Istanbul Medipol University
School of Engineering and Natural Sciences
Graduation Project

2022-2023

PROJECT TITLE
AI Chess Playing Robotic Arm
PROJECT ADVISOR
Dr. Bahadır Kürşat Güntürk
TEAM MEMBERS
Abdul Rahman Akl Youssef Darahem

Istanbul Medipol University

School of Engineering and Natural Sciences

Graduation Project

Project Code
Project Title: AI Chess Playing Robotic Arm
Project Advisor: Dr. Bahadır Kürşat Güntürk
Project Team Members: Abdul Rahman Akl 61190019 - Youssef Darahem 64190021
Sponsor Company (if any) : TÜBİTAK

BUDGET (TL)	PROPOSED	CONSENTED
IMU FUNDING	3000	3000
SPONSOR COMPANY FUNDING	6000	6000
TOTAL	9000	9000

PROJECT PLAN	PROPOSED	CONSENTED
PROJECT PLAN Duration in Weeks	28 Weeks	28 Weeks
STARTING DATE	26/09/2022	26/09/2022

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Project Code	
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PROJECT OVERVIEW/SUMMARY/ABSTRACT

Nowadays, robots, specifically robotic arms, are being widely used in many different fields. Our project's target was to make a chess-playing robotic arm that can identify the different types of chess pieces and moves them correctly on the chess board. Chess is a sport actively played by about 2% of the world's population [1]. The originality in our project comes from the use of Jetson Nano, a unique software algorithm based on analyzing changes in camera frames of the chess board to let the robotic arm know when its turn is in addition to some security measures such as giving warning signals to the user in case he makes an illegal move. The method implemented was detecting and identifying the chess board and chess pieces observed by the camera using jetson nano and playing chess moves by moving the pieces across the board using motors controlled by Arduino UNO. The project cost us about 9000 TL. Main success criteria in our project include:

- 100% detection accuracy of the chessboard
- 97% detection and identification accuracy of chess pieces (error tolerance of two chess pieces)
- Dropping the chess piece within the boundaries of the square on the chessboard

We are proud to say that all the components of our project are functioning seamlessly, resulting in a chess-playing robotic arm capable of engaging in matches with human players. Additionally, this arm can also be utilized to train chess players for tournaments by providing them with unique scenarios for practice. Furthermore, another social benefit of our project is the robotic arm model which can be used as a SmartArm that can carry objects from one place to another. This can be applied in school or university labs where the robotic arm can be used to organize different lab equipment.

Keywords: Robotic arm, chess playing, jetson nano

1. OBJECTIVE OF THE PROJECT: Simply put, the project's main goal is to make a robotic arm that identifies the different types of chess pieces and moves them correctly on the chess board. After completing the project, we currently have a robotic arm that can carry on a short chess match with a human player. In the upcoming period, we can continue to work on making the robotic arm made adaptable to different chess boards and chess pieces. In addition, our project can be used to train chess players for tournaments by playing with them in different possible scenarios they might face in a real chess match. This is due to the unique experience provided by our robotic arm making the players feel as if they are playing against another human player. Consequently, the sub-objectives for this project can be defined as:

1) Chess-playing robotic arm
2) Playing matches with human players
3) Training chess players for tournaments
4) The design of the project (SmartArm) can be used for different purposes such as organizing lab equipment, not only playing chess.

2. LITERATURE REVIEW: After setting our objectives straight, we went through some literature to see what others have done for the same or similar objectives to then contribute or do something different. Some of the papers found had done similar projects however not using the traditional chess set but Chinese chess instead [2][5]. There were many similarities between the papers read in general as they serve the same purpose, but the differences were mainly in the way the problem was divided and then approached and the materials used. There were also some slight differences in the methodology implemented. Regarding the materials used aspect, some papers went with ready-to-use robotic arms such as the prototype from FabLab RUC in Denmark and minimized the design [7][8]. On the other hand, some papers replaced the robotic arm completely with an XY-plotter [5][11]. Moving on to other hardware materials, some papers used stepper motors rather than servo motors and microprocessors other than Arduino (such as PIC16F877A [4]). Also, one of the papers replaced Jetson Nano that we plan on using with NanoPi M2A development board [2]. For the differences in division and approach, one of the papers divided the project into Camera vision system, Main control system, Robotic arm kinematics and Chess game motor [3] whereas another paper divided the project into Chess board layer, Board Layer, Pixel classification layer, Chess algorithm, Command Layer and Inverse kinematics layer [6]. There were also some differences in methodologies implemented. Examples include kinematics of the robotic arm, in one of the papers, Iterative Cyclic Coordinate Descent method was used [3]. Other papers solved inverse kinematics [6] and forward kinematics [9] of the robotic arm. Moreover, some papers used hand detection method to let the robotic arm know when its turn is such that if the robotic arm detects a hand, it knows that the human player is making his move and vice versa [4][10]. Another paper used a button to be pressed to let the robotic arm know when its turn is [5]. Table 1 below shows a summary of the methods and remarks on the papers read throughout the literature review.

