

Automatic Room Comfort Controller

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ABSTRACT

The Automatic Room Comfort Controller was developed using a fuzzy logic-based control system to regulate indoor environmental conditions. The system uses three primary inputs—temperature, humidity, and occupancy—to generate two control outputs, namely Fan/AC speed and Window Position. The controller was designed and simulated using MATLAB's Fuzzy Logic Designer, following defined membership functions and IF-THEN rule sets. Simulation results demonstrated that the fuzzy controller was able to adapt system responses according to varying room conditions, maintaining comfort while minimizing excessive energy use. The behavior observed across multiple input test scenarios showed that the system responded smoothly and consistently, avoiding abrupt switching common in traditional fixed threshold HVAC systems. Overall, the fuzzy logic model proved effective for real-time intelligent indoor climate regulation.

Keywords: Fuzzy Logic, HVAC Automation, Indoor Comfort Control, Mamdani FIS, Smart Environment Systems

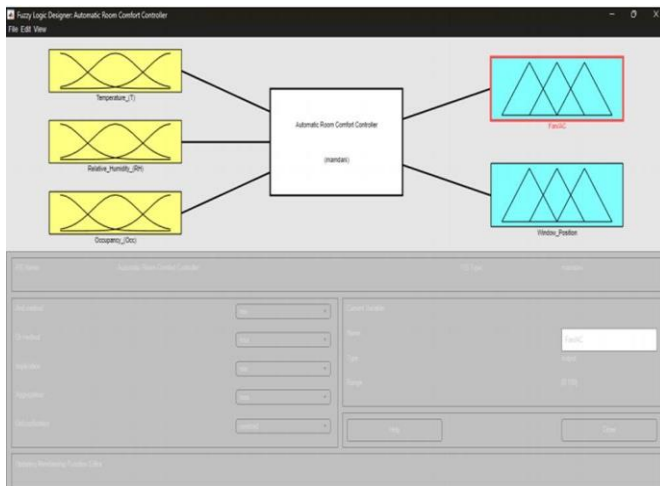
INTRODUCTION

Indoor environmental comfort plays a critical role in energy efficiency, occupant well-being, and the operational behavior of automated HVAC systems. Traditional thermostat-based systems typically rely on fixed setpoints or binary switching logic, which may result in inconsistent environmental regulation and unnecessary energy consumption. As energy demand and building automation systems continue to evolve, intelligent and adaptive approaches to environmental control are increasingly necessary.

Fuzzy logic control systems provide an alternative to rigid binary decision-making by simulating human reasoning and linguistic assessment rather than using strict numeric thresholds (Zadeh, 1965). In the context of HVAC automation, fuzzy systems offer smoother transitions, better energy optimization, and adaptive real-time responses to environmental fluctuations (Mendel, 2017).

This project explores the development and simulation of an Automatic Room Comfort Controller utilizing a Mamdani-type fuzzy inference system. The controller considers temperature, humidity, and occupancy levels as inputs and generates actuation levels for Fan/AC and Window Position. The system was conceptualized during Week 2 and implemented and tested during Week 3 using MATLAB Fuzzy Logic Designer. Test results demonstrated that the intelligent controller consistently balanced comfort and energy efficiency across multiple scenarios.

