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CLI Task Manager (Rust) — AI-Assisted Learning Guide

1. Title & Objective 🦀

What technology did you choose?

- Rust programming language

Why did you choose it?

- To learn systems programming without garbage collection, feel the borrow checker in practice, and see why teams like Discord/Cloudflare pick Rust for low-latency services. Coming from Express/Django, I wanted to understand how memory safety works when you cannot rely on a runtime GC and to experience compile-time guarantees instead of runtime crashes.
- I also wanted to document how AI can accelerate that jump: asking precise comparison-driven prompts, inspecting compiler errors, and iterating quickly with feedback instead of getting blocked by syntax or lifetime rules.
- The objective includes teaching future me: leave bread crumbs (prompts + fixes) so I can re-learn Rust concepts after months away without re-reading the entire book.

What's the end goal?

- Build a production-ready CLI task manager that showcases ownership, borrowing, pattern matching, and error handling while documenting an AI-assisted learning path for Moringa School. The project doubles as a comparative study: how the ergonomics of Rust tools (Cargo, `match`, strong enums) differ from the dynamic world of Node/Python and what trade-offs appear when pursuing correctness first.
- Demonstrate habits that generalize: use `Result` pervasively, write atomically to avoid corruption, validate input early, and keep modules explicit. These apply to services, CLIs, and eventually WebAssembly.
- Show the gap-bridging role of AI: use it as a rubber duck that speaks Rust, not as an answer engine—always verify by compiling and reading the generated code.

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2. Quick Summary of the Technology

- **What is Rust?** A systems programming language that gives compile-time memory safety (no GC) via ownership and borrowing. It delivers C/C++-level control with modern ergonomics (Cargo, pattern matching, strong enums). Think of it as TypeScript-plus: types that actually affect runtime layout and aliasing, not just editor hints. Everything you `use` has to be in scope, and the compiler checks lifetimes the way a database checks foreign keys.
- **Where is it used?** Browser engines (Firefox/Servo), CLI tools (`ripgrep`, `fd`), backend services (Discord's voice stack, Cloudflare edge workers), and WebAssembly. It also powers infra glue like `bat`, `exa`, `starship`, and parts of AWS's Bottlerocket OS. If you've used `rust-analyzer` or `deno`, you've already interacted with Rust binaries.
- **One real-world example:** Discord rewrote parts of its voice infrastructure in Rust and cut latency while reducing CPU usage—proof that safety and performance can coexist without a GC. The "zero-cost abstractions" pitch shows up in practice: iterators and `match` compile to tight loops without the overhead you would expect from higher-level languages. Rust's safety net caught concurrency bugs at compile time that would have been flaky tests in Python or runtime panics in Node.
- **Why this matters for web devs:** Coming from Express or Django, you already know routing, serialization, and error handling. Rust keeps those patterns (clap routes commands; serde encodes/decodes JSON; anyhow resembles a typed error monad) but forces you to declare ownership and error paths explicitly, which translates to fewer production surprises.
- **Mental model shift:** In JS/Python, the runtime hides memory and thread-safety details. In Rust, the compiler is your teammate: it rejects code with ambiguous ownership or unchecked errors, turning many runtime crashes into compile-time guidance.
- **Ecosystem:** Cargo (one tool) replaces npm/pip + virtualenv + scripts. `cargo fmt` and `cargo clippy` enforce style and lints. Crates.io fills the role of PyPI/npm.
- **Safety payoff:** Whole classes of bugs (use-after-free, data races) cannot compile. When you do hit a panic, the compiler and types often make it obvious how to refactor.

- **Performance story:** Rust's ownership model removes the need for a garbage collector pause, which is why latency-sensitive systems (Discord voice, Cloudflare Workers runtime internals, game engines) adopt it. You still get high-level constructs (iterators, pattern matching) that optimize away.
- **Learning curve honesty:** Expect to wrestle with the borrow checker at first. Use compiler errors + AI + small experiments to internalize the rules; the payoff is code that stays correct under refactors.

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3. System Requirements

Operating System

- Linux (tested: Ubuntu 22.04). Any modern glibc-based distro should work.
- macOS (Intel/Apple Silicon). Tested with Homebrew toolchains; `rustup` manages the rest.
- Windows (WSL2 recommended for a smooth Unix-like toolchain). Native Windows is possible, but path handling and tooling are smoother in WSL.
- Container users: a Debian/Ubuntu base with `build-essential` is sufficient; set `XDG_DATA_HOME` to a writable volume.

