
[TELKOMNIKA] Please Revise Your Paper #

4 messages

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: sr_sulistiyanti@eng.unila.ac.id

Thu, Feb 21, 2019 at 3:59 PM

Dear Sir/Madam,

For preparing your final paper to publish in **TELKOMNIKA (Telecommunication, Computing, Electronics and Control) ISSN: 1693-6930, e-ISSN: 2302-9293**. After checking, we found something that must be corrected. Please revise your paper based on the comment on the paper. **You have 2 days to revise your paper until February 23, 2019**. Please revise in the paper that attached in this email and follow the template that attached in this email. We hope your response soon. Thank you.

Best regards,
TELKOMNIKA StaffVirus-free. www.avg.com

2 attachments**00 TELKOMNIKA August 2019 Template.docx**
452K**1570470386_rev (24Nov18).docx**
555K

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>
To: Hany Safitry F <hanyjournal.iaes@gmail.com>

Fri, Feb 22, 2019 at 8:05 AM

Dear Editor,
Thank for your information.
We'll fix it as soon as possible

[Quoted text hidden]

--

Best Regards,
Sri Ratna Sulistiyanti
Dept. of Electrical Engineering
Faculty of Engineering
University of Lampung

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>
To: Hany Safitry F <hanyjournal.iaes@gmail.com>

Fri, Feb 22, 2019 at 9:40 AM

Dear Editor
Here we submit the revised article according to the template.
Please look at the attachment.
Thank for your kind attention and good cooperation.

On Thu, Feb 21, 2019 at 4:00 PM Hany Safitry F <hanyjournal.iaes@gmail.com> wrote:

[Quoted text hidden]

[Quoted text hidden]

**1570470386_rev (24Nov18)_rev (22Feb2019).docx**
515K

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Fri, Feb 22, 2019 at 12:09 PM

Received, thank you.

[Quoted text hidden]

Detection of The Air Pollution Based on an Infrared Image Using Image Processing

S. R. Sulistiyanti¹⁾, F. X. A. Setyawan²⁾, M. Komarudin³⁾

Department of Electrical Engineering
Faculty of Engineering, University of Lampung
Jl. Prof. Dr. Soemantri Brodjonegoro No. 1, Bandar Lampung 35145
Telp./Fax. +62721704947

e-mail: sr_sulistiyanti@eng.unila.ac.id, fx.arinto@eng.unila.ac.id, m.komarudin@eng.unila.ac.id

Abstract

This paper proposes a method of detecting air pollution in a region using image processing techniques. The image used is the infrared image that obtained using a modified digital camera by mounting the SRS filter. Image processing technique used is to utilize wavelet transformation. Pollutants are detected based on the average number of white pixels that appear on the image. The emergency of this white pixel due to the reflection of wavelengths from pollutant that hit the sensor on the camera. From the results of the proposed method detection is known that the highest pollution occurs in 12.00 which is the busiest traffic time and the lowest pollution occurred in 08.00 where the traffic passing through the area has not been crowded.

Keywords—pollution, detection, infrared image, SRS filter, wavelet

1. Introduction

Air pollution is a condition of air contaminated by chemicals, substances/particles, and other biological materials that could endanger the health of living beings and other organisms. Air pollution could be caused by motor vehicle fumes, a factory fumes or the forest fires. The negative impact of air pollution on health is could be caused breathing problems or inflammation of the respiratory tract, skin health disorders, and stress. This negative impact is what drives the need for research about air pollution detection.

This research aims to identify the presence of air pollution in one place by using digital image processing in real time. Image processing in this research conducted in the frequency domain. Therefore, the previous done the transformation of the spatial domain to the frequency domain using wavelet transforms. After the image transformation results obtained, hence can be done analysis further.

The use of image processing basically utilizes the electronic visual sensor (camera) which replaces the human visual system (eye). The advantages of the electronic visual sensor are to have a wavelength range that is larger than the human eye. In addition, an electronic visual sensor is also more sensitive in distinguishing the degree of intensity of each pixel of the image. By using image processing the little difference of the pixel intensity between pollutants and air through this sensor can be differentiated.

A lot of research about the detection of air pollution has been done before. Wang has been doing research about the rendering process of air pollutants based on image processing [1] [2]. In contrast to the research conducted by Wang, this research uses wavelet transformation to detect air pollution from an infrared image. The Infrared imagery-based research has been done before by doing image segmentation in infrared images to determine the environmental conditions [3]. The infrared image obtained by using SRS filters whose characteristics known from the previous research [4] [5]. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera [6]. This proposed research is done outdoors by taking infrared images using a camera. The other research that has been done is the detection of air pollution on satellite images [7] [8].

The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image based research has been done before by doing image segmentation in infrared images to determine the environmental conditions [3]. The infrared image obtained by using SRS filters whose characteristics known from the previous research [4] [5]. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera [6]. This proposed research is done outdoors by taking infrared images using a camera. The other research that has been done is the detection of air pollution on satellite images [7] [8]. The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image.

2. Research Method

2.1 Air pollution

Air pollution is a condition in which air is polluted by chemical or biological particles that can harm the health of living things. The particles that pollute the air are also called pollutants. In urban areas, sources of the pollutants come from vehicle fumes and industrial factory smoke.

At low pollution levels, the number of particles in the outdoor air can reach 5,000-10,000 particles/cm³. At high pollution levels, for example, when high traffic volume can reach 300,000-100.000 particles/cm³ [9]. This particle size is very small namely less than 2.5 mm so the human eye cannot see it directly [10]. The existence of these particles can be detected using a digital camera. These particles will be captured by the camera as noise. The principle of pollutant detection using a digital camera is shown in Fig. 1.

2.2 Infrared image

The infrared images are images that obtained from a camera that uses filters to block visible light and allowed a near infrared light (infrared photography). The wavelength ranges used in infrared photography is about from 700 nm to 900 nm, shown in Fig. 2. To get this image, the digital camera is modified by installing an infrared filter. The infrared filter used in this research is the SRS filter [5].

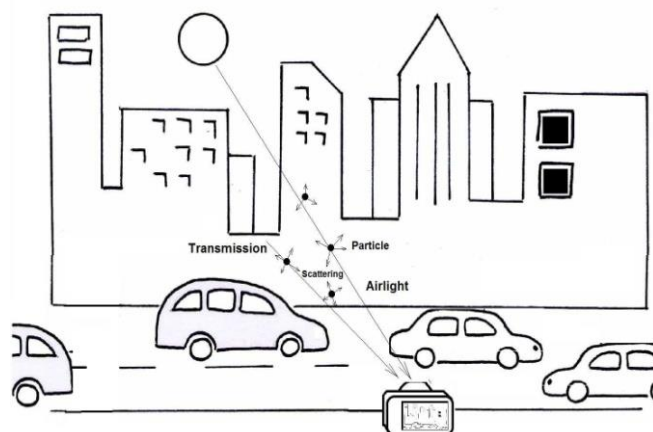


Fig. 1 The radiance reaching the camera is the summation of the transmitted light from the object and light from the sun after scattering by particles.

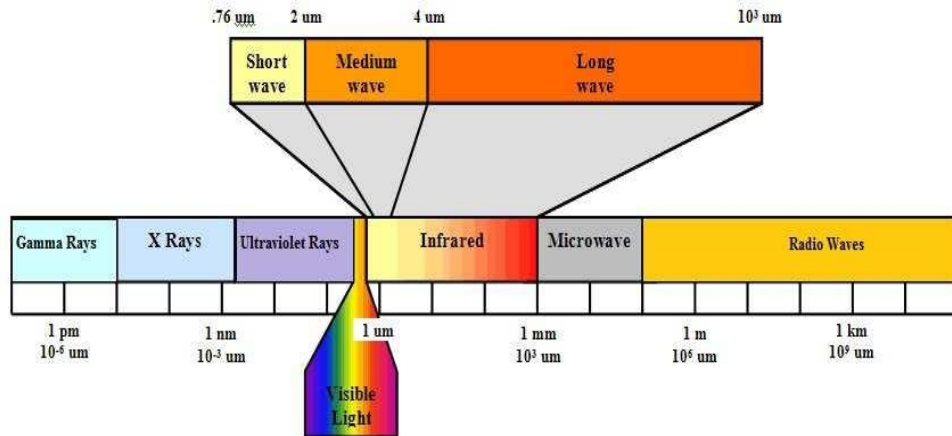


Fig. 2 The wavelength range in photography

The previous research on the use of infrared images has been widely done. The infrared images can be used to obtain the thermal condition information of an object by performing a spatial filtering of an object [11] [12]. Another research was to use an infrared image captured by digital cameras to determine isothermal calorimeter [13]. In addition, the other research used infrared images to determine the ignition point from the magnesium chip cutting temperature [14].

2.3 Wavelet

The wavelet transform can be used as a multi-resolution analysis that can represent the time and frequency information of a signal. A signal whose frequency varies in time can be well analyzed using this transformation. In image processing, the wavelet transforms used are 2-D wavelet transforms. The image for image processing is represented as a 2-D matrix.

The decomposition process in the wavelet transform will attempt to divide the signal into two parts by the same number of sampling signals. These two parts are separated by two types of filters which have two different frequency bands, i.e. high-pass filter ($h[n]$) and lowpass filter ($g[n]$). After that the process is continued by modifying the signal based on the function of scale and time. This process repeatedly to determine the Discrete Wavelet Transform level and will affect the magnitude of the frequency band in each coefficient. The wavelet decomposition process is shown in Fig. 3.

Decomposition process can be through one or more levels Mathematical, the one level decomposition is expressed by the following equation:

$$Y_{High}[k] = \sum_n X[n]h[2k - n] \quad (1)$$

$$Y_{Low}[k] = \sum_n X[n]g[2k - n] \quad (2)$$

Here Y_{High} and Y_{Low} are results from highpass filters and lowpass filters, $x[n]$ is origin signal, $h[n]$ is highpass filter, and $g[n]$ is lowpass filter. In the Haar wavelet, each step of the transformation always takes into account the wavelet coefficients and the average set. The equations for calculating an average a_i and Wavelet coefficients (c_i) are:

$$a_i = \frac{s_i + s_{i+1}}{2} \quad (3)$$

$$c_i = \frac{s_i - s_{i+1}}{2} \quad (4)$$

Here s_i is the i -th data, s_{i+1} is the data after i -th data, s_{i-1} is the data before i -th data, a is the data average, and c is the wavelet coefficient.

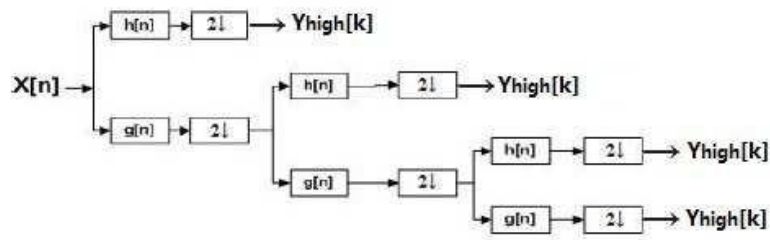


Fig. 3 The wavelet decomposition

3. Results and Analysis

In this research, the image was taken using a digital camera mounted a SRS infrared filter. The usefulness of this filter is to pass the infrared light and to filter the other light. The image data were taken around the Bambu Kuning market, Bandar Lampung between 08:00 until 16:00 and intervals of data collected every 2 hours. The captured image results are shown in Fig. 4. The image size obtained from the camera is 4 Mp. The image is cropped with a size of 100x200 pixels on the area to be observed (region of interest/ROI), shown in Fig. 5.

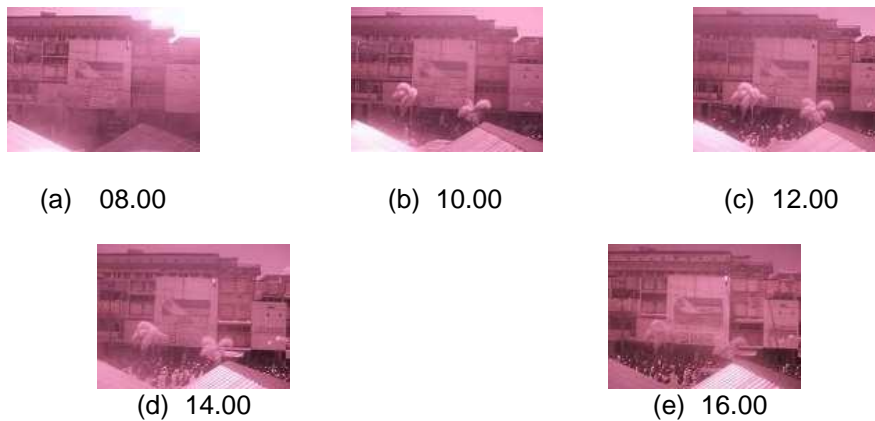


Fig. 4 The results of capturing an image

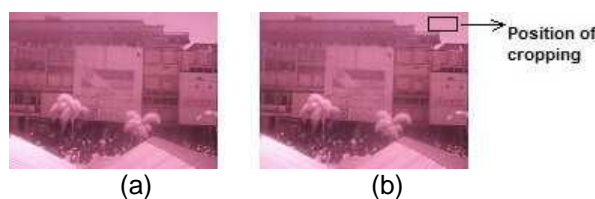


Fig. 5 The position of the observed area in the research (a) original image and (b) the position of cropping

In this proposed method, infrared images of a RGB mode are converted into a grayscale to find out how much noise of the object. In this conversion process, the original image has a 24-bit pixel depth become to 8 bits. The next step is the image registration process. This process is done to get the same area on the different image. This process is done because the image is taken at different times so that there may be changes a camera position due to movement.

The use of cropping which has 8-bit image format is assigned wavelet transformation process and then done the decomposition process. The result of the decomposition process is shown in Fig. 6. From the decomposition result, the intensity of the four images is summed to obtain the final image, shown in Fig. 7.

The image of the summing of these intensities is segmented into 4 segments, 8 segments or 16 segments. From the final image is calculated the average intensity to obtain image data that represents the presence of pollutants. Calculation of the average intensity using equation (5):

$$I_{average} = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I(i,j)}{M \times N} \quad (5)$$

Here M is the image width, N is the image height, and $I(i,j)$ is the intensity of the (i,j) pixel.

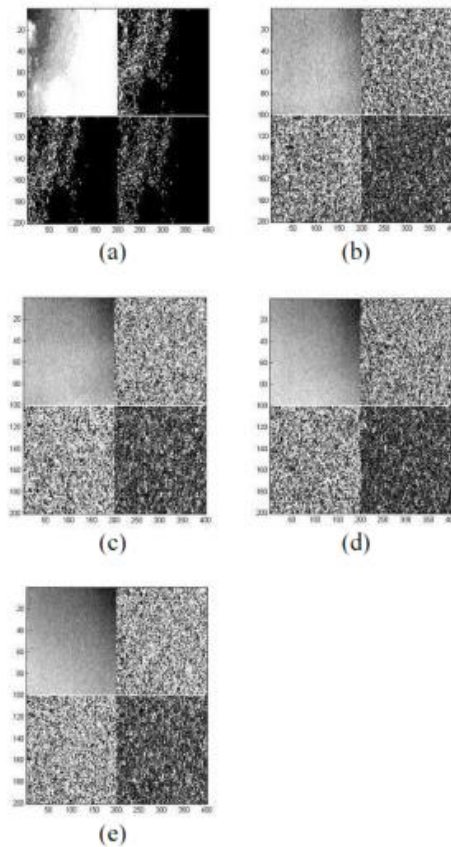


Fig. 6 The wavelet decomposition result in the image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

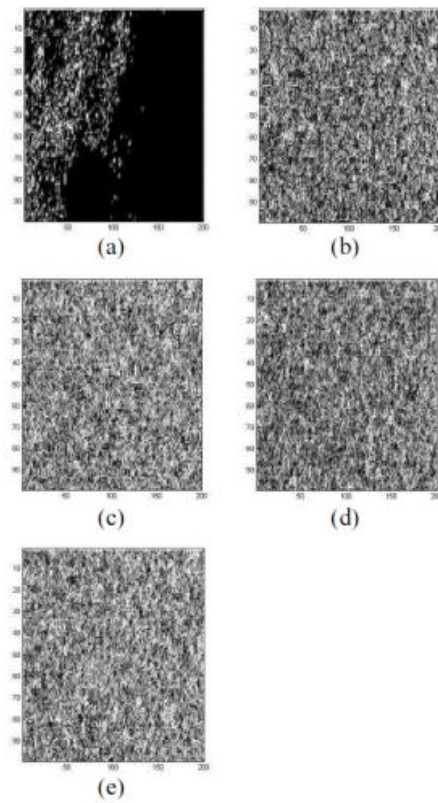


Fig. 7 The summing result of the decomposition image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

Table 1. The result value of the sum and average of the intensity.

