

ISBN 978-1-7281-3832-9

**isemantic**  
International Seminar on Application for Technology of  
Information and Communication  
**2019**

**PROCEEDINGS**

# PROCEEDING

**INDUSTRY 4.0;  
RETROSPECT  
PROSPECT  
AND CHALLENGES**



**21–22  
September  
2019**  
Universitas  
Dian Nuswantoro  
Semarang

**isemantic**  
International Seminar on Application for Technology of  
Information and Communication  
**2019**

ISBN 978-1-7281-3832-9

Technically Supported by:



Listed in  
**ifory**

Organized by:



# PROCEEDINGS

2019 International Seminar on Application for Technology of  
Information and Communication  
(iSemantic)

**Industry 4.0: Retrospect, Prospect, and Challenges**

September 21<sup>st</sup> – 22<sup>nd</sup>, 2019  
Universitas Dian Nuswantoro  
Semarang, Indonesia

ISBN: 978-1-7281-3832-9  
IEEE Catalog Number: CFP19CUE-ART

# COPYRIGHT

## **2019 International Seminar on Application for Technology of Information and Communication (iSemantic)**

Copyright© 2019 by the Institute of Electrical and Electronics Engineers, Inc. All right Reserved

### **Copyright and Reprint Permission:**

Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law, for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

Other copying, reprint, or reproduction requests should be addresses to IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE Catalog Number: CFP19CUE-ART  
ISBN: 978-1-7281-3832-9

Additional copies of this publication are available from  
Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
+1 845 758 0400  
+1 845 758 2633 (FAX)  
email: [curran@proceedings.com](mailto:curran@proceedings.com)

## TABLE OF CONTENT

Paper ID	Paper Title	Page
1570537343	Evaluation of Feature Extraction TF-IDF in Indonesian Hoax News Classification	1 - 6
1570542590	Classification of Troso Fabric Using SVM-RBF Multi-class Method with GLCM and PCA Feature Extraction	7 - 11
1570542638	Performance Analysis of Face Recognition using Eigenface Approach	12 - 16
1570557685	Image Deblurring using Bi-directional Akamatsu Transform	17 - 22
1570558323	Real-Time Multiple Vehicle Counter using Background Subtraction for Traffic Monitoring System	23 - 27
1570556575	Secure Reversible Data Hiding in the Medical Image using Histogram Shifting and RC4 Encryption	28 - 33
1570548164	ShiftMod Cipher: A Symmetrical Cryptosystem Scheme	34 - 38
1570579794	Spread Embedding Technique in LSB Image Steganography based on Chaos Theory	39 - 44
1570547755	Neural Network based on GLCM, and CIE L*a*b* Color Space to Classify Tomatoes Maturity	45 - 50
1570549862	Tchebichef Image Watermarking based on PN-Sequence	51 - 55
1570550234	Wireless Sensor Network using Wireless Fidelity for Environmental Monitoring System	56 - 62
1570544753	New Method of Artificial Intelligence for Disaster Information Floods use Distributed Wireless Sensors	63 - 67
1570556640	Hybridization Fuzzy Simple Additive Weighting and Electre in Recipient Selection of Subsidized Rice	68 - 72
1570557166	Intelligent Spatial Logistics DSS for tracking and tracing in horticultural food security	73 - 77
1570557520	Classification of Twitter Contents Using Chi-Square and K-Nearest Neighbour Algorithm	78 - 81
1570557532	An Anatomy of Machine Learning Data Visualization	82 - 87
1570557560	Interlanguage of Automatic Speech Recognition	88 - 93
1570558225	Improvement of Collaborative Filtering Recommendation System to Resolve Sparsity Problem using Combination of Clustering and Opinion Mining Methods	94 - 99
1570558350	Predictive Demand Analytics For Inventory Control in Refined Sugar Supply Chain Downstream	100 - 104
1570558912	A Classification Method of Traditional Decor Pattern Based on Support Vector Machines Approach and Gray Level Co-occurrence Matrix with Mean and F-Score	105 - 109

Paper ID	Paper Title	Page
1570558963	Development of First-Person Shooter Games Using Human Voice Command and its Potential Use for Serious Game Engines	110 - 115
1570558973	Sentiment Analysis Of 'Indonesian No Dating Campaigns' on Twitter Using Naïve Bayes Algorithm	116 - 120
1570565253	Sentiment Analysis of Restaurant Review with Classification Approach in the Decision Tree-J48 Algorithm	121 - 126
1570566312	Visualizing 3D Objects Using Augmented Reality Application to Enhance Students Retention in Social Science Subject	127 - 132
1570566628	New Method For Classification Of Spermatozoa Morphology Abnormalities Based On Macroscopic Video Of Human Semen	133 - 140
1570566680	Mobile Cloud Learning System Using Laravel Framework and Android Studio Web View	141 - 144
1570567126	Preeclampsia Classification Modeling Based on Fuzzy Rules	145 - 151
1570568140	Ant System for Face Detection	152 - 156
1570568631	Estrous Cycle Prediction of Dairy Cows for Planned Artificial Insemination (AI) Using Multiple Logistic Regression	157 - 162
1570569000	Text Difficulty Classification Based on Lexile Levels Using K-Means Clustering and Multinomial Naive Bayes	163 - 170
1570569383	Performance Analysis of Hierarchical Process Model	171 - 177
1570569420	Determination of Hospital Rank by Using Analytic Hierarchy Process (AHP) and Multi Objective Optimization on the Basis of Ratio Analysis (MOORA)	178 - 183
1570569427	A Communication Aid System for Deaf and Mute using Vibrotactile and Visual Feedback	184 - 190
1570569429	Determine Types of Indonesian Hospital by Criteria-based Proses Model, K-means Cluster, and Hierarchical Average Linkage	191 - 195
1570569436	Clustering Methods Based on Indicator Process Model to Identify Indonesian Class Hospital	196 - 201
1570569444	Time Performance Evaluation of Agile Software Development	202 - 207
1570569447	Detection of Bottleneck and Social Network in Business Process of Agile Development	208 - 213
1570569452	Detecting Bottleneck and Fraud in Agile Development by using Petri net Performance and Trace Clustering	214 - 218
1570569491	Usability Evaluation Using GOMS Model for Education Game "Play and Learn English"	219 - 223
1570570379	Simulation of Agent-Based and Discrete Event for Analyzing Multi Organizational Performance	224 - 229
1570573663	Comparison Method in Emotion Speech Recognition and Classification	230 - 235

