Autonomous Connect Four
"AutoCon4"

Functional Requirements List and Performance Specifications

Wayne Bogart   Justin Middleton

Advisor: Dr. James Irwin
Co-Advisor: Nick Schmidt

November 8, 2006

Introduction

Connect Four has been marketed by companies such as Milton Bradley for many years now. When in truth it can actually be traced all the way back to Captain James Cook and his voyages, where he and his subordinates would play quite often. The captain played so often that his crew gave it the name "Captains Mistress"

This project will take a Connect 4 board game and automate the game play. Two different phases of game play will be available; Person vs. Computer, and Computer vs. Computer. Computer refers to the use of the EMAC development board and its 80C535 microcontroller. Goals for the project are to be able to fully automate every aspect of the game, from resetting the game to placing the pieces and all the way to actually playing the game without human interaction.

Overall System

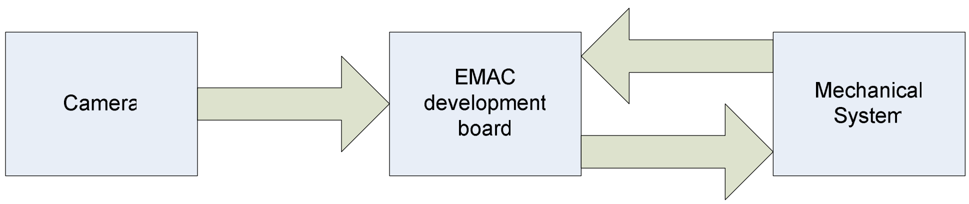

Figure 1
High-level System Block Diagram

The EMAC development board will handle all the processing and decision making of the system. The mechanical system and a camera will be the inputs to the EMAC. The EMAC will also send output signals to the mechanical system. Software will be written to handle all inputs and outputs. Figure 1 shows a basic block diagram of the overall system.

There are three subsystems; each subsystem can be developed independently. While each subsystem can be developed independently, each system gathers information that the other systems will use. The three main subsystems are:

- Image processing
- Game play algorithms
- Mechanical system

Image Processing

Image processing will be used to determine the status of the Connect4 board. A black and white camera will be used and from this gray scale voltage levels will be identified by the EMAC, which will then distinguish between three different colors. Black, red, and white are the colors that need to be sensed. Red and black need to be detected since they are the two colors of the game pieces used. White will represent an empty space on the game board. Figure 2 shows the high level flowchart for the image processing.

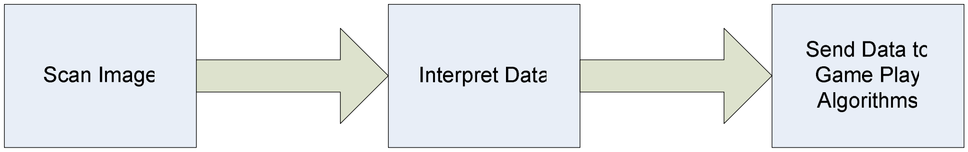

Figure 2
Image Processing Flow Chart

Game Play Algorithms

Once the status of the board is known, game play algorithms will determine where to place the next piece. Algorithms will be used to control the offense and defense of a computer player. The algorithms will be comprised of a set of rules, from which decisions for game piece placement will be made. Figure 3 shows the block diagram of the algorithm process.

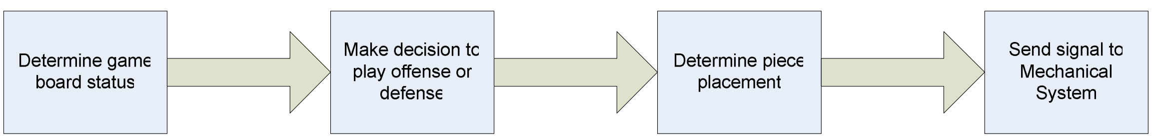

Figure 3
Block Diagram of Game Play **Algorithm**

Mechanical System

The mechanical system will then place the next game piece based on the output of the algorithms. The mechanical system controls all physical movements for the computers turn. A hopper will be placed beneath the game board. Its function is to collect the game pieces from previous games and get them ready to be used in future games. Once in the hopper, the game pieces will be funneled into a track, which will raise the pieces to the top of the game board. When it is time for a game piece to be played, it will be released and the corresponding slot above the game board will be opened so the piece will be directed to its desired position.

An optical switch will be used to determine the color of the piece that is next in line to be played. If the piece that is ready to be played is not the correct color needed to be played, it will be rejected. The switch to be used will be a mini-micro switch. Figure 4 shows the block diagram for the mechanical system.