Author	Period	Title	Method/Remarks
Jiaqian Wang, Xiangcheng Wu, Tonghui Qian, Hai Luo and Cong Hu	2019	"Design and Implementation of Chinese Chess Based on Manipulator”	In this paper [2], the project was done on Chinese chess where they used a model that detected circles (pieces in Chinese chess) and their positioning and recognized colors and characters. For their search algorithm to provide the best move at the current position, they used alpha-beta algorithm. What we will do instead is use Stockfish [12], an open-source chess engine, to get the best move.
Musa Ataş, Yahya Doğan and İsa Ataş	2014	"Satranç Oynayan Robot Kolu Chess Playing Robotic Arm"	The paper used a robotic arm from Lynxmotion and used Java mostly for communication with the robotic arm and the camera vision system. For kinematics of the robotic arm, the Iterative Cyclic Coordinate Descent method was used. The general architecture was based on Camera vision system, Main control system, Robotic arm kinematics and Chess game motor [3].
Hafiz Muhammad Luqman and Mubeen Zaffar	2016	"Chess Brain and Autonomous Chess Playing Robotic System"	The process flow of the project consists of Camera, CV algorithm, Chess engine, Robot controller, Robotic manipulator and Chessboard. They used PIC16F877A microprocessor instead of the Arduino UNO we are going to be utilizing. In addition, they used hand detection method to let the robotic arm know when its turn is such that if the robotic arm detects a hand, it knows that the human player is making his move and vice versa [4].
Ng, Chin Pang	2020	"Chinese chess robot with real time interaction and environment setup for AI recognition"	The project was done on Chinese chess with the use of magnets. In the paper, the robotic arm was replaced with an XY Plotter. They also used a button to be pressed to let the robotic arm know when its turn is [5].
David Urting and Yolande Berbers	2003	"MarineBlue: A Low-Cost Chess Robot"	In this paper, Robix RC-6 arm was used in addition to a Sony DFW-VL500 camera. The project was divided into Chess board layer, Board Layer, Pixel classification layer, Chess algorithm, Command Layer and Inverse kinematics layer [6].
Dr. G. Ranganathan	2007	"An Economical Robotic Arm for Playing Chess Using Visual Servoing"	This paper used a robotic arm prototype from FabLab RUC in Denmark and minimized the design. They also used a four-finger gripper built using Solidworks. Furthermore, they used a Siamese network structure.

Cristian del Toro, Carlos Robles-Algarin and Omar Rodriguez Alvarez	2019	"Design and Construction of a Cost-Effective Didactic Robotic Arm for Playing Chess, Using an Artificial Vision System"	This paper used a robotic arm prototype from FabLab RUC in Denmark and minimized the design. They used a four-finger gripper and solved inverse kinematics of the robotic arm. [8]
Yunhai Wang	2012	"Playing Chess with Robotic Arm"	In this paper, the robotic arm design was initially downloaded and then modified using Solidworks to satisfy requirements of the project. In addition, they used a vacuum gripper. Moreover, forward kinematics theory was used in the paper. [9]
Kaifeng Zhao, Liqiang Bao, Qing Li, Mengxin Cao, Zhiyuan Liu and Guang Li	2010	"Demo: ROX Player - A Xiangqi Playing Robotic System "	In this paper, a UR5 robotic arm and a Kinect sensor were used. The perception of the robotic arm consisted of Board localization, Piece detection and recognition and Hand detection method to let the robotic arm know when its turn is such that if the robotic arm detects a hand, it knows that the human player is making his move and vice versa. The robotic arm was experimented on 20 participants who gave positive feedback such as it being more enjoyable than playing with traditional virtual opponent and negative feedback such as slow manipulation, huge size and occasional imprecise gripping. [10]
Sunandita Sarker	2015	"Wizard Chess: An Autonomous Chess Playing Robot "	In this paper, XY Cartesian table or XY plotter was utilized. They also used Arduino Mega controller and Matlab code to control the robot. [11]
Cynthia Matuszek, Brian Mayton, Roberto Aimi, Marc Peter Deisenroth, Liefeng Bo, Robert Chu, Mike Kung, Louis LeGrand, Joshua R. Smith, Dieter Fox	2011	Gambit: An Autonomous Chess-Playing Robotic System	The paper talks about a robotic system called Gambit that is designed to play board games. The robot starts with an image and then passes it through a series of detectors: Square detector, Piece/background detector, Color detector and finally chess piece classifier. One unique thing about Gambit is that it verbally states every move taken through the match.

F.C.A. Groen, G.A. den Boer, A. van Inge, and R. Stam	1992	A CHESS PLAYING ROBOT: LAB COURSE IN ROBOT SENSOR INTEGRATION	This paper utilized UMI RTX robotic arm and Sony CCD camera. The project was divided into three different modules: Image processing module, Path planner module and Inverse kinematics module.
Mabkhout, A.	2023	COMPUTER VISION-ENABLED CHESS-PLAYING ROBOTIC ARM	A chess playing robotic arm utilizing Computer Vision (CV) techniques and Convolutional Neural Networks (CNN)
Srivatsan, R., Badrinath, S., Aimi, Dr. Lakshmi Sutha, G.	2020	Autonomous chess-playing robotic arm using Raspberry PI	This paper utilized the use of Raspberry Pi throughout in addition to DNN (Deep Neural Networks) and Transfer learning

3. ORIGINALITY:

Our originality comes from:

- Use of Jetson Nano
- Unique Algorithm
- Security Measures

Starting with Jetson Nano, which is a small AI computer that we utilized in our project for computer vision purposes such as detection of chess board and chess pieces, none of the previous work done included the use of Jetson Nano. As for the software algorithm, some of the previous work used hand detection algorithm to tell the robotic arm when its turn is [4][10]. For instance, when it detects the hand of a person, it knows that it should not make a move and vice versa. Another software algorithm implementation done previously was using a button such that when the person presses the button, the robotic arm will know that it is its turn and will make a move accordingly [5]. Yet, in our project, the robotic arm knows when its turn is by constantly analyzing camera frames of the chess board and detecting changes by comparing the current state with the previous state. In addition, another point of originality comes from some security measures we implemented such as giving warning signals to the user in case he makes an illegal move and halting a move if the robotic arm detects a human hand.