Clock	4 segment		8 segment		16 segment	
	Sum	Average	Sum	Average	Sum	Average
08.00	224592	11.2296	246000	12.3000	235024	11.7512
10.00	789156	39.4578	726477	36.3239	809631	40.4816
12.00	1003695	50.1846	898299	44.9150	912234	45.6117
14.00	821454	41.0727	742931	37.1466	721778	36.0889
16.00	927678	46.3839	776300	38.8150	815852	40.7946

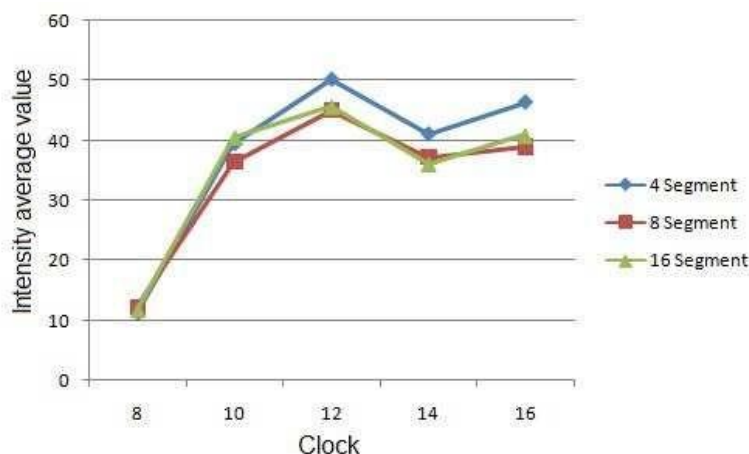


Fig. 8 The average value of intensity for each segment

The result value of the sum and average of the intensity for each segment and time is shown in Table 1. The minimal number of pollutants in the observed area occurred at 08.00 and the maximum number of pollutants occurred at 12.00. The area observed is the shopping area where the trade activity and the busiest traffic occurred in 12.00. In the observed area, the primary source of the pollutant comes from the smoke of vehicles passing through the area. At 08.00, traffic conditions in the area have not been crowded because the shops open at 09.00 so the condition of air pollution is still low. Similar pollutant detection results from the use of segmentation of 4 segments, 8 segments, and 16 segments, is shown by the graph in Fig 8.

Seen in Fig. 8, in the morning (08.00) qualitatively produces images that look mostly dark, this means the air condition is still relatively clear. The black color declared a state of air condition that there are no pollutants while the color other than black is a pollutant because it is due to the wavelength reflections of the pollutants. Increased white pixels that indicate the presence of pollutants in the air in the observed area looks at 10.00—16.00. Increased air pollution is due to the increasing number of vehicles that pass through or has activities in the area.

The pollution peak occurs at 12:00 because at that hour the store employees use their time for activities in the outside because that time is a rest time. At 2 pm there was a decrease in pollution because traffic activity was not as busy as at 12.00. The increased of the pollution occurred again in 16.00 because ahead of the shops closed so that traffic vehicle activity of the buyers who leave a shop increased.

This research proves that the more pollutant in the air, then the more noise arising in the image too, this phenomenon is shown in Fig. 1. This noise appears from the reflection of the wavelength transmitted by pollutants that hitting the sensors in the camera. The wavelength of this pollutant is different from the wavelength reflected by the background object. This difference is that causes the occurrence of spots as if the noise.

4. Conclusion

This paper proposes a pollutant detection technique on air pollution using Wavelet transforms. Using a wavelet transforms, the noise on the image can be well recognized so that it can be used to represent the presence of pollutants. The trends of an increase of the air pollution are obtained from the calculation data of the intensity average of the image in the observed area. This is in accordance with the condition that at 12.00 is the busiest traffic time resulting in maximum air pollution in the area.

In the future, calibration will need to be done using a calibrated detector so that the number of pollutants in the area can be known the value. In addition, it also needs to be measured to determine the condition of the air pollution in the area was observed for 24 hours. The shorter time intervals of the observation (1 hour) can provide more accurate information about air pollution in the observed area. In addition, it is also necessary to

experiment for various conditions such as rain and blustery. In order to be utilized maximally then this detection system needs to be made into a system that can be accessed in real time that monitored directly using the internet network.

Acknowledgment

Thanks to Directorate Research and Community Service, Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Republic Indonesia for providing financial support through Research Grant.

References

- [1] D.Wang, Y. Huang and W. Li, "Real-Time Air Pollutants Rendering based on Image Processing," *I.J. Information Technology and Computer Science*, Vol. 5, pp. 32-38, 2011
- [2] N. Divya, N. P.Lakkakula, A. Nelikanti, "Detection of Ozone Layer Depletion Using Image Processing and Data Mining Technique", (*IJCSIT*) *International Journal of Computer Science and Information Technologies*, Vol. 5, No.5, pp. 6383-6388, 2014.
- [3] S. R. Sulistiyanti, M. Komarudin, L. Hakim, A. Yudamson, "Intensity Average Value of Image Segmentation for Infrared Image of Environmental Condition" *Proc. of 2015 2nd Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)*, Indonesia, Oct 16-18th, pp. 220-224, 2015.
- [4] S.R. Sulistiyanti., "Characteristic Filter Absorber Based on Influence Intensity Sun Variety", *Proceeding Seminar Hasil Penelitian dan Pengabdian Masyarakat Universitas Lampung*, 2007.
- [5] S.R. Sulistiyanti, A. Susanto, FX. A. Setyawan, "Histogram Characterizations of Infrared Images Captured by a Modified Digital Camera", *International Journal of Electronic Engineering Research (IJEER)*, Research India Publications (RIP), Vol. 1, No. 4, ISSN 0975 –6450, pp. 329-336, 2009.
- [6] N. Khamisan, K. H. Ghazali and W. L. Ching, "Detection of Indoor Air Pollution On Wet Or Moist Walls Using Thermal Image Processing Technique", *ARPN Journal of Engineering and Applied Sciences*, Vol 10, no. 3, pp. 1154-1160, 2015.
- [7] A. Prochazka, M. Kolinova, J. Fiala, P. Hampl, K. Hlavaty, "Satellite Image Processing And Air Pollution Detection", *ICASSP '00. Proceedings. 2000 IEEE International Conference on Acoustics, Speech, and Signal Processing*, 2000.
- [8] M. Hamzelo, A. Gharagozlou, S. Sadeghian, S.H. baikpour, A. Rajabi, "Modelling of Carbon Monoxide Air Pollution in Large Cities by Evaluation of Spectral LANDSAT8 Images," *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Volume XL-1/W5, pp. 281-285, 2015.
- [9] M.J. Utell, M.W. Frampton, "Acute health effects of ambient air pollution: the ultrafine particle hypothesis," *J. Aerosol Med.*, Vol. 13, pp. 355–359, 2000.
- [10] Y. Li, Q. Chen, H. Zhao, L. Wang, R. Tao, "Variations in PM10, PM2.5 and PM1.0 in an Urban Area of the Sichuan Basin and Their Relation to Meteorological Factors," *Atmosphere*, Vol. 6, pp. 150–163, 2015.
- [11] S.R. Sulistiyanti, A. Susanto, T.S. Widodo, G.B. Suparta, "Noise Filtering on Thermal Images Acquired by Modified Ordinary Digital Camera," *Proceeding International Conference on Electronics and Information Technology (ICEIE)*, Kyoto, Japan, , 1-3 August 2010.
- [12] S.R. Sulistiyanti, A. Susanto, T. S. Widodo, G. B. Suparta, "Histogram Slicing to Better Reveal Special Thermal Objects," *Proceeding Int. Conference on Signal and Image Processing (ICSIP)*, World Academy of Science, Engineering, and Technology (WASET), Singapore, 25-27 August, 2010.
- [13] S.R. Sulistiyanti, A. Susanto, T.S. Widodo, G.B. Suparta, "Surface (2D) Fitting to Exhibit the Inaccessible Isotherms Contours of Thermograms Acquired by a Consumer Digital Camera," *International Journal of Computer Science and Technology (IJCST)*, Vol. 2 Issue 1, ISSN:0976-8491 (online), and ISSN: 2229-4333 (Print), 2011.
- [14] S.R. Sulistiyanti, Y. Burhanudin, S. Harun, "Characterization of Cutting Temperature and Ignition Phenomena of Magnesium Chip using Infrared Imaging," *Advanced Materials*

Research, ©(2012) Trans Tech Publications, Switzerland doi:10.4028/www.scientific.net/AMR. Vols. 588—589, pp. 1744, 2012.

A title is fewest possible words, accurately describe the content XYZ

(Center, Bold, Arial 16, max 10 words in English, using sentence case)

First Author¹, Second Author², Third Author³

^{1,3}First Institution/affiliation (Department, Faculty and Name of University/Institution)
address, telp/fax of first institution/affiliation

²Second Institution/affiliation (Department, Faculty and Name of University/Institution)
address, telp/fax of second institution/affiliation

*Corresponding author, e-mail: xxxx@xxxx.xxx¹, yyyy@yyyy.yyy², zzzz@zzzz.zzz³

Abstract

A well-prepared abstract enables the reader to identify the basic content of a document quickly and accurately, to determine its relevance to their interests, and thus to decide whether to read the document in its entirety. The Abstract should be informative and completely self-explanatory, provide a clear statement of the problem, the proposed approach or solution, and point out major findings and conclusions. The Abstract should be 100 to 150 words in length. The abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited. The keyword list provides the opportunity to add keywords, used by the indexing and abstracting services, in addition to those already present in the title. Judicious use of keywords may increase the ease with which interested parties can locate our article.

Keywords: maximum 5 keywords from paper

Copyright © 2019 Universitas Ahmad Dahlan. All rights reserved.

1. Introduction

The main text format consists of a flat left-right columns on A4 paper (quarto). The margin text from the left, right, top, and bottom 3 cm. The manuscript is written in Microsoft Word, single space, Arial 10pt and maximum 12 pages, which can be downloaded at the website: <http://www.telkomnika.ee.uad.ac.id>

A title of article should be the fewest possible words that accurately describe the content of the paper. Omit all waste words such as "A study of ...", "Investigations of ...", "Implementation of ...", "Observations on ...", "Effect of....", "Analysis of ...", "Design of..." etc. Indexing and abstracting services depend on the accuracy of the title, extracting from it keywords useful in cross-referencing and computer searching. An improperly titled paper may never reach the audience for which it was intended, so be specific [1-4].

The Introduction should provide a clear background, a clear statement of the problem, the relevant literature on the subject, the proposed approach or solution, and the new value of research which it is innovation. It should be understandable to colleagues from a broad range of scientific disciplines [5].

Organization and citation of the bibliography are made in Vancouver style in sign [6, 7] and so on. The terms in foreign languages are written italic (italic). Authors are suggested to present their articles in the section structure: **Introduction - The Proposed Method/Algorithm (optional) - Research Method - Results and Discussion – Conclusion [8-11].**

Literature review that has been done author used in the chapter "Introduction" to explain the difference of the manuscript with other papers, that it is innovative, it are used in the chapter "Research Method" to describe the step of research and used in the chapter "Results and Discussion" to support the analysis of the results [2]. If the manuscript was written really have high originality, which proposed a new method or algorithm, the additional chapter after the "Introduction" chapter and before the "Research Method" chapter can be added to explain briefly the proposed method or algorithm [9-11].

2. Research Method

Explaining research chronological, including research design, research procedure (in the form of algorithms, Pseudocode or other), how to test and data acquisition [1], [3]. The description of the course of research should be supported references, so the explanation can be accepted scientifically [2], [4].

Tables and Figures are presented center, as shown below and cited in the manuscript.

Table 1. The Performance of ...

Variable	Speed (rpm)	Power (kW)
x	10	8.6
y	15	12.4
z	20	15.3

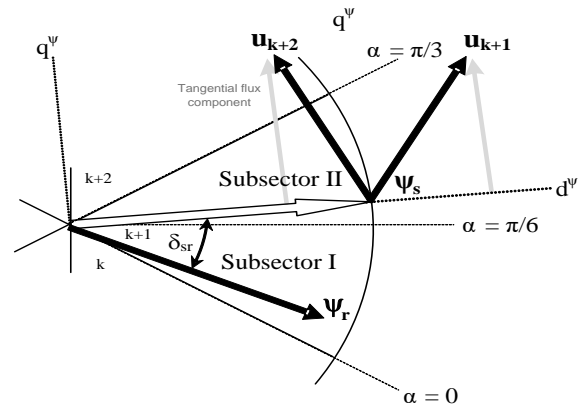


Figure 1. Effects of selecting different switching under dynamic condition

3. Results and Analysis

In this section, it is explained the results of research and at the same time is given the comprehensive discussion. Results can be presented in figures, graphs, tables and others that make the reader understand easily [2], [5]. The discussion can be made in several sub-chapters.

3.1. Sub Bab 1

xx

3.2. Sub Bab 2

yy

4. Conclusion

Provide a statement that what is expected, as stated in the "Introduction" chapter can ultimately result in "Results and Discussion" chapter, so there is compatibility. Moreover, it can also be added the prospect of the development of research results and application prospects of further studies into the next (based on result and discussion).

References

The main references are international journals and proceeding. All references should be to the most pertinent and up-to-date sources. References are written in Vancouver style. **Each citation should be written in the order of appearance in the text.** Please use a consistent format for references – see examples below:

If your references are from journal articles:

- [1] Author1 A, Author2 B. Title of Manuscript. *Name of Journal or its Abbreviation*. year; Vol.(Issue): pages.
- [2] Casadei D, Serra G, Tani K. Implementation of a Direct Control Algorithm for Induction Motors Based on Discrete Space Vector Modulation. *IEEE Transactions on Power Electronics*. 2007; 15(4): 769-777. (in this case Vol. 15, Issues 4, and page 769-777)

If your references are from Proceeding articles:

If the proceedings consists of several volumes

- [3] Author1 A, Author2 B. *Title of Manuscript*. Name of Conference of Seminar. City. Year; volume: pages.
- [4] Calero C, Piatini M, Pascual C, Serrano MA. *Towards Data Warehouse Quality Metrics*. Proceedings of the 3rd Intl. Workshop on Design and Management of Data Warehouses (DMDW). Interlaken. 2009; 39: 2-11. (*in this case, city: Interlaken, year: 2009, Vol.39, page: 2-11*)

If the proceedings in single volume

- [5] Author1 A, Author2 B. *Title of Manuscript*. Name of Conference or Seminar. City. year: pages.
- [6] Yamin L, Wanming C. *Implementation of Single Precision Floating Point Square Root on FPGAs*. IEEE Symposium on FPGA for Custom Computing Machines. Napa. 2008: 226-232.