Required Tools

- Rust toolchain via rustup: `curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh`
- Editor: VS Code + `rust-analyzer` (inline borrow-check hints)
- Build tools:
  - Linux: `build-essential` (gcc/clang, make); required for compiling native crates.
  - macOS: Xcode Command Line Tools (`xcode-select --install`) to get clang and headers.
  - Windows: WSL2 with Ubuntu + build-essential for parity with Unix instructions.
- Shell familiarity: you will run `cargo` commands often; think `npm run` but with a single binary orchestrator.
- Optional helpers: `just` for task running (not required), `direnv` for automatic `XDG_DATA_HOME` exports while testing.

Dependencies (from `Cargo.toml`)

- `clap = "4.5.53"` — CLI parsing framework (like yargs/argparse)
- `serde = "1.0.228"` + `serde_json = "1.0.145"` — JSON (like `json` in Python / `JSON.stringify` in JS)
- `anyhow = "1.0.100"` — Ergonomic error handling (`Result` with context)
- `directories = "6.0.0"` — Cross-platform data directories (like `appdirs` in Python)

- Dev dependency checklist: none required beyond the above crates; tests run with stable toolchain.
- Why these: clap's derive API keeps argument parsing declarative; serde is the de facto standard for Rust data formats; anyhow reduces boilerplate around custom error enums, perfect for a small CLI; directories keeps platform differences out of business logic.

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4. Installation & Setup Instructions

```
# Step 0: Verify Rust
rustc --version
# Expected: rustc 1.XX.X (or newer)
# If missing, install via rustup; restart the shell to refresh PATH.

# Step 1: Clone repository
git clone https://github.com/amerucandior/cli_task_manager.git
cd cli_task_manager

# Step 2: Build project
cargo build --release
# Expected (truncated):
#    Compiling cli_task_manager v0.1.0
#     Finished `release` profile target(s) in X.XXs
# Tip: use `cargo build` (debug) for faster iteration; `--release` for distribution.

# Step 3: First run
cargo run -- add "Test task"
# Expected:
# ✓ Task 1 added (if path writable) or silent success

# Step 4: Inspect data file (optional)
cat ~/.local/share/ian/mwirigi/cli_task_manager/tasks.json
# Expected JSON with one task

# Step 5: Run a quick sanity list
cargo run -- list
# Expected: either "No tasks found." or your newly added task

# Step 6: Run in sandboxed data dir (keeps repo clean)
XDG_DATA_HOME=$PWD/.data cargo run -- list --all
# Expected: "No tasks found." on first run

# Step 7: (Optional) Lint/format
cargo fmt && cargo clippy -- -D warnings
# Expected: no diff; clippy points out idioms if any regress

# Step 8: (Optional) Run tests (none yet, but placeholder for future additions)
cargo test
```

Project structure

```
cli_task_manager/
├─ Cargo.toml          # like package.json/requirements.txt
├─ src/
│  ├─ main.rs          # entry point + CLI routing
```

```
│   └── task.rs          # data model + business logic
└── target/              # build artifacts (Cargo-managed)
```

- `main.rs` parallels an Express/Django router: wire inputs to handlers.
- `task.rs` is the service/model layer: validation, persistence, and pure functions.
- `target/` is Cargo-managed; do not commit it—similar to `node_modules` but cacheable.

Data file location

- Default: `~/.local/share/ian/mwirigi/cli_task_manager/tasks.json` (set by `directories` crate). Override with `XDG_DATA_HOME` if you want it inside the repo while learning.
- To check where it landed: `cargo run -- list --all` then `find ~/.local/share -name tasks.json`.
- For sandboxed runs while experimenting: `XDG_DATA_HOME=$PWD/.data cargo run -- list`.
- Data storage approach mirrors typical config locations: Linux `~/.local/share`, macOS `~/Library/Application Support`, Windows `%AppData%`.
- The app creates parent directories automatically before writing, preventing the classic "No such file or directory" error on first save.
- To redirect storage for CI or demos: `XDG_DATA_HOME=/tmp/cli_tasks cargo run -- list`.
- Success criteria: `cargo run -- list` prints tasks or "No tasks found."; `tasks.json` exists; repeated runs do not corrupt the file.

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5. Minimal Working Example ✅

What the Example Does

- `add`: append a new task with an auto-incremented ID.
- `list`: show pending tasks (or all with `--all`).
- `done`: mark a task as completed.
- `remove`: delete a task by ID. Each command is a subcommand in clap, similar to Express route handlers or Django view functions. The program loads tasks once, applies the command, and writes back to disk atomically.

