



Mental Health and Well-being Surveillance among children

¹Adlin Wiseley I, ²Siva Ranjani R, ³Makima Satthi N, ⁴Mrs. S. Nithya

^{1 2 3} Bachelor of Technology, ⁴Assistant Professor

^{1 2 3 4}Department of Artificial Intelligence and Data Science

^{1 2 3 4}Kamaraj College of Engineering and Technology, Virudhunagar, India

Abstract : Early identification of cognitive disorders is crucial for children's developmental growth, helping to prevent academic struggles, behavioral issues, and social difficulties. This project introduces an interactive web-based system designed to evaluate children's cognitive abilities through engaging, game-based activities. These activities assess essential skills such as memory, pattern recognition, problem-solving, and logical reasoning in an enjoyable, non-intrusive manner. An AI-powered chatbot, developed using a Retrieval-Augmented Generation (RAG) model, offers real-time responses to parents' queries and provides personalized guidance based on assessment results. The chatbot retrieves accurate, context-aware information from a vast knowledge base, empowering parents to interpret their child's cognitive performance and consider professional evaluation if necessary.

The system incorporates a structured evaluation process, using performance data from interactive games to generate comprehensive, easy-to-understand reports. Data-driven insights guide parents in deciding whether professional intervention is needed. Additionally, the platform prioritizes privacy by eliminating database storage, enabling lightweight deployment and safeguarding sensitive information. Our research highlights the effectiveness of combining game-based learning with artificial intelligence to create a user-friendly, supportive environment for children and caregivers. This solution bridges the gap between early cognitive assessment and professional support, promoting early diagnosis and proactive intervention to enhance children's cognitive development.

Keywords- IQ assessment, cognitive development, RAG chatbot, web-based evaluation, child psychology, AI in healthcare, early intervention, gamification

1. INTRODUCTION

Childhood cognitive development is a vital aspect of overall growth, shaping a child's ability to learn, communicate, and navigate challenges. Early detection of developmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD), dyslexia, and Autism Spectrum Disorders (ASD) is essential for effective intervention. Without timely diagnosis, these conditions can lead to difficulties in academics, social interactions, and emotional well-being. Traditional assessment methods, which often involve structured evaluations by psychologists or educators, can be costly, time-consuming, and inaccessible to many families. Additionally, prolonged waiting times for appointments and assessments may delay intervention, increasing developmental challenges.

Advancements in artificial intelligence (AI) and web-based technologies are driving the development of accessible digital tools for early cognitive assessment. Interactive online platforms use gamified tests and real-time data analysis to evaluate children's cognitive skills while maintaining engagement. These AI-powered systems adapt dynamically to a child's performance, offering personalized experiences and accurate assessments. Moreover, they reduce dependence on professional evaluations, making early detection more accessible and efficient.

This study introduces an innovative web application that combines IQ-based games, an AI-driven chatbot, and an automated analytical framework to support parents in assessing their child's cognitive abilities. The platform is designed to be intuitive and engaging, providing children with interactive games that assess problem-solving skills, memory retention, and logical reasoning. Simultaneously, parents benefit from a Retrieval-Augmented Generation (RAG)-powered chatbot, which delivers context-aware responses to queries and guidance based on test results. Unlike conventional assessment tools, this system operates without a centralized database, ensuring lightweight deployment, faster processing, and enhanced data security.

The RAG-powered chatbot plays a pivotal role by providing real-time, evidence-based insights into children's cognitive performance. It offers parents recommendations, explains assessment outcomes, and provides information about cognitive milestones. By bridging the gap between initial assessments and professional diagnosis, the platform empowers parents with actionable insights, fostering timely intervention and improved developmental outcomes for children. This technology-driven approach highlights the potential of digital tools to revolutionize cognitive assessment and contribute to early childhood development.

