# Binoculars

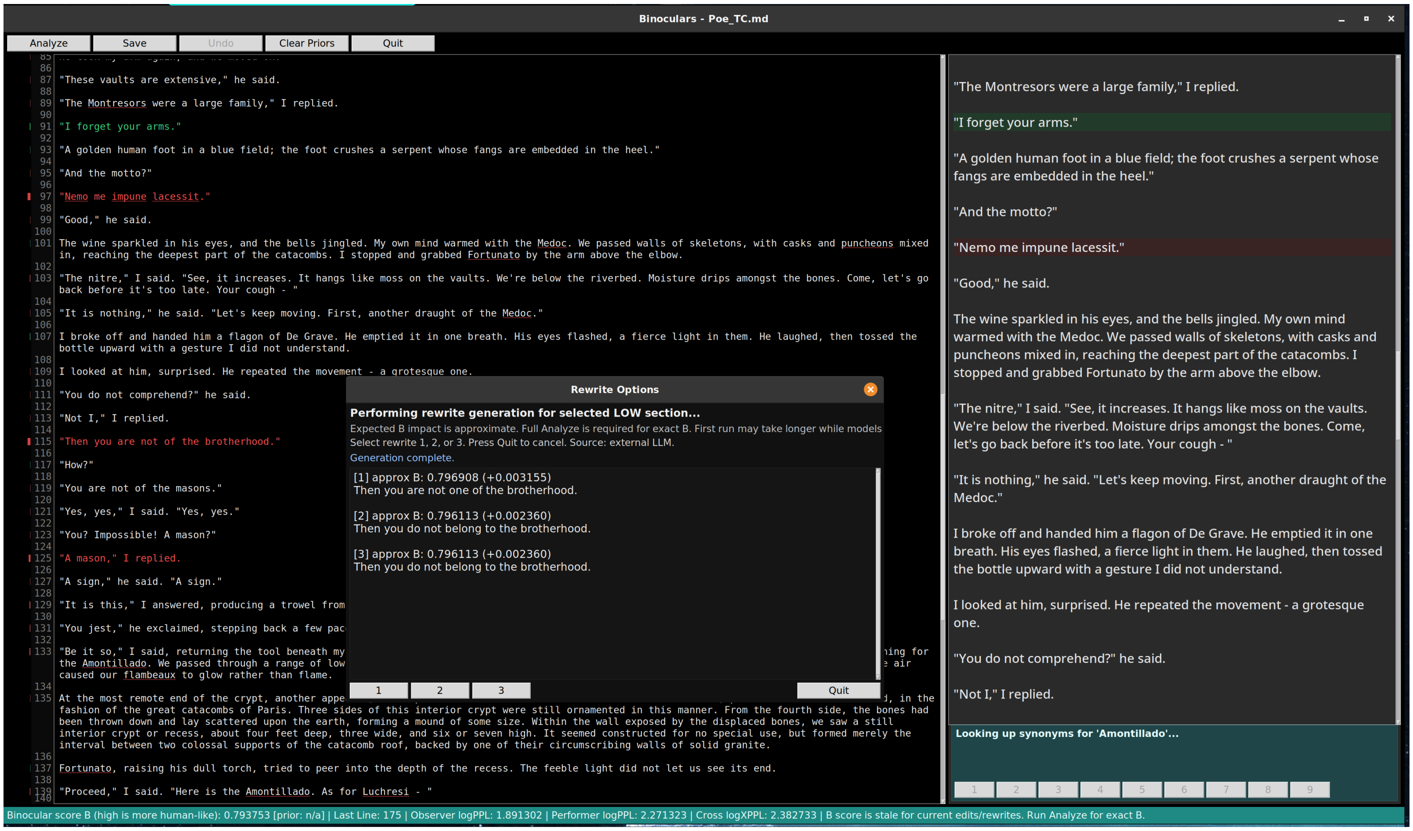
`Binoculars` is a local workflow tool for AI text forensics and humanization. It uses two related `llama.cpp` models - observer and performer - to compute Binoculars-style scores from full logits, then guides you through iterative rewrites of high-risk text spans in the GUI.

