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A Comparative Study for Skeleton Representation Methods Using Data Visualization

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ABSTRAT

Data visualization is a technique used to see the unseen information, that will help humanity to discover important things. There are many methods to represent the datasets, but data visualization is the best because it can preserve the information. Skeleton is used to analyse the visualization, thus data visualization gives efficient results. Comparison among well-known methods is the goal of this paper. The conclusion of this paper showed all the comparative results will be important for any further study. This study will use data visualization to discover novel dataset representations, which is the main goal of data visualization and can be useful in presenting necessary data.

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1. Introduction

Recently, data visualization is used find new representation to unseen datasets. The benefits of data visualization appear by helping humans to discover patterns, make deductions, and draw conclusions, where tables, charts, histograms, graphs, and other visualization tools are used to present data. Data visualization, on the other hand, uses entity relationship diagrams, trees, and data flow charts to make data easier to interpret. The Main Objective of Data visualization can be beneficial in displaying important data [1]. Photo-processing strategies are an important and fundamental part of the visualization pipeline. First, such strategies may be used in visualization packages that paintings on photo records to preprocess the input photos so as to improve their suitability for similarly filtering operations, as an instance via getting rid of noise. Imaging techniques also are beneficial for put up processing the pics output by means of visualization applications to help their readability, e.g., through adjusting comparison and luminance. Subsequently, photograph processing may be used as a part of the facts-enrichment component of the visualization pipeline on the way to extract higher-stage information content material from basic picture records. linked element detection and skeletonization operations fall inside this elegance Recall the visualization pipeline[2]. Skeletonization research can be

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broken down into three sections. First, if an object's segmentation is known, various algorithms can do skeletonization. In general, these algorithms are extremely sensitive to form distortions. This difficulty, however, can be addressed using new ways. Second, several standard image processing algorithms that use gradient intensity maps to construct skeletons can be used. They create skeletons even for things like the sky, sea, and other natural phenomena that generally require the presence of an item before being repressed. Finally, certain supervised learning algorithms necessitate ground truth skeletons of training photos in order to learn [3]. Thinning is the process of determining an object's skeleton Where The skeleton is a thinned-out version of a shape. The skeleton is simply an object's central line extraction as a result of thinning. A skeleton is a simple representation of an object's essential topological and shape information. Thinning is a crucial preprocessing step in the analysis and recognition of many image formats[4].

2. Data Visualization

Data visualization is a powerful and effective tool for quickly interpreting and comprehending data[5].Because most scientific studies generate large amounts of data, processing relies on the analytical side to concentrate on the most relevant parts of the data and extract the most usable information. Thus, data visualization with an acceptable data structure can be combined to obtain a reliable data fusion solution[6], where the relationship between the original data points is incomprehensible, visualization is a straightforward way to understand the high-dimensional space[7]. The dealing with different datasets is one of the challenges might face most of the researchers. Thus, data visualization is one of the best solutions to find best result with ability in preserving the information [8]. The conversion of high-dimensional data to a lower dimension while keeping the key properties of the original space is a common requirement in visualization[9].

2.1. Data visualization pipeline

The visualization process is made up of a series of processes, or operations, that manipulate the dataset generated by the research process to produce the required Visualization. On a practical level, this technique allows us to build visualizations by putting together reusable and modular data-processing procedures, similar to how other domains of software engineering do it. As a result of this modular decomposition, the visualization process may be thought of as a pipeline with numerous stages, each described by a different data processing operation. The input data "flows" through this pipeline, undergoing different transformations until the output Visualization are generated. Given this approach, the visualization pipeline refers to the sequence of data changes that occur during the visualization process[2].

Data importing, data filtering and enrichment, data mapping, and data rendering are the four stages of the visualization process. Figure 1 shows a schematic representation of them[8].

