Detection of aflatoxin contamination in corn

by Kukuh Yudistiro

Detection of aflatoxin contamination in corn using The Simplified Gabor Wavelet algorithm

Kukuh Yudistiro[1*], Gatot Suharto Abdul Fatah[2], Lasinta Ari Nendra Wibawa[3], Yudi Prastiyono[4]

[1]University of Merdeka Malang, Malang, East Java, Indonesia

[2, 3, 4] National Research and Innovation Agency (BRIN), Indonesia

*Corresponding author: kukuh.yudistiro@unmer.ac.id

Abstract:

The quality of corn is essential to determine whether it is still suitable for consumption and what type of corn it is. Corn is one type of vegetable that is indispensable for the nutritional needs of the Indonesian people today and is a mixture of other essential ingredients. Corn is rich in fiber, which is good for improving digestion and overcoming constipation, controlling blood sugar levels, maintaining heart health, overcoming depression, maintaining eye health, and preventing diverticulitis. In this research, image recognition is used to determine and detect the content of aflatoxin, one type of abnormality or disorder in corn. This affects the quality of corn, whether corn is suitable for human consumption, and what impact aflatoxin has on the human body. On testing using parameters Non-UV image, SGW Filter Image $\theta = 0, 90, 180$, and 270, and The resulting SGW image with the number of orientations $N = 4$, $\theta = \theta + pi/N$, and $\theta = \theta + 2*pi/N$, The aflatoxin content in humans can cause carcinogenic or liver cancer and acute necrosis, cirrhosis, and carcinoma in the animal liver.

Keywords: corn quality, image processing, aflatoxin, detection

1. INTRODUCTION

Corn is one of the food production commodities other than rice, one of the Indonesian people's staple foods. So that the need for corn is essential in addition to being a basic need for the Indonesian people, becoming an export commodity or a source of the community's economy, a source of nutrition or health, and other benefits. But one of the people is aflatoxin. This aflatoxin is found in corn. This aflatoxin is a toxic compound produced by *Aspergillus flavus* and *Aspergillus parasiticus*, and its growth depends on a specific humidity level. Conventional farmers have tried to eliminate Aspergillus flavus and Aspergillus parasiticus utilizing drying corn, but they are not optimal. The aflatoxin content in humans can cause carcinogenic or liver cancer and acute necrosis, cirrhosis, and carcinoma in the animal liver. In this study, an attempt was made to detect aflatoxins in corn using the simplified Gabor wavelet algorithm [1,2,3,4]. The aflatoxin detection process was carried out under ultraviolet light and in a dark environment. Other algorithms are used in telecommunication [17,18,19,23,24].

2. METHOD

A. The Simplified Gabor Wavelet (SGW) algorithm

The simplified Gabor Wavelet algorithm [5,6,7,8] detects corn edge objects on corn shells and performs calculations on corn objects indicated by aflatoxins. Moreover, Fig. 1 is a System Block Diagram that illustrates step-by-step image recognition in this research, and Fig. 1 will provide information on the percentage of aflatoxin content in corn.
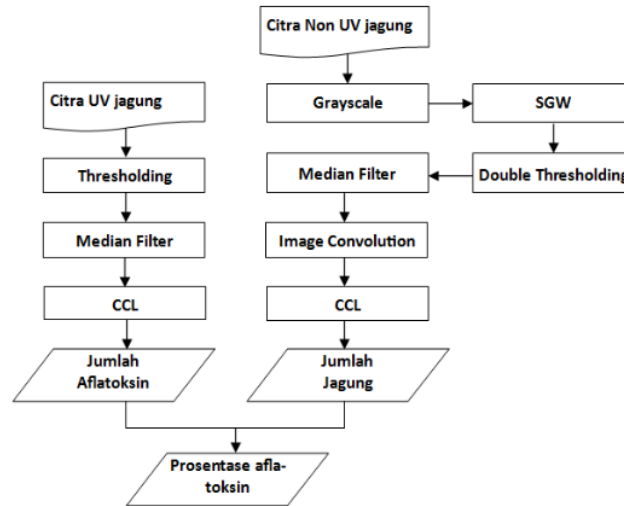

