

Implementation of Probability using FIR Filter

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Abstract—This paper develops a method which resolves the problems faced in mathematically calculating the probability of occurring an event. It develops a technique which determines probability of occurring an event in case of dice and coins by using the response of a FIR filter through MATLAB(matrix laboratory)by creating a relationship between response of an FIR filter and probability of occurring an event.

Index terms — Digital, Direct-1, Fir Filter, Gain, Matlab, Probability, Response, Simulation

I. INTRODUCTION

Digital systems have become a part of our lives. A digital system can be defined as an electronic network that processes information using only 0s and 1s to implement calculations and operation. Over the years complexity of mathematical calculation of probability is increasing. here in this paper by using digital filter there is an ease in calculating probability. this paper also include correlation of gain with probability. Digital devices are based on the binary number system.

Therefore, we have to design the digital system in such a way that the out comes of probability is correlated with gain coefficients of FIR Direct-1 filter, the FIR filter is a Matlab tool Direct-1 is designed using “fdatool” in matlab.

II. PROBABILITY

If a random experiment results in N mutually exclusive, equally likely and exhaustive outcomes, out of which n are favourable to the occurrence of an event A, then the probability of occurrence of a, usually denoted by p(A), given by

$$P(A) = n/N$$

Here $0 \leq P(A) \leq 1$ [1]

In digital if we have two input digital system then the binary input that can be applied to the digital circuit are-

00,01,10,11

00,01,10,11

Similar is in the case of two coins or tossing a coin two times the possible outcomes are-

H on 1st & H on 2nd (HH)

H on 1st & T on 2nd (HT)

T on 1st & H on 2nd (TH)

T on 1st & T on 2nd (TT)

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III. FIR FILTER

A finite impulse response (FIR)[3] filter is a filter structure that can be used to implement almost any sort of frequency response digitally. An FIR filter is usually implemented by using a series of delays, multipliers, and adders to create the filter's output.

$$y[n] = b_0x[n] + b_1x[n-1] + \dots + b_nx[n-N]$$

$$= \sum b_i x[n-i]$$

Figure 1 shows the basic block diagram for an FIR filter of length N. The delays result in operating on prior input samples. The P_k values are the coefficients used for multiplication, so that the output at time n is the summation of all the delayed samples multiplied by the appropriate coefficients.

The process of selecting the filter's length and coefficients is called filter design. The goal is to set those parameters such that certain desired stop band and pass band parameters will result from running the filter. Most engineers utilize a program such as MATLAB to do their filter design[5].

FIR filters require no feedback. This means that any rounding errors are not compounded by summed iterations. The same relative error occurs in each calculation. This also makes implementation simpler.

FIR filter are inherently stable. This is due to the fact that, because there is no required feedback, all the poles are located at the origin and thus are located within the unit circle (the required condition for stability in a discrete, linear-time invariant system).

FIR filters are clearly bounded-input bounded- output (BIBO) stable, since the output is a sum of a finite number of finite multiples of the input values, so can be no greater than times the largest value appearing in the input.

To design a filter means to select the coefficients such that the system has specific characteristics. Most of the time filter specifications refer to the frequency response of the filter. There are different methods to find the coefficients from frequency specifications.

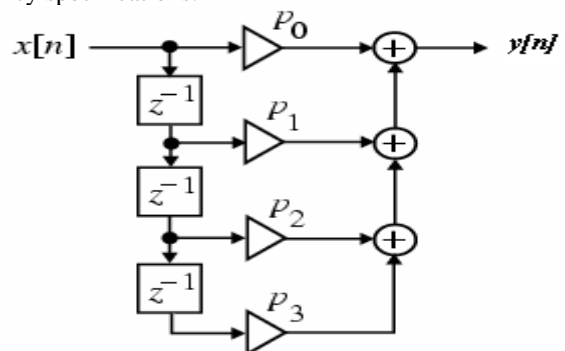


Figure 1: Basic FIR filter[4]



IV. IMPLIMENTATION AND COMPARISION OF DIGITAL INPUT

In general, in n bit binary code groups of n bits can have 2n distinct combination of 1's & 0's with each combination representing one element of the set that is being coded. The no. of input that can be applied to a digital system can be obtained by 2n
 Similarly the no.of outcomes of tossing a coin can be found out by the similar formula used in digital circuit i.e. 2ⁿ.
 Now if we consider H=0&T=1 Then for

TABLE 1: SINGLE TOSS-

H	0
T	1

TABLE 2: TWICE A COIN-

HH	00
HT	01
TH	10
TT	11

TABLE 3: THRICE A COIN-

HHH	000
HHT	001
HTH	010
HTT	011
THH	100
THT	101
TTH	110
TTT	111

TABLE 4: CORRELATING THE VARIOUS CONDITION IN DIGITAL WITH TOSSING A COIN-

	DIGITAL INPUT	Y ₁	Y ₂	Y ₃	Y ₄
HHH	000	0	0	1	0
HHT	001	0	1	1	0
HTH	010	0	1	1	0
HTT	011	1	0	0	1
THH	100	0	1	1	0
THT	101	1	0	0	1
TTH	110	1	0	0	1
TTT	111	0	0	0	1

V. EQUATING PROBABILITY WITH GAIN-

First of all we define the probability of occurrence of an event as the ratio of favorable no.of outcomes to the total no. of equally likely outcomes.