If you need to evaluate or revise long-form text without sending documents to a remote detector, this repository provides a practical solution.

- Data and models remain local by default.
- The system computes inspectable signals (`logPPL`, `logXPPL`, `B`) rather than opaque labels.
- Paragraph-level heatmaps show exactly where score pressure originates.
- For any flagged line or selected block, you can generate three rewrite options and rank them by estimated B impact for quick humanization passes.
- Full analysis can be re-run only when you need exact checkpoint scores.
- Optionally, you may use an OpenAI-compatible rewrite backend, with automatic fallback to internal local generation if needed.

Reference paper (also in `background/`): https://arxiv.org/abs/2401.12070

Acknowledgment: The Binoculars paper authors - Abhimanyu Hans, Avi Schwarzschild, Valeriia Cherepanova, Hamid Kazemi, Aniruddha Saha, Micah Goldblum, Jonas Geiping, and Tom Goldstein - provided the foundational method for this project.



```
"These vaults are extensive," he said.

"The Montresors were a large family," I replied.

"I forget your arms."

"A golden human foot in a blue field; the foot crushes a serpent whose fangs are embedded in the heel."

"And the motto?"

"Nemo me impune lacessit."

"Good," he said.

The wine sparkled in his eyes, and the bells jingled. My own mind warmed with the Medoc. We passed walls of skeletons, with casks and puncheons mixed
in, reaching the deepest part of the catacombs. I stopped and grabbed Fortunato by the arm above the elbow.

"The nitre," I said. "See, it increases. It hangs like moss on the vaults. We're below the riverbed. Moisture drips amongst the bones. Come, let's go
back before it's too late. Your cough - "

"It is nothing," he said. "Let's keep moving. First, another draught of the Medoc."

I broke off and handed him a flagon of De Grave. He emptied it in one breath. His eyes flashed, a fierce light in them. He laughed, then tossed the
bottle upward with a gesture I did not understand.

I looked at him, surprised. He repeated the movement - a grotesque one.

"You do not comprehend?" he said.

"Not I," I replied.

"Then you are not of the brotherhood."

"How?"

"You are not of the masons."

"Yes, yes," I said. "Yes, yes."

"You? Impossible! A mason?"

"A mason," I replied.

"A sign," he said. "A sign."

"It is this," I answered, producing a trowel from

"You jest," he exclaimed, stepping back a few pac

"Be it so," I said, returning the tool beneath my                                           ning for
the Amontillado. We passed through a range of low                                           e air
caused our flambeaux to glow rather than flame.

At the most remote end of the crypt, another appe                                           d, in the
fashion of the great catacombs of Paris. Three sides of this interior crypt were still ornamented in this manner. From the fourth side, the bones had
been thrown down and lay scattered upon the earth, forming a mound of some size. Within the wall exposed by the displaced bones, we saw a still
interior crypt or recess, about four feet deep, three wide, and six or seven high. It seemed constructed for no special use, but formed merely the
interval between two colossal supports of the catacomb roof, backed by one of their circumscribing walls of solid granite.

Fortunato, raising his dull torch, tried to peer into the depth of the recess. The feeble light did not let us see its end.

"Proceed," I said. "Here is the Amontillado. As for Luchresi - "
```

**Performing rewrite generation for selected LOW section...**

Expected B impact is approximate. Full Analyze is required for exact B. First run may take longer while models

Select rewrite 1, 2, or 3. Press Quit to cancel. Source: external LLM.

Generation complete.

[1] approx B: 0.796908 (+0.003155)
Then you are not one of the brotherhood.

[2] approx B: 0.796113 (+0.002360)
Then you do not belong to the brotherhood.

[3] approx B: 0.796113 (+0.002360)
Then you do not belong to the brotherhood.

"The Montresors were a large family," I replied.

"I forget your arms."

"A golden human foot in a blue field; the foot crushes a serpent whose fangs are embedded in the heel."