If your references are from Texbooks:

If the references are refer to specific page range in a book

- [7] Author1 A, Author2 B. The Title of the Book. Edition. City: Publishert. year: pages.
- [8] Mohan N, Undeland TM, Robbins WP. *Power Electronics*. New York: John Wiley & Sons. 2005: 11-13.
- [9] Ward J, Peppard J. *Strategic planning for Information Systems*. Fourth Edition. West Susse: John Willey & Sons Ltd. 2007: 102-104.

If the references are refer to some separate pages in a book.

- [10] Author1 A, Author2 B. Judul Buku. City: Publisher. Year.
- [11] Mohan N, Undeland TM, Robbins WP. *Power Electronics*. New York: John Wiley & Sons. 2005.
- [12] Ward J, Peppard J. *Strategic planning for Information Systems*. Fourth Edition. West Susse: John Willey & Sons Ltd. 2007.

Edited book:

- [13] Author1 A, Author2 B. *Editors*. Title of the Book. City: Publisher. Year.
- [14] Zade F, Talenta A. *Editors*. *Advanced Fuzzy Control System*. Yogyakarta: UAD Press. 2010.

Chapter in a book:

- [15] Author1 A, Author2 B. Title of the Book. In: Editor1 A, Editor2, B. Title of the Book. Edition. City: Publisher. Year: pages.
- [16] Arkanuddin M, Fadlil A, Sutikno T. A Neuro-Fuzzy Control for Robotic Application Based on Microcontroller. In: Krishnan R, Blaabjerg F. *Editors*. *Advanced Control for Industrial Application*. 2nd ed. London: Academic Press; 2006: 165-178.

Translated Books.

- [17] *Originil* Author. Year. Title of the Translated Book. Translater. City: Publisher of the translated book. Year of the translated book.
- [18] Pabla. 2004. *Sistem Distribusi Tenaga Listrik*. Abdul Hadi. Jakarta: Erlangga. 2007.

If your references are from Thesis/Disertation:

- [19] *Author*. Title of Thesis/Disertation. Thesis/Disertation. City & Name of University/Institute/College; Year.
- [20] Rusdi M. A Novel Fuzzy ARMA Model for Rain Prediction in Surabaya. PhD Thesis. Surabaya: Postgraduate ITS; 2009.

If your references are from Paten:

- [21] Author1 A, Author2 B.. *Title (this should be in italics)*. Patent number (Patent). Year of publication.
- [22] Ahmad LP, Hooper A. *The Lower Switching Losses Method of Space Vector Modulation*. CN103045489 (Patent). 2007.

If your references are from Standards:

- [23] Name of Standard Body/Institution. Standard number. *Title (this should be in italics)*. Place of publication. Publisher. Year of publication.
- [24] IEEE Standards Association. 1076.3-2009. *IEEE Standard VHDL Synthesis Packages*. New York: IEEE Press; 2009.

If your references are from Reports

- [25] Author/Editor (if it is an editor/editors always put (ed./eds.) after the name). *Title (this should be in italics)*. Organisation. Report number: (this should be followed by the actual number in figures). Year of publication.

- [26] James S, Whales D. *The Framework of Electronic Government*. U.S. Dept. of Information Technology. Report number: 63. 2005.

Internet:

Avoid wherever possible

Note:

Please be sure to check for spelling and grammar before submitting your paper.

[TELKOMNIKA] Please Revise Your Paper #

4 messages

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Mon, Mar 4, 2019 at 2:49 PM

Dear Sir/Madam,


For preparing your final paper to publish in **TELKOMNIKA (Telecommunication, Computing, Electronics and Control) ISSN: 1693-6930, e-ISSN: 2302-9293**. After checking, we found something that must be corrected. Please revise your paper based on the comment on the paper. **You have 2 days to revise your paper until February 23, 2019**. Please revise in the paper that attached in this email and follow the template that attached in this email. We hope your response soon. Thank you.

Best regards,
TELKOMNIKA Staff

TELKOMNIKA Telecommunication, Computing, Electronics and Control

ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018

Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com

 1570470386_rev (24Nov18)_rev (22Feb2019).docx
546K

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>
To: Hany Safitry F <hanyjournal.iaes@gmail.com>

Mon, Mar 4, 2019 at 3:12 PM

Assalamu'alaikum WW

I have send manuscript revised on 22 Feb 2019.
What our manuscript not yet accepted in this email?

Wassalamu'alaikum WW

Sent from [BlueMail](#)
[Quoted text hidden]

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Tue, Mar 5, 2019 at 4:40 PM

Walaikumussalam warahmatullah,
Dear Sir/Madam,

The references from the paper that you sent before still have 15 references. Please add your references minimal 25. It's a policy from TELKOMNIKA. And please follow te TELKOMNIKA Template about writing references. We will wait your revised paper until March 7, 2019. Thank you

Best regards,
TELKOMNIKA Staff

TELKOMNIKA Telecommunication, Computing, Electronics and Control

ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018

Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com

 Virus-free. www.avg.com

[Quoted text hidden]

 Virus-free. www.avg.com

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>
To: Hany Safitry F <hanyjournal.iaes@gmail.com>

Tue, Mar 5, 2019 at 4:44 PM

Ok. Thanks for your info

Sent from [BlueMail](#)
[Quoted text hidden]

Detection Air Pollution Based on Infrared Image Processing

Sri Ratna Sulistiyanti^{*1}, F. X. Arinto Setyawan², Muhamad Komarudin³

^{1,2,3}Department of Electrical Engineering, Faculty of Engineering, University of Lampung
Jl. Prof. Dr. Soemantri Brojonegoro No. 1, Bandar Lampung 35145
Telp./Fax. +62721704947

*Corresponding author, e-mail: sr_sulistiyanti@eng.unila.ac.id

Abstract

This paper proposes a method of detecting air pollution in a region using image processing techniques. The image used is the infrared image that obtained using a modified digital camera by mounting the SRS filter. Image processing technique used is to utilize wavelet transformation. Pollutants are detected based on the average number of white pixels that appear on the image. This white pixel appears due to the reflection of the wavelength of the pollutant that hits the sensor on the camera. From the results of the proposed method detection is known that the highest pollution occurs in 12.00 which is the busiest traffic time and the lowest pollution occurred in 08.00 where the traffic passing through the area has not been crowded.

Keywords: pollution, detection, infrared image, SRS filter, wavelet

Copyright © 2018 Universitas Ahmad Dahlan. All rights reserved.

1. Introduction

Air pollution is a condition of air contaminated by chemicals, substances/particles, and other biological materials that could endanger the health of living beings and other organisms. Air pollution could be caused by motor vehicle fumes, a factory fumes or the forest fires. The negative impact of air pollution on health is could be caused breathing problems or inflammation of the respiratory tract, skin health disorders, and stress. This negative impact is what drives the need for research about air pollution detection.

This research aims to identify the presence of air pollution in one place by using digital image processing in real time. Image processing in this research conducted in the frequency domain. Therefore, the previous done the transformation of the spatial domain to the frequency domain using wavelet transforms. After the image transformation results obtained, hence can be done analysis further.

The use of image processing basically utilizes the electronic visual sensor (camera) which replaces the human visual system (eye). The advantages of the electronic visual sensor are to have a wavelength range that is larger than the human eye. In addition, an electronic visual sensor is also more sensitive in distinguishing the degree of intensity of each pixel of the image. By using image processing the little difference of the pixel intensity between pollutants and air through this sensor can be differentiated.

A lot of research about the detection of air pollution has been done before. Wang has been doing research about the rendering process of air pollutants based on image processing [1, 2]. In contrast to the research conducted by Wang, this research uses wavelet transformation to detect air pollution from an infrared image. The Infrared imagery-based research has been done before by doing image segmentation in infrared images to determine the environmental conditions [3]. The infrared image obtained by using SRS filters whose characteristics known from the previous research [4, 5]. The SRS filter is a filter that transmits infrared waves made from cellulose films. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera [6]. This proposed research is done outdoors by taking infrared images using a camera. The other

research that has been done is the detection of air pollution on satellite images [7, 8]. The SRS filter (the name of creator) is a filter that transmits infrared waves made from cellulose films.

The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image based research has been done before by doing image segmentation in infrared images to determine the environmental conditions. The infrared image obtained by using SRS filters whose characteristics known from the previous research. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera. This proposed research is done outdoors by taking infrared images using a camera. The other research that has been done is the detection of air pollution on satellite images [8, 9]. The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image.

2. Research Method

Air pollution is a condition in which air is polluted by chemical or biological particles that can harm the health of living things. The particles that pollute the air are also called pollutants. In urban areas, sources of the pollutants come from vehicle fumes and industrial factory smoke. At low pollution levels, the number of particles in the outdoor air can reach 5,000—10,000 particles/cm³. At high pollution levels, for example, when high traffic volume can reach 300,000—1,000,000 particles/cm³ [10]. This particle size is very small namely less than 2.5 mm so the human eye cannot see it directly [11]. The existence of these particles can be detected using a digital camera. These particles will be captured by the camera as noise. The principle of pollutant detection using a digital camera is shown in Figure. 1.

The previous research on the use of infrared images has been widely done. The infrared images can be used to obtain the thermal condition information of an object by performing a spatial filtering of an object [12, 13]. Another research was to use an infrared image captured by digital cameras to determine isothermal calorimeter [14]. In addition, the other research used infrared images to determine the ignition point from the magnesium chip cutting temperature [15].

In this research, the image was taken using a 5 MP digital camera mounted a SRS infrared filter. The usefulness of this filter is to pass the infrared light and to filter the other light. The image data were taken around the Bambu Kuning market, Bandar Lampung between 08:00 until 16:00 and intervals of data collected every 2 hours. The infrared images are images that obtained from a camera that uses filters to block visible light and allowed a near infrared light (infrared photography). The wavelength ranges used in infrared photography is about from 700 nm to 900 nm, shown in Figure 2. To get this image, the digital camera is modified by installing an infrared filter. The infrared filter used in this research is the SRS filter.

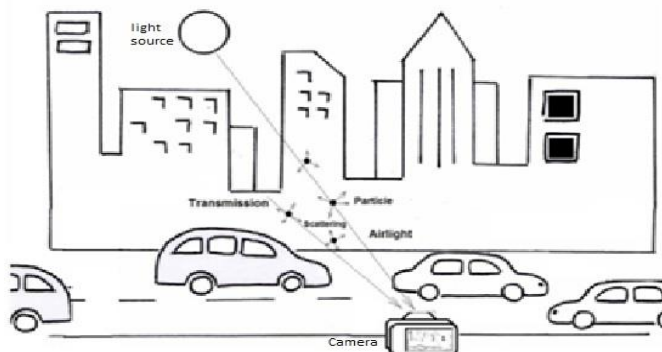


Figure 1. The radiance reaching the camera is the summation of the transmitted light from the object and light from the sun after scattering by particles.

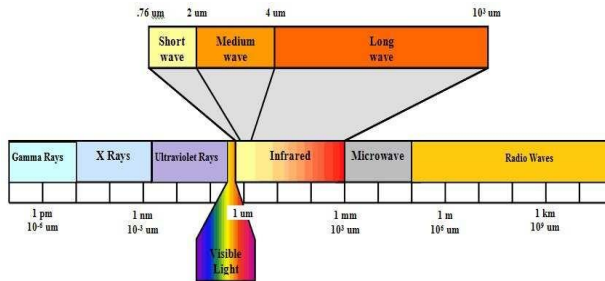


Figure 2. The wavelength range in photography

Then the captured infrared images are processed using image processing in the frequency domain, namely wavelet transform. The wavelet transform can be used as a multi-resolution analysis that can represent the time and frequency information of a signal. A signal whose frequency varies in time can be well analyzed using this transformation. In image processing, the wavelet transforms used are 2-D wavelet transforms. The image for image processing is represented as a 2-D matrix.

The decomposition process in the wavelet transform will attempt to divide the signal into two parts by the same number of sampling signals. These two parts are separated by two types of filters which have two different frequency bands, i.e. high-pass filter ($h[n]$) and lowpass filter($g[n]$). After that the process is continued by modifying the signal based on the function of scale and time. This process repeatedly to determine the Discrete Wavelet Transform level and will affect the magnitude of the frequency band in each coefficient. The wavelet decomposition process is shown in Figure 3.

Decomposition process can be through one or more levels Mathematical, the one level decomposition is expressed by the following equation (1) and (2):

$$YHigh[k] = \sum_n X[n]h[2k - n] \tag{1}$$

$$YLow[k] = \sum_n X[n]g[2k - n] \tag{2}$$

Here $YHigh$ and $YLow$ are results from highpass filters and lowpass filters, $x[n]$ is origin signal, $h[n]$ is highpass filter, and $g[n]$ is lowpass filter. In the Haar wavelet, each step of the transformation always takes into account the wavelet coefficients and the average set. The equations for calculating an average a_i and Wavelet coefficients (c_i) are equation (3) and (4):

$$a_i = \frac{s_i + s_{i+1}}{2} \tag{3}$$

$$c_i = \frac{s_i - s_{i+1}}{2} \tag{4}$$

Here s_i is the i -th data, s_{i+1} is the data after i -th data, s_{i-1} is the data before i -th data, a is the data average, and c is the wavelet coefficient.

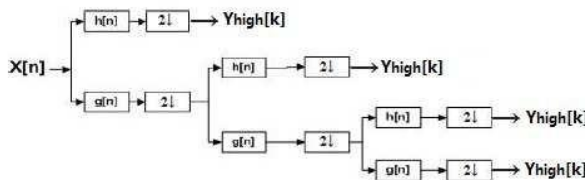


Figure 3. The wavelet decomposition

3. Results and Analysis

The captured image results are shown in Figure 4. The image size obtained from the camera is 4 Mp. The image is cropped with a size of 100x200 pixels on the area to be observed (region of interest/ROI), shown in Figure 5 respectively.

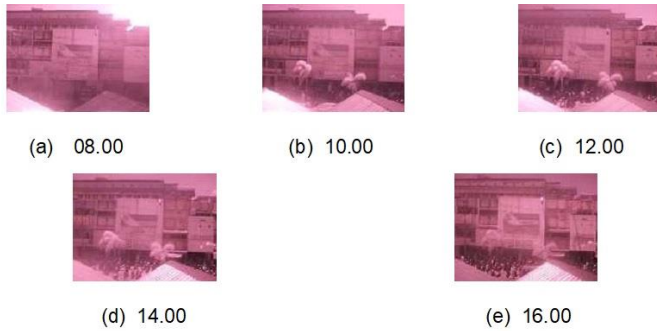


Figure 4. Results of capturing an image

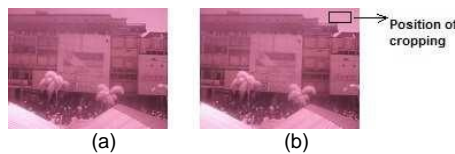


Figure 5. The position of the observed area in the research (a) original image and (b) the position of cropping

In this proposed method, infrared images of a RGB mode are converted into a grayscale to find out how much noise of the object. In this conversion process, the original image has a 24-bit pixel depth become to 8 bits. The next step is the image registration process. This process is done to get the same area on the different image. This process is done because the image is taken at different times so that there may be changes a camera position due to movement.

The use of cropping which has 8-bit image format is assigned wavelet transformation process and then done the decomposition process. The result of the decomposition process is shown in Figure 6. From the decomposition result, the intensity of the four images is summed to obtain the final image, shown in Figure 7.

