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DESIGN AND DEVELOPMENT OF AUTONOMOUS CHESS PLAYING ROBOT

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Abstract

This paper presents an autonomous chess playing robot that interacts with a human player. The game begins when the robot makes a move. The coordinates of the piece's original location and its current location are fed into a computer. Using suitable image processing techniques moves are detected and fed into the chess engine. The chess engine then replies with its move, giving the piece's current location and the desired destination. An XY positioning table underneath the board moves to the location of the piece to be moved. An electromagnet is then initiated to attract the above piece and the piece is moved to the desired destination. The electromagnet is then demagnetized, and the XY positioner returns to its home position and waits till the next human move.

Keywords: Autonomous Chess Robot, Machine Vision, Human Robot Interaction, Chess, Artificial Intelligence.

1. INTRODUCTION

In the year 1809, Napoleon Bonaparte was beaten by a chess computer in only 24 moves. The founder Wolfgang von Kempelen narrated, only the very complex combination of many years would be the secret of success. Behind a wooden box, a puppet, wearing the clothes of a turkish pasha, was sitting. Opening the two doors of this box everybody was able to see many rolls, levers and gears. At the beginning of every chess match von Kempelen winded the puppet and it was playing a game by itself. At the day of von Kempelens deth the function of the turk was still a secret. The last owner, Edgar Allan Poe, revealed the true situation in the year 1840: in the interior of the box was enough space for one person, so the turk was only a magic trick. Nevertheless this story shows the fascination autonomous chess playing was able to attract even many years ago. This is one reason why playing chess is a very good example for building robots.

This paper introduces autonomous chess playing robot, a robotic system that is designed to autonomously play board games against human (or robotic) opponents. A large number of chess playing automata that have been imagined or constructed in the last three centuries suggests that robot chess could be interesting as an entertainment application.

It can be difficult, to find someone who plays on the same level as you do. To solve this dilemma, and to increase playing skills, the chess robot comes in handy.

Most of the work done previously on autonomous chess playing robots makes use of sensory boards to detect moves using magnetic pieces and sensors. It is done with the help of magnetic pieces and sensors kept beneath the board to detect the movement of the pieces. Instead an image processing technique can be used to detect moves, since in that case any simple chess board can be used to play chess and we can play chess in any environment-anytime and anywhere without any special requirements. Robotic arms to pick up pieces and place them is very inaccurate and unreliable since the gripper and the pieces orientation may get varied and cannot be kept exactly at its position for each moment of time which causes difficulty in picking up pieces. Also the design is unstable because of the fact that the gripper along with the arm is very heavy thus destabilizing the system grounded through a single base.

2. MACHINE VISION

a. Anatomy of Machine Vision

Machine vision can be defined as the interpretation of an image of an object or scene through the use of optical non contact sensing mechanics for the purpose of obtaining information and/or controlling machines or processes. The Machine Vision system consists of image acquisition system, frame grabber, image processing software and a controller. The image acquisition system comprises of lighting system, lens and a camera. The efficiency of a machine vision system mainly depends on the image acquisition system. Once a proper image is acquired the

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remaining steps of the image processing becomes simpler. The frame grabber is used to convert an analog image into a digital image. It has to be used only if image acquisition device is an analog camera. The image processing software is used to execute the image processing algorithm. The image processing software discussed in this paper is MATLAB. The controller is used to take decisions and/or control the system based on the output from the image processing software. The controller controls the actuator in this case.

The anatomy of a simple machine vision system is shown in Fig. 1.

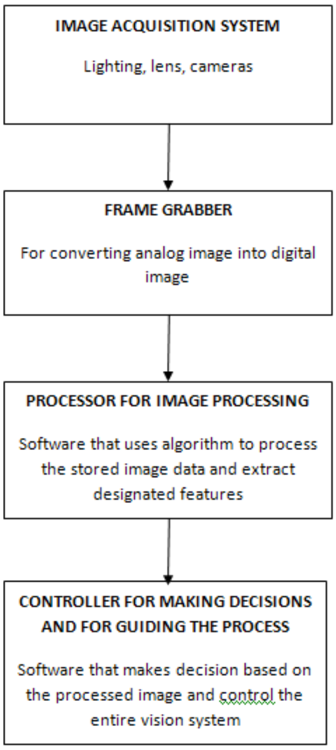

Fig. 1 Anatomy of a Machine Vision System

Chess Engine Communication Protocol

Chess Engine Communication Protocol is an open communication protocol that enables a chess engine to communicate with its user interface. Two engines can be communicated with each other using winboard/xboard. An xboard chess engine runs as a separate process from xboard itself, connected to xboard through a pair of anonymous pipes. The engine does not have to do anything special to set up these pipes. Xboard sets up the pipes itself and starts the engine with one pipe as its standard input and the other as its standard output. The engine then reads commands from its standard input and writes responses to its standard output. It was initially intended to only communicate with the GNU Chess engine which only accepted text input and produced text output. In fact, the first version of this protocol is nothing more than the behavior of GNU Chess's command line interface. XBoard, using the protocol, "wrapped around" GNU Chess by feeding the engine the expected text input, parsing the text output, and presenting this information on a graphical chess board.

Another computer chess protocol is the Universal Chess Interface (UCI). XBoard/WinBoard supports this protocol (and its dialects USI and UCCI, which are in common use for Shogi and Chinese Chess) through adapter programs such as Polyglot and UCI2WB.

2. HARDWARE SETUP

a. Mechanical Design

The mechanical design of the chess robot with the position of motors and grippers as indicated is shown in Fig. 2. The mechanical setup consists of a XY table with motors attached to it for the movement of the gripper in the required direction.

