Novel Coordinate Rotation Digital Computer (CORDIC) Algorithm by Ancient Vedic Mathematics Concept and Its Use on Computer Vision Applications

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Abstract
This is the age of high-tech science & technology which is based on 9D, 5G & high tech medical science. All these type of technology use the computer vision system , most of computer vision algorithm use the trigonometry mathematics, as per the trigonometric COSINE & SINE these are the two most powerful function which is use in most of CV algorithm. Current era we have high speed processing unit where we use ALU logic, in terms of fast graphics calculation we need GPU on GPU there is separate trigonometric calculation processing unit is there which is called CORDIC. So in this paper basically we proposed a novel algorithm which is able to calculate the SINE & COSINE value in less time. For application level analysis we use DCT and as per result point of view we did the comparative analysis between proposed & previous existing approaches.

Key words:
Sine, Cosine, Trigonometric, HD, GPU, ALU, Vedic Mathematics, Multiplier

1. Introduction

This is the era of high speed internet, 4D graphics video, and 5G network. 2020 is the era of high class medical, aerospace, automation, multimedia technology. As per these type technology there is requirement of good quality of algorithm which is able to do fast processing in very less time. As we know for multimedia application now a days computer vision is played every important role as per the computer vision, basically it's a virtual vision system which is show the imaginary content in to the real world. For these kind of high graphics based computer vision there must be a need of great quality level based fast processing algorithm which are able to create a fast processing software for those type o computer vision application. As we know all these algorithms are working on processing unit and as per the processing unit there is must be a Arithmetic unit is there which is able to do all type of mathematical calculation, now the question is only ALU unit is sufficient to do fast processing for these kind of application and the answer is no. As per the calculation of those kind of application need a Graphics processing unit where GPU have all different type of calculation process. Now CORDIC algorithm is one of the most important algorithms which are used in GPU for the calculation of trigonometric functions. In this paper we proposed a novel Cordic algorithm which is based on approximation logic, apart from that in this paper we did the proper comparative analysis on existing CORDIC algorithm and Proposed cordic algorithm. As per the our comparative analysis on algorithm level we use Discrete Cosine Transform based image compression algorithm and perform the quality level analysis in terms of image quality parameters . The rest of the paper is sub arranged as follows. Important foundation and fundamental guideline of CORDIC Algorithm is given in Section II while Section III presents the Proposed Cordic Algorithm. Section IV presents the result analysis & comparative analysis Section V is end which wraps up the whole paper.

2. Literature Review

The Initial CORDIC algorithm contain is made in 1959 proper starting at now moved closer to reply for trigonometric restriction and flip tally, but this methodology is searching with modified trouble like significant gadget is pine for, trustworthy time period and scale element is except an integral issue [10]. Broadening inquisitive technique is made [11], starting at now take a gander at some inquisitive new events like log, exponential and rectangular root but this region is in addition all the all the moreover limiting a relative badly designed troubles scale factor, monster equipment, steady term. After the above buildings a giant degree of development is finished in CORDIC figuring and many summarized technique are engaged for choosing gathered cutoff communities like in reverse of cosecant and secant [12],[13],changes[14],[15], models/converse of enemies of logarithms, rectangular roots, Eigen regards [16], etc. Relic of days surpassed thru [17], there has been fundamental advances in the shape of