2. System Architecture

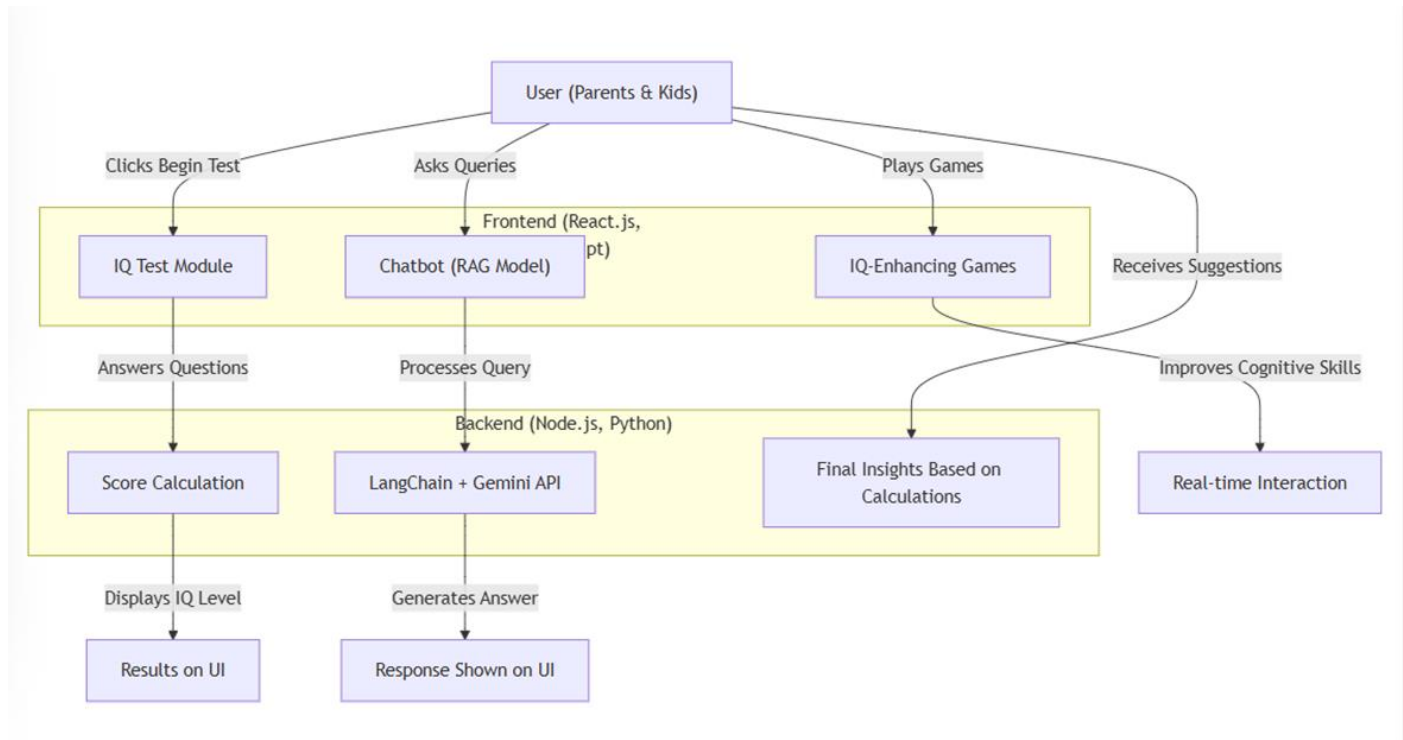


Figure 2.1- System Design

The user flow of the system as shown in Figure 2.1 is designed to ensure a smooth, interactive, and insightful experience for both children and parents. The platform facilitates a structured approach to assessing cognitive abilities while providing real-time guidance to parents. Below is a detailed breakdown of the user flow:

2.1 Registration and Initial Setup

Parents begin by registering their child's details on the web application. This step includes entering essential information such as: Child's name, age, and gender. Any known developmental concerns or previous diagnoses (optional) Parent or guardian contact details for follow-up and further assistance. Once the registration is complete, the system personalizes the experience based on the child's age and cognitive abilities, ensuring that the games and assessments are tailored accordingly.