Paper ID	Paper Title	Page
1570575236	Comparison of Skewness Normalization Methods on Document of Javanese Manuscript	236 - 240
1570575907	Face Recognition Using Local Binary Pattern Histogram for Visually Impaired People	241 - 245
1570577929	Design and Implementation of Smart Advertisement Display Board Prototype	246 - 250
1570579212	Javanese Gender Speech Recognition Using Deep Learning And Singular Value Decomposition	251 - 254
1570579293	The Application of RPG Game "Hello Counselor" to Support Students' Self-Study about Simultaneous Linear Equations	255 - 259
1570579456	Short Term Prediction on Bitcoin Price Using ARIMA Method	260 - 265
1570579706	Development of Test Environment Platform for IMA using COTS components	266 - 271
1570579860	Diabetic Retinopathy Grade Classification based on Fractal Analysis and Random Forest	272 - 276
1570579965	Angular Detection System on Goal Frame using Image Processing with LabVIEW	277 - 281
1570582380	An Interpretive Structural Modeling (ISM) approach for Institutional Development in the Central Java Potato Agroindustry	282 - 287
1570552848	Development of Mobile e-Participation System to Enhance e-Government Performance	288 - 293
1570557280	Developing Maturity Levels of IT Governance for Family Businesses	294 - 299
1570569279	The Affect of Technical Familiarity and Consumer Protection Behavior in Using E-Commerce as Platform Online Shopping	300 - 305
1570572434	Analysis & Implementation of Six Sigma Methods: The Case of PPSDM Migas Cepu	306 - 312
1570558353	Mobile Monitoring of Toddler's Body Temperature For Early Effort of Febrile Seizure Prevention	313 - 318
1570570583	Human Emotion Classification Based on EEG Signals Using Naïve Bayes Method	319 - 324
1570579873	Design and Implement an Application for Determination of Blood Chemistry	325 - 330
1570547222	Classification of Ship Based Automatic Identification System Using k-Nearest Neighbors	331 - 335
1570554647	Hardware Implementation of an Asymmetrical 11-Level Inverter with Automatic Boost Charge Control in PV Applications	336 - 341
1570555558	Analysis of Reactive Routing Protocols in MANET Based on Quality of Service	342 - 345
1570556191	Data Acquisition in Determining Lab Work Assesment Ranking Using Fuzzy Analytic Hierarchy Process (FAHP)	346 - 353
1570557235	MPPT Design For Photovoltaic System Under Partially Shaded Condition	354 - 359



Paper ID	Paper Title	Page
1570544249	VLC-UM: A Novel Virtual Laboratory using Machine Learning and Artificial Intelligence	360 - 365
1570557743	Topographic Data Acquisition of The Heroes Monument using Quad-Rotor Unmanned Aerial Vehicle (UAV)	366 - 371
1570557809	Performing Robot's Head Motion Simulation by Human Head Movement Activity Using 3D-AAM	372 - 376
1570557945	Performance Shunt Hybrid Power Filter and Line Reactor Methode for Harmonic Mitigation in 5 Dominant Order IHD-V	377 - 382
1570557949	Performance Analysis of Vertical Wind Turbine Type Savonius-L Based on Wind Speed, Rotation Speed, and Number of Blades	383 - 388
1570544644	Face Emotional Detection using Computational Intelligence based Ubiquitous Computing	389 - 393
1570558436	Performance Analysis LEACH Based Genetic Algorithm In Wireless Sensor Network	394 - 399
1570558675	An Application Real-time Acquiring EEG Signal from Single Lead Electrode to Recognize Brain Activity using Neurosky Sensor	400 - 404
1570558720	The Design of Low-Cost Patient Monitor Based on Computer	405 - 410
1570558755	Performance Evaluation of ACO-MPPT and Constant Voltage Method for Street Lighting Charging System	411 - 416
1570558761	The Measuring of Vital Signs Using Internet Of Things Technology (Heart Rate And Respiration)	417 - 422
1570558776	Design of Cardiac Monitor for Multi Parameters	423 - 428
1570558780	A Portable Vital Sign Device with Liquid Crystal Display TFT Touchscreen	429 - 433
1570558975	Survey of Methods in the Spatial Domain Image Steganography based Imperceptibility and Payload Capacity	434 - 439
1570559600	The Comparative Analysis Between LEACH and DEEC Based on The Number of Nodes and The Range of Coverage Area	440 - 445
1570567253	Comparison of Fetal Heart Rate Detection Using Envelope Extraction and Shannon Energy	446 - 449
1570569047	Implementation of Plant-Wide PI-Fuzzy Controller in Tennessee Eastman Process	450 - 454
1570571908	Design and Implementation Bidirectional DC-DC Converter for Load Sharing and Charging Battery	455 - 459
1570573025	Finding Location of Transformer that overload using IoT Method	460 - 464
1570573066	Implementation of AC-AC Voltage Controller for Reduce Transient Current at Three Phase Induction Motor	465 - 470
1570573081	Real-Time Battery Monitoring and Fault Identification Application on Electric Scooter	471 - 475