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the take a appear at to beat its ensured deficiency. In [18], [19], [20] makers propose the utilization of invigorated day day out estimations for seeing the minimize back scale turns. The hassle of these structures relies upon upon the probability of flip aspect which is the central issue. Execution of it involving format is in reality sifted through and it is going towards every other unstable issues. For decline of scale thing trouble low multifaceted nature structure is used and the gadget is Taylor graph growth which in like manner has two or three damages. Level of combo is a key issue, for lessening of this hassle some new shape is supported. [21], [22] are structures subordinate upon Taylor approach. The preceding encounters low diploma of affiliation (RoC) which renders it inadmissible for broadly popular use, at the same time as the closing builds up the RoC however them ascending to hassle of sturdy scale-factor. The Scaling-Free CORDIC and modified barring scale CORDIC [23], [24] in [24] maker proposed new way of questioning for time of sine/cosine, suited now discard a ROM and an awesome barrel shifter in the mechanical assembly use of the CORDIC structure, however this system encounters low diploma of blending (RoC) which render take a seat down limited for critical use. In [25] maker pushed closer to a structure for decreasing of scale factor and variety of cycles. They centered on Radix-4 Modified Booth recording-Modification of CORDIC depend quantity is Radix-4 balanced corner recording. In previous work clarification at the again of the except scaling CORDIC area is between zero to rad regardless appropriate now diploma is between $-\pi/2$ to $\pi/2$, [24], [25] in like direction ascending to regular scale factor issue. In [28] right here maker proposes the stylish one piece seeing proof structure to see the little increment turns. The scale free course of movement of the empowered take a seem at relies upon Taylor method action of the sine and cosine waves. In [29] maker use a day-to-day standpoint but there they execute Hyperbolic CORDIC work. A tools knowledgeable structure for making inverse of cosecant and secant waves undertaking to the CORDIC (Coordinate Rotation Digital Computer) check. [26], this maintained a technique at once formerly than prolonged uses driving one piece publicity shape to see the greater unassuming diploma turns. This technique takes out difficult preparations check. The scale free methodology of the estimation depends upon Taylor graph broadness speak of cosecant and secant. This advised figuring is up to fourth demand of Taylor layout. This supported check is in addition looking with modified problems like headway in goof; number of supplement increases, to scale again this problem every other standpoint is gotten a cope with on [27]. Right now the use of identical method of [26] but they convert that working in to appear to be like structure they requested CORDIC proportionate rotator use to be maximally upgraded for world type with the lower value in a place ingesting up. Supriya [24] this paper suggests an area time educated CORDIC tally that virtually disposes of the scale-factor. In like manner, achieves the perfect diploma of coalition. Other than we have inspired an estimation to rename the quintessential plots for diminishing the extent of CORDIC cycles. A summed up little diploma flip attestation notion subject to eager most-and necessary 1-territory ruins the staggering key for seeing the reduce again scale changes. Causo 2012[25] wishes a sagacious thinking type about the cordic figuring through acclimating an equal rotator skilled with turn for greater than one smaller degree alternate element per time. Systems for choosing the dynamic minimize decrease returned scale change facilities solidifies in like way as the most fitting approach for the requested approach, are right here speedy and dirty. Supriya 2012[26]: This paper suggests a mechanical get jointly exceptional game-plan for making backward of cosecant and secant waves undertaking to the CORDIC (Coordinate Rotation Digital Computer) tally. In this remarkable structure the cordic experiences quintessential downsides like scale-factor figuring, slowness and best affirmation of little diploma turns. The asked figuring beats these weights. We make use of using one piece disclosure device to see the little boom turns. The scale free technique of the requested estimation depends upon on Taylor manner enhancement of the sine and cosine waves. Supriya 2013[27] this paper shows a novel completely sans scaling CORDIC figuring in rise up mode for hyperbolic heading. They use most-immense 1 piece ID approach for reduce once more scale flip improvement age to scale again the proportion of cycles. These are preceding investigates which are identified with the CORDIC figuring. As per the previous existing technology there is lots of improvement is require here we also see there is lots of complexity in CORDIC processing unit. AS per the previous existing approach we found some of the common issues which are

1. Quality Issue: Most of the existing approaches have the quality issue; they are not able to manage all quality level parameters.
2. Accuracy Issue: As we know in computer vision accuracy is most important parameter but in most of the Cordic algorithm there is issue in accuracy.
3.Time Complexity: As we know for any computer vision application there is need of fast process, but as per the existing approaches are not good in time complexity.
4. Not Applicable for all Applications

In this paper basically we try to solve the previous existing issues and try to propose a novel approach which is able to get the followings output:

1. Improvement in Time Complexity
2. Improvement in Quality
3. Improvement in Accuracy
4. Applicable for most of the applications

3. Methodology and Implementation

CORDIC algorithm is most powerful algorithm which used in GPU, due to that algorithm now a days we are able to get the great experiences on video & image processing system. As per the classic CORDIC algorithm they use the vector, Va[Xa, Yb] be derived via rotating the vector Vb[Xa, Yb] through an angle, then:

$$\begin{bmatrix} Xb \\ Yb \end{bmatrix} = Rp.\begin{bmatrix} Xa \\ Ya \end{bmatrix}, Rp = \begin{bmatrix} Cos\theta & -Sin\theta \\ Sin\theta & Cos\theta \end{bmatrix} \quad (1)$$