2.2 Engagement with IQ-Testing Games

After the initial setup, the child gains access to various interactive IQ-testing games designed to assess different cognitive skills. The games cover multiple domains, including:

- Logical reasoning – Pattern recognition puzzles, sequence completion, and problem-solving challenges
- Memory retention – Short-term and long-term memory-based activities such as recall exercises
- Spatial awareness – Shape-matching and navigation-based problem-solving

These games adapt dynamically based on the child's responses. If a child excels in a particular category, the difficulty level is increased to further challenge their abilities. Conversely, if they struggle, the game adjusts to provide appropriate support. This adaptive mechanism ensures an accurate and personalized assessment experience.

2.3 Performance Data Collection and Evaluation

As the child interacts with the IQ-testing games, the system continuously records responses and evaluates key performance metrics, including:

- Speed – The time taken to complete tasks, which reflects cognitive processing speed
- Accuracy – The correctness of responses, measuring problem-solving efficiency
- Consistency – Patterns in performance across different attempts, identifying strengths and areas of improvement

The data is analyzed to detect trends in the child's cognitive performance. By comparing responses with age-appropriate benchmarks, the system ensures that the evaluation is both reliable and relevant.

2.4 AI-Driven Parental Guidance and Support

Once the initial assessments are completed, parents gain access to an AI-powered chatbot that provides real-time insights into their child's progress. This chatbot, powered by Retrieval-Augmented Generation (RAG), assists parents by:

- Explaining test results – Breaking down the child's strengths and areas that may need improvement
- Providing cognitive development insights – Offering general information about milestones expected at different ages
- Suggesting next steps – Recommending whether additional cognitive exercises or professional consultation may be necessary

Since the chatbot does not rely on a traditional database, it dynamically fetches updated information from credible sources, ensuring that parents receive reliable and research-backed advice.

2.5 Final Assessment and Report Generation

Based on the collected performance data, the system generates a final report that provides a detailed analysis of the child's cognitive abilities. The report includes:

- Overall IQ score estimate – A summary of the child's cognitive strengths
- Comparisons with cognitive development benchmarks – An analysis of how the child's results align with typical age-based expectations
- Potential cognitive concerns – Identification of any patterns that may indicate learning difficulties or developmental delays
- Personalized recommendations – Suggested exercises, learning strategies, and next steps for parents to support their child's growth

The system ensures that the final suggestion is not a conclusive diagnosis but an early-stage evaluation. If the child's performance indicates potential cognitive concerns, parents are encouraged to consult specialists for further professional assessment.

2.6 Next Steps and Recommendations

To guide parents on the best course of action, the system provides tailored recommendations, which may include:

- Encouraging the child to participate in additional cognitive exercises to strengthen specific skills
- Suggesting educational tools or interactive learning activities based on the child's assessment results
- Advising parents to monitor progress over time by re-engaging with the platform at regular intervals
- Recommending professional consultation if there are significant deviations from expected cognitive development milestones.

3. Methodology

The proposed system follows a structured three-stage methodology designed to provide a comprehensive and efficient assessment of a child's cognitive abilities. By integrating interactive game-based assessments, AI-driven parental support, and probability-based evaluation, the system ensures accurate and reliable cognitive analysis while maintaining accessibility and ease of use for parents.

3.1 Game-Based Cognitive Testing

- The first stage of the methodology involves a series of interactive games that evaluate various aspects of intelligence, including logical reasoning, spatial awareness, linguistic abilities, and memory retention. Each game is designed to target specific cognitive skills, ensuring a well-rounded assessment. The system records a child's responses, analyzing accuracy, speed, and patterns in decision-making to gauge cognitive strengths and potential areas of concern.
- **Logical Reasoning:** Puzzle-based tasks challenge a child's ability to recognize patterns, deduce conclusions, and solve problems using analytical thinking.
- **Spatial Awareness:** Shape-matching and navigation-based tasks assess how well a child perceives and interprets spatial relationships between objects.
- **Linguistic Abilities:** Word association and sentence-building exercises evaluate vocabulary strength, reading comprehension, and language processing skills.
- **Memory Retention:** Short-term and long-term memory recall tasks help determine the child's ability to retain and retrieve information effectively.
- The system continuously adapts the difficulty level based on a child's performance, ensuring personalized assessments. By tracking progress over multiple sessions, it provides insights into cognitive development trends rather than relying solely on a one-time evaluation.

