Chainsaw Sound and Vibration Detector System for Illegal Logging

By Giva Andriana Mutiara

Chainsaw Sound and Vibration Detector System for Illegal Logging

Dirga Chandra Prasetyo, Giva Andriana Mutiara, Rini Handayani
Applied Science School
Telkom University
Bandung, Indonesia
dirga.student@gmail.com, giva.andriana@tass.telkomuniversity.ac.id, rini.handayani@tass.telkomuniversity.ac.id

***Abstract*—Illegal logging is timber theft activity that can harm many aspects. One of the issues is logging on a large scale can damage a forest ecosystem and affect human life. One way to reduce illegal logging is implementing a technology. This research was designing a prototype that can detect the occurrence of illegal logging. This system uses a combination of sound sensor and vibration sensor. Sound sensor, it applies to identify the chainsaw while the vibration sensor, it uses to detect the falling trees. This research was designed with Arduino Nano and GSM module as information providers for forest guard patrols. The threshold value of 63.4 dB for the chainsaw and the threshold value of 4400 for vibration sensors can provide the excellent combination to detect illegal logging.**

Keywords—Illegal Logging, Sound Sensor, GSM Module, Vibration Sensor, Chainsaw Sound

I. INTRODUCTION

Forests are natural resources that have various essential benefits for the survival of living things. Forests have a primary function as carbon dioxide absorbers, producing oxygen as well as habitat for flora and fauna. Forests must be appropriately treated to provide the optimal benefits for the community. However, Indonesian public awareness of the importance of forest functions is still low. Therefore, it is not surprising that a lot of forests has been degradation in Indonesia. This can be proven from the data that released by the Indonesian Ministry of Environment and Forestry, that the forest area in Indonesia has decreased by 684,000 hectares from the year of 2010 to 2015 [1].

Forests degraded due to many various things. However, most things caused by illegal logging [2]. Based on fig.1, it was seen that the most reported forest crime in Indonesia during the year 2008 – 2011 caused by the illegal logging. The occurrence of the decline year by year does not mean that illegal logging has declined since there are still a lot of illegal logging practices cases that have not reported yet.

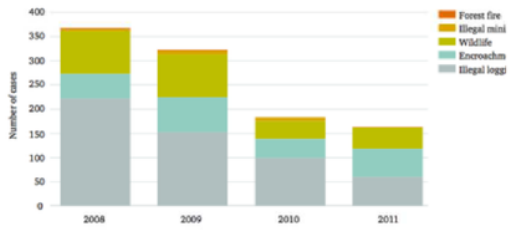

Fig. 1. Reported Forest Crime In Indonesia

Illegal logging is an activity of logging trees in the forest, transporting, and selling timber with correlation with permits or unauthorized restrictions or not having permission from local authorities. The term logging occurs because it caused more complicated crimes, include deforestation by destroying nature accompanied by damage to other ecosystems and the activities carried out without the permission of the authorities that seen in Indonesian Law of Forestry No.19 of the year 2004 [3] and Law no.41 of the year 1999 concerning about forestry [4].

The category of illegal logging according to clause no 50: (1) licensing, a kind of activity does not have a permit or there is no permit or permit that has expired (2) practice, if in practice it does not apply to log in accordance with regulations, (3) location, if it is done at a location outside the permit, cutting down in the conservation/protection area, or the origin or the location cannot be shown, (4) timber production, if the wood is carelessly type (protected), there are no diameter limit, there is no wood origin identity, no company identification, (5) documents, if there is no legal document (6) the perpetrator, if the person or business entity does not hold a logging business license or carry out activities that violate the law in the forestry sector, and (7) sales, if at the time of sale, there were no documents or physical characteristics of wood or wood smuggled. This logging case has involved many parties and carried out in an organized and systematic manner. This crime has penetrated protected areas and national park [5].

Due to economic problems, in Indonesia there are still many local people who were still doing illegal logging in a protected forest and far from the attention of forest officials patrol. They use large axes or chainsaws. They stole the timber and sold it secretly without permission [6]. Many technologies have been used to prevent and reduce the occurrence of illegal logging. But, according to the characteristics of the probability of frequent occurrence of illegal logging with traditional methods in Indonesia, this research will try to create a prototype that can detect the sound of chainsaws and the vibration that generated by the axes, using combining sensor sound and vibration sensor which is integrated with the Arduino Nano and GSM module. Based on that description, the system aims to detect the chainsaw sounds and the vibration that generated from the axe and provide information to forest patrol officers quickly when the illegal logging happened.