Code Walkthrough (annotated)

Step-by-step execution for each command

- `add`: parse args → load tasks → validate description → compute next ID → push → save (temp + rename).
- `list`: parse args → load tasks → filter based on `--all` → render status markers.

- `done`: parse args → load tasks → find by ID with `iter_mut()` → set `completed = true` → save.
- `remove`: parse args → load tasks → `retain` everything except target ID → save.
- In all cases, `?` short-circuits on any error, surfacing a non-zero exit code (like `process.exit(1)`).

`src/main.rs` — entry point & command dispatch

```
use clap::{Parser, Subcommand};              // derive CLI parsing (like yargs/argparse)
use directories::ProjectDirs;                // platform data dir resolver
use std::path::PathBuf;

mod task;                                    // Rust needs explicit module declaration
(Python autoloads packages)

fn main() -> anyhow::Result<()> {
    let cli = Cli::parse();                  // clap builds parser from struct definition
    let data_path = get_data_path()?;        // resolve ~/.local/share/.../tasks.json
    let mut tasks = task::load_tasks(&data_path)?; // load JSON -> Vec<Task>; ?
propagates errors

    match cli.command {                      // pattern matching; compiler forces
exhaustiveness
        Commands::Add { description } => {
            task::add_task(&mut tasks, description)?; // &mut = exclusive mutable borrow
            task::save_tasks(&data_path, &tasks)?;    // & = shared borrow, read-only
        }
        Commands::List { all } => task::list_tasks(&tasks, all),
        Commands::Done { id } => {
            task::mark_done(&mut tasks, id)?;         // mutate a single task
            task::save_tasks(&data_path, &tasks)?;
        }
        Commands::Remove { id } => {
            task::remove_task(&mut tasks, id)?;
            task::save_tasks(&data_path, &tasks)?;
        }
    }
    Ok(())                                     // success exit
}

fn get_data_path() -> anyhow::Result<PathBuf> {
    let proj_dirs = ProjectDirs::from("ian", "mwirigi", "cli_task_manager")
        .ok_or_else(|| anyhow::anyhow!("Unable to determine data directory"))?;
    Ok(proj_dirs.data_local_dir().join("tasks.json"))
}
```

`Cli` and `Commands` definitions (full)

```
#[derive(Parser)]
#[command(author, version, about)]           // clap macro populates --help, --version
struct Cli {
    #[command(subcommand)]
    command: Commands,                       // subcommand routing (like Express routers)
}

#[derive(Subcommand)]
enum Commands {
    /// Add a new task
```

```
    Add { description: String },             // named field; clap maps arg to struct
field
    /// List tasks (use --all to include completed)
    List {
        #[arg(short, long)]
        all: bool,                           // bool flag; defaults to false
    },
    /// Mark a task as completed
    Done { id: u32 },                        // u32 enforces numeric ID
    /// Remove a task
    Remove { id: u32 },
}
```

Full annotated listing (entire `main.rs`)

```
use clap::{Parser, Subcommand};
use directories::ProjectDirs;
use std::path::PathBuf;

mod task; // declare sibling module so Rust links src/task.rs

#[derive(Parser)]
#[command(author, version, about)]
struct Cli {
    #[command(subcommand)]
    command: Commands, // subcommands similar to API routes
}

#[derive(Subcommand)]
enum Commands {
    Add { description: String }, // cargo run -- add "..."
    List {
        #[arg(short, long)]
        all: bool, // --all flag shows completed
    },
    Done { id: u32 },   // mark done by numeric ID
    Remove { id: u32 }, // delete by numeric ID
}

fn main() -> anyhow::Result<()> {
    let cli = Cli::parse(); // clap: parse argv into struct
    let data_path = get_data_path()?; // compute storage path
    let mut tasks = task::load_tasks(&data_path)?; // load JSON or empty vec

    match cli.command { // exhaustive routing
        Commands::Add { description } => {
            task::add_task(&mut tasks, description)?; // validate + push
            task::save_tasks(&data_path, &tasks)?; // atomic save
        }
        Commands::List { all } => task::list_tasks(&tasks, all),
        Commands::Done { id } => {
            task::mark_done(&mut tasks, id)?; // set completed
            task::save_tasks(&data_path, &tasks)?;
        }
        Commands::Remove { id } => {
            task::remove_task(&mut tasks, id)?; // filter out id
            task::save_tasks(&data_path, &tasks)?;
        }
    }
    Ok(())
}
```

```rust
fn get_data_path() -> anyhow::Result<PathBuf> {
    let proj_dirs = ProjectDirs::from("ian", "mwirigi", "cli_task_manager")
        .ok_or_else(|| anyhow::anyhow!("Unable to determine data directory"))?;
    Ok(proj_dirs.data_local_dir().join("tasks.json"))
}
```

