

Minesweeper - System Architecture Document

Team 28

The University of Kansas

EECS 581 - Software Engineering II

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System Architecture Document

Document Revision History

Date	Version	Comment	Author
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09/04/2025	1.1	Added relevant information for Board Structure	Nabeel Ahmad
09/14/2025	1.2	Complete Components, Update Table of Contents,	Nabeel Ahmad, Omar Mohammed
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10/01/2025	1.4	Adjust Purpose for New Programming Language (Python), Add New Subsections for Added Functionalities, Update Diagrams	Nabeel Ahmad
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Section 1 - Purpose

The purpose of this project is to develop a single-player puzzle game known as Minesweeper. The game consists of a 10×10 grid with a random number of mines accounting for less than 20% of the grid squares. The grid has columns labeled A-J and rows numbered 1-10. Players uncover a cell by clicking on the cell. Each player action also plays a unique sound effect correlating to the input. When a player uncovers a mine, the game ends. However, uncovering a mine reveals a number from 0-8 indicating adjacent mines. Cells with zero adjacent mines trigger recursive uncovering of adjacent cells. Players can toggle flags on covered cells to mark suspected mines. Players can also use an Artificial Intelligence (AI) Solver with turns alternating between player and AI if in interactive mode, or solving automatically. There are varying difficulty levels with the AI (easy, medium, hard). We implement this using Python with Pygame for Graphical User Interface (GUI) operability for the user.

Section 2 - Components

2.1 Board Manager

This component manages the 10×10 grid and tracks cell states. Cell states can be either covered, flagged, uncovered, or a mine).

Key responsibilities:

- Manage 10×10 grid
- Track each cell state for:
 - Covered (hidden, default state)
 - Flagged (player suspects a mine)
 - Uncovered (revealed, safe cell)
 - Mine (dangerous cell)

2.2 Game Logic

This component enforces Minesweeper rules. It processes uncovering, flagging, and recursive revealing of adjacent zero-valued cells. It detects game-ending conditions (loss when a mine is uncovered, victory when all safe cells are revealed) and communicates updated status to the User Interface. Upon board initialization, the Game Logic component ensures the first-clicked cell is guaranteed mine free.

Key responsibilities:

- Validate moves (ignore uncovering flagged cells)
- Count adjacent mines (0-8) for each revealed cell
- Handle recursive flood-reveal when zero mines are adjacent
- Trigger “reveal all mines” on loss

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- Track win/loss status
- First-clicked cell is guaranteed mine free

2.3 User Interface (UI)

The UI presents the game state visually to the player inside a web browser. It renders the 10x10 grid with column labels (A-J) and row labels (1-10), shows flagged, uncovered, and covered cells, and displays the remaining mine count and current game status (“You Win” or “You Lost”).

Key responsibilities:

- Provide intuitive controls for uncovering and flagging cells
- Display accurate cell contents (number, blank, mine, flag)
- Update dynamically in response to Board Manager and Game Logic state changes

2.4 Input Handler

The Input Handler captures and interprets user actions such as left-click (uncover cell) and right-click (toggle flag). It validates these inputs (ex. preventing uncovering a flagged cell) and forwards them to the Game Logic. It also handles optional keyboard shortcuts if implemented. Depending on the type of user action requested, different sounds will play for the respective action.

Key responsibilities:

- Translate raw user interactions into structured commands
- Translate raw user interactions into sound effects
- Prevent invalid moves
- Provide consistent communication between UI and Game Logic

2.5 Artificial Intelligence (AI) Solver

The Artificial Intelligence (AI) Solver operates on the same board configuration, with turns alternating between player and AI if in interactive mode, or solving automatically.