Paper ID	Paper Title	Page
1570573245	Hardware Implementation of Sensorless BLDC Motor Control To Expand Speed Range	476 - 481
1570573297	SPWM Volt/Hz Based Speed Control of Induction Motor	482 - 486
1570573344	Hardware Implementation of Simplified VVVF Inverter for Induction Motor Based on SVM	487 - 491
1570573375	Implementation Buck-Boost Converter using PI Control for Voltage Stability and Increase Efficiency	492 - 496
1570573581	Implementation of Fuzzy Logic Control for Soft-Starting Method Brushless DC Motor at Electric Bicycle	497 - 502
1570575460	Heartbeat and Blood Pressure Monitoring System Wireless-Based	503 - 506
1570575819	Development of BTS Gate Smart Key Based on Internet of Things	507 - 512
1570578321	Determining Qibla Direction using al-Biruni's First Method from Kitab Tahdid Nihayat al-Amakin with The Implementation Based on Board Arduino MCU, GPS Module, and Digital Compass	513 - 518
1570547753	Evaluation Of Histogram Of Oriented Gradient (HOG) And Learning Vector Algorithm Quantization (LVQ) In Classification Carica Vasconcellea Cundinamarceensis	519 - 522
1570580001	PWM Control Strategy of Regenerative Braking to Maximize The Charging Current into The Battery in SRM Drive	523 - 527
1570557757	The Concept of "Anti-Hoax Intelligence (CI1)" Inside Social Media using Ken Watanabe & Johari Window Methods	528 - 535
1570558774	Altruism and Egoism in e-WOM: The moderating effect of Facebook perceived ease of use	536 - 541
1570558917	Translation Learning Enrichment Using Smart Application Creator 3.0: An Attempt to Design a Mobile Application in Translation for Tourism Purpose Course	542 - 547
1570573424	Translation Course 4.0 Redefined: Enhancing Work Efficiency and Meaning Accuracy Using AEGISUB 3.2.2 Subtitling Software	548 - 553
1570574947	Google vs. Instagram Machine Translation: Multilingual Application Program Interface Errors in Translating Procedure Text Genre	554 - 558
1570579955	Influence of Augmented Reality on the Achievement and Student Learning Independence	559 - 563
1570548631	Applying Customer Loyalty Classification with RFM and Naive Bayes for better Decision Making	564 - 568
1570556869	Applying Innovative LMS with Gamification Framework	569 - 573
1570569401	Determination of Hospital Rank by Using Technique For Order Preference by Similarity to Ideal Solution (TOPSIS) and Multi Objective Optimization on the Basis of Ratio Analysis (MOORA)	574 - 578



# Tchebichef Image Watermarking based on PN-Sequence

Andik Setyono  
Department of Informatics Engineering  
Dian Nuswantoro University  
Semarang, Indonesia  
andik.setyono@dsn.dinus.ac.id

De Rosal Igantius Moses Setiadi  
Department of Informatics Engineering  
Dian Nuswantoro University  
Semarang, Indonesia  
moses@dsn.dinus.ac.id

**Abstract**— In the modern era, sharing and distribution of digital data over the internet have increased significantly. This makes it easier to duplicate data, even though not all data may be duplicated without permission because it has copyright. Image watermarking is the most popular solution for protecting copyright in digital images. The way to embed copyright is generally by transforming the image into the frequency domain, which in this way proves that copyright embedding is more resistant to various attacks. Discrete Tchebichef transform (DTT) is a domain transformation that has advantages in computational speed, is low in complexity and can reduce memory usage and has properties similar to discrete cosine (DCT) transformations. DCT is the most popular transformation to be developed, wherein one of the studies using the PN Sequence combined with DCT at the time of the embedding process, it was proven to improve imperceptibility quality. However, the increase in imperceptibility generally makes watermark resistance less. Based on this hypothesis the research aims to implement a watermark embedding scheme with PN Sequence on DTT to obtain a watermarking scheme that produces better imperceptibility and keeps the quality of watermark resilience against various manipulations. Based on the results of testing and measurement using PSNR, it is evident that the imperceptibility quality rises around 3dB. Watermark resistance testing for attacks also proves that using the proposed scheme but can maintain watermark resistance.

**Keywords**— *Tchebichef, Copyright Protection, Spread Spectrum, Imperceptibility, Image Watermarking*

## I. INTRODUCTION

The traffic of transmission, distribution, and sharing of multimedia data in the cyber world is increasingly dense in today's modern era. This is due to a revolution in the way manual data is stored using hard files into digital file storage. So that the security of digital files in cyberspace becomes the main requirement. Various methods have been carried out by several security techniques such as cryptography, steganography, watermarking to become a popular technique used, and even combined to improve security[1]–[6]. Multimedia files such as images, audio, and videos are some files whose numbers continue to increase and not a few of these files are copyrighted. Of the three methods, watermarking is the most important role to maintain copyright security[1].

