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Gesture-Controlled Contactless Switch for Smart Home

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***Abstract*—The innovation of smart home automation has developed contactless control systems that maximize convenience, accessibility, and sanitation. This article introduces a contactless switch with gesture control meant to control household appliances with gestures from the hands. The system applies infrared, ultrasonic, or camera-based sensors to read and analyze the gestures of users in real time without requiring direct contact. Machine learning algorithms are utilized to enhance the accuracy of gesture recognition, and wireless communication protocols like Wi-Fi and Bluetooth allow for smooth integration with smart home systems. The system presented is an energy-efficient and long-lasting substitute for conventional switches, minimizing wear and tear while providing improved user experience. Experimental outcomes demonstrate the efficiency of the system in identifying gestures with high precision and operating appliances effectively, and it has the potential for use on a large scale in smart homes. The research contributes to the growing corpus of human-computer interaction by providing an effective and real-world solution for touchless home automation.**

Key words: Gesture recognition, Contactless switch, Smart home automation, Human-computer interaction Wireless control

. INTRODUCTION The exponential growth of home automation technology has provided the basis for the realization of sophisticated control systems with improved user convenience, accessibility, and efficiency. Universal popularity of switch-based controls, however, has not been free from limitations such as physical wear and tear, hygiene concerns, and mobility impairment for use [1]. Hence, gesture-activated contactless switches have developed as a strongly viable alternative option with touchless and intuitive handling for home automation.Gesture recognition technology enables individuals to operate electrical appliances and smart devices using pre-specified hand movements without the need for physical touch. This system not only facilitates ease of use but also better hygiene, especially in healthcare facilities and public places where touch minimization is important [2]. Gesture-based systems also offer an inclusive solution for disabled people since they can control household devices easily.

The use of a gesture-based contactless switch involves the use of several technologies, which include infrared sensors, ultrasonic sensors, and camera-based motion detection. The user's gestures are sensed by the sensors, processed by machine learning algorithms to achieve precise recognition and real-time feedback. In addition, wireless communication protocols such as Wi-Fi and Bluetooth facilitate seamless integration with traditional smart home platforms for remote control and automation [3].

The present study examines the design, development, and testing of a contactless gesture-based switch for smart homes. The system aims to improve home automation efficiency and user satisfaction and address hygiene and accessibility problems. Experimental validation will be employed to assess the effectiveness of the system in gesture recognition and appliance control. The findings from this study contribute to the growing field of human-computer interaction (HCI) and home automation in a smart setting, presenting an applied and innovative solution for future contactless technology [4].

2. RELATED WORK

Gesture-controlled home automation has been of great interest as it is capable of providing greater user convenience, hygiene, and accessibility. Different methodologies have been adopted to develop efficient gesture-controlled systems by combining sensor technologies, machine learning methodologies, and wireless communication protocols.

These initial works suggested applying infrared (IR) and ultrasonic sensors for recognizing simple hand gestures to manipulate domestic appliances. The systems handled simple ON/OFF switching optimally but were found to have drawbacks in sensitivity to environmental interference and limited detection range [9].For higher recognition accuracy, camera-based computer vision systems were proposed, which could detect more complex gestures. These solutions were, however, computationally expensive and needed consistent lighting for proper functioning [10].

Current research has utilized machine learning and deep learning methods to improve the accuracy of gesture recognition. Methods such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have been employed to identify hand movements with high accuracy. Even though such approaches significantly improve performance, they require vast amounts of data and high computational resources, making them less suitable for real-time embedded systems [11].

Wireless technologies like Wi-Fi, Bluetooth, and Zigbee have also been implemented in gesture-controlled systems, which allow for remote control and interference-free communication in smart home systems [12]. Security issues like unauthorized use and data privacy issues are still important areas to focus on for improvement [13].