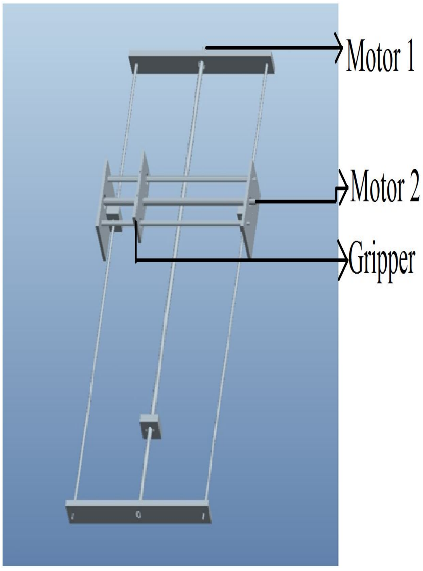

Fig. 2 CAD model of XY Table

The chess board has a dimension of 600*600mm. In which each square comprises of 75mm. The pieces diameter comprises of half of the square size. The pieces are attached to a magnet or metal at the bottom and placed above the chess board. The Board is mounted over the XY Table. Two lead screws are used for the X and Y axes movement and the specifications of the lead screws are as follows: the lead screw for X-Axis has a length of 1000mm, diameter of 16mm and pitch of 2mm; the lead screw for Y-Axis has a length of 600mm, diameter of 16mm and pitch of 2mm. Motor placed at the base position is used to move the arm in the X direction. As it has to carry the entire weight of the setup a high torque motor is chosen. The second motor placed in the position 2 as indicated in Fig.2 is used for movement of the arm in Y direction. It carries a block on which the lead screw and the gripper are placed.

b. Vision system

A camera is used to record the image of the chess pieces placed on the table. Area scan camera has to be used as the image of entire board has to be recorded.

c.Control system

Since the system uses chess engine communication protocol. The game play can be made visual in a computer instead of using any microcontroller to operate the system. The entire system can be controlled with a work station.

3. Working of the System

Camera calibration is done before starting the working process. An image with pieces on board is taken as a reference image. After a move is made from opponent, the image processing algorithm is executed. The processed image contains the move made by the opponent and it is feed to the chess engine communication as chess notation. Chess engine replies with the move to be made by the robot. The move replied will be in chess notation. The computed data is then sent to the gripper. The gripper moves the chess piece to the required location. After the move is made the gripper is brought back to its original position. The opponent makes opposition move and the move is fed to the workstation, the process continues until the game ends. The flowchart of the process is shown in Fig. 3.

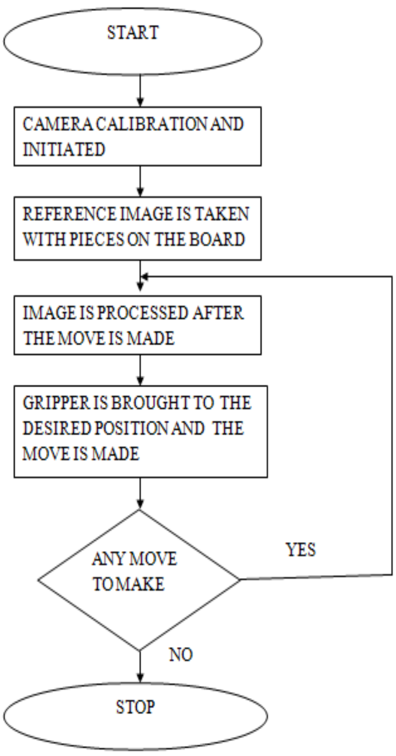

Fig. 3 Flowchart of the process

4. Image Processing Algorithm

Before starting the image processing algorithm, it is necessary to calibrate the camera. In general, camera calibration is the problem of determining the intrinsic and extrinsic parameters of a camera. It involves mapping the real world co-ordinates to the camera sensor plane co-ordinates. After calibrating the camera, the image of the chess board with and without chess pieces are taken as reference image. The captured image is then converted into a binary image by selecting a proper threshold value. The image captured after move is made is subtracted from the original image. After every move the previous image acts as reference image in which we find whether a move is made or not using image subtraction. The image conversions that take place during processing are shown in the Fig. 4.

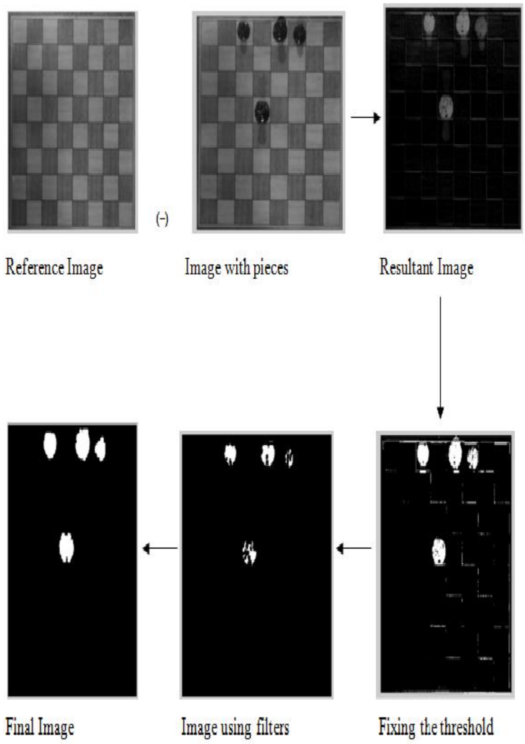

Fig. 4 Processing of the image

5. Conclusion

In this study, an autonomous chess playing robot was designed and developed. The algorithm was developed based on 2D vision technique. The system was robust and could be operated at any environment and at any time. Occlusion was cleared since the images were recorded only after the move is made. The system interacts well with the user and can handle any level of difficulty

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