This paper will describe in six chapters. Chapter one is telling about the introduction to the background of the research. Next chapter two will define the technology that has

been used and developed by the researcher. Chapter three explain the proposed prototype system. Chapter four illustrates the testing scenario, discuss and analyze the test results. Chapter five is giving the conclusion. Chapter six is the last chapter that providing information about future research.

II. Overview of Related Works

Many sensors can be used in the forestry sector, including temperature sensors, heat sensors, motion sensors, audio sensors and many more. However, there are only two sensors that are often used to detect illegal logging. The sensors are a vibration sensor and a sound sensor.

Starting with Czùni et.al, a researcher who is doing the investigation to detect the signal which comes from different chainsaw sound and make the same feature extraction to identify the sound of a chainsaw [7]. In the following year Czùni et.al was still researching to get chainsaw audio signals with TESPAR audio techniques using time domain audio and do a review for different methods that would be used for detecting illegal logging for optimized the energy saving. Even though this research is using a chainsaw sensor, but the paper is concerning the optimized energy saving on their WSN [8]. The study was further developed by other researchers who proposed a solution for using wireless sensor networks that were suitable for illegal logging by using a sound spectrum that produced by chainsaw [9].

Another researcher, Yussof et.al, try to implement other sensors that embed with Arduino. Several Gas sensors to detect the environmental of the forest, gathered the data and transmitted to the user using GSM by sending a message in real-time condition. This research is helping the forest official to know the information about the situation inside the forest, whether is a fire or not? [10]. Kalhara et.al, proposed and explain the three-tier architecture for forest monitoring based on wireless sensor network using the sound of a chainsaw and neural network. They also use devices nRF24L01 and Wi-Fi module on Arduino Uni and Raspberry Pi 3 model B, solar panel and battery pack [11].

A novel found by Chen et.al, they found the technique for sleep scheduling on WSN. They were also using two sensors as vibration and detection sound from a chainsaw. They focused the research on the monitoring system logging in real time [12].

Based on the description above, all the researchers except Chen et.al, using a sound sensor to detect the sound of the chainsaw as an alert to inform the occurrence of illegal logging. But according to the circumstances in the forest, sound sensors are sometimes lack of precise measurement to determine the sounds. According to that situation, this research will propose a prototype of detector system which collaborated the sound of the chainsaw and the vibration to tackle the illegal logging. This system is focusing on the signal of the chainsaw, how it is working with the vibration sensor, and the power consumed for the system. This system implemented consists of several main components, sound sensor (FC-04), vibration sensor (SW420), Arduino Nano, GSM Module (SIM 800L), RTC module DS3231, power bank solar cell, and using Arduino IDE to create programs.

III. Proposed System

Before designing the system, the placement or mapping the tree area blocks in a detection area must be created first. As shown in fig.2 each tree is determined as a star topology. The sound sensor placed in a tree that set in the middle of the detection area, while the vibration sensor placed on each tree in the detection area. The figure shows the mapping of two area blocks detection. Setting the sound sensors in the middle of the block (central) has a purpose in order to hear or detect the sound of a chainsaw from the trees that located around the central area. Meanwhile, the placement of vibration sensors on each tree has a purpose in a condition if the sound sensor in the central tree cannot detect or hear the sound of the chainsaw, the vibration sensor can provide information to the forest patrol officer whether illegal logging has happened in the forest.

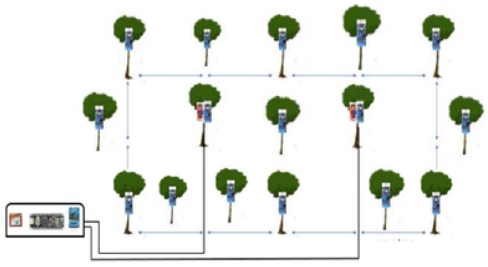

Fig. 2. Mapping Block of Tree Area Detection

After mapping the tree area detection, the next step is designing a block diagram of the proposed system, which can be seen in fig.3. All the component is designed with Arduino Uno, whereas sound sensor and vibration sensor is an input for Arduino Uno. Power bank solar cell 8800 m AH as a power supply and RTC module as a time module for Arduino Uno. The LCD as an output is a display to inform the state of current information happened in the forest. The GSM Module is an output module to give information to the forest patrol officers.