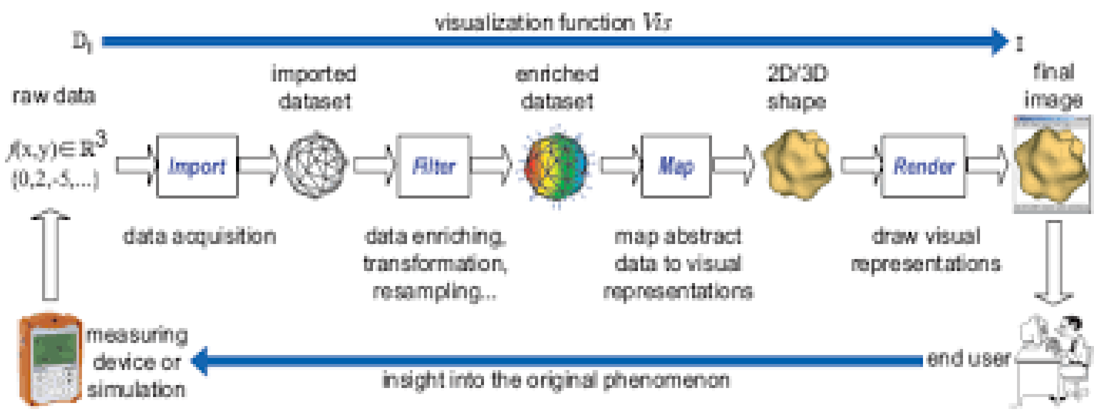

Figure (1): Data visualization pipeline[2]

2.2.The visualization pipeline stages

Data visualization require to five phases to processing any datasets in order to find satisfactory representation. The pipeline of data visualization are the set of actions that are done on data to produce meaningful visualization , These general actions can be applied to any datasets , regardless of which visualization pipeline was used to create it.

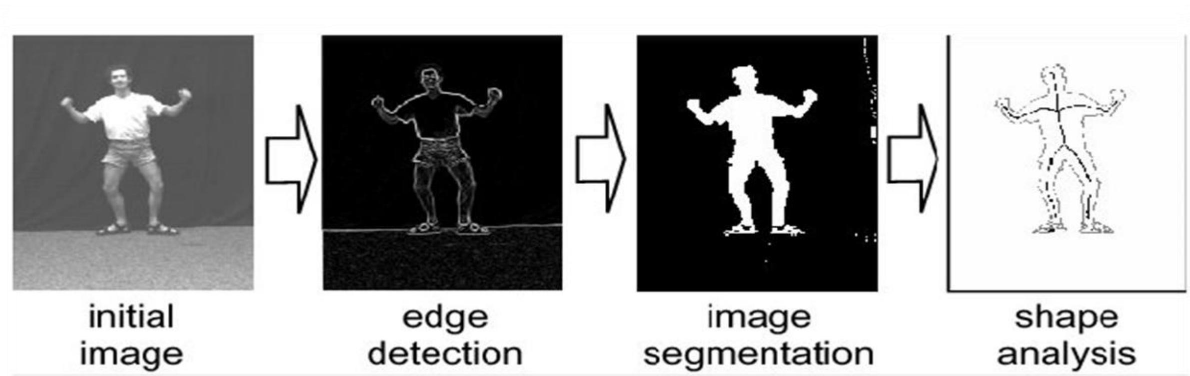

Figure (2): Shape Analysis pipeline[2]

2.3. Skeletonization

The concept of skeletonization embraced in photograph processing, computer vision, and images community became delivered by Blum inside the form of grassfire remodel of crisp or binary shapes. It simulates a fire propagation process where fireplace is concurrently set in any respect boundary factors of a grass discipline representing the object. fire propagates inwardly at a uniform velocity, and the skeleton is shaped at singularity or quench factors in which multiple hearth-fronts meet[10].

