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Maze Bomber

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ABSTRACT

Maze Bomber Game

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This report describes the development process of a Bomberman-inspired strategic game featuring advanced AI bots, dynamic map generation, and multiplayer capabilities. The game aims to provide an engaging player experience by integrating power-up systems, pathfinding algorithms for strategic movements, and robust collision handling mechanisms.

Key technical components include the implementation of real-time game mechanics, such as bomb placements, explosion rendering, and trap mechanisms. Furthermore, the system supports both single-player and multiplayer game modes. Future developments will incorporate online play functionalities using ENet.

Keywords: Game Development, Bomberman, AI Pathfinding, Multiplayer, Dynamic Map Design.

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1. INTRODUCTION

1.1 The Aim of the Project

The primary objective of this project is to develop a Bomberman clone game called **Maze Bomber**, featuring both single-player and multiplayer modes. The game integrates strategic AI bots, dynamic map generation, and power-up elements to offer an engaging and competitive experience. The project focuses on game logic development, player interactions, and efficient resource management.

By leveraging advanced pathfinding algorithms and real-time event management, the project showcases practical applications of algorithmic problem-solving techniques in game development.

1.2 Literature Review

Bomberman, a classic arcade game, has inspired numerous research and development projects in AI-driven game environments. Modern implementations often utilize pathfinding algorithms such as A* for decision-making in grid-based mazes, enhancing player and bot strategies.

The development of this project leverages the **I-See-Bytes (ICBYTES)** graphics library—a modern alternative to OpenCV. Unlike OpenCV, which is complex and lacks robust GUI support, ICBYTES combines Python's ease of use with C++ performance, making it more accessible for beginners and faster for professional development. Additionally, ICBYTES simplifies the creation of visually appealing applications with built-in GUI features.

Game development tools and libraries have advanced significantly over the past two decades, moving beyond the limitations of older frameworks such as OpenCV. ICBYTES addresses these challenges by offering runtime-determined matrix structures and an efficient data manipulation interface, significantly reducing the complexity of graphics-based game development.

2. TECHNOLOGIES USED

The development of Maze Bomber incorporates a combination of advanced technologies and custom algorithms to deliver an interactive and strategic game experience. The I-See-Bytes (ICBYTES) graphics library serves as the backbone for

rendering game visuals and handling player interactions, while other frameworks and techniques are employed for event management, AI behavior, and resource optimization.

ICBYTES, a cutting-edge alternative to OpenCV, merges the simplicity of Python with the performance of C++. Unlike OpenCV, which lacks comprehensive GUI features, ICBYTES enables developers to design visually appealing applications more efficiently. This library simplifies matrix operations and enhances image manipulation tasks by dynamically determining data types at runtime, thus eliminating OpenCV's reliance on numerous predefined macros.

To handle asynchronous tasks such as player movements, explosion effects, and bot decisions, the project utilizes the Windows Threads API. This allows parallel processing of multiple game components, ensuring a smoother and more responsive gameplay experience.

The Chrono library is employed for precise time-based operations, including power-up activation timers, trap delays, and explosion effect durations. This library facilitates accurate event scheduling and helps manage time-sensitive gameplay features.

Additionally, A* pathfinding is implemented for AI bot movement, enabling bots to navigate the maze efficiently, avoid obstacles, and pursue strategic objectives such as power-ups and enemy players. The algorithm’s heuristic-based approach ensures optimal path selection, contributing to the game’s challenging and dynamic nature.

Overall, the integration of these technologies and tools has resulted in a well-optimized and engaging Bomberman clone game that provides a robust foundation for future expansions, including the planned online multiplayer functionality.

3. GAME DESIGN

Maze Bomber is an action-strategy game in which players strategically place bombs within a maze to eliminate their opponents. The game map consists of various elements such as indestructible walls, destructible blocks, power-ups, and traps. The primary goal of the players is to gain advantageous positions on the map, eliminate their opponents, and be the last surviving player.

This section details the core components of the game, including the map structure, game mechanics, and power-up systems.

3.1 Map Structure

The game map is structured as a 15x15 grid, where each cell has a specific function. The map components are defined as follows:

- Indestructible Walls: These walls serve as fixed barriers within the game area, restricting player movement and creating strategic zones. They are unaffected by bombs and ensure the stability of the map layout.
- Destructible Blocks: These blocks can be destroyed by bombs and may contain power-ups. Players can break these blocks to open new pathways and expand the game area.
- Player Starting Points: The starting positions of players are predetermined and designed as safe zones. This ensures a balanced beginning by preventing immediate attacks at the start of the game.
- Power-Up Areas: Power-ups are randomly distributed across the map and are hidden behind destructible blocks. Players must collect these power-ups to develop different strategies as the game progresses.

