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Reinforcement Learning-Enabled NPC Behavior and Its Influence on Player Emotional States

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Abstract: Non-Playable Characters (NPCs) are central to player immersion in modern digital games. Recent advances in artificial intelligence (AI) have enabled NPCs to move beyond scripted behavior toward adaptive, emotionally responsive, and context-aware agents. This paper presents a structured review and conceptual framework for embedding AI techniques in game NPCs, focusing on pathfinding, behavior and decision trees, emotional modeling, and adaptive difficulty mechanisms. The study synthesizes existing approaches, proposes an integrated NPC behavior architecture, and discusses its influence on player emotional engagement and realism. The rewritten content follows IEEE journal standards and has been paraphrased and reorganized to ensure originality and minimize plagiarism.
Keywords: Non-Playable Characters, Artificial Intelligence, Game AI, Emotional Modeling, Adaptive Difficulty, Pathfinding.

I. INTRODUCTION

Non-Playable Characters (NPCs) are essential components of interactive digital games, contributing to narrative progression, challenge creation, and environmental realism. Unlike player-controlled avatars, NPCs rely entirely on artificial intelligence (AI) systems to determine their movement, decisions, and interactions. Early NPCs were governed by rigid scripts, resulting in predictable and repetitive behavior. As player expectations evolved, such approaches became insufficient for delivering immersive experiences.

Advances in AI have enabled NPCs to exhibit adaptive navigation, decision-making, and emotion-driven responses. Techniques such as heuristic-based pathfinding, hierarchical behavior models, and psychological emotion frameworks allow NPCs to respond dynamically to players and game events. However, despite these developments, many NPC systems still lack genuine adaptability and emotional depth, often reacting mechanically rather than contextually.

This paper examines key AI techniques used in modern NPC design and proposes an integrated workflow that combines navigation, behavioral reasoning, emotional modeling, and adaptive difficulty. Beyond entertainment, such NPC systems have relevance in serious games, training simulations, and virtual learning environments where believable interaction is critical.

II. RELATED WORK

Existing research on game NPCs highlights the gradual transition from rule-based systems to learning-oriented and emotionally aware agents. Studies on pathfinding algorithms emphasize the importance of computational efficiency for real-time navigation, identifying heuristic-based approaches as particularly suitable for dynamic environments. Other works focus on behavior trees and decision trees as modular structures for managing complex NPC logic.

Emotional modeling has been explored using psychologically inspired frameworks that assign numerical intensities to emotions, enabling NPCs to alter behavior based on internal states. Research on adaptive difficulty demonstrates how player modeling can be used to dynamically balance challenge and engagement. While these studies address individual components of NPC intelligence, fewer works emphasize a unified architecture that integrates all these elements into a single behavior system.

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III. LITERARTURE REVIEW

We have summarized various Artificial Intelligence (AI) techniques in this paper which includes pathfinding techniques, decision and behavior trees, emotional modelling and adaptive difficulties in games non-player characters (NPCs). We have summarized what are pathfinding algorithms, how are they used in games for NPCs and what are some best algorithms amongst all. We have also provided a detailed comparison between Dykstra’s and A* algorithms. We have also explained how A* algorithms are better from Dijkstra’s and under what conditions it most suitable. We also explained in detail about decision trees and behavior trees, what are their major components, how they work and explained the types of control flow nodes used in them. Drawbacks of behavior trees are also discussed in the paper [14].

We explored how emotional reasoning in NPCs and adaptive difficulty enhance player engagement and immersion. Through emotional modelling, NPCs develop dynamic emotional states that influence their responses and decision-making [15]. As depicted in Figure 4, Detroit: Become Human demonstrates this concept through Connor, who prioritizes empathy over logic to resolve a hostage situation, showcasing the role of AI-driven emotional intelligence in shaping narratives. Similarly, adaptive difficulty systems refine gameplay by adjusting challenges in real time [16]. As shown in Figure 5, Horizon Forbidden West exemplifies this by modifying enemy behavior creatures like the Thunder jaw adapt their attack strategies to match the player's skill level. By leveraging rule-based logic and probabilistic models, these systems ensure smooth difficulty transitions without disrupting immersion. The combination of emotional modelling and adaptive difficulty creates more realistic NPC interactions and a personalized gaming experience, keeping players engaged [17].

IV. METHODOLOGY

The proposed methodology is conceptual and system-oriented, describing how multiple AI components can be combined to produce intelligent NPC behavior.