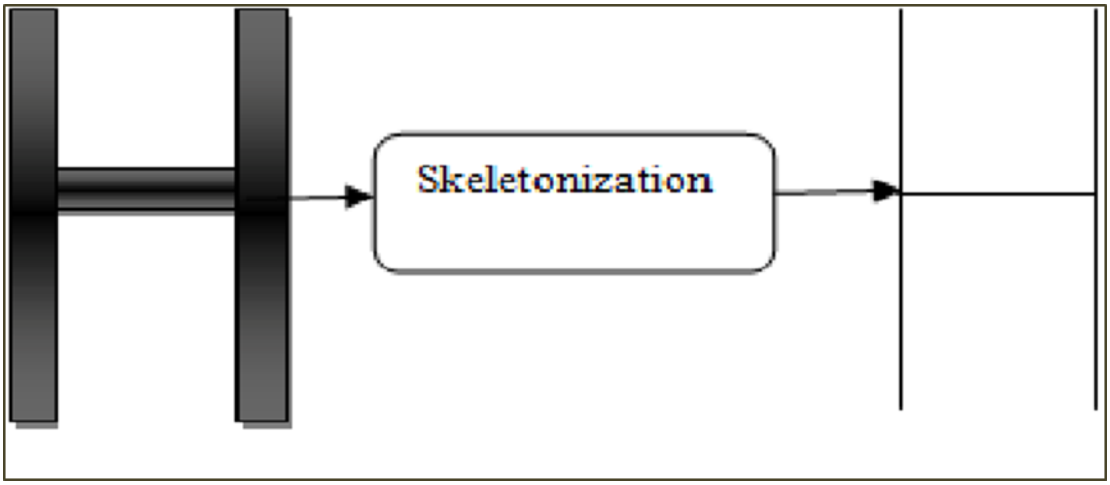

Figure (3):skeletonization concept[11]

2.4. Skeletonization Methods

Many skeletonization methods had been proposed, and there are three popular types of computing a skeleton from a discrete structure[12]:

– Distance map techniques that take into account the space to the boundary,

– Strategies based totally on the Voronoi diagram of factors at the shape boundary.

– Thinning techniques that use a morphological operator on a binary form.

Skeletonization (also known as thinning) is a popular method for recovering an object's skeleton by lowering its dimensionality. Skeletonization is a technique for reducing a binary image to a one-pixel-width representation that is useful in image processing and computer vision applications such as face or fingerprint recognition, detection of specular tumors on mammograms or blood vessels, natural street-object recognition, text identification, and human action recognition[13].

3. Thinning Algorithms

There are Many algorithms on this subject that have been published, and Most Important of them are Suggested for comparison in order to demonstrate and evaluate the efforts of other researchers in developing and implementing a variety of algorithms for various applications[14].

Hilditch Thinning Algorithm

The Hilditch thinning technique is frequently used in as an effective form of pre-processing. Hilditch's algorithm is available in two forms, one with a 4×4 window and the other with a 3×3 window, Where The 3×3 window variant is considered in this study . The goal of the thinning method for pixel p_0 is to determine whether it should be kept as part of the output skeleton or removed from the image [15].

P_9	P_2	P_3
P_8	P_1	P_4
P_7	P_6	P_5

Figure (4): MATRIX 3×3 REPRESENTS 8-NEIGHBOORHOOD OF PIXEL P_1

For deleting a pixel, the Hilditch algorithm checks four conditions:

1- $2 \leq B(P_1) \leq 6$ -----------------------------(1)

Where $B(P_1)=P_2+p_3+p_4+\ldots\ldots.+p_9$

2- $A(P_1) = 1$ -----------------------------(2)

where $A(p_1)$ Represented Sequence of 1 and 0

3- ($P_2 \wedge P_4 \wedge P_8 = 0$) or $A(P_2) \mathrel{!}= 1$ ---------------------------(3)

4- ($P_2 \wedge P_4 \wedge P_6 = 0$) or $A(P_4) \mathrel{!}= 1$ --------------------------(4)

Hilditch algorithm does not work on all styles. for example, it gets rid of staircase patterns nearly absolutely[16]. It is a very old and famous parallel-sequential thinning set of rules[17], and to keep two-pixel wide lines, prevent erosion, and maintain link Gray-scale photos were also employed with this technology[18]. The essential drawback of this algorithm is that it erases the diagonal and 2 × 2 styles[17].

3.2. Zhang-Suen thinning method(ZS)

The ZS algorithm is a parallel iterative algorithm with sub-cycles in each generation. The set of rules examines the 3×3 nearby neighbourhood of a pixel (determine) to decide if a pixel should be deleted. the first sub-cycle is used to delete southeast pixels. It deletes a pixel if the subsequent four situations are satisfied:

- $2 \leq B(P_1) \leq 6$ --------------------------(5)
- $A(P_1) = 1$ ---------------------------(6)
- $P_2 \vee P_4 \vee P_6 = 0$ ---------------------------(7)
- $P_4 \vee P_6 \vee P_8 = 0$ ---------------------------(8)

inside the second sub-generation, north-west pixels are eliminated which satisfies the following four conditions:

- $2 \leq B(P_1) \leq 6$ ----------------------------(9)
- $A(P_1) = 1$ ----------------------------(10)
- $P_2 \vee P_4 \vee P_8 = 0$ ----------------------------(11)
- $P_2 \vee P_6 \vee P_8 = 0$ ---------------------------(12)

This algorithm thins the virtual styles to 1-pixel width and executes speedy. however it suffers from some drawbacks: First, it is insensitive to small noise close to the northeast and southwest corners. Second, it doesn't keep eight-connectivity in all cases. Besides this, it completely removes styles including 2×2 squares. any other disadvantage is that the algorithm can also go away behind a few 2 -pixel extensive diagonal strains in the skeleton[16].

