

# Implementation of Autonomous Robotic Arm for Nerenchi Board Game

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**Abstract:** Sri Lankan board games have a special place in Sri Lankan traditions. Peralikatuma, Olinda Keliya and nerenchi are some examples for these board games. Among these games, nerenchi is one of the oldest board games and it is even mentioned in Sri Lankan ancient textbooks. Nerenchi is a board game that can play up to two players. Playing board games like nerenchi helps us to improve our soft and tactical skills. With the improvement of social media and video games, the new generation is distanced from these games. Because of this, old folk games like nerenchi are on the brink of extinction. It is urgent to use new technologies to attract the young generation to these games. A web-based game that can play nerenchi game up to 2 players is introduced to overcome this issue. UI/UX of that web-based game is not up to date because of that it is difficult to attract the new generation. This paper discusses a robotic solution to automate the nerenchi board game. The proposed system consists of two main parts. They are smart nerenchi board and robotic arm. Smart nerenchi board consists of 24 IR sensors which are used to detect the nerenchi pieces on the board and are powered by Arduino mega board. A fully 3D-printed 5 DOF robotic arm was used for this system. Arduino Mega board is also used in the robotic arm to control the function of the servo motors. The proposed system is going to be tested in laboratory conditions and compared with the detection accuracy using the image processing approach.

**Keywords:** Nerenchi, Robotic arm, Sensors

## 1. Introduction

Sri Lanka is one of the very few countries that has a very vast and rich cultural diversity. The traditional culture of Sri Lanka is very unique and therefore contributes to the Sri Lankan identity. This culture contains many types of customs and rituals, which date to more than twenty-five centuries and were handed down from generation to generation. Furthermore, Sri Lanka is enriched with rich artistic tradition, with distinct creative forms such as rituals, visual arts, folk games, and folk music and dance (Meththananda and Hettige, 2015).

Folk games of Sri Lanka take a special place in Sri Lankan culture and are unique to the country. Most of

these traditional games connect with people's life during the Sinhala and Tamil new year season. Not only that but also, these games have a rich history of more than two thousand years and some of the historical writings such as Mahawanshaya and Thupawanshaya provide evidence (Meththananda and Hettige, 2015). Furthermore, these games can be played both indoors and outdoors. Gal kireema, Neranchi, Pancha dameema, Olinda keliya (Muthu keliya), Wala kaju gaseema, Lunu paneema, Onchili padima, Porapol gaseema are some of the popular examples for Sri Lankan folk games. Among these games, Nerenchi and pancha dameema are indoor games while Olinda keliya (Muthu keliya), Wala kaju gaseema, Lunu paneema, Onchili padima, Porapol gaseema are outdoor games. These games are designed in a simple way that all generations could enjoy together. In addition, the equipment that are used to play these games are mainly made from natural materials such as fruit seeds or wood.

Board games are indoor games that are very popular around the world. Playing board games helps us to spend our leisure time in a more meaningful way. Playing these games especially helps children to develop their soft skills like creativity, adaptability, leadership, teamwork, strategies and tactics, and communication skills. Chess, Monopoly, checkers, and Go are some examples of popular board games.

Sri Lankan folk games also have consisted of unique board games. Pancha keliya, Olinda keliya, and nerenchi are examples of these games. Among them, nerenchi is one of the oldest Sri Lankan board games. Nerenchi is even played in the Anuradhapura kingdom time. Nerenchi can play up to two players. Nerenchi is a highly competitive strategic game. Nerenchi's game design is similar to Nine Men's Morris.

Although these traditional games are popular among the old generation, with the improvement of technologies like social media and video games the younger generation is distanced from these traditional games. Board games like nerenchi build the thinking and learning abilities of children. And these games are designed to relax our minds. But on the other hand, video games only teach violence and impatience. Addiction to social media and video games

leads to mental health issues among school children in Sri Lanka. Depression is one of the main mental health problem common among school children(van den Broek *et al.*, 2021). The main cause for this issue is that the new generation is distanced from our cultural and traditional values. Nowadays board games like nerenchi have a threat of going extinct.

To overcome this issue various web-based video games have been designed. Because of the poor UI/UX and game design, those systems failed to attract new generations to the platform. It's urgent to involve new technological aspects to solve this problem.