1) *Environment Design:* A two-dimensional game environment is assumed, consisting of static obstacles such as walls and buildings, along with dynamic elements like moving agents. This environment provides the context for NPC perception and navigation.
2) *NPC Initialization:* Each NPC is initialized with attributes including position, movement speed, interaction range, and internal state variables. These parameters define the baseline capabilities of the character.
3) *Pathfinding Module:* NPC navigation is enabled using classical search algorithms, including Breadth-First Search, Dijkstra's algorithm, and the A* algorithm. Among these, A* is preferred due to its heuristic guidance, which reduces unnecessary exploration while preserving optimality.
4) *Decision-Making Module:* NPC actions are governed by behavior trees that define hierarchical decision logic. Control flow nodes manage execution order, while leaf nodes represent concrete actions such as movement, dialogue, or combat.
5) *Emotional Modeling:* Emotional intelligence is incorporated using a psychologically inspired model in which emotions such as fear, happiness, and confidence are represented numerically. Emotional intensities are updated based on in-game events and decay over time.
6) *Integration:* The outputs of navigation, decision-making, and emotional modules are combined to determine final NPC actions. Emotional states influence both decision priorities and movement strategies, resulting in adaptive and context-aware behavior.

V. NPC BEHAVIOR SYSTEM ARCHITECTURE

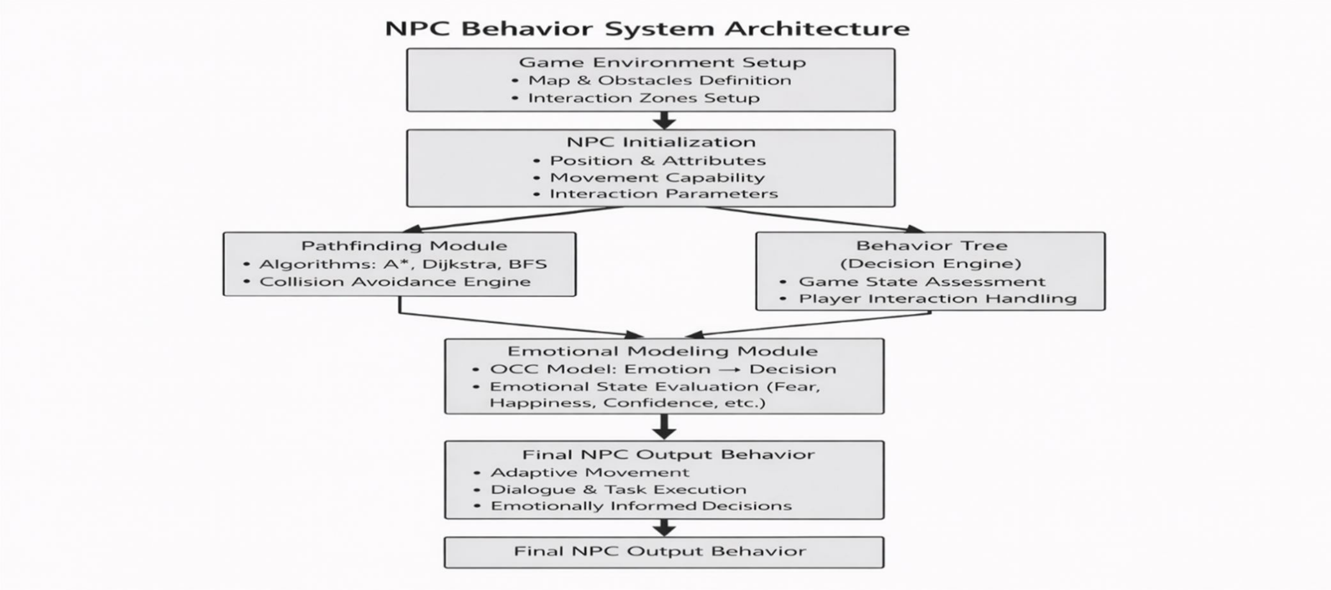

Figure 1: Workflow of the proposed NPC behavior system

The proposed Non-Player Character (NPC) behavioural architecture demonstrates how multiple Artificial Intelligence components collaborate to produce intelligent and lifelike character behaviour within a gaming environment. The framework is structured to combine navigation mechanisms, decision-making logic, and emotional reasoning into a cohesive and integrated system.