The image of the summing of these intensities is segmented into 4 segments, 8 segments or 16 segments. From the final image is calculated the average intensity to obtain image data that represents the presence of pollutants. Calculation of the average intensity using equation (5):

$$I_{average} = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I_{(i,j)}}{M \times N} \tag{5}$$

Here M is the image width, N is the image height, and $I_{(i,j)}$ is the intensity of the (i,j) pixel.

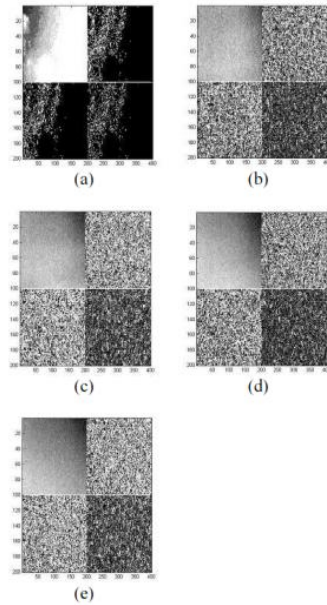


Figure. 6 The wavelet decomposition result in the image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

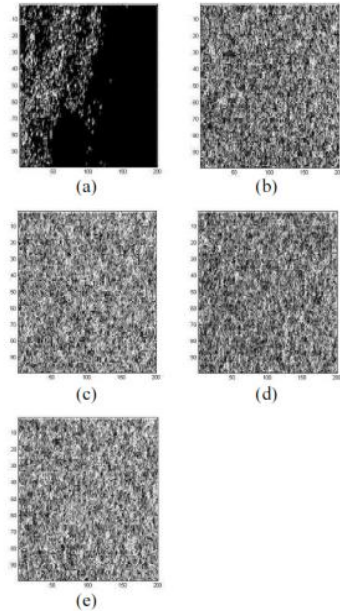


Figure 7. The summing result of the decomposition image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

The result value of the sum and average of the intensity for each segment and time is shown in Table 1. The minimal number of pollutants in the observed area occurred at 08.00 and the maximum number of pollutants occurred at 12.00. The area observed is the shopping area where the trade activity and the busiest traffic occurred in 12.00. In the observed area, the primary source of the pollutant comes from the smoke of vehicles passing through the area. At 08.00, traffic conditions in the area have not been crowded because the shops open at 09.00 so the condition of air pollution is still low. Similar pollutant detection results from the use of segmentation of 4 segments, 8 segments, and 16 segments, is shown by the graph in Figure 8.

Seen in Figure 8, in the morning (08.00) qualitatively produces images that look mostly dark, this means the air condition is still relatively clear. The black color declared a state of air condition that there are no pollutants while the color other than black is a pollutant because it is due to the wavelength reflections of the pollutants. Increased white pixels that indicate the presence of pollutants in the air in the observed area looks at 10.00—16.00. Increased air pollution is due to the increasing number of vehicles that pass through or has activities in the area.

The pollution peak occurs at 12:00 because at that hour the store employees use their time for activities in the outside because that time is a rest time. At 14:00 there was a decrease in pollution because traffic activity was not as busy as at 12:00. The increased of the pollution occurred again in 16:00 because ahead of the shops closed so that traffic vehicle activity of the buyers who leave a shop increased. CO₂ measurement were carried out using a Combo IAQ meter at a location and the same hour proving that the highest levels of CO₂ were at 12:00 and 16:00, shown in Figure 9.

This research proves that the more pollutant in the air, then the more noise arising in the image too, this phenomenon is shown in Figure 1. This noise appears from the reflection of the wavelength transmitted by pollutants that hitting the sensors in the camera. The wavelength of this pollutant is different from the wavelength reflected by the background object. This difference is that causes the occurrence of spots as if the noise.

Table 1. The result value of the sum and average of the intensity.

Clock	4 segment		8 segment		16 segment	
	Sum	Average	Sum	Average	Sum	Average
08:00	224592	112296	246000	12.3000	235024	117512
10:00	789156	39.4578	726477	36.3239	809631	404816
12:00	1003695	501846	898299	44.9150	912234	456117
14:00	821454	410727	742931	371466	721778	360889
16:00	927678	463839	776300	38.8150	815852	40.7946

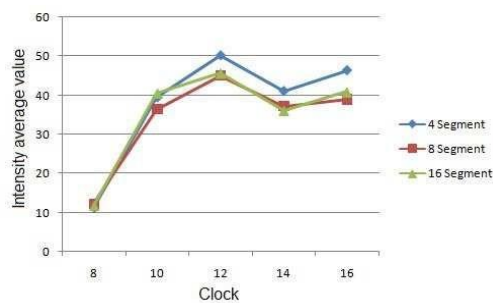


Figure 8. The average value of intensity for each segment

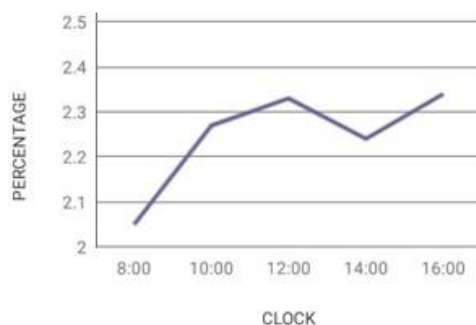


Figure 9. Trend of percentage CO₂ levels in the air using Combo IAQ meter

4. Conclusion

This paper proposes a pollutant detection technique on air pollution using Wavelet transforms. Using a wavelet transforms, the noise on the image can be well recognized so that it can be used to represent the presence of pollutants. The trends of an increase of the air pollution are obtained from the calculation data of the intensity average of the image in the observed area. This is in accordance with the condition that at 12:00 is the busiest traffic time resulting in maximum air pollution in the area.

Acknowledgment

Thanks to Directorate Research and Community Service, Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Republic Indonesia for providing financial support through Research Grant.

References

- [1] Wang D, Huang Y, and Li W. Real-Time Air Pollutants Rendering based on Image Processing. *International Journal of Information Technology and Computer Science*. 2011; 5: 32-38.
- [2] Divya N, Lakkakula NP, Nelikanti A. Detection of Ozone Layer Depletion Using Image Processing and Data Mining Technique. *International Journal of Computer Science and Information Technologies (IJCSIT)*. 2014; 5(5): 6383-6388.
- [3] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. Study of Environmental Condition Using Wavelet Decomposition Based on Infrared Image. *Proc. of the 1st Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)*. Indonesia. 2014; 170-174.
- [4] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. Intensity Average Value of Image Segmentation for Infrared Image of Environmental Condition. *Proc. of the 2nd Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)*. Indonesia. 2015; 220-224.
- [5] Sulistiyanti SR. Characteristic Filter Absorber Based on Influence Intensity Sun variety. *Prosiding Seminar Hasil Penelitian dan Pengabdian Masyarakat*. Lampung. 2007.
- [6] Sulistiyanti SR, Susanto A, Setyawan FXA. Histogram Characterizations of Infrared Images Captured by a Modified Digital Camera. *International Journal of Electronic Engineering Research (JEER)*. Research India Publications (RIP). 2009; 1(4): 329-336.
- [7] Khamisan N, Ghazali KH, and Ching WL. Detection of Indoor Air Pollution On Wet Or Moist Walls Using Thermal Image Processing Technique. *ARPN Journal of Engineering and Applied Sciences*. 2015; 10(3): 1154-1160.
- [8] Prochazka A, Kolinova M, Fiala J, Hampi P, Hlavaty K, Satellite Image Processing and Air Pollution Detection. *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing*. 2000.
- [9] Hamzelo M, Gharagozlou A, Sadeghian S, Baikpour SH, Rajabi A. Modelling of Carbon Monoxide Air Pollution in Large Cities by Evaluation of Spectral LANDSAT8 Images. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 2015; XL-1/W5: 281-285.
- [10] Utell MJ, Frampton MW. Acute health effects of ambient air pollution: the ultrafine particle hypothesis. *J. Aerosol Med*. 2000; 13: 355-359.

- [11] Li Y, Chen Q, Zhao H, Wang L, Tao R. Variations in PM10, PM2.5 and PM1.0 in an Urban Area of the Sichuan Basin and Their Relation to Meteorological Factors. *Atmosphere*. 2015; 6: 150–163.
- [12] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Noise Filtering on Thermal Images Acquired by Modified Ordinary Digital Camera. *Proceeding of International Conference on Electronics and Information Technology (ICEIE)*. Kyoto. 2010; 2: 462-464.
- [13] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Histogram Slicing to Better Reveal Special Thermal Objects. *Proceeding of Int. Conference on Signal and Image Processing (ICSIP)*. World Academy of Science, Engineering, and Technology (WASET). Singapore. 2010; 810-812.
- [14] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Surface (2D) Fitting to Exhibit the Inaccessible Isotherms Contours of Thermograms Acquired by a Consumer Digital Camera. *International Journal of Computer Science and Technology (IJCST)*. 2011; 2(1).
- [15] Sulistiyanti SR, Burhanudin Y, Harun S. Characterization of Cutting Temperature and Ignition Phenomena of Magnesium Chip using Infrared Imaging. *Advanced Materials Research*. Trans. Tech Publications. Switzerland. 2012; 588-589: 1744-1747.

Commented [i-1]: Please add your references minimal 25. It's a policy from TELKOMNIKA. And please follow te TELKOMNIKA Template about writing references

Please follow the writing of references in TELKOMNIKA .Please see the TELKOMNIKA Template

1570470386_rev (07Maret2019).docx' with you

2 messages

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Thu, Mar 7, 2019 at 3:48 PM

To: hanyjournal.iaes@gmail.com, Sri Ratna Sulistiyanti <sriratnasulistiyanti@gmail.com>

Dear Editor,

Here is our manuscript revised.
Please look at the attachment.
Thanks a lot for your a kind attention.

Shared from Word for Android

<https://office.com/getword>Sent from [BlueMail](#)**1570470386_rev (07Maret2019).docx**

691K

Hany Safitry F <hanyjournal.iaes@gmail.com>

Mon, Mar 11, 2019 at 10:26 AM

To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Cc: Sri Ratna Sulistiyanti <sriratnasulistiyanti@gmail.com>

Dear Sir/Madam,

Received, thank you

Best regards,
TELKOMNIKA Staff

TELKOMNIKA Telecommunication, Computing, Electronics and Control

ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018

Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com

[Quoted text hidden]

Detection Air Pollution Based on Infrared Image Processing

Sri Ratna Sulistiyanti^{*1}, F. X. Arinto Setyawan², Muhamad Komarudin³

^{1,2,3}Department of Electrical Engineering, Faculty of Engineering, University of Lampung
Jl. Prof. Dr. Soemantri Brojonegoro No. 1, Bandar Lampung 35145
Telp./Fax. +62721704947

^{*}Corresponding author, e-mail: sr_sulistiyanti@eng.unila.ac.id

Abstract

This paper proposes a method of detecting air pollution in a region using image processing techniques. The image used is the infrared image that obtained using a modified digital camera by mounting the SRS filter. Image processing technique used is to utilize wavelet transformation. Pollutants are detected based on the average number of white pixels that appear on the image. This white pixel appears due to the reflection of the wavelength of the pollutant that hits the sensor on the camera. From the results of the proposed method detection is known that the highest pollution occurs in 12.00 which is the busiest traffic time and the lowest pollution occurred in 08.00 where the traffic passing through the area has not been crowded.

Keywords: pollution, detection, infrared image, SRS filter, wavelet

Copyright © 2018 Universitas Ahmad Dahlan. All rights reserved.

1. Introduction

Air pollution is a condition of air contaminated by chemicals, substances/particles, and other biological materials that could endanger the health of living beings and other organisms. Air pollution could be caused by motor vehicle fumes, a factory fumes or the forest fires. The negative impact of air pollution on health is could be caused breathing problems or inflammation of the respiratory tract, skin health disorders, and stress. This negative impact is what drives the need for research about air pollution detection.

This research aims to identify the presence of air pollution in one place by using digital image processing in real time. Image processing in this research conducted in the frequency domain. Therefore, the previous done the transformation of the spatial domain to the frequency domain using wavelet transforms. After the image transformation results obtained, hence can be done analysis further.

The use of image processing basically utilizes the electronic visual sensor (camera) which replaces the human visual system (eye). The advantages of the electronic visual sensor are to have a wavelength range that is larger than the human eye. In addition, an electronic visual sensor is also more sensitive in distinguishing the degree of intensity of each pixel of the image. By using image processing the little difference of the pixel intensity between pollutants and air through this sensor can be differentiated.

A lot of research about the detection of air pollution has been done before. Wang has been doing research about the rendering process of air pollutants based on image processing [1-3]. In contrast to the research conducted by Wang, this research uses wavelet transformation to detect air pollution from an infrared image. Joans has been used images diffusion process and ratio factor to analysis polluted images. The Infrared imagery-based research has been done before by doing image segmentation in infrared images to determine the environmental conditions [4]. The infrared image obtained by using SRS filters whose characteristics known from the previous research [5-7]. The SRS filter is a filter that transmits infrared waves made from cellulose films. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera [8]. This proposed research is done outdoors

by taking infrared images using a camera. The other research that has been done is the detection of air pollution on satellite images [9-13].

The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image based research has been done before by doing image segmentation in infrared images to determine the environmental conditions. The infrared image obtained by using SRS filters. The SRS filter (the name of creator) is a filter that transmits infrared waves made from cellulose films whose characteristics known from the previous research. This proposed research is done outdoors by taking infrared images using a camera. The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image.

2. Research Method

Air pollution is a condition in which air is polluted by chemical or biological particles that can harm the health of living things. The particles that pollute the air are also called pollutants. In urban areas, sources of the pollutants come from vehicle fumes and industrial factory smoke. At low pollution levels, the number of particles in the outdoor air can reach 5,000—10,000 particles/cm³. At high pollution levels, for example, when high traffic volume can reach 300,000—1,000,000 particles/cm³ [14]. This particle size is very small namely less than 2.5 mm so the human eye cannot see it directly [15]. The existence of these particles can be detected using a digital camera. These particles will be captured by the camera as noise. The principle of pollutant detection using a digital camera is shown in Figure. 1.

The previous research on the use of infrared images has been widely done. Sulistiyanti has been conducted research on infrared image enhancement [16, 17]. The infrared images can be used to obtain the thermal condition information of an object by performing a spatial filtering of an object [18-21]. Another research was to use an infrared image captured by digital cameras to determine isothermal calorimeter [22]. In addition, the other research used infrared images to determine the ignition point from the magnesium chip cutting temperature [23], and object discrimination [24]. Furthermore, practical applications for national security used this image processing [25].

In this research, the image was taken using a 5 MP digital camera mounted a SRS infrared filter. The usefulness of this filter is to pass the infrared light and to filter the other light. The image data were taken around the Bambu Kuning market, Bandar Lampung between 08:00 until 16:00 and intervals of data collected every 2 hours. The infrared images are images that obtained from a camera that uses filters to block visible light and allowed a near infrared light (infrared photography). The wavelength ranges used in infrared photography is about from 700 nm to 900 nm, shown in Figure 2. To get this image, the digital camera is modified by installing an infrared filter. The infrared filter used in this research is the SRS filter.