Here equation (1) shapes the fundamental rule for iterative arrange calculation in CORDIC algorithm [1].

$$\theta = \sum_{i=0}^{B} ui * ai \quad (2)$$

Here $ui = -1,1; ai = \tan^{-1} 2^{-i}$

As we can see in equation (3), the scale issue Ki is free and no longer dependent of the direction of micro-rotation

$$Rp = Ki.\begin{bmatrix} 1 & -ui.2^{-t}\theta \\ ui.2^{-t} & Cos\theta \end{bmatrix} \quad (3)$$

3.1 Proposed Algorithm:

As per our proposed algorithm we basically follow the mathematical formula for the calculation of Sine & Cosine value, we perform the followings steps:

1. Angel Calculation
2. Value Calculation using Classic Radian Formula
3. Sine & Cosine Value Generation

Angel Calculation: As per our proposed algorithm first we calculate the Θ Value, here we calculate the Θ value by using of followings formulas:

Angle= A1-A2 (1)

Where A1 & A2 is input degree value which is modify as per the input value if input value is less than 45 degree so A1 is always Θ, Similar if input value is >45<90 so A1 is always 90, similar it follows the 360 degree rotation rule.

- Input<45: A1=Input & A2=0
- 45<Input>90: A1=90 & A2=Input
- 90<Input>125: A1=Input & A2=90
- 125<Input>180: A1=180 & A2=Input
- 180<Input>225: A1=180& A2=Input
- 225<Input>270: A1=Input & A2=270
- 270<Input>325: A1=270 & A2=Input
- 325<Input>360: A1=Input & A2=360

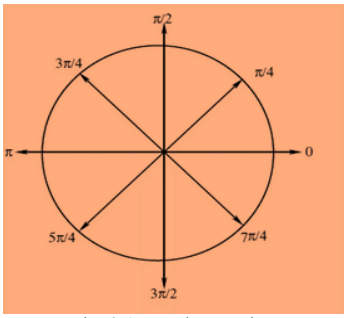

Fig. 3.1 Angele Rotation

3.2 Value Calculation using Classic Radian Formula

In this step basically we use the classic mathematical expression which is known as Radian formula by using of that formula basically we generate the Values for sine & cosine. As per trigonometric we know between 0 to 45 degree the value of radian is equal to original value of sine. Similar as per trigonometry the value of Cosine for 45 to 90 degree is equal to sine value of 0 to 45 degree. So by using of this basic value we can generate the value for entire 0 to 360 degree.

Sine Value Calculations for 0 to 45 degree:

Radian formula = $\frac{\theta X \pi}{180}$ **(4)**

As per our proposed approach we are following approximation logic and based on that logic we try to modify the formula as there is π which is a float value so it require floating multiple which increase the latency so here we by using of approximation our modified formula is:

Modified Radian formula K1 = $\frac{\theta X 9}{512}$ **(5)**

As per equation 5 why we use this formula because $\frac{\pi}{180}$ Is equal to 0.01744 and as per our modify formula 9/512 is 0.0175 which is equal to original value. Now as we know cosine value for 45 to 90 degree is same as sine 0 to 45 degree. Now we have to calculate sine 45 to 90 degree value so for that we have to modify the radian formula, as we can see there is sin45 and sine46 is there so we have to take difference of that vale and add that value to calculate other sine 46 to 90 degree value, here we have to use some constant value which will do justification with real value as a constant value we use H as a constant symbol, so as per that modify formula is:

Modified Radian formula K2 = $\frac{(H X 9 + 45)}{512} + \frac{(45-\theta)X21}{256}$ **(6)**

As per calculation H is a constant whose value is fluctuating between 0 to 4. Now if K2 value is greater than 1 so it will approximately equal to 1.

