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# A Comprehensive Review- Adaptive Snake Game with AI Control

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**Abstract:** *A complex browser-based game called Advanced Snake was created to improve the traditional Snake experience by combining AI-controlled and manual gameplay. A growing snake must be guided across a small grid in traditional snake games, avoiding collisions with the walls or with itself. This project adds some cutting-edge elements to make the game more entertaining and instructive while maintaining the fundamental mechanics of the original.*

*Players can choose between two main ways of play: AI-controlled mode, which uses the A* pathfinding algorithm to automatically figure out the best way to get food while avoiding obstacles, and player-controlled mode, where players move the snake using keyboard inputs (arrow keys or WASD). Users are able to see how pathfinding and collision avoidance algorithms work in a dynamic, real-time setting with this AI setup. As the snake's position and the game board alter, the AI constantly recalculates its course, illustrating basic ideas of artificial intelligence decision-making.*

*The project incorporates customizable speed options to improve the user experience by enabling players to adjust the game's tempo to suit their skill level. You can apply different visual skins (Classic, Neon, and Retro) to change how the snake and game grid look. Furthermore, a toggleable grid overlay can be turned on to help AI or players better visualize the game area.*

**Keywords**: AI in games, A* pathfinding, JavaScript, Snake games, browser-based games, interactive user interfaces, and game development

## I. INTRODUCTION

A staple of arcade gaming, Snake has remained popular for many years because of its straightforward yet incredibly captivating principles. The basic idea behind the game is simple: the player controls a snake that has constant movement inside a small rectangular space. Gathering food items that show up at random spots on the game board is the goal; as you eat them, the snake gets longer. Because the player must avoid colliding with the game board's walls and the snake's own ever longer body, the task increases as the snake gets bigger. The game is fun and intellectually stimulating despite its straightforward rules, which successfully test players' reflexes, strategic planning, and spatial awareness.

Many iterations and modifications of the Snake game have surfaced over time on a variety of platforms, including console games, online browsers, and mobile phones. Although these versions include some modest gameplay adjustments or visual improvements, the most still maintain the fundamental fundamentals and do not incorporate sophisticated technological or computational ideas.

The Advanced Snake project aims to update the classic Snake game by adding a number of cutting-edge features while maintaining the game's intuitive, captivating gameplay. A prominent improvement is the addition of AI-controlled gaming. The A (A-star) pathfinding algorithm*, a popular technique in computer science and artificial intelligence, is employed in this AI mode to determine the shortest path between points in a space while taking obstacles into account. As the gaming environment changes as a result of the snake's growth or the development of new obstacles, the AI-controlled snake in the Snake game dynamically calculates the best path to the closest food item.


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Furthermore, the AI guarantees collision avoidance by anticipating possible collisions with walls and self-intersections, illustrating the usefulness of algorithmic decision-making in real-time settings. Learners and users can learn about basic AI principles like adaptive decision-making, pathfinding, and problem-solving in dynamic and constrained systems by watching the AI behavior.

The project integrates a number of elements to improve user personalization and engagement in addition to AI. Players may adapt the game's tempo to suit their skill level thanks to features like the customizable speed control. Beginners can begin at slower speeds to get a feel for the game's principles, while more experienced players can push themselves to play at faster speeds, which makes the game more challenging and thrilling. Users can also choose from a variety of visual skins, such as Classic, Neon, and Retro, to alter the design of the game board and snake. In addition to adding to the game's visual attractiveness, these skins provide players a sense of customization and immersion that suits their own tastes.

Furthermore, the optional grid overlay functions as a visual aid that is especially helpful for comprehending movement patterns and strategy because it clearly divides the playing area into cells. This helps the AI, which uses the grid layout for pathfinding calculations, as well as human players, who can better plan their movements.

The Advanced Snake project is technically implemented using HTML5, CSS, and JavaScript as a browser-based application. All game elements, including the snake, food, and grid, are rendered by a responsive canvas element that is part of HTML5, which serves as the application's structural basis. By managing color palettes, implementing various skins, and creating aesthetically pleasing layouts, CSS gives the game a polished and expert appearance. The essential game logic, such as level progression, AI pathfinding methods, score computation, snake movement, collision detection, and user input processing, is handled by JavaScript. To make sure the snake moves effectively and securely in the direction of the goal meal, the JavaScript-implemented AI module continuously assesses the game situation and makes decisions based on the A* pathfinding principles.

The buttons and controls for halting the game, beginning a new one, changing speed, flipping the grid, and alternating between player-controlled and AI-controlled modes are all part of the engaging and intuitive game interface. In player mode, the movement of the snake can be responsively and intuitively controlled by keyboard inputs such as WASD or arrow keys. In addition to enabling players to try out various gameplay setups, these design decisions guarantee a flawless user experience.

Data persistence via localStorage is another important component of the concept. The game may save user-specific information, including high scores, current score, and selected settings, thanks to this browser feature, which lets players keep improving during sessions. Without the need for server-side data storage or an internet connection, the game offers a continuous and customized experience by utilizing localStorage.

There is significant instructional value in the Advanced Snake project. By incorporating AI into a straightforward and well-known game, the project develops a practical learning and experimentation platform. In addition to learning how pathfinding algorithms function in dynamic situations, players can watch the AI make decisions in real time and investigate the effects of various speed and strategy combinations. The project additionally shows how web technologies such as HTML5, CSS, and JavaScript may be used to provide interactive, aesthetically pleasing, and computationally intelligent.

## II. LITERATURE SURVEY

Chen (2025) et al. [1] evaluated K-Nearest Neighbors, Decision Tree, and Linear Regression models in a comparative research titled "Car Price Prediction Using Machine Learning." Despite being centered on predictive modeling in automobiles, this study highlights the significance of algorithm selection and decision-making procedures, which are directly related to using AI logic in games. " In order to give a comparative analysis that can guide real-time decision systems, akin to pathfinding in AI-controlled games, the primary goal was to ascertain the model's correctness and efficiency.

Harris (2023) et al. [2] created an AI pathfinding Snake game for the browser that showcases grid-based movement and obstacle avoidance. Making an autonomous snake that can move effectively in the direction of food without running

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into obstacles was the goal. The primary goal was to demonstrate the use of pathfinding algorithms in real-time gameplay, providing information on useful AI applications for online games.

Parsons (2022) et al. [3] investigated autopilot methods for Snake in more detail with the goal of demonstrating autonomous navigation. The ability of AI to dynamically modify movement methods in response to game-state changes is demonstrated in this work, with a focus on route optimization and decision-making.

Johar (2021) et al. [4] developed a reinforcement learning Snake AI to show how to make adaptive decisions based on input from the surroundings. In order to maximize rewards and minimize collisions, the study sought to investigate how AI might gradually learn the best routes.

Zhou (2021) et al. [5] examined using reward-based pathfinding techniques to teach an AI to play Snake through reinforcement learning. Both research highlight how intelligent, self-governing games that dynamically increases performance with experience can be made possible via reinforcement learning.

Schoberg (2019) et al. [6] Schoberg's research centered on applying AI to the vintage Snake game and examined how algorithmic tactics might improve gameplay. The study focused on methods for effective food gathering and collision avoidance, two crucial facets of Snake AI. The AI could dynamically modify its travel direction and anticipate possible collisions with walls or its own tail by utilizing rule-driven logic and heuristic-based techniques. The research also focused on optimization techniques that minimized dangerous actions while enabling the AI to prioritize food items. By showing how comparatively basic algorithms may provide intelligent, adaptive gaming

Kharrufa (2021) et al. [7]aimed at using pathfinding methods that are designed for grid navigation to improve Snake's AI performance. Methods for choosing the best pathways in a limited area were presented in the study, which focused on dynamic obstacle avoidance, including the snake's tail and environmental restrictions. In contrast to heuristic-based methods that depend on preset rules, pathfinding algorithms such as A* or Dijkstra's method enabled the AI to assess several possible routes and assign scores based on factors like distance, risk, and food collection possibility. This study demonstrated the significance of computational foresight and algorithmic efficiency by demonstrating that meticulous route optimization greatly increased survival time and overall performance.In order to better grasp algorithmic decision-making in dynamic, limited surroundings, Kharrufa's AI displayed a more strategic, intelligent gameplay style by methodically balancing the trade-off between risk (collision probability) and reward (food acquisition).

Mase (2021) et al.[8]aimed to show how pathfinding algorithms react in real-time to changing game states by showing AI-controlled Snake gameplay. The primary goal was to demonstrate how AI functions in a real-world setting with dynamic barriers and snake growth. According to the study, algorithms such as A* could effectively recalculate trajectories as the game state changed, preventing collisions and maximizing routes for food collection. The visualization technique made it possible for developers and consumers to examine how AI decision-making changes depending on the situation. The use of pathfinding logic in dynamic systems is better understood thanks to this study.The application of pathfinding logic in dynamic systems is better understood thanks to this study. Incorporating AI visualization techniques into instructional tools is another use for it. The study highlighted adaptability and real-time response as crucial measures for assessing AI performance. All things considered, it connects theoretical AI ideas with real-world application in interactive online games.

Patel (2020) et al. [9]highlighted the significance of canvas rendering and interactive user interfaces in their analysis of HTML5, CSS, and JavaScript-based browser-based game development. The study sought to give programmers methods for making visually appealing and responsive web games. According to Patel's research, CSS improves appearance and interactivity while HTML5 canvas allows dynamic rendering of game elements. Showing off best practices for game logic management, layout design, and performance optimization were among the goals. Other issues covered in the article included synchronization between game rendering and user input. This study offers a methodical approach to web-based game design, which is helpful for creating interactive games like Snake. It acts as a technical basis for integrating browser-based implementations of AI.

Li (2019) et al. [10]examined AI algorithms by contrasting the BFS, DFS, and A* pathfinding techniques in straightforward grid-based games. The goal was to assess each algorithm's efficacy and efficiency in navigating dynamic gaming situations. The study discovered that A*'s heuristic-based strategy, which balanced accuracy and speed, produced the best pathfinding result. Li showed that while BFS and DFS were capable of basic navigation, they

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were less effective in bigger or dynamic grids. Informing developers about algorithm selection for real-time games that require adaptive decision-making was the primary goal. The study also demonstrated how these algorithms might be used in game contexts to teach students about computational problem-solving. A fundamental guide for putting AI-controlled Snake games into practice is provided by this work.

Singh (2022)et al. [11]applied adaptive AI to arcade games, emphasizing independent mobility through pathfinding and collision avoidance. To increase task efficiency and survival, the goal was to create AI that could dynamically modify its behavior based on game conditions. According to the study, adaptive AI might adjust its course in real time and respond to shifting obstacles. Singh underlined how crucial it is to combine decision-making logic with pathfinding algorithms in order to produce intelligent agents in video games. The study advances the idea that AI may learn from its surroundings and predict future conditions, which is relevant to Snake AI. Performance indicators including accuracy, speed, and flexibility were also emphasized. The results back the incorporation of AI into interactive learning resources. Overall, the research connects autonomous game theory and practice.

Kumar (2021) et al.[12]investigated customizing the user interface (UI) of web games, including interactive panels, themes, and speed control. The study sought to improve player involvement and offer more customization in the gaming experience. Kumar showed how user-friendly interfaces enhance user happiness and let players modify game settings based on their preferences and skill level. Design techniques for interactive buttons, dynamic content updates, and web-based gaming panels were highlighted in the study. Incorporating technological elements like event management and real-time rendering with a simple layout was one of the goals. The primary contribution was demonstrating the impact of UI elements on usability and gameplay perception. Because visual feedback and control accessibility are essential in browser-based games like Snake, this study is especially pertinent. For the best possible user experience, it combines interactive game dynamics with UI design.

## III. PROPOSED METHODOLOGY

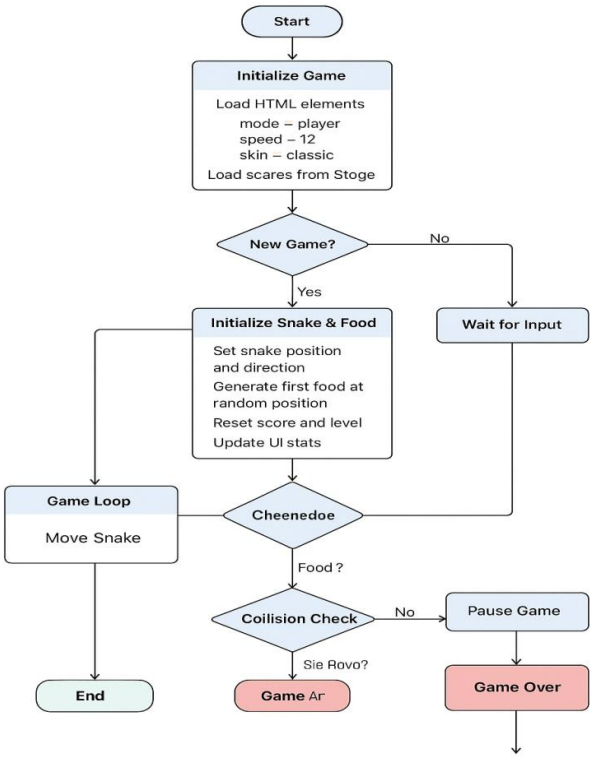


Fig. Flow chart of Adaptive Snake Game with AI Control

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The Advanced Snake Game with AI Pathfinding flowchart illustrates the game's logical structure and execution flow from setup to the conclusion of playtime. Through the use of A* pathfinding, artificial intelligence is incorporated into this project to create an improved version of the traditional Snake game that allows for autonomous gameplay. Initialization, player or AI control, continuous repeating of game activities, collision detection, and game termination are just a few of the ways that the flowchart illustrates how different game elements interact.

The Start node, which denotes the beginning of the game on a web browser, is the first step in the flowchart. The HTML, CSS, and JavaScript files are loaded when the player launches the game. These files comprise the foundational functionality found in app.js and ai.js, the visual styling specified in style.css, and the index.html structure. Before the user interacts with the interface, this stage guarantees that all required components are available. The flow moves on to the Initialize Game step, when the game environment is initially built up, after the resources have been loaded.

During Initialize Game, the system carries out a number of important tasks. The JavaScript code is first recognized and linked to the necessary HTML components, including the canvas for rendering graphics, the control buttons for launching and stopping the game, and the display areas for the score, level, and mode. At this point, default settings are also established for the skin (Classic), speed (12), and mode (Player). In order for players to keep track of their highest scores, the system also pulls the saved high score from the local storage of the browser. The system asks the user if they would like to start a new game after initialization is finished and the game is ready.

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All dynamic game elements are reset by the Initialize Snake & Food phase when a new game is launched. The snake is positioned and oriented according to its initial values, which are usually in the middle of the canvas. The initial food is created at random on the grid, making sure it doesn't cross over into the snake's body. The interface is updated to reflect the new values while the score and level counts are reset simultaneously. The initialization stage guarantees that every game session begins with a clear state and reliable performance. Following this setup, the game's most crucial phase, the Game Loop, is reached.

The key component of the Snake game is the Game Loop, which runs continually until a stopping condition—like pausing or quitting the game—is satisfied. The snake's movement, interactions with food, and collisions with objects are all controlled by this loop in real time. Based on the active mode, the system chooses the snake's movement for each loop cycle.

Whether the player is in control of the snake or if the AI mode is on is determined by the Check Mode choice. When the mode is set to "Player," the application watches for keyboard inputs to change the snake's direction, usually the arrow keys or WASD. In contrast, the system uses the A* pathfinding method, which is implemented in ai.js, if the mode is set to "AI." Through an analysis of the game grid and the treatment of impediments like walls or the snake's own body as barriers, this algorithm determines the quickest and safest path to the food. The AI then determines the path of the snake's subsequent move, thereby enabling it to play on its own.

Once the direction has been established, the Move Snake method modifies the snake's grid position. In the present direction, the head advances one step, and each body segment travels to the location of the one before it. The snake grows if it has just consumed food since its tail does not move. The system assesses different interactions in the flowchart's next section, Collision and Event Checking. Checking for a food collision is the first step. A fresh food item is created at a different random place, the snake becomes longer, and the score rises if the head position of the snake matches the location of the food. Additionally, based on the score, the level may rise, which makes the snake faster and more challenging.

The second crucial check is for self-collision or walls. The game detects a collision event when the snake's head crosses the canvas' edge or comes into contact with its own body. The loop is immediately broken by entering the Game Over state. The loop carries on as usual if no collision is found. After the checks, the system runs the Render Canvas

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procedure, which updates the game's visual representation. After clearing the canvas, new items are drawn, such as the location of the food, the snake's updated position, and any active grid that the player may have toggled on. The snake's color and design are determined by its skin type (Classic, Neon, or Retro).

The pause function is particularly helpful during longer sessions or when the player needs to temporarily stop. The Pause / Resume decision in the flowchart represents the player's ability to pause the game at any time during gameplay. When the pause command is triggered, the game loop temporarily halts, freezing all movements and actions, allowing players to take a break without losing progress. When the player resumes, the game continues from the exact same state, adding convenience and control to the gameplay experience.

Upon detecting a collision, the system enters the Game Over condition. The game loop ends at this point, and the player is presented with the phrase "Game Over." The system determines if the score now surpasses the high score that was saved. In local storage, the old record is replaced by the new value if it does. Users are incentivized to enhance their performance during sessions by this permanent rating system. The player has two options after the game over event: either exit the game or resume by selecting "New Game," which returns the flow to the startup stage.

The End state is the last node in the flowchart. The current game session is either ended or nearing its conclusion. Local storage guarantees that progress, including high scores, is preserved for use in subsequent games even when the session ends. The player feels a sense of accomplishment and continuity long after the game window has been closed because to this design.

The Advanced Snake Game's logical structure is depicted in the flowchart, which also shows how user involvement, AI-driven automation, and system procedures are all balanced. It begins with initialization, moves through player- or AI-controlled real-time gameplay, manages dynamic events like collisions and scoring, and ends with termination. The seamless transition between choices and actions guarantees fluid gameplay and consistent behavior. This project successfully blends the concepts of artificial intelligence and web-based interactive design by incorporating pathfinding intelligence, numerous skins and modes, and local data persistence. Thus, the flowchart offers a visual representation of how each step adds to the Advanced Snake Game's overall functionality in addition to a technical summary of the game's logic.

## IV. CONCLUSION

The Advanced Snake Game project effectively illustrates how contemporary artificial intelligence techniques can be used with vintage arcade gaming. In addition to offering customers an interesting interactive experience, the system's integration of Player Mode and AI Mode demonstrates the usefulness of the A* (A-star) pathfinding algorithm in real-time decision-making. The AI-controlled snake exhibits intellectual behavior akin to that of human gamers by effectively calculating the best routes, avoiding obstacles, and reaching the target meal on its own.

Additionally, the project highlights the usage of web technologies like HTML5, CSS, and JavaScript, which make it responsive, lightweight, and available through a browser without the need for extra installations. The whole user experience is improved by its numerous skins, speed controls that can be adjusted, and an intuitive user interface. Furthermore, the game strikes a balance between technical innovation and simplicity by incorporating features like dynamic canvas rendering, pause/resume capabilities, and local storage for high scores.

In summary, this project successfully accomplishes its goals of fusing entertainment with web development and artificial intelligence instruction. It illustrates how cutting-edge programming techniques and clever algorithms may bring back the appeal of traditional games. Thus, the Advanced Snake Game serves as a real-world illustration of how to combine web-based game design, AI pathfinding, and user interaction into a single, integrated system. The potential of this creative endeavor could be further increased by future improvements such as more sophisticated AI learning models, multiplayer options, or variable difficulty.

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