Fig 1. System Block Diagram

Equation 1 shows a formula that calculates edge detection in corn images using the Simple Gabor Wavelet (SGW) algorithm.

$$S(x,y) = \exp\left[-\frac{x^2 + y^2}{2\sigma^2}\right] \sin\left[\omega(x\cos\theta + y\sin\theta)\right] \tag{1}$$

$$\psi_{\omega,\theta}(x) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2}{2\sigma^2}\right) \exp(i\omega x). \tag{2}$$

Furthermore, equation 2, used to describe the dimensions or shape of the object with the Simple Gabor Wavelet (SGW) algorithm [20,21,22] Fig. 2 is an example of a simplified thing of the image-level quantization process. Equation 2 was developed for one of the case studies of an object in Fig. 2. Pseudocode 1 is the programming step to detect aflatoxin in this research. Pseudocode is essential to do to analyze any previous analysis [10,11,12,13,14].

```
1.  [Input UV image]
2.  [Take every pixel from the image to convert to binary pixels]
        while i < imageUV.width
        while j < imageUV.height
        takepixel = imageSGW.GetPixel(i,j)
        r = Convert.ToInt16(c.R);
        g = Convert.ToInt16(c.G);
        b = Convert.ToInt16(c.B);
        checkpixel = ((r + (g + b)) / 3)
3.  [Set minimum threshold=0 and maximum threshold according to input
    from users]
4.  [Change pixels that are 0 remain 0, otherwise 255]
        6.2 if pixels > thresMax then r=255, g=255, b=255;
        elseif pixel < thresMin then r=255, g=255, b=255;
        else r=0, g=0, b=0;
5.  [Change the obtained values of r, g, b into values of Pixels take
    pixels = Color.FormArgb(r,g,b)]
6.  [Change initial pixels from position i,j to value
    take a pixel for the coordinates of that pixel]
        imageBinerUV.SetPixel(i, j, take pixel)
7.  [Continue to repeat pixel check to all coordinates
        pixel to the last pixel in the image]
```

Pseudocode 1. Detection of aflatoxin by thresholding afla
luminescence color]

TABLE 1. SGW QUANTITATIVE ANALYSIS COMPARISON

No	Algorithm	Average Run Time (ms)
1	Canny	76,5
2	Prewitt	23,4
3	Roberts	21,8
4	Sobel	78
5	Gabor Wavelet	47
6	Simplified Gabor Wavelet	31

The comparison between the *Simple Gabor Wavelet* (SGW) algorithm and other algorithms can be seen in table 1. Although not as fast as the average Run Time (ms) in Prewitt, Roberts, the Simplified Gabor Wavelet has good performance and data processing speed and is suitable for practical and real-time applications.
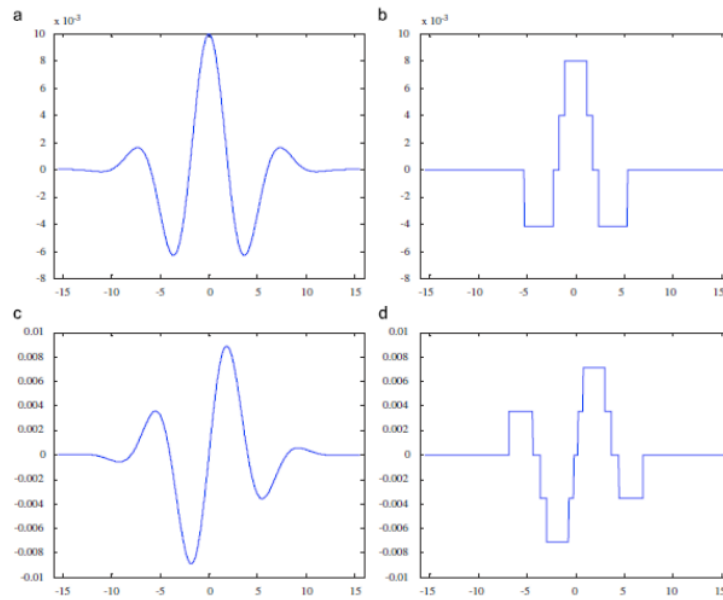
Fig.2 Gabor function on (a) Real 1-D GW section, (b) simplified version, (c) imaginary wavelet section, (d) simplified version of (c)
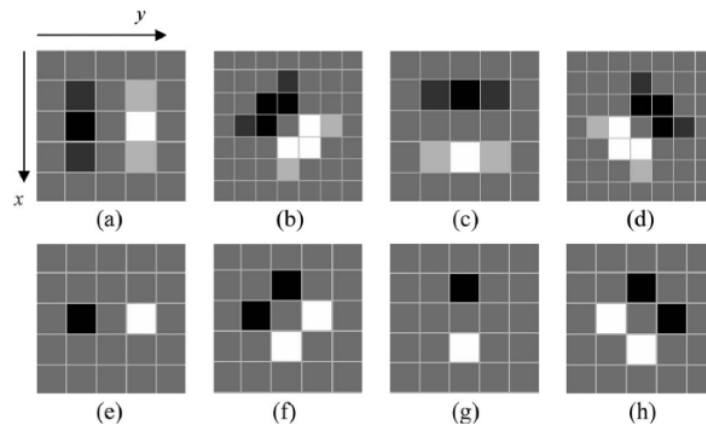