3.3 Sine & Cosine Value Generation

Now as per K1 & K2 now we are able to generate the value of sine & cosine for 0 to 360 degree. SO 0 to 360 Sine values are:

- θ <45: Sine=K1
- 45< θ >90: Sine=K2
- 90< θ >135: Sine=K2
- 135< θ >180: Sine=K1
- 180< θ >225: Sine=-K1
- 225< θ >270: Sine=-K2
- 270< θ >325: Sine=-K1
- 325< θ >360: Sine=-K2

0 to 360 Cosine values are:

- θ <45: Cosine=K2
- 45< θ >90: Cosine =K1
- 90< θ >135: Cosine =-K1
- 135< θ >180: Cosine =-K2
- 180< θ >225: Cosine =-K2
- 225< θ >270: Cosine =-K1
- 270< θ >325: Cosine =K1
- 325< θ >360: Cosine =K2

Using this way we calculate the value of sine & Cosine, as per this proposed algorithm we are able to get output, now for multiplication point of view use use the approximate vedic multiplier [30].

3.4 Approximate Vedic Multiplier

As per this multiplier use the concept of Urdhva tiryakbhyam, as per this design 4 BIT Accurate Urdhava multiplier, 4 Bit Semi Approximate Urdhava Multiplier and at last we design 4 Bit pure Approximate Urdhava multiplier. According to Pure approximate multiplier our initial 4 bit is generated by the combination of 1,0. For Semi approximate our initial two is generated by 1,0 combination.

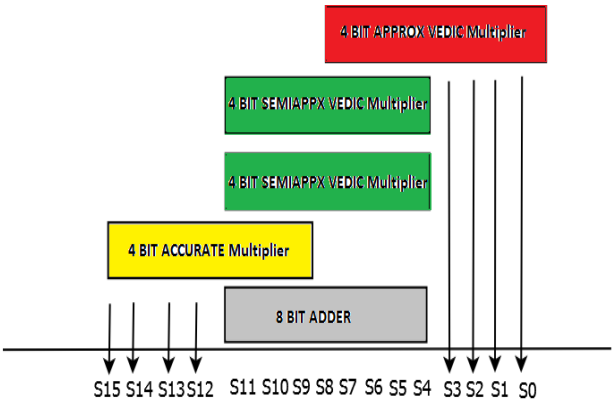

Fig. 3.2 8 Bit Approximate Multiplier

Proposed Algorithm

Start

Insert Input θ
Calculation of Angel: A1-A2
Value Calculation using Classic Radian Formula
8 Bit Approximate Vedic Multiplier
Sine & Cosine Value Generation

End

Application Level Analysis on DCT [29]:

Here we use DCT for application level analysis as we know DCT is very important algorithm for the image and video processing. DCT is commonly used in most of image and video compression systems like JPEG, MPEG etc. Here we use our proposed and previous existing CORDIC algorithm and based on that we calculate the sine & Cosine value and apply that value on the DCT matrix and based on DCT algorithm we did the comparative analysis.

4. Result & Analysis

In this section we are doing the comparative analysis based on different kind of parameters. In algorithm level we use some of the image quality parameters which are:

1. PSNR
2. SSIM
3. RFSIM
4. FSIM

Here we use boat as a test image and for application point of view we use DCT and based on different algorithm we got different output image and in terms of algorithm level we perfume the comparative analysis.

Table 5.1 Error Analysis

θ	CORDIC	Scaling Free	Efficient CORDIC[24]	Taylor Based	Proposed CORDIC
0-90	0	0-$8*10^{-8}$	0-$9*10^{-8}$	0-$10*10^{-8}$	0-$7*10^{-8}$
90-180	0	0-$6*10^{-8}$	0-$8*10^{-8}$	0-$8*10^{-8}$	0-$7*10^{-8}$
180-270	0	0-0.036	0-0.00256	0-$9*10^{-8}$	0-$7*10^{-8}$
270-360	0	0-0.096	0-0.002369	0-$8*10^{-8}$	0-$7*10^{-8}$

4.1 Image Quality Comparative analysis:

Table 5.2 Image Quality Parameter Analysis

Parameters	CORDIC	Efficient CORDIC	Scaling Free	Taylor Based	Proposed CORDIC
SSIM	0.9523	0.9342	0.9353	0.9411	0.9511
PSNR	45	30	35	38	39
FSIM	0.9219	0.8446	0.8634	0.9029	0.9145
RFSIM	0.9189	0.8236	0.8413	0.8689	0.9089

According to the table 5.1 and 5.2 we can see the exhibition of the all past CORDIC calculation general Efficient CORDIC [24] is better in the entirety of the past methodology.

