Design and Implementation of Line-to-Ground Fault Detection and Location Monitoring in Three-Phase Transmission Lines

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Abstract: Electrical power systems rely on three-phase transmission lines to deliver electricity efficiently over long distances. However, faults such as line-to-ground (LG) faults are among the most common disturbances in transmission systems. These faults occur when one phase conductor accidentally encounters the ground due to insulation failure, lightning, equipment malfunction, or environmental conditions. Such faults can lead to power outages, equipment damage, and system instability, making rapid detection and accurate fault location essential for maintaining reliable power supply. This project focuses on the detection and monitoring of line-to-ground faults in a three-phase transmission line and determining the exact location of the fault. The proposed system uses sensors and monitoring circuits to continuously measure electrical parameters such as voltage and current in each phase. When a fault occurs, the abnormal variations in these parameters are detected by the control unit, which identifies the faulty phase and triggers protective actions. The system also incorporates a fault location technique that estimates the distance of the fault from the monitoring station based on changes in line impedance or voltage levels. The detected fault information is then displayed through a monitoring interface or transmitted to a control center, enabling quick maintenance response and faster restoration of power**.** By implementing this system, the reliability and safety of transmission networks can be improved. The proposed method helps reduce fault detection time, maintenance costs, and power interruption duration**,** thereby enhancing the overall performance of the electrical power distribution infrastructure.

Keywords: Three-phase transmission lines; Line-to-ground fault; Fault detection; Fault location; Arduino UNO; ACS712 sensor; Smart monitoring.

1. Introduction

Three-phase transmission lines are the backbone of modern electrical power systems, enabling the efficient transfer of large amounts of electrical energy over long distances. These lines are designed to maintain reliability, stability, and continuous supply to consumers. However, faults in transmission lines are inevitable due to insulation failures, lightning strikes, equipment malfunctions, or environmental factors such as trees, animals, or storms. Among the various types of faults, line-to-ground (LG) faults are the most common, accounting for approximately 70–80% of all transmission line faults. A line-to-ground fault occurs when one phase conductor encounters the earth or any grounded object. This fault can cause significant voltage dips, current surges, and system instability if not detected and isolated quickly. Rapid detection and accurate fault location monitoring are therefore critical to minimize damage, reduce downtime, and enhance the reliability of the power system [1-5]. Electrical power systems are broadly divided into three stages: generation, transmission, and distribution. The transmission system is responsible for carrying bulk electrical power from generating stations to substations through high-voltage transmission lines. Three-phase transmission systems are widely used because they provide: Higher efficiency in power transfer. Constant power delivery. Reduced conductor material requirement. Better voltage regulation. Due to these advantages, three-phase systems are the backbone of modern electrical power networks [6-10].

A paper on Three-Phase Transmission Lines, Line-to-Ground Fault Detection and Location Monitoring is important because electrical power systems must operate safely, reliably, and efficiently. Transmission lines carry large amounts of electrical power from generating stations to substations and consumers. However, faults frequently occur in transmission lines due to environmental conditions, equipment failure, or human interference. Among these faults, line-to-ground (L-G) faults are the most common. The main need for this study is to detect faults quickly and identify the exact location on the transmission line where the fault occurs. If faults are not detected and cleared immediately, they can cause serious problems such as power outages, equipment damage, and safety hazards. By developing a system that can monitor transmission lines and detect line-to-ground faults, the reliability and stability of the power system can be improved.

Another important reason for this research is to reduce maintenance time and operational cost**.** Traditional fault detection methods often require manual inspection, which is time-consuming and inefficient. An automated monitoring system using microcontrollers, sensors, and communication modules can quickly identify the fault location, allowing maintenance teams to respond faster and restore power supply. To implement a system that can identify line-to-ground (L-G) faults in three-phase transmission lines in real time. Reduce the time delay between fault occurrence and detection to prevent further damage. To develop a method to locate the exact position of the fault on the transmission line. Enable maintenance teams to respond faster and reduce system downtime. To continuously monitor current and voltage in all three phases. Identify abnormal conditions that may indicate potential faults. To automate fault detection and location processes to minimize manual inspections. Enhance system efficiency by providing precise fault information. To protect equipment from damage caused by undetected faults. Ensure uninterrupted power supply and safety of personnel working with transmission lines. To utilize microcontrollers, current sensors, relay modules, and LCD displays for real-time fault detection. Develop a reliable software interface for data acquisition, processing, and display [11-20].