4. SCOPE OF THE PROJECT AND EXPERIMENTS/METHODS:

After getting ahold of our idea and making it original, we went on and defined the boundaries of our project and the work packages required to accomplish our project objectives. We divided our project into 7 work packages as follows:

- **WP #1:** Creating a 3D model for the arm and printing it
- **WP #2:** Building the robotic arm to be controlled by motors connected to Arduino

- **WP #3:** Detection of Chessboard
- **WP #4:** Detection and Identification of Chess Pieces
- **WP #5:** Mapping Identified Chess Pieces to FEN Notation
- **WP #6:** Execution of Movements from Stockfish
- **WP #7:** Optimization of the project

The work packages can be divided into three main parts: Hardware, Software, and Integration. The hardware part consists of the first two work packages while the software part consists of the following three work packages (WPs #3, #4, and #5). Finally, the last two work packages are part of the integration part which is the integration of the hardware and software parts.

WP #1: Creating a 3D model for the arm and printing it

The first step is to find a robotic arm design that fits our objective and criteria to print in order to use in our project.

WP #2: Building the robotic arm to be controlled by motors connected to Arduino

After the parts are ready, we will build the robotic arm. After building the robotic arm, we will try to control it manually to play some chess moves.

WP #3: Detection of Chessboard

After finishing the hardware part, we will move on to the Software part and start by detecting the chess board and its squares. We will detect the chess board by applying some Computer Vision techniques such as Canny Edge and Hough Transform.

WP #4: Detection and Identification of Chess Pieces

After detecting the chess board, we move to detecting and identifying the chess pieces. To do that, we will first create a dataset of chess piece pictures and then create an AI model and train it with the dataset created.

WP #5: Mapping Identified Chess Pieces to FEN Notation

After detecting and identifying the chess pieces, the next step is to convert the state detected to FEN Notation which will be fed to Stockfish which will give us the next best move as feedback.

WP #6: Execution of Movements From Stockfish

After getting the next best move from Stockfish, the robotic arm has to execute this move. We will have a library of Arduino commands for each square on the chess board and the robotic arm will execute the move received by referring to the library. This work package is very important as it involves the integration of hardware and software parts, and it will tell whether the project was a success or not.

WP #7: Optimization of the Project

In this work package, we will try to fix any problems with the project implementation and try to reduce errors obtained as much as possible. Finally, we will make the project more appealing to the eye of the user.

Figure 1 below shows the overall process or implementation of the project.

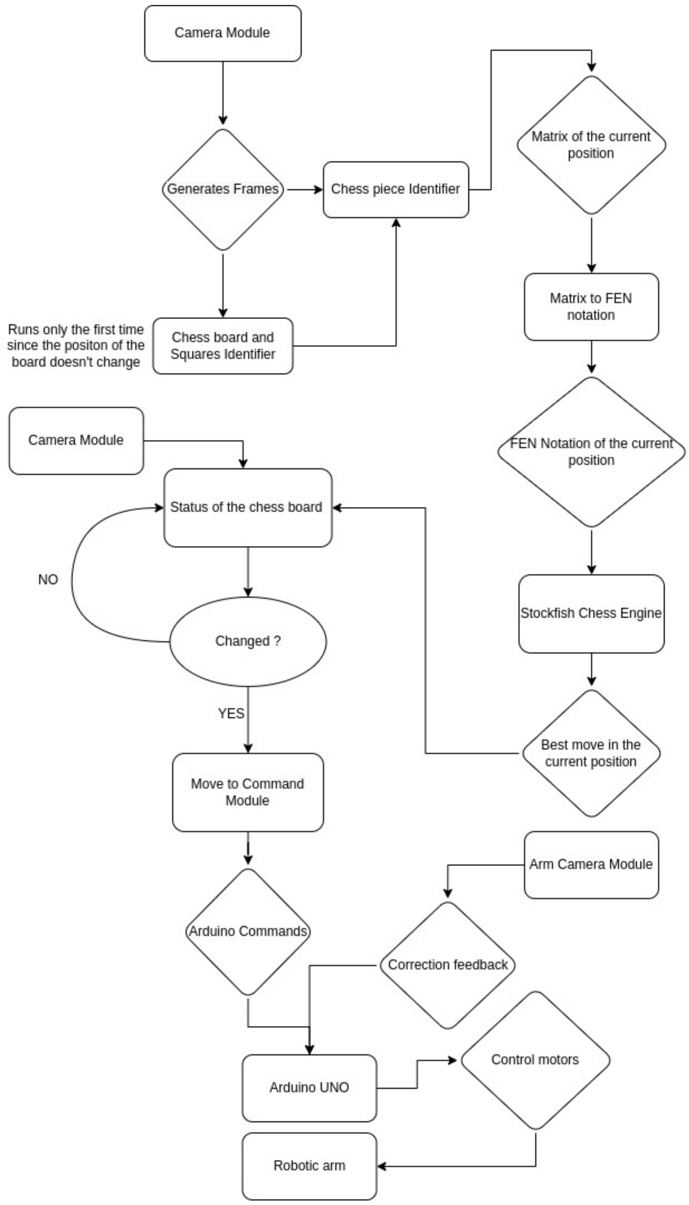

Figure 1: Block diagram of the project

5. **PROJECT TARGETS AND SUCCESS CRITERIA**: There are two main key performance numbers in the project:
   1. Detection accuracy
      a. Detection of chess board
      b. Detection and identification of chess pieces
   2. Movement accuracy
      a. Picking up the correct chess piece
      b. Moving the chess piece to the correct destination