This structure allows players to develop both offensive and defensive strategies, ensuring balanced game dynamics.

3.2 Game Mechanics

The game mechanics are based on fundamental elements such as bomb placement, explosion calculations, trap usage, and environmental interactions.

Bomb Mechanism and Explosion Calculations

Players place bombs that explode after a certain period, allowing them to trap opponents and clear pathways.

- When a bomb’s timer runs out, it explodes in four main directions (up, down, left, right).
- The explosion radius starts with a fixed value but can be increased through power-ups.
- Bombs can destroy destructible blocks but are blocked by indestructible walls.
- Players caught in the explosion are eliminated unless they possess specific power-ups (such as shields) that protect them.
- Players can pass through bombs before they explode, but escaping during the explosion becomes more difficult.

These mechanisms encourage players to develop both tactical attack strategies and defensive maneuvers.

Trap Usage and Strategic Effects

Players can strategically place traps to restrict their opponents' movements.

- Traps become invisible shortly after being placed, making them harder for opponents to detect.
- Players stepping on traps experience temporary movement speed reduction, limiting their ability to escape.
- AI-controlled bots memorize the locations of traps and attempt to avoid them.
- Traps cannot be destroyed by explosions, maintaining their presence as a constant threat on the map.

This system allows players to gain an advantage not only through direct attacks but also by controlling their opponents' movements.

3.3 Power-Up System

Maze Bomber features a power-up system that grants players various advantages. Power-ups are randomly placed behind destructible blocks and can be collected by players.

Types of Power-Ups:

- Speed Boost: Increases the player's movement speed, enhancing their ability to escape.
- Explosion Range Boost: Expands the explosion radius of bombs, allowing them to cover a larger area.
- Bomb Count Boost: Increases the number of bombs a player can place simultaneously.
- Shield: Grants temporary immunity against explosions.
- Trap: Allows players to set traps for their opponents.
- Debuff: Causes a random power-up to be removed from an opponent.

Power-Up Mechanics:

- Power-ups are randomly distributed while ensuring a fair balance in each match.

- Multiple power-ups can be collected simultaneously, but each has a specific upper limit.
- Power-ups dropped by eliminated players can be picked up by others.

This system enables different playstyles to emerge as the game progresses, increasing the level of competition.

3.4 Game Controls

	1st Player Controls:	2nd Player Controls:
Movevement	W, A, S, D	Arrow Keys
Places a bomb	E	Numpad 0
Places a trap.	Q	Numpad 3

4. AI BOT STRATEGY

The AI bots in *Maze Bomber* are designed to provide a competitive experience against players. These bots do not rely solely on basic movement algorithms but also employ strategic decision-making mechanisms that adapt to the game's dynamic environment. While the *A (A-Star) pathfinding algorithm** is used to optimize movement, the bots also analyze the current state of the map to execute tactical maneuvers.

AI bots operate based on three primary strategies: **defensive escape, offensive targeting, and resource collection**. They dynamically switch between these strategies depending on the current game state to determine the optimal move.

4.1 Defensive Strategy: Escaping to a Safe Zone

When a bot detects that it is within the blast radius of an active bomb, it prioritizes finding the quickest escape route. It identifies safe zones by analyzing existing explosives and blast areas. The *A algorithm** calculates the shortest path to a non-dangerous area. If no escape route is available, the bot attempts to minimize damage by positioning itself in the least exposed spot.

4.2 Offensive Strategy: Predicting Opponent Movements

Bots continuously track the locations of enemy players on the map. If an opponent is trapped in a specific area or unable to escape from an explosion, the bot strategically places a bomb to capitalize on the situation. By considering **bomb timers and explosion range**, the AI ensures that the opponent's escape routes are cut off at the right moment.

4.3 Resource Collection Strategy: Evaluating Power-Ups

Several **power-ups** are scattered across the map, including **speed boosts, bomb capacity increases, shields, explosion range enhancements, and traps**. Bots detect and prioritize power-ups based on their current needs and playstyle. For instance, an aggressive bot will prioritize **bomb capacity and explosion range upgrades**, whereas a defensive bot will favor **speed and shield power-ups** for survival.