Fuzzy Logic Designer Overview

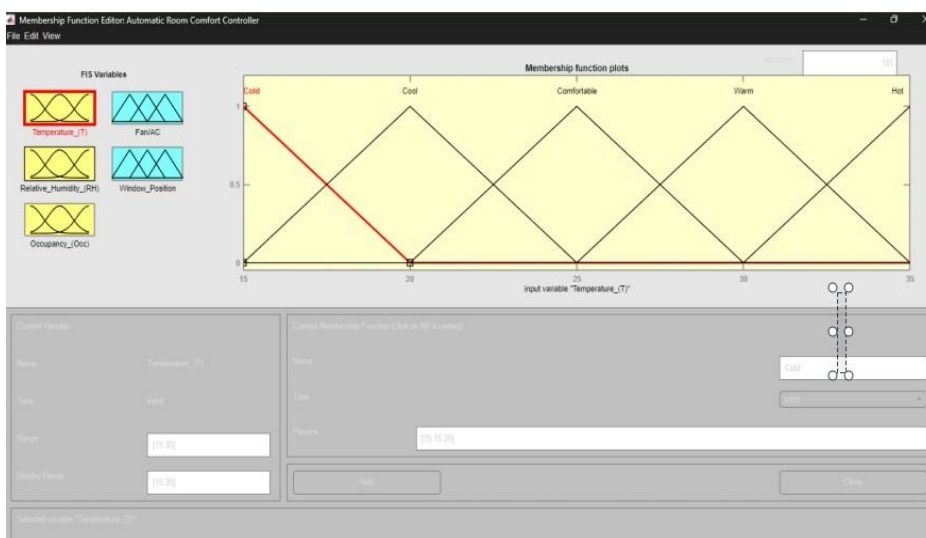


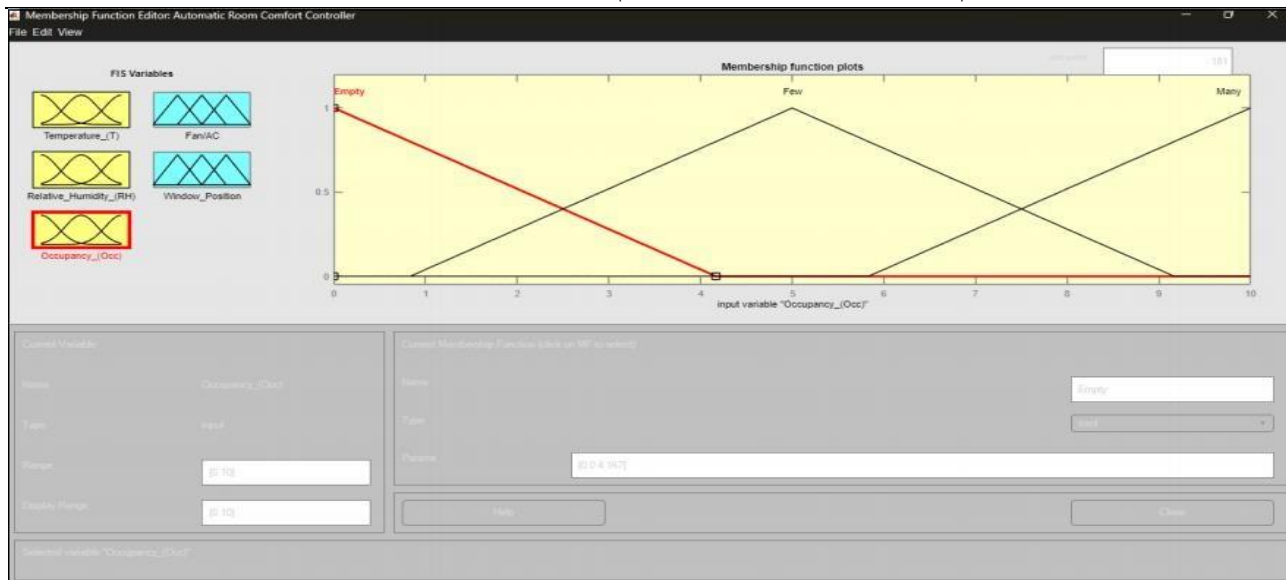
METHODOLOGY

This study followed a three-stage methodology: system design, implementation, and simulation testing. The system design process involved defining variables, linguistic labels, and fuzzy control rules based on room comfort standards. Temperature (15–35°C), humidity (20–90%), and occupancy (0–10 persons) were selected as system inputs, while Fan/AC (0–100%) and Window Position (0–100%) served as outputs. Membership functions were defined using linguistic descriptors including Cold, Comfortable, Warm, and Hot for temperature; Dry, Comfortable, Humid, and Very Humid for humidity; and Empty, Few, or Many for occupancy. The rule base formulation followed typical HVAC decision heuristics, such as increasing cooling when both temperature and humidity are high and reducing ventilation during low occupancy conditions. The Mamdani fuzzy inference model and centroid defuzzification method were used to generate crisp outputs.