For the detection of the chessboard, we ran the code over 20 times and were able to obtain 100% accuracy with all the squares on the chess board successfully detected each time. For detection and identification of chess pieces, we aimed for at least 97% accuracy with an error tolerance of two chess pieces yet when we ran our model over 10 times, we were able to detect all the chess pieces correctly. On the other hand, for movement accuracy, we aim to pick up the correct piece and move it to the correct destination. However, while trying to do this process, when dropping the chess piece to its destination, it might not be dropped perfectly at the center of the square. Accordingly, we decided that as long as the chess piece lies within the boundaries of the square on the chess board, we will count the move as successful, and we were able to satisfy this condition.

6. **RISKS AND B PLANS:**

Work Package #	**Risk**	**B-Plan**	**Occurred or not? Ways of Overcoming**
WP 1	Problems with printing or building the robotic arm	Use X-Y Plotter instead of robotic arm	No
WP 2	Not being able to control robotic arm as wanted	Use X-Y Plotter instead of robotic arm	No
WP 2	Servo motors not supplying sufficient power for the robotic arm	Try different types of servo motors or use stepper motors	Yes, we changed the motors a couple of times until we settled on the ones we are using now
WP 4	Low accuracy of detection of chess pieces	Try collecting more data for training or using different training architecture	Yes, we painted each chess piece with different colors to make it easier for the model to identify.
WP 6	Gripper not being able to pick up the pieces correctly	Use a different design for the gripper	No

7. WORK TIME PLAN OF THE PROJECT: Figure 2 shows our original plan and detailed schedule for the project. Since we were two people in the project, we decided to divide the work equally upon us. We worked together on the work packages and each one of us had an equal contribution of 50% for each work package. One reason for this is that the work packages are connected to each other, we couldn't move to the other work package unless we finished the current work package. Even though we faced some setbacks such as some of the risks stated above, we were able to finish all the work packages 100% by applying suggested B-Plans above or other practical solutions we found to be useful and help us overcome these risks.

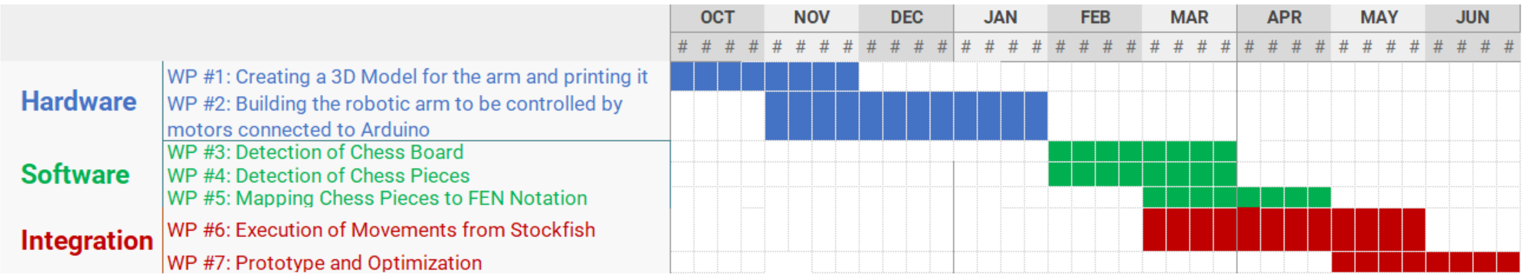

Figure 2: Detailed schedule of the project

8. **DEMO PLAN**: For the demo, we plan to have a candidate human player play a short chess match with our robotic arm. We will bring our project to the class where the presentation will take place in the form of a set and we will play a 5-minute chess match with the robotic arm to show how our project is working properly as wanted.

9. FINANCIAL EVALUATION: The materials required for the project cost us about 9000 TL. We spent 8000 TL on machines/instruments such as Jetson Nano (5000 TL), RaspberryPi camera (50 TL), HD Webcam (2500 TL) and Arduino UNO (450 TL). The other 1000 TL was spent on materials such as 3D printer filaments (700 TL), screws (150 TL) and jumper wires (150 TL). The actual spendings on the project did in fact meet the planned project budget.

10. (PRELIMINARY) RESULTS: In this part, we will present our project journey and step-by-step implementation of the work packages and their results.

<u>WP #1: Creating a 3D model for the arm and printing it</u>

Before starting to work on the project, we had a discussion with our advisor. As a result of our discussion, we decided to work on the Hardware part first and finish it by the end of the Fall semester as it is a very crucial part of the project, and work on the Software and Integration parts in the Spring semester. So, the first step was to find a robotic arm design to print to use in our project. After dedicated and detailed research, we decided to go with the design shown in Figure 1 found on Thingiverse. After deciding on the robotic arm design, the next step was to print the parts.