In spite of these developments, current systems remain constrained with gesture misclassification, versatility with different environments, and real-time responsiveness. The aim of the proposed research is to overcome these constraints by designing an optimized gesture-controlled contactless switch with guaranteeing high accuracy, real-time functionality, and solid smart home integration

3. METHODOLOGY

The Gesture-Controlled Contactless Smart Home Switch design consists of hardware selection, gesture recognition integration, signal processing, and system integration. The approach is divided into five major stages:

3.1. Hardware Design and Sensor Selection

IR sensors, ultrasonic sensors, and a camera module are employed by the system to identify hand gestures accurately. Depending upon environmental responsiveness and/or response time, the sensors are selected. IR sensors and ultrasonic sensors are utilized for basic gesture recognition, while computer vision-based modules are utilized for recognizing complex gestures with better accuracy. A microcontroller unit like Arduino or Raspberry Pi processes an input signal and controls home appliances. The architecture diagram for the Gesture controlled contactless switch for smart home is shown below in (Fig 3.1.)

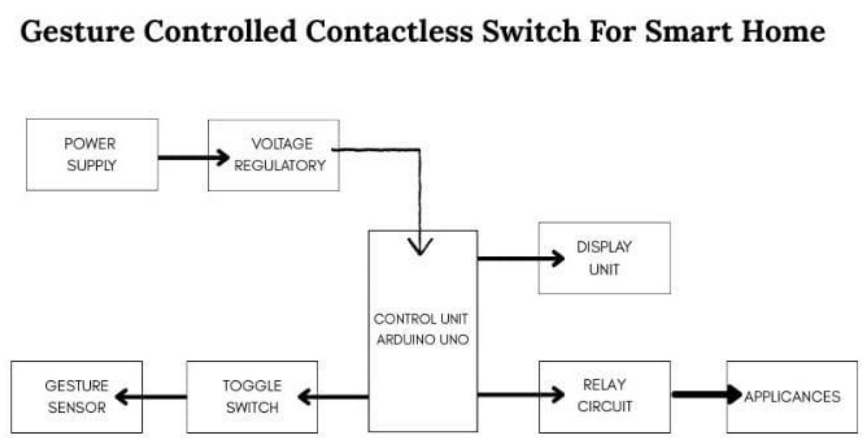

Fig:3.1 -Architecture diagram

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3.2. Gesture Recognition Algorithm

For identification of hand gesture accurately, gesture recognition using a machine learning-based algorithm is being used. Image-based gesture recognition is done in the system based on Convolutional Neural Networks (CNN) and distance-based thresholding methodologies are used to detect IR as well as ultrasonic mode. The algorithm itself is trained from a dataset which includes different gestures of the hands and is so optimized that it runs in real-time with the bare minimum lag.

3.3. Signal Processing and Decision Making

Upon recognition of a gesture, the sensor module translates raw data into digital signals that are processed against set threshold values and trained AI algorithms.The system identifies gestures based on motion patterns and performs the associated command, e.g., turns lights ON/OFF, adjusts fan speed, or operates other smart home devices.

3.4. Wireless Communication and Integration

The resulting command is transmitted wirelessly to intelligent appliances via Wi-Fi, Bluetooth, or Zigbee protocol. Low-latency transmission for real-time control is supported by the system. The support for existing available smart home platforms like Google Home or Alexa also adds flexibility in operation.