4.4 Avoiding Traps and Countermeasures

The game includes various traps that can restrict bot movement and impact their decision-making. Bots have a memory system that helps them recognize and avoid previously triggered traps. If a bot steps into a trap, it temporarily reduces its speed (debuff effect) and switches to an escape strategy to reach a safer location.

4.5 Dynamic Decision-Making and Strategy Adjustment

AI bots do not rely on static behaviors; instead, they **dynamically adjust** their strategies based on real-time analysis of the game environment. Every second, each bot reevaluates the game state, modifying its actions accordingly. For example, if a bot detects an opportunity to trap an opponent, it immediately switches to an offensive approach. If an explosion is imminent nearby, it shifts into defensive mode and calculates the safest escape route. This constant adaptation creates a more **realistic and unpredictable** gameplay experience.

These advanced decision-making mechanisms allow bots to challenge players effectively, ensuring that each match offers a unique and engaging experience. In future updates, bot strategies will be further refined, and **machine learning models** will be explored to enhance AI behavior, making the game even more immersive.

5. ONLINE INTEGRATION

In its current version, *Maze Bomber* supports local multiplayer gameplay. Players can connect directly with others on the same network and compete in matches. However, local multiplayer is limited to players within the same physically and does not cater to a

broader audience. Therefore, future updates will introduce full online multiplayer functionality.

In upcoming versions, the game will incorporate the **ENet** library to enable online connectivity. ENet provides low-latency data transmission and reliable UDP connections, ensuring a smoother and more stable multiplayer experience. This technology will allow players to connect remotely and compete without the need for a shared local network.

To facilitate seamless player connections, an **online room management system** will be developed. Players will be able to create or join game rooms using the *"Create Room"* and *"Join Room"* options within the game interface. The server will handle room management and ensure proper communication between clients. Additionally, support for virtual network solutions such as Hamachi will be provided as an alternative method for connectivity.

Real-time data synchronization is one of the most critical components of the online mode. Player movements, bomb placements, and explosion effects will be synchronized across all clients with minimal latency. To prevent data loss, the **reliable packet transmission mechanisms** of ENet will be utilized, ensuring that all in-game actions are processed simultaneously across all connected players.

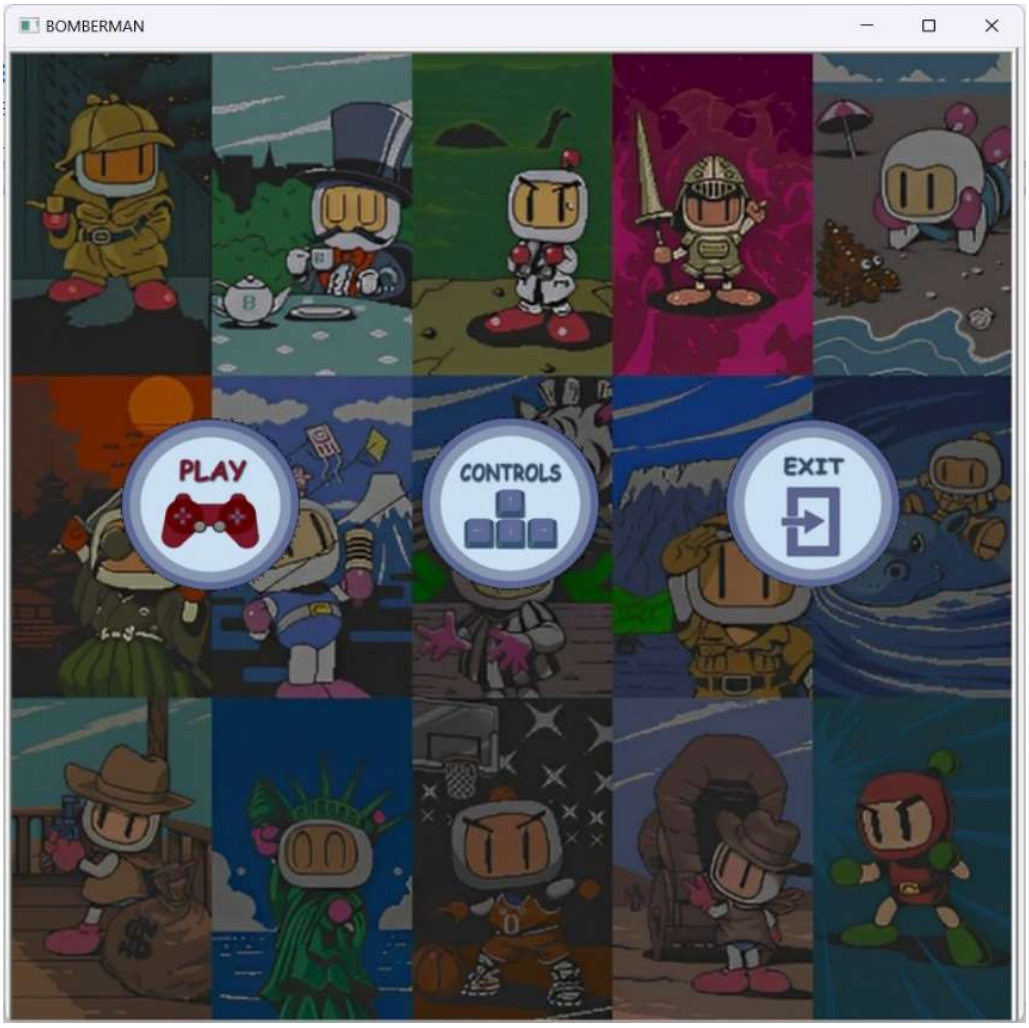
To mitigate potential connection issues and synchronization errors, **fault tolerance and connection management mechanisms** will be implemented. If a player's connection is lost, a reconnection system will be in place to allow them to rejoin the game. Additionally, data packets will be periodically checked to resolve any inconsistencies and ensure a fair and synchronized gameplay experience for all participants.