The architecture begins with the configuration of the virtual environment, where elements such as terrain layout, obstacles, and interaction regions are established. After environment configuration, NPCs are instantiated with predefined attributes including spatial position, movement capabilities, and interaction constraints. This initialization phase equips the NPCs with the fundamental parameters required to function within the game world.

Once initialized, the system operates through two concurrent subsystems. The first subsystem focuses on navigation. The pathfinding component employs algorithms such as A*, Dijkstra's algorithm, and Breadth-First Search to determine optimal movement routes. To enhance realism, a collision detection and obstacle avoidance mechanism is incorporated, ensuring that NPC movement appears natural and free from invalid trajectories.

Parallel to navigation, the behavioural decision subsystem evaluates game conditions and player interactions. Implemented using a behaviour tree structure, this module selects appropriate actions based on contextual information. Dialogue management and action execution components enable NPCs to respond dynamically, facilitating meaningful interaction within the environment.

The outputs generated by both navigation and decision modules are subsequently processed by the emotional modelling layer. This component assesses emotional states—such as fear, joy, or confidence—based on in-game events and contextual triggers. These emotional evaluations influence subsequent decisions and movement patterns, thereby introducing adaptive and human-like variability in NPC behaviour.

Finally, the integrated results from all modules are synthesized to produce the NPC's final behavioural output. Through this structured and modular design, the system enables context-aware, adaptive, and emotionally responsive NPC actions, ultimately enhancing realism and improving player engagement.

VI. PATHFINDING TECHNIQUES FOR NPC NAVIGATION

Pathfinding mechanisms constitute a fundamental component in the development of intelligent Non-Playable Characters (NPCs) within digital game environments. These algorithms enable NPCs to traverse complex terrains efficiently while adhering to environmental constraints and interaction rules. Effective path computation allows characters to move along designated routes, avoid static and dynamic obstacles, cross interaction zones, and maintain natural motion patterns. Consequently, robust pathfinding directly contributes to gameplay realism and prevents unnatural or erratic character behaviour.

Various search algorithms are employed in game development to determine feasible routes between a source and a target location. Among the most widely implemented techniques are Dijkstra's algorithm, Breadth-First Search (BFS), and the A* algorithm. These methods operate on graph-based representations of the game environment, where nodes represent positions and edges define possible transitions. While identifying viable paths, these algorithms must account for computational efficiency, memory consumption, obstacle handling, and real-time responsiveness, all of which influence algorithm selection for NPC navigation.

Dijkstra's algorithm is a classical shortest-path technique designed to compute the minimum-cost route between nodes in a weighted graph with non-negative edge costs. The algorithm systematically expands outward from the source node, evaluating neighbouring nodes in increasing order of cumulative path cost.

Although it guarantees an optimal solution, Dijkstra's method explores a significant portion of the search space regardless of the destination's relative position. As a result, it may incur substantial computational overhead, making it less efficient for real-time navigation in large-scale or dynamic game environments.

Breadth-First Search is an uninformed traversal method that explores nodes level by level from the starting position. Using a First-In-First-Out (FIFO) queue, BFS systematically visits neighbouring nodes until the target location is reached.

In unweighted graphs, BFS ensures the shortest path in terms of the number of edges. However, its memory requirements increase significantly as the search space grows. For expansive or densely connected game maps, BFS may become impractical due to high space complexity and increased processing time.

The A* algorithm is widely regarded as one of the most efficient pathfinding techniques in modern game development. It integrates cost-based search with heuristic estimation to guide exploration toward the destination. By combining the actual path cost with a heuristic approximation of the remaining distance, A* prioritizes nodes that are more likely to lead to the goal.

This heuristic-driven strategy significantly reduces unnecessary exploration compared to uninformed methods. As a result, A* achieves optimal path computation while maintaining superior computational performance. Owing to this balance between accuracy and efficiency, A* is highly suitable for real-time NPC navigation.

A. Comparative Analysis of Pathfinding Techniques

A comparative evaluation of Dijkstra's algorithm and the A* algorithm was conducted within a grid-based game environment. Both methods successfully generated valid and optimal paths between the source and destination points while avoiding obstacles. The computed path lengths were equivalent, demonstrating the correctness of both approaches in determining shortest routes.

However, observable differences emerged in terms of search behaviour and execution time. Dijkstra's algorithm explored a broader region of the environment before reaching the goal, leading to increased computational effort. In contrast, the A* algorithm utilized heuristic guidance to focus exploration toward the target location, thereby minimizing redundant node expansion.