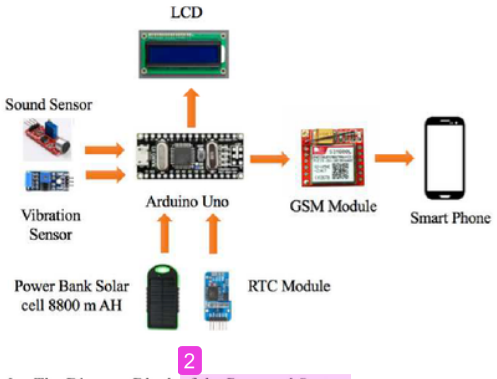

Fig. 3. The Diagram Block of the Proposed System

The architecture of the proposed system seen in fig 4. Fig.4 shows that all the component that used in the system is embedded one to each other. The system works when the sound and vibrates sensor detect the trees that were cut by receiving the chainsaw sound frequency and identifying vibration values. If the sensor has received a sound frequency

and vibration value from the sensors, it will be processed by the microcontroller, Arduino Uno. The GSM module will collect data that has been transformed by Arduino Uno and send a message via SMS immediately. The mobile device will receive output that has been sent by the GSM module.

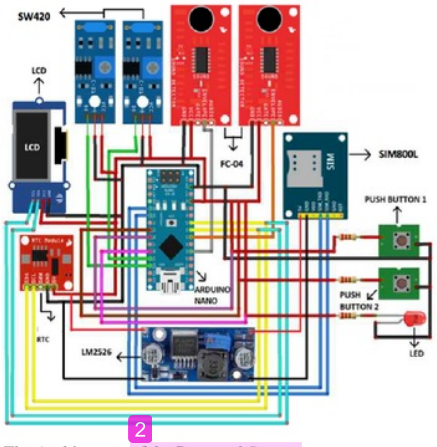

Fig. 4. The Architecture of the Proposed System

The flowchart of the proposed system seen in fig 5. The system starts when the sound sensor or vibration sensor detects the frequency or value threshold. If the vibration detected and sound detected, the system will inform the logging status in block x area detection and send an SMS into the forest patrol officers. If the vibration detected but the sound sensor is not detected the system will inform the tree on block x is fall, and the system still send an SMS into the forest patrol officers. This condition is a handling process if the sound sensor does not work properly. The last state if there is no detected sound or vibration, the system will inform the secure status only on the LCD.

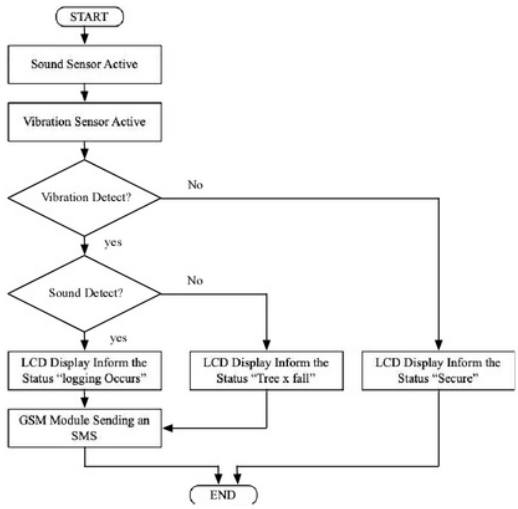

Fig. 5. Flowchart of Proposed System

The prototype system can be seen in fig.6. It shows the prototype that made using a casing with dimension 14.5 cm x 7 cm x 5 cm as a component container. The type of PCB is using single sided.

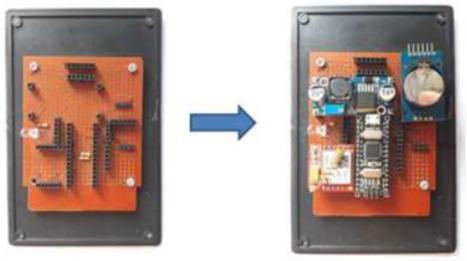

Fig. 6. A Prototype of Proposed System

IV. Testing and Result

The testing system will be done with several scenarios. (1) the first scenario is testing the sound of the chainsaw using a sound level meter, (2) the second scenario is testing the sound distance that can still be detected by sound sensor, (3) the third scenario is testing the comparison of the chainsaw sound with other sounds, (4) the forth scenario is testing the vibration sensor to find the threshold value that states the occurrence of logging, (5) the fifth scenario is testing the system for GSM modules and LCD display in the event of detection of the chainsaw, (6) the sixth scenario is testing the durability of the power bank.