Research on digital watermarking has been done a lot, especially in image media. Several discrete domain transformation methods have been proposed, such as Fourier (DFT), Cosinus (DCT), Wavelet (DWT), Tchebichef (DTT), and Singular Value Decomposition (SVD) [2], [7]–[11]. Of the four transformations, Fourier is the oldest transformation, while Cosinus and Wavelet are the most popular transformations applied in various watermarking researches.

Unlike the three, Tchebichef's transformation is not as popular and has not been widely developed in image watermarking research. DTT is also actually not a new transformation model, in some studies, it has even proven to have several advantages in computational speed, low complexity and can reduce memory usage, so this transformation has a greater chance to be examined again and applied to image watermarking. Some studies such as [1], [2], [7], [8], [12]–[15] have applied Tchebichef's transformation to image watermarking, its advantages have also been proven and even proven that DTT has properties similar to DCT, even with some modifications and combinations methods can solve imperceptibility and robustness trade-off problems.

Imperceptibility and robustness are the two most important aspects in image watermarking, in addition, there are also several other aspects such as security and capacity. But imperceptibility and robustness are the two most studied things. Generally, imperceptibility and robustness are two contradictory things, where if imperceptibility increases, robustness will decrease, and vice versa. This is the biggest challenge in image watermarking research. Some image watermarking research uses Tchebichef transformation as in [1], [2], [8] has successfully solved this problem by combining it with other methods such as color space conversion and edge detection, Psychovisual Threshold, and combining with singular value decomposition (SVD). Other techniques such as PN-Sequence can also be used so that copyright embedding spreads, so it can also solve this [4]. So in this research the PN-Sequence technique was implemented and analyzed the results of the tradeoff in these two aspects.

## II. RELATED WORK

Tchebichef's transformation has been applied in several image watermarking studies, as in the research of Ernawan et al.[8]. In his research Tchebichef transformation was applied based on small blocks with dimensions of  $8 * 8$  pixels. From the results of the transformation of each block the coefficient (1.1), (2.0), and (0.2) are selected. From the three coefficients, one of the coefficients is chosen to insert a watermark based on random numbers generated from the PN generator. The strength of the watermark insertion can be adjusted using the threshold values of 0.25, 0.5, 0.75 and 1. Using this scheme the PSNR value is around 45dB up to 57dB, depending on the threshold value. This scheme is also resistant to various attacks.

Other research was also conducted by Setiadi et al.[7], in his research the performance of DTT and DCT was tested and analyzed. This is done because many of the references contained in his research say that these two transformations have similarities, then a performance test is performed. Performance tests are carried out by measuring the output

quality (imperceptibility) and resistance to various attacks. Based on the results of the test it was found that Tchebichef's performance was quite identical to DCT, a striking difference was the superiority of Tchebichef's transformation in terms of computational speed.

Najih et al. [4] proposed a combination of PN Sequence and DCT for information hiding. In his research, it has been proven that the use of PN Sequence to insert a watermark can make watermarks more spread throughout the image so that the watermarked image looks better. This is evidenced by the PSNR value increasing around 3dB. Another research conducted by Ernawan [2], has developed a scheme found in research [8]. The Tchebichef transformation is applied to 24-bit imagery by converting to the YCoCg-R color space and using edge detection. In this way better results are obtained in terms of quality and resistance to attacks.

From some related research above, in this research, the image watermarking scheme using Tchebichef's transformation in research [7] was developed with a combination of PN Sequence on the insertion scheme to improve the image quality of the watermark, as in the research conducted in [4]. This is done because of the similarity of the Tchebichef transformation with DCT. Based on this hypothesis, the watermark insertion scheme using the PN Sequence-based Tchebichef transformation should improve the quality of the watermarking scheme using the Tchebichef transformation.

### III. PROPOSED METHOD

Image watermarking has two main processes, namely embedding and extraction. At the embedding stage, three inputs are needed in the form of container images, watermark images, and PN keys. In more detail, the watermark insertion stages are explained in the flowchart presented in Fig. 1.