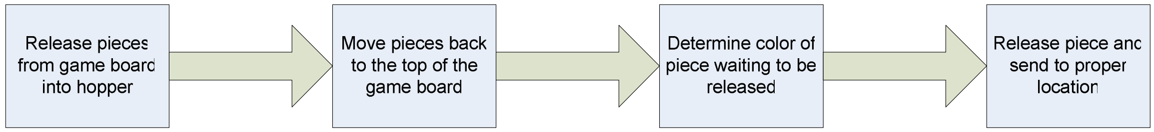

Figure 4
Block Diagram for Mechanical System

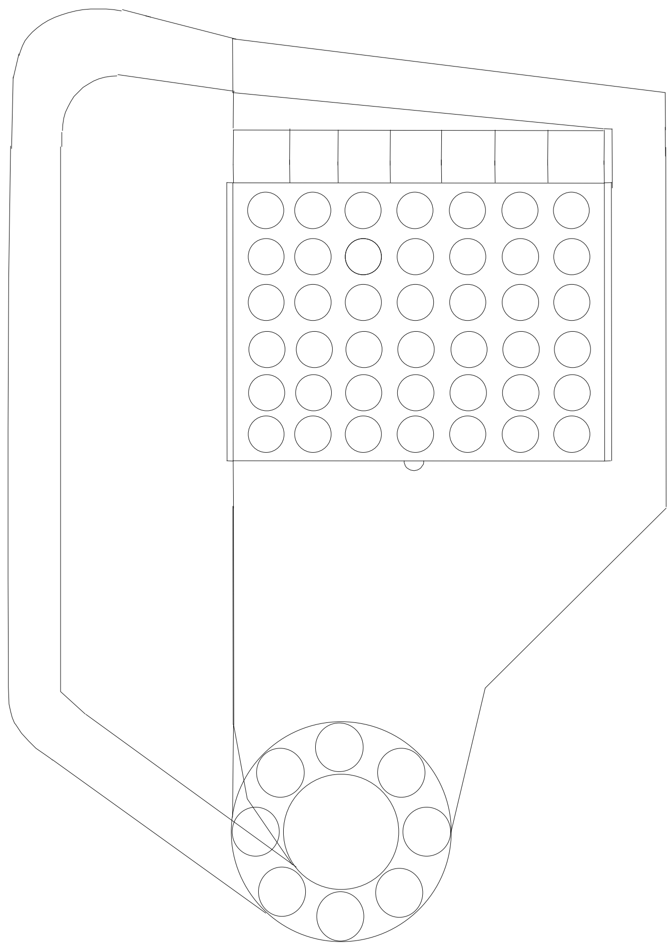

Figure 5
Turbo CAD drawing for front view of Mechanical System

The System catches the chips that fall from the Connect4 game board. The dial then pushes the chips through the track up to the top of the system. Shown in Figure 6 is the method for dropping the chips into the desired column.

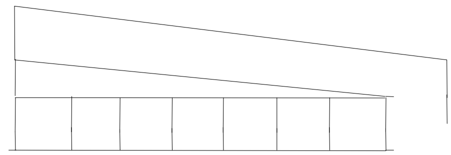

Figure 6
Column selection track

Once a chip is released the track, shown in Figure 6, controls whether the chip is passed into a specific column or is rejected. When a chip is chosen to fall into a specified column then that column will open a door and the chip will fall into its place. When no doors open, then the chip drops into the reject column.

Functional Requirements

Image processing only occurs once per round. The board will be scanned three times to ensure that the color seen is actually that specific color. Scans will be conducted after the player has taken their turn. Determining where the chips are on the board shall not exceed 1 second, with an accuracy of 100% on determining chip placement. If the accuracy falls below 100%, then the calibration program is needed. To meet the timing requirements of the A/D of the microcontroller, image processing will sample the chip positions in columns. Following this pattern (x, y) where x is the row and y is the column. X will increase (1-6) then increment Y; then x will increment (1-6) then increment Y again.

Game play algorithms will take the data recorded from image processing and from the chip positions that are recorded will decide where to place the computers chip. Deciding the placement will take no longer than .5 seconds. This brings the total lag behind deciding where to place a chip to 1.5 seconds max.

The mechanical system must be broken up into subsections to fully explain: column selection track, hopper, and the feeding track.

Column selection track is the most complex of the three subsections. Utilizing solenoids a trap door will be opened to drop the chip into a column specified by the microcontroller. This will be done just before the feeding track releases a chip. The column selection track has 8 columns to choose from. Seven are controlled by the solenoids and the last one is a reject track which is always open.

The hopper is where all the chips sit and wait to be used. At the base of the hopper is a motor with a spinning plate that grabs the chips and pushes them into the feeding track. The motor only moves when current is supplied to it, controlled by the microcontroller. When the motor spins it only spins enough to push one chip into the feeding track. This controls when a chip is being released from the track into the column selection track.

The feeding track is the most basic of the three. Literally, a track that just holds the chips in place so that they are ready to be dispersed when needed. Mounted to the track are two sensors. One is a photo sensor, which allows us to detect what color is about to be dispensed. The other sensor is attached to the spring loaded catch. Its job is to hold the chip inside the track until another chip is pushed up into the track. When the catch is drawn back because a chip is being pushed through it, it trips a sensor that indicates to the microcontroller that a chip has been released.