In statistical approach we define probability of an event as the ratio of observed frequency to the total frequency.

$$P(E) = \text{observed frequency} / \text{total frequency}$$

Where as in the case of digital system the gain is equal to the output of the digital system to the input applied.

$$G(S) = \text{output of digital system} / \text{input to digital system}$$

By this defination we can conclude that the probability is approximately equal to gain.

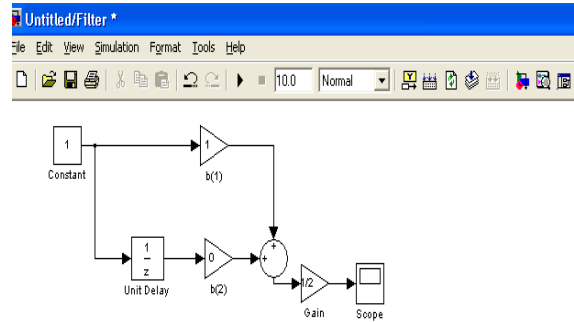


FIGURE 2: SIMULATION IN MATLAB

This is a designed direct-1 IIR filter, now tossing a coin gives output a head or a tail, if we calculate probability of getting a head it is 1/2 = 0.5.

Now in digital system considering head as output then b(1)=1 & b(2)=0, which are coefficients of FIR filter now applying on filter the output is the gain which is equal to the probability, shown in below figure.

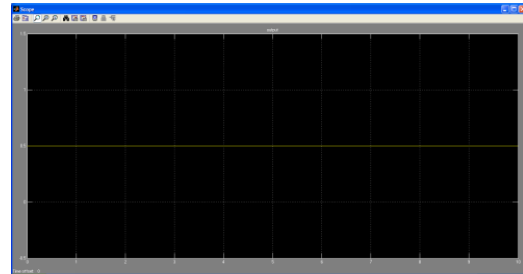


FIGURE 3: GAIN EQUAL TO PROBABILITY OF A DIGITAL FILTER

Getting exactly 1 H -

$$Y_1 = (b_5, b_6, b_7)$$

The condition is equal to when exactly one of the input is low.

Getting exactly 1 T-

$$Y_2 = (b_2, b_3, b_5)$$

The condition is equal to when exactly one of the input is high.

Getting exactly 2H or 1T-

$$Y_3 = (b_2, b_3, b_5)$$

The condition is equal to when only one input is high and output is high.

Getting exactly 2T-

$$Y_4 = (b_4, b_6, b_7)$$

The condition is equal to when only one input is low and output is high.

Getting more than 1 H-

$$Y_5 = (b_1, b_2, b_3, b_5)$$

The condition is equal to when two or more input are low and output is high.

Getting more than 1T-

$$Y(4) = (b_4, b_6, b_7, b_8)$$

The condition is when two or more input are high and output is high.

Getting at least 1T-

$$Y(7) = (b_2, b_3, b_4, b_5, b_6, b_7, b_8)$$

The condition is when any of the input is high and output is high.



**VI. GENERATION OF DIGITAL SYSTEM GAIN
FORMULA & THEORETICAL
EXPLANATION-**

If n input are applied at input x(n) then

$$y(n) = \left\{ \frac{1}{n} \right\} \sum b(k)x(n) \quad (1)$$

$$gain = \frac{y(n)}{x(n)} = \frac{1}{n} \sum b(k)x(n) \quad (2)$$

Which is best applicable to find the gain and is equal to the probability of the occurrence of event.

$b_k \rightarrow$ coefficient(having binary value 0 or 1)

Depending on the o/p is high or low,value of b_k is selected as 0 or 1.

TABLE 4: TOSSING TWO COINS-

Probability Occurrence of event	Digital i/p to system	y_1	y_2	y_3	y_4	b_k
HH	0 0	1	0	1	0	b_1
HT	0 1	0	0	1	1	b_2
TH	1 0	0	0	1	1	b_3
TT	1 1	0	1	0	1	b_4

Exactly 2H = Both the input are low

$$Y_1 = b_1$$

Exactly 2T = Both the input are high

$$Y_2 = b_4$$

One or more H = Any or both input is low

$$Y_3 = \{b_1, b_2, b_3\}$$

One or more T = Any or both input are high

$$Y_4 = \{b_2, b_3, b_4\}$$

Now calculating probability-

Figure 4 calculates that gain of an digital FIR filter having unit delay which is equal to probability of occurring odd numbers or even numbers on a dice which is shown in further results-