The ZS algorithm produces higher outcomes in terms of thinning rate, thinning speed, visual quality and connectivity maintenance, in this algorithm the problem of lack of connectivity is because of the entire removal of 2 × 2 square incurred in ZS and excessive erosion [19]. In Adaptive When compared to the Hilditch thinning algorithm, the Zhang Suen thinning algorithm is recognized for being a quick thinning method that is simple to build and may be used to attenuate a variety of digital patterns[20]. In This method, the shape topology and connectivity are preserved. In some circumstances, though, it displays two pixels in width[21]. Because the ZS technique is raster-based, it is computationally intensive[22].

3.3. Lu-wang thinning method(LW)

Lu and Wang (LW) proposed the algorithm to solve the problem of diagonal lines in the ZS rule set. It is a ZS update algorithm, which the first condition will be changed in the ZS algorithm with the condition: the sum of pixels with a value of 1 in the 8 neighbors must be between 3 and 6. LW rules must reduce diagonal lines correctly, but other lines do not receive a single pixel skeleton. [18]. There are distinct algorithms is been worked in which LW works well. However, in the case of handwritten numerals, ZS gives better outcomes with a maximum average result[20]. The LW algorithm presented an improved ZS algorithm, dubbed LW, to address the problem of excessive tilt line erosion by changing the neighbourhood state by modifying the region. However, the 2×2 square problem has an impact on this technique[23].

4 . Performance Measurement Parameters

If a one-pixel thick visualization created by a thinning algorithm is one pixel wide, the character must be precisely thinned, the character's curves must not be distracted, and there must be little noise at joints, among other things. In this study, the thinning rate (TR) is used to determine how much character is present. The additional pixels that remain after thinning are measured by Noise Sensitivity Rate(SR) [21], And The reduction rate is a percentage representation of the original image's pixel reduction rate(RR)[24].

RR = (((fps-fpt)/fps)*100) --------------------------(13)

Where fps = The number of pixels with a value of (1) in the original object (x), and fpt = The number of pixels with a value of (1) present in the object after processing (y).

SR = 1-[zertoone(y)/fps] --------------------------(14)

TR = (1 - (thin(y)/thin(x))); ---------------------------(15)

Where **Thin**(obj)= [(P_9*P_1*P_2) + (P_9*P_1*P_8) + (P_8*P_1*P_7) + (P_7*P_1*P_6) + (P_6*P_1*P_5) + (P_5*P_1*P_4) + (P_4*P_1*P_3) + (P_3*P_1*P_2)]/[((max(row,col)-1)*(max(row,col)-1))/4]

5. Experiments and results

In this study, we used a data set , each data with width: 213px; aspect-ratio: auto 213 / 178; height: 178px;a size of 9KB and dimensions of 369x305.

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Table(1) : Table of Results

Thininng algorithms	Sensitivity	Reduction	Thinning
Zhang Suen	0.9388	96.9412	0.9985
Hilditch	0.9264	97.0832	1.0000
Lu Wang	0.9287	95.9680	0.9946

From this performance analysis as showed in Figure (6), and Figure (7), it was concluded that Lu Wang gives the best result among all the mitigation algorithms in the thinning rate and the reduction rate as our results show. As for the sensitivity rate in Figure (5), the Hilditch algorithm shows the best result among the other thinning algorithms. In the data set, all algorithms give a result that is not as good as in the normal data set and does not give any guarantee that there is a single component after thinning.