Robotics and automation is one of the trending area in the field of computing. Nowadays Robotics and automation have been used in every field. The robotic arm is one of the key aspects of robotics. The robotic arm is a mechanical component that is built to simplify a set of tasks that needs high accuracy. Robots are used in both domestic and industrial environments. Robots can perform tasks in intensive environments where humans couldn't work.

This paper going to discuss the design and implementation of the robotic arm to automate the nerenchi board game. This system uses IR sensor-based technology to detect nerenchi pieces in the nerenchi board. Arduino mega with three multiplexers used in smart nrenchi board to control the functions of the smart nrenchi board. Three MG996R Servo motors and Three SG90 Micro Servo motors are used in the robotic arm. And Adafruit 16-Channel 12-bit PWM/Servo Driver is used to control all the motors in the system. Arduino mega is used in the robotic arm also to control the motion of the robotic arm. After detection, the robotic arm pickup nerenchi pieces and moves them on the board according to the nerenchi rules. This system can use to attract a new generation to these old Sri Lanka folk games. Also, this system can be used in hotels and restaurants to promote Sri Lankan cultures and traditions among tourists around the world.

The paper is structured as follows. Section 2 describes the overview of nerenchi game. Section 3 describes related works and technologies. Section 4 presents the system design. section 5 describes the results and evaluations of the system. section 6 of the paper presents the conclusion and the further work of the project.

### I. Overview of The Nerenchi Game

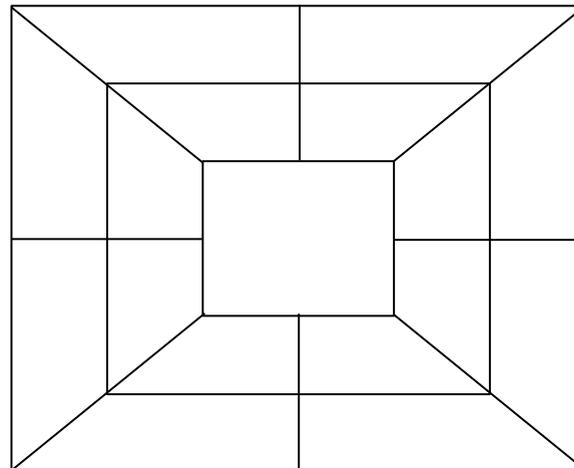


Figure 1. Nerenchi Board

Nerenchi is a two-player strategic game. Nerenchi board was designed with diagonal lines joining the corners of the squares as shown in Figure 1. Wood is mainly used to build nerenchi board. Nerenchi board design is a bit similar to the Mill and nine Morris game. When playing Nerenchi it has two main phases: placing nerenchi pieces and moving nerenchi pieces. A brief description of each phase is given below.

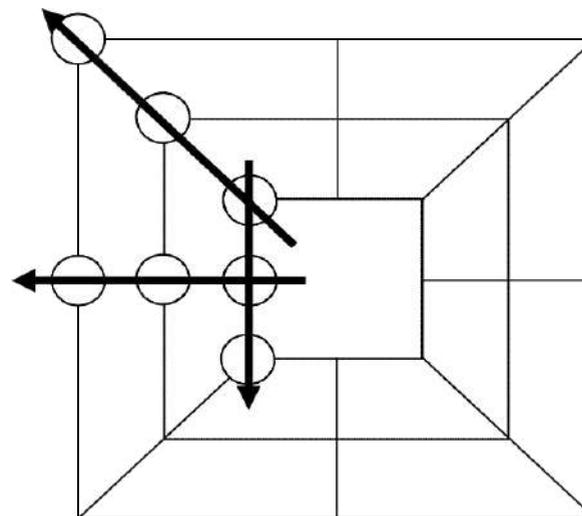


Figure 2. Placing Nerenchi Pieces

#### A. Placing Nerenchi Piece

In the first phase of the game, players have to place nerenchi pieces on the board. Players need to place 22 nerenchi pieces on the board with the 12 pieces that each player has. If one player successfully placed three nerenchi pieces on a straight line horizontally, vertically, or diagonally, that player will get a bonus called "Nerenchi". This phase continues until the nerenchi pieces on the board reach 22 or one player places all 12 nerenchi

pieces on the board. After that second phase of the game started.