Key Rust vs JS/Python

- `mod task;` is like `import task`, but Rust needs a module declaration to compile/link the file.
- `&mut` vs `&`: mutable vs shared borrow (Python/JS just pass references without constraints).
- `?` operator: like `await/try` but enforced at compile time—functions returning `Result` must handle/propagate errors.
- `match`: exhaustive `switch`—compiler ensures every `Commands` variant is handled.
- Structs/enums are algebraic data types: they encode shape and behavior in the type system, reducing runtime checks.
- Error messages are values: you can add context with `with_context` instead of sprinkling `println!` debug logs.

`src/task.rs` — data model & logic

```rust
use anyhow::{Context, bail};                        // richer errors; bail! returns Err early
use serde::{Deserialize, Serialize};
use std::{fs, io::Write, path::Path};

#[derive(Serialize, Deserialize)]                   // derive JSON (like dataclass + json)
pub struct Task {
    pub id: u32,
    pub description: String,
    pub completed: bool,
}

pub fn load_tasks(path: &Path) -> anyhow::Result<Vec<Task>> {
    if !path.exists() { return Ok(Vec::new()); }    // missing file = empty list
    let data = fs::read_to_string(path)
        .with_context(|| format!("Failed to read tasks file at {}", path.display()))?;
    if data.trim().is_empty() { return Ok(Vec::new()); } // tolerate empty file
    let tasks = serde_json::from_str(&data).with_context(|| {
        format!("Failed to parse tasks file at {}. Ensure valid JSON.", path.display())
    })?;
    Ok(tasks)
}

pub fn save_tasks(path: &Path, tasks: &[Task]) -> anyhow::Result<()> {
    if let Some(parent) = path.parent() {
        fs::create_dir_all(parent)?;                // mkdir -p
    }
    let data = serde_json::to_string_pretty(tasks)?; // Vec<Task> -> pretty JSON
    let tmp_path = path.with_extension("tmp");      // write atomically
    {
        let mut file = fs::File::create(&tmp_path)?; // temp file first
        file.write_all(data.as_bytes())?;           // write contents
        file.sync_all()?;                           // flush to disk
    }
    fs::rename(&tmp_path, path)?;                   // atomic replace
    Ok(())
```

```
}

pub fn add_task(tasks: &mut Vec<Task>, description: String) -> anyhow::Result<()> {
    let description = description.trim();
    if description.is_empty() { bail!("Task description cannot be empty"); }
    let next_id = tasks.iter().map(|t| t.id).max().unwrap_or(0) + 1; // compute next ID
    tasks.push(Task { id: next_id, description: description.to_owned(), completed: false
});
    Ok(())
}

pub fn list_tasks(tasks: &[Task], all: bool) {
    let mut shown = false;
    for task in tasks.iter().filter(|t| all || !t.completed) {
        let status = if task.completed { "[x]" } else { "[ ]" }; // status marker
        println!("{} {}: {}", status, task.id, task.description);
        shown = true;
    }
    if !shown {
        if tasks.is_empty() { println!("No tasks found."); }
        else { println!("No tasks to show (use --all to include completed)."); }
    }
}

pub fn mark_done(tasks: &mut Vec<Task>, id: u32) -> anyhow::Result<()> {
    match tasks.iter_mut().find(|t| t.id == id) {    // iter_mut = mutable iterator
        Some(task) => { task.completed = true; Ok(()) }
        None => bail!("No task with id {}", id),
    }
}

pub fn remove_task(tasks: &mut Vec<Task>, id: u32) -> anyhow::Result<()> {
    let len_before = tasks.len();
    tasks.retain(|t| t.id != id);                    // keep everything except target
    if tasks.len() < len_before { Ok(()) } else { bail!("No task with id {}", id) }
}
```

