An Efficient and Fast Partial Template Matching Technique – Enhancement in Normalized Cross Correlation

M. Noorjahan, A. Punitha

Abstract: ***Template matching forms the basis of many image processing algorithms and hence the computer vision algorithms. There are many existing template matching algorithms like Sum of Absolute Difference (SAD), Normalized SAD (NSAD), Correlation methods (CORR), Normalized CORR(NCORR), Sum of Squared Difference (SSD), and Normalized SSD(NSSD). In general, as image requires more memory space for storage and much time for processing. The above said methods involves much computation. In any processing, efficiency constraints include many factors, especially accuracy of the results and speed of processing. An approach to reduce the execution time is always most appreciated. As a result of this, a novel method of partial NCC (PNCC) template matching technique is proposed in this paper. A block window approach is used to reduce the number of operations and hence to speed up the processing. A comparative study between existing NCC algorithm and the proposed partial NCC, PNCC algorithm is done. It is experimented and results proves that the execution time is reduced by 8 - 47 times approximately based on the various template images for different main images in PNCC. The accuracy of the result obtained is 100%. This proposed algorithm works for various types of images. The experiment is repeated for various sizes of templates and different sizes of main image. Further improvement in the speed of execution can be achieved by implementation of the proposed algorithm using parallel processors. It may find its importance in the real time image processing.***

Keywords: ***computer vision, template matching, partial matching, parallel processing, NCC, PNCC.***

I. INTRODUCTION

Computer Vision is a science that develops models and methods for understanding, analyzing, acquiring and processing images and generally high-dimensional structured data. Computer Vision is an inter-disciplinary field with strong links to Machine Learning, Optimization, Biology, Computer Graphics, and Human Computer Interaction. There has been a meteoric rise in computer vision field in the recent past. There is a huge development in the level of techniques used to accomplish certain computer vision tasks. These tasks include reconstructing the scene, motion analysis, image restoration and image matching [1].

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Computer vision comprises of many fields of computer science which simulates the working of the brain in various aspects such as recognizing, identifying and so on. Among many fields, image processing and artificial intelligence are the major ones. Accuracy and speed are the parameters often expected as an efficiency constraint in any processing. As image processing always consumes much computation and as the accuracy factor cannot also be compromised, many algorithms came in to existence. Every algorithm is unique and differs from one another. Though the aim of the algorithm is same, there is difference in the efficiency criteria i.e. image matching. It is a sub domain of computer vision thus focusing on finding a similarity or similarities between a group of images and finding an eventual match between them Like wise for the template matching which is an important component of computer vision, algorithms such as Sum of Absolute Difference (SAD), Normalized SAD (NSAD), Correlation methods (CORR), Normalized CORR(NCORR), Sum of the Squared Difference (SSD), and Normalized SSD(NSSD) are existing. These method uses the algebraic calculation heavily on the all the coordinate values between the main and the template image. Improvement in the processing speed needs some partial but efficient operations to be considered. It had been experimented and observed that processing a block of an image, which is the sub image itself is enough to locate the position of the template. Naturally Partial operation reduces the number of operations and hence the result can be arrived faster. It can also be done by skipping few blocks of the image in the target or the main image to speed up the process. It is dependent on the application, in which the matching is done.

The organization of this paper is as below. Section 1 describes the introduction part. It introduces the concept of template matching and partial template matching. Section 2 describes the related works with respect to the proposed method. Section 3 explains the proposed method. Section 4 deals with the experiment and results of the proposed method. Section 5 concludes the paper.

II. RELATED WORKS

Various related papers have been studied. The observation from various works have been referred and presented as below. The efficiency of the proposed algorithm is the improvement in 1 D template matching. For more robust template matching, the proposed method, has a new feature added for the vectors made in one dimensional algorithm [2][4].

