Text-Terminal: A UTF-8 Text Editor for the Linux Shell

Project Report
Operating Systems Lecture Spring Semester 2025

University of Basel
Faculty of Science
Department of Mathematics and Computer Science

Heinrich Ahrend
Yorik Metzger
Jorn Riedel
Shura V. Ruben

June DD, 2025

Contents

1 Introduction

Text editors are an essential tool that is quite often taken for granted since pretty much every single operating system has one included by default. Despite this, quite a lot of software engineering is required to develop a software product that is able to full fill the requirements posed by the tasks we need and wish to perform in our text editors.This is especially the case when features like word and line count should work well with very large files.
Since these aspects intrigued us and we wanted to try and develop our own solution from the ground up, we choose to develop a full text editor as our OS course project. More specifically we have opted to try and develop a plain text (file) editor, with good handling of large (even very large files), since this is one of the major weak points we identified with VS Code and other text editors. Additionally:

- it should support UTF-8 encoding since it is essential when writing a text in German and French.
- it should be compatible with the three most common line break standards: `\n` (Linux), `\r\n` (Windows), `\r` (Mac).
- the user interface should be a bit easier to use then pure keyboard text editors (e.g. vi/vim); it should allow to use the mouse for most important operations.
- and finally the user interface should be responsive even when operating on large files.

2 Background

For the text structure we did some research and settled on implementing our own *piece table* data structure inspired by C. Crowley's research paper [1]. *Piece tables* are a good choice in our use case since they require almost no preprocessing (good for large files), allow for very efficient inserts and deletes even in large files and fit well with memory mapped files (which we implemented). More about *piece tables* and our implementation in the next section 3.

The GUI uses ncursesw version 6 [2], it is the library that we chose to build our text-based UI because it has good terminal support. Specifically we chose the wide characters version of ncruses so that it can support Unicode and international character sets (standard ncurses only has ASCII support).

We also used xclip [3] for our copy/paste functionality. It allows accessing the clipborad in X11, which is the Linux desktop environment. It bridges the terminal and GUI clipboard.

3 Methodology

After deciding on our project topic we fixed our software requirements in more concrete form. Having done so we identified that it would be most beneficial to divide our future code into front end and backed with the main interface being between graphical user interface (GUI) and text data structure. The `textStructure.h` header is the main interface connecting the GUI in `main.c` and the actual text data structure implementation in `textStructure.c` [4]. The other files are mostly built around these two central pieces of code. A more visual layout can be seen in 1.

Figure 1: Project Code Structure

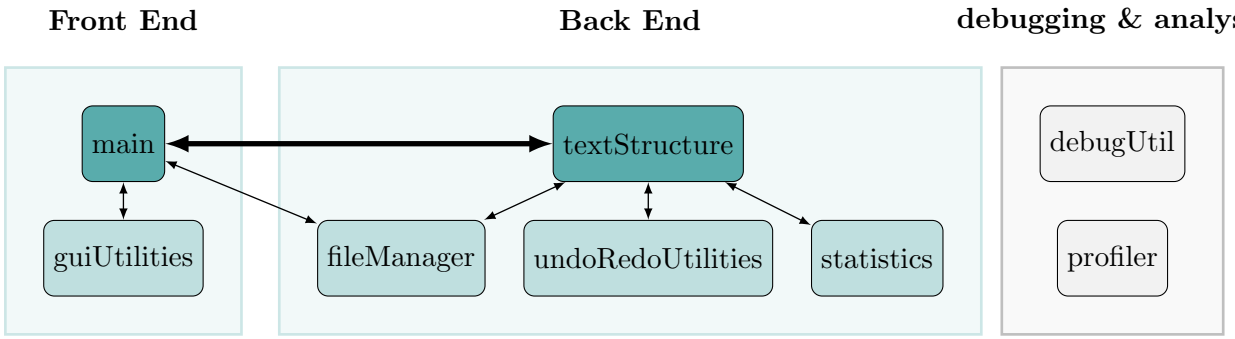
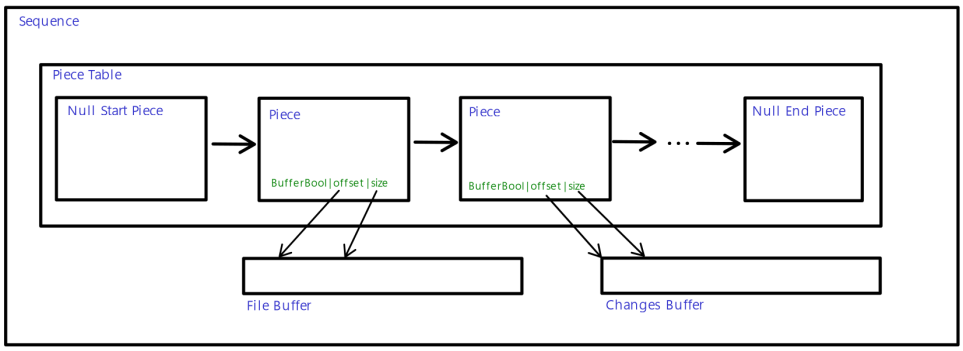


