iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.70958

Automated Smart Chessboard

Deepesh Meena[1], Ghanshyam Sain[2], Deependra Singh Tanwar[3], Dr. Priyanka Jain[4]
Department of Electrical Engineering, Arya College of Engineering & Information Technology, Jaipur, India

Abstract: This paper discusses the design, implementation, and challenges of a Smart Automated Chessboard. The system utilizes an Arduino Uno microcontroller, A4988 stepper motor drivers, and a Cartesian (X-Y) mechanism driven by NEMA 17 stepper motors and lead screws to autonomously move chess pieces based on external commands. Key features include integration with the Stockfish chess engine for AI-powered gameplay, voice control capabilities for hands-free operation, connected through an HC-05 Bluetooth module. The core functionality involves magnetic manipulation of chess pieces using a servo-controlled permanent magnet, executing moves received from the user or AI. The project aims to enhance the traditional chess experience by offering a physical opponent, improving accessibility, particularly for players with disabilities, and providing an engaging alternative to screen-based chess, thereby reducing screen time.
Keywords: Chess, AI, Voice Command, Automated Movement, Accessibility

I. INTRODUCTION

Chess, a game of strategy and patience with origins dating back before the 7th century in India, remains a globally popular intellectual challenge. Played on an 8x8 grid with 64 squares, it involves two players manoeuvring 16 pieces each according to specific rules, aiming to checkmate the opponent's king. Chess is recognized for its cognitive benefits, particularly in enhancing memory and strategic thinking [2]. In an increasingly digital world, excessive screen time associated with devices like smartphones and laptops poses health risks, including potential eye damage [6]. This project addresses this concern by offering a tangible, physical chess-playing experience, bridging the gap between the classic board game and modern technology. The Smart Automated Chessboard provides a physical opponent, simulating a real game experience that virtual platforms cannot fully replicate. It serves as a training companion for players and significantly improves accessibility for individuals with physical disabilities.

II. LITERATURE REVIEW

Creating an automated chessboard involves robotics, artificial intelligence (AI), and human-computer interaction (HCI). This review synthesizes relevant literature across these domains, incorporating insights from recent studies.

A. Robotic Manipulation and Control

The core mechanical challenge involves precise positioning and manipulation of chess pieces based on received commands. Cartesian coordinate robots (XY plotters), driven by stepper motors, are a common solution for planar positioning tasks due to their straightforward kinematics and control [1]. Systems like the one presented here often use like H-Bots [6, 13] or belt drives [2] to convert rotary motion to linear motion. Stepper motors, paired with drivers like the A4988, allow for open-loop control with reasonable accuracy. Alternatives include using robotic arms, such as 4-DOF SCARA robots [14] or more complex 6-DOF arms [7, 14], which offer greater flexibility but often come at a higher cost and complexity. Magnetic actuation, using either electromagnets or permanent magnets coupled with servos for engagement/disengagement, provides a non-contact or minimal-contact method for handling appropriately designed pieces, simplifying gripper design [3, 14]. The choice between electromagnets and permanent magnets involves balancing controllability with power consumption and heat generation [4]. Microcontroller platforms like Arduino [5, 8, 15] provide accessible and cost-effective means for integrating sensors, actuators, and communication modules in such robotic systems.

B. Artificial Intelligence in Chess

Chess has been a benchmark problem in AI since Shannon's early work [6]. The victory of IBM's Deep Blue over Garry Kasparov marked a significant milestone [7]. Modern chess engines, such as Stockfish (used in this project and others [2, 13, 14]), employ highly optimized alpha-beta search algorithms [14, citing 39] or Minimax variants [16] with sophisticated evaluation functions. Some projects explore alternative engines like Sunfish [15] or techniques like Monte Carlo Tree Search [16] or Neural Networks [5]. Integrating such engines provides a formidable opponent for human players using automated boards. Move representation often uses Forsyth-Edwards Notation (FEN) [14].

C. Human-Computer Interaction

Effective interaction is crucial for usability and command input. Applications connected via Bluetooth offer a common method for wireless control and move transmission [8, 9]. Voice control represents an increasingly important modality, particularly for enhancing accessibility and providing move commands [8, 10]. Pilueta et al. [8] specifically developed "Chessbot" with voice control (using Google Speech and phonetic alphabet commands like 'Alpha', 'Bravo') and modes for blind players. Designing intuitive interfaces, whether graphical or voice-based, is essential for a positive user experience [11]. Tangible interfaces, like physical automated boards executing received moves, provide an alternative to purely screen-based interaction [12].