Key responsibilities:

- Difficulty Modulation
 - Easy: AI uncovers cells randomly, avoiding flagged or already uncovered cells
 - Medium: AI uncovers randomly until a safe cell is revealed, then uncovers adjacent cells strategically using revealed numbers
 - Hard: AI “cheats” by always uncovering a safe cell, simulating perfect knowledge without detonating mines

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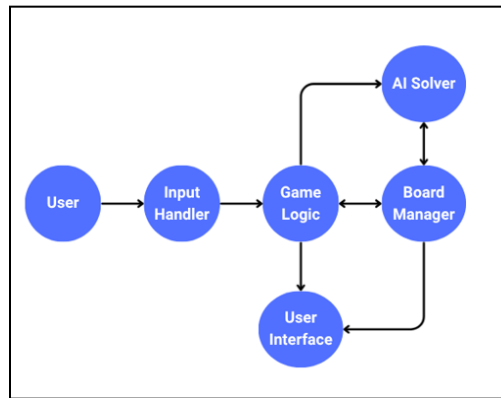


Figure 1: Component Interaction Pathway

Section 3 - Data Flow

3.1 User Input → Input Handler → Game Logic

User Input (ex. clicking a cell) is first captured by the Input Handler. The Input Handler translates the actions by the user into commands that can be processed by the system. If an invalid command is generated, the handler will ignore the input, otherwise valid commands are to be passed to Game Logic. The Game Logic Component will interpret the input given the context of the current state of play (ex. cell uncovering or flag toggling).

3.2 Game Logic → Board Manager

Once the Game Logic interprets a valid user action, board update requests are sent to the Board Manager. The Board Manager is utilized in areas where the state of the grid needs to be adjusted. This includes whether a cell is covered, flagged, or contains a mine. Game Logic works to delegate grid manipulation to the Board Manager. Game Logic maintains the rules of the game, while the Board Manager maintains the underlying data.

3.3 Board Manager → User Interface

The Board Manager supplies the User Interface with the current state of the board. The User Interface requests the necessary details from the Board Manager (ex. cell is hidden, flagged, or uncovered). With incoming data from the Board Manager, the User Interface ensures the user views the board in the most current and relevant state.

3.4 Board Manager → AI Solver → Game Logic

The Board Manager supplies the AI Solver with the current state of the board. The AI Solver requests the necessary details from the Board Manager about the current state of the board. When it is the AI's turn to move, using Game Logic the AI will make decisions on the next possible course of action that should be taken. Once the next move is identified, the AI Solver will make the move and the Board Manager will update the board accordingly. This interaction between

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components helps to shape the AI as an autonomous player, seamlessly integrating with the existing system flow.