Figure 2: High level text data structure (sequence) illustration



File management(see `fileManager.c` [4]) The way we load files into the editor is optimized even for very large files (we tested up to 5.5 GB text files). This partly because we directly map the file buffer of the sequence onto a mmap of the opened file. This directly leverages the speed and adavantage of the Linux mmap capabilites. Uppon save we also use mmaps to write, but we decided to still take the slight overhead of copying the original file to a temporary location in order to keep the sequece's peice table in it's current state and there for also the whole undo history alive. Otherwise it would need to be reset each time a save is done, which we found not very user friendly.

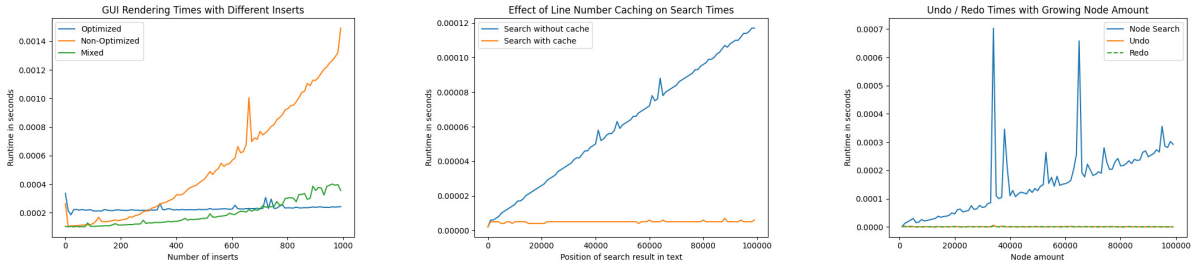
`print_items_after` is one of our most important parts and our method to that displays text in our terminal. Prints a certain number of lines starting from a chosen atomic position in our text sequence. Checks if sequence exists and line break standards. If good proceeds. It walks through blocks of text data and handles things liek UTF-8 character boundaries, skips control characters and detects line breaks or end-of-block to finish a text line.
Changes current line segment to wide-character string for terminal compatibility. Output is the processed string that goes to the terminal at correct screen position.
For efficiency it only prints lines that are actually visible on the terminal, so out of view lines don't get printed. For that we have a variable that has the absolute position of the line at the top of the screen (e.g. top line is actually the 5th line in the entire text). Also this is where the lineStats get update and if a line goes across multiple blocks the counters(atomicsInLine, nbrOfUtf8CharsNoControlCharsInLine) carry over to next block

In `guiUtilities` we have our line statistics like what is the current line number at the top of the screen or how many chars are in the specified line. The methods in here are used for

things like scrolling, jumping to a specific line when using the search function or managing the line stats. Standouts are the converter from UTF-8 to wide characters and a way to translate cursor position to a position in our data structure.

Our Cursor refreshs independent of our text. That means when our cursor moves position it doesn't cause the text to also be refreshed, that would be a big performance hit.

