A Study Paper on CORDIC Algorithm and Its Need & Applications for Future Technology

Vandana C. Maindargi
Department of E&TC
TPCT's College Of Engineering, Osmanabad

Abstract-- *CORDIC (Coordinate Rotation Digital Computer), otherwise called the digit-by-digit technique and Volder's calculation. This is an extraordinary reason advanced PC for continuous airborne calculation. In this, an extraordinary figuring procedure is utilized which is particularly appropriate for explaining the trigonometric connections required in plane arrange turn and transformation from rectangular to polar directions. CORDIC algorithm is likewise appropriate for square root, Logarithmic, Exponential capacity and for computerized PC. In algorithm unit trigonometric capacities are extremely significant; at exhibit numerous numerical capacity require Sine, Cosine, Tangent and so on, and by utilizing this algorithm it simple to process. With continuous innovation and constraints on control, working recurrence and vitality utilization, on the off chance that we are creating any trigonometry capacities by utilizing of multiplier, snake, divider those structures expends more equipment and computational time in-wrinkles, for lessening of this issue CORDIC algorithm is changed over into equipment frame which is known as CORDIC processor. In this paper essentially we did a relative report between the current CORDIC calculation. In display time CORDIC algorithm is utilized as a part of numerous applications like Multimedia, Digital Signal Processing applications like Smooth Filters, DCT, FFT and so on.*

Keywords-CORDIC, Algorithm , FLOW, Communication, Latency

I. INTRODUCTION

CORDIC (Coordinate Rotation Digital Computer), otherwise called the digit-by-digit strategy and Volder's calculation. This is a unique reason computerized PC for constant airborne calculation. In this, an extraordinary figuring procedure is utilized which is particularly appropriate for comprehending the trigonometric connections required in plane organize turn and transformation from rectangular to polar directions.

CORDIC algorithm is likewise pertinent for square root, Logarithmic, Exponential capacity and for advanced PC. In algorithm unit trigonometric capacities are exceptionally pivotal; at introduce numerous numerical capacity require Sine, Cosine, Tangent and so forth, and by utilizing this algorithm it simple to figure. With on going technolgy and confinements on control, working recurrence and vitality utilization, on the off chance that we are producing any trigonometry capacities by utilizing of multiplier,adder, divider, those designs devours more equipment and computational time in-wrinkles, for diminishment of this issue CORDIC algorithm is changed over into equipment shape which is known as CORDIC processor. This processor lessens the issue of division and duplication.

In CORDIC processor we can figure the capacities by utilizing of shifter, snake and substractor. In introduce period CORDIC algorithm is utilized as a part of numerous applications like Multimedia, Digital Signal Processing. To begin with CORDIC algorithm [1] is changed over into equipment so it was confronting a few issues like scale consider, tedious and so forth. In CORDIC algorithm numerous change is done yet at the same time it confronting numerous issues so with respect to future degree this CORDIC processor require numerous alteration.

As we probably am aware is available time each mixed media and aviation based application is require quick preparing unit. We likewise know whether any framework is finished in view of General reason processor so proficiency of the entire framework will be decrease. For application detail there is need of committed application particular processor. So here for the aviation and sight and sound application which depends on trigonometric capacity. So for those sort of utilization there is need of particular process which is known as CORDIC processor.

1.1 Applications:

CORDIC utilizes straight forward move include operations for a few processing undertakings, for example, the count of trigonometric, hyperbolic and logarithmic capacities, genuine and complex increases, division, square-root computation, arrangement of direct frameworks, eigen value estimation, particular esteem disintegration, QR factorization and numerous others. As an outcome, CORDIC has been utilized for applications in differing zones, for example,

1. Signal and picture processing[20]

2. Communication and Wireless Technology [21]
3. Robotics and 3D designs
4. Aerospace Application.
5. Discrete Cosine Transform (Image Compression Unit).
6. Different DSP and DIP Filters.
7. Network Security [22]
8. Biometric [23]
9. Fuzzy Logic based Control System [24]
10. Multimedia Applications