6. GRAPHICAL USER INTERFACE (GUI)

The **Graphical User Interface (GUI)** of *Maze Bomber* is designed to provide an intuitive and visually cohesive experience while ensuring smooth navigation. The interface consists of several key components: the **main menu, game mode selection screen, in-game interface, controls screen, in-game menu, and winner screen**. Each component has been carefully structured to maintain simplicity while supporting the game’s strategic elements.

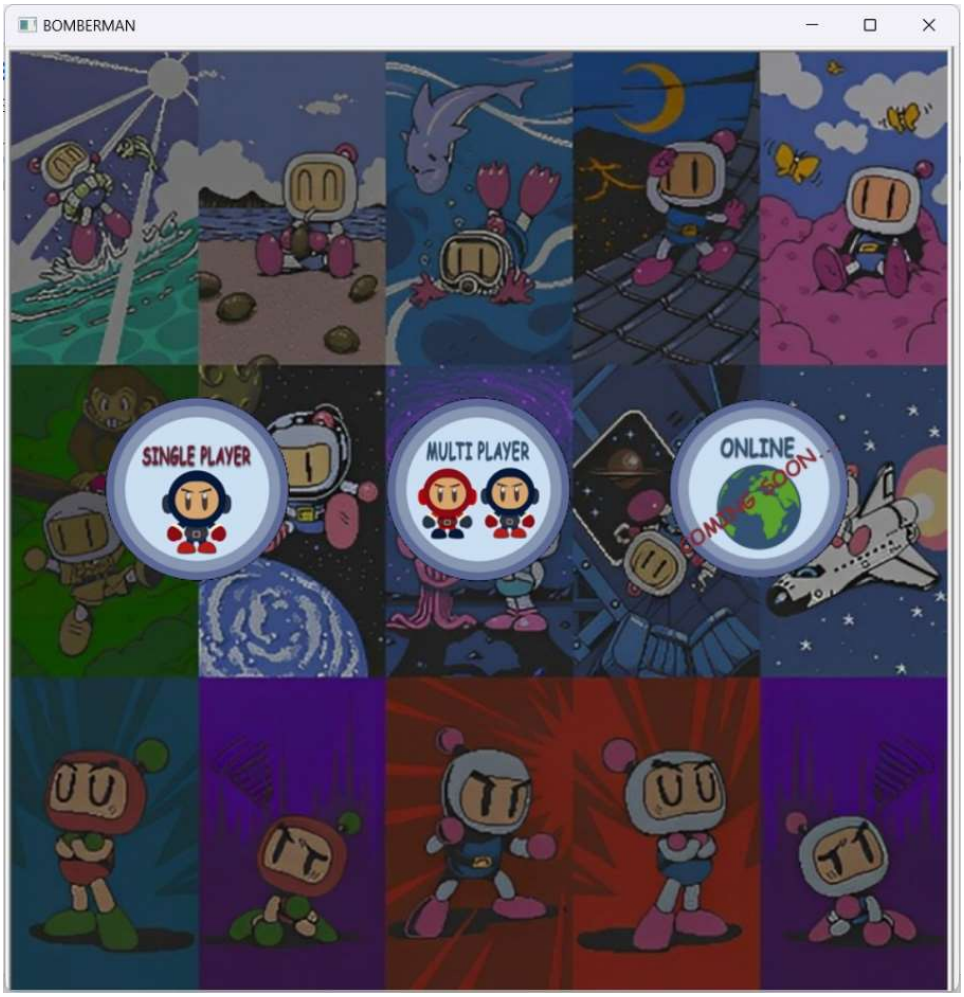
6.1 Main Menu

The **main menu** serves as the starting point of the game and includes three essential buttons: **Play**, which directs players to the game mode selection screen; **Controls**, where players can view the control scheme; and **Exit**, which closes the game. The menu design follows a minimalist approach, ensuring quick