Fig 3. Mask from SGW with (a) $\omega = 0.3$; $\theta = 0$, (b) $\omega = 0.3$; $\theta = \pi/4$, (c) $\omega = 0.3$; $\theta = \pi/2$, (d) $\omega = 0.3$; $\theta = 3\pi/4$, (e) $\omega = 0.5$; $\theta = 0$, (f) $\omega = 0.5$; $\theta = \pi/4$, (g) $\omega = 0.5$; $\theta = \pi/2$, and (h) $\omega = 0.5$; $\theta = 3\pi/4$.

Fig. 3 is an example of using the SGW algorithm on specific objects or images with different parameters ω and θ. Furthermore, this experiment will use the theoretical basis for detecting aflatoxins in corn.

B. Corn Image Capture Method

When taking the image of corn, it doesn't use Ultraviolet light. Still, when detecting aflatoxins, Ultraviolet light is used Fig. 4 is a photo of corn that does not use Ultraviolet light. Fig. 5, Fig. 6, and Fig. 7 are UV images of corn with ISO 400, 800, and ISO 1600.

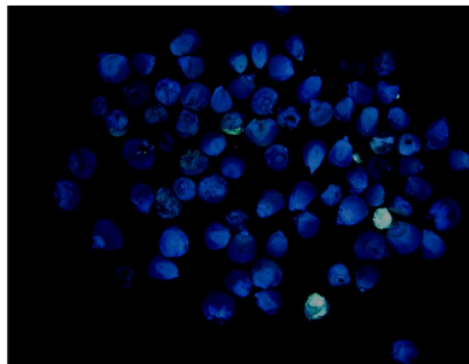**Fig 4.** Corn images that don't use Ultraviolet light
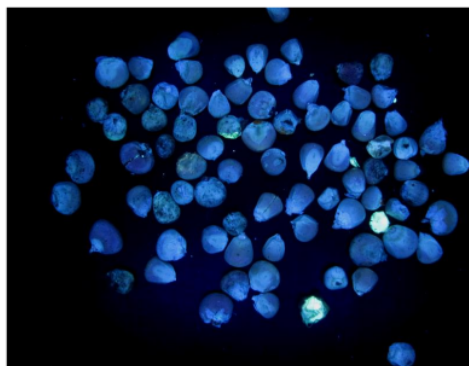