On the off chance that we are discussing the working of CORDIC algorithm on those applications, so its followings:

1.1.1 Signal and picture handling: Image information which is prepared for correspondence for the most part experience with a few gauges of Digital Image Processing(DIP) pressure like JPEG (Joint Photographic Expert Group) , MPEG-x (Motion Picture Expert Group),... which starts significant segment in the present information focused world. Picture and video parade oversees mostly with the preparing unit for the most part known as pressure unit. Pressure unit is recognized on two sorts: Lossless: In this the picture pixels are not compacted or bargained. Lossy: With the assistance of some change, most extreme pressure is accomplished. Here DCT is an application which require cosine flag so on that application we can apply CORDIC calculation. Comparative DWT, Gabour filter require this calculation.

1.1.2 Discrete Cosine Transform (Image Compression Unit): Like different changes, the Discrete Cosine Transform (DCT) endeavors to de-relate the picture information. After de-connection each change coefficient can be encoded autonomously without losing pressure proficiency. This area portrays the DCT and some of its vital properties. Utilizing CORDIC algorithm we discover the change.

1.1.3 Multimedia application : In exhibit time, sight and sound has turned into an incorporated piece of each correspondence and contains information like message, pictures, recordings, as wellspring of data. This data constitutes an extensive stream of information into organize and along these lines influences the channel transmission capacity with more power necessity for hand-held gadgets. This restrains the interactive media application to end up easy to use, yet in-reality the greater part of utilizations for the most part manages picture and video information, since human are more pulled in towards visual (picture/video) information. CORDIC algorithm act a vital part for these applications.

1.1.4 Aerospace Application: This application require CORDIC algorithm in light of the fact that in this application we need to discover the movement of the aviation and that is conceivable by the count some trigonometric capacities.

1.1.5 Communication System: This system also need the CORDIC algorithm because in this application we have to calculate multiple trigonometric function which are use in the transformation of 3G and $g network

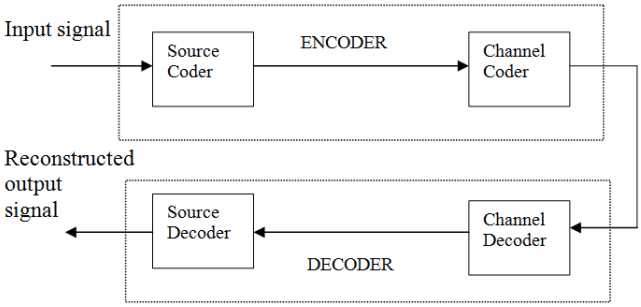

Fig. 1.1.1 Communication System

This paper is device in five section where, second one is literature review, third one is previous research issues, fourth one is future scope of CORDIC algorithm and last one is conclusion which conclude the whole paper.

II. LITERATURE REVIEW

First CORDIC algorithm is developed in 1959 in this the author proposed solution for trigonometric function and rotation, but this approach is facing with many problem like heavy hardware is require, constant term and scale factor is also a major problem [1]. An-other new approach is developed [2], in this paper author discuss some new factions like log, exponential and square root but this approach is also facing the same major problems scale factor, large hardware, constant term.

After the above methods a lot of improvement is done in CORDIC algorithm and many generalized technique are proposed for computing various functions like sine/cosine [3], [4], transforms [5], [6], exponents/logarithms, square roots, Eigen values [7] etc. During the past 50 years [8], there have been major advances in the design of the algorithm to overcome its major drawbacks. In [9], [10], [11] authors suggest the use of greedy search algorithm s for identifying the micro-rotations.

The efficiency of these approaches are based on the probability of rotation angle which is the main problem. implementation of it in terms of hardware is difficult and itis facing another major problem; variable scale factor. This factor is which reduces the advantage of latency. For reduction of scale factor problem low complexity technique is used and

the approach is Taylor series expansion which also has some draw backs. Range of convergence is a major problem ,for Reduction of this problem some new approach is suggested. The low complexity technique for eliminating the scale factor is the use of Taylor series expansion. The Scaling-Free CORDIC and modified scale-free CORDIC [12, 13] are techniques based on Taylor series approach. The former suffers from low range of convergence (RoC) which renders it unsuitable for practical applications, while the latter extends the RoC but them facing problem of constant scale-factor of $1/\sqrt{2}$.