"And the motto?"

"Nemo me impune lacessit."

"Good," he said.

The wine sparkled in his eyes, and the bells jingled. My own mind warmed with the Medoc. We passed walls of skeletons, with casks and puncheons mixed in, reaching the deepest part of the catacombs. I stopped and grabbed Fortunato by the arm above the elbow.

"The nitre," I said. "See, it increases. It hangs like moss on the vaults. We're below the riverbed. Moisture drips amongst the bones. Come, let's go back before it's too late. Your cough - "

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I looked at him, surprised. He repeated the movement - a grotesque one.

"You do not comprehend?" he said.

"Not I," I replied.

**Looking up synonyms for 'Amontillado'...**

Binocular score B (high is more human-like): 0.793753 [prior: n/a] | Last Line: 175 | Observer logPPL: 1.891302 | Performer logPPL: 2.271323 | Cross logXPPL: 2.382733 | B score is stale for current edits/rewrites. Run Analyze for exact B.

*Screenshot of the GUI*

# VS Code Extension

This repository also includes a native VS Code extension in `vscode-extension/` that provides the Binoculars workflow directly inside the editor.

Current extension capabilities:

- Analyze current chunk and analyze next chunk.
- Rewrite current selection/line with ranked options.
- LOW/HIGH text overlays plus per-line contribution gutter bars.
- One-click `Clear Priors` plus prior contributor faint backgrounds (major contributors only) after re-analysis.
- `Toggle Colorization` to hide/show text overlays without losing analysis state.
- Chunk-aware status bar metrics, including `Prior B` when available.
- Sidecar persistence in `*.json` next to markdown files for restoring analysis state.

Detailed extension guide:

- `USERGUIDE-VC.md`

# What This Does

Given input text, `binoculars` computes:

- Observer log-perplexity: `logPPL`

- Cross log-perplexity: `logXPPL` (observer distribution scored against performer distribution)
- Binoculars ratio: `B = logPPL / logXPPL`

It can also generate paragraph-level diagnostics and heatmaps.

## Why Local / Full Logits

The Binoculars-style cross-entropy term depends on full next-token distributions. In practice, this means:

- `logits_all=True` is required
- Top-k API logprobs are not sufficient for faithful reconstruction
- Observer and performer tokenizer alignment must be exact

The reference paper is included at:

- `background/2401.12070v3.pdf`

Additional local design notes:

- `initial-scoping.md` (local, gitignored)

## Theory

Let a tokenized document be:

$$ x_1,, x_2,, \dots,, x_T $$

with observer model $M_o$ and performer model $M_p$.

**Observer log-perplexity:**

$$ \log \mathrm{PPL}*{M_o}(x) = -\frac{1}{T-1} \sum*{t=1}^{T-1} \log p_{M_o}(x_{t+1} \mid x_{\leq t}) $$

**Cross log-perplexity:**

$$ \log \mathrm{XPPL}*{M_o, M_p}(x) = -\frac{1}{T-1} \sum*{t=1}^{T-1} \sum_{v \in V} p_{M_o}(v \mid x_{\leq t}) \log p_{M_p}(v \mid x_{\leq t}) $$

**Binoculars score:**

$$ B(x) = \frac{\log \mathrm{PPL}*{M_o}(x)}{\log \mathrm{XPPL}*{M_o, M_p}(x)} $$

The current UI/CLI interpretation used by this repository:

- Higher `B` is treated as more human-like
- Lower paragraph `logPPL` is treated as more AI-like for heatmap colouring

Important: This is a scoring signal, not proof of authorship.