### B. Moving Nerenchi Pieces

After placing nerenchi piece on the board, In the next phase players are allowed move nerenchi pieces on the board vertically or horizontally along the line to an adjacent joint but not diagonally. In this phase, players allow capturing other players' nerenchi pieces. The player is allowed to capture nerenchi piece of another player if that player gets a “Nerenchi” reward.

In This phase, it decides the winner of the game. To win the game a player must capture all nerenchi pieces of the opponent or block all the possible moves of the opponent.

## 2. Related Works

This section of the paper discusses the technologies and concepts that are related to this project.

(Bandaranaike and Hettige, 2021) developed a CNC model to automate the “Nerenchi” board game. In this project, they used IR sensors to detect nerenchi pieces. A 24-bit array has been used to store the position of the object on the board. It generates a new 24-bit array when a new object is placed on the board. Then that array is sent back to the system and the system uses the CNC model to place the object in the relevant position. In this project, they used Arduino mega as their main microcontroller.

(Meththananda and Hettige, 2015) implemented a computational model for “Nerenchi” game by using 2 matrices. One matrix for controlling the user errors and another matrix for set rules. They developed this system as a web-based application using the .NET framework and MySQL. They developed human-human mode and human-computer as their main two-game mode. They used the PROLOG engine for human-computer mode.

(Goonatilleke and Hettige, 2021) in this research they implemented a robotic arm to automate traditional drums in Sri Lanka. Sri Lankan drums are one of the key components of Sri Lankan tradition. This system consists of six main modules. They are the power module, processing module, solenoid control module, servomotor controller module, input module, and display module. In this system, they used two robotic arms.

(Shuang *et al.*, 2017) developed a robot that can play a chess board game. They developed the game engine for the system using C language and LabVIEW. In this system, they used image processing technologies to

recognize chess pieces. They used STM32 to image processing technologies and Arduino for the mechanical part of the system. Image processing errors and positioning inaccurate are the main downsides of this system.

(Srivatsan, Badrinath and Lakshmi Sutha, 2020) developed a robotic arm using raspberry pi to automate chess board game. OpenCV library is used for image processing and canny edge detection is used as the main image processing technique. A 4-DOF robotic arm is used for this system. In this system, TensorFlow deep learning framework has been used with image processing technologies to identify the chess objects on the board.

(del Toro, Robles-Algarín and Rodríguez-Álvarez, 2019) designed a 4-DOF robotic arm for automating chess games. Solid work was used to design the robotic arm. convolutional neural networks are used for the detection of the chess pieces on the board. Kanade–Lucas–Tomasi method is used in this system for image processing. Stockfish open-source game engine used in this system. Arduino is used as the main microcontroller to control the robotic arm.

(Kopets *et al.*, 2020) developed a robotic system to automate the Russian checker’s game. An unsupervised learning algorithm called Alpha Zero was used to develop the game engine of the project. In this project, they used a magnetic sensor-based system to identify the checker pieces instead of using image processing. The accuracy of recognizing objects on the board is higher in this system than in the systems that use image processing techniques.

(Chen *et al.*, 2020) developed a robotic system to automate Chinese chess. In this system, they used a 5-DOF robotic arm, and forward and inverse kinematics are used to control the robotic arm. MATLAB is used for image recognition. convolutional neural networks (CNNs) are used for the recognition of chess pieces.

(Al-Saedi and Mohammed, 2015) developed a 5-DOF robotic arm to automate the chess board game. “SharpChess” open-source game engine that is used for this system. The downside of this project is that robot manipulator accuracy decreases over time.

## 3. System Design

The main components used in the implementation of this project are:

- Arduino Mega

Two Arduino Mega boards are used in this system. One Arduino Mega is used for the smart nerenchi board to control the function of the IR sensors and multiplexers.

And one Arduino Mega board to control the servo motors of the robotic arm.

- IR sensors

In this system, 24 IR sensors are used to detect the nerenchi pieces on the nerenchi board.