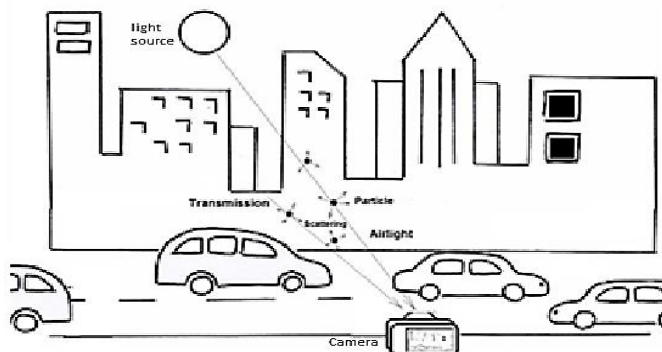


Figure 1. The radiance reaching the camera is the summation of the transmitted light from the object and light from the sun after scattering by particles.

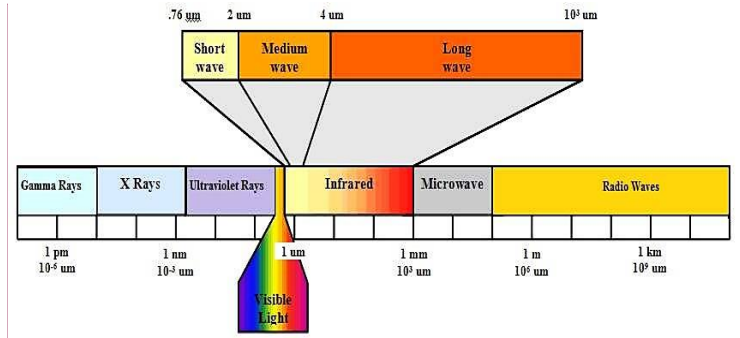


Figure 2. The wavelength range in photography

Commented [i-1]: Please change with high quality figure
 Commented [SRS2R1]: Done

Then the captured infrared images are processed using image processing in the frequency domain, namely wavelet transform. The wavelet transform can be used as a multi-resolution analysis that can represent the time and frequency information of a signal. A signal whose frequency varies in time can be well analyzed using this transformation. In image processing, the wavelet transforms used are 2-D wavelet transforms. The image for image processing is represented as a 2-D matrix.

The decomposition process in the wavelet transform will attempt to divide the signal into two parts by the same number of sampling signals. These two parts are separated by two types of filters which have two different frequency bands, i.e. high-pass filter ($h[n]$) and lowpass filter($g[n]$). After that the process is continued by modifying the signal based on the function of scale and time. This process repeatedly to determine the Discrete Wavelet Transform level and will affect the magnitude of the frequency band in each coefficient. The wavelet decomposition process is shown in Figure 3.

Decomposition process can be through one or more levels Mathematical, the one level decomposition is expressed by the following equation (1) and (2):

$$Y_{High}[k] = \sum_n X[n]h[2k - n] \tag{1}$$

$$Y_{Low}[k] = \sum_n X[n]g[2k - n] \tag{2}$$

Here Y_{High} and Y_{Low} are results from highpass filters and lowpass filters, $x[n]$ is origin signal, $h[n]$ is highpass filter, and $g[n]$ is lowpass filter. In the Haar wavelet, each step of the transformation always takes into account the wavelet coefficients and the average set. The equations for calculating an average a_i and Wavelet coefficients (c_i) are equation (3) and (4):

$$a_i = \frac{s_i + s_{i+1}}{2} \tag{3}$$

$$c_i = \frac{s_i - s_{i+1}}{2} \tag{4}$$

Here s_i is the i -th data, s_{i+1} is the data after i -th data, s_{i-1} is the data before i -th data, a is the data average, and c is the wavelet coefficient.

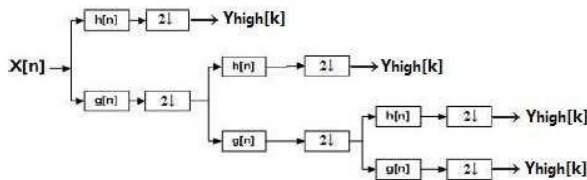


Figure 3. The wavelet decomposition

3. Results and Analysis

The captured image results are shown in Figure 4. The image size obtained from the camera is 4 Mp. The image is cropped with a size of 100×200 pixels on the area to be observed (region of interest/ROI), shown in Figure 5 respectively.

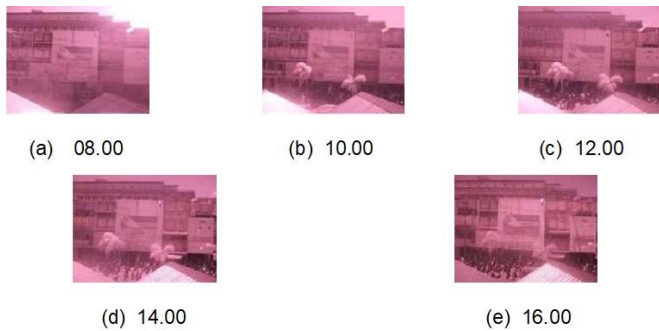


Figure 4. Results of capturing an image

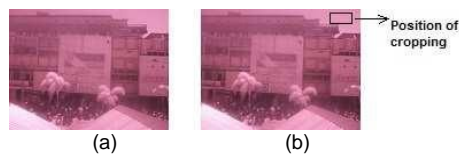


Figure 5. The position of the observed area in the research (a) original image and (b) the position of cropping

In this proposed method, infrared images of a RGB mode are converted into a grayscale to find out how much noise of the object. In this conversion process, the original image has a 24-bit pixel depth become to 8 bits. The next step is the image registration process. This process is done to get the same area on the different image. This process is done because the image is taken at different times so that there may be changes a camera position due to movement.

The use of cropping which has 8-bit image format is assigned wavelet transformation process and then done the decomposition process. The result of the decomposition process is shown in Figure 6. From the decomposition result, the intensity of the four images is summed to obtain the final image, shown in Figure 7.

The image of the summing of these intensities is segmented into 4 segments, 8 segments or 16 segments. From the final image is calculated the average intensity to obtain image data that represents the presence of pollutants. Calculation of the average intensity using equation (5):

$$I_{average} = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I_{(i,j)}}{M \times N} \quad (5)$$

Here M is the image width, N is the image height, and $I_{(i,j)}$ is the intensity of the (i,j) pixel.

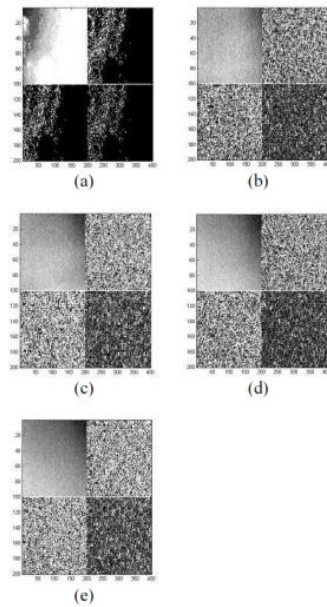


Figure. 6 The wavelet decomposition result in the image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

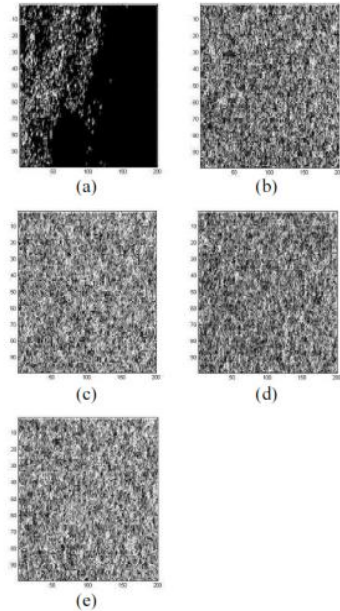


Figure 7. The summing result of the decomposition image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

The result value of the sum and average of the intensity for each segment and time is shown in Table 1. The minimal number of pollutants in the observed area occurred at 08.00 and the maximum number of pollutants occurred at 12.00. The area observed is the shopping area where the trade activity and the busiest traffic occurred in 12.00. In the observed area, the primary source of the pollutant comes from the smoke of vehicles passing through the area. At 08.00, traffic conditions in the area have not been crowded because the shops open at 09.00 so the condition of air pollution is still low. Similar pollutant detection results from the use of segmentation of 4 segments, 8 segments, and 16 segments, is shown by the graph in Figure 8.

Seen in Figure 8, in the morning (08.00) qualitatively produces images that look mostly dark, this means the air condition is still relatively clear. The black color declared a state of air condition that there are no pollutants while the color other than black is a pollutant because it is due to the wavelength reflections of the pollutants. Increased white pixels that indicate the presence of pollutants in the air in the observed area looks at 10.00—16.00. Increased air pollution is due to the increasing number of vehicles that pass through or has activities in the area.

The pollution peak occurs at 12:00 because at that hour the store employees use their time for activities in the outside because that time is a rest time. At 14:00 there was a decrease in pollution because traffic activity was not as busy as at 12:00. The increased of the pollution occurred again in 16:00 because ahead of the shops closed so that traffic vehicle activity of the buyers who leave a shop increased. CO2 measurement were carried out using a Combo IAQ meter at a location and the same hour proving that the highest levels of CO2 were at 12:00 and 16:00, shown in Figure 9.

This research proves that the more pollutant in the air, then the more noise arising in the image too, this phenomenon is shown in Figure 1. This noise appears from the reflection of the wavelength transmitted by pollutants that hitting the sensors in the camera. The wavelength of this pollutant is different from the wavelength reflected by the background object. This difference is that causes the occurrence of spots as if the noise.

Table 1. The result value of the sum and average of the intensity.

Clock	4 segment		8 segment		16 segment	
	Sum	Average	Sum	Average	Sum	Average
08:00	224592	112296	246000	12.3000	235024	117512
10:00	789156	39.4578	726477	36.3239	809631	404816
12:00	1003695	501846	898299	44.9150	912234	456117
14:00	821454	410727	742931	371466	721778	360889
16:00	927678	463839	776300	38.8150	815852	40.7946

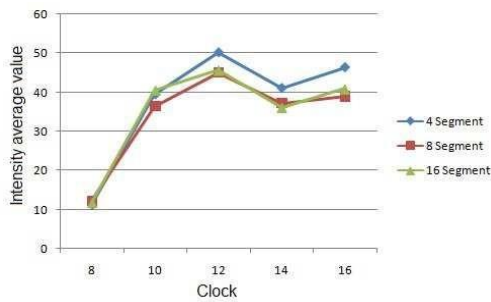


Figure 8. The average value of intensity for each segment

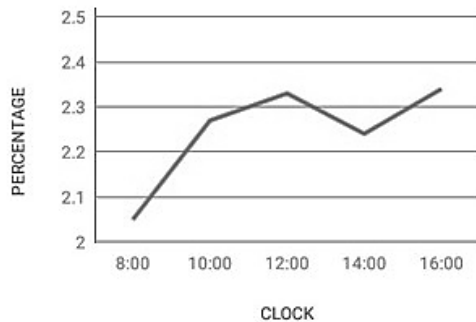


Figure 9. Trend of percentage CO₂ levels in the air using Combo IAQ meter

Commented [i-[3]: Please change with high quality figure

Commented [SRS4R3]: Done

4. Conclusion

This paper proposes a pollutant detection technique on air pollution using Wavelet transforms. Using a wavelet transforms, the noise on the image can be well recognized so that it can be used to represent the presence of pollutants. The trends of an increase of the air pollution are obtained from the calculation data of the intensity average of the image in the observed area. This is in accordance with the condition that at 12:00 is the busiest traffic time resulting in maximum air pollution in the area.

Acknowledgment

Thanks to Directorate Research and Community Service, Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Republic Indonesia for providing financial support through Research Grant.

References

- [1] Wang D, Huang Y, and Li W. Real-Time Air Pollutants Rendering based on Image Processing. *International Journal of Information Technology and Computer Science*. 2011; 5: 32-38.
- [2] Joans SM, Pavithra M. Air Pollution Monitoring Through Image Processing. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*. 2017; 5(X): 1377-1382.
- [3] Divya N, Lakkakula NP, Nelikanti A. Detection of Ozone Layer Depletion Using Image Processing and Data Mining Technique. *International Journal of Computer Science and Information Technologies (IJCSIT)*. 2014; 5(5): 6383-6388.
- [4] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. Study of Environmental Condition Using Wavelet Decomposition Based on Infrared Image. *Proc. of the 1st Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)*. Indonesia. 2014; 170-174.
- [5] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. Intensity Average Value of Image Segmentation for Infrared Image of Environmental Condition. *Proc. of the 2nd Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)*. Indonesia. 2015; 220-224.
- [6] Sulistiyanti SR. Characteristic Filter Absorber Based on Influence Intensity Sun variety. *Prosiding Seminar Hasil Penelitian dan Pengabdian Masyarakat*. Lampung, 2007.
- [7] Sulistiyanti SR, Susanto A, Setyawan FXA. Histogram Characterizations of Infrared Images Captured by a Modified Digital Camera. *International Journal of Electronic Engineering Research (IJEER)*. Research India Publications (RIP). 2009; 1(4): 329-336.
- [8] Khamisan N, Ghazali KH, and Ching WL. Detection of Indoor Air Pollution on Wet or Moist Walls Using Thermal Image Processing Technique. *ARNP Journal of Engineering and Applied Sciences*. 2015; 10(3): 1154-1160.
- [9] Prochazka A, Kolinova M, Fiala J, Hampl P, Hlavaty K. Satellite Image Processing and Air Pollution Detection. *Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing*. 2000.
- [10] Muzammil M, Salahudin, Hanan Z, Ashaari. Application of Remote Sensing Instruments in Air Quality Monitoring in Malaysia. *Pertanika Journal of Scholarly Research Reviews (PJSRR)*. 2017; 3(1): 93-112.

- [11] Palve SN, Nemade PD, Ghude SD. *The Application of Remote Sensing Techniques for Air Pollution Analysis and Climate Change on Indian Subcontinent*. 8th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing. Kuala Lumpur. 2016; 37: 1-10.
- [12] Gan CM, Gross B, Wu YH, Moshary F. Applications of Remote Sensing Instruments in Air Quality Monitoring. In: Mazzeo N. *Air Quality Monitoring, Assessment and Management*. Croatia: InTechEurope; 2011: 173-204.
- [13] Hamzelo M, Gharagozlou A, Sadeghian S, Baikpour SH, Rajabi A. Modelling of Carbon Monoxide Air Pollution in Large Cities by Evaluation of Spectral LANDSAT8 Images. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 2015; XL-1/W5: 281-285.
- [14] Utell MJ, Frampton MW. Acute health effects of ambient air pollution: the ultrafine particle hypothesis. *J. Aerosol Med*. 2000; 13: 355-359.
- [15] Li Y, Chen Q, Zhao H, Wang L, Tao R. Variations in PM₁₀, PM_{2.5} and PM_{1.0} in an Urban Area of the Sichuan Basin and Their Relation to Meteorological Factors. *Atmosphere*. 2015; 6: 150-163.
- [16] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Noise Filtering on Thermal Images Acquired by Modified Ordinary Digital Camera. *Proceeding of International Conference on Electronics and Information Technology (ICEIE)*. Kyoto. 2010; 2: 462-464.
- [17] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Histogram Slicing to Better Reveal Special Thermal Objects. *Proceeding of Int. Conference on Signal and Image Processing (ICSIP)*. World Academy of Science, Engineering, and Technology (WASET). Singapore. 2010; 810-812.
- [18] Amritphale AN. A Digital Image Processing Method for Detecting Pollution in the Atmosphere from Camera Video. MSc Thesis. Las Vegas: University of Nevada; 2013
- [19] Zhang H, Avdelidis NP, Osman A, Castanedo CI, Sfarra S, Fernandes H, Matikas TE, Maldague XPV. Enhanced Infrared Image Processing for Impacted Carbon/Glass Fiber-Reinforced Composite Evaluation. *Sensors*. 2018; 18(45): 1-13.
- [20] Usamentiaga R, Venegas P, Guerediaga J, Vega L, Molleda J, Buines FG. Infrared Thermography for Temperature Measurement and Non-Destructive Testing. *Sensors*. 2014; 14(7): 12305-12348
- [21] Wu K, Feng Y, Yu G, Liu L, Li J, Xing Y, Li F. Development of an Imaging Gas Correlation Spectrometry Based Mid-Infrared Camera for Two-Dimensional Mapping of CO in Vehicle Exhaust. *Optics Express*. 2018; 26(7): 8239-8251.
- [22] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Surface (2D) Fitting to Exhibit the Inaccessible Isotherms Contours of Thermograms Acquired by a Consumer Digital Camera. *International Journal of Computer Science and Technology (IJCST)*. 2011; 2(1).
- [23] Sulistiyanti SR, Burhanudin Y, Harun S. Characterization of Cutting Temperature and Ignition Phenomena of Magnesium Chip using Infrared Imaging. *Advanced Materials Research*. Trans. Tech Publications. Switzerland. 2012: 588-589: 1744-1747.
- [24] Bosch I, Gomez S, Molina R, Miralles R. Object Discrimination by Infrared Image Processing. In: Mira J, Ferrández JM, Álvarez JR, de la Paz F, Toledo FJ. *Editors*. *Bioinspired Applications in Artificial and Natural Computation*. Lecture Notes in Computer Science, vol 5602. Berlin, Heidelberg: Springer; 2009: 30-40.
- [25] Sosnowski T, Bieszczad G, Madura H. Image Processing in Thermal Cameras. In: Nawrat A., Bereska D, Jedrasiak K. *Editors*. *Advanced Technologies in Practical Applications for National Security*. Studies in Systems, Decision and Control, vol 106. Cham: Springer; 2018: 35-57.