## Repository Layout

- `binoculars.py`: main CLI and GUI application; `binoculars.sh`: wrapper that activates venv, cleans old instances, and forwards Ctrl-C
- `binocular.sh`: alias wrapper (`exec binoculars.sh`); `config.binoculars.json`: master profile selector (`default` and `profiles`)
- `config.binoculars.llm.json`: optional OpenAI-compatible rewrite backend config for GUI rewrite suggestions; `config.llama31.cuda12gb.fast.json`: fast profile (currently `text.max_tokens=4096`)
- `config.llama31.cuda12gb.long.json`: long profile (currently `text.max_tokens=12288`); `USERGUIDE-GUI.md`: detailed GUI user guide and iterative workflow guidance
- `vscode-extension/`: VS Code extension source, manifest, bridge, and packaging assets
- `USERGUIDE-VC.md`: detailed VS Code extension user guide
- `background/2401.12070v3.pdf`: background paper; `samples/`: sample markdown inputs
- `tests/test_regression_v1_1_x.py`: regression suite; `tests/fixtures/`: fixture docs used by regression tests

## Requirements

- Linux or macOS shell
- Python 3.10 or newer
- `numpy`
- `llama-cpp-python`
- Optional: `nltk` (for local WordNet synonym expansion in GUI)
- GGUF models on local disk

Install into the repository venv:

```
venv/bin/pip install numpy llama-cpp-python
```

Optional WordNet setup for richer synonym suggestions:

```
venv/bin/pip install nltk
venv/bin/python - <<'PY'
import nltk
nltk.download("wordnet", quiet=True)
nltk.download("omw-1.4", quiet=True)
PY
```

## Model Files

Configs in this repository point to local model paths under `models/`, for example:

- Base observer: Llama 3.1 8B Q5_K_M

- Instruct performer: Llama 3.1 8B Instruct Q5_K_M

You may use different models if tokenizer and vocabulary alignment are preserved.

## Configuration

### 1) Master Profile Config

`config.binoculars.json` selects profile by label:

```
{
  "default": "long",
  "profiles": {
    "fast": "/abs/path/config.llama31.cuda12gb.fast.json",
    "long": "/abs/path/config.llama31.cuda12gb.long.json"
  }
}
```

`profiles` entries can be either:

- String path (current repository default), or
- Object form:

```
{
  "path": "/abs/path/config.json",
  "max_tokens": 8192
}
```

`max_tokens` in object form (if present) overrides `text.max_tokens` in the concrete profile.

### 2) Concrete Observer/Performer Profile

Each profile must define:

- `observer`
- `performer`

Optional blocks:

- `text` (`add_bos`, `special_tokens`, `max_tokens`)
- `cache` (`dir`, `dtype`, `keep`)

Notes:

- `n_ctx: 0` means auto (`n_ctx = analyzed token count`)
- `text.max_tokens > 0` truncates input token window

- `cache.dtype` may be `float16` or `float32`

### 3) Optional Rewrite LLM Config (GUI)

If `config.binoculars.llm.json` is present and enabled, GUI rewrite suggestions can use an external OpenAI-compatible endpoint. If missing or disabled, internal performer-model generation is used. If present but unreachable or invalid at runtime, GUI rewrites automatically fall back to internal generation.

Supported fields include:

- `llm.enabled`; `llm.endpoint_url`
- `llm.request_path` (default `/chat/completions`); `llm.model`
- `llm.api_key` or `llm.api_key_env` (also supports `OPENAI_API_KEY` when enabled); `llm.api_key_header` / `llm.api_key_prefix`
- `llm.timeout_s`; `llm.max_tokens`
- `llm.temperature`; `llm.top_p`
- `llm.context_chars_each_side`; `llm.context_paragraphs_each_side`
- `llm.context_window_max_chars`; `llm.extra_headers`
- `llm.extra_body`

Example:

```
{
  "llm": {
    "enabled": true,
    "endpoint_url": "http://localhost:4141/v1",
    "model": "gpt-4.1",
    "request_path": "/chat/completions",
    "api_key_env": "OPENAI_API_KEY",
    "max_tokens": 220,
    "temperature": 0.78,
    "top_p": 0.95,
    "context_chars_each_side": 1800,
    "context_paragraphs_each_side": 2,
    "context_window_max_chars": 5200
  }
}
```

## Execution Model

`binoculars.py` loads models sequentially:

1. Tokenize with observer and performer in `vocab_only=True`
2. Hard-fail if tokenization differs
3. Run observer with full logits
4. Persist observer logits to memmap

5. Unload observer, load performer
6. Compute cross-entropy term from observer distribution versus performer logits
7. Emit metrics and optional diagnostics or heatmap

This approach keeps VRAM usage lower than concurrent dual-model loading.