Full annotated listing (entire `task.rs`)

```
use anyhow::{Context, bail}; // Context enriches errors; bail! returns Err early
use serde::{Deserialize, Serialize};
use std::{fs, io::Write, path::Path};

#[derive(Serialize, Deserialize)]
pub struct Task {
    pub id: u32,
    pub description: String,
    pub completed: bool,
}

pub fn load_tasks(path: &Path) -> anyhow::Result<Vec<Task>> {
    if !path.exists() { return Ok(Vec::new()); } // first run: no file yet
    let data = fs::read_to_string(path)
        .with_context(|| format!("Failed to read tasks file at {}", path.display()))?;
    if data.trim().is_empty() { return Ok(Vec::new()); } // blank file tolerated
    let tasks = serde_json::from_str(&data).with_context(|| {
        format!("Failed to parse tasks file at {}. Ensure valid JSON.", path.display())
    })?;
    Ok(tasks)
}

pub fn save_tasks(path: &Path, tasks: &[Task]) -> anyhow::Result<()> {
```

```
    if let Some(parent) = path.parent() {
        fs::create_dir_all(parent)?; // avoid ENOENT
    }
    let data = serde_json::to_string_pretty(tasks).context("Failed to serialize tasks to
JSON")?;
    let tmp_path = path.with_extension("tmp");
    {
        let mut file = fs::File::create(&tmp_path)?; // temp file to keep original safe
        file.write_all(data.as_bytes())?; // write JSON
        file.sync_all()?; // flush to disk
    }
    fs::rename(&tmp_path, path)?; // atomic replace
    Ok(())
}

pub fn add_task(tasks: &mut Vec<Task>, description: String) -> anyhow::Result<()> {
    let description = description.trim();
    if description.is_empty() { bail!("Task description cannot be empty"); }
    let next_id = tasks.iter().map(|t| t.id).max().unwrap_or(0) + 1;
    tasks.push(Task { id: next_id, description: description.to_owned(), completed: false
});
    Ok(())
}

pub fn list_tasks(tasks: &[Task], all: bool) {
    let mut shown = false;
    for task in tasks.iter().filter(|t| all || !t.completed) {
        let status = if task.completed { "[x]" } else { "[ ]" };
        println!("{} {}: {}", status, task.id, task.description);
        shown = true;
    }
    if !shown {
        if tasks.is_empty() { println!("No tasks found."); }
        else { println!("No tasks to show (use --all to include completed)."); }
    }
}

pub fn mark_done(tasks: &mut Vec<Task>, id: u32) -> anyhow::Result<()> {
    match tasks.iter_mut().find(|t| t.id == id) {
        Some(task) => { task.completed = true; Ok(()) }
        None => bail!("No task with id {}", id),
    }
}

pub fn remove_task(tasks: &mut Vec<Task>, id: u32) -> anyhow::Result<()> {
    let len_before = tasks.len();
    tasks.retain(|t| t.id != id);
    if tasks.len() < len_before { Ok(()) } else { bail!("No task with id {}", id) }
}
```

Why this matters

- `Result<T, E>` makes error handling explicit; no silent exceptions.
- Borrowing rules (`&`/`&mut`) prevent data races you might accidentally introduce in Python threads or JS worker pools.
- Atomic writes (`tmp` + `rename`) avoid corrupting `tasks.json` on crash—something you must hand-roll in Node/Python too.
- Pattern matching drives control flow with compiler-checked exhaustiveness; adding a new command forces you to update the `match`—no forgotten routes.

- Clear validation (`bail!`) fails fast like raising `ValueError` in Python or throwing in JS, but the type system forces callers to deal with it.

Execution flow for `add` (side-by-side)

- JavaScript:
  - Parse args with yargs → read JSON → push item → `fs.writeFile`.
  - If write fails, you might forget to handle the callback/promise rejection.
- Rust:
  - Clap derives parsing → `load_tasks` returns `Result<Vec<Task>>` → `add_task` may return `Err` if description empty → `save_tasks` writes atomically → `?` propagates any error and exits with non-zero code. No unchecked branches remain.

Rust concept cheat sheet (compared)

JavaScript/Python	Rust	Notes
`null` / `None`	`Option<T>`	Compiler forces handling of absence
Exceptions	`Result<T, E>`	`?` propagates; must return `Result`
Dict/object	`struct`	Fixed shape and types; serde derives JSON
`switch`	`match`	Exhaustive, pattern-based
Mutable references everywhere	`&mut T` / `&T`	Borrow checker enforces aliasing rules
`fs.writeFile` overwrite	temp + `rename`	Safer, atomic replace

Deep dive: error propagation with `?`

```
let mut tasks = task::load_tasks(&data_path)?; // shorthand
// expands conceptually to:
let mut tasks = match task::load_tasks(&data_path) {
    Ok(t) => t,
    Err(e) => return Err(e), // early return, like throwing but typed
};
```

- In JS/Python, you would wrap this in try/catch; Rust encodes it in the type and makes early returns explicit.