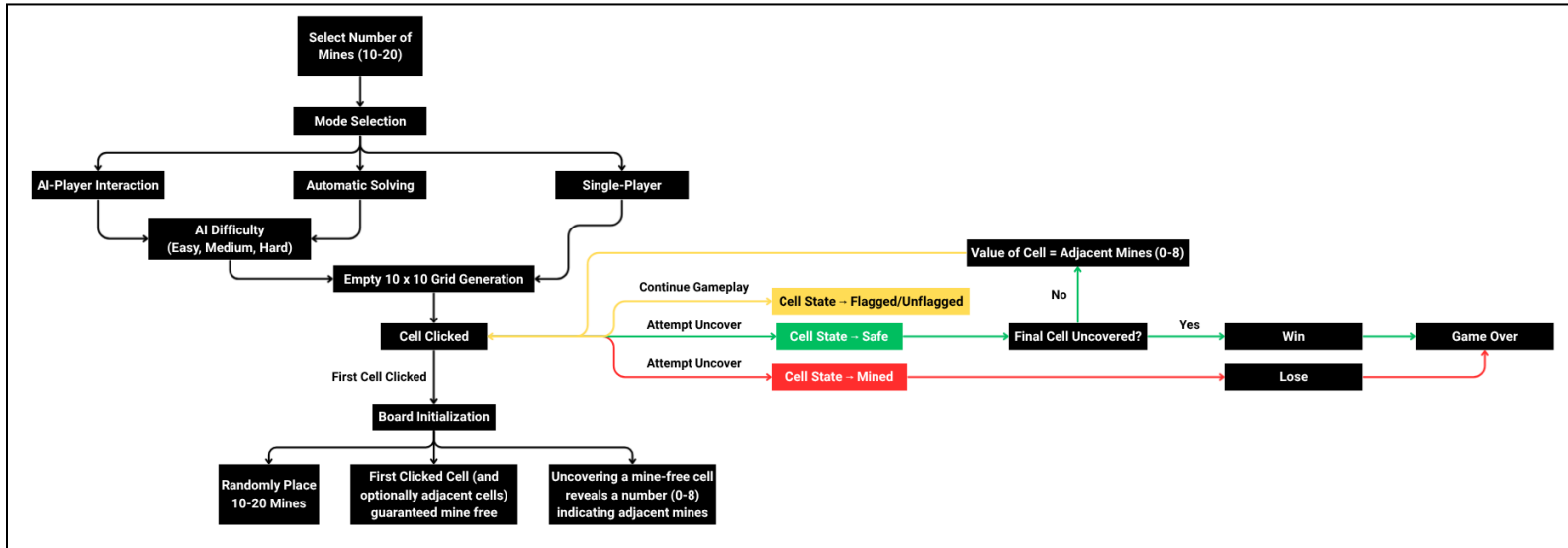


Figure 2: Data Flow Chart

Section 4 - Key Data Structures

4.1 Cell

- Purpose: Unit of game state stored in the board representing one square in the grid
- Fields (as used across UI/Logic):
 - *row: number* → immutable grid coordinator (0-9)
 - *col: number* → immutable grid coordinator (0-9)
 - *x: number* → pixel x-coordinate adjusted for labels/gutter
 - *y: number* → pixel y-coordinate adjusted for labels/header
 - *is_mine: boolean* → whether the square holds a mine
 - *is_revealed: boolean* → whether the square is uncovered
 - *is_flagged: boolean* → whether the player marked a flag
 - *adjacent_mines: number* → count of adjacent mines (0-8)
 - *_border: boolean* → visual highlight for AI-chosen cells

4.2 Board

- Purpose: Authoritative grid of cells and basis for adjacent queries with mine placement logic
- Shape: *self.grid* → where this is a 10×10 grid in current configuration
- Provided/used operations:
 - *_ini_(num_mines, difficulty)* → initialize cells and AI strategy

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- *place_mines(first_click_row, first_click_col)* → populate mines (first-click safe)
- *calculate_all_adjacent_mines()* → compute adjacent counts for all cells
- *count_adjacent_mines(row, col)* → get mine count for specific cell
- *reveal_cell(row, col)* → reveal cell with flood expansion for zero-adjacent cells
- *reveal_all_mines()* → show all mines (on loss)
- *neighbors(cell)* → yield 8 adjacent cells (bounds-checked)
- *uncover_cell_easy/medium/hard()* → AI strategies for cell selection
- *wrapper(cell)* → picks a cell via the wrapped strategy

4.3 GameState

- Purpose: High-level session state owned by main game controller
- Fields:
 - *num_mines: number* → total number of mines placed at the start of the game
 - *board: Board object* → contains the 10x10 grid of Cell objects
 - *game_over: boolean* → True when game ends (hit mine or win)
 - *win: boolean* → True if player won (all non-mines revealed)
 - *first_click: boolean* → True until first reveal (used for safe mine placement)
 - *running: boolean* → main loop control flag
 - *flags_placed: number* → count of currently placed flags
 - *difficulty: string* → AI difficulty level (e.g. easy | medium | hard)
 - *is_interactive: boolean* → True for player control, False for AI auto-play
 - *last_game_status: string | null* → result of previous game for display

4.4 Audio

- Purpose: Sound effects management facade
- Fields:
 - *enabled: boolean* → whether the audio system is available
 - *sounds: dict* → mapping of event names to pygame Sound objects