## CLI Usage

Show help:

```
./binoculars.sh --help
```

Basic usage:

```
./binoculars.sh samples/Athens.md
```

JSON output:

```
./binoculars.sh --config long samples/Athens.md --json
```

Heatmap mode:

```
./binoculars.sh --config fast --input samples/Athens.md --heatmap --diagnose-top-k 10
```

Diagnostics:

```
./binoculars.sh --diagnose-paragraphs --diagnose-top-k 10 samples/Athens.md
./binoculars.sh --diagnose-paragraphs --diagnose-print-text samples/Athens.md
```

Run from any directory:

```
cd ~
/home/npepin/Projects/binoculars/binoculars.sh --config long /tmp/doc.md --json
```

Alias wrapper:

```
/home/npepin/Projects/binoculars/binocular.sh --config fast /tmp/doc.md
```

### Input Rules

- Provide input as either:
  - Positional `INPUT`, or
  - `--input INPUT`
- If both are provided, the command errors
- If multiple positional paths are given, only the first is used (a warning is emitted)
- If no input is given, stdin (`-`) is used

### CLI Options

- `--master-config FILE`: master profile mapping file; `--config PROFILE`: profile label (`fast`, `long`, etc.)
- `--input FILE|-`: explicit input; `--output FILE`: write text output
- `--json`: emit JSON result object; `--diagnose-paragraphs`: rank low-perplexity hotspot paragraphs
- `--diagnose-top-k N`: hotspot count (also used by heatmap selection); `--diagnose-print-text`: print full hotspot text segments
- `--heatmap`: emit console and markdown heatmap output; `--gui FILE`: launch interactive GUI editor/analyzer

`--heatmap` cannot be combined with `--json`.

`--gui` is mutually exclusive with:

- `--input`
- Positional `INPUT`
- `--output`
- `--json`
- `--heatmap`

## Heatmap Mode (`--Heatmap`)

When enabled:

- Console output shows:
  - Red and green highlights (ANSI)
  - Simple note markers like `[1]`
  - Line-drawing notes table
  - Wrapped layout (about 85% terminal width)
- File output writes markdown to:
  - `[[HTML_BLOCK_6]]_heatmap.md` in the same directory as the source input
  - Existing heatmap file is backed up first:

        - `[[HTML_BLOCK_7]].YYYYMMDD_HHMMSS.bak` (timestamp format may vary by implementation helper)

Heatmap semantics:

- Red sections: lowest paragraph `logPPL`
- Green sections: highest paragraph `logPPL`
- Note table columns:
    - `Index`; `Label`
    - `% contribution`; `Paragraph`
    - `logPPL`; `delta_vs_doc`
    - `delta_if_removed`; `Transitions`
    - `Chars`; `Tokens`

## GUI Mode (`--Gui [[HTML_BLOCK_8]]`)

Launches an editor/analyzer with:

- Window/app name: `Binoculars`
- Left pane: editable source text
- Left gutter:
    - Logical line numbers
    - Red and green contribution bars per line
- Right pane: live markdown preview
- Right-pane footer: real-time synonym panel for clicked words
- Controls:
    - `Open`
    - `Analyze`
    - `Analyze Next` (shown after first chunk when unscored text remains)
    - `Save`
    - `Undo` (one level)
    - `Clear Priors`
    - `Quit`
- Status bar:
    - `Binocular score B (high is more human-like): ...`
    - Shows active chunk range and chunk-relative metrics

For a detailed workflow-oriented guide, see:

- `USERGUIDE-GUI.md`

### GUI Behaviour

- `Analyze`:

    - On first run, analyzes from document start (`char 0`) up to the token-limited chunk boundary