and efficient access to game options. The button placement allows players to navigate effortlessly, keeping distractions to a minimum.



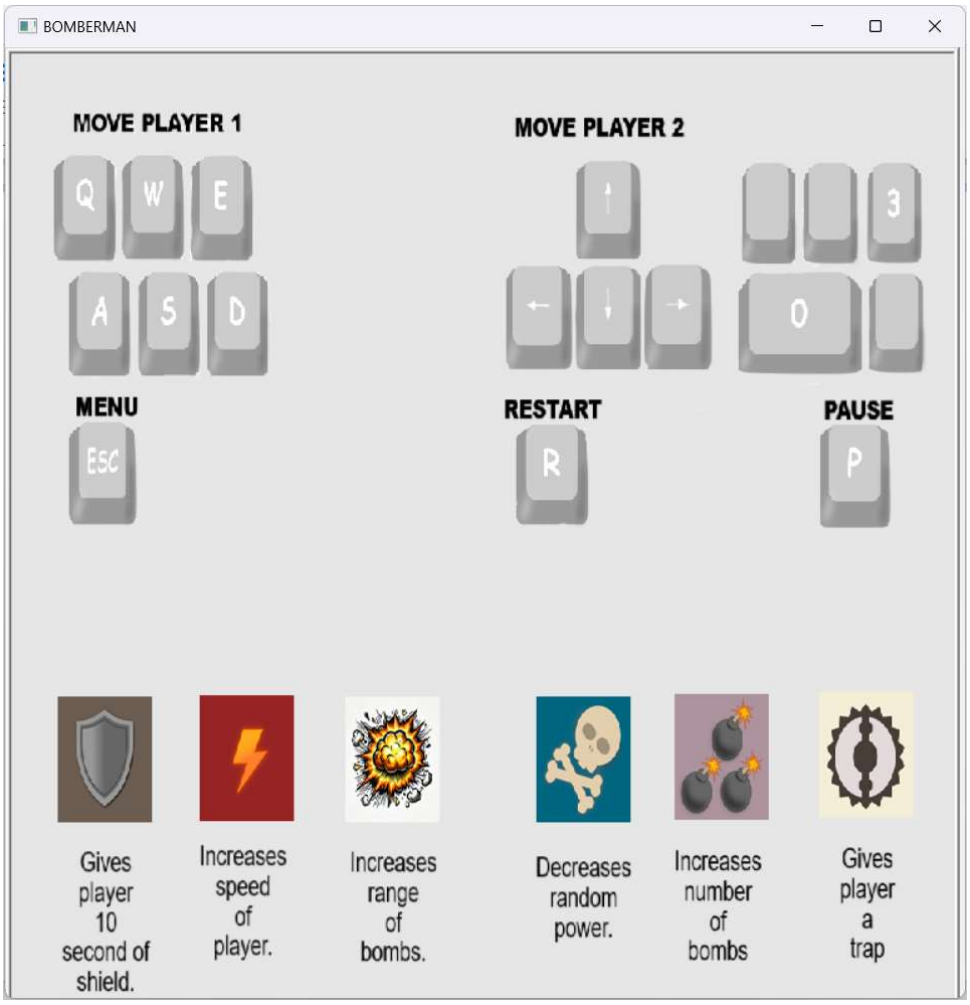
6.2 Game Mode Selection Screen

When players press **Play**, they are taken to the **game mode selection screen**, where they can choose between different game modes. The available options include **Singleplayer**, in which the player competes against AI-controlled bots; **Multiplayer**, allowing two players to compete locally on the same keyboard; and **Online Mode**, a planned feature for future updates that will introduce online multiplayer functionality. Each game mode is clearly labeled with a brief description to help players make informed choices. The design ensures that all options are easily accessible, maintaining a smooth flow from selection to gameplay.