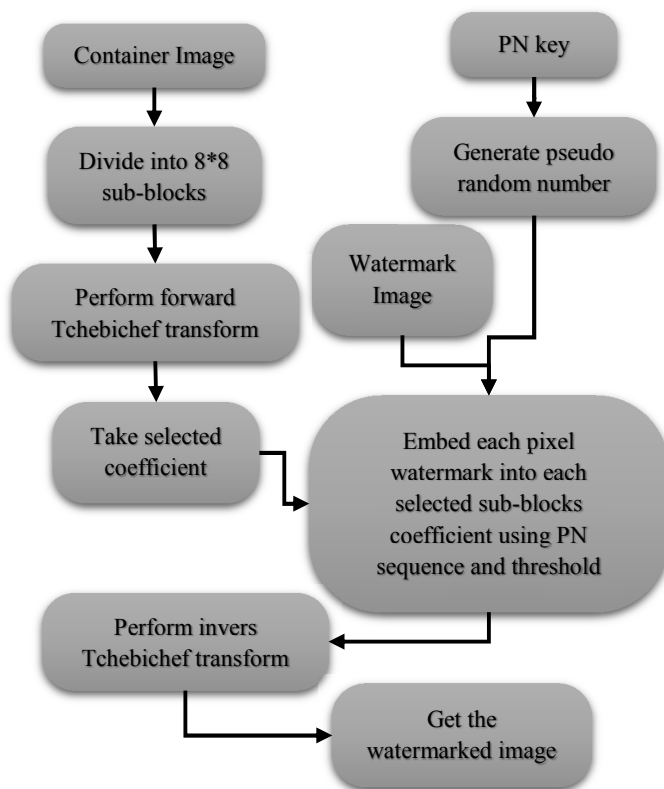


Fig. 1. Embedding proposed scheme

Based on Fig. 1 it appears that the Tchebichef transformation is carried out based on small sub-blocks with dimensions  $8 * 8$ . The  $8 * 8$  pixels dimension was chosen to be a standard dimension in the image transformation process in various researches [1], [2], [7], [8]. After the transformation in the sub-block, the spatial value of the image changes to the frequency value, the frequency value that is at the coefficient (0,0) is chosen to do the watermark embedding. Each coefficient (0,0) in the sub-block is filled with one-pixel watermark value. Where the embedding process is done based on random numbers generated by PN generators and PN keys. The embedding algorithm is shown in formula (1).

$$\begin{cases} M_{0,0} = T_{0,0} + (\alpha * W_{x,y}), PN = 1 \\ M_{0,0} = T_{0,0} - (\alpha * W_{x,y}), PN = 0 \end{cases} \quad (1)$$

Where T is the selected Tchebichef coefficient value, W is the watermark value, x and y are watermark pixel coordinates, M is the modified coefficient value after the watermark is embedded,  $\alpha$  is the watermark embedding threshold value.

After obtaining the modified coefficient value after pinned a watermark. Each frequency sub-block is returned to the spatial value by inverse transformation, then rearranged into the watermarked image. Furthermore, the quality of the watermarked image was measured using MSE and PSNR which can be calculated using formula (2) for MSE and formula (3) for PSNR.

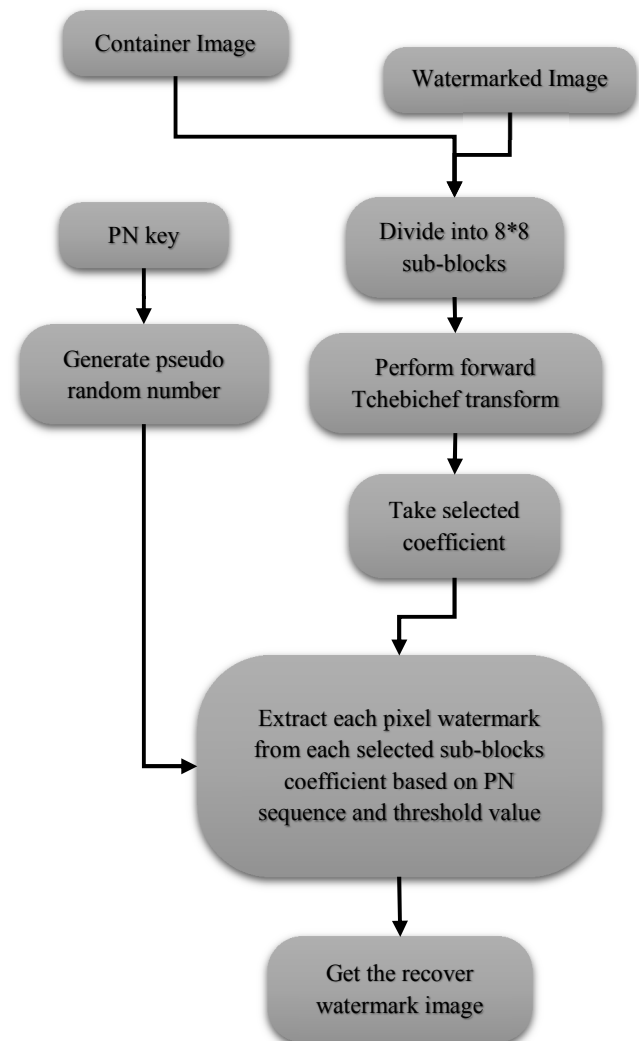


Fig. 2. Extracting proposed scheme

$$MSE = \sum_{w=0}^W \sum_{h=0}^H \|I(w, h) - I'(w, h)\| \quad (2)$$

$$PSNR = 10 \log_{10} \left( \frac{255^2}{\sqrt{MSE}} \right) \quad (3)$$

Where  $I$  is the image of the original container,  $I'$  is the watermarked image,  $w$  is the image width and  $h$  is the image height.

The MSE value that is getting closer to zero indicates that the error squared value is getting smaller, in other words, the watermarked image has good image quality. Conversely, the better the value of the PSNR must be greater. At least the PSNR value must reach 40dB so that it is included in the excellent quality category[5].

While the proposed watermark extraction stage is presented in Fig. 2. In the extraction phase, three inputs are also needed, namely the original container image, watermarked image, and PN key used during the embedding process. In the original image container, the watermarked image carried the same first three processes, namely dividing the image into sub-blocks of dimension  $8 * 8$ . Next, transform each sub-block with DTT. Then take the coefficient (0,0) in each sub-block. On the other hand the PN key is used to generate random sequence numbers for the extraction process. To retrieve the pixel value of a watermark image taken from the extraction process, formula (4) is used. Then each pixel is rearranged into a retrieved watermark.

$$\begin{cases} R_{x,y} = (W'_{0,0} - C_{0,0})/\alpha, PN = 1 \\ R_{x,y} = (C_{0,0} - W'_{0,0})/\alpha, PN = 0 \end{cases} \quad (4)$$

Where  $R$  is retrieved watermark image,  $W'$  is the watermarked image, and  $C$  is the original container image.