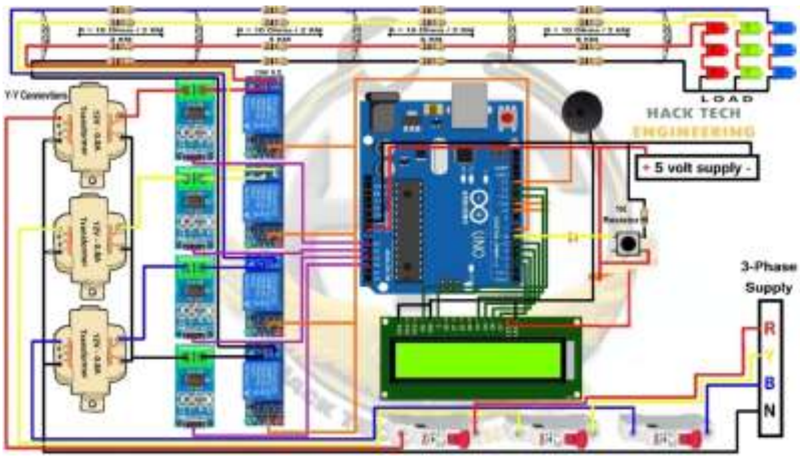

Fig:1 Schematic Diagram

2. SYSTEM ARCHITECTURE

2.1.1 ARDUINO

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. Arduino is a single-board microcontroller meant to make the application more accessible which are interactive objects and its surroundings. Arduino is an open-source electronics platform based on easy-to-use hardware and software. The hardware features with an open-source hardware board designed around an 8-bit Atmel AVR micro controller or a 32- bit Atmel ARM. The Arduino UNO is a popular microcontroller development board used for building electronics projects. It is based on the ATmega328P microcontroller, and it features an easy-to-use programming environment, making it ideal for both beginners and advanced users. Here's an overview of the key components and features of the Arduino UNO

The UNO uses the ATmega328P microcontroller, which operates at 16 MHz and comes with 32 KB of flash memory, 2 KB of SRAM, and 1 KB of EEPROM. 14 digital input/output pins, 6 of which can be used as PWM (Pulse Width Modulation) outputs. 6 analog inputs, allowing you to read variable voltages (0-5V). One USART (Universal Synchronous Asynchronous Receiver-Transmitter) for serial communication, often used for communication between the Arduino and a computer or other devices. The Arduino UNO is programmed using the Arduino IDE (Integrated Development Environment), where you can write code in C/C++.Code is uploaded to the board via USB, and once uploaded, the board executes the program autonomously.

Basically, the processor of the Arduino board uses the Harvard architecture where the program code and program data have separate memory. It consists of two memories such as program memory and data memory. Wherein the data is stored in data memory and the code is stored in the flash program memory. The Arduino UNO architecture refers to the specific layout and components that make up the Arduino UNO board, enabling it to perform tasks like reading inputs, controlling outputs, and communicating with other devices. The architecture consists of both hardware and software elements.

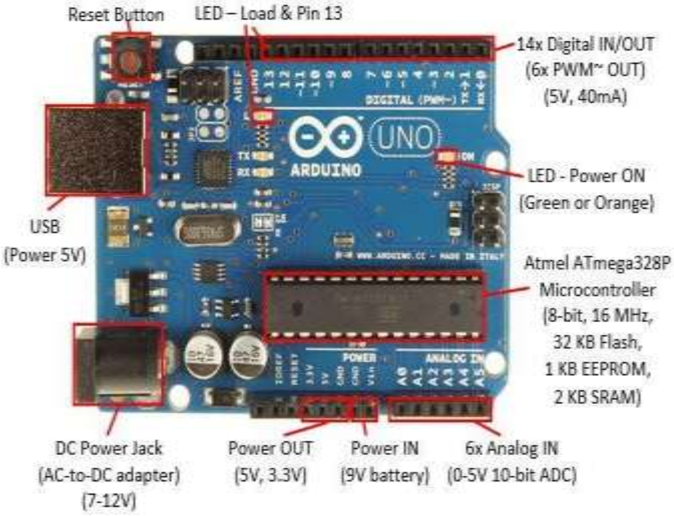

Fig:1. ARDUINO UNO BOARD

SPECIFICATIONS OF THE ARDUINO UNO:

- Microcontroller: ATmega328 AVR microcontroller
- Operating Voltage: 5V
- Input Voltage: 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins:14
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB

2,1.2. ACS712 CURRENT SENSOR:

The ACS712 is a fully integrated, hall effect-based linear current sensor with 2.1kVRMS voltage isolation and a integrated low-resistance current conductor. Technical terms aside, it's simply put forth as a current sensor that uses its conductor to calculate and measure the amount of current applied.

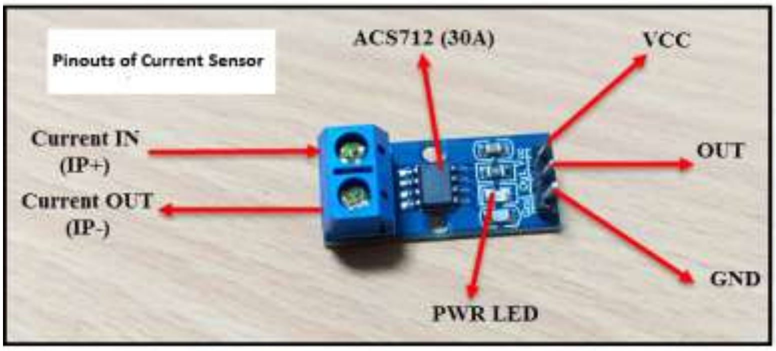

Fig:2. ACS712 Current sensor

3. CONFIGURING ARDUINO WITH PC

STEP-1: ARDUINO IDE

Once the software has been installed on your computer, go ahead and open it up. This is the Arduino IDE and is the place where all the programming will happen. Take some time to look around and get comfortable with it.

STEP-2: CONFIGURATION TOOLS

- Menu Bar: Gives you access to the tools needed for creating and saving Arduino sketches.

- Verify Button: Compiles your code and checks for errors in spelling or syntax.
- Upload Button: Sends the code to the board that's connected such as Arduino Uno in this case. Lights on the board will blink rapidly when uploading.
- New Sketch: Opens up a new window containing a blank sketch.
- Sketch Name: When the sketch is saved, the name of the sketch is displayed here.
- Open Existing Sketch: Allows you to open a saved sketch or one from the stored examples.
- Save Sketch: This saves the sketch you currently have open.
- Serial Monitor: When the board is connected, this will display the serial information of your Arduino
- Code Area: This area is where you compose the code of the sketch that tells the board what to do.
- Message Area: This area tells you the status on saving, code compiling, errors and more.
- Text Console: Shows the details of an error messages, size of the program that was compiled and additional info.
- Board and Serial Port: Tells you what board is being used and what serial port it's connected to.