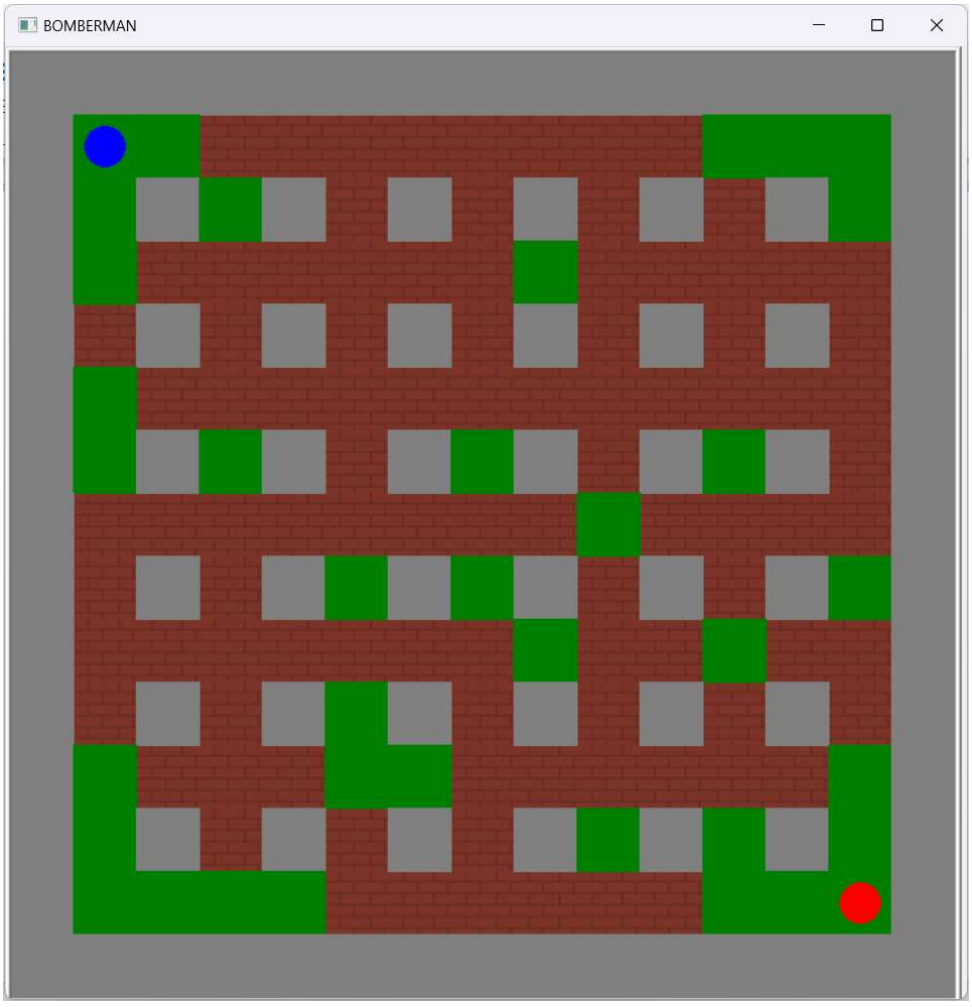
6.3 Controls Screen

The **controls screen** provides a detailed overview of the key bindings used for movement and actions in the game. Player 1 moves using **W, A, S, D**, places bombs with **E**, and sets traps with **Q**. Player 2 moves using the **arrow keys** and places bombs with **Numpad 0**. This screen is accessible from both the **main menu** and the **in-game menu**, ensuring that players can easily review the controls whenever necessary. The control layout is designed to be intuitive, allowing players to quickly adapt and focus on strategic gameplay.