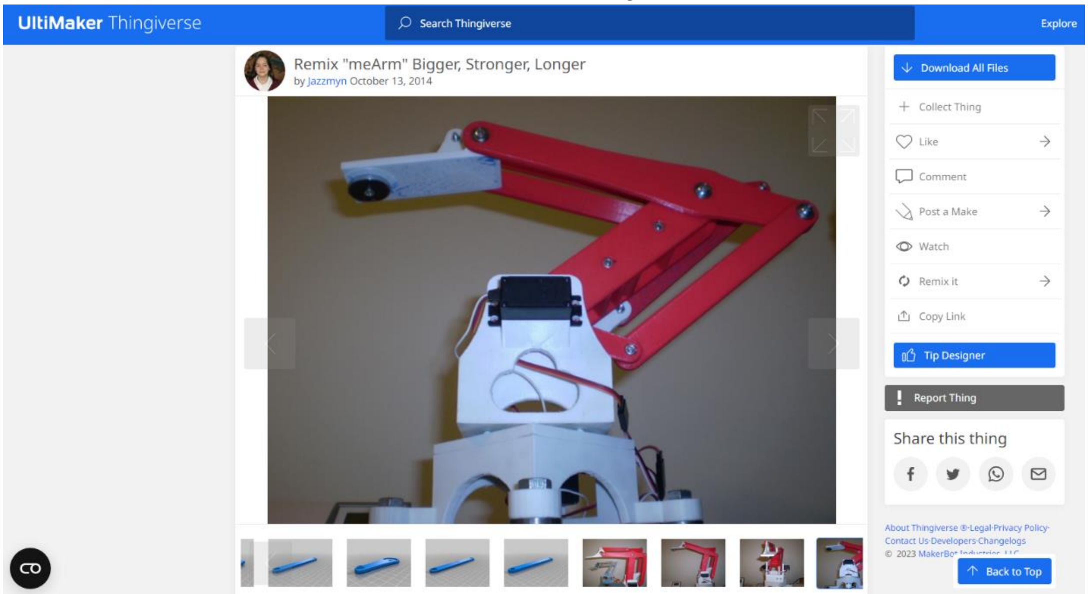

Figure 3: Robotic arm design found on Thingiverse

WP #2: Building the robotic arm to be controlled by motors connected to Arduino

After printing the parts, we built the robotic arm as shown in Figure 2. After we built the robotic arm we tried to grab and move some chess pieces across the chess board manually and we were successful in doing so; we were able to drop the pieces within the square boundaries.

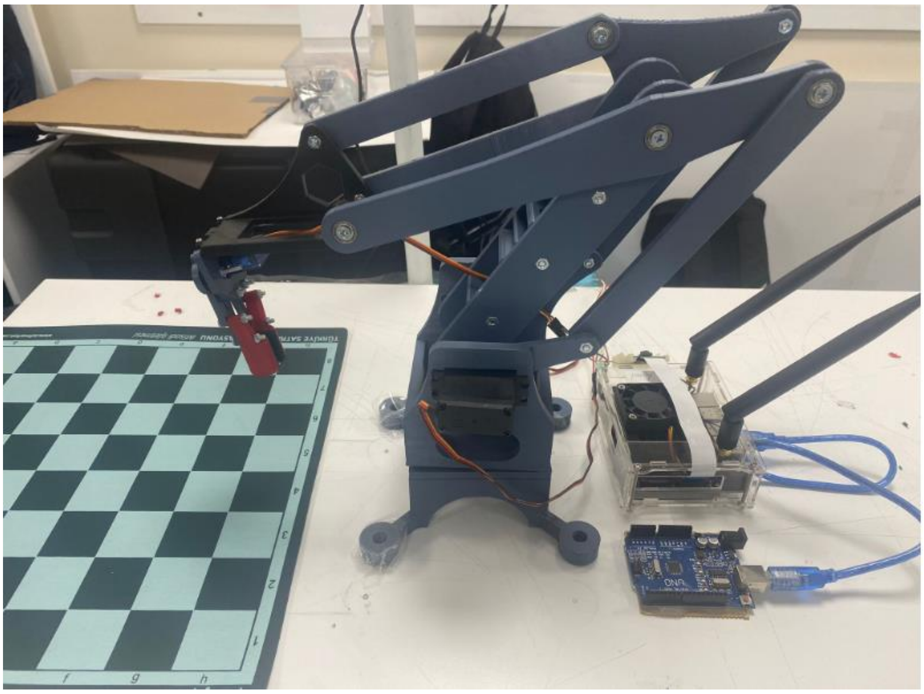

Figure 4: The robotic arm we built

<u>WP #3: Detection of Chessboard</u>

After we ensured that the robotic arm design printed fits our criteria and purpose, we moved on to the Software part of the project. We started with the detection of the chess board and its 64 squares. We ran the code for detecting the chessboard over 20 times and were able to detect the chess board and the squares successfully each time fulfilling our success criteria of 100%. The process of detecting the chess board and its squares is shown in Figure 5.