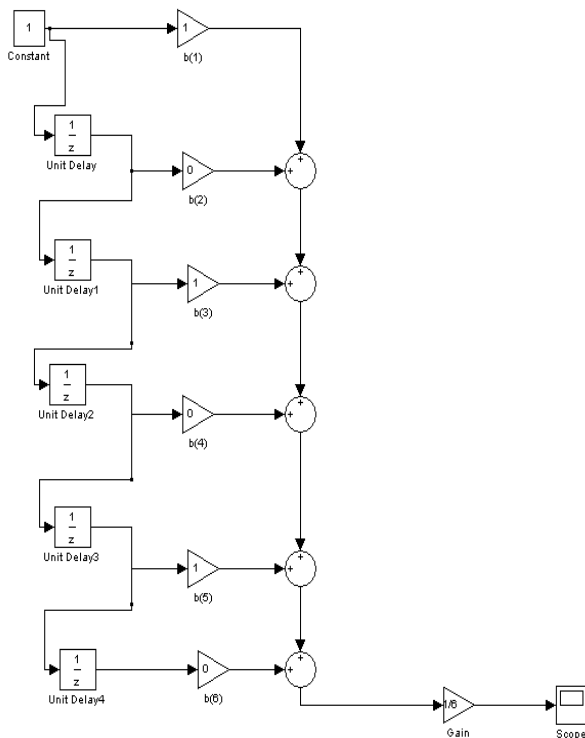


FIGURE 4:DESIGNED FIR FILTER

$$1) P_1(\text{odd}) = 1/2 = 0.50$$

$$2) P_2(\leq 2) = 1/4 = 0.66$$

$$3) P_3(\text{even}) = 3/4 = 0.75$$

Now by Gain formula calculating Gain-

No. of i/p, $n = 6$

$$b_k = b_1 + b_2 + b_3 + b_4 + b_5 + b_6 = 1$$

$$1) b_1 = b_3 = b_5 = 0, b_2 = b_4 = b_6 = 1$$

$$6y = x \sum b_k$$

$$6y = x[b_1 + b_2 + b_3 + b_4 + b_5 + b_6]$$

$$6y = x$$

$$G = y/x = 0.50$$

$$2) b_1 = b_2 = 0; b_3 = b_4 = b_5 = b_6 = 1$$

$$4y = x[b_1 + b_2 + b_3 + b_4 + b_5 + b_6]$$

$$4y = x$$

$$G = y/x = 0.50$$

$$3) b_1 = b_3 = b_5 = 1, b_2 = b_4 = b_6 = 0$$

$$6y = x \sum b_k$$

$$6y = x[b_1 + b_2 + b_3 + b_4 + b_5 + b_6]$$

$$6y = x$$

$$G = y/x = 0.50$$

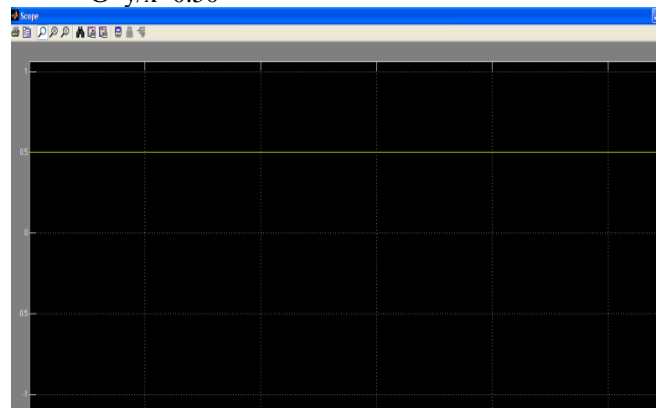


FIGURE 5 : PROBABILITY OF COMING ODD NUMBER

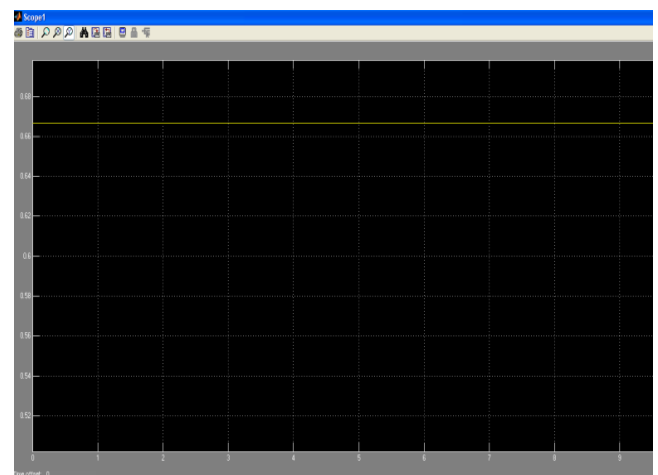


FIGURE 6 :PROBABILITY OF COMING NUMBER LESS THEN TWO



FIGURE 7 :PROBABLIITY OF COMING EVEN NUMBER

VII. CONCLUSION

In this paper probability of coins is determined by using digital finite impulse response filter through MATLAB. By using digital FIR filter there is ease in calculating probability rather than calculating it mathematically. Further more ,this paper correlates gain with probability. In future, the proposed system is expected to implement complex cases of probability by using digital filters.

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