Commented [i-5]: Please add your references minimal 25. It's a policy from TELKOMNIKA. And please follow the TELKOMNIKA Template about writing references

Please follow the writing of references in TELKOMNIKA. Please see the TELKOMNIKA Template

Commented [SRS6R5]: Done

[TELKOMNIKA] Asking Figure #25 12824

2 messages

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Fri, May 10, 2019 at 9:01 AM

Dear Sir/Madam,

For preparing your final paper to publish in **TELKOMNIKA (Telecommunication, Computing, Electronics and Control) ISSN: 1693-6930, e-ISSN: 2302-9293**. After checking, we found the figure in your paper is blur. Please sent us the high quality image of Figure 1. **You have 1 days to sent the figure until May 11, 2019**. We hope your response soon. Thank you.

Best regards,
TELKOMNIKA Staff

TELKOMNIKA Telecommunication, Computing, Electronics and Control

ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com

Virus-free. www.avg.com

Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>
To: Hany Safitry F <hanyjournal.iaes@gmail.com>

Fri, May 10, 2019 at 12:05 PM

Dear Sir/Madam
Thank you for requesting repair Figure 1.
Please look at the attachment about for the revision of Figure 1.

Thanks for your kind attention.

On Fri, May 10, 2019 at 9:02 AM Hany Safitry F <hanyjournal.iaes@gmail.com> wrote:

>
> Dear Sir/Madam,
>
> For preparing your final paper to publish in TELKOMNIKA (Telecommunication, Computing, Electronics and Control) ISSN: 1693-6930, e-ISSN: 2302-9293. After checking, we found the figure in your paper is blur. Please sent us the high quality image of Figure 1. You have 1 days to sent the figure until May 11, 2019. We hope your response soon. Thank you.
>
> Best regards,
> TELKOMNIKA Staff
>
> TELKOMNIKA Telecommunication, Computing, Electronics and Control
> ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
> Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com
>
> Virus-free. www.avg.com

--
Best Regards,
Sri Ratna Sulistiyanti
Dept. of Electrical Engineering
Faculty of Engineering
University of Lampung

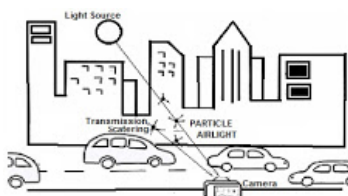
2 attachments

Figure 1.jpg
37K

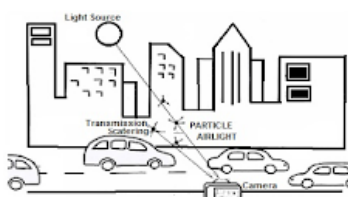


Figure 1.png
68K

[TELKOMNIKA] AUGUST 2019 Proofreading #12824

2 messages

Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Mon, May 13, 2019 at 3:37 PM


Dear Authors,

We hope this email reach you well. We are from TELKOMNIKA Staff want to inform you that your paper ID 12824 1570470386 entitled undefined already published in August 2019 Issue. The final pdf of your paper attached in here. We suggest you to read again your paper and check all element.

If you have something to tell us about your paper, please reply this email. We wait for your response until May 10, 2019.
Thank you for your cooperation.

Best regards,
TELKOMNIKA Staff

TELKOMNIKA Telecommunication, Computing, Electronics and Control
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
Editor in Chief : tole@journal.uad.ac.id / Staff : team@journal.uad.ac.id/hanyjournal.iaes@gmail.com

 **25 12824 1570470386_rev (07Maret2019) (DDV).pdf**
588K


Hany Safitry F <hanyjournal.iaes@gmail.com>
To: Sri Ratna Sulistiyanti <sr_sulistiyanti@eng.unila.ac.id>

Mon, May 13, 2019 at 3:39 PM

Dear Authors,

We hope this email reach you well. We are from TELKOMNIKA Staff want to inform you that your paper ID 12824 1570470386 entitled undefined already published in August 2019 Issue. The final pdf of your paper attached in here. We suggest you to read again your paper and check all element.

If you have something to tell us about your paper, please reply this email. We wait for your response until May 16, 2019.
[Quoted text hidden]

 **25 12824 1570470386_rev (07Maret2019) (DDV).pdf**
588K

Detection air pollution based on infrared image processing

Sri Ratna Sulistiyanti*, F. X. Arinto Setyawan, Muhamad Komarudin

Department of Electrical Engineering, Faculty of Engineering, University of Lampung, Indonesia

*Corresponding author, e-mail: sr_sulistiyanti@eng.unila.ac.id

Abstract

This paper proposes a method of detecting air pollution in a region using image processing techniques. The image used is the infrared image that obtained using a modified digital camera by mounting the SRS filter. Image processing technique used is to utilize wavelet transformation. Pollutants are detected based on the average number of white pixels that appear on the image. This white pixel appears due to the reflection of the wavelength of the pollutant that hits the sensor on the camera. From the results of the proposed method detection is known that the highest pollution occurs in 12.00 which is the busiest traffic time and the lowest pollution occurred in 08.00 where the traffic passing through the area has not been crowded.

Keywords: *detection, infrared image, pollution, SRS filter, wavelet*

Copyright © 2019 Universitas Ahmad Dahlan. All rights reserved.

1. Introduction

Air pollution is a condition of air contaminated by chemicals, substances/particles, and other biological materials that could endanger the health of living beings and other organisms. Air pollution could be caused by motor vehicle fumes, a factory fumes or the forest fires. The negative impact of air pollution on health is could be caused breathing problems or inflammation of the respiratory tract, skin health disorders, and stress. This negative impact is what drives the need for research about air pollution detection. This research aims to identify the presence of air pollution in one place by using digital image processing in real time. Image processing in this research conducted in the frequency domain. Therefore, the previous done the transformation of the spatial domain to the frequency domain using wavelet transforms. After the image transformation results obtained, hence can be done analysis further. The use of image processing basically utilizes the electronic visual sensor (camera) which replaces the human visual system (eye). The advantages of the electronic visual sensor are to have a wavelength range that is larger than the human eye. In addition, an electronic visual sensor is also more sensitive in distinguishing the degree of intensity of each pixel of the image. By using image processing the little difference of the pixel intensity between pollutants and air through this sensor can be differentiated.

A lot of research about the detection of air pollution has been done before. Wang has been doing research about the rendering process of air pollutants based on image processing [1-3]. In contrast to the research conducted by Wang, this research uses wavelet transformation to detect air pollution from an infrared image. Joans has been used images diffusion process and ratio factor to analysis polluted images. The Infrared imagery-based research has been done before by doing image segmentation in infrared images to determine the environmental conditions [4]. The infrared image obtained by using SRS filters whose characteristics known from the previous research [5-7]. The SRS filter is a filter that transmits infrared waves made from cellulose films. The other research that has been done is the detection of indoor air pollution on wet or moist walls using a thermal camera [8]. This proposed research is done outdoors by taking infrared images using a camera. The other research that has been done is the detection of air pollution on satellite images [9-13].

The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image based research has been done before by doing image segmentation in infrared

images to determine the environmental conditions. The infrared image obtained by using SRS filters. The SRS filter (the name of creator) is a filter that transmits infrared waves made from cellulose films whose characteristics known from the previous research. This proposed research is done outdoors by taking infrared images using a camera. The difference with this research is the method used. In this experiment, the image processing is done in the frequency domain while the research that has been conducted using the image processing in the spatial domain. Another difference is in the coverage area of the image.

2. Research Method

Air pollution is a condition in which air is polluted by chemical or biological particles that can harm the health of living things. The particles that pollute the air are also called pollutants. In urban areas, sources of the pollutants come from vehicle fumes and industrial factory smoke. At low pollution levels, the number of particles in the outdoor air can reach 5,000-10,000 particles/cm³. At high pollution levels, for example, when high traffic volume can reach 300,000-1,000,000 particles/cm³ [14]. This particle size is very small namely less than 2.5 mm so the human eye cannot see it directly [15]. The existence of these particles can be detected using a digital camera. These particles will be captured by the camera as noise. The principle of pollutant detection using a digital camera is shown in Figure 1.

The previous research on the use of infrared images has been widely done. Sulistiyanti has been conducted research on infrared image enhancement [16, 17]. The infrared images can be used to obtain the thermal condition information of an object by performing a spatial filtering of an object [18-21]. Another research was to use an infrared image captured by digital cameras to determine isothermal calorimeter [22]. In addition, the other research used infrared images to determine the ignition point from the magnesium chip cutting temperature [23], and object discrimination [24]. Furthermore, practical applications for national security used this image processing [25].

In this research, the image was taken using a 5 MP digital camera mounted a SRS infrared filter. The usefulness of this filter is to pass the infrared light and to filter the other light. The image data were taken around the Bambu Kuning market, Bandar Lampung between 08:00 until 16:00 and intervals of data collected every 2 hours. The infrared images are images that obtained from a camera that uses filters to block visible light and allowed a near infrared light (infrared photography). The wavelength ranges used in infrared photography is about from 700 nm to 900 nm, shown in Figure 2. To get this image, the digital camera is modified by installing an infrared filter. The infrared filter used in this research is the SRS filter.

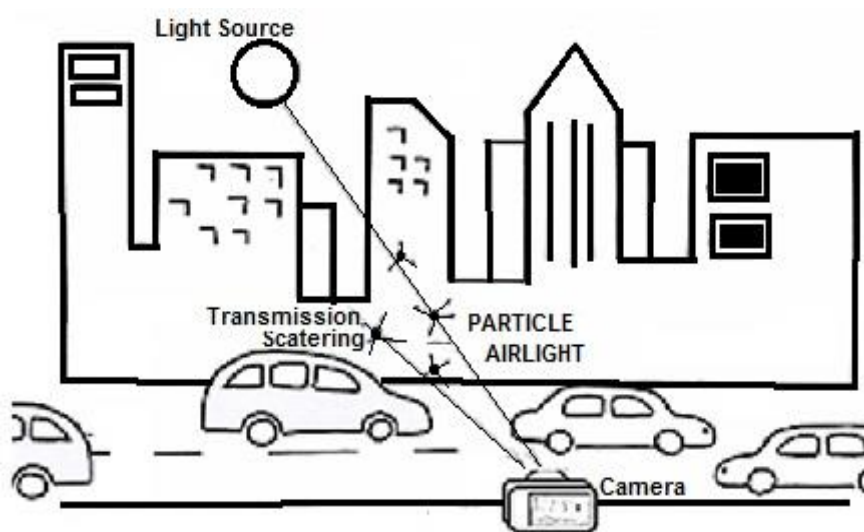


Figure 1. The radiance reaching the camera is the summation of the transmitted light from the object and light from the sun after scattering by particles

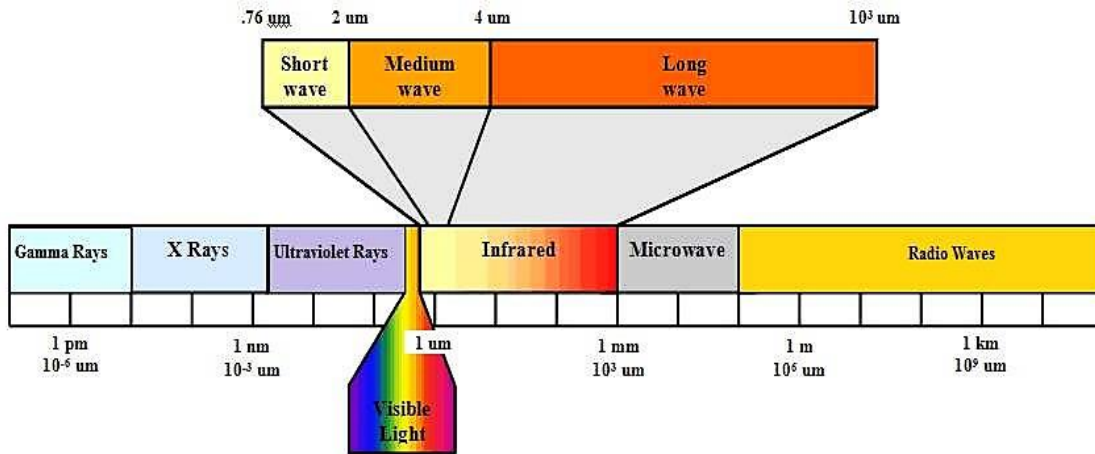


Figure 2. The wavelength range in photography

Then the captured infrared images are processed using image processing in the frequency domain, namely wavelet transform. The wavelet transform can be used as a multi-resolution analysis that can represent the time and frequency information of a signal. A signal whose frequency varies in time can be well analyzed using this transformation. In image processing, the wavelet transforms used are 2-D wavelet transforms. The image for image processing is represented as a 2-D matrix.

The decomposition process in the wavelet transform will attempt to divide the signal into two parts by the same number of sampling signals. These two parts are separated by two types of filters which have two different frequency bands, i.e. high-pass filter ($h[n]$) and lowpass filter ($g[n]$). After that the process is continued by modifying the signal based on the function of scale and time. This process repeatedly to determine the Discrete Wavelet Transform level and will affect the magnitude of the frequency band in each coefficient. The wavelet decomposition process is shown in Figure 3.