III.SYSTEM COMPONENTS

1) Stepper Motors: Two NEMA-17 Bipolar Stepper motors (12V, 350mA, 1.8°/step) are used for X and Y axis movement.
2) Stepper Motor Drivers: Two A4988 Stepper Motor Driver with heat sinks, providing micro stepping control and current limiting for the NEMA 17 motors. Delivering 2A per phase with cooling.
3) Servo Motor: SG90 Servo Motor servo motor(1.8 kg.cm torque) for Z-axis control (lifting/lowering the magnet).
4) Arduino UNO: The Arduino UNO is a ATmega328P-based micro controller board, acting as the brains of the project.
5) Bluetooth Module: The HC-05 Bluetooth Module enables wireless serial communication (Bluetooth 2.0+EDR) between the arduino and the computer.
6) Lead Screws: The lead screws used here are steel threaded with bronze nuts, converting rotational motor motion to precise linear X and Y movement.
7) Permanent Magnet: Neodymium Permanent Magnet is mounted on the servo motor for picking up and placing chess pieces. An early design utilized an electromagnet for piece manipulation. However, this proved problematic due to high power consumption and significant heat generation. Furthermore, it required protective circuitry. This led to the adoption of a servo-controlled permanent neodymium magnet, which offered superior magnetic strength, zero power consumption while holding, no heat generation, and simpler control, proving much better in all aspects.
8) Chess Pieces: The chess pieces used were standard 32-piece set, each embedded with a magnet at the base. Both sides ,i.e, black and white comprises of 16 pieces each. There are 8 pawns, 1 king, 1 queen, 2 rooks, 2 bishops and 2 knights on each sides.
9) Stockfish Chess Engine: Stockfish is a strong, open-source chess engine that uses the alpha-beta search algorithm to analyze chess positions and find the best moves. It's known for its powerful analysis capabilities and is widely used for training, game analysis, and even as a tool for cheating in online games. It's a simple and powerful Chess Engine that is integrated to provide AI opponent logic and move commands. It also validates the player move if its legal.
10) Wokwi Simulation: Wokwi is an online simulation tool for embedded systems and IoT projects, allowing users to simulate projects using various development boards like Arduino, ESP32, and Raspberry Pi Pico without needing physical hardware

Wokwi Simulatioin was used for virtual testing and debugging of the Arduino code and hardware interactions before physical implementation.

IV.METHODOLOGY

The system employs a Cartesian coordinate system using lead screws, differing from SCARA [14] or other arm-based approaches. Two NEMA 17 stepper motors, controlled by A4988 drivers under Arduino command, drive the lead screws along the X and Y axes. This positions a carriage holding the servo-mounted permanent magnet beneath any target square on the acrylic playing surface based on received move commands.

User inputs are sent to the Arduino via the HC-05 Bluetooth module or directly by connecting the Arduino by data cable. The Arduino parses these commands (e.g., "A4C4" or voice equivalent) and calculates the required steps for the X and Y motors to reach the piece's starting square based on commands received via Bluetooth/voice. The servo motor then lifts the permanent magnet to attract and lift the piece. The stepper motors moves the carriage (and piece) to the destination square, where the servo lowers the magnet, releasing the piece.

Then the AI analyzes the player's move and then calculates its move and sends it to the Arduino and the cycle continues till checkmate.