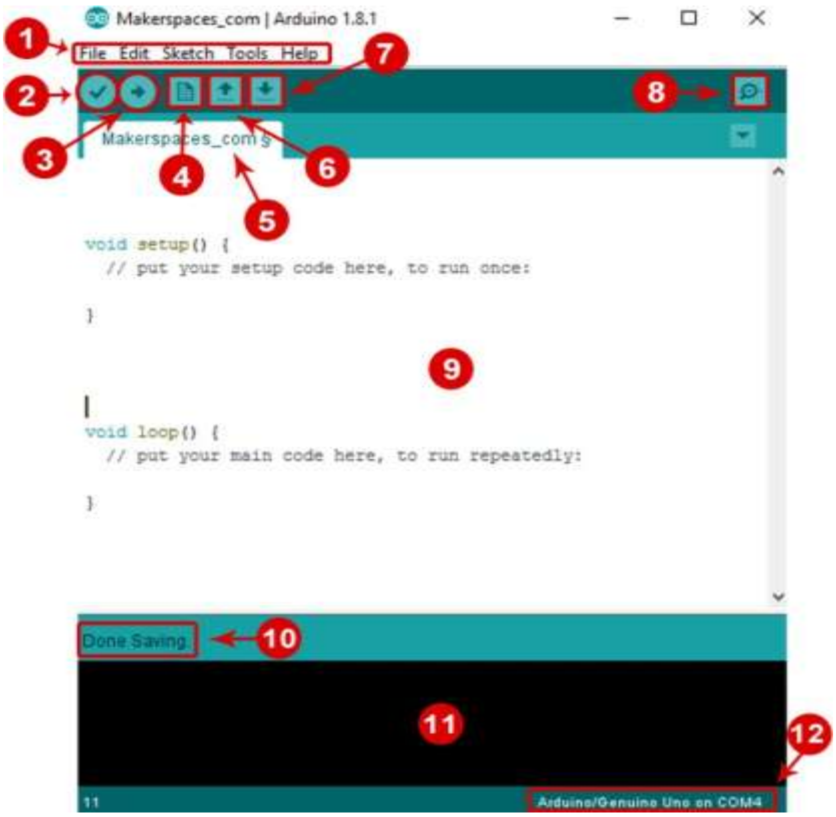

Fig:3. Arduino tools

STEP 3: LINK ARDUINO UNO TO PC

- At this point you are ready to connect your Arduino to your computer. Plug one end of the USB cable to the Arduino Uno and then the other end of the USB to your computer's USB port.
- Once the board is connected, you will need to go to Tools then Board then finally select Arduino Uno
- Next, you must tell the Arduino which port you are using on your computer.
- To select the port, go to Tools then Port then selects the port that says Arduino

STEP 4: COMPILE AND UPLOAD

You need to click on the verify button (check mark) that's located in the top left of the IDE box. This will compile the sketch and look for errors. Once it says "Done Compiling" you are ready to upload it. Click the upload button (forward arrow) to send the program to the Arduino board.