Fig 5. UV image of corn with ISO 400

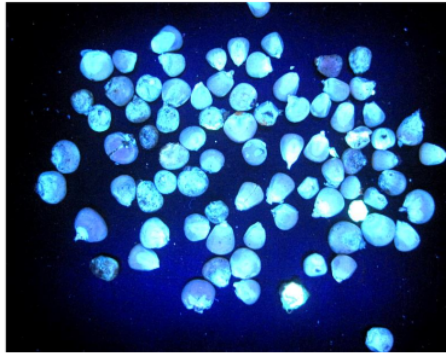**Fig 6.** UV image of corn with ISO 800

Fig 7. UV image of corn with ISO 1600

3.   RESULT AND ANALYZES

3.1 Corn Image Capture Result

In this chapter, we discuss image processing results [9, 15, 16] using the Simplified Gabor Wavelet algorithm with different θ parameters in the filter image and value. Fig. 8 and Fig. 9 are the boxes used to serve as test kits for aflatoxin detection. Fig. 9 is the position of the UV lamp in the second drawer.
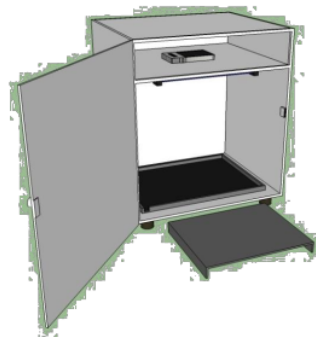
(a)

(b)

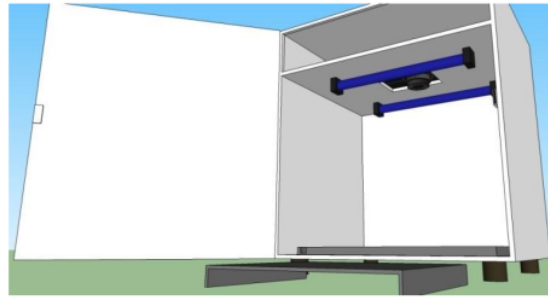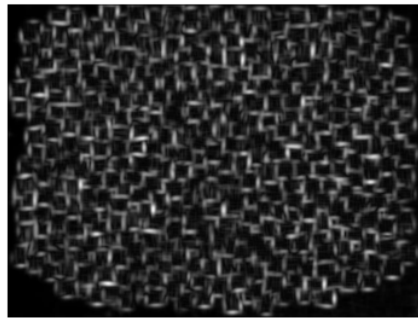*Fig 8.* (a and b) Design a test kit with a camera drawer on top
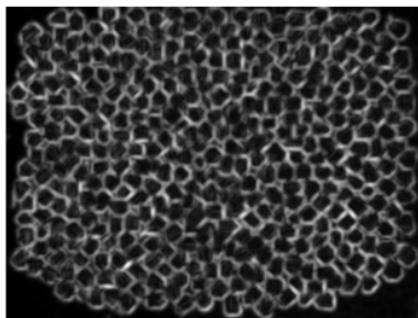
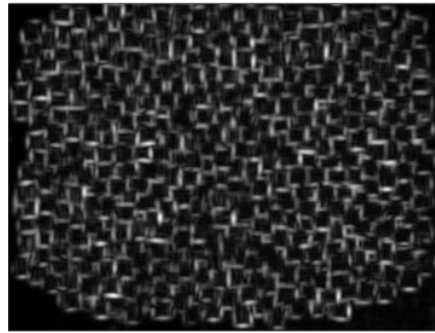**Fig 9.** UV lamps in the second drawer

(a)

(b)

Fig 10. Non UV image, (b) SGW Filter Image θ = 0, 90, 180 and 270

(a)

(b)

Fig 11. The resulting SGW image with the number of orientations N = 4, (a) $\theta = \theta + \text{pi}/N$, (b) $\theta = \theta + 2*\text{pi}/N$