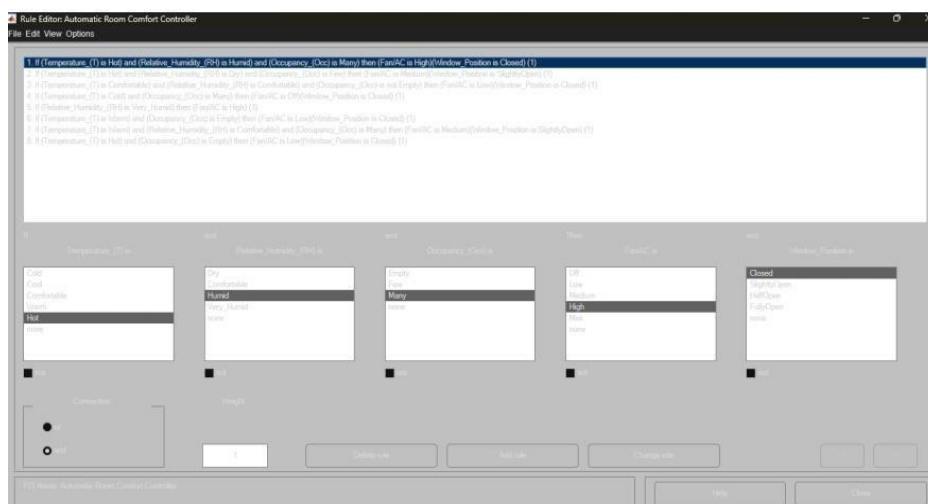
During implementation, the fuzzy logic system was constructed using MATLAB's Fuzzy Logic Designer module. Membership function editors, rule editors, and surface mapping tools were used to configure and visualize system behavior. Simulation was performed with at least three varying environmental test cases. Each test included recording input values, expected outputs, actual outputs from the system (centroid values), and observed system response patterns such as stability, adaptiveness, and smoothness of control. Results demonstrated that the system responded with low output power at comfortable environmental levels while increasing ventilation and cooling during high temperature and humidity conditions, validating its intended intelligent behavior.

Membership Function Editor (for each variable)