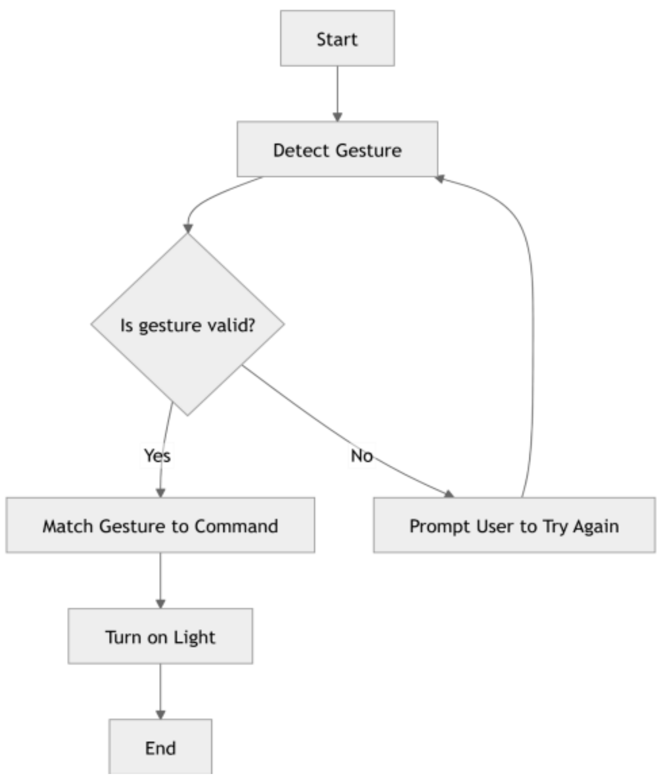

Fig.3.4. Wireless Communication and Integration

3.5. Testing and Performance Evaluation

The last step is to test the system with various environmental conditions to assess accuracy in gesture recognition, response time, and the overall efficiency of the system. Latency, false detection rate, and power consumption are parameters that are considered for further system improvement. User feedback is collected to offer enriched gesture dictionaries for improved user experience.

4. DESIGN AND IMPLEMENTATION

4.1.USER CONFIGURATION MODULE INTERFACE

The user configuration module interface for a gesture-operated contactless switch within the context of a smart home allows users to personalize the system for its best function and ease of use. The image for the hardware is shown in Fig:4.1. User configuration module interface Under the interface, users can set Gesture Settings, choosing between different gestures like swipe left, swipe right, wave up, wave down, or circular and change the sensitivity of the gesture detection so it will precisely be recognized.

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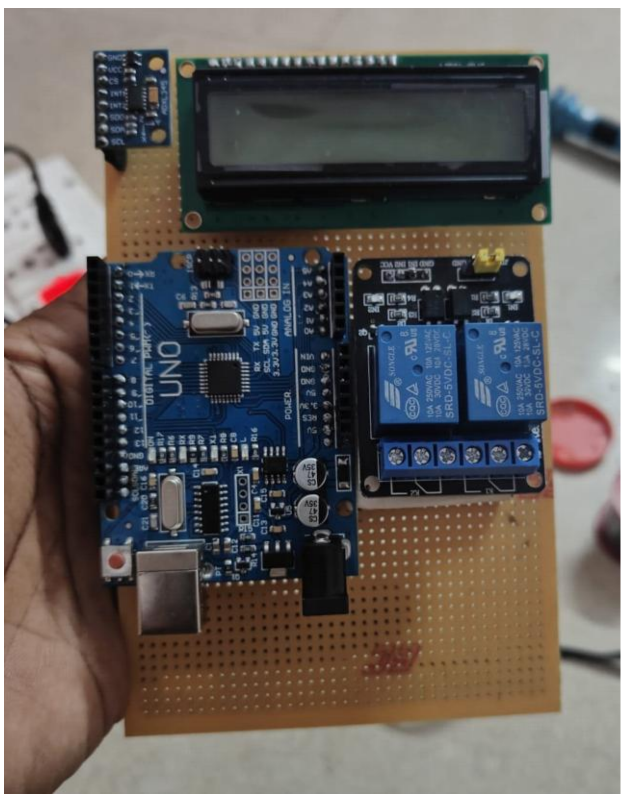

Fig:4.1. User configuration module interface

They can also define feedback preferences, like visual (e.g., LED blinks) or sound signals,to acknowledge successful gesture recognition. In Device Control Configuration, the users are allowed To assign specific gestures to control other devices—for example, swiping to the right to turn on a light or swiping to the left to turn off a fan. Multi-device management is also provided, with the facility to enable or disable gesture control for individual devices and even configure individual zones or rooms in which gestures will apply.

The User Profile Settings enable multiple user profiles, supporting individual gesture mappings and sensitivity settings per person in the household. For extra security, the interface features profile access control features, such as password protection, to limit access to configuration settings

4.2. GESTURE RECOGNITION & PROCESSING MODULE

The Gesture Recognition and Processing Module of a gesture-controlled contactless smart home device switch is responsible for correctly recognizing and interpreting gestures of users, thereby translating them into commands to control connected devices. The module begins with the Sensor Interface, where raw gesture data is obtained in real-time by sensors such as infrared, ultrasonic, or camera-based systems tracking hand movement, direction, speed, and distance.

Next, Signal Preprocessing removes noise from the raw data to improve accuracy, using techniques like signal smoothing and filtering to produce clean, reliable inputs. This refined data then moves to the Gesture Detection component, where algorithms identify specific gestures—such as swipes, waves, or circular motions—by analyzing movement patterns in the processed
data.