BBS outperforms competing methods. The performance ranges 4:6% compared to BDS to over 30% compared to SSD [3]. In the fields such as ethnology, biology, various similarity measures in binary domain have been proposed. It is found that, these measures in the binary domain require less significant resources, when compared to gray domain measures in order to find the similarity among gray-level images, there is no necessity for multiplications, square, floating point and summing operations. [4]. In this paper, a method of template matching is proposed, namely Pyramid Sum of Absolute Difference (PSAD). The investigations show that there is a considerable improvement in execution time and accuracy of the process which results boost up in the overall performance. This is true for both noise and clean data [5]. This paper presents a review on binary similarity measures and proposes optimal template matching method whose execution time is less. This paper presents an application, which protects the Manga copy right, is a system in which bitwise operators and parallel processing are exploited, thus supporting fast and accurate optimal binary template matching. The performance of this system is better when compared to the FFT based template matching. The efficiency is measured in terms of high processing speed and maximum accuracy in detection. It is reported that this experiment results in an acceleration factors from 1.8 to 4 in comparison to FFT [6]. One of the popular methods among real-time object matching applications is Chamfer matching. In order to speed up the computation, various supplementary approaches have been recommended. One such recommendation is to simplify the description of the objects, so as to match them by representing using minimum number of points. As searching for these transformation parameters is very time-consuming, few algorithmic measures for speed up have been proposed. Borgefors [7] had suggested a hierarchical edge matching, which is based on a "coarse to fine" spatial resolution approach. In this paper NCC-based pattern search from an image, a very efficient algorithm for is proposed. Efficiency in computation achieved by, summing up the cross correlation obtained at various levels and then applying the winner update scheme. This helps to find the location with maximal NCC. The block partition order is adaptively determined by the sum of gradient magnitudes for each partitioned region in the template. For the NCC pattern search, the winner update scheme is applied in conjunction with the upper bound for the cross correlation derived from Cauchy–Schwarz inequality [8]. Here a new fast template matching method with partial skipping using sub-template is proposed. The method is as follows. we use sub-template to search point by point in the current searched window. The SAD calculated is compared with threshold. If some calculated SAD exceeds the threshold, then a new threshold equal to this SAD value is set and this point is one potential optimization location. After all the points in the current window are compared, we will get a minimum value and an optimization location, then skip the other points whose SAD is not the minimum value [9]. This study proposes parallel algorithms for TM problems using conventional search (NCC) and SI (PSO) techniques, and the experimental results show that the proposed PNCC and PPSO reduce the computational time considerably [10].

III. THE PROPOSED METHOD

The template matching is the process of exhaustive search to find the relation between the main image and its corresponding template. Whenever template matching is considered, the method of similarity measure Normalized Cross Correlation (NCC) is often adopted similarity measure. It is found to be robust with respect to variation in the photometric parameter.

$$R(x,y) = \frac{\sum_{x',y'}(T(x',y') \cdot I(x+x',y+y'))}{\sqrt{\sum_{x',y'} T(x',y')^2 \cdot \sum_{x',y'} I(x+x',y+y')^2}}$$

Hence the proposed partial template matching algorithm is considered as the variation of NCC which is PNCC. The method is as below. Given the original image I and the (sub image) template T, it is necessary to find or locate whether the template image T lies in the Original image I. If it is found, then the position at which the match occurred is recorded. It is also possible that, the same template image may be appearing at multiple instances in the main image. In that case the positions of the multiple occurrences are also recorded. In general, the images are represented in the form of a two-dimensional matrix as I (i, j). Its partial image or sub image may be defined as follows

- **a)** A row major one-dimensional array R (1, j)
- **b)** A column major one-dimensional array C (i, 1)
- **c)** A Two-dimensional array of any size S (i, j) [1<=i<=m, 1<=j<=n]

Where 'i 'is the row, 'j' is the column, m is the total number of rows and n is the total number of columns in the template image. Here the partial image of pattern **(a)** is considered. A sliding window technique is applied here, in order to find the similarity between the portion of a main image and the similar portion of the template image.

A. Workflow of the Proposed Method:

A sliding window approach is followed. Initially the template image and the original image dimensions are registered. A row vector from the template, TI is taken. It is slide over the entire image starting from the initial pixel I (1,1). The process is repeated starting from this position to I (n, n), till the entire image is covered. While the process is executing, if a match occurs, the position (i, j) is recorded. The steps of this method are as follows:

PNCC Algorithm

Step 1: Input the Image I (m, n) and the Template T (x, y). // I and T are image matrices

Step 2: Extract a portion of the image say PT (0, y) from the template T// PT is a row vector taken from T.

Step 3: From the Initial position of I, say I (0,0) to I (0, n)// throughout the first-row vector

Step 4: Slide the Partial Template PT on the Image I.

Step 5. Check for a match between the pixels of PT and I

Step 6: Repeat the process until the end of the row is reached.

Step 7: Record the position M (i, j,) where a match occurs.
Step 8: Repeat the process for the entire row of the image for multiple instances of the template match.
Step 9: Bound the position of MATCH with a rectangle to highlight the positions matched.
Step 10: If until the end of the image is reached, there is no match then display "The given template is not found in the image".