The Scaling-Free CORDIC and modified scale-free CORDIC [14, 15] in [14] author suggested new approach for generation of sine/cosine, in this approach author eliminate a ROM and a large barrel shifter in the hardware implementation of the CORDIC system, but this approach suffers from low range of convergence (RoC) which render sit unsuitable for practical applications, in [15] author proposed one new technique for reduction of scale factor and number of iterations. They focused on Radix-4 Modified Booth Recording- Modification of CORDIC algorithm is Radix-4 modified booth recording, with this it keeps working without a scale factor and the corresponding hardware for data path can still be excluded, while enabling each iteration in pipeline stage which process two bits at a time from the vector. By this author achieve reduction in number of iterations. Constant multiplier- there is one constant term is produce which is $1/\sqrt{2}$ for this constant term in previous works extra hardware is require, so this can be avoided by constant multiplier which is reduce extra hardware problem. Domain Folding Elimination, In previous work angle of the scaling-free CORDIC kernel is between 0 to $\frac{\pi}{8}$ rad but in this work convergence range is between $-\frac{\pi}{2}$ to $\frac{\pi}{2}$, [14,15] also facing constant scale factor problem. In [18] here author propose the leading-one bit detection technique to identify the micro-rotations. The scale free design of the proposed algorithm is based on Taylor series expansion of the sine and cosine waves. In [19] author use the same approach but there they implement Hyperbolic CORDIC function.

A hardware efficient architecture for generating SINE and COSINE waves based on the CORDIC (Coordinate Rotation Digital Computer) algorithm . [16].this suggested an novel approach in this approach author uses leading-one bit detection technique to identify the micro-rotations. This process eliminate complex search algorithm . The scale free design of the algorithm is based on Taylor series expansion of the sine and cosine waves. This proposed algorithm is up to fourth order of Taylor series. Micro-Rotation Sequence Generation, in previous work for angle rotation ROM is required but by using of Micro Rotation Sequence Generation no any ROM require for storing the elementary angles of rotation. this proposed algorithm is also facing with many problems like increase in error, number of iteration increases, to reduce this problem another approach is suggested [17]. In this approach author using same technique of [16]but they convert that architecture in to parallel form they proposed CORDIC parallel rotator implementation to be maximally optimized for high performance with the lower cost in area-consuming.

2.1 Basic CORDIC Algorithm :

CORDIC ALGORITHM [1] The underlying principle of the CORDIC algorithm is based on two-dimension geometry. This algorithm operates either in or rotation or vectoring mode, following linear, circular or hyperbolic trajectories. We focus on rotation mode of operation in circular trajectory.

A. Conventional CORDIC Algorithm Let the vector Va[Xa, Yb] be derived by rotating the vector Vb[Xa Yb] through an angle Θ ,then:

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

Equation (1) forms the basic principle for iterative coordinate algorithm in CORDIC algorithm [1]. The key concept in realizing rotations using CORDIC is to express the angle of rotation Θ as an aggregation of pre-defined elementary angles defined as: where b is the word-length in bits. (2)

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

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

The RoC of the conventional CORDIC is [−99.9 deg, 99.9 deg] and using extra iter-ation step can be extended to the entire coordinate space. The rotation matrix Rp,in its original form is computation intensive; it requires computing sine and cosine functions with four multiplication and two addition operations. Factoring the cosine term simplifies the rotation matrix Rp (1) by converting the multiplication to shift operations, as tangent of the elementary angles is defined in negative powers of two(2). But the penalty paid is the introduction of the scale-factor which varies according to the cosine of the elementary-rotation.