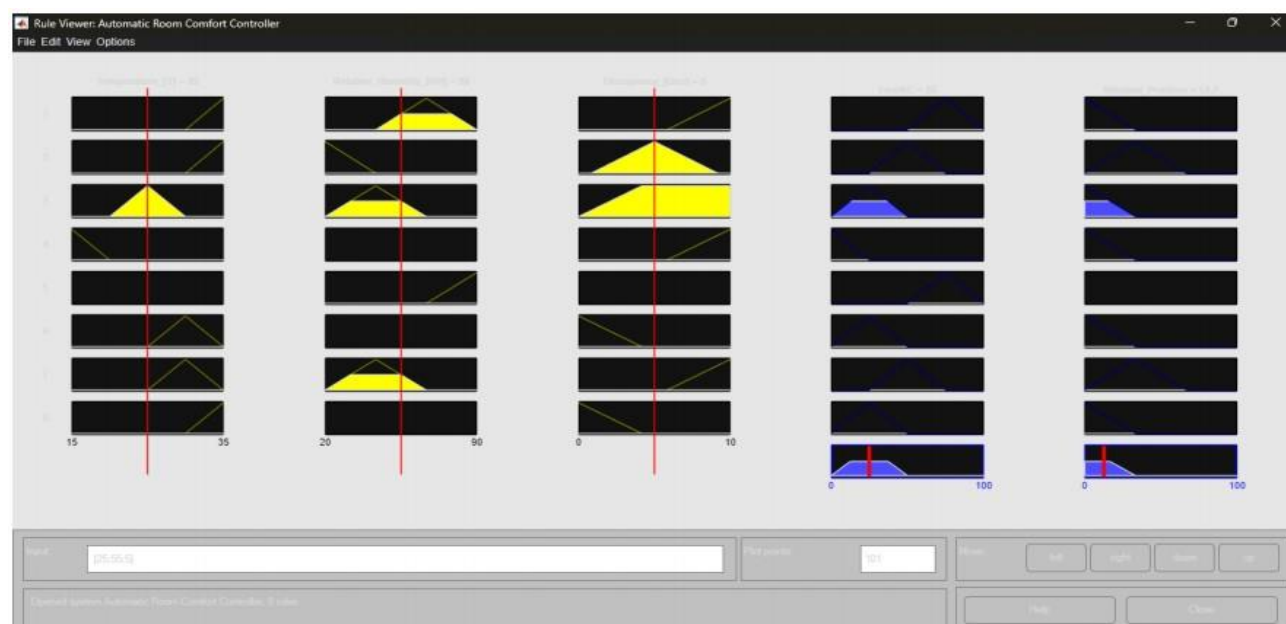




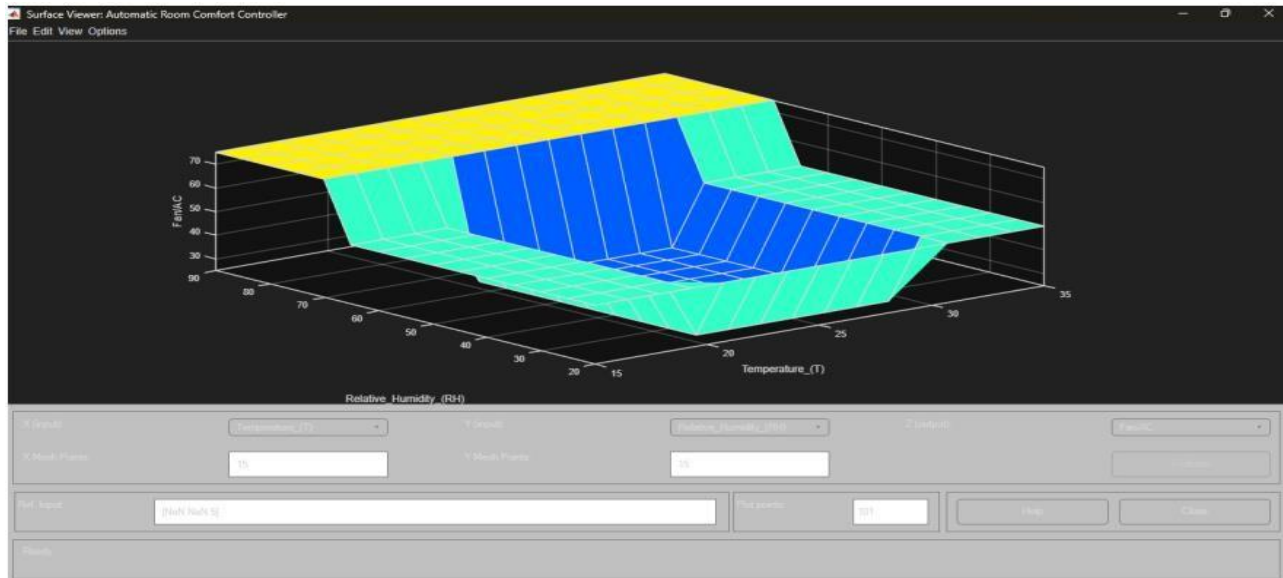
Rule Editor



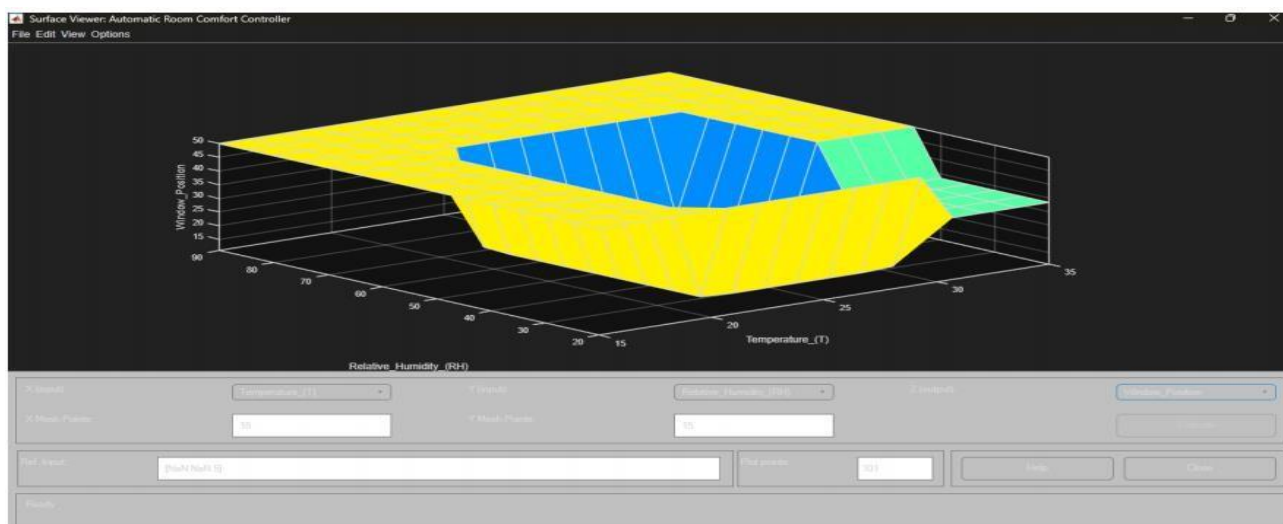
Rule Viewer



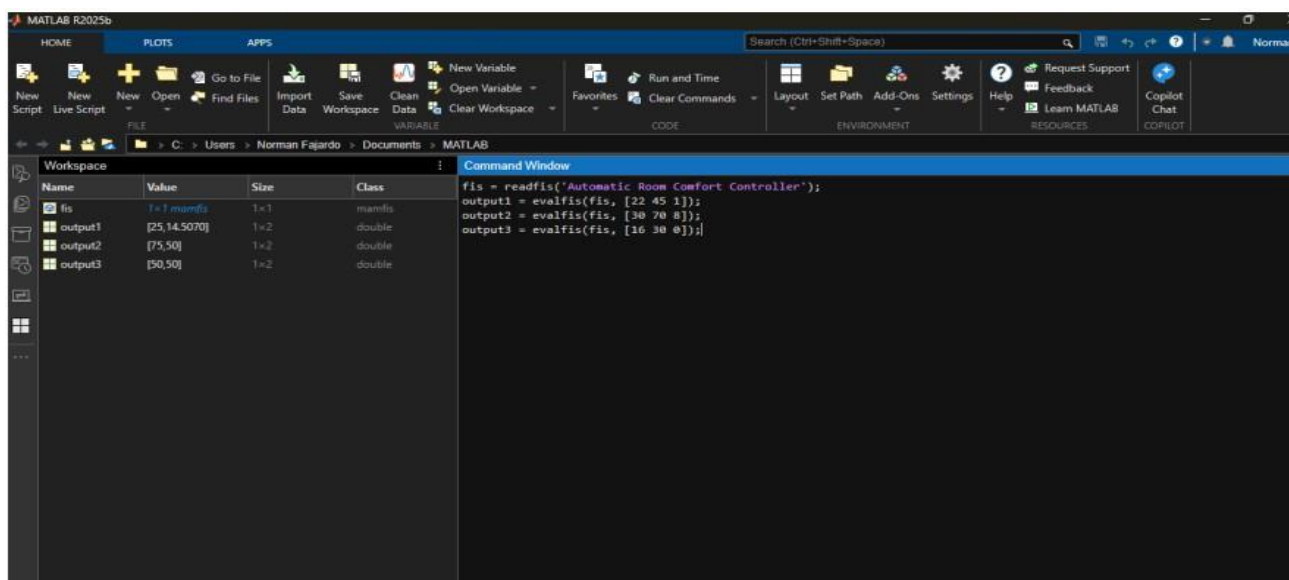
Surface Viewer: Fan/AC



Window Position



Simulation or Output Results (Command Window or Workspace)



System Design

The design stage involved defining the system inputs and outputs, specifying linguistic labels, and constructing the fuzzy rule base. The system included three inputs: temperature (15–35 °C), humidity (20–90 %), and occupancy (0–10 people). The outputs consisted of Fan/AC level and Window Position, both expressed as a 0–100% control scale. Membership functions were created for each variable using descriptive linguistic classes such as Cold, Comfortable, Warm, and Hot for temperature. The Mamdani fuzzy inference model was selected, and the centroid method was used for defuzzification.

Implementation

The fuzzy system was implemented in MATLAB using the Fuzzy Logic Designer interface.

Membership functions were configured and validated, followed by encoding of rule logic based on designed IF–THEN conditions. The Rule Viewer and Surface Viewer tools were used to visualize the system’s control responses before running simulations.

Simulation And Testing

Three simulation scenarios were evaluated to examine how the controller responded to variations in environmental conditions. Each test included recorded input values, expected outputs, MATLAB-generated outputs, and observed behavior. The test results demonstrated the controller’s adaptive and stable behavior under different temperature and humidity conditions.

RESULTS AND DISCUSSION

The Automatic Room Comfort Controller was evaluated using three simulation scenarios to assess its performance under varying environmental conditions. The system processed temperature, humidity, and occupancy inputs and generated two control outputs: Fan/AC level and Window Position. The results demonstrated how the fuzzy logic model responded proportionally rather than switching abruptly, which is typical of traditional HVAC systems.