IV. EXPERIMENT AND FINDINGS

The experiment is done in PC, Processor speed 2.67 GHz, x64 based processor and RAM of 4.00 GB. It is repeated for various images and their templates. The Experiment was done by the proposed PNCC method and is found to be successful. It is proved to show better results than the full template matching namely NCC. The comparison of the results between the complete template matching and the partial template matching is given in **Table 1** and the result is show in **graph 1**. The accuracy is maximum in both the cases and the execution time is faster in partial method than the full template matching. The observations from **table 1** is as follows.

Case 1. Same size of the original image and various template sizes.

a. For image 2 the template size is bigger and the matching time is more.
   The ratio between the full and the partial NCC is approximately 35, which implies PNCC is 35 times faster than NCC.
b. For image 4 and 5 the template size is smaller and the matching time is less.
   The ratio between the full and the partial NCC is approximately between 8 to 10, which implies PNCC is 8 to 10 times faster than NCC.

Case 2. The image size is the biggest and the matching time is more.
The ratio between the full and partial NCC is approximately 46. This which implies PNCC is 46 times faster than NCC, which is the highest value in the table.
A check for a partial match is done initially. If a partial match occurs at this position, then there is possibility of entire template match. By this partial approach, the number of comparisons between the images is reduced. This naturally speed up the processing. In this method the partial approach is experimented for the existing Normalized Cross Correlation method.

V. CONCLUSION

Speed and accuracy of image processing plays a vital role in the computer vision algorithms. Hence a new method is proposed which uses the partial template matching approach. The proposed method is experimented. As expected, the experiment result proves to reduce the processing time or to increase the speed of operation. It also works with maximum accuracy. As speed is always a factor in image processing, the proposed method has been proved that it is multiple times faster than the existing method based on the image sizes and formats. From the experiment table it can be found that, the processing time is between to 5 to 12 seconds in the proposed method whereas in the existing method it is between 60 to 500 seconds. This is a huge figure in terms of comparison of processing speed. Furthermore, speed up can be achieved by implementing the same proposed algorithm in multiple processing parallel environment.

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APPENDICES

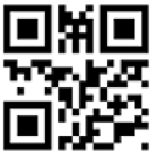
S. No	Main image	Template image	Output
1		 bmp	
2		 bmp	
3		 tif	
4		 jpg	
5		 Png	
6		 Tif	
7		 bmp	

Fig 1: List all the pictures and respective templates used and the output of the experiment.