Fig:4. Code verification & upload

4. Result

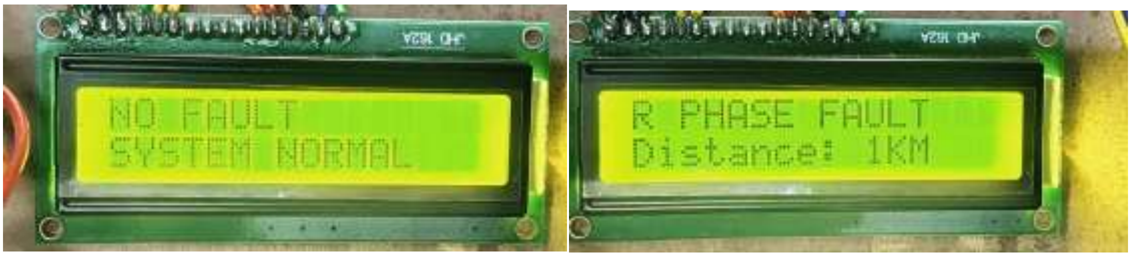

Fig:5. LCD output

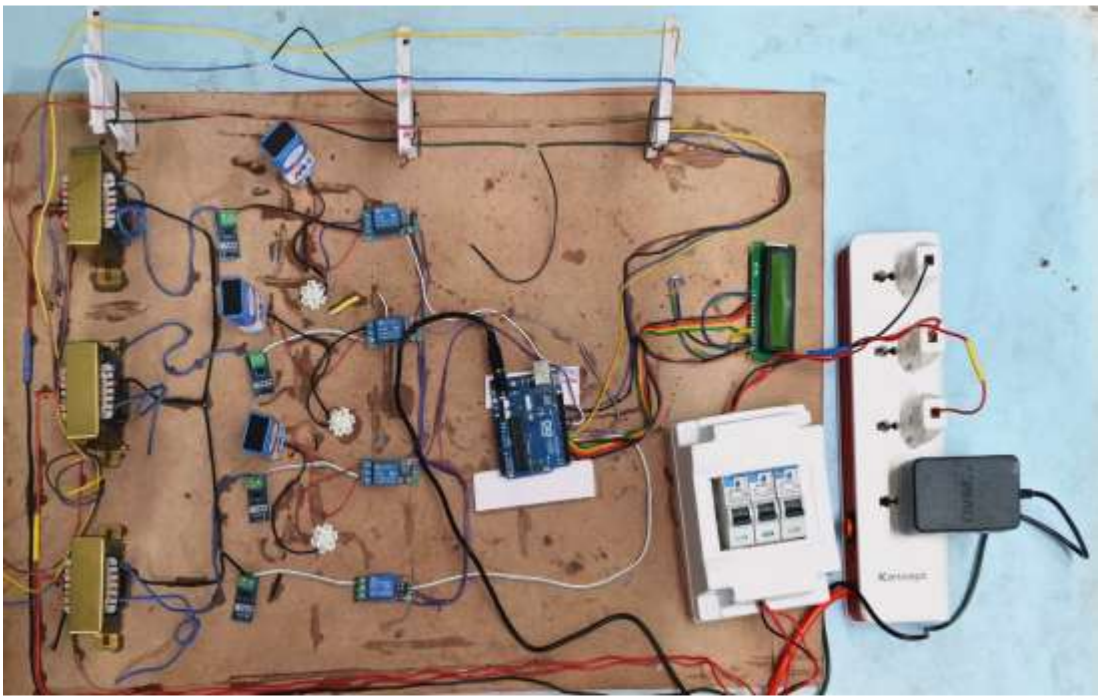

Fig: 5.2 Project image

CONCLUSION

In modern power systems, three-phase transmission lines play a crucial role in delivering electrical energy efficiently over long distances. However, these lines are vulnerable to different types of faults, among which line-to-ground (L-G) faults are the most common. These faults occur when one phase conductor accidentally encounters the ground due to insulation failure, lightning, equipment damage, or environmental factors. The detection and location monitoring of line-to-ground faults is essential for maintaining system reliability, safety, and continuity of power supply. By using protection techniques such as protective relays, current and voltage sensors, microcontroller-based monitoring systems, and communication technologies, faults can be identified quickly and accurately. Modern systems often employ digital relays, impedance-based fault location methods, and real-time monitoring using IOT or SCADA systems. Accurate fault location monitoring significantly reduces the time required to identify the faulted section of the transmission line. This enables faster maintenance, minimizes outage duration, reduces operational costs, and improves overall system stability. In conclusion, implementing an effective line-to-ground fault detection and location monitoring system enhances the protection of three-phase transmission networks. It ensures quick fault identification, precise fault location, improved power system reliability, and efficient maintenance, thereby supporting the safe and uninterrupted operation of modern electrical power systems.

REFERENCES

[1] Mishra, D. P., & Ray, P. (2018). Fault detection, location and classification of a transmission line. Neural Computing and Applications, 30(5), 1377-1424. https://doi.org/10.1007/s00521-017-3295-y

[2] Yadav, A., & Dash, Y. (2014). An overview of transmission line protection by artificial neural network: fault detection, fault classification, fault location, and fault direction discrimination. Advances in Artificial Neural Systems, 2014(1), 230382. https://doi.org/10.1155/2014/230382

[3] Resmi, R., Vanitha, V., Aravind, E., Sundaram, B. R., Aswin, C. R., & Harithaa, S. (2019, February). Detection, classification and zone location of fault in transmission line using artificial neural network. In 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT) (pp. 1-5). IEEE._ 10.1109/ICECCT.2019.8868990

[4] Fahim, S. R., Sarker, Y., Islam, O. K., Sarker, S. K., Ishraque, M. F., & Das, S. K. (2019, November). An intelligent approach of fault classification and localization of a power transmission line. In 2019 IEEE International Conference on Power, Electrical, and Electronics and Industrial Applications (PEEIACON) (pp. 53-56). IEEE. 10.1109/PEEIACON48840.2019.9071925

[5] Jamil, M., Sharma, S. K., & Singh, R. (2015). Fault detection and classification in electrical power transmission system using artificial neural network. SpringerPlus, 4(1), 334. https://doi.org/10.1186/s40064-015-1080-x

[6] Fathabadi, H. (2016). Novel filter based ANN approach for short-circuit faults detection, classification and location in power transmission lines. International Journal of Electrical Power & Energy Systems, 74, 374-383. https://doi.org/10.1016/j.ijepes.2015.08.005