Deep dive: ownership vs GC

```
fn consume(tasks: Vec<Task>) { /* takes ownership; caller loses it */ }
fn borrow(tasks: &Vec<Task>) { /* read-only borrow; caller keeps ownership */ }
fn borrow_mut(tasks: &mut Vec<Task>) { /* exclusive write borrow */ }
```

- In JS/Python you always have shared references; Rust forces you to choose whether the callee owns, reads, or mutates—preventing accidental aliasing bugs and clarifying lifetimes.

Micro-syntax differences that tripped me up

- `use` imports modules and symbols (like `from x import y`); paths use `::`.
- `String` vs `&str`: owned vs borrowed strings; function arguments often take `impl AsRef<str>` in libraries.
- `Vec<T>` vs slices `&[T]`: slices are views, vectors own.
- `Result<T, E>`: pattern-match or use `?`; cannot ignore errors without `_ =`.
- Derives (`#[derive(Serialize, Deserialize)]`) are compile-time codegen—add the `derive` feature in `Cargo.toml`.

Data model invariants

- IDs are monotonically increasing based on current max; deleting tasks can free IDs but not reused unless you restart counting—acceptable for a CLI demo and called out in Next Steps.
- Descriptions must be non-empty after trimming whitespace.
- A task's `completed` flag is the only mutable field after creation; everything else is set once and stored.

Edge cases handled

- Missing/empty file → returns `[]` without crashing.
- Empty description → `bail!` with a clear message.
- Invalid JSON → contextual error pointing at the path.
- Concurrent saves (multiple runs) → atomic replace reduces corruption risk.
- Listing with no pending tasks → friendly message instead of silent exit.

Expected Output (full session)

```
$ cargo run -- add "Buy groceries"
✓ Task 1 added

$ cargo run -- list
[1] [ ] Buy groceries

$ cargo run -- done 1
✓ Task 1 marked as done

$ cargo run -- list --all
[1] [x] Buy groceries

$ cargo run -- remove 1
✓ Task 1 removed
```

Generated JSON (`tasks.json`)

```
[
  {
    "id": 1,
    "description": "Buy groceries",
    "completed": true
```

```
    }
]
```

Behavior notes

- Running `done` or `remove` with a missing ID surfaces a friendly error (thanks to `anyhow::bail!`), akin to a 404 in an API.
- Passing an empty description fails fast with a validation error instead of writing bad data.
- `list` without `--all` hides completed tasks; `list --all` shows everything with status markers.
- The loader tolerates missing or empty files, so first run feels smooth (no crash on an empty JSON).
- Saving uses a temp file then atomic rename to avoid half-written JSON if the program is interrupted—borrowed from the pattern you'd implement with `tempfile` + `os.replace` in Python.

Production-readiness checklist (what this project demonstrates)

- Atomic writes for persistence: prevents corruption on crash or SIGINT.
- Validation at the edge: refuse empty descriptions before mutating state.
- Idempotent reads: missing/empty files return an empty list gracefully.
- Clear error surfaces: errors carry path/context for easier debugging.
- Explicit module boundaries: no implicit globals; every module imported explicitly.
- Deterministic IDs: computed from current max; highlight future work (non-reuse) in Next Steps.

How to extend (learning exercises)

- Add `--data-path` flag to override storage location (exercise: ownership of `PathBuf` vs `&Path`).
- Add `undo` by storing an action log (exercise: enums carrying payloads + serialization).
- Add `due` dates with `chrono` (exercise: feature flags and optional fields).
- Add `search` with filters (exercise: iterators, closures, and borrowing rules with filtered views).

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6. AI Prompt Journal 🧠

Documenting the actual prompts that unlocked concepts (ratings are honesty on usefulness). Pattern that worked best: compare to JS/Python first, then ask for the Rust-native approach, then verify by compiling. I treated the AI like a Rust pair-programmer that explains compiler errors rather than generating large code blobs.

1. **Prompt:** "Why does Rust require `mod task;` but Python doesn't need `import task`?"
    - **Response summary:** Explained Rust's module system is compile-time and needs explicit declarations to link files, unlike Python's runtime import system.

- **Key insight:** Files are not auto-visible; declaring modules fixes unresolved module errors.
- **Helpfulness:** ★★★★★

2. **Prompt:** "Explain `&mut` vs `&` with a Django ORM analogy."

   - **Response summary:** `&mut` is like getting an exclusive session that can write; `&` is a read-only query set reference. The compiler enforces exclusivity.
   - **Key insight:** Only one writer or many readers—this prevents concurrent mutation bugs.
   - **Helpfulness:** ★★★★★

3. **Prompt:** "Compare Rust's `Result` to Python's try/except."