- Adafruit PWM/Servo Driver

In this system, we used Adafruit 16-Channel 12-bit PWM/Servo Driver to control the Three MG996R Servo motors and Three SG90 Micro Servo motors used in the robotic arm.

- CD4052B Multiplexer

All the data which are taken from the IR sensors are sent to this IC and it multiplies the data inputs.

#### A. Smart nerenchi Board

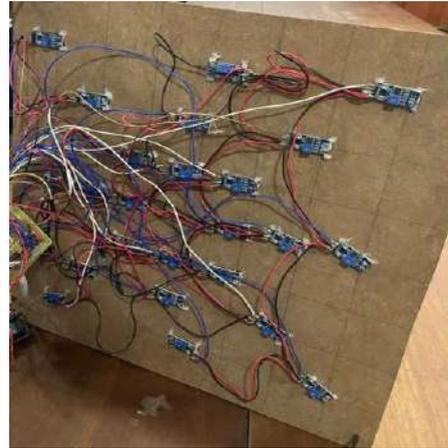


Figure 4. Smart nerenchi board

The smart nerenchi board was developed using 24 IR sensors and with three CD4052B Multiplexers. 24 IR sensors are used in nerenchi places on the nerenchi board for the detection of the nerenchi pieces when they are placed on the nerenchi board. The data taken from IR sensors are sent to the Multiplexers. The multiplexers are used in this system to multiply the output of the IR sensors. Here multiplexers give relevant feedback through 8 channels. Nerenchi board consists of two layers. one layer to hold nerenchi pieces and the other layer to attach the 24 IR sensors.

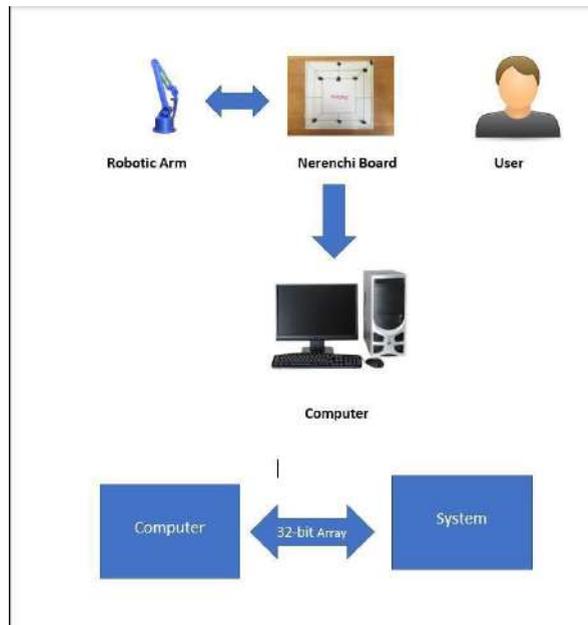


Figure 3. System overview

This system has two main parts.