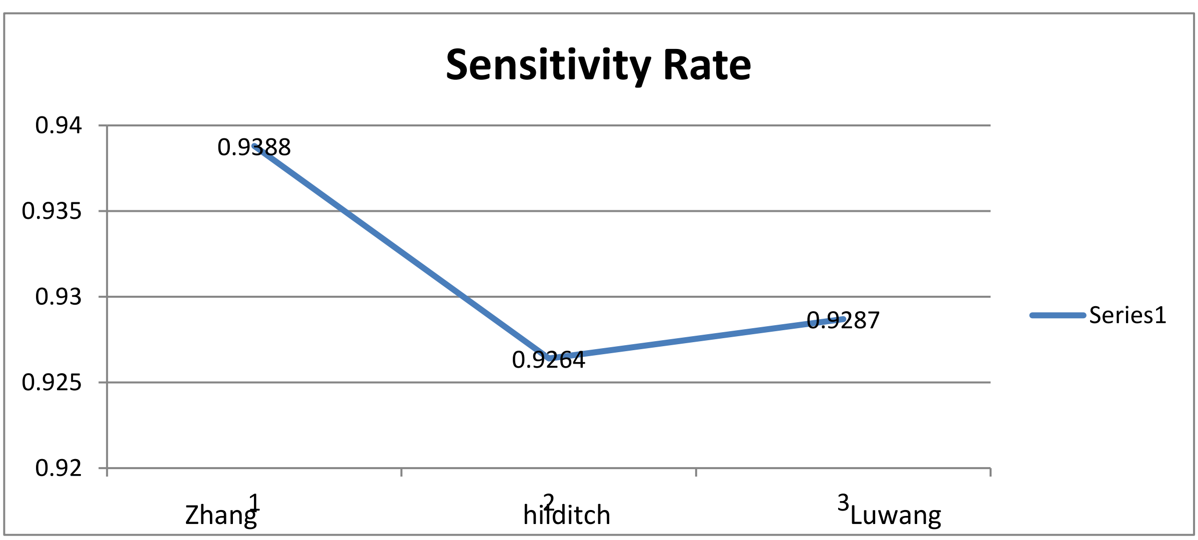

Figure (5) : diagram comparing thinning algorithms by sensitivity rate

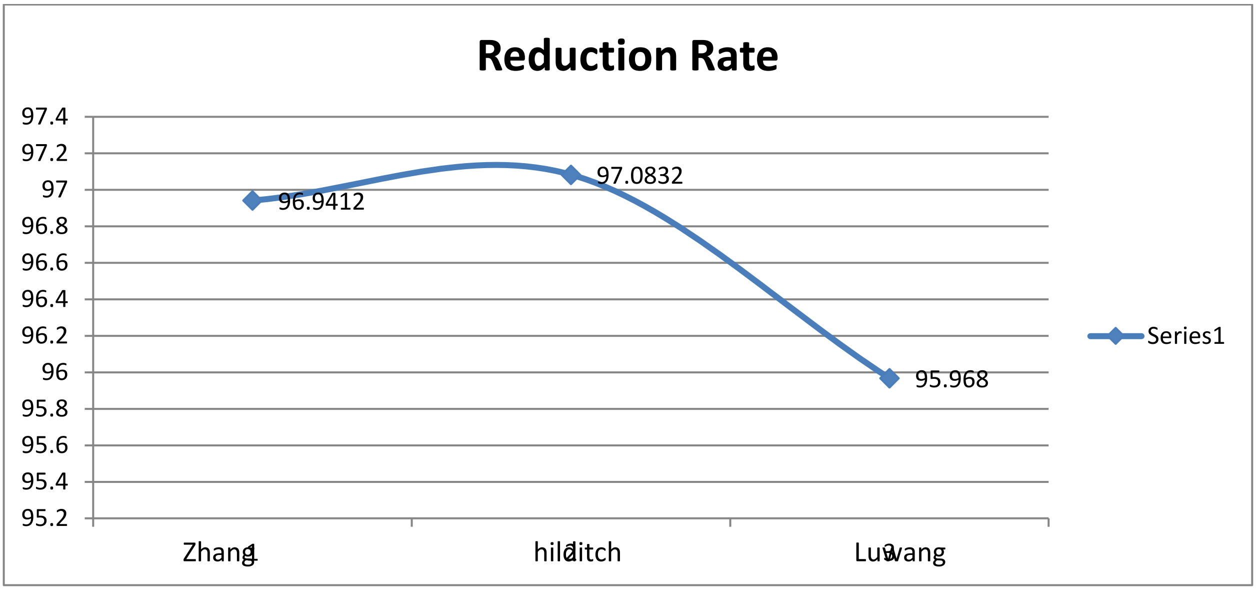

Figure (6): diagram comparing thinning algorithms by Reduction rate

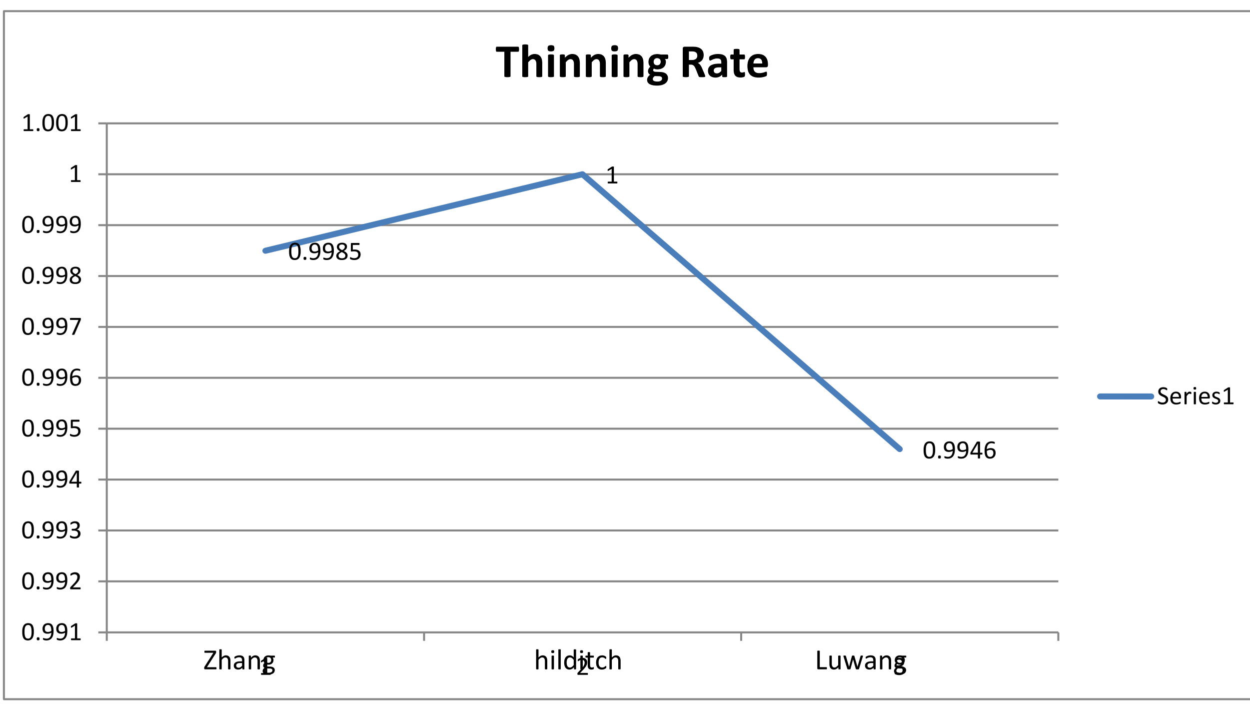

Figure (7): diagram comparing thinning algorithms by thinning rate

6. Conclusions:

In this paper, we used three well-knows methods that can be used to find the skeleton of any visualization. Data visualization is used to find the best one. the result showed some of the methods get good results according to their techniques in dealing with neighbour points. In future work, other more efficient and effective thinning algorithms will be proposed for representing data and proving its efficiency compared to known algorithms and different measurements.

References

[1] Stamatis Papadakis, Anastasios Kristofer Barianos, in-Game Raw Data Collection and Visualization in the Context of the "ThimelEdu " Educational Game, Communications in Computer and Information Science book series (CCIS, volume 1220), 2019.

[2] A. Telea, Data visualization, 2nd ed. Boca Raton: CRC Press, Taylor & Francis Group, 2015.

[3] Koteswar Rao Jerripothula , Jianfei Cai , Jiangbo Lu, and Junsong Yuan Object Co-skeletonization with Co-segmentation,2017.

[4] MATÚŠ GRAMBLIČKA1 , JOZEF VASKÝ1, Assoc. Prof., Slovak, COMPARISON OF THINNING ALGORITHMS FOR VECTORIZATION OF ENGINEERING DRAWINGS, Journal of Theoretical and Applied Information Technology 31st December 2016. Vol.94. No.2.

[5]Basaeir Y.Ahmad, Zainab H.Majeed and Safa A.Najim , Applying the visualization technique to solve the human color blindness,2020.

[6]Zainab H Majeed1 , Basaeir Y Ahmed2 and Safa A Najim, Specifying the visualizing type of multi-dimensional data, et al 2019 J. Phys.: Conf. Ser. 1294 032033.