A. Testing the Sound of the Chainsaw

This scenario aims in order to find out the frequency of the sound that has been generated by the chainsaw. The frequency that has been produced by the chainsaw were various (see. Fig.7) with minimum frequency in 41.4 dB, and the maximum frequency is in 104.8 dB, the average range between minimum and a maximum value is 63.4 dB.

Fig. 7. Result Testing Sound Value Chainsaw

According to fig.8, it can be seen that comparing the waves or frequencies obtained by the sound sensor using chainsaw sound from logging process until the trees fall by differentiating the results of the stability of the streaming wave so that it can determine the time assumed to be used in the system. This wave is comparing the analog value to the number of reading sensor. The minimum analog value that can be stated for the sound chainsaw is 80.

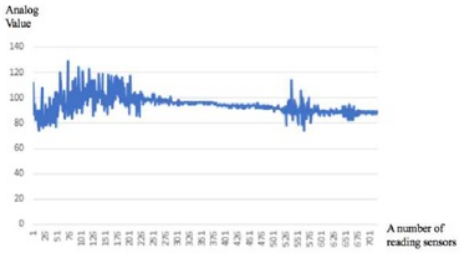

Fig. 8. Sound Wave of Chainsaw

B. Testing the Sound Distance

This testing aims to find out the maximum distance of sound sensor detection. The result can be seen in table 1.

TABLE I. TESTING RESULT DISTANCE DETECTION

Distance (m)	Analog Value	Distance (m)	Analog Value
0.1	571	0.8	127
	51		53
	182		126
	909		82
	232		48
	36		114
	404		55
			100
			58
0.4	127	3.6	84
	53		86
	126		82
	82		86
	48		79
	114		79
	55		92
	100		88
	58		80

It can be seen in table 2 that the farther the distance from the center of the sound, the resulting analog value gets smaller and stops being detected by the sensor at a distance of 3.6 meters.

C. Testing the Comparison of the Chainsaw Sound with Other Sound

This testing aims to compare the waves or frequencies that obtained by the sensor using chainsaw sound from the logging process versus motor cross sound to distinguish the results of wave's stability. Based on that, it can be determining the time assumption that will be used in the system. Fig.9 shows the streaming wave from the motor cross comparing to an analog value and the number of reading sensors.

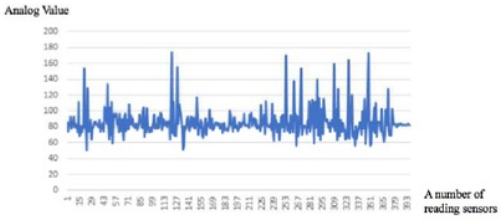

Fig. 9. Sound Wave of Motor Cross

Due to fig.8 and fig.9, it stated that the stability of waves that exceeds 100, can last stand for 3 seconds or 3 times in a row on the chainsaw sound. According to that condition, it can be concluded and assumed that if the sound sensor detects the sound transcend 63.4 dB three times in a row, it can be interpreted that the detected sound is a chainsaw sound.

D. Testing the Vibration Sensor

The purpose of the test on the vibration sensor is to determine the value of the sensitivity of the sensor to several vibrations that may occur in the forest. Thus, if the sensor sensitivity value found, then it can be used as a parameter sensitivity in the Arduino program. The sensor will be tested in the tree branch and placed as showed in fig.10.

Fig. 10. Vibration Sensor Testing

In this scenario, there are three experiments vibration sensor testing. The first experiment was done by shifting, sliding, shaking and rocking the tree branch. The second experiment was done by blowing the sensor and the branch by an electric fan. The third experiment was done by dropping the branch into the ground.

Based on table 2, the overall results of the testing can be concluded that the experiment when the branches are dropped to the ground produces a significant vibration analog value, in the range 77 – 7295. It is 5 out of 12 experiments produce values that are included in the range of the first test and second test. Whereas in first and second experiments where the branches are shaken and blown by the electric fan, the results vary with the range vibration value is 0 – 377 depending on the size of the magnitude of the shake and the blowing given to the vibration sensor.