  - On later runs, analyzes from the active chunk start (not from the cursor line itself)
  - Replaces any overlapping prior chunk descriptor with the new analysis result
  - Can move the effective chunk end boundary forward or backward after edits
  - Preserves cursor and top-view position
  - Updates red and green foreground highlights
  - Updates hover tooltips (`% contribution`, `logPPL`, `delta_if_removed`, `delta_vs_doc`, ranges)
  - Updates status metrics for the active chunk
  - Keeps `Performing analysis on current text...` visible until analysis finishes
  - Edits since last analysis show in yellow

- `Analyze Next`:

  - Appears after first successful analysis if unscored text remains
  - Starts at the contiguous covered tail (`analysis_covered_until`)
  - Extends coverage into the next token-limited chunk
  - Remains available until contiguous coverage reaches end-of-document

- Active chunk selection priority for status and `Analyze`:

  - Selection overlap with analyzed chunks (largest overlap wins)
  - Else cursor line if visible and inside an analyzed chunk
  - Else majority overlap with currently visible editor window
  - Else nearest analyzed chunk by distance

- Chunk boundaries are operational, not immutable:

  - Chunks are stored as descriptors with local metrics.
  - Coverage intervals are merged for rendering/unscored display.
  - Overlapping chunk descriptors are replaced on re-analysis.
  - Result: boundaries can shift after edits and a second `Analyze`.

- Example:

  - First pass analyzes lines `1-999` as chunk 1.
  - Cursor is at line `999` and user presses `Analyze`.
  - Binoculars re-analyzes starting at chunk-1 start (line 1), not line 999.
  - If edits changed token density, chunk 1 may now end at line `972` or `1031`.
  - Status then reports metrics for that updated chunk range.

- On advancing to the next `Analyze`, previous highlights or edits are reduced to faint backgrounds, indicating prior states.

- Executing `Clear Priors` clears only these faint backgrounds, leaving other markings intact.

- The `Save` command initiates a write operation:

- `[[HTML_BLOCK_9]]_edited_YYYYMMDDHHMM.md`

- Output is directed to the same directory as the source file.

- During the write process, a modal `Saving...` popup displays the destination filename.

Always-on English spell checking is active:

- Misspelled words are underlined in red.

Synonym suggestions are available:

- Left-click any word in the left pane to request synonyms.
- Lookup actions are debounced to prevent triggering during drag-selection.
- The synonym panel displays up to nine options in three columns, each with a `1..9` button.
- Selecting a synonym replaces the chosen word and marks the change as an edit (yellow).
- The lookup sequence is: local fallback list, then WordNet (if installed), then Datamuse API as a fallback.

Rewrite suggestions can be accessed as follows:

- Right-click a red (`LOW`) paragraph segment to open three rewrite options. Alternatively, highlight a block (multi-line selection allowed) and right-click to request block rewrites.
- Highlighted-block rewrites round the selection to full lines. If unscored lines are included, they are preserved unchanged while scored/analyzed lines are rewritten.
- The popup displays the approximate B impact for each option (exact B requires `Analyze`). Options are sorted by expected B increase, with more human-like choices first.
- Select an option using the mouse or keyboard (`1`/`2`/`3`), or `Quit`. The selected rewrite is inserted as an edit (yellow), and prior backgrounds are preserved according to previous line status.
- The B score is not automatically recalculated; the status marks it as stale until the next `Analyze`.

Delete and undo operations are tracked:

- Deleting a selected block with `Delete` or `Backspace` is recorded as a single undoable action.
- `Undo` supports one level of undo for selected-block delete, synonym replacement, red-segment rewrite, and block rewrite.
- Successful undo status is shown briefly, after which metrics return.

Preview selection mirroring is supported:

- Selecting a block in the left pane causes the right preview to mirror the same line range.
- Selected preview lines display LOW, HIGH, or neutral background styles.

Status-bar transient messages:

- Non-analysis events (such as Save, Clear Priors, Delete, or Undo) temporarily replace metrics.
- Most transient messages restore metrics after approximately eight seconds.
- A successful `Undo applied...` restores metrics quickly, in about 1.8 seconds.