[7] Elnozahy, A., Sayed, K., & Bahyeldin, M. (2019, October). Artificial neural network based fault classification and location for transmission lines. In 2019 IEEE Conference on Power Electronics and Renewable Energy (CPERE) (pp. 140-144). IEEE._ 10.1109/CPERE45374.2019.8980173

[8] Leh, N. A. M., Zain, F. M., Muhammad, Z., Abd Hamid, S., & Rosli, A. D. (2020, August). Fault detection method using ANN for power transmission line. In 2020 10th IEEE international conference on control system, computing and engineering (ICCSCE) (pp. 79-84). IEEE. 10.1109/ICCSCE50387.2020.9204921

[9] Samantaray, S. R., Dash, P. K., & Panda, G. (2007). Distance relaying for transmission line using support vector machine and radial basis function neural network. International Journal of Electrical Power & Energy Systems, 29(7), 551-556. https://doi.org/10.1016/j.ijepes.2007.01.007

[10] Mukherjee, A., Kundu, P. K., & Das, A. (2021). Transmission line faults in power system and the different algorithms for identification, classification and localization: a brief review of methods. Journal of the Institution of Engineers (india): Series B, 102(4), 855-877. https://doi.org/10.1007/s40031-020-00530

[11] Jamil, M., Kalam, A., Ansari, A. Q., & Rizwan, M. (2014). Generalized neural network and wavelet transform based approach for fault location estimation of a transmission line. Applied Soft Computing, 19, 322-332. https://doi.org/10.1016/j.asoc.2014.02.020

[12] Roy, N., & Bhattacharya, K. (2015). Detection, classification, and estimation of fault location on an overhead transmission line using S-transform and neural network. Electric Power Components and Systems, 43(4),461-472 https://doi.org/10.1080/15325008.2014.986776

[13] Panahi, H., Zamani, R., Sanaye-Pasand, M., & Mehrjerdi, H. (2021). Advances in transmission network fault location in modern power systems: Review, outlook and future works. IEEE Access, 9, 158599-158615. https://doi.org/10.1109/ACCESS.2021.3129838

[14] Moradzadeh, A., Teimourzadeh, H., Mohammadi-Ivatloo, B., & Pourhossein, K. (2022). Hybrid CNN-LSTM approaches for identification of type and locations of transmission line faults. International Journal of Electrical Power & Energy Systems, 135, 107563 https://doi.org/10.1016/j.ijepes.2021.107563

[15] Tunio, N. A., Hashmani, A. A., Khokhar, S., Tunio, M. A., & Faheem, M. (2024). Fault detection and classification in overhead transmission lines through comprehensive feature extraction using temporal convolution neural network. Engineering Reports, 6(12), e12950. https://doi.org/10.1016/j.ijepes.2021.107563

[16] Bhowmik, P. S., Purkait, P., & Bhattacharya, K. (2009). A novel wavelet transform aided neural network-based transmission line fault analysis method. International Journal of Electrical Power & Energy Systems, 31(5), 213-219. https://doi.org/10.1016/j.ijepes.2009.01.005

[17] Kanwal, S., & Jiriwibhakorn, S. (2024). Advanced fault detection, classification, and localization in transmission lines: A comparative study of ANFIS, neural networks, and hybrid methods. IEEE access, 12, 49017-49033. https://doi.org/10.1109/ACCESS.2024.3384761

[18] Rajesh, P., Kannan, R., Vishnupriyan, J., & Rajani, B. (2022). Optimally detecting and classifying the transmission line fault in power system using hybrid technique. ISA transactions, 130, 253-264. https://doi.org/10.1016/j.isatra.2022.03.017

[19] Bishal, M. R., Ahmed, S., Molla, N. M., Mamun, K. M., Rahman, A., & Al Hysam, M. A. (2021, August). ANN based fault detection & classification in power system transmission line. In 2021 International Conference on Science & Contemporary Technologies (ICSCT) (pp. 1-4). IEEE. https://doi.org/10.1109/ICSCT53883.2021.9642410

[20] Shakiba, F. M., Azizi, S. M., Zhou, M., & Abusorrah, A. (2023). Application of machine learning methods in fault detection and classification of power transmission lines: a survey. Artificial Intelligence Review, 56(7), 5799-5836. https://doi.org/10.1007/s10462-022-10296-0