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Milestone # 1

Robotics (Edpt1009) W’21 course project

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**Chess Playing Robotic Arm**

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***Literature Review***

The development of robotic chess playing games gained lots of interestin the robotics field, artificial intelligence and education. A standard complex game is a remarkable testbed for robotic manipulation, decision making algorithms and human robot interaction. Computer chess implementations migrated to digital platforms while offering powerful chess engines, yet at the expense of physical interaction. Consequently, concerns have been raised regarding increased screen time, diminished tactile engagement and offering lower educational value in youth chess training. A robotic arm will be capable of autonomously playing chess by combining the strategic depth of chess APIs with tangible benefits of over-the-board play.

In [1], an autonomous robotic chess arm that integrates a Raspberry Pi controller running python with Stockfish chess engine for real-time gameplay. A Cartesian arm with top-down gripper, designed to manipulate standard tournament pieces safely and efficiently where the system features. Design included Pugh matrices to balance manufacturability, precision and robustness. Prototype included limitations such as reduced wrist twist and flexibility, yet it showed the ability to execute moves within competitive time constraints.

In [2], a SCARA robotic arm which is capable of chess simultaneously on three regulation boards. It is 3D printed for lower costs controlled by an Arduino Mega 2560 with stepper motors and programmed in C with custom communication protocol. Gippers which are servo based with an integrated camera enabled accurate manipulation of pieces with millimetric accuracy. Despite limitations such as multiple redesigns of the gripper and Z-axis, the prototype achieved stable performance and demonstrated the feasibility of low cost multi board robotic chess. Future work included emphasized integrating sensory chess board and engine connectivity to enable fully autonomous play chess against human opponents.

A robotic chess system built on a desktop which incorporates computer vision and motion planning to control semi-autonomous chess manipulation is described in [3]. The system uses a Kinetic v2 camera to scan the chessboard and individual pieces with RANSAC and corner / line location algorithms. The resultant processed positional data are relayed to a Stockfish chess engine via the Universal Chess Interface (UCI) protocol to allow smart move choices. The system architecture is a composite of legacy .NET Framework modules, which will take care of Kinetic input handling, combined with a modern .NET core application via memory mapped files to ensure efficient inter-process communication and real time data editing. Trajectory planning was done through a modified 3D Bresenham supercover line algorithm to remove the possibility of a collision during the movement of the manipulator. Other features are the ability to configure board positions by users, ability to dynamically reconfigure without halting the game, and the use of various modes, including human-AI, AI-AI, and historical-PGN game replays. The experimental analysis showed drawbacks, including light sensitivity and low frame rate (46 FPS). The improvements that are suggested including automatic parameter tuning and the replacement of the Kinect sensor with an Intel RealSense camera to achieve greater precision and stability.

In [4], an open-source robotic chess player designed to provide both easy accessibility and use in educational purposes. Built using a SCARA structure which is a simple mechanical model, only using three mechanical motors while incorporating cam-driven mechanisms for a reliable magnetic pickup. The system develops Tiny ROS; a custom robot operating system suitable for resource- constrained embedded chips like the RK3566 and uses lightweight, YOLOv7-tiny model for real-time chess piece detection. The robot achieves an acceptable 90.96% manipulation success rate during gameplay, yet its main asset is the full open sourcing of its design (including hardware, software, and protocol).

In [5], is a smart robotic system designed also for human interaction like the previously discussed arms; the system combined AI-based decision support. The system faced limitations including dependency on lighting conditions for vision accuracy and moderate speed of operation, yet the study provided solid framework for robotic chess playing platforms.

**References**

**[1]** D. Goldman, C. Anderson, A. Natarajan, and J. Meyer, “Design and Implementation of an Autonomous Robotic Chess-Playing System,” *Proceedings of the IEEE MIT Undergraduate Research Technology Conference (URTC)*, Boston, MA, USA, 2021, pp. 1–4. doi: [10.1109/URTC52217.2021.9452896].

**[2]** C. F. Pațanghel and M. Breazu, “A Robotic Arm for Playing Chess,” *International Journal of Advanced Statistics and IT&C for Economics and Life Sciences*, vol. XIV, no. 1, pp. 1–15, Dec. 2024. doi: [10.2478/ijasitels-2024-0018].

**[3]** A. Khan, K. Khan, M. I. Khan, and Z. Khan, “Chess Robot Arm: A Smart Robotic System for Playing Chess with Humans,” in *2022 International Conference on Robotics and Automation (ICRA)*, IEEE, 2022, pp. 1–6. doi: [10.1109/ICRA2022.9811527].

**[4]** S. An, G. Che, J. Guo, Y. Xu, G. Wang, K. A. Tsintotas, F. Zhang, J. Ye, C. Fu, H. Zhu, and H. Zhang, "An Open-Source Robotic Chinese Chess Player," in *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, Detroit, USA, Oct. 1-5, 2023, pp. 6238-6245.

**[5]** K. Khan, A. Rashid, M. I. Khan, Z. Khan, “Chess Robot Arm: A Smart Robotic System for Playing Chess with Humans,” *IEEE Access*, vol. 10, pp. 3150792, 2022.