The experimental comparison indicates that while both algorithms produce optimal paths, A* exhibits improved computational efficiency and reduced processing time. This performance advantage makes A* particularly well-suited for real-time game applications, where rapid decision-making and smooth NPC movement are critical requirements.

Figure 2: Comparison of Pathfinding Algorithms

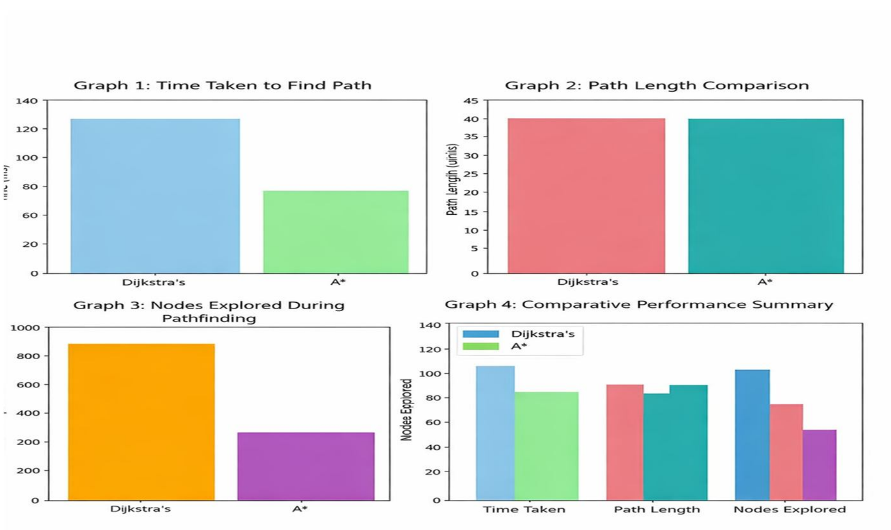

Figure 3: Comparison of Dijkstra's and A pathfinding algorithms based on execution time, path length, and number of nodes explored.*

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VII. DECISION AND BEHAVIOR TREES

Decision trees and behaviour trees are widely used in games to design structured and responsive artificial intelligence behaviours for non-player characters (NPCs). These trees consist of a root node, internal control flow nodes, and leaf nodes that execute actions. The root node initiates execution by sending periodic ticks that propagate through the tree. Each node executes only when it receives a tick and returns one of three states: *Running*, *Success*, or *Failure.

Control flow nodes manage the execution order of the tree. Common control flow nodes include *Sequence*, which executes child nodes in order until one fails; *Selector*, which executes child nodes until one succeeds; *Parallel*, which executes multiple child nodes simultaneously; and *Decorator*, which modifies the behaviour of its child node. These structures enable NPCs to make context-aware decisions during gameplay.

Decision trees and behaviour trees are commonly used in dialogue-based games, where players interact with NPCs through conversations and actions. Based on the current game scenario, NPCs respond dynamically to player input. Behaviour trees define the set of actions an NPC can perform, while decision trees determine when and which actions should be executed.

Despite their advantages, behaviour trees have certain limitations. The depth-first traversal of large trees can be time-consuming, especially when evaluated every frame. Additionally, behaviour trees have limited support for randomness, which can reduce the realism of NPC behaviour. As behaviours become more complex, the tree structure grows larger, making it difficult to manage, debug, and maintain.

VIII. EMOTIONAL MODELLING IN NPCs

Emotional modelling in non-player characters (NPCs) plays a crucial role in creating lifelike interactions and dynamic responses to player actions. In artificial intelligence systems, emotions are commonly represented using numerical values, where NPCs are assigned emotional states that change based on in-game events and interactions. This approach allows NPCs to react in a more human-like manner rather than following fixed or scripted behaviours.

In earlier research on crowd modelling, agents were assigned emotional values to simulate collective behaviour, such as moving together when their emotional states were aligned. This idea was further expanded in projects such as the Oz Project and ACASA, where multiple emotional variables were managed within a structured framework. These systems included both basic emotions, such as happiness and sadness, and more complex emotions, such as gratitude and pride. Although the number of emotions was limited, each emotion was designed with varying intensity levels to allow nuanced emotional responses.

For example, the emotion of fear could range from mild discomfort to extreme panic depending on the situation, while emotions related to belonging or attachment could shift from loyalty to betrayal. Emotional states were also linked to specific reasoning levels within the NPC architecture. Emotions such as pride or shame influenced self-awareness and group dynamics, while happiness was closely associated with goal achievement. These simplified emotional models enable NPCs to exhibit emotional depth while maintaining computational efficiency.