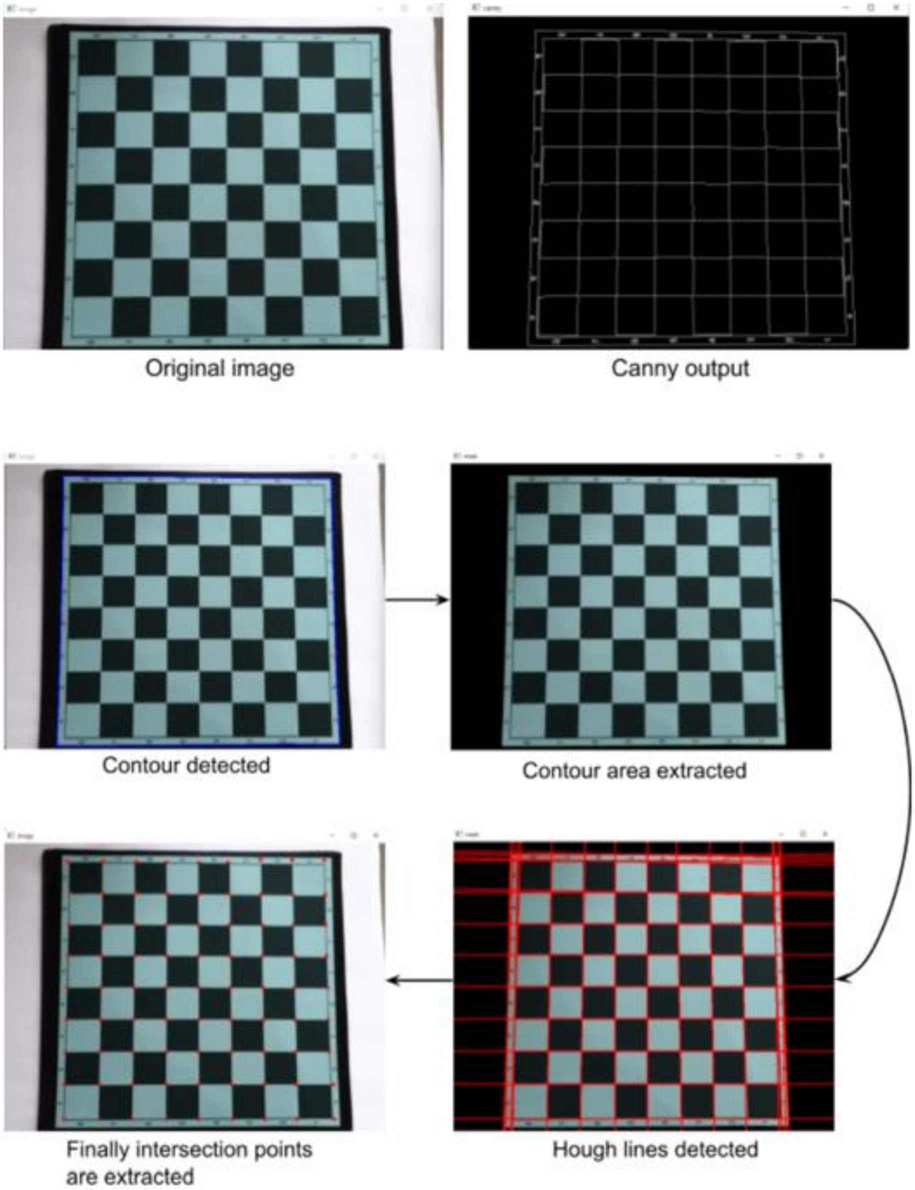

Figure 5: Chess Board Detection Process

WP #4: Detection and Identification of Chess Pieces

After successfully detecting the chess board, we moved on to detecting and identifying the chess pieces on the chess board and squares. To do that, we first created our own dataset of chess pieces to train the AI Model. Our dataset contains 650 pictures with 50 pictures for each class (There is a total of 13 classes). After finishing the dataset, we started working on our AI Model. We went with a VGG16 pre-trained model and obtained a 97% training accuracy. An example of our AI model detection is shown in Figure 6 below.