As seen from (3), the scale factor Ki is independent of the direction of micro-rotation. With sequential execution of large number of iterations it tends to a constant, referred to as the gain of the CORDIC algorithm . The scale-factor is thus compensated either in the post or pre processing unit.

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

B. Scale Free Review:

Scaling-free CORDIC [12] was the first attempt to design scale-free coordinate CORDIC equations using Taylor series expansion. Here, the micro-rotations are restricted to anti-clockwise direction only, such that, any angle of rotation is represented as the algebraic sum of elementary angles. The sine and cosine functions are approximated to:

$$Sinai = 2^{-i}, Cosai = 1 - 2^{2i+1} \quad (4)$$

III. PROBLEMS IN PREVIOUS RESEARCH

As per past research there is heaps of issues are there on CORDIC algorithm and CORDIC processor. Those issues are, for example, Scale Factor Many calculations are confronting from Scaling component issue and which was tended to by numerous specialists consequently the dormancy has been ignored in the enhanced approach. Substantial equipment Many calculations require multiplier consider some are require consistent multiplier figure some require number of shifter rationale and vigorously snake and substractor. Latency[17] This approach lessens dormancy issue yet at the same time we can diminish inertness in term of equipment. These issues can even now resolve and these are most critical issues which need to determine in future since the present moment we are in the period of HD vision and 4G correspondence innovation where we require quick calculations.

IV. FUTURE SCOPE ON CORDIC ALGORITHM

CORDIC algorithm is useful in many application like Digital Signal Processing, Multimedia, Function Generation but still CORDIC processor faeces many problems which I discussed in research gap. So there are followings objectis which will resolve in future:

1. Reduction in Hardware complexity
2. Reduce Scale factor problem
3. Reduction in Latency.
4. Accuracy issues

So this is the future scope of this CORDIC algorithm which will give a new direction to the researchers.

V. CONCLUSION

According to current technology future is totally based on virtual world. Right now every thins is based on online like shopping, movies, images, educations eta. So for these type of application there is need of some other supportive system which are know as communitarian system, networking, Internet of things etc. now all these system is based on some mathematical functions which are well know as trigonometric function. Now trigonometric function is calculated by using of a interesting algorithm which is known as CORDIC algorithm . So in this paper basically we discuss about the previous existing technology and changes of technology by using of CORDIC algorithm . We also discuss the issues which is faces by CORDIC algorithm . CORDIC algorithm have lots of future scope. This algorithm will change the level of the application efficiency.

REFERENCES

[1] J. E. Volder, The CORDIC Trigonometric Computing Technique, IRE Trans. Elec-tronic Computing, Vol. EC-8, Sept 1959, pp. 330- 334.
[2] J. S.Walther, A unified algorithm for elementary functions, Spring Joint ComputerConf., 1971, Proc., pp. 379-385.
[3] S. F. Hsiao, Y. H. Hu and T. B. Juang, A Memory Efficient and High SpeedSine/Cosine Generator Based on Parallel CORDIC Rotations, IEEE Signal Pro-cessing Letters, Vol. 11, No.2, Feb-2004, pp. 152-155
[4] N. Takagi, T. Asada, and S. Yajima, Redundant CORDIC methods with a constantscale factor for sine and cosine computation, IEEE Trans. Computers, vol. 40, pp.989995, Sept. 1991.
[5] K. Maharatna and S. Banerjee, A VLSI array architecture for hough transform, Pattern Recognit., vol. 34, pp. 15031512, 2001.
[6] K. Maharatna, A. S. Dhar, and S. Banerjee, A VLSI array architecture for real-ization of DFT, DHT, DCT and DST, Signal Process., vol. 81, pp. 18131822,2001.
[7] Y. H. Hu and H. M. Chern, VLSI CORDIC array structure implementation ofToeplitz eigensystem solvers, in Proc. IEEE Int. Conf. Acoust. Speech, Signal Processing, NM, 1990, pp. 15751578.
[8] Pramod K. Meher, Javier Walls, Tso-Bing Juang, K. Sridharan, Koushik Ma-haratna, 50 Years of CORDIC : Algorithm s, Architectures and Applications, IEEE Transactions on Circuits and Systems I: Regular Papers, Vol. 56, No. 9, Sept.2009, pp. 1893- 1907.
[9] C. S. Wu and A. Y. Wu, Modified vector rotational CORDIC (MVR-CORDIC)algorithm and architecture, IEEE Trans. Circuits Syst. II, vol. 48, pp. 548561,June, 2001