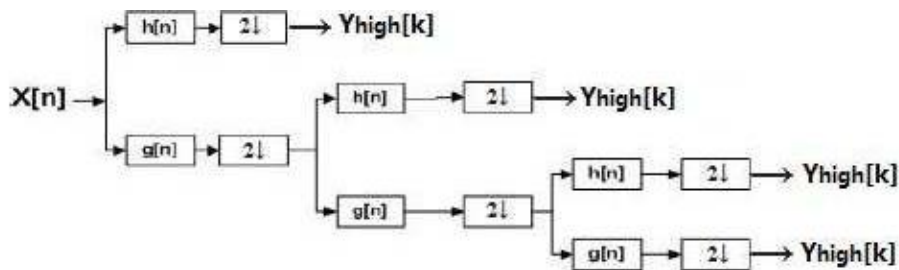


Figure 3. The wavelet decomposition

Decomposition process can be through one or more levels Mathematical, the one level decomposition is expressed by the following (1) and (2):

$$YHigh[k] = \sum_n X[n]h[2k - n] \tag{1}$$

$$YLow[k] = \sum_n X[n]g[2k - n] \tag{2}$$

Here $YHigh$ and $YLow$ are results from highpass filters and lowpass filters, $x[n]$ is origin signal, $h[n]$ is highpass filter, and $g[n]$ is lowpass filter. In the Haar wavelet, each step of the transformation always takes into account the wavelet coefficients and the average set. The equations for calculating an average a_i and Wavelet coefficients (c_i) are (3) and (4):

$$a_i = \frac{s_i + s_{i+1}}{2} \quad (3)$$

$$c_i = \frac{s_i - s_{i+1}}{2} \quad (4)$$

here s_i is the i -th data, s_{i+1} is the data after i -th data, s_{i-1} is the data before i -th data, a is the data average, and c is the wavelet coefficient.

3. Results and Analysis

The captured image results are shown in Figure 4. The image size obtained from the camera is 4 MP. The image is cropped with a size of 100x200 pixels on the area to be observed (region of interest/ROI), shown in Figure 5 respectively.

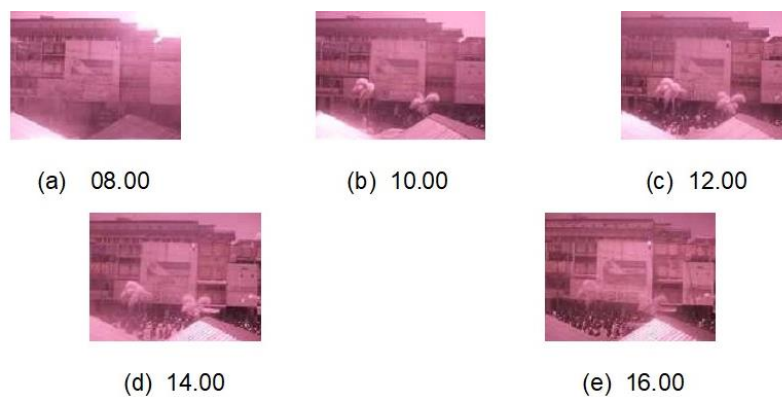


Figure 4. Results of capturing an image

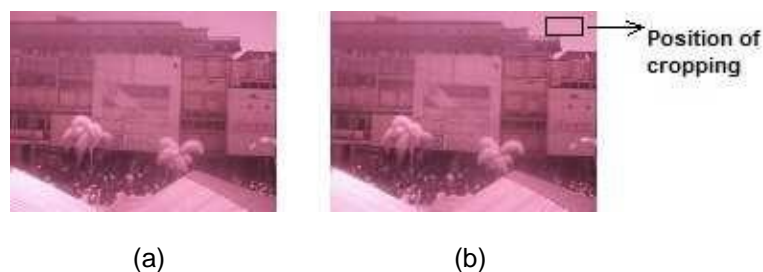


Figure 5. The position of the observed area in the research (a) original image and (b) the position of cropping

In this proposed method, infrared images of a RGB mode are converted into a grayscale to find out how much noise of the object. In this conversion process, the original image has a 24 bit pixel depth become to 8 bits. The next step is the image registration process. This process is done to get the same area on the different image. This process is done because the image is taken at different times so that there may be changes a camera position due to movement.

The use of cropping which has 8-bit image format is assigned wavelet transformation process and then done the decomposition process. The result of the decomposition process is shown in Figure 6. From the decomposition result, the intensity of the four images is summed to obtain the final image, shown in Figure 7.

The image of the summing of these intensities is segmented into 4 segments, 8 segments or 16 segments. From the final image is calculated the average intensity to

obtain image data that represents the presence of pollutants. Calculation of the average intensity using (5):

$$I_{average} = \frac{\sum_{i=0}^{M-1} \sum_{j=0}^{N-1} I_{(i,j)}}{M \times N} \quad (5)$$

here M is the image width, N is the image height, and $I_{(i,j)}$ is the intensity of the (i,j) pixel.

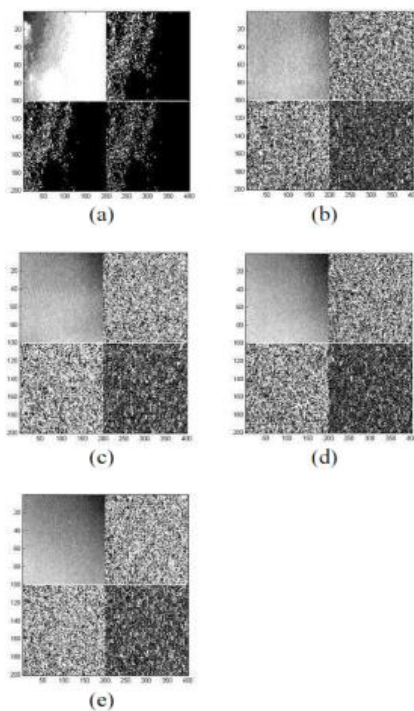


Figure. 6 The wavelet decomposition result in the image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

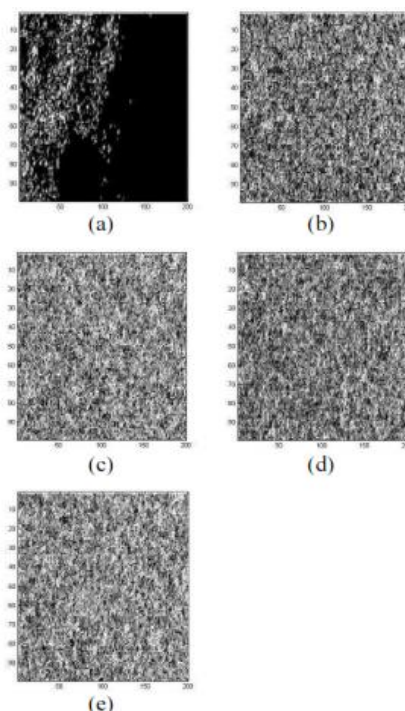


Figure 7. The summing result of the decomposition image at (a) 08.00, (b) 10.00, (c) 12.00, (d) 14.00, and (e) 16.00

The result value of the sum and average of the intensity for each segment and time is shown in Table 1. The minimal number of pollutants in the observed area occurred at 08.00 and the maximum number of pollutants occurred at 12.00. The area observed is the shopping area where the trade activity and the busiest traffic occurred in 12.00. In the observed area, the primary source of the pollutant comes from the smoke of vehicles passing through the area. At 08.00, traffic conditions in the area have not been crowded because the shops open at 09.00 so the condition of air pollution is still low. Similar pollutant detection results from the use of segmentation of 4 segments, 8 segments, and 16 segments, is shown by the graph in Figure 8.

Seen in Figure 8, in the morning (08.00) qualitatively produces images that look mostly dark, this means the air condition is still relatively clear. The black color declared a state of air condition that there are no pollutants while the color other than black is a pollutant because it is due to the wavelength reflections of the pollutants. Increased white pixels that indicate the presence of pollutants in the air in the observed area looks at 10.00-16.00. Increased air pollution is due to the increasing number of vehicles that pass through or has activities in the area.

The pollution peak occurs at 12:00 because at that hour the store employees use their time for activities in the outside because that time is a rest time. At 14:00 there was a decrease in pollution because traffic activity was not as busy as at 12:00. The increased of the pollution occurred again in 16:00 because ahead of the shops closed so that traffic

vehicle activity of the buyers who leave a shop increased. CO₂ measurement were carried out using a Combo IAQ meter at a location and the same hour proving that the highest levels of CO₂ were at 12:00 and 16:00, shown in Figure 9.

This research proves that the more pollutant in the air, then the more noise arising in the image too, this phenomenon is shown in Figure 1. This noise appears from the reflection of the wavelength transmitted by pollutants that hitting the sensors in the camera. The wavelength of this pollutant is different from the wavelength reflected by the background object. This difference is that causes the occurrence of spots as if the noise.

Table 1. The Result Value of the Sum and Average of the Intensity

Clock	4 segment		8 segment		16 segment	
	Sum	Average	Sum	Average	Sum	Average
08:00	224592	112296	246000	12.3000	235024	117512
10:00	789156	39.4578	726477	36.3239	809631	404816
12:00	1003695	501846	898299	44.9150	912234	456117
14:00	821454	410727	742931	371466	721778	360889
16:00	927678	463839	776300	38.8150	815852	40.7946

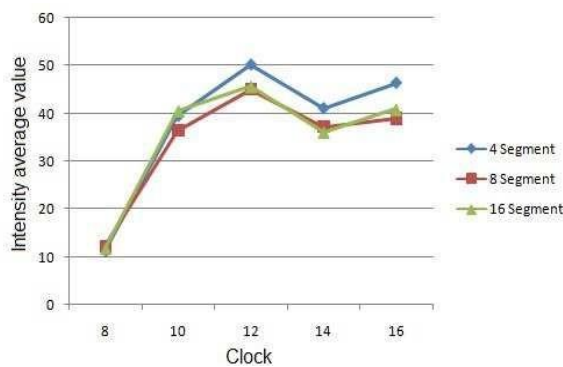


Figure 8. The average value of intensity for each segment

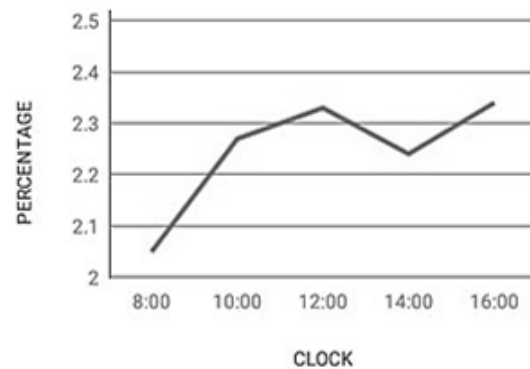


Figure 9. Trend of percentage CO₂ levels in the air using Combo IAQ meter

4. Conclusion

This paper proposes a pollutant detection technique on air pollution using Wavelet transforms. Using a wavelet transforms, the noise on the image can be well recognized so that it can be used to represent the presence of pollutants. The trends of an increase of the air pollution are obtained from the calculation data of the intensity average of the image in the observed area. This is in accordance with the condition that at 12:00 is the busiest traffic time resulting in maximum air pollution in the area.

Acknowledgment

Thanks to Directorate Research and Community Service, Directorate General of Research and Development, Ministry of Research, Technology, and Higher Education, Republic Indonesia for providing financial support through Research Grant.

References

- [1] Wang D, Huang Y, and Li W. Real-Time Air Pollutants Rendering based on Image Processing. *International Journal of Information Technology and Computer Science*. 2011; 5: 32-38.
- [2] Joans SM, Pavithra M. Air Pollution Monitoring Through Image Processing. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*. 2017; 5(X): 1377-1382.
- [3] Divya N, Lakkakula NP, Nelikanti A. Detection of Ozone Layer Depletion Using Image Processing and Data Mining Technique. *International Journal of Computer Science and Information Technologies (IJCSIT)*. 2014; 5(5): 6383-6388.

- [4] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. *Study of Environmental Condition Using Wavelet Decomposition Based on Infrared Image*. Proc. of the 1st Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE). Indonesia. 2014; 170-174.
- [5] Sulistiyanti SR, Komarudin M, Hakim L, Yudamson A. *Intensity Average Value of Image Segmentation for Infrared Image of Environmental Condition*. Proc. of the 2nd Int. Conference on Information Technology, Computer and Electrical Engineering (ICITACEE). Indonesia. 2015; 220-224.
- [6] Sulistiyanti SR. *Characteristic Filter Absorber Based on Influence Intensity Sun variety*. Prosiding Seminar Hasil Penelitian dan Pengabdian Masyarakat. Lampung. 2007.
- [7] Sulistiyanti SR, Susanto A, Setyawan FXA, Histogram Characterizations of Infrared Images Captured by a Modified Digital Camera. *International Journal of Electronic Engineering Research (JJEER). Research India Publications (RIP)*. 2009; 1(4): 329-336.
- [8] Khamisan N, Ghazali KH, and Ching WL. Detection of Indoor Air Pollution on Wet or Moist Walls Using Thermal Image Processing Technique. *ARPJ Journal of Engineering and Applied Sciences*. 2015; 10(3): 1154-1160.
- [9] Prochazka A, Kolinova M, Fiala J, Hampl P, Hlavaty K, *Satellite Image Processing and Air Pollution Detection*. Proceedings of IEEE International Conference on Acoustics, Speech, and Signal Processing. 2000.
- [10] Muzammil M, Salahudin, Hanan Z, Ashaari. Application of Remote Sensing Instruments in Air Quality Monitoring in Malaysia. *Pertanika Journal of Scholarly Research Reviews (PJSRR)*. 2017; 3(1): 93-112.
- [11] Palve SN, Nemade PD, Ghude SD. *The Application of Remote Sensing Techniques for Air Pollution Analysis and Climate Change on Indian Subcontinent*. 8th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing. Kuala Lumpur. 2016; 37: 1-10.
- [12] Gan CM, Gross B, Wu YH, Moshary F. Applications of Remote Sensing Instruments in Air Quality Monitoring. In: Mazzeo N. *Air Quality Monitoring, Assessment and Management*. Croatia: *InTechEurope*; 2011: 173-204.
- [13] Hamzelo M, Gharagozlou A, Sadeghian S, Baikpour SH, Rajabi A. Modelling of Carbon Monoxide Air Pollution in Large Cities by Evaluation of Spectral LANDSAT8 Images. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*. 2015; XL-1/W5: 281-285.
- [14] Utell MJ, Frampton MW. Acute health effects of ambient air pollution: the ultrafine particle hypothesis. *J. Aerosol Med*. 2000; 13: 355–359.
- [15] Li Y, Chen Q, Zhao H, Wang L, Tao R. Variations in PM₁₀, PM_{2.5} and PM_{1.0} in an Urban Area of the Sichuan Basin and Their Relation to Meteorological Factors. *Atmosphere*. 2015; 6: 150–163.
- [16] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. *Noise Filtering on Thermal Images Acquired by Modified Ordinary Digital Camera*. Proceeding of International Conference on Electronics and Information Technology (ICEIE). Kyoto. 2010; 2: 462-464.
- [17] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. *Histogram Slicing to Better Reveal Special Thermal Objects*. Proceeding of Int. Conference on Signal and Image Processing (ICSIP). World Academy of Science, Engineering, and Technology (WASET). Singapore. 2010; 810-812.
- [18] Amritphale AN. *A Digital Image Processing Method for Detecting Pollution in the Atmosphere from Camera Video*. MSc Thesis. Las Vegas: University of Nevada; 2013
- [19] Zhang H, Avdelidis NP, Osman A, Castanedo CI, Sfarra S, Fernandes H, Matikas TE, Maldague XPV. Enhanced Infrared Image Processing for Impacted Carbon/Glass Fiber-Reinforced Composite Evaluation. *Sensors*. 2018; 18(45): 1-13.
- [20] Usamentiaga R, Venegas P, Guerediaga J, Vega L, Molleda J, Buines FG. Infrared Thermography for Temperature Measurement and Non-Destructive Testing. *Sensors*. 2014; 14(7): 12305-12348
- [21] Wu K, Feng Y, Yu G, Liu L, Li J, Xing Y, Li F. Development of an Imaging Gas Correlation Spectrometry Based Mid-Infrared Camera for Two-Dimensional Mapping of CO in Vehicle Exhaust. *Optics Express*. 2018; 26(7): 8239-8251.
- [22] Sulistiyanti SR, Susanto A, Widodo TS, Suparta GB. Surface (2D) Fitting to Exhibit the Inaccessible Isotherms Contours of Thermograms Acquired by a Consumer Digital Camera. *International Journal of Computer Science and Technology (IJCST)*. 2011; 2(1): 7-9.
- [23] Sulistiyanti SR, Burhanudin Y, Harun S. Characterization of Cutting Temperature and Ignition Phenomena of Magnesium Chip using Infrared Imaging. *Advanced Materials Research. Trans. Tech Publications. Switzerland*. 2012; 588-589: 1744-1747.
- [24] Bosch I, Gomez S, Molina R, Miralles R. Object Discrimination by Infrared Image Processing. In: Mira J, Ferrández JM, Álvarez JR, de la Paz F, Toledo FJ. *Editors. Bioinspired Applications in Artificial and Natural Computation. Lecture Notes in Computer Science*. Berlin, Heidelberg: *Springer*. 2009; 5602: 30-40.
- [25] Sosnowski T, Bieszczad G, Madura H. Image Processing in Thermal Cameras. In: Nawrat A., Bereska D, Jędrasiak K. *Editors. Advanced Technologies in Practical Applications for National Security. Studies in Systems, Decision and Control*. Cham: *Springer*. 2018; 106: 35-57.