Fig 10. and Fig 11. are corn sampling without using UV with different parameters θ. There are still no specific results or differences from this test between corn without aflatoxin and corn containing aflatoxin. So it was continued by using binary thresholding in Fig. 12 and taking corn samples using UV in Fig. 13.
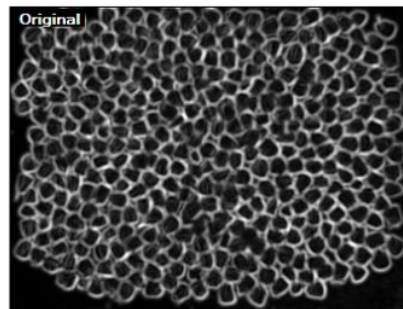
(a)
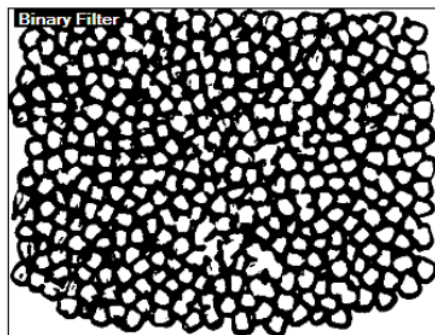
(b)

Fig 12. Example of Binary Thresholding on corn image, (a) SGW image, (b) binary thresholding results, (c) histogram thresholding
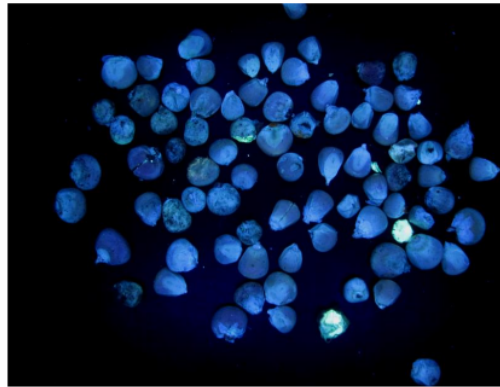
(a)

(b)

Fig 13. Example of thresholding to get aflatoxin, (a) Original image, (b) Thresholding result

Fig. 13 shows the possibility of aflatoxin in corn quite; clearly, Fig. 13 results from UV light testing. In Fig. 13, part b, it is seen the potential of aflatoxin in corn.

3.2 Aflatoxin processing display

This section analyzes corn for aflatoxin content using UV light and software with different combinations of corn amounts. The number of corn, among others, is 200 ears and 390 ears. From the test, it was found that aflatoxin was significant from the thresholding process and processing display and calculation of the area of the whole corn.

(a)

(b)

Fig 14. Example of thresholding to get aflatoxin, (a) Original image, (b) Thresholding result

Fig 15. Example of thresholding to get aflatoxin

Fig. 14 is an example of thresholding to get aflatoxin, part (a) Original image and (b) Thresholding result, then Fig. 15 is an example of thresholding to get aflatoxin, and Fig. 16 is an Image of aflatoxin Noise on thresholding results and a Median filter results. Moreover, Fig. 17 is the Aflatoxin processing display and

calculation, Finally, Fig. 18 is Aflatoxin processing display and calculation, and Table 2 is a test data to get the percentage of aflatoxin in corn.
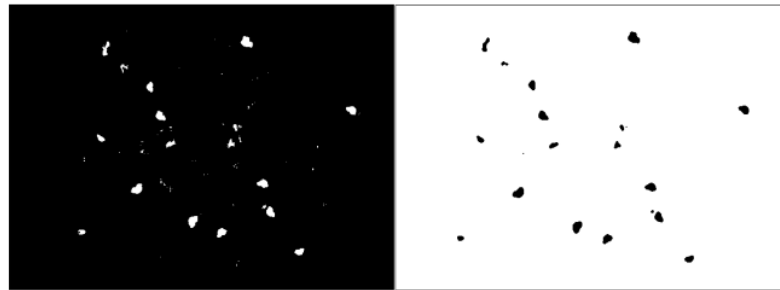

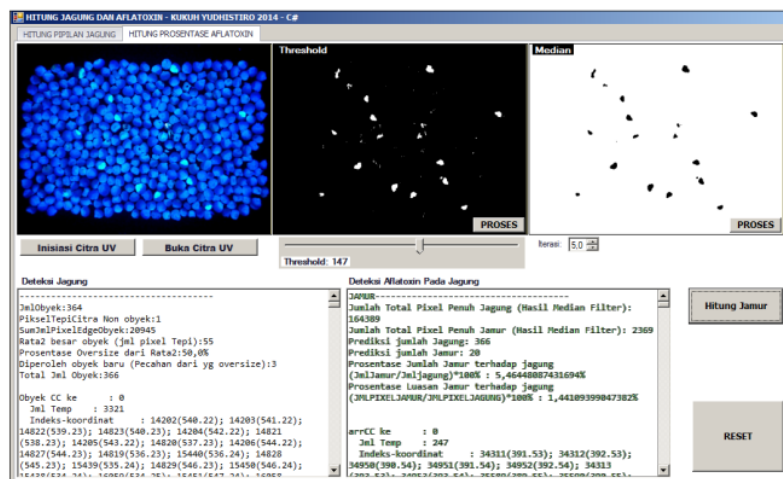*Fig 16.* Image of aflatoxin Noise on thresholding results and Median filter results

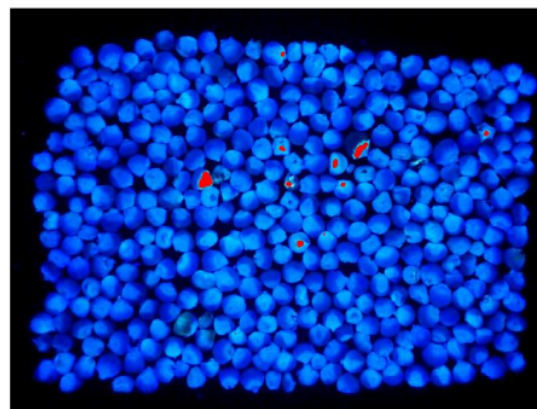*Fig 17.* Aflatoxin processing display and calculation, the area of the whole corn

Fig 18. Aflatoxin processing display and calculation, the area of the whole corn

TABLE 2. A DATA TEST TO OBTAIN THE PERCENTAGE OF AFLATOXIN IN CORN

Aflatoksin					Jagung												% Prediksi Cemaran		% Selisih	%Akurasi
1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19	21
No DS UV	Threshold	Iterasi Median	Total Piksel	Prediksi	No DS nonUV hasil SGW	Double Thresholding		Iterasi Median	Prediksi awal	Obyek non jagung	Sum Piksel Tepi Obyek	Rata-rata besar obyek	% Oversize ukuran Rata-rata	Perolehan pecahan dari oversize	Total Piksel Penuh Jagung	Total prediksi	Based on area	Based on Qty	Based on Qty Prediksi vs Aktual	Jagung
						Min	Max													
1	147	4	737	9	1	44	255	4	364	1	20945	55	50%	3	164389	366	0,45%	2,46%	0,11%	94%
2	149	4	605	10	2	47	255	4	370	1	19244	50	50%	2	163039	371	0,37%	2,70%	-0,13%	95%
3	148	4	671	8	3	44	255	4	361	1	21690	57	50%	2	182159	362	0,37%	2,21%	0,35%	93%
4	147	5	673	10	4	43	255	4	351	1	20965	56	50%	2	186155	352	0,36%	2,84%	-0,28%	90%
5	149	5	1364	10	5	39	255	4	349	2	19214	52	50%	2	388568	349	0,35%	2,87%	-0,30%	89%
6	150	4	568	8	6	39	255	4	352	1	20781	56	50%	3	183454	354	0,31%	2,26%	0,30%	91%
7	147	4	1649	10	7	43	255	3	377	3	25894	60	50%	2	526876	376	0,31%	2,66%	-0,10%	96%
8	146	5	596	10	8	40	255	3	356	2	21263	47	50%	2	188920	356	0,32%	2,81%	-0,24%	91%
9	148	4	1757	8	9	41	255	4	320	7	19861	54	50%	2	525210	315	0,33%	2,54%	0,02%	81%
10	148	4	530	7	10	47	255	4	355	1	19245	51	50%	2	172024	356	0,31%	1,97%	0,60%	91%
11	147	4	560	7	11	41	255	4	351	1	19201	52	50%	3	186774	353	0,30%	1,98%	0,58%	91%
12	150	4	1162	9	12	41	255	3	380	2	23865	53	50%	2	378942	380	0,31%	2,37%	0,20%	97%
13	150	4	1269	8	13	47	255	4	376	1	22074	57	50%	2	353682	377	0,36%	2,12%	0,44%	97%
14	153	5	1229	9	14	47	255	4	358	1	26350	72	50%	2	327840	359	0,37%	2,51%	0,06%	92%
15	150	4	650	9	15	35	255	4	379	1	21663	54	50%	2	198735	380	0,33%	2,37%	0,20%	97%

4. CONCLUSION

With The Simplified Gabor Wavelet (SGW) algorithm and the help of Ultraviolet light, detailed aflatoxin results are obtained, and the percentage of aflatoxin in corn shells can be calculated. From several equations to produce a number of orientation angles, the equation $\theta = \theta + pi/N$ with N=8 orientation is quite accurate in finding the feature boundaries of corn kernel objects that overlap and overlap. So it has a fairly good accuracy compared to using only four orientations with the equation $\theta = \theta + 2 * pi/N$. The equation $\theta = \theta + pi/N$, N=8 has a more detailed angular density than the equation $\theta = \theta + 2 * pi/N$, N=4, so that the edge of the corn object can be detected more real even though the first equation undergoes computation and time, which is longer due to a number of iterations of N orientations. This research can continue to be developed with new, more sophisticated methods that can be applied to objects other than corn. And a more significant number of shelled corn can be analyzed using a larger container to produce a more specific analysis.

REFERENCES

1. C. Sujatha, D. Selvathi, S. Karthigai Lakshmi, "Hardware implementation of road network extraction using simplified Gabor wavelet in field programmable gate array," Jan 2018.

2. C.L. Chowdhary, et al., "An Improved Tumour Identification with Gabor Wavelet Segmentation," Research Journal of Pharmacy and Technology 11(8):3451, DOI: 10.5958/0974-360X.2018.00637.6, Jan 2018.

3. F. Shao et al. "Real-Time Traffic Sign Detection and Recognition Method Based on Simplified Gabor Wavelets and CNN's," Sensors 18(10):3192, DOI: 10.3390/s18103192, Sep 2018.

4. I.Junejo, "Pedestrian Attribute Recognition using Gabor Wavelet Layers," DOI: 10.5121/csit.2021.111502, 3rd International Conference on Machine Learning & Applications (CMLA 2021), Sep 2021.

5. I.Junejo, N.Ahmed, M.Lataifeh, "Pedestrian Attribute Recognition using Trainable Gabor Wavelets," Heliyon 7(6):e07422, DOI: 10.1016/j.heliyon.2021.e07422, Jun 2021.

6. J.Zhanhuai, Y.Shenggang, B.Jinqing, "An improved Gabor wavelet and its complete transforms," 2015 IEEE International Conference on Signal Processing, Communications and Computing (ICSPCC), DOI: 10.1109/ICSPCC.2015.7338925, Sep 2015.

7. K. Fujita, "Gabor Wavelet Transformation on the Sphere and Its Related Topic," DOI: 10.1007/978-3-030-04459-6_51, In book: Security and Privacy, Jan 2019.

8. L.Khouf, et al., "Liquid Sloshing in a Flexible Tank Subjected to a Gabor Wavelet Excitation," September 2021, 19th International Conference of Numerical Analysis and Applied Mathematics (ICNAAM 2021)At Rhodes, Greece

9. M.Shirasuna, Z.Zhang, H.Toda, T.Miyake, "Approximate tight wavelet frame using Gabor wavelet," 2015 International Conference on Wavelet Analysis and Pattern Recognition (ICWAPR), DOI: 10.1109/ICWAPR.2015.7295934, Jul 2015.

10. M.Shirasuna, Z.Zhang, H.Toda, T.Miyake, "Design of Approximate Tight Wavelet Frames Using Gabor Wavelet," Journal of Signal Processing 20(1):41-53, DOI: 10.2299/jsp.20.41, Jan 2016.

11. O.Falade W. Onifade, P.Akinde, F.O. Isinkaye, "Circular Gabor wavelet algorithm for fingerprint liveness detection," Journal of Advanced Computer Science & Technology 9(1), DOI: 10.14419/jacst.v9i1.29908, Jan 2020.

12. P. M. K. Prasad, Y. R.Rao, "Edge Feature Extraction of X-Ray Images Based on Simplified Gabor Wavelet Transform," DOI: 10.1007/978-981-10-7868-2_46, In book: Artificial Intelligence and Evolutionary Computations in Engineering Systems, Jan 2018.

13. P.Gorgel, A.Eksi, "Minutiae-Based Fingerprint Identification Using Gabor Wavelets and CNN Architecture," DOI: 10.5152/electr.2021.21065, August 2021.

14. P.Corke, "Images and Image Processing," In book: Robotic Vision, DOI: 10.1007/978-3-030-79175-9_4, Jan 2022.

15. P.D.P.Adi, Akio Kitagawa, "Performance Evaluation of LoRa ES920LR 920 MHz on the Development Board", International Journal of Advanced Computer Science and Applications 11(6), January 2020, DOI: 10.14569/IJACSA.2020.0110602, Jan 2020.

16. P.D.P.Adi, Akio Kitagawa, "A Review of the Blockly Programming on M5Stack Board and MQTT Based for Programming Education", 2019 IEEE 11th International Conference on Engineering Education (ICEED), DOI: 10.1109/ICEED47294.2019.8994922, Nov 2019.

17. P.D.P.Adi, Akio Kitagawa, J.Akita, "Finger Robotic control use M5Stack board and MQTT Protocol based", DOI: 10.1109/ICITACEE50144.2020.9239170, 2020 7th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE)At Semarang-Indonesia, Oct 2020.

18. P.D.P.Adi, Akio Kitagawa, "ZigBee Radio Frequency (RF) Performance on Raspberry Pi 3 for Internet of Things (IoT) based Blood Pressure Sensors Monitoring", International Journal of Advanced Computer Science and Applications 10(5), DOI: 10.14569/IJACSA.2019.0100504, Jan 2019.

19. P.D.P.Adi, Akio Kitagawa, "Performance Evaluation of Low Power Wide Area (LPWA) LoRa 920 MHz Sensor Node to Medical Monitoring IoT Based", DOI: 10.1109/EECCIS49483.2020.9263418, 2020 10th Electrical Power, Electronics, Communications, Controls, and Informatics Seminar (EECCIS), Malang – Indonesia, Nov 2020.

20. S.K. Shelke, S.K.Sinha, G.S.Patel, "Study of End to End Image Processing System Including Image De-noising, Image Compression & Image Security," Wireless Personal Communications 121(11), DOI: 10.1007/s11277-021-08631-9, Springer, Nov 2021.

21. Tai Sing Lee. , "Image Representation Using 2D Gabor Wavelets", IEEE Transaction on Pattern Analysis and Machine Intelligence, 1, Vol 18, No. 10. 1996.

22. Xiang Ou et al., "Skin Image Retrieval Using Gabor Wavelet Texture Feature," International Journal of Cosmetic Science 38(6), DOI: 10.1111/ics.12332, April 2016.

23. M. Niswar et al., "Performance evaluation of ZigBee-based wireless sensor network for monitoring patients' pulse status," 2013 International Conference on Information Technology and Electrical Engineering (ICITEE), 2013, pp. 291-294, DOI: 10.1109/ICITEED.2013.6676255.

24. P.D.P.Adi, Siregar. V.M.M., "Soil moisture sensor based on Internet of Things LoRa." Iota,2021, ISSN 2774-4353, Vol.01, 02. https://doi.org/10.31763/iota.v1i2.49

Detection of aflatoxin contamination in corn