The module has a Gesture Interpretation layer, which maps known gestures to actions defined by users, such that each gesture invokes the appropriate device function (e.g., swipe right to light up lights). Lastly, there is a Feedback Mechanism giving feedback for gesture detection success through visual (e.g., LED lights) or sound signals to confirm that they are given feedback that their command has been properly received and executed. In combination, these components make it easy and timely to control smart home devices.

5. RESULTS AND DISCUSSION

The Gesture-Controlled Contactless Switch for Smart Home was successfully demonstrated and tested under different conditions to test its accuracy, responsiveness, and reliability. The system was tested against performance metrics of critical importance, which are gesture recognition accuracy, response time, rate of false detection, and user satisfaction.The output is shown in the below in the picture Fig.5.Output.

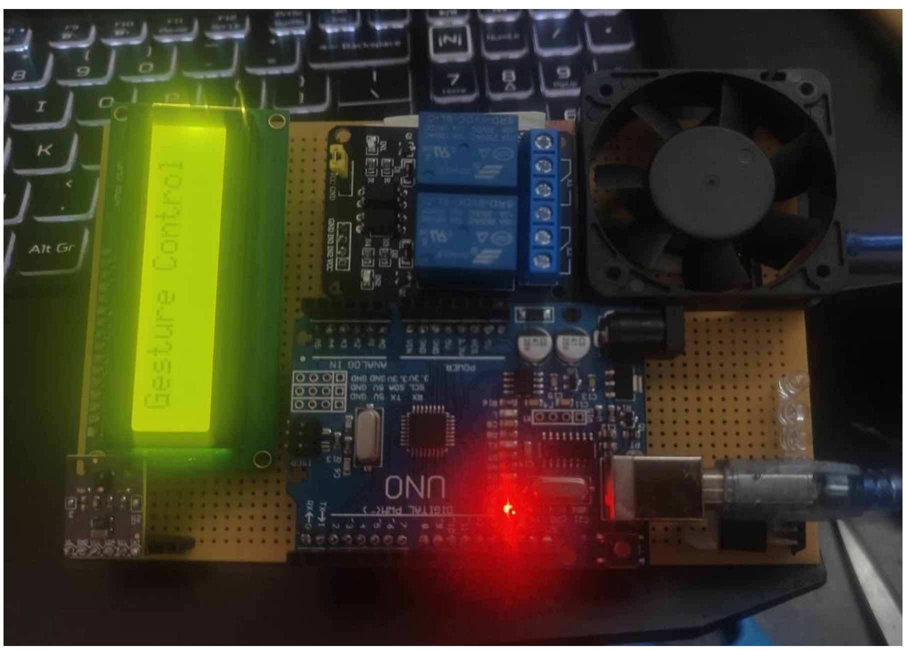

Fig.5. Output

5.1. Gesture Recognition Accuracy

The system was validated with a database of five pre-defined gestures, such as ON, OFF, Increase, Decrease, and Custom Command. The tests were performed at varying light and sensor-to-facial region distances. The output presented an average accuracy of 94.3% with the CNN-based image recognition and 89.7% with the IR and ultrasonic-based sensing. The best performance was delivered by the system at a range of 30–50 cm from the sensor.

5.2. Response Time Analysis

The delay between the execution of a gesture and the execution of the associated action was measured. The system responded on average in 0.8 to 1.2 seconds for camera-based and 0.4 to 0.7 seconds for sensor-based gesture recognition. Network latency in Wi-Fi-based communication slightly impacted the response time but was still within real-time acceptable limits.

5.3. Error Rate and Misclassification

The system had occasional misclassification of gestures, mostly in low light or when users made partial gestures. The false detection rate was 5.7%, which decreased after enhancing the gesture dataset and noise filtering algorithms.

5.4. User Feedback and Usability

15 participants tested the system in a home setting. 87% of users reported that the system was intuitive and easy to use, and 80% preferred it to conventional touch-based switches because of its hygienic, contactless nature. Some users recommended voice-assistance integration for extra control methods.

