Design and Implementation of a C-based Spreadsheet Program

COP290 Project Documentation

1 Program Structure and Design Decisions

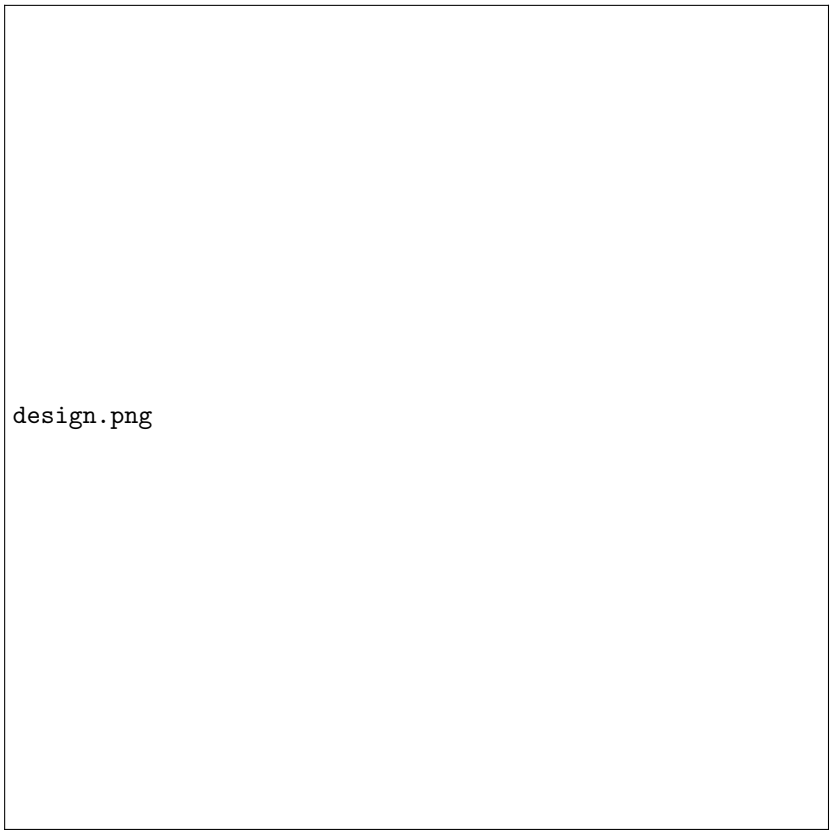
1.1 Modular Architecture

The program follows a modular design with six core components:

- **Initialization Module (init.c/h)**: Handles memory allocation and sheet initialization
- **I/O Handler (io.c/h)**: Manages input parsing and command validation
- **Process Handler (process.c/h)**: Executes commands and evaluates formulas
- **Display Manager (display.c/h)**: Controls the visual representation
- **Dependency Manager (dependent.c/h)**: Manages cell relationships and updates
- **Stack Operations (stack.c/h)**: Provides auxiliary data structure support.

1.2 Key Design Decisions

1. **Cell Dependencies**
   - Implementation of parent-child relationships for formula tracking
   - Use of adjacency lists for cycle detection
   - Topological sorting for ordered updates
2. **Command Processing**
   - Structured parsing using ParsedCommand data structure
   - Support for arithmetic operations and cell ranges
   - Implementation of statistical functions (MIN, MAX, SUM, AVG, STDEV)


design.png

3. **Memory Management**
    - Dynamic allocation for sheet structure
    - Careful memory cleanup to prevent leaks
    - Efficient storage of formulas and dependencies

2 Implementation Challenges

2.1 Technical Challenges

1. **Circular Dependency Detection**
    - Challenge: Detecting cycles in formula references
    - Solution: Implementation of depth-first search algorithm
    - Prevention of infinite loops during cell updates
2. **Formula Evaluation**
    - Challenge: Parsing and evaluating complex formulas
    - Solution: Stack-based evaluation system
    - Handling of nested functions and arithmetic operations
3. **Memory Management**
    - Challenge: Managing dynamic memory for cells and dependencies
    - Solution: Structured allocation and deallocation procedures
    - Prevention of memory leaks in dependency updates
4. **SLEEP Function**
    - Challenge: Implementing time delays without blocking spreadsheet operations
    - Solution: Custom function type with dependency-aware sleep mechanism
    - Prevention of deadlocks in formula evaluation chains

3 Error Handling and Edge Cases

3.1 Input Validation

- Cell reference validation (e.g., "A1", "ZZ999")
- Formula syntax checking
- Range validation (e.g., "A1:B10")
- Function name and argument validation

3.2 Error Scenarios Handled

1. **Formula Errors**
   - Division by zero
   - Invalid cell references
   - Malformed expressions
   - Circular dependencies
2. **Range Errors**
   - Invalid range specifications
   - Out-of-bounds references
   - Empty cell ranges in functions
3. **Memory Errors**
   - Allocation failures
   - Memory leak prevention
   - Buffer overflow protection

4 Test Suite Coverage

4.1 Unit Tests (tests)

1. **Input Parsing Tests**
   - Command type identification
   - Parameter extraction
   - Formula parsing
   - Function argument validation
2. **Validation Tests**
   - Cell reference validation
   - Range specification validation
   - Function name validation
   - Numeric input validation
3. **Cell Conversion Tests**
   - String to row/column conversion
   - Boundary value testing
   - Invalid input handling

4.2 Edge Case Coverage

1. **Formula Evaluation**
    - Complex nested formulas
    - Multiple cell references
    - Statistical function edge cases
    - Error propagation
2. **Dependency Management**
    - Circular reference detection
    - Multiple dependency chains
    - Update propagation
    - Dependency cleanup
3. **Memory Management**
    - Large sheet handling
    - Dynamic resizing
    - Resource cleanup