4.5 Game Configuration

- Purpose: Constants defining game layout and appearance
- Fields:
 - *GRID_SIZE: number* → 10 × 10 grid dimension
 - *CELL_SIZE: number* → pixel size of each cell
 - *COLOR_*: tuples* → RGB color definitions for all UI elements
 - *AI_SOLVER_TIMEOUT: number* → ms between AI moves in auto-play mode

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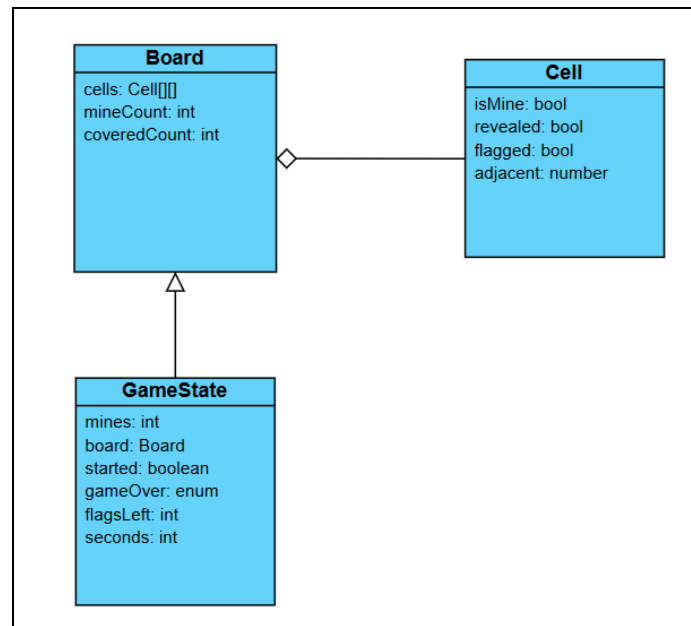


Figure 3: Unified Modeling Language (UML) Diagram for Key Data Structures

Section 5 - Assumptions

5.1 Game Setup

- Fixed 10 × 10 grid size
 - Columns labeled A-J
 - Rows numbered 1-10
- Number of Mines: User specified, 10-20
 - Randomly placed at game start
- First clicked cell (and optionally adjacent cells) guaranteed mine-free
- Initial State: All cells start covered with no flags

5.2 Gameplay

- Players uncover a cell by selecting it (clicking)
- Uncovering a mine ends the game in a loss
- Uncovering a mine-free cell reveals a number (0-8) indicating adjacent mines
- Cells with zero adjacent mines trigger recursive uncovering of adjacent cells
- Players can toggle flags on covered cells to mark suspected mines

5.3 Mine Flagging

- Players place/remove flags on covered cells to indicate potential mines
- Flagged cells cannot be uncovered until unflagged

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- Display remaining flag count (*total mines* – *placed flags*)

5.4 Player Interface

- Display a 10×10 grid showing cell states:
 - covered
 - flagged
 - uncovered (number or empty for zero adjacent mines)
- Show remaining mine count (*total mines* – *total flags*)
- Provide a status indicator for gameplay

5.5 Game Conclusion

- Loss: Triggered by uncovering a mine, revealing all mines
- Win: Achieved by uncovering all non-mine cells without detonating any mines

Section 6 - Person-Hours Estimation

6.1 Estimation Methodology

For the person-hours estimate, a structured approach was used to evaluate a probable length of time for determining task completion. This structure relied on experience in previous software engineering projects, ranging from real-world application to school applications. This was especially useful for areas related to team member contributions and dynamics. For each task, time estimates were derived using references from previous projects allowing for realistic estimations. For areas where historical reference was not applicable, a consensus-based method was used to provide informed estimates. For project uncertainties and external implications, additional time was added to ensure the overall time allocation remained practical.

6.2 Person-Hours Estimate Table

The Person-Hours Estimate Table is located in the GitHub Repository.

Section 7 - Actual Person-Hours Accounting

7.1 Actual Person-Hours Table

The Actual Person-Hours Accounting Table is located in the GitHub Repository.