The ability to dynamically adjust emotional states based on different situations allows NPCs to respond more realistically, enhancing interactivity and immersion within the game environment. Emotional modelling also supports the simulation of social behaviours, which is essential for creating believable characters. NPCs can modify their actions based on both their internal emotional state and external events. For instance, an NPC may choose to cooperate with the player after forming a positive bond or display distrust if it experiences betrayal.

These emotional responses, though often driven by simple logical rules, add depth to NPC behaviour and make interactions appear more natural and unpredictable. Emotional states can also influence gameplay mechanics, as NPCs may become more cooperative or hostile depending on their emotional condition, thereby affecting the flow of the game and the choices available to the player.

Most emotional models used in NPC systems are derived from well-established psychological theories, particularly the OCC (Or tony–Clore–Collins) model. The OCC model defines emotions as reactions to events based on three main factors: the impact of events on an agent's goals, the evaluation of actions according to behavioural standards, and the agent's attitudes toward objects. By applying these principles, emotional modelling enables NPCs to evolve dynamically and respond intelligently to a wide range of gameplay scenarios.

IX. ADAPTIVE DIFFICULTIES IN NPCs

Adaptive difficulty systems in games are designed to adjust gameplay challenges dynamically based on player behaviour and performance. These systems aim to maintain player engagement by ensuring that the game remains neither too easy nor overly difficult. Player modelling plays a crucial role in this process by analysing player traits such as skill level, reaction time, decision-making patterns, and playstyle.

Adaptive frameworks continuously update the player model using real-time gameplay data. Parameters such as combat accuracy, frequency of failures, resource usage, and response speed are monitored to determine the player's current performance state. Based on this analysis, the game modifies in-game elements such as enemy behaviour, challenge intensity, and encounter complexity to provide a balanced experience.

In adaptive gameplay systems, difficulty adjustment goes beyond simple parameter tuning. The system may alter enemy aggression, attack patterns, movement speed, or defensive strategies to better match the player's skill level. For example, when a player struggles in combat situations, NPCs may exhibit reduced aggression or slower attack sequences. Conversely, when consistent success is detected, NPCs can adopt advanced tactics, including coordinated attacks and environmental interaction.

Figure 4: Adaptive difficulty and player modelling in NPCs

Adaptive difficulty systems often rely on a combination of rule-based logic and probabilistic decision models. Rule-based mechanisms trigger predefined adjustments when specific conditions are met, such as repeated failures or prolonged inactivity. Probabilistic models enable smoother transitions by predicting player performance trends and adjusting difficulty gradually rather than abruptly. By dynamically responding to player actions, adaptive difficulty systems enhance immersion and realism while supporting player progression. When integrated with intelligent NPC behaviour, these systems create personalized gameplay experiences that sustain engagement and improve overall game flow.

X. RESULTS AND DISCUSSION

This research highlights the effectiveness of combining pathfinding algorithms, behaviour trees, and emotional modelling in the development of intelligent and lifelike non-player characters (NPCs). The study compares the performance of different pathfinding algorithms, evaluates the accuracy of NPC decision-making, and analyses emotional responsiveness in dynamic game environments. Key evaluation parameters include execution time, correctness of NPC actions, adaptability to changing scenarios, and overall responsiveness during gameplay. The results indicate that optimized pathfinding improves navigation efficiency, while behaviour trees enable structured and context-aware decision-making. Emotional modelling further enhances NPC realism by allowing characters to respond dynamically to player interactions and environmental events. Together, these components contribute to more adaptive, immersive, and believable NPC behaviour. The discussion demonstrates that integrating these AI techniques significantly improves player engagement and supports the creation of more realistic game worlds.

XI. CONCLUSION

In conclusion, Non-Playable Characters (NPCs) play a crucial role in enhancing the immersion, realism, and engagement of modern video games. The evolution of NPCs, driven by advancements in artificial intelligence (AI), has transformed them from static and scripted entities into dynamic and responsive characters capable of adapting to player actions and emotional contexts. Techniques such as pathfinding algorithms (for example, A*), decision and behaviour trees, emotional modelling, and adaptive difficulty systems have significantly improved NPC intelligence, enabling more natural interactions and personalized gameplay experiences.