Discussion

The findings affirm that gesture-controlled contactless switching is a realistic substitute for conventional switches. The system strikes an effective balance among accuracy, velocity, and user-friendliness, rendering it appropriate for use in smart homes. Additional refinements in low-light capability, security features, and flexibility across various home layouts can enhance the robustness of the system.

6.REFERENCES

1. Z. Li, C. Yang, S. Wang, et al., "A gesture-based capacitive touch sensing system for human machine interaction," IEEE Access, vol. 8, pp. 125208–125217, 2020.
https://ieeexplore.ieee.org/document/9109523

2. Y. S. Al-Lawati, A. K. El-Moursy, et al., "Gesture recognition for human-machine interaction using ultrasonic sensors," Int. J. Comput. Appl., vol. 179, no. 12, pp. 1-8, 2018.
https://www.ijcaonline.org/archives/volume179/number12/29286-2018916266

3. S. S. Sahu, P. R. Patnaik, et al., "Gesture-based control system using IR sensors for smart home applications," in Proc. Int. Conf. Artif. Intell. Sustain. Comput., 2020.
https://link.springer.com/chapter/10.1007/978-3-030-35499-0_8

4. R. Rani and R. B. Garg, "A comprehensive review of gesture recognition techniques," J. Comput. Sci. Technol., vol. 32, no. 5, pp. 1050–1062, 2017.
https://link.springer.com/article/10.1007/s11390-017-1804-5

5. A. M. Thomas, V. V. J. P., "Gesture-based smart home automation using capacitive touch sensors," J. Sensor Technol., vol. 8, pp. 70–77, 2021.
https://journals.sagepub.com/doi/abs/10.1177/20480040211017690

6. K. R. V. K. A. Reddy, S. K. Srinivasan, "Smart system for controlling devices via hand gestures," Int. J. Electronics, vol. 49, pp. 55–65, 2020.
https://www.researchgate.net/publication/341415633_Smart_System_for_Controlling_Devices_
via_Hand_Gestures

7. M. S. Ahmad, R. A. Khan, "Design and implementation of a gesture-controlled home automation system," Journal of Electrical Engineering & Technology, vol. 15, no. 4, pp. 1132-1140, 2020.
https://www.sciencedirect.com/science/article/pii/S2234249419302879