TABLE II. VIBRATION SENSOR RESULT TEST

Vibration Sensor Value		
First Experiment	*Second Experiment*	*Third Experiment*
0	108	80
0	189	263
0	0	77
0	0	826
176	0	342
50	0	890
4	0	650
266	0	7295
70	77	472
189	128	4479
0	0	87
80	377	532

According to the vibration sensor result test, it decided that the threshold value installed in the Arduino's program to determine the occurrence of logging is set at a value 4400.

E. Testing the GSM Modules and LCD Display.

The purpose of the test is to test the GSM modules and LCD display whether the system can send SMS or not if there is the event of logging. The testing was carried out around 25 km from where the logging occurs. The result can be shown as fig.11. The figure shows the status condition of each block. When the logging happens in area block status 1, the display will show logging occurs while others block status is insecure condition. The SMS sent if logging occurs in one area and write the time when the logging occurs, and SMS sent.

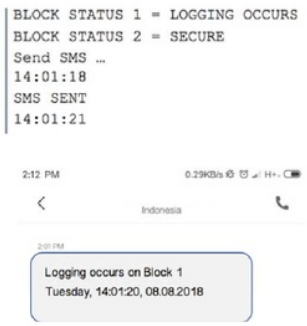

Fig. 11. GSM Module Testing Result

We do more than 20 experiments in testing the GSM module. The module is 100% sending the SMS into the official forest patrol. Fig 12 shows the LCD display system. The LCD shows the resulting testing when there is no logging happened.

Fig. 12. LCD Display Testing Result

F. Testing the Durability of the Power Bank

The purpose of the testing is to find out the battery life as the durability of the solar cell power bank. This system used power bank with 8800 mAH. This battery is testing to the system without any charges from the solar cell. The battery can provide endurance at last for 4 hours 50 minutes.

V. Conclusion

The use of combination sensor between sound sensors and vibration sensors produces a potential combination to be able to handle illegal logging cases. The implementation of vibration sensors here is to confirm the occurrence of logging to the sound recognition limitations of the sound sensor. By placing a vibration sensor, there are two times process checking (sound and vibration) to ensure that illegal logging has happened. The system can also send SMS in duration two minutes into the forest patrol officers so that they can act immediately in the event of logging.

The sensor tested with a variety of possible conditions environment that occur in the forest. Based on the test results, it can be concluded that the system successfully tested by placing an analog threshold value of 63.4 dB in the sound sensor and an analog threshold value of 4400 in the vibration sensor since the system recognizes that value to supervise the environment as the sound of the chainsaw and the vibration from the falling tree.

VI. Future Work

This system can further be developed in future research. This system enhanced by using a wireless sensor network by utilizing sophisticated communication technology. In terms of voice recognition from the chainsaw sound, it can be developed using any methods of signal processing in order to have a smoothing signal that can be interpreted as a chainsaw sound. The vibration sensor used can also be given vibration training using artificial intelligence or neural networks. Regarding of monitoring, the using of API technology can be implemented as a protocol to store all collected data sensor.

On the WSN, it can be developed how are the methods of data communication between sensors, nodes, gateways have happened. According to all describe future research, it will be expected that the entire system will be able to be embed and become a complete system to tackle illegal logging in Indonesia.

Acknowledgment

We would like to thank for PPM of Telkom University for the financial support to publish this research, and School of Applied Science, Telkom University, which provides a testing ground for the implementation.

References

[1] H. Cipto, "Setiap Tahun Hutan Indonesia Hilang 684.000 Hektar," Kompas.com, 2016. [Online]. Available: https://regional.kompas.com/read/2016/08/30/15362721/setiap.tahun.hutan.indonesia.hilang.684.000.hektar. [Accessed: 12-Sep-2018].

[2] J. Saunders, "Illegal Logging and Related Trade The Response in Lao PDR. A Chatham House Assessment.," no. October, 2014.

[3] I. President, Undang-Undang Republik Indonesia No.19, 2004th ed. 2004.

[4] D. S. Suyodono,Imam, Lailan Syaufina, "Analisis Pola Kemitraan Agroforestri Dalam Rangka Mengurangi Ancaman Perambahan Hutan (Studi Kasus Tumpangsari Tanaman Pangan Di Iuphhk-Ht Pulau Laut Kotabaru Kalimantan Selatan," J. Penelit. Kehutan. Wallacea, vol. 11, no. 1, pp. 46–64, 2014.