#### IV. IMPLEMENTATION AND RESULTS

At this stage, the first container image dataset is selected as shown in Fig. 3. The selected container images are standard test images that are widely used. This image has dimensions of 512 pixels wide and 512 pixels high with 8-bit depths.

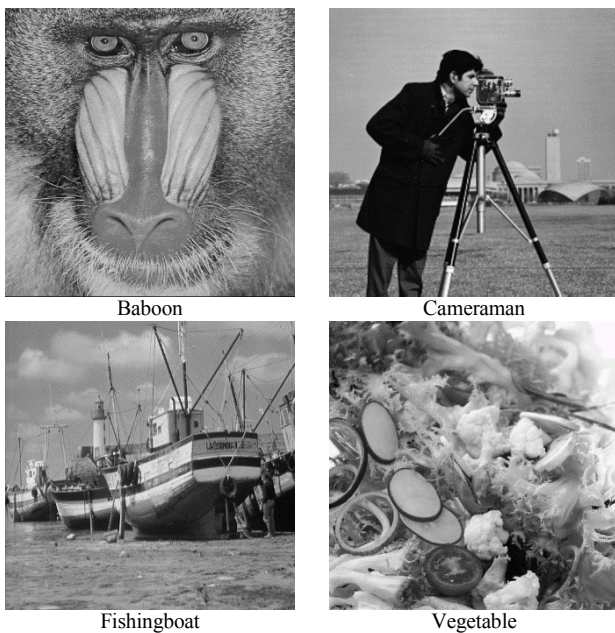


Fig. 3. Container image used



Fig. 4. Binary watermark image

Whereas for the watermark image used is presented in Fig. 4. Then for the embedding stage, first the container image is divided into  $N * N$  sub-blocks as described in the previous section. Each sub-block is transformed using two dimensions (2D) - forward DTT with the formula (5).

$$T_{bc} = \sum_{d=0}^{N-1} \sum_{e=0}^{N-1} r_b(d)r_c(e)B(d, e) \quad (5)$$

Where  $B$  is are original sub-block with  $d, e$  dimensions,  $T$  is transformed sub-block with  $a, c$  dimensions,  $a, c, d, e = 0, 1, \dots, N-1$ ,  $r_b(d)$  and  $r_c(e)$  is Tchebichef polynomial recursion calculation which is further elaborated in the formula (6) until (11).

$$r_0(d) = \frac{1}{\sqrt{N}} \quad (6)$$

$$r_1(d) = (2d + 1 - N) \sqrt{\frac{3}{N(N^2 - 1)}} \quad (7)$$

$$r_b(d) = (\Delta_1 d + \Delta_2)r_{x-1}(d) + \Delta_3 r_{x-2}(d), \quad (8)$$

$$x = 2, 3, \dots, N - 1$$

where:

$$\Delta_1 = \frac{2}{a} \sqrt{\frac{4a^2 - 1}{N^2 - a^2}} \quad (9)$$

$$\Delta_2 = \frac{1 - N}{a} \sqrt{\frac{4a^2 - 1}{N^2 - a^2}} \quad (10)$$

$$\Delta_3 = \frac{a - 1}{a} \sqrt{\frac{2a - 1}{2a - 3}} \sqrt{\frac{N^2 - (a - 1)^2}{N^2 - a^2}} \quad (11)$$

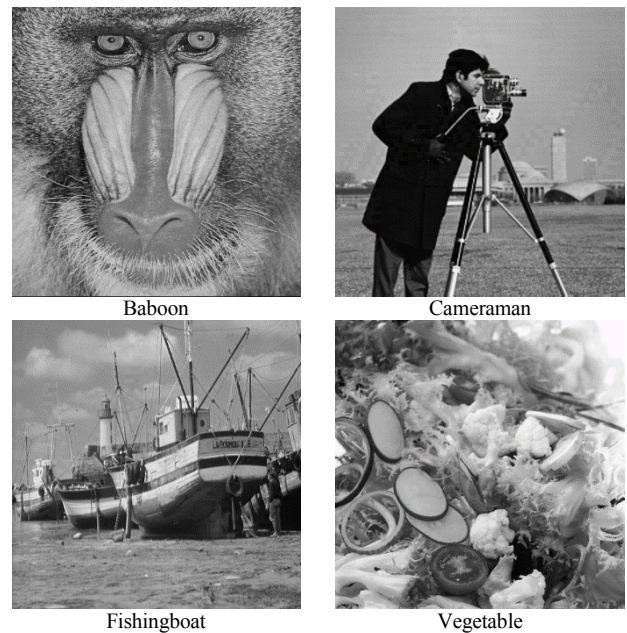


Fig. 5. Watermarked image results

After each sub-block is transformed and a watermark has been inserted using formula (1). Then inverse DTT is performed on each sub-block using formula (12). Furthermore, the results of inverse DTT restructured into the watermarked image is presented in Fig. 5. While the results of PSNR and MSE measurements in each watermarked image are presented in Table 1.

$$B_{(d,e)} = \sum_{a=0}^{N-1} \sum_{c=0}^{N-1} T_{ac} r_a(d) s_c(e) \quad (12)$$