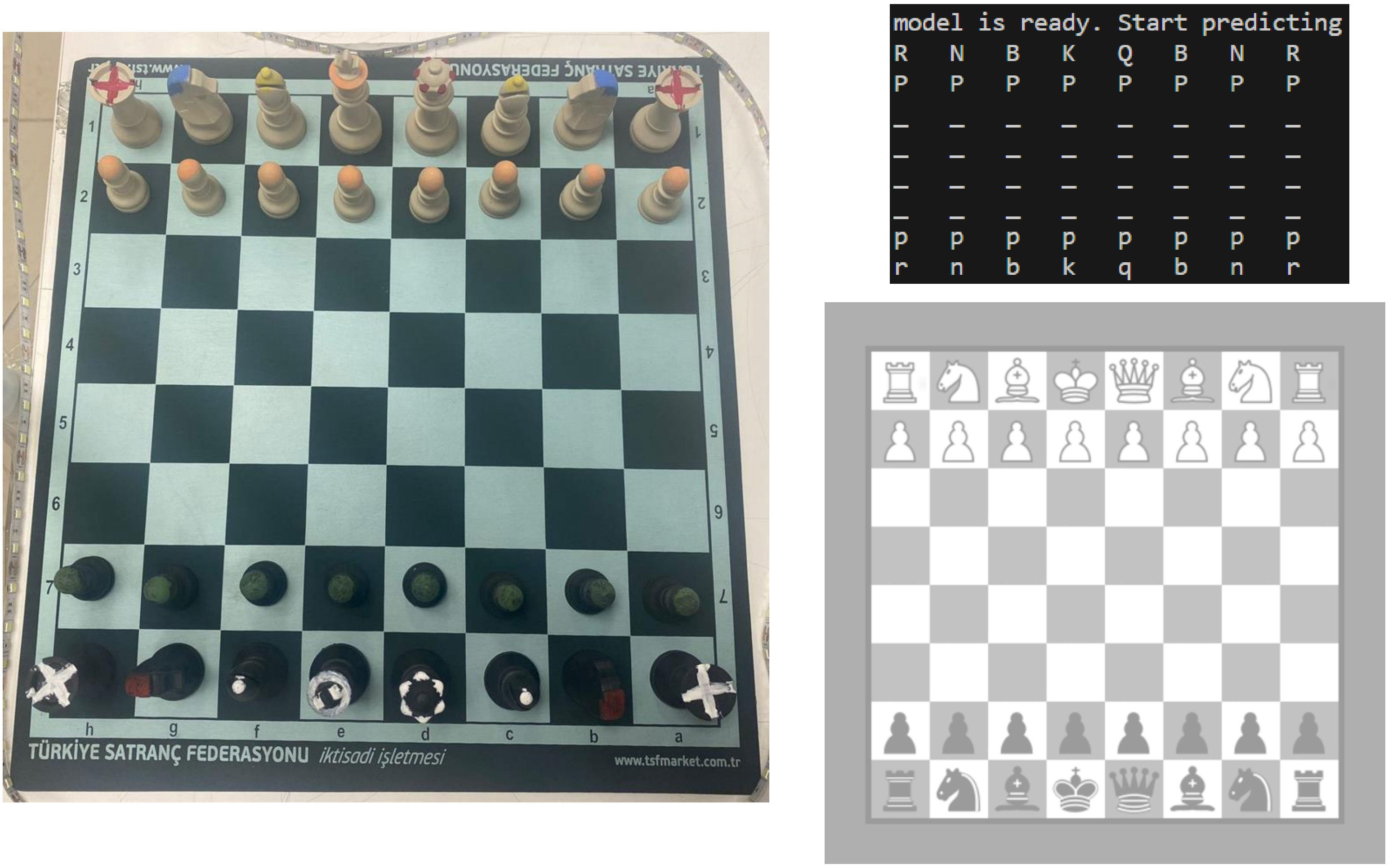

Figure 6: Example of Chess Piece Detection and Identification

WP #5: Mapping Identified Chess Pieces to FEN Notation

After being able to successfully detect and identify the chess pieces, we converted or mapped the state detected to FEN Notation so that we can feed it to the Stockfish engine for it to give us the next best move. FEN Notation is important to obtain the next best move from Stockfish engine.

WP #6: Execution of Movements From Stockfish

After getting the next best move from Stockfish, our robotic arm executes this move. We have Arduino commands for the robotic arm to pick up and drop the chess pieces for each square on the chess board. When the move from Stockfish is obtained, the robotic arm executes the move based on the stored Arduino commands.

WP #7: Optimization of the Project

In this work package, we aimed to fix any problems faced with the integration and execution of movements coming from Stockfish. We tried our best to make sure that the robotic arm functions properly and the objective of the project is accomplished. We made improvements to reduce errors and make the project more user-friendly. For instance, we made the project in the form of a set by fixating the robotic arm on a cardboard piece so that the user will get it and immediately be able to play. In addition, we tried to hide the complexity of the connections by reducing the number of wires used. In other words, we worked on the abstract of our project.

11. DISCUSSION: Going through our 7 work packages, we first printed the robotic arm and built it. Then, we tried playing some chess moves manually and we met the success criteria of dropping the chess pieces within the square boundaries in each move played for this work package. Then, we moved on to the software part where we detected the chessboard and the squares. We achieved the success criteria of 100% as we ran the code over 20 times and detected the chess board successfully in all trials. After that, we created our dataset of chess pieces images to train our AI Model so that it can identify the different chess pieces. The model worked perfectly most of the time with one or two mistakes in some other trials yet keeping us above the minimum requirement of 97% success criteria for the work package. The next package was converting the detected chess pieces to FEN Notation. We compared the chessboard generated by our computer with the real chessboard state or situation. In all the times the chess board state was converted to FEN Notation, we found the model to be always correct thus allowing us to achieve our desired 100% success criteria. Finally, moving on to the integration part where we execute the moves coming from Stockfish chess engine, we were able to carry on some short chess matches with our robotic arm where it was able to perform the received moves and drop the chess pieces within the boundaries of the targeted square.

12. CONCLUSION: In conclusion, we achieved our goals and objectives concerning this project as we were successful in creating our own chess-playing robotic arm that can play short chess matches with human players. We were also able to achieve the success criteria set for each work package. We achieved the desired high accuracy (100% for the detection of the chessboard and > 97% for the identification of chess pieces) in the software part and regarding the hardware part, our robotic arm drops the chess pieces within the square boundaries of the targeted square. Finally, after completing our project, as mentioned before, it can be used in training chess players. In addition, the design of the robotic arm helps in it being used in labs as an equipment organizer. We are happy to have implemented the idea we had in mind in real life regarding the project of a real chess-playing robotic arm.

13. PLAN FOR FUTURE STUDIES: We have successfully finished and finalized the project. It was a worthwhile journey. We plan on making our project codes open source to help other people planning on doing similar projects.

14. **ASSESSMENT OF ENGINEERING COURSES:** Introduction to Computer Vision course, Introduction to Machine Learning course, and Image Processing in Embedded Systems course are the main three courses that have benefited us throughout the project as they contain most of the work done in the project.

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16. PROJECT ACTIVITIES AND WORK PLAN

For this part, we want to see how you distribute the work items into weeks and who in your team will perform these work items. A better plan should distribute work uniformly over the weeks and project team members. Also, make sure you finish some work items during the planning so that you assess if the project is going well or not. The tables after the one below targets this requirement.