## Preview Sync and Debug Controls

Environment variables:

- `BINOCULARS_GUI_DEBUG=1`: Starts with the debug overlay enabled; can be toggled in-app with `F9`.
- `BINOCULARS_PREVIEW_VIEW_OFFSET_LINES=-3`: Adjusts vertical view calibration for the right pane, affecting only the preview viewport position (not line mapping).

## Wrapper Behaviour (`Binoculars.Sh`)

`binoculars.sh` performs the following:

- Activates the repository virtual environment.
- Runs `binoculars.py`.
- Deactivates the virtual environment on exit.
- Forwards Ctrl-C to the child process.
- Terminates prior running instances by default to free GPU or VRAM resources.

To disable automatic termination if necessary:

```
BINOCULARS_DISABLE_AUTO_KILL=1 ./binoculars.sh ...
```

## Output Contract (JSON)

Top-level keys include:

- `input`
- `observer`
- `performer`
- `cross`
- `binoculars`
- `cache`

Optional:

- `diagnostics.low_perplexity_spans` (when `--diagnose-paragraphs` is enabled)

## Performance and Tuning Notes

- Main memory usage is driven by full logits (`tokens x vocab`).
- Long contexts are resource-intensive, even if VRAM appears available.
- `text.max_tokens` is the primary limit for runtime and memory safety.
- `n_ctx: 0` is typically optimal (auto-sizes to analyzed tokens).
- Observer and performer components are loaded sequentially.

Current shipped profile token limits:

- `fast`: 4096

- `long`: 12288

Adjust these values in profile JSON files as needed for your hardware.

## Troubleshooting

Tokenizer mismatch error:

- Use a model pair from the same family (base and instruct sibling).
- Ensure both configurations reference compatible tokenizer and vocabulary models.

Missing file errors:

- Verify `config.binoculars.json` profile paths.
- Check model paths in the configuration JSON files.

GUI unavailable:

- Confirm that Tkinter is installed in your Python environment.

Unexpected GPU memory contention:

- Close other LLM processes, or rely on the wrapper's auto-kill feature.
- Reduce `text.max_tokens`.
- Lower `n_batch` if necessary.

llama.cpp context warnings:

- Low-signal llama.cpp runtime logs (`INFO`, `WARN`, `DEBUG`, including `llama_context` initialization messages) are suppressed by default for cleaner output.
- To disable log suppression for debugging, set `BINOCULARS_SUPPRESS_LLAMA_CONTEXT_WARNINGS=0`.

## Tests

To run the regression suite:

```
./venv/bin/python -m unittest -v tests/test_regression_v1_1_x.py
```

## License

PolyForm Noncommercial License 1.0.0. This project is licensed under the **PolyForm Noncommercial License 1.0.0** (see `LICENSE.md`).

Important scope clarification:

- The licence applies to the code, configuration, scripts, and documentation in this repository.

- It does not claim ownership of, or restrict use of, the Binoculars approach described in the associated paper.

Key points:

- Noncommercial use only: use, modification, and redistribution are permitted for noncommercial purposes.
- Commercial use requires explicit authorization. Any paid product or service that incorporates this code must have the author's permission.
- Attribution is mandatory. Redistribution or use of substantial portions of this project must include clear credit and preserve the licence and notice requirements described in `LICENSE.md`.

For commercial applications, contact the author to discuss participation or licensing.

## Limitations

- No calibrated classifier thresholds are implemented yet.
- There is no claim of definitive authorship attribution.
- Markdown is processed as plain text; semantic markdown parsing is not performed.
- Long documents may need to be truncated due to full-logit computational cost.

## Chunk-Aware Large-File Analysis (Current Behaviour)

For files that exceed one-pass token limits, GUI analysis is chunk-aware.