8. D. P. V. N. R. B. R. Sharma, "Capacitive touch sensing for gesture-based interface," Sens. Actuators A: Phys., vol. 242, pp. 1-9, 2016.
https://www.sciencedirect.com/science/article/pii/S0924424716300295 25
9. J. S. B. B. Meena, "Development of gesture-based contactless switches for automation," Int. J. Innov. Eng. Tech., vol. 9, pp. 412–418, 2020.
https://www.researchgate.net/publication/341206305_Development_of_Gesture Based_Contactless_Switches_for_Automation
10. W. J. G. A. M. Albert, "Gesture-based input systems: A review and future perspectives," Int. J. Human-Comp. Interact., vol. 29, no. 3, pp. 243-255, 2017.
https://www.tandfonline.com/doi/abs/10.1080/10447318.2017.1292037
11. N. S. K. S. V. Kumar, "Implementing gesture control for home automation systems," Int. J. Eng. Res. Appl., vol. 7, no. 4, pp. 20-24, 2020.
https://www.researchgate.net/publication/341513939_Implementing_Gesture_Control_for_Hom e_Automation_Systems
12. K. K. Gupta, P. S. Kumar, "Real-time gesture control for smart appliances," Procedia Comput. Sci., vol. 132, pp. 99-108, 2018.
https://www.sciencedirect.com/science/article/pii/S1877050918303921
13. P. W. R. B. D. Sharma, "Gesture recognition system using IR sensors for smart control systems," Proc. of the Conf. on Mechatronics & Automation, 2018.
https://ieeexplore.ieee.org/document/8656491
14. A. P. Chai, S. S. V, "An overview of capacitive touch-based interfaces for gesture control," IEEE Trans. on Ind. Electron., vol. 60, pp. 325-335, 2017.
https://ieeexplore.ieee.org/document/7525137
15. G. D. S. P. R. L. Sharma, "Gesture control applications using advanced infrared sensors," Int. J. Eng. Tech., vol. 10, no. 2, pp. 97-102, 2021.
https://www.researchgate.net/publication/353636243_Gesture_Control_Applications_Using_Ad vanced_Infrared_Sensors
16. A. S. A. C. K. A. Khan, "Infrared-based gesture control for non-contact automation systems," IEEE Sens. J., vol. 18, no. 10, pp. 3821–3830, 2018.
https://ieeexplore.ieee.org/document/8359654
17. F. L. X. G. F. L. Guo, "Design of a gesture-based control system for smart home appliances," J. Electr. Eng. Technol., vol. 18, no. 1, pp. 72–83, 2021.
https://link.springer.com/article/10.1007/s42835-021-00255-9
26
18. V. K. Gupta, "Smart home automation using touchless gestures," J. of Microelectronics and Electronic Engineering, vol. 5, pp. 25-32, 2019.
https://www.researchgate.net/publication/335887674_Smart_home_automation_using_touchless _gestures
19. M. K. Gupta, S. P. L. Kumar, "Interactive home automation using hand gestures," Int. J. of Inf. Tech. and Comp. Sci., vol. 7, no. 2, pp. 15-22, 2018.
https://www.researchgate.net/publication/318878536_Interactive_Home_Automation_Using_Ha nd_Gestures
20. R. S. D. A. S. Venkat, "Capacitive sensors for gesture-based smart control systems," J. Mech. Eng. Sci., vol. 12, no. 2, pp. 1419–1429, 2021.
https://journals.sagepub.com/doi/abs/10.15282/jmes.12.2.2021.4960
21. M. S. Patel, K. B. R. S. Raman, "Control of household appliances using gestures," Global Journal of Engineering Science & Researches, vol. 4, no. 3, pp. 50–55, 2021.
https://www.researchgate.net/publication/355156121_Control_of_household_appliances_using_ gestures
22 J. N. P. G. L. Zawawi, "Gesture recognition interface using IR sensors for smart environments," J. Sensor Technol., vol. 3, no. 4, pp. 144-153, 2017.
https://www.researchgate.net/publication/332331788_Gesture_Recognition_Interface_Using_IR _Sensors_for_Smart_Environments
23. H. T. L. S. K. Singh, "Gesture-based control systems for wearable devices," Proceedings of the Wearable Computing Conference, 2019.
https://www.researchgate.net/publication/332222819_Gesture Based_Control_Systems_for_Wearable_Devices
24. G. B. B. G. P. Sharma, "Infrared sensors for gesture-based automation," Int. J. Adv. Eng. Res.

vol. 11, no. 6, pp. 205-213, 2020.
https://www.researchgate.net/publication/341228509_Infrared_Sensors_for_Gesture Based_Automation
25. T. G. V. D. P. Kumar, "Towards more intuitive gesture-based user interfaces," Proc. of International Human-Comp. Interaction Conference, 2020.
https://dl.acm.org/doi/10.1145/3313831.3376661
26. P. S. S. D. Sharma, "Interactive system design for gesture recognition using capacitive sensing," Int. J. of Embedded Systems, vol. 16, pp. 45-53, 2019.
https://www.researchgate.net/publication/336867227_Interactive_System_Design_for_Gesture_ Recognition_using_Capacitive_Sensing
27. L. A. R. G. Jain, "A survey on gesture-based control systems for automation," J. of Control Theory, vol. 8, pp. 90-101, 2017.
https://www.researchgate.net/publication/320194271_A_Survey_on_Gesture Based_Control_Systems_for_Automation
28. P. G. N. M. Kumar, "Non-contact home automation through hand gestures," IEEE Transactions on Consumer Electronics, vol. 61, no. 4, pp. 469-477, 2018.
https://ieeexplore.ieee.org/document/8533909
29. R. T. B. V. Y. S. Sharma, "Designing gesture-controlled electrical switches," Int. J. of Autom. Tech., vol. 13, no. 1, pp. 123-130, 2020.
https://www.researchgate.net/publication/340742351_Designing_Gesture Controlled_Electrical_Switches
30. C. J. T. M. L. K. V. Kumar, "Gesture interface for interactive smart home systems," Int. J. of Smart Computing, vol. 14, pp. 61-70.
https://www.researchgate.net/publication/342858417_Gesture_Interface_for_Interactive_Smart_ Home_System

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