[5] L. Hidup and D. I. Indonesia, "Ketentuan Hukum Pidana Terhadap Praktik Illegal Logging Dan Upaya Pelestarian Lingkungan Hidup Di Indonesia," vol. 21, no. 5, pp. 1–15, 2016.

[6] A. Casson, "From New Order to Regional Autonomy : Shifting Dynamics of '" Illegal "' Logging in Kalimantan , Indonesia," vol. 30, no. 12, pp. 2133–2151, 2002.

[7] L. Czúni and P. Z. Varga, "Lightweight Acoustic Detection of Logging in Wireless Sensor Networks," Int. Conf. Digit. Information, Networking, Wirel. Commun., pp. 120–125, 2014.

[8] L. Czúni and P. Z. Varga, "Time Domain Audio Features for Chainsaw Noise Detection Using WSNs," IEEE Sens. J., vol. 17, no. 9, pp. 2917–2924, 2017.

[9] V. Andrei, "Considerations on Developing a Chainsaw Intrusion Detection and Localization System for Preventing Unauthorized Logging," J. Electr. Electron. Eng., vol. 3, no. 6, p. 202, 2015.

[10] A. Yusoff, S. Shafiril, G. Wills, L. Gilbert, and R. Crowder, "Utilizing the application of sensors to develop low-cost remote sensing system for monitoring forest environmental activity," 2016 IEEE Conf. Wirel. Sensors, ICWiSE 2016, vol. 2017–December, pp. 1–6, 2017.

[11] P. G. Kalhara, V. D. Jayasinghearachchd, A. H. A. T. Dias, V. C. Ratnayake, C. Jayawardena, and N. Kuruwitaarachchi, "TreeSpirit: Illegal logging detection and alerting system using audio identification over an IoT network," 2017 11th Int. Conf. Software, Knowledge, Inf. Manag. Appl., pp. 1–7, 2017.

[12] Y.-Y. Chen and J.-J. Liaw, "A Novel Real-time Monitoring System for Illegal Logging Events Based on Vibration and Audio," 2017 Ieee 8Th Int. Conf. Aware. Sci. Technol., no. iCAST, pp. 470–474, 2017.

Chainsaw Sound and Vibration Detector System for Illegal Logging

ORIGINALITY REPORT

4%

SIMILARITY INDEX

PRIMARY SOURCES

1	Yunanta Ilham Nugraha, Giva Andriana Mutiara, Rini Handayani. "Log Data Structure for Illegal Logging Tracking System", International Journal of Engineering & Technology, 2018 Crossref	51 words —	1%
2	article.sciencepublishinggroup.com Internet	20 words —	1%
3	Asdi Galvani, Andrian Rakhmatsyah, Giva Andriana Mutiara. "Prototype of microcontroller-based odometer reading for early warning in the vehicle lubricants replacement", 2015 3rd International Conference on Information and Communication Technology (ICoICT), 2015 Crossref	18 words —	1%
4	Submitted to Telkom University Your Indexed Documents	11 words —	< 1%
5	dspace.sliit.lk Internet	11 words —	< 1%
6	Dini Novalanty Ohara Daulay, Jafron Wasiq Hidayat. "Carbon Value Analysis of Batang Gadis National Park, Mandailing Natal Regency, North Sumatera Province, Indonesia", E3S Web of Conferences, 2018 Crossref	9 words —	< 1%
7	P. G. Kalhara, V. D. Jayasinghearachchd, A. H. A. T. Dias, V. C. Ratnayake, C. Jayawardena, N. Kuruwitaarachchi. "TreeSpirit: Illegal logging detection and alerting	7 words —	< 1%

system using audio identification over an IoT network", 2017 11th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), 2017
Crossref

8 Giva Andriana Mutiara, Gita Indah Hapsari, Periyadi. "Performance comparison of communication module againts detection location for blind cane", 2017 11th International Conference on Telecommunication Systems Services and Applications (TSSA), 2017 6 words — < 1%
Crossref

EXCLUDE QUOTES	ON	EXCLUDE MATCHES	OFF
EXCLUDE BIBLIOGRAPHY	ON		