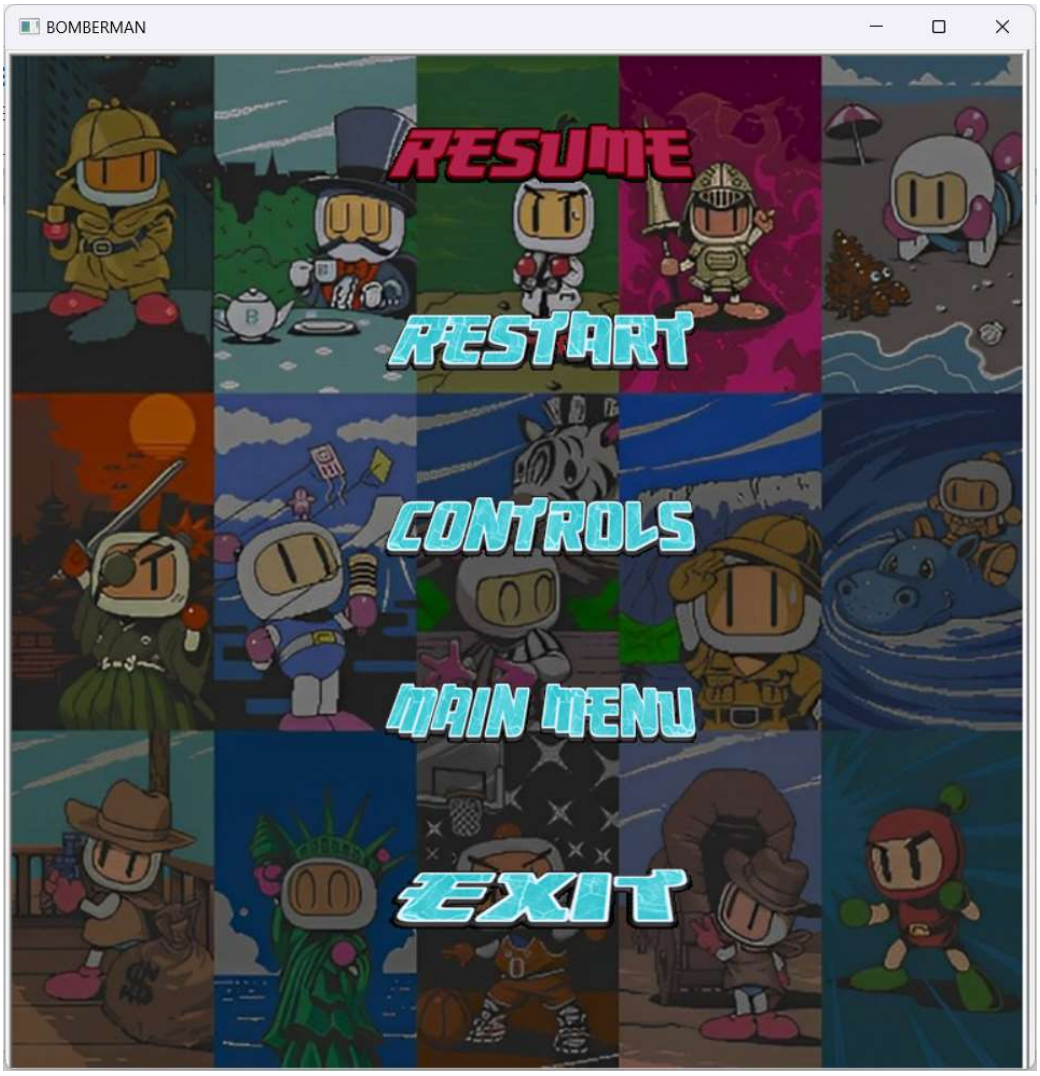
6.4 In-Game Interface

During gameplay, the **in-game interface** provides essential real-time information while maintaining an unobstructed view of the game. This interface displays **player status**, including active power-ups such as increased movement speed or bomb range. A **bomb timer** indicates the countdown until placed bombs detonate, allowing players to strategize their movements accordingly. Additionally, if the game mode includes a **round timer**, it is displayed to indicate the remaining match duration, adding an extra layer of urgency and strategic depth. The interface is carefully designed to position these elements in a way that enhances visibility without interfering with gameplay.



6.5 In-Game Menu

The **in-game menu** provides players with essential options during a match, ensuring flexibility without disrupting the gameplay experience. The available options include **Resume**, which allows the game to continue from where it was paused; **Restart**, which resets the match; **Controls**, for quick access to key bindings; **Main Menu**, which exits the match and returns to the starting screen; and **Exit**, which completely closes the game. The in-game menu is structured for quick adjustments, allowing players to manage their session efficiently.



6.6 Winner Screen

At the end of each match, the **winner screen** is displayed, featuring **custom-designed visuals tailored to the winning player's color**. Each character—blue, red, green, or yellow—has a unique **originally designed victory screen** that enhances the immersion and provides a personalized experience for the winner. This feature adds a distinctive visual identity to the game and makes each victory feel rewarding. All graphical elements in *Maze Bomber* have been **exclusively designed**, ensuring a unique aesthetic that aligns with the game's overall theme.