Author details

< Return to search results 1 of 1

Sulistiyanti, S. Ratna

[View potential author matches](#)

Profile actions

[Edit author profile](#)

[Connect to ORCID](#)

Alerts
[Set citation alert](#)
[Set document alert](#)

[Save to author list](#)

[Learn more about Scopus Profiles](#)

Author ID: 36606902600 ⓘ

<http://orcid.org/0000-0003-1666-623X>

Affiliation(s): ⓘ

Universitas Lampung, Bandar Lampung, Indonesia [View more](#) ▾

Other name formats: [Sulistiyanti, Sri Ratna](#) [Sulistiyanti, S. Ratna](#) [Sulistiyanti, S. R.](#)

Subject area: [Computer Science](#) [Engineering](#) [Mathematics](#) [Physics and Astronomy](#) [Energy](#)
[Decision Sciences](#)

Documents by author

13

[Analyze author output](#)

Total citations

23 by 17 documents

[View citation overview](#)

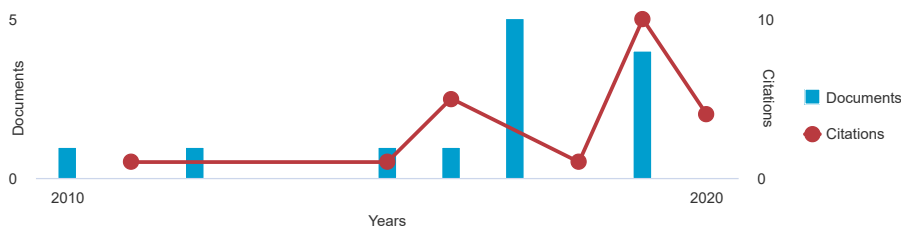
h-index: ⓘ

3

[View *h*-graph](#)

SS [S. Ratna Sulistiyanti](#) ↗
13 Documents
[View Mendeley profile](#) ↗

Document and citation trends:



13 Documents Cited by 17 documents 25 co-authors Topics

[View in search results format](#) > [View 121 references](#) >

Sort on: [Date \(newest\)](#) ▾

[Export all to CSV file](#) ▾ [Save all to list](#) [Set document alert](#) [Set document feed](#)

Document title	Authors	Year	Source	Cited by
----------------	---------	------	--------	----------

Model Design of Tomato Sorting Machine Based on Artificial Neural Network Method Using Node MCU Version 1.0 Open Access	Istiadi, A., Sulistiyanti, S.R., Herlinawati, Fitriawan, H.	2019	Journal of Physics: Conference Series 1376(1),012026	1
--	---	------	--	---

[View abstract](#) ▾ [View at Publisher](#) [Related documents](#)

Detection air pollution based on infrared image processing	Sulistiyanti, S.R., Setyawan, F.X.A., Komarudin, M.	2019	Telkomnika (Telecommunication Computing Electronics and Control) (4), pp. 1796-1802	0
--	---	------	---	---

[View abstract](#) ▾ [View at Publisher](#) [Related documents](#)

Adaptive background subtraction for monitoring system	Miranto, A., Sulistiyanti, S.R., Arinto Setyawan, F.X.	2019	2019 International Conference on Information and Communications Technology, ICOIACT 2019 8938501, pp. 153-156	0
---	--	------	---	---

Document title	Authors	Year	Source	Cited by
View abstract View at Publisher Related documents				
Multisensors System for Real Time Detection of Length, Weight, and Heartbeat of Premature Baby in the Incubator	Purwiyanti, S., Sulistiyanti, S.R., Setyawan, F.A., (...), Atmaja, K.S., Fitriawan, H.	2019	Proceedings of 2018 International Conference on Electrical Engineering and Computer Science, ICECOS 2018 8605208, pp. 85-88	1
View abstract View at Publisher Related documents				
A moving objects detection in underwater video using subtraction of the background model	Prabowo, M.R., Hudayani, N., Purwiyanti, S., Sulistiyanti, S.R., Setyawan, F.X.A.	2017	International Conference on Electrical Engineering, Computer Science and Informatics (EECSI) 2017-December	2
View abstract View at Publisher Related documents				
A moving objects detection in underwater video using subtraction of the background model	Prabowo, M.R., Hudayani, N., Purwiyanti, S., Sulistiyanti, S.R., Setyawan, F.X.A.	2017	International Conference on Electrical Engineering, Computer Science and Informatics (EECSI) 4, pp. 414-417	4
View abstract View at Publisher Related documents				
Telemetry and tele-control of electronic appliances for smart-home-system	Nurfaif, M.B., Sulistiyanti, S.R., Komarudin, M., Nama, G.F.	2017	2017 International Symposium on Electronics and Smart Devices, ISESD 2017 2018-January, pp. 18-23	0
View abstract View at Publisher Related documents				
Meat quality classification based on color intensity measurement method	Yulianti, T., Yudamson, A., Septama, H.D., (...), Setiawan, F.X.A., Telaumbanua, M.	2017	2016 International Symposium on Electronics and Smart Devices, ISESD 2016 7886727, pp. 248-252	1
View abstract View at Publisher Related documents				
The detection of 3D object using a method of a Harris Corner Detector and Lucas-Kanade Tracker based on stereo image	Prawira, W., Nasrullah, E., Sulistiyanti, S.R., Setyawan, F.X.A.	2017	ICECOS 2017 - Proceeding of 2017 International Conference on Electrical Engineering and Computer Science: Sustaining the Cultural Heritage Toward the Smart Environment for Better Future 8167126, pp. 163-166	3
View abstract View at Publisher Related documents				
Intensity average value of image segmentation for infrared image of environmental condition	Sulistiyanti, S.R., Komarudin, M., Hakim, L., Yudamson, A.	2016	ICITACEE 2015 - 2nd International Conference on Information Technology, Computer, and Electrical Engineering: Green Technology Strengthening in Information Technology, Electrical and Computer Engineering Implementation, Proceedings 7437802, pp. 216-220	1
View abstract View at Publisher Related documents				
Study of environmental condition using wavelet decomposition based on infrared image	Sulistiyanti, S.R., Komarudin, M., Hakim, L., Yudamson, A.	2015	2014 1st International Conference on Information Technology, Computer, and Electrical Engineering: Green Technology and Its Applications for a Better Future, ICITACEE 2014 - Proceedings 7065736, pp. 172-176	3
View abstract View at Publisher Related documents				
Characterization of cutting temperature and ignition phenomena of magnesium chip using infrared imaging	Sulistiyanti, S.R., Burhanudin, Y., Harun, S.	2012	Advanced Materials Research 588-589, pp. 1744-1747	2

[View abstract](#) [View at Publisher](#) [Related documents](#)

Noise filtering on thermal images acquired by modified ordinary digital camera Sulistiyanti, S.R., Susanto, A., Widodo, T.S., Suparta, G.B. 2010 ICEIE 2010 - 2010 International Conference on Electronics and Information Engineering, Proceedings 2,5559817, pp. V2462-V2464 5

[View abstract](#) [View at Publisher](#) [Related documents](#)

Display: results per page

[1](#)

[^ Top of page](#)

The data displayed above is compiled exclusively from documents indexed in the Scopus database. To request corrections to any inaccuracies or provide any further feedback, please use the [Author Feedback Wizard](#).

About Scopus

[What is Scopus](#)
[Content coverage](#)
[Scopus blog](#)
[Scopus API](#)
[Privacy matters](#)

Language

[日本語に切り替える](#)
[切换到简体中文](#)
[切换到繁體中文](#)
[Русский язык](#)

Customer Service

[Help](#)
[Contact us](#)

ELSEVIER

[Terms and conditions](#) [Privacy policy](#)

Copyright © Elsevier B.V. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

We use cookies to help provide and enhance our service and tailor content. By continuing, you agree to the use of cookies.

 RELX



Science research journal

International Journal of Research and Innovation in Applied Science
IJRIAS

rsisinternational.org

OPEN

Telkomnika

Country
Subject Area and Category

Indonesia -  SIR Ranking of Indonesia

Engineering
Electrical and Electronic Engineering

Publisher

Institute of Advanced Engineering and Science (IAES)

Publication type

Journals

ISSN

16936930, 2087278X

Coverage

2011-2020

Scope

TELKOMNIKA (Telecommunication Computing Electronics and Control) is a peer reviewed International Journal in English published four issues per year (March, June, September and December). The aim of TELKOMNIKA is to publish high-quality articles dedicated to all aspects of the latest outstanding developments in the field of electrical engineering. Its scope encompasses the engineering of signal processing, electrical (power), electronics, instrumentation & control, telecommunication, computing and informatics which covers, but not limited to, the following scope: Signal Processing[...] Electronics[...] Electrical[...] Telecommunication[...] Instrumentation & Control[...] Computing and Informatics[...]



[Homepage](#)

[How to publish in this journal](#)

[Contact](#)



[Join the conversation about this journal](#)

18

H Index

Science research journal

International Journal of Research and Innovation in Applied Science IJRIAS

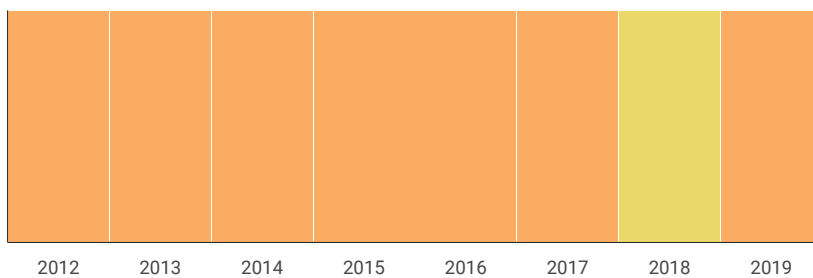
rsisinternational.org

OPEN

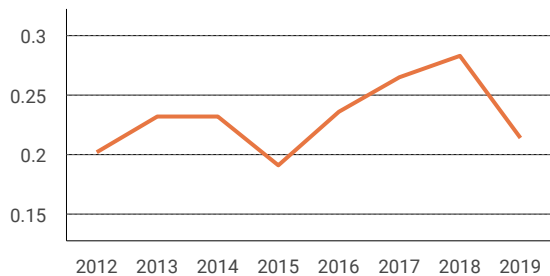
Quartiles



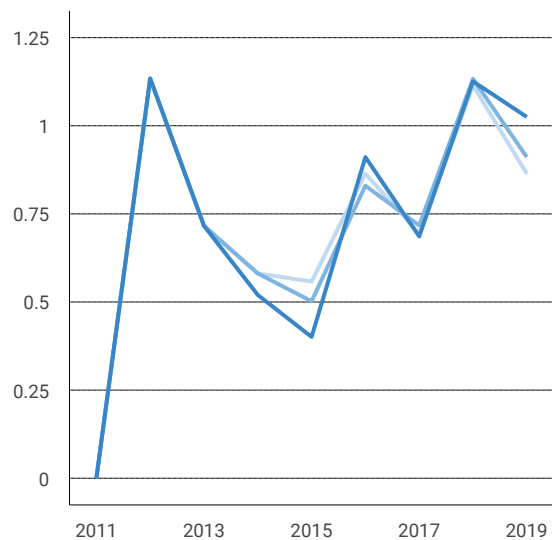
Electrical and Electronic Engineering



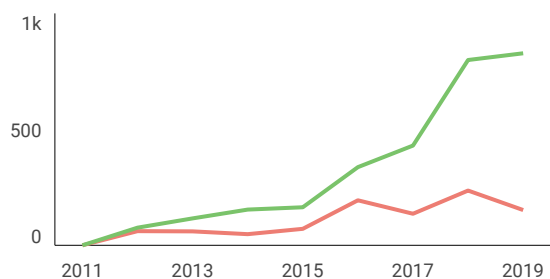
SJR



Citations per document

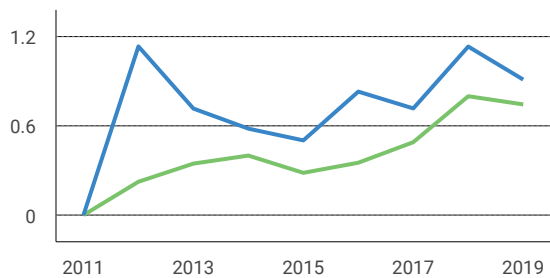


Total Cites Self-Cites

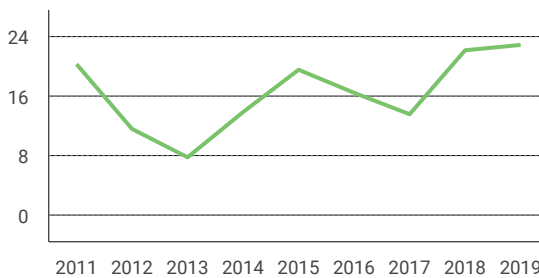


- Cites / Doc. (4 years)
- Cites / Doc. (3 years)
- Cites / Doc. (2 years)

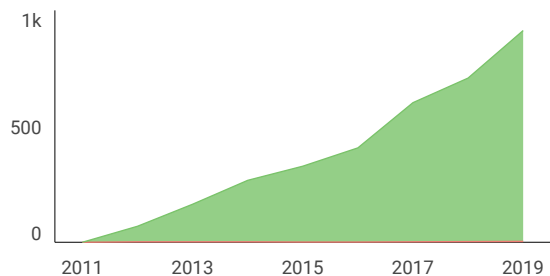
External Cites per Doc Cites per Doc



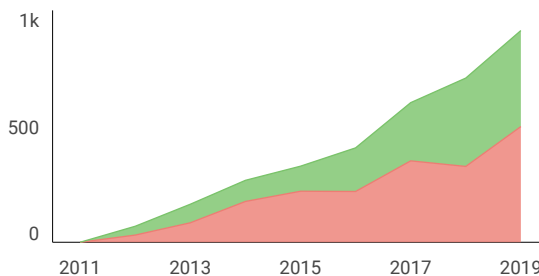
% International Collaboration



Citable documents Non-citable documents



Cited documents Uncited documents



Show this widget in your own website

Just copy the code below and paste within your html code:

```
<a href="https://www.scimago"
```