4 Results



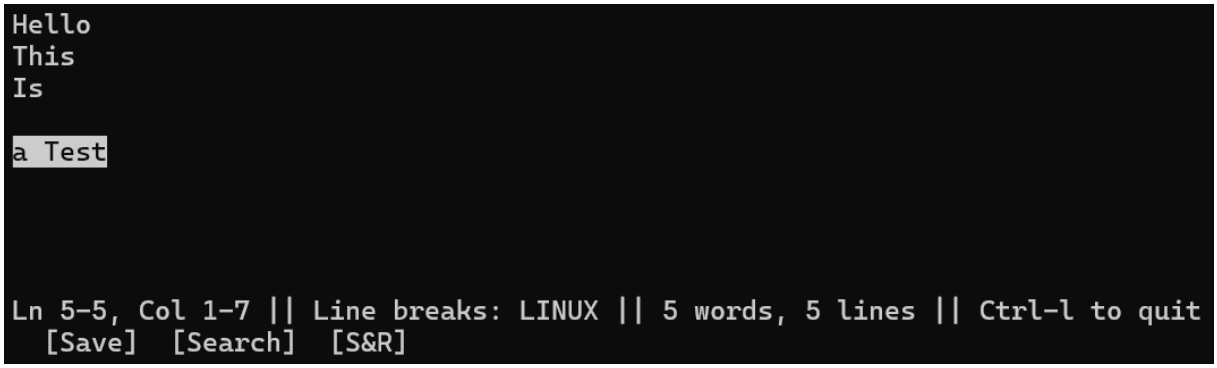


Figure 4: GUI of our text editor running on WSL

Above you can see our GUI. From the top left you can see 5 lines written, one of the blank. 'a Test' is marked and can be use to copy/paste or delete this section. Ln 5-5 means marked are rows from 5 to 5, same for Col but column 1 to 7. 'Line breaks: LINUX' means that the current line break style used is LINUX (\n). It also supports MSDOS (\r\n) and MAC (\r). Next to it you also have total line and total word count and to the right is the short-cut to exit the editor. At the very bottom are buttons that you can press to use them. S&R means search and replace.
All aspetcs of our GUI will be shown in this video [5], as some of these things are impractical to show on a picture.

5 Discussion

We have most normal features a text editor should have like a cursor, mouse integration, deleting, line breaks etc. We even have some advanced features like search/replace, copy/past and can even open multi GB files, so in terms of actual features we are pretty satisfied with the outcome. But there are also some problems that could use some work, for example emojis are displayed as more than one character even though they are only one UTF-8 character, so they are cumbersom

to use in the editor and can cause bugs.
Horizontal scrolling is also not working in the final build, it used to work at some point but stopped working somwhere down the line. Now when you reach the right end of the screen it just stops.

6 Conclusion

7 Lessons Learned

For the GUI aspect we learned that cursor and internal position can very easily de-synchronized, it happened way too often and not even because of wide character support.
The other big part for the GUI group was also time management, we were way too slow at the beginning and middle of the project and definitely caused the other group some headaches. Next time we should definitely try to put a lot more work into the beginning.

Text structure wise we learn very much in this project, especially what considerations go into the design of a text editor and what should be given special attention when handling UTF-8 encoded text. Last but not least we took great pleasure in discovering the low level optimization capabilities provided by C and the satisfaction of having code run accelerated and fast (compared to java).

References

[1] C. Crowley, "Data structures for text sequences," *Computer Science Department, University of New Mexico*, pp. 1–29, 1998.

[2] Thomas E. Dickey, "ncurses." [Online]. Available: https://invisible-island.net/ncurses/. Accessed 10 Jun. 2025.

[3] astrand & Contributors, "xclip: Command line interface to the X11 clipboard." [Online]. Available: https://github.com/astrand/xclip. Accessed 10 Jun. 2025.

[4] Heinrich Ahrend,Yorik Metzger, Jorn Riedel, Shura V. Ruben, "GithUb repository of the project." [Online]. Available: https://github.com/sruben1/Text-Terminal. Accessed 10 Jun. 2025.

[5] Jorn Riedel, "Demo of Text Editor Project." [Online]. Available: https://drive.google.com/file/d/1obnfqQgP9Gp3SvdBcAY_Rjes19-MmlR8/view?usp=drive_link. Accessed 10 Jun. 2025.

Appendix A: Plots

Appendix B: Materials

B.1 Software Requirements

Requrements we set ourselves at the initial project submission:

- custom data structure
- possibility to open files
- utf8 support
- line break styles
- move cursor
- clickable buttons
- selectable text
- edit text
- special functions: find, replace
- copy ,paste
- handle different line break standards
- word count statistic
- line break type statistic

Additional requirements we managed to do:

- cursor position statistic
- line statistic
- replace all occurences

Appendix C: Declaration of Independent Authorship

Copy text from https://dmi.unibas.ch/fileadmin/user_upload/dmi/Studium/Computer_Science/Diverses/Verwendung_AI/2025-02-17_Eigenstaendigkeitserklaerung_Declaration-of-Independent-Authorship_DE_EN_neu.pdf

And sign it (all authors!)

Signature of all authors as PDF