Fig. 1 Working Prototype

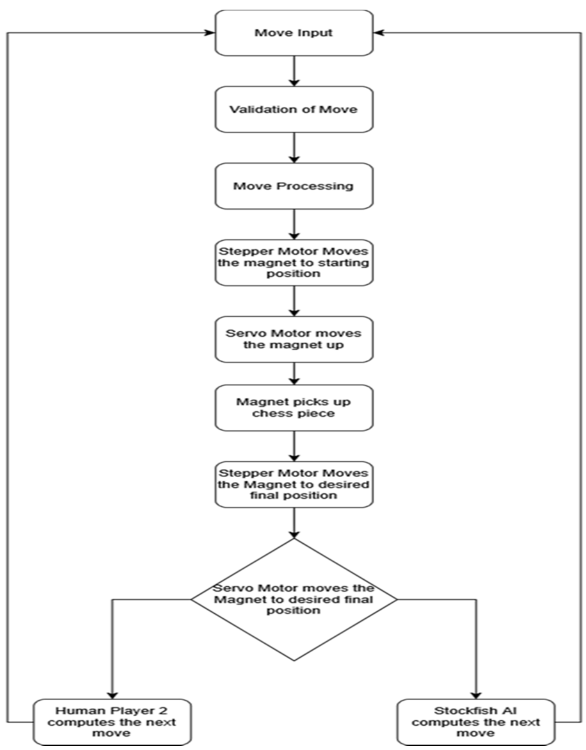


Fig. 2 Flowchart

V. CONCLUSIONS

This project successfully demonstrates the feasibility of creating a Smart Automated Chessboard using readily available components like Arduino, stepper motors, lead screws, and a permanent magnet system, controlled via Bluetooth and voice commands. The integration of the Stockfish AI engine provides a challenging opponent to play with. The system accurately translates digital or voice commands into physical piece movements, offering a modern, interactive, and accessible chess-playing experience by directly executing received instructions. The final prototype effectively bridges traditional board gameplay with modern automation and AI, offering benefits like reduced screen time and enhanced accessibility.

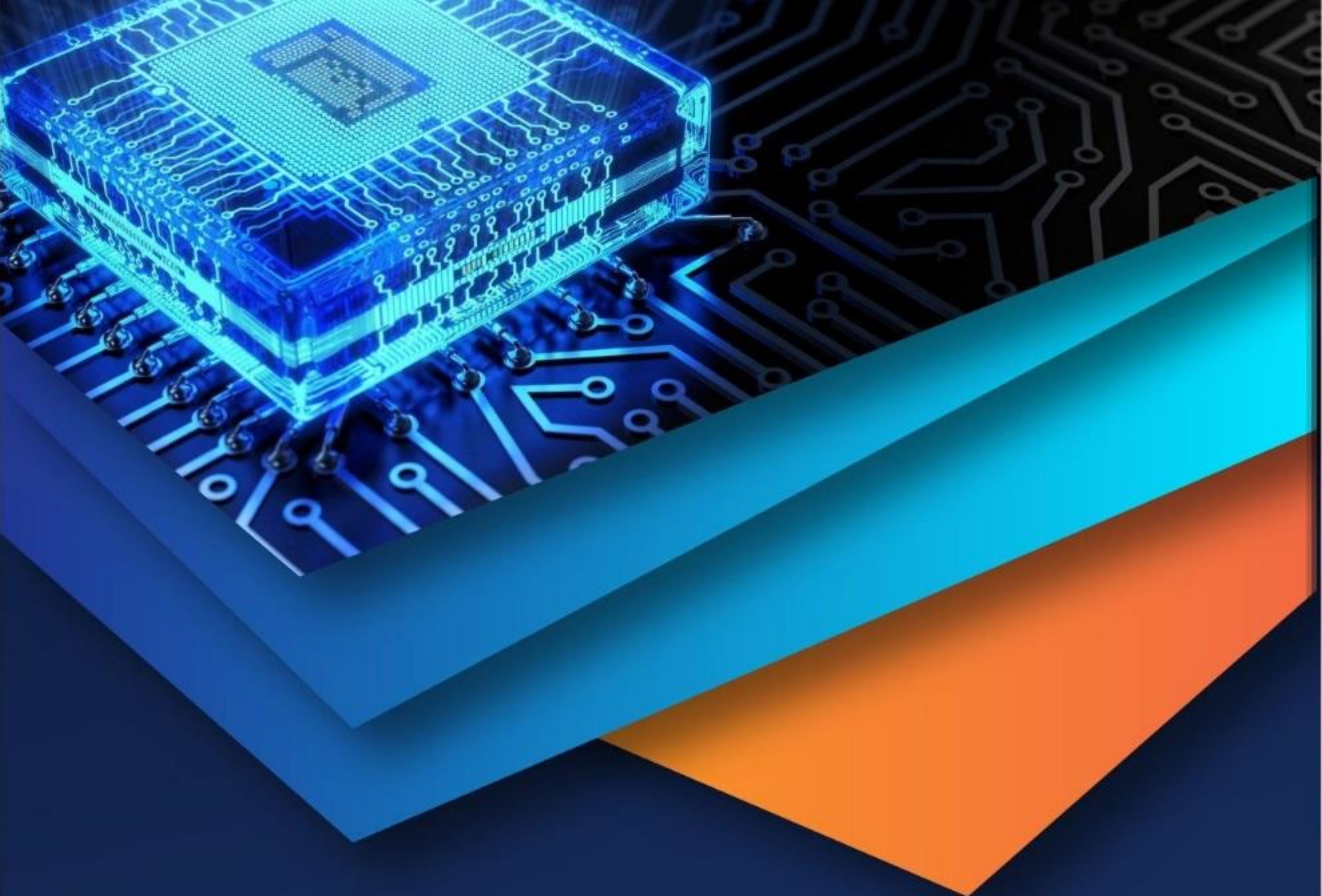
It serves as a compelling example of applying robotics and AI to enhance a classic game with modern technologies.