[10] Cheng-Shing Wu, An-Yeu Wu and Chih-Hsiu Lin, A High- Performance/Low-Latency Vector Rotational CORDIC Architecture Based on Extended Elementary Angle Set and Trellis-Based Searching Schemes, IEEE Transcations on Circuits and SystemsII : Analog and Digital Signal Processing, Vol. 50, pg. 589601, No. 9,Sept. 2003.

[11] Y. H. Hu and S. Naganathan, An angle recoding method for CORDIC algorithm implementation, IEEE Trans. Computers, vol. 42, pp. 99–102, Jan. 1993.

[12] K. Maharatna, S. Banerjee, E. Grass, M. Krstic, and A. Troya, Modified virtually scaling-free adaptive CORDIC rotator algorithm and architecture, IEEE Trans. Circuits Syst. Video Technol., vol. 11, no. 11, pp. 14631474, Nov. 2005.

[13] K. Maharatna, A. Troya, S. Banerjee, and E. Grass, Virtually scaling free adaptive CORDIC rotator, IEE Proc.-Comp. Dig. Tech., vol. 151, no. 6, pp. 448456, Nov.2004.

[14] Leena Vachhani, K. Sridharan and Pramod K. Meher, Efficient CORDIC Algo-rithms and Architectures for Low Area and High Throughput Implementation, IEEE Transactions on Circuit and SystemsII: Express Briefs, Vol. 56, No. 1, pg.61-65., January 2009.

[15] F.J. Jaime, M. A. Sanchez, J. Hormigo, J. Villalba and E. L. Zapata, ”Enhanced scaling-free CORDIC ,” IEEE Trans. Circuits and Systems I: Regular Papers, Vol.57 No.7, pp. 1654-1662. July 2010.

[16] Aggarwal, S.; Meher, P.K.; Khare, K., ”Area-Time Efficient Scaling-Free CORDIC Using Generalized Micro-Rotation Selection,” Very Large Scale Integration (VLSI)Systems, IEEE Transactions on , vol.20, no.8, pp.1542,1546, Aug. 2012 doi:10.1109/TVLSI.2011.2158459

[17] Causo, M.; Ting An; Alves de Barros Naviner, L., ”Parallel scaling-free and area-time efficient CORDIC algorithm ,” Electronics, Circuits and Systems (ICECS),2012 19th IEEE International Conference on , vol., no., pp.149,152, 9-12 Dec.2012 doi: 10.1109/ICECS.2012.6463778

[18] Aggarwal, S.; Khare, K., "Hardware Efficient Architecture for Generating Sine/Cosine Waves," VLSI Design (VLSID), 2012 25th International Conference on , vol.,no.,pp.57,61,7-11Jan.2012

[19] Aggarwal, S.; Meher, P.K.; Khare, K., "Scale-Free Hyperbolic CORDIC Processor and Its Application to Waveform Generation," Circuits and Systems I: Regular Papers, IEEE Transactions on , vol.60, no.2, pp.314,326,Feb.2013

[20] Pravin Yadav “ Watermark Implementation & Application” Akriti 2011, Rajnanadgaon.

[21] Pravin Yadav “ Electronic Wairelss Technology Beyond 3G” Aicon 2011, Durg C.G..

[22] Pravin Yadav “ Network Security” Aicon 2011, Durg, C.G.

[23] Pravin Yadav “ Network Security using Biometric Applications” Akriti 2011, Rajnanadgaon.

[24] Pravin Yadav “ Fuzzy system for control applications” AICTE sponsored national Seminar on Morden trends in applied mathematics towards the application on fuzzy logic, 2010, Durg.