1. Smart nerenchi board
2. Robotic arm

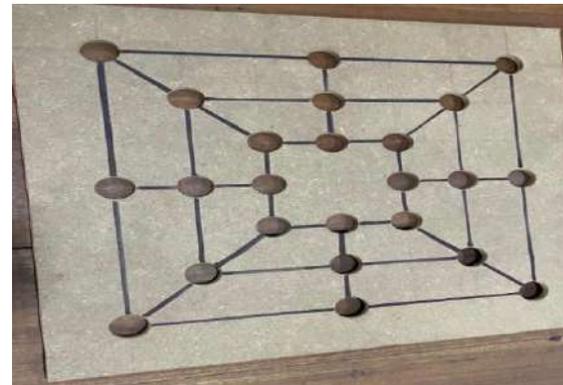


Figure 5. Layer 1



Figure 6. Layer 2

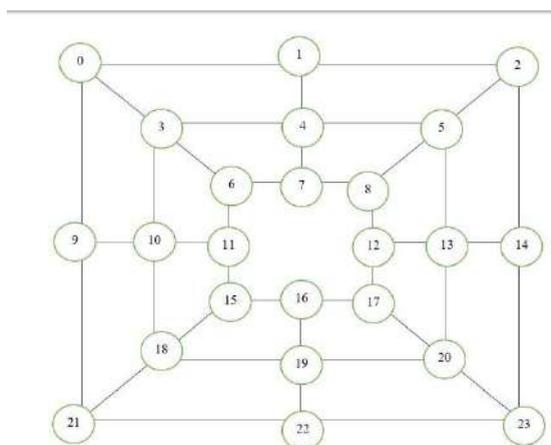


Figure 7. Smart Nerenchi board array Design

As shown in figure 7 nerenchi places on the nerenchi board are numbered and taken as a location array. This array changes according to the way nerenchi pieces are placed on those nerenchi places on nerenchi board. If there is no nerenchi object detected by the IR sensors, then the array value is 0. for example, when no objects are on the board the location matrix is;

Location matrix: [0 0]

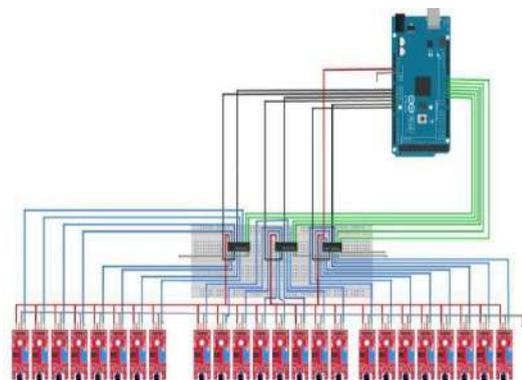


Figure 8 . Circuit diagram Of Nerenchi Board

#### B. Robotic Arm



Figure 9. Robotic Arm

A fully 3D printed 5 DOF robotic arm is used in this system. Three MG996R Servo motors have been used for the waist, shoulder, and elbow of the robotic arm. Three SG90 Micro Servo motors have been used for wrist roll, wrist pitch, and gripper of the robotic arm. Adafruit 16-Channel 12-bit PWM/Servo Driver is used to control all the motors in the system. The robotic arm is powered by an Arduino Mega board which is used to control the motions of the robotic arm. In this system, Inverse kinematics is used to determine and calculate all the possible sets of joint angles that could be used to attain this given position and orientation.

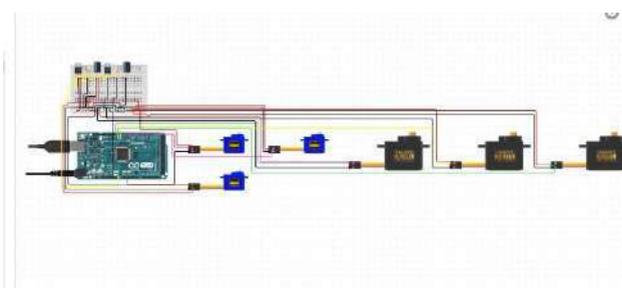


Figure 10. Circuit diagram of the robotic arm

#### 4. System in Action

When the IR sensors on the board detect a nerenchi piece on the board the data collected by IR sensors are sent to the computer. Then it generates a 24-bit array according to the position of the nerenchi piece. Then the computer process and generates a new 24-bit array with a new location and sent back to the system and then the robotic arm moves the nerenchi pieces according to that array. The robotic arm can perform 3 tasks according to the array.

- Move a new nerenchi piece onto the board
- Remove an existing nerenchi piece from the board
- Replace an existing nerenchi piece with another nerenchi piece

Here, the Inverse Kinematic algorithm is used for the movement of the robotic arm.

## 5. Conclusion and Further Work

With the improvement in technology, Sri Lankan traditional games are on the verge of existence. Especially the traditional board games like Nerenchi. Playing these board games helps us to develop our creativity, adaptability, leadership, teamwork, strategies and tactics, and communication skills. Addiction to social media and video games ruins much of young life. It's urgent to bring old folk games back to life. By using technology, we can bring back our generation towards these old folk games.

this proposed system, it uses IR sensors instead of image processing techniques to identify the objects. Arduino-powered 5 DOF robotic arm is used in this system to move the objects on the game board.

For Further work need to add AI algorithms to the system so that it can apply more advanced game tactics when playing with a human. The testing of the system going to do in laboratory conditions and the result will compare the detection accuracy with the image processing approach.

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