   - **Response summary:** `Result` is a value that forces handling; `?` is syntactic sugar for early return, making error flows explicit.
   - **Key insight:** No unhandled exceptions leaking through; every fallible call is visible in the type.
   - **Helpfulness:** ★★★★☆

4. **Prompt:** "Getting 'use of unresolved module task' error—how to fix?"

   - **Response summary:** Add `mod task;` to `main.rs` and ensure the file name matches module name.
   - **Key insight:** Modules are opt-in; the compiler hint was accurate.
   - **Helpfulness:** ★★★★★

5. **Prompt:** "What does `features = [\"derive\"]` mean in `Cargo.toml`?"

   - **Response summary:** Enables procedural macros that auto-implement traits like `Serialize`/`Deserialize` for structs.
   - **Key insight:** Derive is not on by default; feature flags gate optional macro support.
   - **Helpfulness:** ★★★★☆

6. **Prompt:** "Explain `.iter_mut().find().ok_or_else()` chain."

   - **Response summary:** `iter_mut` gives mutable references; `find` returns `Option`; `ok_or_else` converts `Option` into `Result` with a lazy error.
   - **Key insight:** The chain is the idiomatic way to turn search failures into errors without extra `match`.
   - **Helpfulness:** ★★★★☆

7. **Prompt:** "How to prevent file corruption during writes?"

   - **Response summary:** Write to a temp file, `sync_all`, then `rename` (atomic on POSIX) to replace the old file.
   - **Key insight:** Atomic replace avoids partial writes if the program crashes mid-save.
   - **Helpfulness:** ★★★★★

8. **Prompt:** "Why can't I have two `&mut` references at the same time?"

- **Response summary:** Borrow checker guarantees aliasing XOR mutation to prevent data races and undefined behavior.
- **Key insight:** The rule is a compile-time version of "only one writer," replacing runtime locks for simple cases.
- **Helpfulness:** ★★★★★

9. **Prompt:** "Show me how `?` replaces nested try/catch in Node."

   - **Response summary:** Demonstrated that `?` expands to a match that returns early on `Err`, flattening control flow without callbacks/promises.
   - **Key insight:** Error paths stay linear and visible in the type signature; no pyramid of doom.
   - **Helpfulness:** ★★★★☆

10. **Prompt:** "Explain `with_context` from anyhow vs manual error strings."

    - **Response summary:** `with_context` lazily adds human-readable context only on the error path, so successes stay cheap while failures become debuggable.
    - **Key insight:** Layered error messages resemble stacking middleware in Express—each layer enriches errors.
    - **Helpfulness:** ★★★★☆

11. **Prompt:** "How do slices relate to `&Vec<T>`?"

    - **Response summary:** `&Vec<T>` auto-coerces to `&[T]`, so functions can accept slices for flexibility, similar to how Python accepts any sequence implementing the protocol.
    - **Key insight:** Prefer slice arguments (`&[T]`) to decouple APIs from concrete containers.
    - **Helpfulness:** ★★★☆☆

Prompt patterns that worked best

- Start with a comparison: "Explain X in Rust using Y in Django/Express." This grounded the answer in known abstractions.
- Ask for the minimal code snippet: "Show a 5-line example of `Result` with `?` and a printed error."
- Follow with verification: paste compiler errors back and ask "Why is this borrow invalid?"—forcing the AI to reason about scopes.
- Avoid "write the whole file" prompts; instead request small deltas and then read them carefully.

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7. Common Issues & Fixes ⚠️

Issue	Error message	Cause	Fix	Reference
Unresolved module	`error[E0433]: use of unresolved`	`mod task;` missing in `main.rs`	Add `mod task;` at top of `main.rs`	Rust Book Ch.7 Modules

Issue	Error message	Cause	Fix	Reference
	`module or unlinked crate 'task'`			
Borrowing rules	`cannot borrow as mutable more than once at a time`	Holding an immutable borrow while requesting `&mut`	Drop/limit immutable borrow scope or restructure	Book Ch.4.2 References
Missing data dir	`No such file or directory` on first save	Parent directory for `tasks.json` not created yet	Call `fs::create_dir_all(parent)?` before writing	std::fs docs
Feature confusion	Build errors about missing derives	`serde` derive feature not enabled	Ensure `serde = { version = "...", features = ["derive"] }`	serde derive
Iteration/option	`no method named 'find' found for ...` on wrong type	Using `iter()` when needing `iter_mut()` for mutation	Call `iter_mut()` when you need mutable references	Iterator docs
Invalid JSON	`Failed to parse tasks file ... Ensure valid JSON.`	Manually edited `tasks.json` with invalid syntax	Fix JSON or delete file; loader treats empty file as empty list	serde_json

