e-Yantra Robotics Competition (eYRC-2018)

ArUco Marker

Introduction

ArUco marker is a 5x5 grid that is black and white in color. ArUco markers are based on Hamming code. In the grid, the first, third and fifth columns represent parity bits. The second and fourth columns represent the data bits. Hence, there are ten total data bits. So the maximum number of markers that can be encoded are- 2^10 = 1024. Data and parity bits in an ArUco marker are as shown in Figure 1:

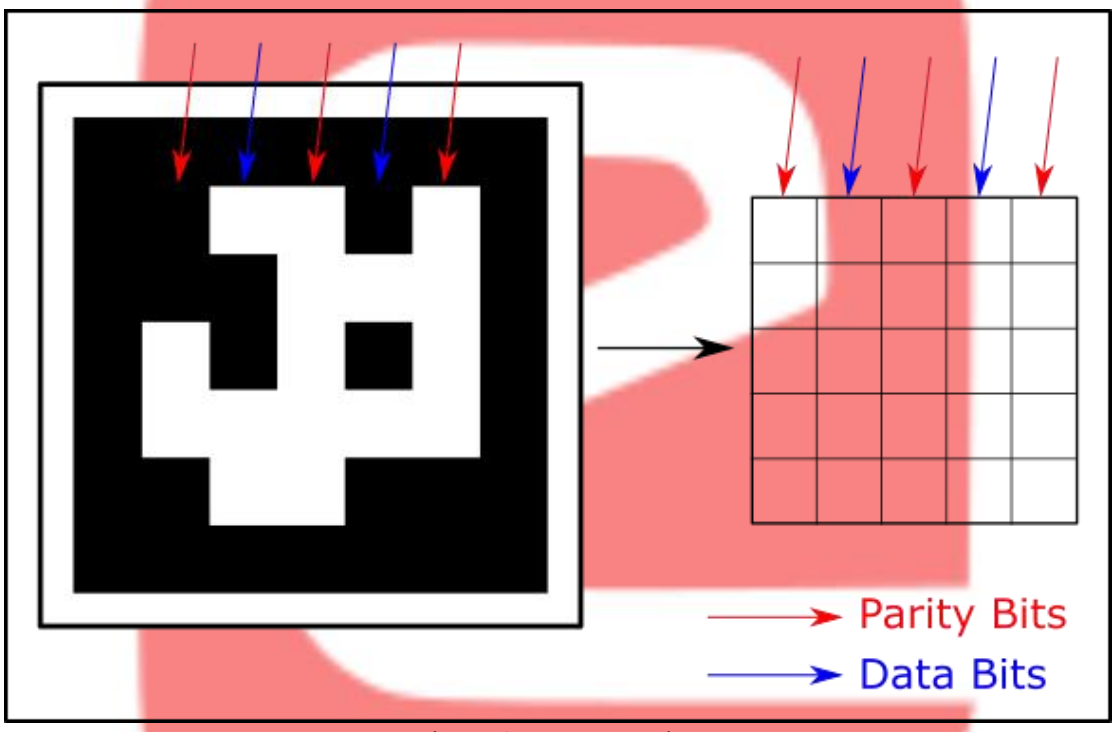

Figure 1: ArUco Marker

Encoding

Let us consider the number 650. Its binary representation is 1010001010. As shown above in Figure 1, there are two data bits in each row.

Now, each row is encoded separately using slightly modified Hamming code. The first and third parity bits are calculated using even parity while the second parity bit uses odd parity. The number 650 is filled accordingly and we get the following encoded values:

Data Bit 2	Parity Bit 3	Data Bit 1	Parity Bit 2	Parity Bit 1
0	0	1	0	1
0	0	1	0	1
0	0	0	1	0
0	0	1	0	1
0	0	1	0	1

We rearrange the bits in each row and get the following data rows as shown in Figure2:

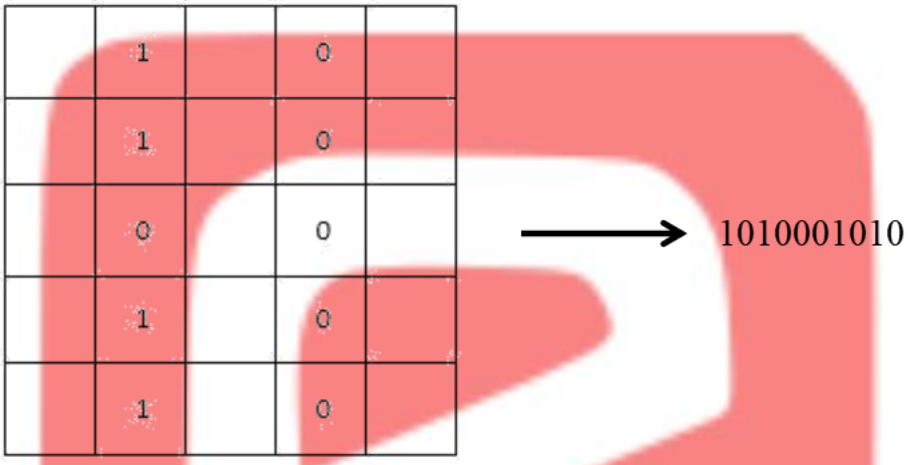

Figure 2: Data Rows

After arranging the parity bits as well, ArUco bits for the number 650 looks as shown in Figure 3:

Parity1	Data1	Parity3	Data2	Parity2
0	1	0	0	1
0	1	0	0	1
1	0	0	0	0
0	1	0	0	1
0	1	0	0	1

Figure 3: ArUco bits for 0b1010001010

If the cell value is 0, color it black; if value is 1, color it white. This will give us the ArUco marker as shown in Figure 4:

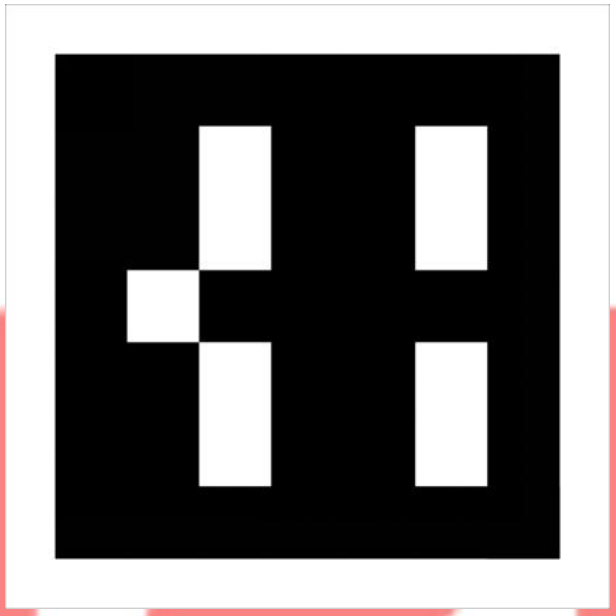

Figure 4: ArUco Marker for 650

You can find that the above marker is padded with one layer of black cells. That layer will be removed during decoding.

Decoding

After understanding the above section, decoding is an extremely simple process. The following steps are to be followed while decoding a perfect, computer-generated image of an ArUco marker.

Step 1: Extract the ArUco from the image.
Step 2: Remove the extra padding.

Step 3: Divide the resulting image into a 5x5 grids and check the color in each cell of the second and fourth columns (in that order) in a top to bottom manner.

Step 4: If the color is white, write 1; else, write it 0.
Step 5: The resulting number will be in binary. Convert it into decimal