TABLE I. PSNR AND MSE MEASUREMENT RESULT

























Image	PSNR (dB)	MSE
Baboon	45.4646	1.8477
Cameraman	45.4659	1.8471
Fishingboat	45.4647	1.8476
Vegetable	45.4697	1.8455
Average	45.4662	1.8470

Based on observations on the watermarked image shown in Fig.5 and the measurement values of PSNR and MSE presented in Table 1, it can be concluded that the results fall into very good criteria. The extraction process is then carried out which aims to test and measure the resistance of the results of the retrieved watermark image. Resistance is measured using the corr2 function in Matlab which can be calculated by the formula (13). While the extraction results are shown in Table 2.

$$corr2 = \frac{\sum_m \sum_n (w_{mn} - \bar{w})(r_{mn} - \bar{r})}{\sqrt{(\sum_m \sum_n ((w_{mn} - \bar{w})^2) (\sum_m \sum_n (r_{mn} - \bar{r})^2)}} \quad (13)$$

Where  $m, n$  is the dimension of watermark image,  $\bar{w}$  is mean of  $w_{mn}$  and  $\bar{r}$  is mean of  $r_{mn}$ .

TABLE II. NC MEASUREMENT AND EXTRACTION RESULTS

Attack	Baboon	Camera man	Fishing boat	Vegetable
No Attack	 1.0000	 1.0000	 1.0000	 1.0000
JPEG Q = 25	 0.9432	 0.9496	 0.9408	 0.9279
Salt and Papper 0.001	 0.9531	 0.9524	 0.9588	 0.9584
Gaussian Noise 0.001	 0.9263	 0.9256	 0.9292	 0.9078
Low Pass Filter	 0.9114	 0.8512	 0.9408	 0.7857
Blur	 0.7351	 0.8527	 0.8256	 0.8231

The results of the extraction process shown in Table 2 look very good. Extraction without attack produces a value of 1, this means the image watermark retrieved is extracted perfectly. While the extraction results in values above 0.9, except for the blur attack the average value is around 0.8.

## V. COMPARISON AND ANALYSIS

After looking at the results of the proposed method, it can be concluded that the proposed method can work well in the stages of embedding and extraction. But the effect of using PN Sequence still needs to be discussed more deeply by comparing it with a method without PN Sequence. Fig. 6 shows a graph comparing the values of PSNR and MSE with and without PN sequence. The PSNR value of the proposed method appears to be superior around 3dB, while the MSE value is also better, which is around 1.8. Without using the PN Sequence the value of MSE obtained is worse, which is around 3.7.

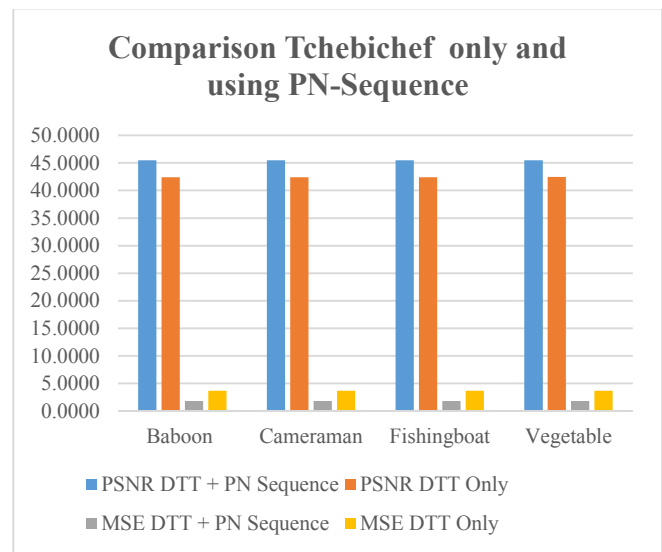


Fig. 6. Comparative chart based on PSNR and MSE results

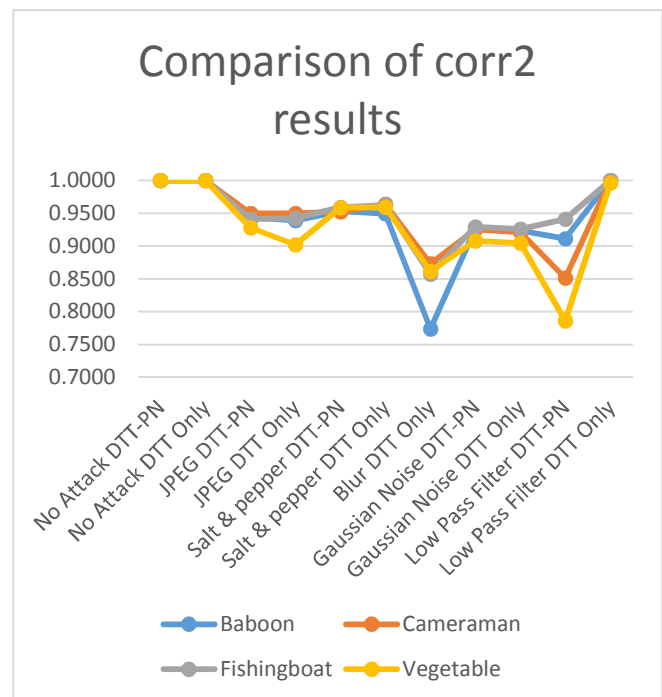


Fig. 7. Comparative chart based on corr2 results

Comparative graph of the watermark resistance value shown in Fig. 7 shows that the resistance of the watermark produced by the proposed method is indeed slightly reduced, but not significant. Even in the JPEG, salt and pepper attacks and the proposed Gaussian noise method produces better corr2 values.