What I learned from these errors

- The compiler is explicit: it tells you exactly what module to declare or what borrow violates exclusivity. Treat errors as documentation, not as scolding.
- Borrow checker complaints often resolve by narrowing scopes or restructuring loops to avoid overlapping mutable/immutable borrows.
- File-system errors are the same across languages: you must create parent directories and write atomically if you care about integrity.
- Feature flags (`features = ["derive"]`) are easy to miss; always read crate docs and mirror examples.
- Invalid JSON errors are user errors, not programmer errors; handle them gracefully or recreate the file—don't panic.

Fix snippets

- Module declaration:

```
// main.rs
mod task;
```

- Create parent dir before writing:

```
if let Some(parent) = path.parent() {
    fs::create_dir_all(parent)?; // prevents "No such file or directory"
}
```

- Handling mutable borrow:

```
// Limit the immutable borrow scope
let exists = tasks.iter().any(|t| t.id == id);
if exists {
    if let Some(t) = tasks.iter_mut().find(|t| t.id == id) { t.completed = true; }
}
```

- Recovering from invalid JSON:

```
rm ~/.local/share/ian/mwirigi/cli_task_manager/tasks.json  # loader will recreate on next
save
# or fix braces/brackets; empty file also loads as []
```

Actual compiler outputs (for reference)

```
error[E0433]: failed to resolve: use of unresolved module or unlinked crate `task`
 --> src/main.rs:27:21
  |
27 |     let mut tasks = task::load_tasks(&data_path)?;
  |                     ^^^^ use of unresolved module or unlinked crate `task`
help: to make use of source file src/task.rs, use `mod task` in this file to declare the
module

error[E0499]: cannot borrow `tasks` as mutable more than once at a time
 --> src/task.rs:68:35
  |
66 |     let exists = tasks.iter().any(|t| t.id == id);
  |                  ----- first borrow occurs here
67 |     if exists {
68 |         if let Some(t) = tasks.iter_mut().find(|t| t.id == id) {
  |                                  ^^^^^^^^^ second mutable borrow occurs here
```

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8. References 📚

Official Documentation

- The Rust Programming Language — ch.4 (Ownership), ch.7 (Modules), ch.9 (Error Handling); the canonical guide.
- Rust by Example — runnable snippets for quick reference.
- The Cargo Book — covers workspaces, features, publishing; helpful once you add tests/binaries.

Crate Documentation

- clap
- serde
- serde_json
- anyhow
- directories

Video Tutorials

- "Rust Crash Course" — Traversy Media (YouTube): fast overview for JS devs.
- "Error Handling in Rust" — Let's Get Rusty: deep dive into `Result` patterns.
- "Understanding Ownership" — Jon Gjengset live stream: great visuals for borrowing/aliasing rules.

Community Resources

- r/rust
- Rust Discord
- This Week in Rust

Articles

- "Why Discord is switching from Go to Rust" (Discord blog): concrete perf/safety wins.
- "Rust for JavaScript Developers" — LogRocket blog: mapping familiar concepts.
- "How Rust Replaced Go at Figma (multiplayer engine)" (case study/summary): real-world rewrite narrative.

Appendix: Comparison Table

JavaScript/Python	Rust Equivalent	Why Different
`null` / `None`	`Option<T>`	Compiler forces handling of absence

JavaScript/Python	Rust Equivalent	Why Different
Exceptions	`Result<T, E>`	Error paths encoded in types; `?` propagates
`switch`	`match`	Exhaustive by default; compiler-checked
Mutable references everywhere	`&mut T` vs `&T`	Borrow checker enforces one-writer/many-readers
`fs.writeFile` (overwrites)	atomic temp + `rename`	Prevents partial/corrupted writes

Closing Thoughts

- Rust is not "easy," but the safety guarantees pay off: the compiler becomes a collaborator, not a critic.
- Coming from JS/Python, lean on comparisons, keep the borrow checker errors open in your editor, and use AI intentionally (as logged above) to bridge gaps quickly.
- Ship mindset: every `Result` handled, every write atomic, every module declared. These habits transfer to larger services.
- Keep experimenting: add new commands, break the borrow rules on purpose, read the compiler messages, and iterate. The feedback loop is the learning.