[7]Safa A. Najim, Information visualization by dimensionality reduction: a review,2014.

[8]Hind Abdel Amir Sebti 1 *, Safa A. Najim2 , Hadeel S. Al Ali 3, Visualization the Bioinformatics of COVID-19 to find Satisfactory Drug, Advances in Mechanics Volume 9, Issue 3, 2021 Page 1512-1525.

[9] Najim, S., Lim, I., Wittek, P. & Jones, M. (2014). FSPE: Visualization of Hyperspectral Imagery Using Faithful Stochastic Proximity Embedding. IEEE Geoscience and Remote Sensing Letters, 12(1), 18-22. http://dx.doi.org/10.1109/LGRS.2014.2324631

[10] Punam K. Saha , Senior Member, IEEE, Dakai Jin, Student Member, IEEE, Yinxiao Liu, Gary E. Christensen, Senior Member, IEEE, and Cheng Chen, Fuzzy Object Skeletonization: Theory, Algorithms, and Applications, IEEE Transaction on Visulaization and computer graphics, VOL. 24, NO. 8, AUGUST 2018.

[11] Prof. Gulshan Goyal1 and Ritika Luthra2, Skeleton Generation for Digital Images Based on Performance Evaluation Parameters, Vol.9, No.2 (2016), pp.47-58.

[12] Oleg Panichev Ciklum, Alona Voloshyna Ciklum, U-Net based convolutional neural network for skeleton extraction,2019.

[13] Debbie Honghee Ko*, Ammar Ul Hassan*, Saima Majeed* , and Jaeyoung Choi*,SkelGAN: A Font Image Skeletonization Method, J Inf Process Syst, Vol.17, No.1, pp.1~13, February 2021

[14] KHALID SAEED ∗, MAREK TAB ˛EDZKI ∗∗, MARIUSZ RYBNIK ∗∗∗, MARCIN ADAMSKI ∗, K3M: A UNIVERSAL ALGORITHM FOR IMAGE SKELETONIZATION AND A REVIEW OF THINNING TECHNIQUES, Int. J. Appl. Math. Comput. Sci., 2010, Vol. 20, No. 2, 317–335

[15] Ming Yin, Seinosuke Narita, Speedup Method for Real-Time Thinning Algorithm, DICTA2002: Digital Image Computing Techniques and Applications, 21--22 January 2002, Melbourne, Australia.

[16] Himanshu Jain, Archana Praveen Kumar, A Sequential Thinning Algorithm For MultiDimensional Binary Patterns, This article was submitted for review to the journal IEEE Transactions on Image Processing on 05/10/2017.

[17] Madhuri Yadav1 , Ravindra Kumar Purwar1 , Mamta Mittal2, Handwritten Hindi character recognition: a review, ISSN 1751-9659 Received on 22nd February 2017 Revised 22nd February 2018 Accepted on 12th June 2018 E-First on 5th July 2018 doi: 10.1049/iet-ipr.2017.0184 www.ietdl.org.

[18] Matúš Gramblička1, a, Jozef Vaský1, b, Thinning algorithms comparison for vectorization of engineering drawings, December 2016.

[19] Fathima Haseena1 , Roseline Clara, Performance Analysis of Iterative Thinning Methods using Zhang Suen and Stentiford Algorithm, International Conference on Advancements in Computing Technologies - ICACT 2018 ISSN: 2454-4248 Volume: 4 Issue: 2.

[20] Sanket B. Suthar1,1 , Rahul S. Goradia2 , Bijal N. Dalwadi3 , Sagar Patel1 , Sandip Patel1 ,Performance Scrutiny of Thinning Algorithms on Printed Gujarati Characters and handwritten Numerals, 15 February 2017.

[21] Bilal Bataineh, An Iterative Thinning Algorithm for Binary Images Based on Sequential and Parallel Approaches, January 2018.

[22] Liping Yang, Diane Oyen, Brendt Wohlberg, A Novel Algorithm for Skeleton Extraction From Images Using Topological Graph Analysis,2019.

[23] N. Neelima et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 981 032005, Rank based Approach for Extracting Unit Pixel Width Skeleton, 2020.

[24] Navjot Mann1 , Parminder Singh2, Medial Axis Transformation based Skeletonzation of Image Patterns using Image Processing Techniques, International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064, Volume 1 Issue 3, December 2012.