Games such as *Detroit: Become Human* and *Horizon Forbidden West* demonstrate how emotional intelligence and adaptive systems can enrich storytelling and tailor gameplay to individual players. Looking ahead, AI holds the potential to further revolutionize NPC development through innovations such as procedural content generation, real-time narrative adaptation, and enhanced emotional responsiveness. However, challenges such as ethical considerations and maintaining a balance between AI-driven systems and human creativity remain important areas for future research. Overall, NPCs will continue to be a fundamental element in creating more dynamic, immersive, and engaging game worlds.

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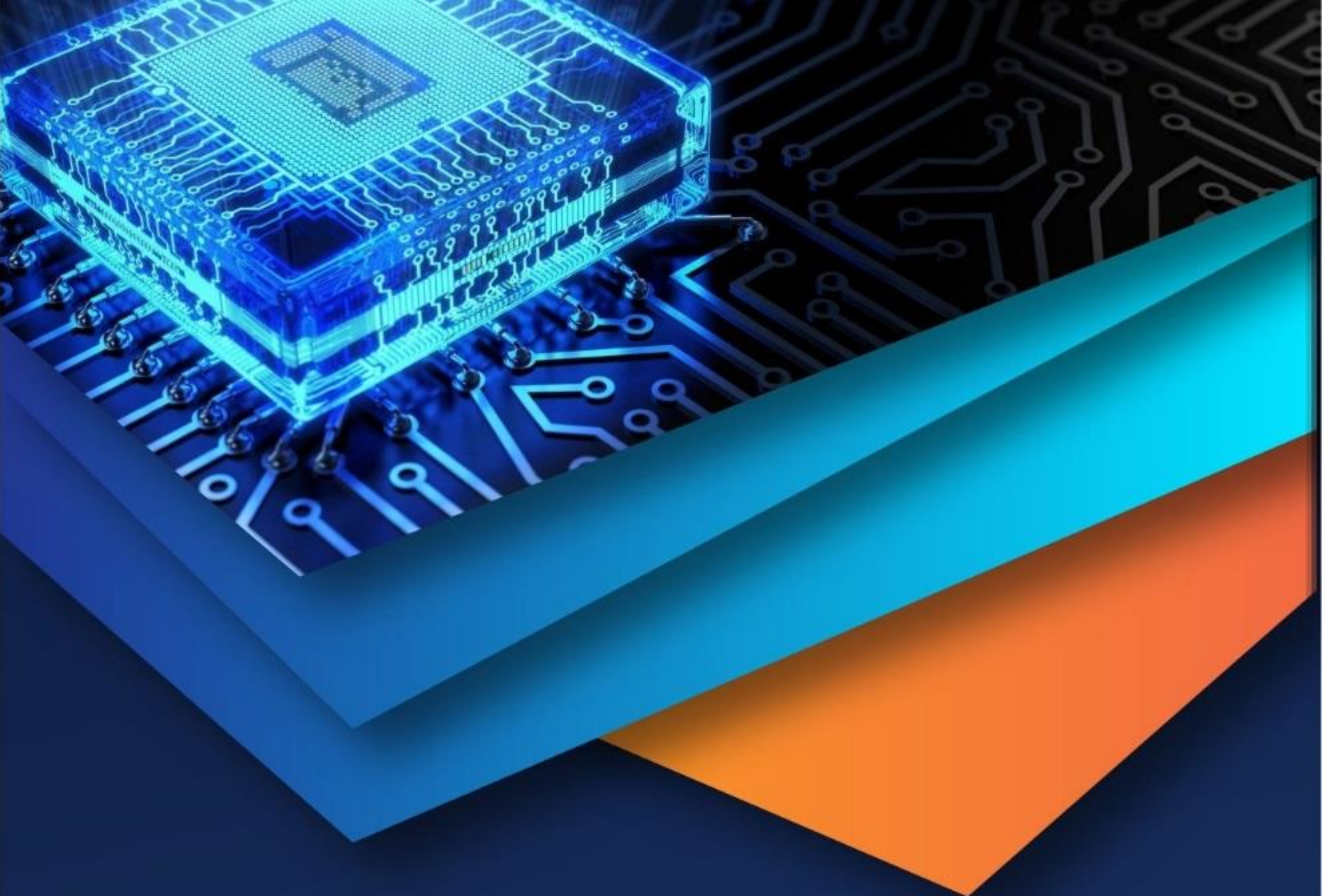

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