## VI. CONCLUSION

This research aims to improve the quality of watermarked images in Tchebichef Image Watermarking. Previous research has proven that the Tchebichef image watermarking works well if it is based on sub-blocks. DTT also has a similar property that is very similar to DCT, where the use of PN Sequence on DCT is proven to improve the quality of watermarked images. From this, the research carried out testing, measuring the results of the combination of DTT and PN sequences in the watermarking scheme. Based on the experimental results and the comparison of the results discussed in the previous section, it is evident that the proposed method is proven to be able to increase imperceptibility. The imperceptibility value increases around 3dB based on PSNR measurements. Whereas in the resistance test there is a decrease and increase in resistance to various variations of attacks where the decrease and increase appear to be insignificant, so it can be concluded that the quality of robustness of the watermark can be maintained.

## ACKNOWLEDGMENT

The authors would like to express very special thanks to the Ministry of Research, Technology and Higher Education Republic of Indonesia for providing financial support of this research project.

## REFERENCES

- [1] R. Noor, A. Khan, A. Sarfaraz, Z. Mehmood, and A. M. Cheema, "Highly robust hybrid image watermarking approach using Tchebichef transform with secured PCA and CAT encryption," *Soft Comput.*, pp. 1–9, Mar. 2019.
- [2] F. Ernawan, "Tchebichef image watermarking along the edge using YCoCg-R color space for copyright protection," *Int. J. Electr. Comput. Eng.*, vol. 9, no. 3, pp. 1850–1860, Jun. 2019.
- [3] D. R. I. M. Setiadi, E. H. Rachmawanto, C. A. Sari, A. Susanto, and M. Doheir, "A Comparative Study of Image Cryptographic Method," in *2018 5th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)*, 2018, pp. 336–341.
- [4] M. N. M. Najih, D. R. I. M. Setiadi, E. H. Rachmawanto, C. A. Sari, and S. Astuti, "An improved secure image hiding technique using PN-sequence based on DCT-OTP," in *2017 1st International Conference on Informatics and Computational Sciences (ICICoS)*, 2017, pp. 47–52.
- [5] E. J. Kusuma, C. A. Sari, E. H. Rachmawanto, and D. R. I. M. Setiadi, "A Combination of Inverted LSB, RSA, and Arnold Transformation to get Secure and Imperceptible Image Steganography," *J. ICT Res. Appl.*, vol. 12, no. 2, p. 103, Sep. 2018.
- [6] D. R. I. M. Setiadi, H. A. Santoso, E. H. Rachmawanto, and C. A. Sari, "An improved message capacity and security using divide and modulus function in spatial domain steganography," in *2018 International Conference on Information and Communications Technology (ICOLACT)*, 2018, pp. 186–190.
- [7] D. R. I. M. Setiadi, T. Sutojo, E. H. Rachmawanto, and C. A. Sari, "Fast and efficient image watermarking algorithm using discrete tchebichef transform," in *2017 5th International Conference on Cyber and IT Service Management (CITSM)*, 2017, pp. 1–5.
- [8] F. Ernawan, M. N. Kabir, M. Fadli, and Z. Mustaffa, "Block-based Tchebichef image watermarking scheme using psychovisual threshold," in *2016 2nd International Conference on Science and Technology-Computer (ICST)*, 2016, pp. 6–10.
- [9] A. Winarno, D. R. I. M. Setiadi, A. A. Arrasyid, C. A. Sari, and E. H. Rachmawanto, "Image watermarking using low wavelet subband based on 8×8 sub-block DCT," in *Proceedings - 2017 International Seminar on Application for Technology of Information and Communication: Empowering Technology for a Better Human Life, iSemantic 2017*, 2018.
- [10] C. A. Sari, E. H. Rachmawanto, and D. R. I. M. Setiadi, "Robust and imperceptible image watermarking by DC coefficients using singular value decomposition," in *International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, 2017.
- [11] A. Setyono and D. R. I. M. Setiadi, "Image Watermarking using Discrete Wavelet-Tchebichef Transform," *Indones. J. Electr. Eng. Comput. Sci.*, vol. 16, no. 3, Dec. 2019.
- [12] S. M. Elshoura and D. B. Megherbi, "High capacity blind information hiding schemes using Tchebichef moments," in *2010 2nd International Conference on Future Computer and Communication*, 2010, pp. V1-649-V1-653.
- [13] S. Govarthini and M. Vadivel, "Integrity verification of medical images using blind forensic method," in *International Conference on Information Communication and Embedded Systems (ICICES2014)*, 2014, pp. 1–6.
- [14] S. M. Elshoura and D. B. Megherbi, "Analysis of noise sensitivity of Tchebichef and Zernike moments with application to image watermarking," *J. Vis. Commun. Image Represent.*, vol. 24, no. 5, pp. 567–578, Jul. 2013.
- [15] E. D. Tsougenis, G. A. Papakostas, D. E. Koulouriotis, E. G. Karakasis, and D. A. Karras, "Color image watermarking via Quaternion Radial Tchebichef Moments," in *2013 IEEE International Conference on Imaging Systems and Techniques (IST)*, 2013, pp. 101–105.