

**The Design and Implementation of an  
Automated Dartboard**

**6.111 Final Project Proposal**

**Submitted By:**

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## INTRODUCTION

Darts is traditionally a game that does not involve electronics. All you need is a board and a set of darts to play, and scoring is most often performed by hand. For this reason we have chosen to fully automate a dartboard, providing a no hassle approach to enjoying the darts. On a high level, our dartboard will be able to tell where darts have been thrown by a player and subsequently keep score according to the rules of the two player game 301.

Before describing the functionality of the dartboard, we must first understand the rules of 301. 301 is a simple and common dart game played between two people. After each player throws three darts, the sum of their points scored is subtracted from the number 301. The first player to reach zero wins. Figure 1 below displays a dartboard so that you can see how scoring is calculated. Each triangle wedge is worth the number of points listed on the outside. The outer ring is worth double that number of points, and the middle ring is worth triple the number of points. Last but not least, the inner ring otherwise known as the bullseye is worth 25 or 50 points depending on whether your dart lands in the green inner circle or the red inner circle. There are two additional rules that are important to the game of 301. Before a player can begin subtracting points from 301, he must “double in”, and this means he must throw a dart in the outer ring of the board which counts as double the score for whatever number wedge the dart lands in. Also, the player must “double out” reaching exactly zero to end the game. For example, if player one is down to 10, he must hit a double 5 to win. A double 5 is pointed to by the red arrow in the dartboard illustration. If he hits a single 15 or any number greater than 10 instead, it is called a “bust” and he must wait until his next turn to throw again. However, if the player scores a combined 6 between his three darts that will be subtracted from his score and the player will be required to hit a double 2 on his next turn to win. The functionality of double in and double out may or may not be included in the game depending on the resolution that we can achieve in detecting darts.



**Figure 1: Dartboard.**  
(Arrow points to double 5)

## DART DETECTION

With this game in mind, there are two main components to our dartboard, dart detection, and a graphical game interface. First, in order to detect dart location we will attempt to perform acoustic triangulation. Using this method, we will place three or four microphones around the board. When a dart is thrown the relative amount of time it takes the sound of impact to reach the microphones will indicate the darts position using triangulation. More specifically, when the microphone closest to the dart detects impact, we will count the clock cycles until the other microphones hear the dart impact. This difference between times allows us to convert clock cycles into a distance from the center using the speed of sound, and the frequency of the clock. In order for the computer to

learn when it should start listening, the user will press a button to indicate the beginning and end of each turn.

## USER INTERFACE

Once we have the x and y coordinates of the darts for a given players turn, our system illustrates the progress of the game on a video display. The display will contain an image of a dartboard, with player 1's score to the left and player 2's score to the right. As darts are thrown, their calculated location will be drawn on the board. In order to do this, there will be a conversion from coordinates detected by the microphone to screen coordinates, depending on the screen size and the placement of the microphones around the board. The details of the graphical user interface and dart detection implementation are described in more detail below in our block diagram.

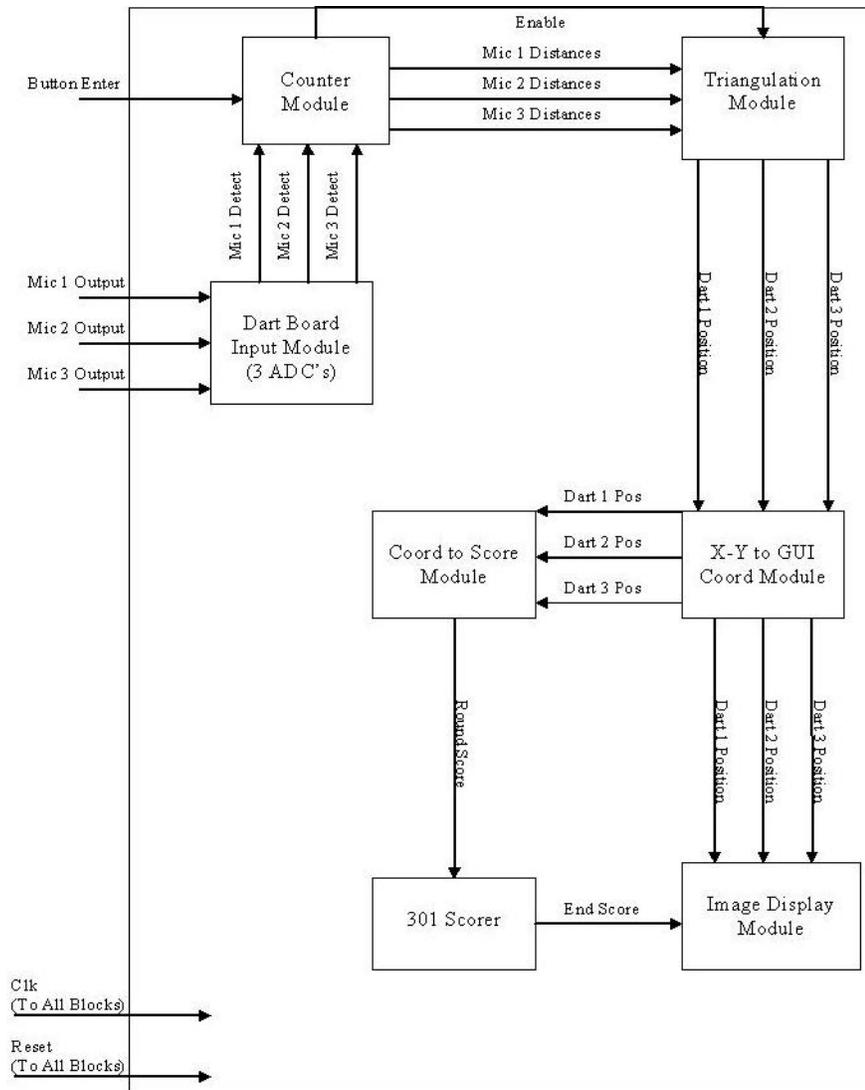


Figure 2: Block Diagram For Dartboard Design

## **BLOCK DIAGRAM DESCRIPTION**

Our design consists of seven major modules. The first step in detecting dart impact points is taking reading from the three microphones and inputting them to the Dart Board Input Module. This module basically interacts with the microphones to detect when each sensor detects the impact. The outputs of this module are fed directly into the Counter Module.

The purpose of the Counter Module is to record differences in detection time between the three microphones. When a dart is thrown and impacts the board, one of the three microphones will detect the sound of impact first, triggering the count to be started to record the time between the detection by the first microphone and the detection by the second microphone. Once the second microphone detects the impact the first count is stopped and another is started and incremented until the last microphone is detects the sound of impact. It is possible to calculate the distance away from each microphone the impact occurs using the difference in detection time and the speed of sound. This process is repeated three times, outputting the distances for each dart to the Triangulation Module. The enable signal is not asserted until the counter module has valid values for the distances from each microphone for all three darts.

The Triangulation Module does the grunt of the math involved in calculating the x-y coordinates for each dart impact based on the distances from each microphone. It is very important that a single coordinate system, most likely with an origin at the bull's-eye, is chosen and all outputted positions are given relative to this system. Once the positions are calculated they must be converted to coordinates useful for the GUI to display.

The Coordinate Conversion Module takes coordinates based on the x-y system of the dart board and scales them to fit on the 1024x768 displayed dart board. These positions will also have to be converted into actual scores used in the scoring of the dart match. Furthermore, they will also have to be passed to the Image Display Module to display (using an X or more clever sign) where the darts landed on the GUI's dart board.

The Score Conversion Module will take positions in the GUI displayed dart board and convert them into values from 0 – 60 pts depending on where the dart landed. The scores from the three darts will be summed and relayed to the Scoring Module which keeps track of the current score in the match.

The Scoring Module will implement the rules of a simple 301 match. The sum input will be deducted from the current player's previous score and outputted to the Image Display Module which will display the player's new score.

The Image Display Module collects where the darts landed and the score of the game and displays it to the user via a VGA display device. The position of the darts will be shown on a reproduced dart board. The score will automatically be calculated for the users and will also be displayed.

## **DIVISION OF WORK**

When thinking about how to divide the work in implementing this project, our group decided that splitting the triangulation calculations or splitting the image display would become confusing. For this reason we decided that one of us will work on

implementing the triangulation modules while the other works on the image display modules. Since both of us find the assembly of the 3 ADC's interesting, we will both work on that part of the lab together. Put more clearly, Ankush Patel will be working on the Triangulation Module, the Counter Module, and the Coordinate Conversion Module. Michael Ehrenberg will be working on the Score Conversion Module, the 301 Scorer and the Image Display Module, while both of us work on the Dart Board Input Module. We feel that splitting the project in this manner will be fair to both parties and will allow both of us to learn by engaging in construction of a 3-input audio connection to the lab kit. Furthermore, we will consult each other in both the design and implementation phases to provide new ideas and to help with debugging. Overall the project should be a great learning experience for both group members as they will become familiar with all aspects of the project by its completion.

## **TESTING**

Based on our division of work, each of our components can be easily tested separately to determine their success. Dart Detection can be tested in a number of ways. The triangulation module can be tested by picking a position on the board, calculating the distance to each of the microphones and calculating by hand the appropriate clock differences to see if the output is the same. Once the triangulation module is completed we can extend testing to using the microphones and throwing darts. When we throw a dart we can make sure that the triangulation module outputs an appropriate set of coordinates. The microphones will need to be tested on their own as well. Initially we will make a grid of microphones and test the retrieval of sound information by making a noise at different distances from each microphone to make sure the appropriate microphones receive the signals in the correct order.

The graphical user interface can be tested alone as well. By passing in a set of dart coordinates for each turn, the user can make sure that darts are correctly being placed on the board, which will be illustrated on the screen. Testing that the scoring is being done correctly can be determined by knowing what regions of the board the test data is located. This will allow us to know the score before it appears on the screen. Once the game is operating correctly, we can combine the two components to successfully play an automated game of darts.

## **IMPLEMENTATION CHALLENGES**

Our automated dart board could greatly enhance the experience of a competitive darts match. There are several challenges which we must overcome in order for our project to be a success. The first challenge is that the 6.111 labkit only has a single microphone input. Consequently we are going to have to use additional hardware to properly feed our audio input into the labkit. Our next major challenge involves accurately detecting dart location. We believe that the microphones we will be using will have enough resolution to calculate dart location to less than one centimeter. However, until we have the specific specifications for the audio hardware and can test the equipment it will be difficult to tell if we will be able to obtain the necessary resolution. This issue will particularly effect being able to correctly score doubles and triples in the

game because the double and triple bands are only about one centimeter across. Finally, an additional challenge we will have to overcome involves handling faulty input from the darts, especially if the resolution we achieve is less than what we anticipate, and how that can be corrected from the user interface.

## **CONCLUSION**

As a whole, we have a number of daunting challenges ahead of us; however, the idea of building an automated dartboard is very exciting and has a lot of potential to become a great project. A no hassle implementation is essential for this technology to be accepted by any dart players. Finally upon the completion of our automated dartboard future enhancements that would be nice to have are implementations for additional games like 601 and cricket.