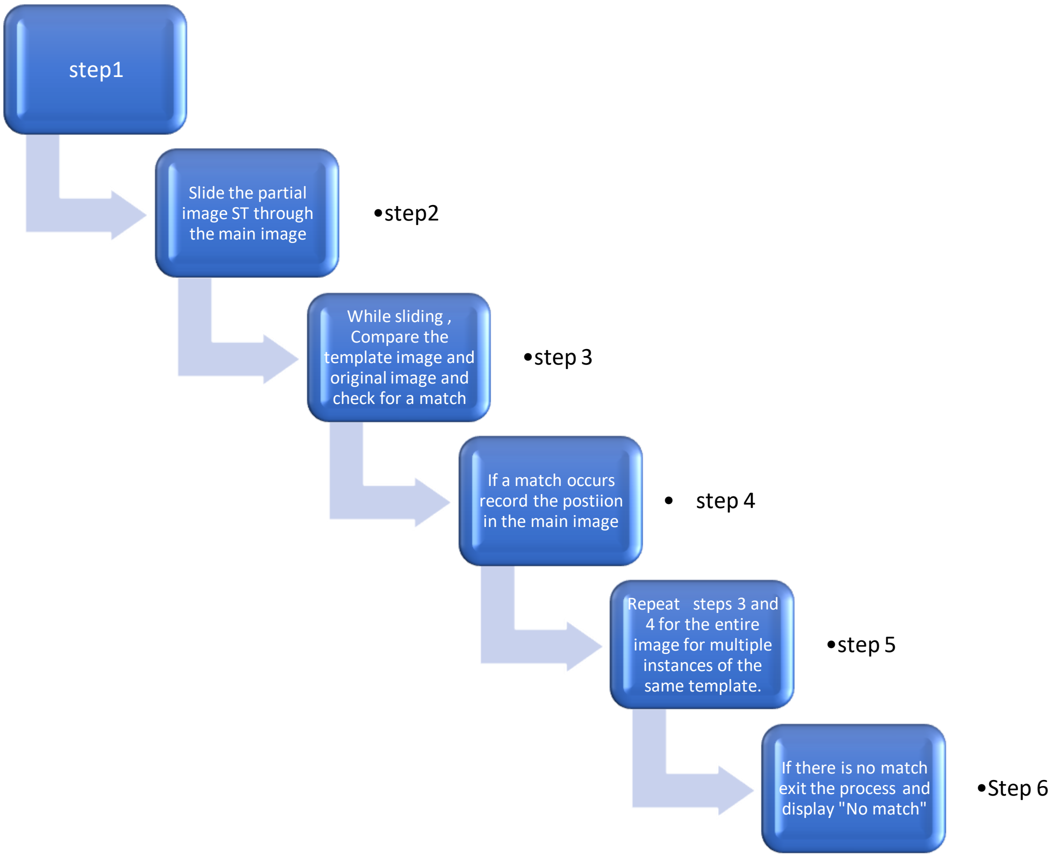
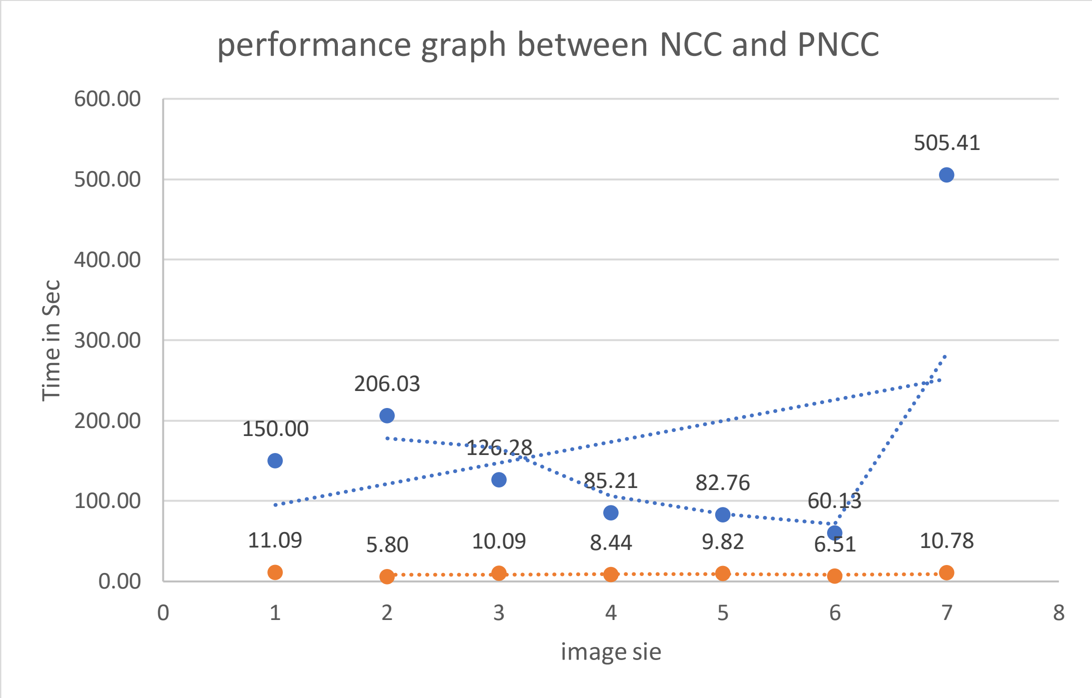


Fig 2: Pictorial representation of Work flow of the proposed algorithm.

Table 1: Experimental result for various types and sizes of images.

S. No	**Image**	**Image Size**	**Template Size**	**NCC**	**Partial NCC**	**ratio**
1	Benten (BMP)	103x86	32x31	150.00	11.09	13.53
2	Lena_grey (BMP)	100x100	46x25	206.03	5.80	35.53
3	Watch(center)(Tif)	136x111	17x17	126.28	10.09	12.52
4	Baloon Jpeg	100x100	17x19	85.21	8.44	10.09
5	QR Png	100x100	17x18	82.76	9.82	8.43
6	Watch Tif (button)	136x111	12x10	60.13	6.51	9.23
7	Benten (watch center)	199x172	23x21	505.41	10.78	46.88



Graph 1: Experimental result for various types and sizes of images.