3.2 AI-Assisted Parental Support

- The second stage involves an AI-powered chatbot using Retrieval-Augmented Generation (RAG) to offer parents real-time insights into their child's cognitive development. The chatbot is trained to process queries related to developmental concerns, cognitive milestones, and recommended interventions, ensuring parents receive timely and accurate information.
- **Reliable Knowledge Base:** Instead of relying on a static database, the chatbot pulls information from pre-trained datasets and verified medical sources. This ensures that the responses remain up-to-date with the latest research on child psychology and cognitive development.
- **Personalized Guidance:** Parents can input specific concerns or questions, and the chatbot will generate tailored responses, guiding them on the next steps based on the child's performance.
- **24/7 Accessibility:** Unlike traditional assessment methods that require scheduled appointments with professionals, the chatbot offers continuous support, allowing parents to seek assistance whenever needed.

- By integrating AI-driven assistance, the system bridges the gap between home-based assessments and professional consultation, providing parents with evidence-based guidance without requiring immediate specialist intervention.

3.3 Probability-Based Assessment

- The final stage of the methodology involves a systematic evaluation of the collected data to determine the probability of a child exhibiting cognitive delays or disorders. This is achieved through a probability-based assessment model that compares test results with predefined benchmarks derived from cognitive development studies.
- **Data Processing and Scoring:** The system assigns weighted scores to different cognitive parameters based on the child's performance. Metrics such as response accuracy, completion time, and consistency are considered in generating an overall cognitive profile.
- **Threshold Comparisons:** The obtained scores are matched against standardized thresholds established from research in developmental psychology. If a child's performance deviates significantly from typical cognitive benchmarks for their age group, the system highlights potential concerns.
- **Final Report Generation:** A structured report is provided to parents, summarizing the child's strengths, areas for improvement, and the likelihood of cognitive challenges. The report also includes actionable recommendations, such as engaging in targeted cognitive exercises or seeking professional evaluation if necessary.
- This three-stage methodology ensures that the assessment process is both scientifically sound and user-friendly. By combining engaging game-based evaluations, AI-powered guidance, and data-driven analysis, the system offers a modern approach to early cognitive assessment, empowering parents with valuable insights to support their child's development.

4. Results and Discussion

Initial testing of the system demonstrates its effectiveness in providing an engaging and educational experience for children while offering insightful feedback for parents. User feedback indicates that the adaptive difficulty of the IQ games helps maintain children's interest while providing meaningful data for analysis. The chatbot's responses effectively clarify doubts and provide structured guidance on further assessments.

Parents appreciated the lightweight nature of the system, as it does not require personal data storage, reducing privacy concerns. However, some challenges remain, including enhancing the chatbot's contextual understanding and expanding the variety of cognitive tests available. Future iterations will integrate additional AI capabilities to further personalize assessments and recommendations.

5. Conclusion

The proposed system provides an innovative and accessible approach to assessing children's IQ through interactive games and AI-powered assistance. By integrating a RAG chatbot and lightweight evaluation methods, it offers a user-friendly and efficient solution for parents to monitor their child's cognitive development. The transition to the Gemini API for chatbot integration ensures enhanced accuracy and adaptability.

This system serves as an early-stage screening tool, promoting timely interventions and better cognitive health outcomes. Future enhancements include personalized game recommendations, AI-driven adaptive difficulty adjustments, and multilingual chatbot support to cater to a global audience. The potential impact of this system in democratizing access to cognitive assessments highlights the importance of continued research and development in AI-driven healthcare applications.

6. Acknowledgement

We express our sincere gratitude to our mentors, peers, and research associates for their guidance and support in developing this project. We also acknowledge the contributions of open-source communities and API providers for facilitating chatbot integration. Special thanks to the developers of the Gemini API and open-source game development communities for their valuable resources.

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