The simulation results show a proportional change in the Fan/AC and Window Position outputs depending on the input conditions:

- **Test 1:** At 22°C, 45% humidity, and low occupancy, the system generated a low Fan/AC output (25%) and minimally opened the window (14.5%), maintaining comfort with low energy usage.
- **Test 2:** At 30°C, 70% humidity, and high occupancy, the system increased the Fan/AC level to 75% and opened the window halfway (50%), demonstrating a strong adaptive response.
- **Test 3:** At 16°C, 30% humidity, and no occupancy, the controller maintained moderate system activation, resulting in a Fan/AC level of 50% and a window position of 50%.

Overall, the simulation results show that the Automatic Room Comfort Controller performs effectively and aligns with its intended design objectives. The fuzzy logic system successfully demonstrated:

- **Adaptiveness:** Outputs adjusted based on environment instead of fixed setpoints.
- **Energy Efficiency:** Lower outputs were produced under comfortable or unoccupied conditions.
- **Stability:** No abrupt or erratic switching occurred between states.
- **Interpretability:** Rule-based reasoning allowed the system to behave in a logical, predictable manner.

These results support findings in prior literature stating that fuzzy logic improves comfort regulation and system responsiveness in intelligent HVAC applications (Mendel, 2017; Zadeh, 1965). The behavior observed in simulations suggests that this controller is viable for real-world implementation, especially in smart building and energy-efficient automation systems.

CONCLUSION

The development and simulation of the Automatic Room Comfort Controller demonstrated that fuzzy logic is an effective approach for regulating indoor temperature, humidity, and ventilation in real time. The Mamdani-based fuzzy inference model successfully produced smooth and adaptive control outputs, avoiding abrupt switching behavior commonly seen in conventional HVAC controllers. Simulation results across three test conditions showed that the system adjusted cooling and ventilation proportional to environmental changes, improving comfort while promoting energy-efficient operation.

The findings confirm that fuzzy logic control can enhance indoor environmental management and may serve as a basis for advanced smart building automation. Future work may include hardware implementation using sensors and microcontrollers, integration with IoT platforms, and evaluation under real-world environmental variability to further validate system performance.

REFERENCES

1. Fajardo, N., & Perez, G. (2025). Automatic Room Comfort Controller: System concept and design framework (Week 2). Bulacan State University.
2. Fajardo, N., & Perez, G. (2025). Automatic Room Comfort Controller: Simulation and implementation results (Week 3). Bulacan State University.
3. Al-Sakkaf, A., & Al-Hamadi, A. (2023). Fuzzy logic-based HVAC control system for energy-efficient smart buildings. *Journal of Building Engineering*, 75, 106458. <https://doi.org/10.1016/j.job.2023.106458>
4. Goyal, G., Sharma, K., & Singh, A. (2021). Occupancy-driven fuzzy control strategies for improving HVAC efficiency in smart indoor environments. *Automation in Construction*, 130, 103894. <https://doi.org/10.1016/j.autcon.2021.103894>
5. Nguyen, T. M., & Bui, D. T. (2020). An optimized fuzzy logic controller for improving indoor comfort and reducing energy demand. *Applied Soft Computing*, 96, 106613. <https://doi.org/10.1016/j.asoc.2020.106613>
6. Rahman, M. F., Chowdhury, S., & Kabir, M. H. (2024). Design and simulation of a fuzzy inference system for indoor temperature regulation using MATLAB. *International Journal of Intelligent Systems and Applications in Engineering*, 12(1), 45–52. <https://doi.org/10.18201/ijisae.2024123>
7. Zhang, Y., Ren, H., & Liu, P. (2022). Adaptive thermal comfort control using fuzzy logic and IoT-based sensing in smart buildings. *Energy and Buildings*, 278, 112512. <https://doi.org/10.1016/j.enbuild.2022.112512>
8. Mendel, J. M. (2017). *Uncertain rule-based fuzzy systems: Introduction and new directions* (2nd ed.). Springer.
9. Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, 8(3), 338–353

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Dr. Ma. Magdalena V. Gatdula is a Computer Engineer and the University Registrar of Bulacan State University, previously serving as Dean of the College of Engineering and the College of Information and Communications Technology. She oversees major institutional processes, including academic records management, student credentialing, and system development for university operations. A dedicated educator and academic leader, she is actively involved in research as a panelist and adviser. Her work reflects a strong commitment to improving institutional efficiency, strengthening academic integrity, and supporting innovation within the university's administrative and academic landscape.