6.7 Visual Design Principles

The GUI follows **clear design principles**, focusing on accessibility and a streamlined user experience. Fonts are chosen for optimal readability, ensuring that players can quickly interpret game information. The color scheme is carefully designed to differentiate UI elements effectively, preventing confusion during gameplay. The overall layout maintains a **minimalist yet informative structure**, prioritizing essential details while avoiding unnecessary clutter. These principles ensure that the GUI not only complements the strategic nature of the game but also enhances player engagement through a visually polished and functional design.

7.FUTURE OF WORKS

The future development of **Maze Bomber** will focus on expanding its features, improving gameplay quality, and enhancing the overall player experience. One of the primary goals is to introduce online multiplayer support using **ENet**, a low-latency networking solution that will allow players to compete globally. This addition will create a more dynamic and competitive environment while ensuring seamless and stable gameplay. Currently, the game supports only local multiplayer, but online functionality will significantly broaden its accessibility and appeal to a wider audience.

To further enhance player interaction and strategic gameplay, an in-game voice chat system will be integrated. Real-time voice communication will allow players to coordinate strategies effectively, making the multiplayer experience more immersive. This feature will be particularly beneficial in competitive matches, enabling players to respond to in-game situations faster and improve their cooperative gameplay.

A global matchmaking system will be implemented to ensure fair and balanced matches. Players will be paired based on their skill levels, reducing the chances of mismatched opponents and fostering a more competitive atmosphere. By implementing a robust ranking and matchmaking system, **Maze Bomber** aims to provide an engaging experience for both casual and experienced players, ensuring that each match remains challenging and rewarding.

Visual quality is another critical area of improvement. The game will receive enhanced animations, refined character movements, and more detailed explosion effects. These graphical improvements will contribute to a more immersive and professional-looking

game. Smooth transitions and high-quality visuals will not only enhance aesthetics but also ensure an engaging and enjoyable experience for players.

To reach a broader player base, **Maze Bomber** will be adapted for cross-platform support. This development will allow players on different devices to seamlessly join matches and play together. Cross-platform functionality is essential for modern multiplayer games, ensuring accessibility and expanding the game's community. By implementing this feature, the game will remain competitive in the evolving gaming landscape.

A significant enhancement to the game's audio experience will be achieved through the integration of **FMOD**, an industry-standard sound engine. FMOD offers high-quality sound processing, real-time audio mixing, and advanced spatial audio effects, ensuring a more immersive gaming environment. With features like 3D positional sound and adaptive soundscapes, the game will deliver realistic explosions, power-ups, and movement sounds, improving player immersion. As FMOD is widely used in professional game development, adopting it will align **Maze Bomber** with industry standards and enhance its overall production quality.

Finally, ongoing performance optimizations will be implemented to improve game engine efficiency, memory management, and network stability. By reducing latency, optimizing resource usage, and refining game mechanics, **Maze Bomber** will provide a smoother and more responsive gameplay experience. These technical enhancements will ensure that the game remains engaging, polished, and competitive within the gaming industry. With these planned developments, **Maze Bomber** aims to establish itself as a high-quality multiplayer game that combines strategic depth with immersive audio-visual elements.

8. TESTING AND EVALUATION

Maze Bomber has undergone various testing phases during its development to evaluate game mechanics, AI behavior, multiplayer functionality, and overall performance. Special attention was given to the accuracy of AI movement algorithms and in-game collision detection. In local multiplayer mode, simultaneous player inputs were tested to ensure error tolerance. Performance analyses led to optimizations in graphical processing, enhancing game smoothness. In the future, additional testing phases will be planned with the integration of audio and online connectivity systems.

9. CONCLUSION

Maze Bomber modernizes the classic Bomberman-style gameplay by incorporating strategic mechanics for both single-player and local multiplayer experiences. With advanced AI, dynamic map generation, and a diverse power-up system, it offers a competitive gaming environment. Future plans include adding online multiplayer support using **ENet**, allowing players to connect remotely and engage in matches. Additionally, the integration of **FMOD**, a professional audio engine, is planned to deliver high-quality sound effects. Continuous performance improvements, cross-platform support, and enhanced animations will further refine the gaming experience. Maze Bomber aims to combine strategic depth, playability, and technological advancements to create an engaging and competitive game.

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