VI. ACKNOWLEDGMENT

The heading of the Acknowledgment section and the References section must not be numbered.
Causal Productions wishes to acknowledge Michael Shell and other contributors for developing and maintaining the IEEE LaTeX style files which have been used in the preparation of this template. To see the list of contributors, please refer to the top of file IEEETran.cls in the IEEE LaTeX distribution.

REFERENCES

[1] Siciliano, B., & Khatib, O. (Eds.). (2016). Springer Handbook of Robotics. Springer.
[2] Rath, P. K., Mahapatro, N., Nath, P., & Dash, R. (2019). Autonomous Chess Playing Robot. 2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), 1-6.
[3] Takeda, Y., Nakamura, Y., & Hirai, S. (2000). Magnetic-based active catheter. Proceedings of the IEEE International Conference on Robotics and Automation (ICRA), 4, 3453-3458.
[4] Furlani, E. P. (2001). Permanent Magnet and Electromechanical Devices: Materials, Analysis, and Applications. Academic Press.
[5] Banzi, M., & Shiloh, M. (2014). Getting Started with Arduino. O'Reilly Media.
[6] Shannon, C. E. (1950). Programming a computer for playing chess. Philosophical Magazine, 41(314), 256-275.
[7] Campbell, M., Hoane Jr, A. J., & Hsu, F. H. (2002). Deep Blue. Artificial Intelligence, 134(1-2), 57-83.
[8] Pilueta, N. U., Grimaldo, H. D., Jardiniano, M. F., & Garcia, M. B. (2022). Chessbot: A voice-controlled chess board with self-moving pieces. AIP Conference Proceedings, 2502(1), 040001.
[9] Stallings, W. (2005). Wireless Communications & Networks. Pearson/Prentice Hall.
[10] Nass, C., & Yen, C. (2010). The Man Who Lied to His Laptop: What We Can Learn About Ourselves from Our Machines. Current.
[11] Norman, D. A. (2013). The Design of Everyday Things: Revised and Expanded Edition. Basic Books.
[12] Ishii, H., & Ullmer, B. (1997). Tangible bits: towards seamless interfaces between people, bits and atoms. Proceedings of the ACM SIGCHI Conference on Human factors in computing systems (CHI), 234-241.
[13] Zurange, K. H. (2020). Professional AI Chess Board Autonomous Chess Board (Human Vs. Robot). International Journal of Engineering Research & Technology (IJERT), V9(05), 135-138.
[14] Phuc, T. D., & Son, B. C. (2025). Development of an autonomous chess robot system using computer vision and deep learning. Results in Engineering, 25, 104091.
[15] Shaha, T., Chaudhari, D., Kshirsagar, A., Doiphode, A., & Mahajan, M. R. (2020). Intelligent Chessboard Using IOT. International Journal of Research and Analytical Reviews (IJRAR), 7(1), 545-552.
[16] Kuklani, O., Kapadne, S., Patne, A., Chaware, J., & Gangrade, K. (2023). Automated Chess Boards: A Comprehensive Review and Analysis of Technology and Applications. International Research Journal of Engineering and Technology (IRJET), 10(12), 586-590.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY