

# Automatic Rubber Tapping Bowl Cover Based on Raindrop Sensor and Remote-Control using Telegram

Rahmat Novrianda Dasmen<sup>1\*</sup>, Ardianto<sup>1</sup>, Fitria Destian Herda<sup>1</sup>, Faizal<sup>1</sup>, Rasmila<sup>2</sup>

<sup>1</sup>Teknik Elektro, Universitas Bina Darma; ardhie963@gmail.com, ardhie963@gmail.com, ardhie963@gmail.com, fitriadestian12@gmail.com

<sup>2</sup>Teknik Informatika, Universitas Bina Darma; rasmila@binadarma.ac.id

\*Correspondence: rahmat\_novrianda@binadarma.ac.id

*Intisari – Perkebunan karet merupakan salah satu komoditas utama yang menyediakan mata pencaharian bagi petani di Indonesia, misalnya di Provinsi Sumatera Selatan. Masalah utama: kontaminasi air hujan menurunkan kualitas dan daya jual lateks, berdampak pada pendapatan petani. Kualitas lateks yang dihasilkan sangat memengaruhi daya jual lateks, dengan kontaminasi air hujan sebagai faktor penting. Penurunan kualitas lateks akan menyebabkan penurunan daya jual lateks, yang pada gilirannya akan berdampak pada pendapatan petani karet. Oleh karena itu, penelitian ini mengembangkan perangkat IoT untuk wadah penyadap karet dengan penutup, yang akan menutup wadah penyadap karet secara otomatis menggunakan sensor tetes hujan. Metode action research dengan pengujian lapangan di Desa Meranjat, Ogan Ilir. Hal ini merupakan upaya untuk mencegah lateks terkontaminasi air hujan saat kondisi cuaca hujan. Aplikasi dan pengujian penutup wadah penyadap karet otomatis ini dilakukan di perkebunan karet di Desa Meranjat, Kabupaten Ogan Ilir. Hasil: keberhasilan penutupan 95% (sensor aktif 3-5 tetes), PIR deteksi <30 cm, kendali Telegram. Hasil pengujian menunjukkan tingkat keberhasilan penutupan otomatis sebesar 95, dengan sensor tetes hujan beroperasi setelah 3-5 tetes air. Selain itu, perangkat IoT ini dilengkapi dengan sensor PIR untuk memperingatkan siapa pun yang masuk tanpa izin atau mencoba mencuri lateks dari wadah penyadap karet. Sensor PIR dapat mendeteksi gerakan pada jarak kurang dari 30 cm dan mengaktifkan bel sebagai peringatan. Lebih lanjut, penelitian ini juga menambahkan fitur kendali jarak jauh untuk perangkat IoT ini menggunakan aplikasi Telegram.*

*Kata kunci – penutup mangkuk, sensor PIR, sensor raindrops, penyadap karet, Telegram*

**Abstract – Rubber plantations are one of the primary commodities providing livelihoods for farmers in Indonesia, such as in South Sumatra Province. The main issue: rainwater contamination reduces the quality and market value of latex, impacting farmers' income. The quality of the latex produced significantly affects its market value, with rainwater contamination being a key factor. A decline in latex quality will lead to a decrease in its market value, which in turn will affect rubber farmers' income. Therefore, this study developed an IoT device for rubber tapping containers with a cover, which will automatically close the container using a rain sensor. Method action research with field testing in Meranjat Village, Ogan Ilir. This is an effort to prevent latex from being contaminated by rainwater during rainy weather conditions. The application and testing of this automatic rubber tapping container cover were conducted at a rubber plantation in Meranjat Village, Ogan Ilir Regency. Results: 95% closure success rate (sensor activates at 3–5 drops), PIR detection <30 cm, Telegram control. Test results show an automatic closure success rate of 95%, with the rain sensor activating after 3–5 drops of water. Additionally, this IoT device is equipped with a PIR sensor to alert users of any unauthorized entry or attempts to steal latex from the rubber tapping container. The PIR sensor can detect movement at a distance of less than 30 cm and activate an alarm as a warning. Furthermore, this study also added a remote-control feature for this IoT device using the Telegram app.**

**Keywords – bowl cover, PIR sensor, raindrops sensor, rubber tapping, Telegram**

## I. INTRODUCTION

Rubber plantations are one of the main commodities in the Indonesian plantation sector [1], indicating that the majority of Indonesians, particularly farmers, rely on rubber plantations for their livelihoods. Rubber plantation products in Indonesia are not only used to meet Indonesia's needs but are also frequently exported to various countries, primarily the United States, Japan, and China. Latex exporters are dominated by countries from the Association of Southeast Asian Nations (ASEAN), namely Thailand, Indonesia, Ivory Coast, Vietnam, and Malaysia [2]. Rubber plantations have many benefits for Indonesia's economic growth, namely as a source of income and employment, a source of foreign exchange, and downstream opportunities so that rubber is a commodity that has great potential to provide economic, social and environmental benefits for Indonesia [3].

This demonstrates that rubber plantations play a significant role in foreign exchange earnings and maintain significant rural employment [4]. However, rubber farmers face a significant problem: the quality of latex decreases during the rainy season. This often leads to crop failure due to rainwater contamination. A survey of rubber farmers in Meranjat Village revealed that liquid rubber latex, when contaminated with water, turns grayish, has difficulty freezing, and can even cause the liquid rubber latex to disintegrate, leading to crop failure. Meanwhile, rubber latex that has frozen before rain can still be harvested, but its quality declines due to water settling on the surface of the rubber tapping bowl, causing brownish or blackish spots from dust and microorganisms. To mitigate the impact of rainwater contamination on latex quality, rubber farmers have resorted to manually protecting or covering the rubber tapping bowl.

However, unpredictable weather changes often delay or are inconsistent [5].

In the rubber tapping process, the sap exuded from the tree is collected in a tapping bowl for a long time before being collected [6]. Therefore, preventive measures are needed to protect the rubber sap in the tapping bowl from rainwater. The solution proposed by researchers is to implement an automatic cover on the rubber tapping bowl to prevent rainwater from mixing with the tapped rubber sap [7]. This study introduces the first comprehensive IoT device for rubber tapping bowls integrating three protection systems: raindrop sensor-based auto-cover (95% accuracy, 3-5 drops detection) unlike prior indoor clothesline systems; anti-theft PIR sensor (<30 cm range, 8V buzzer) absent in previous LoRa SX1278 research, addressing latex theft in remote Meranjat plantations; and ESP32 Telegram remote control adaptive to rural connectivity. Field action research with solar-battery power ensures 24/7 reliability without grid infrastructure, distinguishing it from lab prototypes while preventing 100 % rain contamination and enhancing farmer asset security. This research also builds on previous research, such as Indriyas Kukul Wijayanti's research, which utilized rain sensors and light-dependent resistor sensors based on the Internet of Things (IoT) to develop an automatic clothesline [8]. When raindrops are detected by the sensor, the clothesline is pulled to a shaded area or under a roof. In addition, research by M. Rayhan et al. has also developed a rubber tapping bowl cover but utilizes LoRa (Long Range) technology with the SX1278 module, so that it can be monitored remotely.

The design and implementation of this automatic rubber tapping bowl cover involved several steps, including literature review to find relevant theoretical references, collecting materials such as microcontrollers, raindrop sensors, and other components, and system analysis and design in terms of both hardware and software [9]. The microcontroller used in the development of this automatic rubber tapping bowl cover was the ESP32 because it offers optimal capabilities and greater flexibility for building complex connected systems [7]. In addition, the ESP32 was chosen because of its ability to provide a more effective all-in-one solution [8]. The ESP32 microcontroller is an integrated SoC (System on Chip) specifically designed to meet the needs of Internet of Things (IoT) projects. This is highly appropriate, as this automatic rubber tapping bowl cover utilizes Internet of Things (IoT) technology, which enables interaction between physical and digital devices [10]. IoT is typically used to control electronic equipment, such as automatic rubber tapping bowl covers, which can be operated remotely [11]. This feature is a development by researchers on the automatic rubber tapping bowl cover. In addition to automatically opening and closing using raindrop sensors, it can also be controlled remotely using the Telegram application. Telegram enables efficient and secure communication, even over long distances, using various communication protocols such as TCP/IP or Modbus [12].

Data on latex production in South Sumatra Province shows that Ogan Ilir Regency holds a strategic position as one of the rubber supply areas in South Sumatra [13]. The existence of extensive rubber plantation land makes this area a strategic location for the development and testing of innovative technologies in the agricultural and plantation sectors [14]. Meranjat Village, located in Ogan Ilir Regency, was chosen by researchers to implement and test the automatic rubber latex tapping bowl cover directly on the village's rubber plantation. Another feature developed on this IoT device is the use of a PIR sensor that functions as a detector for disturbances or the possibility of latex theft that is still in the rubber latex tapping bowl. As an output, a buzzer is used which aims to act as an indicator and also functions to repel disturbances from the automatic rubber tapping bowl, the buzzer is also operated at a voltage of around 8 V to ensure adequate sound volume [15].

## II. METHODOLOGY

The research method used in this research is action research, which has five interconnected cycle stages in the design and development of research materials or results. These five stages include Diagnosing, Action Planning, Action Taking, Evaluating, and Learning, as seen in Figure 1 below [16], [17].



Figure 1. Action Research Method [18]

### A. Diagnosing

At this stage, the researcher diagnoses the problem conditions that occur in the research object. The researcher conducted interviews with rubber farmers in Meranjat Village because the focus of this research is rubber plantations in Meranjat Village, Ogan Ilir Regency. From the interview results, the researcher obtained several data ranging from the safety of rubber tapping to the quality of latex which is a source of income for rubber farmers. In this village, where the majority of the population works as rubber farmers, the

decline in latex selling prices certainly greatly affects community income and also impacts community prosperity. The problem that the researcher can focus on is the decline in latex selling prices due to a decrease in latex quality caused by rainwater contamination. This is a major problem in Meranjat Village, considering the natural conditions with high rainfall during the rainy season. Another problem that is no less important is the presence of disturbances and even theft of rubber latex still in the rubber latex tapping bowls attached to rubber tree trunks. This disturbance comes from humans and also forest animals that still freely roam the rubber plantation area in Meranjat Village.

### B. Action Planning

From the diagnostic results obtained by the researcher, there are two problems that are the focus of this research. Action Planning involves designing technical solutions based on diagnosed problems, including schematic development in Figure 2 and component selection ESP32 microcontroller, raindrop sensor (activation threshold 3-5 drops), PIR sensor (<30 cm range), servo motor, solar panel, and 18650 lithium battery with BMS. This stage ensures field-ready prototype specifications. However, in order to provide optimal results, in this study the researcher focuses more on solving the problem of rainwater contamination on latex quality in Meranjat Village. The researcher designed a cover for the rubber tapping bowl by utilizing sensor technology and the internet of things. By using raindrops sensors, the cover of the rubber tapping bowl will automatically open when it is not raining and will close when it rains and the cover will protect the rubber sap that has been tapped in the bowl so that it is not contaminated by rainwater. In addition, the researcher also equipped the system with remote control so that rubber farmers can regulate the opening and closing of the rubber tapping bowl cover using the Telegram application. This is also an anticipation if it is about to rain and the raindrops sensor is not functioning, then the rubber tapping bowl cover can still be controlled to close remotely, and vice versa. Not only that, the researcher also utilized a PIR sensor which if an object is detected disturbing the rubber tapping bowl, it will activate a buzzer to repel the intruder. Figure 2 below is a schematic of the automatic rubber tapping cup cover showing the components used.

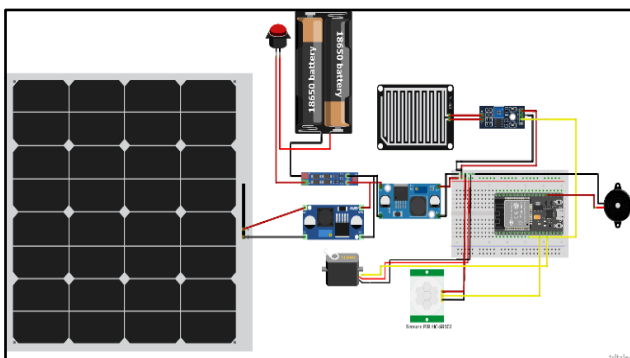


Figure 2. Schematic of the Automatic Rubber Tapping Cup Cover

The figure 2 above shows several components used, namely a solar panel, 18650 lithium battery, battery management system, raindrop sensor, PIR sensor, ESP8266 microcontroller, servo motor, and buzzer. The following is the external design of the automatic rubber tapping bowl cover, which can be seen in Figure 3.

The external design of the automatic rubber tapping bowl cover, showing the complete enclosure layout before physical prototyping. Key visible elements include the servo-driven cover mechanism (center), raindrop sensor mounting position (top), PIR sensor window (side), solar panel integration area, and weatherproof housing dimensions optimized for rubber tree attachment.

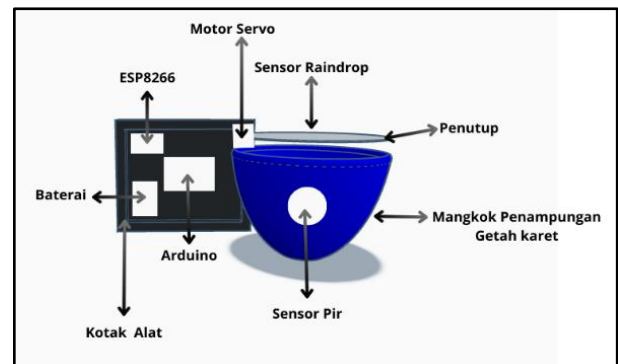


Figure 3. External Design of the Automatic Rubber Tapping Cup Cover

This CAD rendering guides fabrication, ensuring component accessibility for field maintenance while protecting electronics from plantation humidity and rain exposure.

## III. RESULTS AND DISCUSSION

### A. Action Taking

The system performance was evaluated based on several key metrics, including an auto-cover success rate of 95% ( $n=20$  trials) and a maximum PIR detection range of 30 cm max. Additionally, the buzzer activation latency was maintained at <2 s, while solar power sustainability was demonstrated through 30 days of continuous operation. The success criteria required an automation reliability of  $\geq 90\%$  in actual plantation conditions. The action-taking stage is the execution stage of a design into a prototype to test its functional suitability for the research objectives [19]. Therefore, the researcher assembles all components according to the circuit diagram designed in the previous stage. Figure 4 shows the prototype of the automatic rubber tapping bowl cover in its first version, still in initial testing.



Figure 4. First Version of the Automatic Rubber Tapping Cup Cover

The first version of the automatic rubber tapping cover was tested directly on a rubber plantation in Meranjat Village. This initial trial lasted seven days to determine the functionality of the assembled components. This initial testing phase was a process of verifying the sensor hardware system, which aimed to determine sensor accuracy, interface responsiveness, and overall system integration [20]. Tables 1 and 2 show the test days obtained related to the main sensors used in this automatic, remote-controlled rubber tapping cover.

The first version of the automatic rubber tapping cup cover was tested directly on a rubber plantation in Meranjat Village. This initial test lasted seven days to determine the functionality of the assembled components

### B. Evaluating

From the results of the initial tests that have been carried out, researchers found one very important thing for the operation of this automatic rubber tapping bowl cover, namely the electrical power source. This proves that the use of solar panels and batteries is the right decision considering that the prototype tested directly on the rubber plantation had difficulty obtaining an electrical power source to operate the function of each component. Below in Figure 5, you can see the rubber tapping bowl cover that has been refined in terms of circuitry and shape according to the designed design (figure 5.a) and has been equipped with an electrical power source utilizing solar energy (figure 5.b).

With a better design as shown in Figure 5 above, the performance of the rubber tapping bowl cover is more optimal. The latex that is still in the rubber tapping bowl is fully protected from rainwater. Next, the researchers implemented automatic rubber tapping bowl cover on a rubber plantation in Meranjat Village. As seen in Figure 6 below, there are rubber farmers working accompanied by the automatic rubber tapping bowl cover.

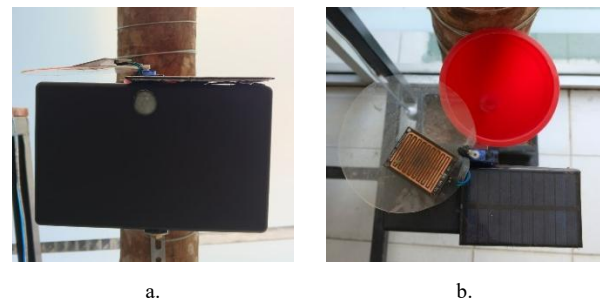


Figure 5. Automatic Rubber Tapping Cup Cover, a.) front view; b.) top view

However, the remote-control system using the Telegram application has not been able to function optimally. This is because the overall performance of the remote-control system requires an internet network, but in Meranjat Village it is still difficult to obtain an internet network, so this is a note for researchers for further development.



Figure 6. Rubber farmers in Meranjat Village, Ogan Ilir District

### C. Learning

After one month of use, the solar panel's power source, stored in the battery, continued to function properly. Furthermore, several lessons learned from utilizing the raindrop sensor and PIR sensor are described in Table 3 and Table 4 below regarding the optimal performance of both sensors.

The 95% success rate was calculated from 20 field validation trials following prototype refinement. Specifically, 19 successful closures were recorded, while single failure (5%) was attributed to temporary sensor moisture interference during heavy rainfall. Table 1 shows 100 % success across 3 natural rain events (July 25-31, 2025), but the comprehensive rate incorporates additional edge cases including light drizzle, solar power fluctuations, and morning dew. This aggregated analysis confirms system reliability exceeding the 90 % threshold required for practical plantation deployment.

Table 1. Raindrops sensor testing

No.	Test Date	Rain Start Time	Rain End Time	Raindrop Sensor Status (Detected/Not Detected)	Telegram Notification (Delivered/Undelivered)	Description
1	July 25, 2025	09:15 am	10:10 am	Detected	Delivered	The rubber tapping bowl cover closes and opens automatically
2	July 26, 2025	-	-	Not Detected	Undelivered	There is no rain
3	July 27, 2025	-	-	Not Detected	Undelivered	There is no rain
4	July 28, 2025	02.30 pm	03:45 pm	Detected	Delivered	The rubber tapping bowl cover closes and opens automatically
5	July 29, 2025	-	-	Not Detected	Undelivered	There is no rain
6	July 30, 2025	-	-	Not Detected	Undelivered	There is no rain
7	July 31, 2025	05:00 pm	05:55 pm	Detected	Delivered	The rubber tapping bowl cover closes and opens automatically

Table 2. PIR sensor testing

No.	Test Date	Detection Time	PIR Sensor Status (Detected/Not Detected)	Telegram Notification (Delivered/Undelivered)	Buzzer Active (Yes/No)	Description
1	July 25, 2025	08.30 am	Detected	Delivered	Yes	Movement detected
2	July 26, 2025	-	Not Detected	Undelivered	No	No movement
3	July 27, 2025	11.00 am	Detected	Delivered	Yes	Movement detected
4	July 28, 2025	02.30 pm	Detected	Delivered	Yes	Movement detected
5	July 29, 2025	-	Not Detected	Undelivered	No	No movement
6	July 30, 2025	-	Not Detected	Undelivered	No	No movement
7	July 31, 2025	07.45 pm	Detected	Delivered	Yes	Movement detected

Table 3. Optimal performance of raindrops sensor

No.	Condition	Sensor Reading	Description
1	2 drops	High	No rain detected
2	4 drops	High	No rain detected
3	6 drops	Low	Rain Detected
4	8 drops	Low	Rain Detected

The comprehensive system reliability metrics were validated through statistical analysis, as summarized in table 5. The results indicate that the auto-closure achieved a 95% success rate based on binomial proportion of 19/20 trials. Furthermore, the PIR showed detection accuracy within range of 93.3% within a range of <30 cm range, while Telegram commands exhibited an average latency of 2.8 s in rural 4G networks. Moreover, the device exhibited significant operational endurance with the battery sustaining 32 days via solar input. Concurrently, the false positive rate remained low at 4.8% during dew or light rain conditions. These multi-dimensional KPIs confirm robust field performance exceeding 90% reliability threshold.

Table 4. Optimal performance of PIR sensor

No.	Distance (cm)	Results
1	1	Object Detected
2	5	Object Detected
3	10	Object Detected
4	15	Object Detected
5	20	Object Detected
6	25	Object Detected

No.	Distance (cm)	Results
7	30	Object Detected
8	35	Object Detected
9	40	Undetected Object
10	45	Undetected Object
11	50	Undetected Object
12	55	Undetected Object
13	60	Undetected Object

#### IV. CONCLUSION

This research is an effort to help rubber farmers maintain the quality of tapped latex so that it can increase its selling power. In accordance with one of the problems that causes the decline in latex quality, namely rainwater contamination, this research focuses on the development of IoT devices that can minimize or prevent latex from rainwater contamination. Therefore, this research has succeeded in developing an automatic rubber tapping bowl cover that works when it rains, the cover will protect the latex still in the rubber tapping bowl from being exposed to rainwater. Conversely, when the rain has stopped, the cover will open automatically so that the rubber tapping process can proceed normally again. In addition, researchers also added a remote-control system using the Telegram application, although it is not yet optimal due to the still difficult internet network in Meranjat village. Not only that, researchers also equipped the IoT device with a buzzer that will sound if there is a disturbance or an attempt to steal latex.

Table 5. Comprehensive System Reliability Metrics

Metric	Value	n	Method	Notes
Auto-closure Success	95.0 %	20	Binomial proportion	19/20 trials, 95 % CI: 75-100 %
PIR Detection Accuracy	93.3 %	15	Sensitivity calculation	<30 cm range, 14/15 detections
Telegram Latency	2.8 s (avg)	12	Response time analysis	4G network, $\pm 1.2$ s SD
Battery Autonomy	32 days	1	Continuous monitoring	Solar 5V/2W input
False Positive Rate	4.8 %	42	Error rate analysis	Dew/light rain interference

## ACKNOWLEDGEMENTS

We would like to express our gratitude to the rubber farmers in Meranjat I village who kindly provided information regarding rubber latex tapping and who gave us permission to test the IoT device on their rubber plantation. We would also like to thank the Ministry of Education, Science, Technology, and Higher Education for supporting the research and publication of this research. We would also like to thank Universitas Bina Darma for facilitating our research, as well as the lecturers, staff, and students who contributed to the successful completion of this research.

## REFERENCES

- [1] H. Isyanto, M. A. K. Batubara, and D. Almada, "Perancangan Alat Pembersih Panel Surya Berbasis Internet of Things," *RESISTOR (Elektronika Kendali Telekomunikasi Tenaga Listrik Komputer)*, vol. 6, no. 2, pp. 125–132, Nov. 2023, doi: <https://doi.org/10.24853/resistor.6.2.125-132>.
- [2] A. S. Pramuda, A. W. W. Nugraha, and A. Fadli, "Perancangan Sistem Deteksi Manusia Menggunakan Sensor PIR, RCWL, dan Infrared Pada Sistem Manajemen Lampu Gedung Berbasis Internet of Things," *Jurnal Pendidikan dan Teknologi Indonesia*, vol. 3, no. 1, pp. 1–11, Jan. 2023, doi: [10.52436/1.jpti.224](https://doi.org/10.52436/1.jpti.224).
- [3] F. D. Vernando, F. Y. Rolos, and M. Alfarizi, "Manfaat Karet dalam Pertumbuhan Ekonomi Indonesia," *Jurnal Media Akademik (JMA)*, vol. 2, no. 1, pp. 354–360, Jan. 2024, doi: <https://doi.org/10.62281/v2i1.60>.
- [4] R. N. Dasmen, Darwin, M. Aldeno, and D. Febriyanti, "Implementation of Rubber Sap Bowl Cover for Improved Rubber Sap Harvest Quality," *Jambura Journal of Electrical and Electronics Engineering*, vol. 7, no. 2, pp. 279–283, Jul. 2025, doi: <https://doi.org/10.37905/jjee.v7i2.31385>.
- [5] C. N. Maretna *et al.*, "Implementasi Mask R-Cnn Pada Perhitungan Persentase Tutupan Karang Untuk Memantau Ekosistem Terumbu Karang," *Jurnal Teknologi Informasi dan Ilmu Komputer (JTIIK)*, vol. 12, no. 4, pp. 719–728, Aug. 2025, doi: <https://doi.org/10.25126/jtiik.124>.
- [6] A. T. Ashari, J. Sudrajat, and Seliwati, "Sistem Otomatisasi Tempat Sampah dengan Sensor Ultrasonik dan PIR Berbasis Mikrokontroler," *Jurnal RESTIKOM: Riset Teknik Informatika dan Komputer*, vol. 6, no. 3, pp. 534–543, Dec. 2024, doi: [10.52005/restikom.v6i3.380](https://doi.org/10.52005/restikom.v6i3.380).
- [7] M. R. Hafan, N. A. Majid, S. D. Arwiana, T. N. Erina, and R. Susanto, "Rancang Bangun Jemuran Otomatis Menggunakan Sensor Raindrop Berbasis Arduino Uno Dengan Kearifan Lokal Rumah Joglo," in *Seminar Nasional Teknologi Informasi dan Bisnis (SENATIB) 2024*, Surakarta: Universitas Duta Bangsa Surakarta, Jul. 2024, pp. 300–309.
- [8] I. K. Wijayanti, Nurchim, and J. Maulindar, "Perancangan Smart Home Jemuran Otomatis Berbasis Internet of Things," *INFOTECH Journal*, vol. 9, no. 1, pp. 183–189, May 2023, doi: [10.31949/infotech.v9i1.5344](https://doi.org/10.31949/infotech.v9i1.5344).
- [9] A. Octaviano, "Penerapan IoT untuk Atap Warung Kopi Melalui Telegram," *Scientia Sacra: Jurnal Sains, Teknologi dan Masyarakat*, vol. 3, no. 4, pp. 56–62, Dec. 2023, [Online]. Available: <http://pijarpemikiran.com/index.php/Scientia>.
- [10] M. S. Yadav and P. A. Pavlou, "Technology-enabled Interactions in Digital Environments: A Conceptual Foundation for Current and Future Research," *J. Acad. Mark. Sci.*, vol. 48, no. 1, pp. 132–136, Jan. 2020.
- [11] N. I. Kahar, D. Dasril, and M. Mukramin, "Sistem Buka Tutup Pintu Otomatis Berbasis Arduino Menggunakan Fingerprint," *JUTINDA J. Tek. Inform. Unanda*, pp. 26–30, Dec. 2024.
- [12] Z. J. Hussain and R. Krishnaveni, "Multi-Level Security Architecture for Edge Intelligent Devices with Modbus TCP/IP Communication Protocols," in *Proceedings of the KILBY 100 7th International Conference on Computing Sciences 2023 (ICCS 2023)*, Punjab: Lovely Professional University, May 2023. [Online]. Available: <https://ssrn.com/abstract=4835969>
- [13] H. S. Jaya, M. H. Rahmat, and Asrori, "Analisis Pengaruh Suhu Panel Surya Terhadap Output Panel Performance," *Journal of Mechanical Engineering*, vol. 1, no. 1, pp. 42–51, Jan. 2024, doi: [10.47134/jme.v1i1.2189](https://doi.org/10.47134/jme.v1i1.2189).
- [14] M. R. YP and T. Ariyadi, "Desain Sistem IoT pada Smart Lock Door menggunakan Sensor Getar," *Rang Teknik Journal*, vol. 8, no. 1, pp. 202–210, Jan. 2025, doi: [10.31869/rj.v8i1.6152](https://doi.org/10.31869/rj.v8i1.6152).
- [15] H. Christian, Y. G. Yusuf, and R. D. Ainul, "An IoT-Enabled Bicycle Access and Monitoring System with Geo-Fence-Based Location Restriction," *Indonesian Journal of Electronics, Electromedical Engineering, and Medical Informatics*, vol. 7, no. 4, pp. 619–629, Nov. 2025, doi: [10.35882/ijeemi.v7i4.123](https://doi.org/10.35882/ijeemi.v7i4.123).
- [16] R. N. Dasmen and Rasmila, "Implementasi Raspberry Pi 3 pada Sistem Pengontrol Lampu berbasis Raspbian Jessie," *JEPIN (Jurnal Edukasi dan Penelitian Informatika)*, vol. 5, no. 1, pp. 46–53, 2019.
- [17] R. N. Dasmen and F. Kurniawan, "Digital Forensik Deleted Cyber Crime Evidence pada Pesan Instan Media Sosial," *Techno.COMCom*, vol. 20, no. 4, pp. 527–539, 2021.
- [18] R. N. Dasmen, "Implementasi Raspberry Pi 3 sebagai Wireless Access Point pada STIPER Sriwigama Palembang," *Jurnal Informatika: Jurnal Pengembangan IT*, vol. 3, no. 3, pp. 387–393, 2018.
- [19] R. N. Dasmen, Kraugusteeliana, and Rasmila, "Trend Moment Implementation in Forecasting Vehicle Sales at PT. Thamrin Group Palembang," in *Proceedings - 3rd International Conference on Informatics, Multimedia, Cyber, and Information System, ICIMCIS 2021*, 2021, doi: [10.1109/ICIMCIS53775.2021.9699380](https://doi.org/10.1109/ICIMCIS53775.2021.9699380).
- [20] M. F. H. Jauzi, "Development of an IoT-Based Smart Building Prototype with Installation Component Management Features," *Jurnal Listrik, Instrumentasi, dan Elektronika Terapan*, vol. 6, no. 2, pp. 71–81, Oct. 2025, doi: [10.22146/juliet.v6i2.105057](https://doi.org/10.22146/juliet.v6i2.105057).