Table 1 *The Work-Activity Plan for Project 1*

Work and Activity Project 1	Responsible Group Member	Timeline													
		1. week	2. week	3. week	4. week	5. week	6. week	7. week	8. week	9. week	10. week	11. week	12. week	13. week	14. week
1. Printing the robotic arm	Abdul Rahman Akl - Youssef Darahem														
2. Building the robotic arm	Abdul Rahman Akl - Youssef Darahem														
3. Controlling the robotic arm	Abdul Rahman Akl - Youssef Darahem														

4. Literature review	Abdul Rahman Akl - Youssef Darahem														

Table 2 *The Work-Activity Plan for Project 2*

Work and Activity Project 1	**Responsible Group Member**	**Timeline**													
		1. week	2. week	3. week	4. week	5. week	6. week	7. week	8. week	9. week	10. week	11. week	12. week	13. week	14. week
1. Detecting chess board	Abdul Rahman Akl - Youssef Darahem														
2. Detecting and identifying chess pieces	Abdul Rahman Akl - Youssef Darahem														
3. Mapping chess pieces and state of board to FEN Notation	Abdul Rahman Akl -														

	Youssef Darahem														
4. Executing movements from Stockfish and integrating hardware and software parts	Abdul Rahman Akl - Youssef Darahem														
5. Optimizing the project	Abdul Rahman Akl - Youssef Darahem														
6. Literature review	Abdul Rahman Akl - Youssef Darahem														

16.1 LIST OF WORK PACKAGES

Table 3 *Detailed Definition of Work and Activity*

WP No	Detailed Definition of Work and Activity
1	Creating a 3D model for the arm and printing it
2	Building the robotic arm to be controlled by motors connected to Arduino
3	Detection of chess board and squares
4	Detection and identification of chess pieces
5	Mapping chess pieces to FEN notation
6	Execution of movements from Stockfish chess engine
7	Optimization of the project

Table 4 *Work package targets, their assessment, and the contribution of each work package to the overall project success.*

Work package	Target	Measurable outcome	Contribution to overall success(%)
WP1	A real robotic arm that can be seen and touched.	100%	10%
WP2	Run some Arduino code and check if the motors move the robotic arm as wanted.	100% (drops piece within square boundaries)	15%
WP3	Obtained result of chess board and squares matches exactly with the real chess board.	100%	10%
WP4	Obtained matrix of chess pieces matches exactly with chess pieces on real chess board.	97%	10%
WP5	FEN notation reflects current state of the chess board.	97%	10%
WP6	Robotic arm moving correct chess piece to the correct destination.	100% (drops piece within square boundaries)	25%
WP7	Project works as it should with minimal error	100% (drops piece within square boundaries)	20%

Table 5 *The work package distribution to project team members: Who works on which work package? Specify the percentage contributions.*

WORK PACKAGE DISTRIBUTION							
Project Member	WP1	WP2	WP3	WP4	WP5	WP6	WP7
Abdul Rahman Akl	50%	50%	50%	50%	50%	50%	50%
Youssef Darahem	50%	50%	50%	50%	50%	50%	50%
Total	100%	100%	100%	100%	100%	100%	100%

17. BUDGET

Table 6 *Proposed Budget in TL*

	ITEMS				
	PEOPLE	MACHINE-INSTRUMENT	MATERIALS	SERVICE	TRAVEL
IMU FUND	-	2000	1000	-	-
SPONSOR COMPANY FUND	-	6000	-	-	-
TOTAL	-	8000	1000	-	-

Table 7 *Actual Budget in TL (what you spent indeed)*

	ITEMS				
	PEOPLE	MACHINE-INSTRUMENT	MATERIALS	SERVICE	TRAVEL
IMU FUND	-	2000	1000	-	-
SPONSOR COMPANY FUND	-	6000	-	-	-
TOTAL	-	8000	1000	-	-

*Provide proforma invoice for machines and materials to be purchased.
*Provide technical specifications for machines and services to be purchased.
*Make a contract for services if necessary

18. SUPPORT LETTERS (if any)

TÜBİTAK

Sayı : B.14.2.TBT.0.06.01.00-221-249164 19/04/2023

Konu : "2209-A Üniversite Öğrencileri Araştırma Projeleri Destekleme Programı 2022 Yılı 2. Dönem Başvurunuz"

İLGİLİ MAKAMA,

TÜBİTAK Bilim İnsanı Destek Programları Başkanlığı (BİDEB) tarafından yürütülen, 2209-A Üniversite Öğrencileri Araştırma Projeleri Destekleme Programı 2022 yılı 2. dönem kapsamında 1919B012220370 numaralı başvuru destek almaya hak kazanmıştır. "Objeleri Tespit Eden, Tanıyan ve Taşıyan Akıllı Robot Kol" başlıklı projede yer alan kişilere dair bilgiler aşağıda sunulmaktadır.

İsim Soyisim	Projedeki Görevi
YOUSSEF IBRAHIM MOHAMED DARAHEM	Yürütücü
BAHADIR KÜRŞAT GÜNTÜRK	Akademik Danışman
ABDULRAHMAN Z. M. AKL	Proje Ortağı

Bilgilerinizi rica ederim.

Prof. Dr. Ömer Faruk URSAVAŞ
Bilim İnsanı Destek Programları Başkanı