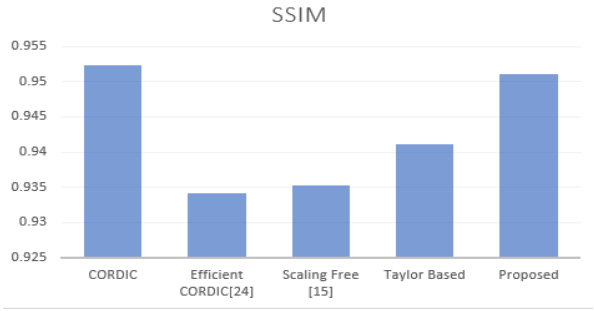

Fig. 4.1 Comparative SSIM

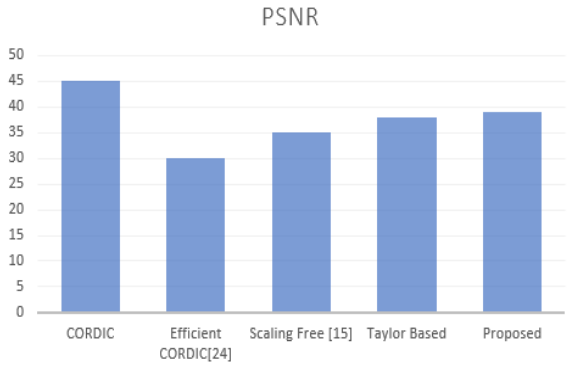

Fig. 4.2 Comparative PSNR

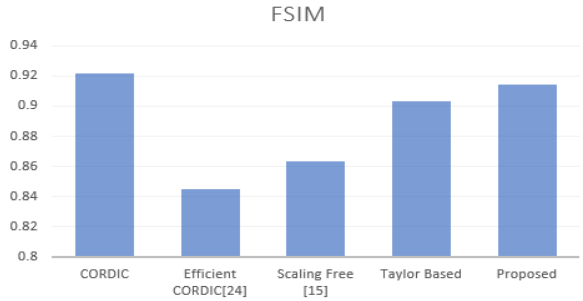

Fig. 4.3 Comparative FSIM

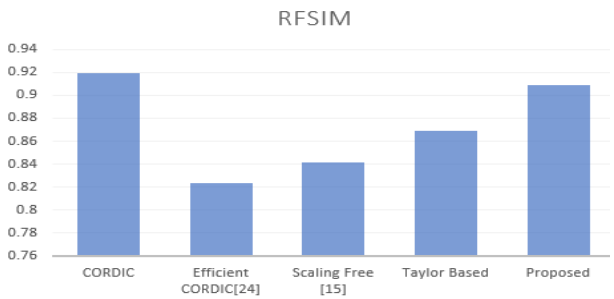

Fig. 4.4 Comparative RFSIM

Fig. 4.5 Test Image

Output Image from Conventional CORDIC [10]

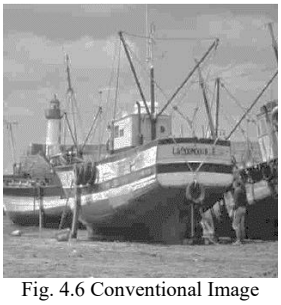

Fig. 4.6 Conventional Image

Output Image from Taylor CORDIC:[29]

Fig. 4.7 Taylor Image

Output Image from Scaling Free CORDIC [15]:

Fig. 4.8 Scaling Image

Output Image from Efficient CORDIC [23]:

Fig. 4.9 Efficient Image

Output Image from Proposed CORDIC:

Fig. 4.10 Efficient Image

Here 4.5 is test image & 4.6, 4.7, 4.8, 4.9, 4.10 shows the output from the different CORDIC & Proposed algorithm which we apply on DCT algorithm.

5. Conclusion

CORDIC algorithm is use in most of the common applications like aerospace, medical science, aeronautical science, computer vision, As per the previous existing CORDIC algorithm had lots of issues which are low latency, less quality, low accuracy, no justification with image quality parameters. So based on those issue here we design a novel algorithm which is based on approximation logic & use the Vedic mathematics & basic trigonometric system, due to approximation logic we are able to get the result in less time & due to basic trigonometric logic we are getting the more accurate results in compare of [15], [24]. Here we did the application level analysis where we can see the quality level is far better than in compare of [15] & [24] here we did the improvement of approximate 15-20%.

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