- First `Analyze` starts at document start and scores the first token-limited chunk.
- `Analyze Next` progresses from contiguous covered tail into the next chunk.
- `Analyze` on later runs targets the active chunk start, not the cursor line.
- Active chunk metrics drive the status bar and rewrite-approximation baselines.
- Unscored regions are rendered as complement intervals over full document length.
- Chunk boundaries may shift after edits because overlapping chunk descriptors are replaced by the newest analysis.

### Chunking FAQ

Q: If my cursor is near the end of chunk 1 (for example line 999) and I press `Analyze`, what gets analyzed?

A: Binoculars analyzes from the active chunk start, not from the cursor line. In that case it re-analyzes from the start of chunk 1 (often line 1) forward to the current token-limited boundary.

Q: Will chunk boundaries stay fixed forever once discovered?

A: No. Chunk metrics are always chunk-local, but chunk boundaries are operational. If text edits change token density, a later re-analysis can move the chunk end earlier or later, and overlapping prior chunk descriptors are replaced by the new result.

## Safety / Responsible Use

Treat outputs as probabilistic signals within a broader review process. Do not use this tool as the sole basis for punitive or high-stakes actions.

## Appendix: GPTZero vs Binoculars (Public Information)

This appendix summarizes public details about GPTZero and compares them to the Binoculars method implemented here.

### 1) What Is Known About Gptzero

Public GPTZero materials describe a layered detection system.

- The initial release (January 2023) focused on `perplexity` and `burstiness` as core indicators.
- Current documentation describes a probabilistic, sentence-level and document-level deep-learning detector that does not rely solely on perplexity or burstiness.
- GPTZero states its production system combines multiple components and outputs trinary sentence labels (`human`, `mixed`, `AI`) with confidence and uncertainty handling.

Details not publicly disclosed:

- Exact model architectures.
- Training data composition.
- Post-processing and thresholding methods.
- Adversarial hardening techniques.

Therefore, GPTZero is partially documented, but the full internal mechanisms remain proprietary.

### 2) How Binoculars Differs

Binoculars is more explicit in its mechanism.

- It is defined by transparent equations over two related language models:
  - observer `logPPL`
  - observer-vs-performer `logXPPL`
  - ratio `B = logPPL / logXPPL`
- It uses a zero-shot detection approach, requiring no target-model-specific training for the detector.
- The paper reports strong low-FPR performance, detecting over 90% of generated samples at 0.01% FPR in tested scenarios.
- Head-to-head comparisons in the paper show Binoculars outperforming GPTZero in their 2023 evaluation setup.

### 3) Why Binoculars Can Compete with Gptzero

Available evidence indicates Binoculars can operate in the same competitive tier, with some caveats.

- Published results show strong discrimination at very low false-positive rates, a key deployment factor.

- The mechanism is model-agnostic in the zero-shot sense and can generalize to unseen generators when assumptions hold.
- The approach is inspectable and reproducible (equations and open implementation), aiding calibration and operational trust.

However, caution is warranted.

- “As robust as GPTZero” is context-dependent and should be validated on your domain, document lengths, and attack or perturbation conditions.
- The Binoculars paper notes important limits, such as degraded recall in some low-resource language settings and no guarantee against motivated adversarial evasion.
- Independent benchmarks indicate that many detectors degrade under perturbation, so robustness claims should be treated as empirical and subject to ongoing review.

In practice:

- Binoculars is credibly “same-league” with commercial detectors in several reported scenarios, especially when low-FPR behaviour is required.
- You should run periodic, domain-specific benchmark checks (including perturbed or paraphrased text) before making strong operational claims.

## 4) Sources

- Binoculars paper (arXiv): https://arxiv.org/abs/2401.12070
- Binoculars paper in repo: `background/2401.12070v3.pdf`
- GPTZero technology page: https://gptzero.me/technology
- GPTZero FAQ (method overview): https://gptzero.me/faqs/how-does-ai-detection-work
- GPTZero original launch note (perplexity/burstiness framing): https://gptzero.me/news/first-release-of-gptzero-for-educators-january-3-2023
- RAID benchmark (robustness context): https://arxiv.org/abs/2406.07958