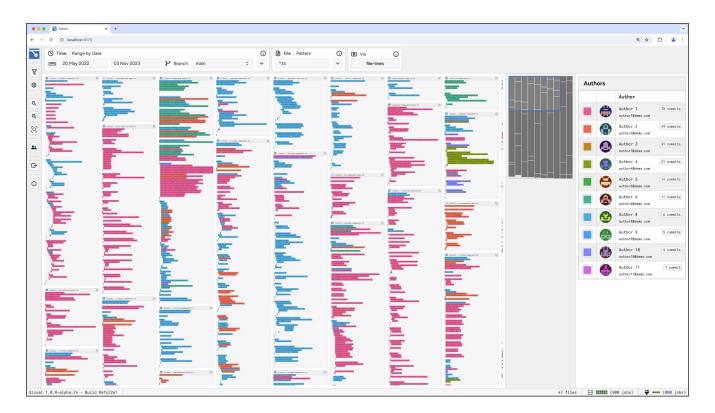
Gizual's line mode (left) compared to mosaic mode (right). [Image created by the author of this presentation.]

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Backup

Palette by Author Encoding

- Colour based on author of line of code instead of timestamp.
- HCL colour space for equal distribution per default.
- Author panel automatically visible.
- Colours can be customised by user.



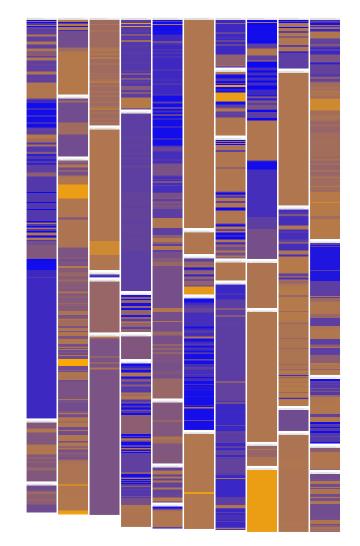
Gizual's main interface with a visualisation in Palette by Author visual encoding. [Image created by the author of this presentation.]

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Backup

SVG Export

- Stable masonry algorithm.
- Files assigned into columns and sorted based on rendered height.
- File header rendered without interactive elements.



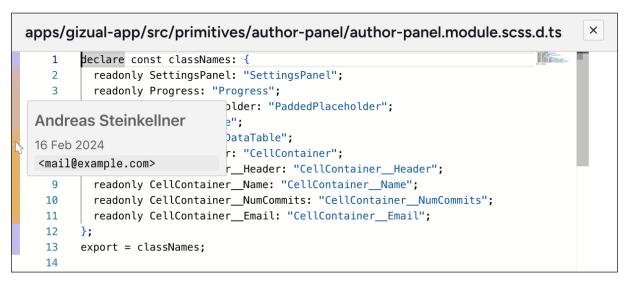
Gizual's SVG Export. [Image created by the author of this presentation.]

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Integrated Code Editor

- Based on Monaco⁵ code editor.
- Custom line gutter and tooltip.





Gizual file content in visualisation (left) vs. file content in integrated editor (right). [Image created by the author of this presentation.]

[5] Monaco: https://microsoft.github.io/monaco-editor/

Master's Examination – Andreas Steinkellner 29 Jan 2025

Query Bar Iterations

-files: view-layer.tsx, main.tsx, app.tsx -contributor: Andreas Steinkellner	Aa .* Q
③ Range: 2022-07-01 2023-07-01 ♀ S Pattern: *.tsx S Gradient by Age: ■ #FF00A8 ■ #00E	0FF 😣 于 🎦
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Different iterations of Gizual's Query Bar, ordered top to bottom from oldest to current. [Image created by the author of this presentation.]

Development Toolchain

- React + TypeScript.
- State management: MobX.
- Component library: Mantine.
- Design: Figma.
- Styling: SCSS.

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Backup

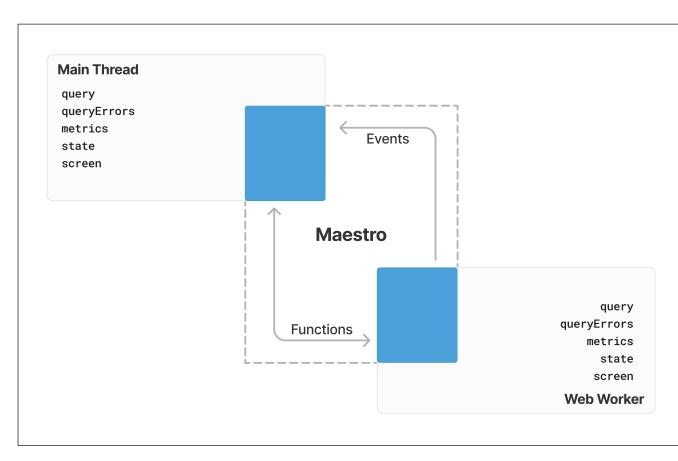
Figma

- Heavily used for design and prototyping.
- Consistent look and feel across separated UI components.

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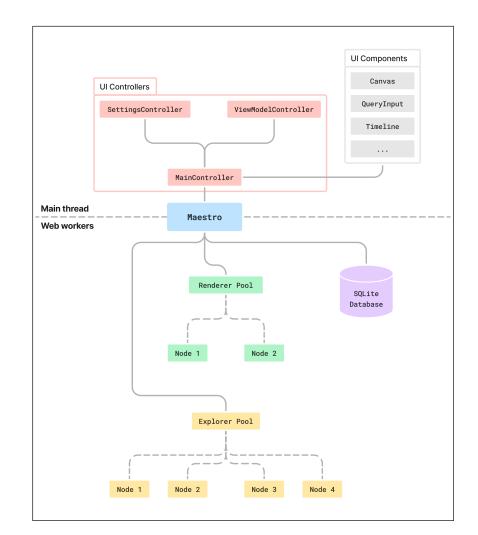
Gizual theme in Figma. [Image created by the author of this presentation.]

Architecture & Maestro



Maestro controller.

[Image jointly created by the author of this presentation and Stefan Schintler¹.]



Gizual architecture.

[Image jointly created by the author of this presentation and Stefan Schintler¹.]

[1] Schintler, Stefan [2024]: Gizual Data Layer: Enabling Browser-Based Exploration of Git Repositories | url: https://ftp.isds.tugraz.at/pub/theses/sschintler-2024-msc.pdf

User Interface Structure

- <component.module.scss>
 SCSS module with all required styles for the component.
- <component.module.scs.d.ts>
 Automatically generated types for the SCSS classes.
- <component.tsx>
 Main entry file for the component.
- index.ts
 Clean export for entry file.

Future Work (1)

- Canvas performance improvements through SVG-based rendering.
- Custom analytics with charts.
- Timeline performance improvements through CSS transforms.
- Binning for visual encoding.
- Brushing for specific lines of code.
- Hierarchical structure overview (treemap).
- SVG export with file content.
- Native build.

Future Work (2)

Quick toggles: Visual encoding.



Ideas:

- Text diff between revisions.
- Merge conflict detector.
- Filter by commit message.