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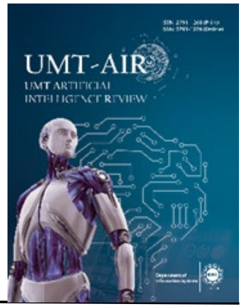

Title: **Machine Learning Based Implementation of Home Automation Using Smart Mirror**

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Machine Learning Based Implementation of Home Automation Using Smart Mirror

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***Abstract*-When ordered, it may be folded in half quickly and effortlessly. IoT (Internet of Things) technology drives the Smart Mirror's functionality. Standard mirror functionality is included, in addition to showing the user's social notifications, daily tasks, weather updates, breaking news, reminders, voice assistant notifications, and smartphone notifications. The Smart Mirror is connected to the Raspberry Pi-based network through Wi-Fi. A two-way mirror or an acrylic mirror sheet is used with the Raspberry-Pi mainboard to conceal the Mirror's rear end from the user. It supports modules written in any programming language. When Python is used as the primary programming language, these changes take care of the hardware and software limitations. This work discusses the creation and building of the Mirror in appropriate manner. In addition, possible uses of the Mirror are discussed. Compared to this DIY method, the cost is substantially lower, and the result is more predictable. The result produced by the support vector machine classifier are of accuracy which is 84% for detecting theft, and the confusion matrix is often diagonal, showing that this classifier can accurately labelled the data. Similarly, F1 score of 0.82% shows that there are a few false positives and false negatives, which is a favorable indicator.**

***Index Terms*- Smart Mirror, Programming, Language, Software, Accuracy, Diagonal, Indicator.**

I. Introduction

Our living environment is dynamic and constantly changing. As science and technology advance, our way of life will become

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increasingly mechanized. Smarter cities, more innovative phones, and more are [1]. Home automation projects are required to keep up with the hectic pace of modern life. Internet of Things (IoT) devices play a significant role in home automation systems. Devices may connect and do activities independently in the Internet of Things (IoT). The Internet of Things (IoT), which consists of a network of wireless sensor networks (WSNs), includes embedded wireless sensors [2].

IoT may be used to create a bright house that regulates the windows' opening and closing according to the weather. In this article, an IoT-based smart mirror is built [3]. A reflecting surface that can display data such as the current date, time, weather, and traffic conditions is referred to as a "smart mirror" [4]. These online capabilities will be implemented using the Raspberry Pi board. The Linux operating system is the one that Raspberry Pi prefers to use. JavaScript and the mean stack approach are employed in building the display page [5].

A smart mirror offers many benefits. No longer need to check phones to see the date or the weather, which makes life simpler. There is everything that is required in front of us right now. The smart mirror may also show browsers and social media platforms. The mirror will be significantly quicker and simpler if it contains a motion sensor [6]. In order to save time and keep the user interested, he can now get ready while concurrently reading the news or watching YouTube videos. After realizing the potential advantages of the smart mirror, Microsoft and Apple have created their versions of it [7].

II.Literature Review

The Reference [8] described that IoT allows devices to interact concurrently in critical areas. Smart doors and smart homes are meant to communicate. Smart mirrors are a critical IoT application. This Mirror is both reflective and interactive. Smart mirrors might be a medical student's simulator or a fitting room help. This paper describes smart mirror usage.

The Reference [9] focused on Smart Mirror-based Future IoT, which has several uses. Arduino and Raspberry Pi-made smart mirrors. This technology will aid in the future with health, sports, learning, etc. Smart mirrors respond to voice or facial recognition. IoT will also enable a smart home, where devices are connected to the internet and can interact. Smart mirrors and IoT can help with regular tasks like parking. Future IoT applications face accuracy, data security, privacy problems, and more. Future Internet of Things use must be protected against these threats, and their consequences minimized. This literature focuses on IoT in the future and its use, sensors and microcontrollers on IoT and Smart Mirror, and IoT-related issues.

The Reference [10] proposed that not just smartphones and PCs are getting smarter. Cutting-edge technology can make any gadget "smarter." This study develops a Raspberry Pi-powered smart mirror for IoT. (IoT). STM32F030C8T6 is the Raspberry Pi host controller's microcontroller. Connect your Raspberry Pi via Wi-Fi to obtain weather forecasts through API. The gadget displays time, date, weather, and calendar—a user-controlled Mirror. Voice interaction connects the SYN6288 speech synthesizer. Webcams are used for facial identification. The smart Mirror is compact, inexpensive, easy to use, and versatile.

The Reference [11] improved health and boosting self-sufficiency are not consistent enough to convince older people to utilize technology. This study uses a smart mirror and digital solutions to enable older people to use technology at home and wearable gadgets on the move. The system's inventors devised two use cases to help older persons with neurological illnesses and stimulate physical rehabilitation at home. In the early stages of pilots for the EU-funded SHAPES project, elements such as reliability, usability, computational resources, performance, and accuracy were explored. SHAPES smart Mirror can help older folks use assistive technologies.

The Reference [12] proposed that mirrors, smartphones, tablets, and computers can use intelligent systems. Raspberry Pi-powered smart mirrors are coming. Wi-Fi connects the raspberry pi to the internet for weather predictions and more. Python programming and a monitor and speaker create an onscreen user interface. This new feature improves security and unravelling. Face emotional identification recognizes facial emotions. Information is apparent on an LED mirror monitor. A mirror may also recognize a user's face and validate their identity.

The Reference [13] proposed that smart mirrors respond to touch or voice commands. Smart mirrors might be for general, medicinal, fashion, or other use. Smart mirrors for the house offer fewer functions than those on the market presently. This article presents a smart mirror with typical and advanced capabilities. Smart mirrors provide emotion recognition, short and long-term emotion monitoring and analysis, double authentication to preserve privacy, and Alexa Skills integration. Deep learning develops the most innovative features. Using actual individuals to evaluate the device's functioning and usability is a good sign.

The Reference [14] described that everyone seeks safety and security. Modern man has evolved in various ways. TV or online, people are happy to get the information they need. Smart Mirror is a framework for re-energizing clients on everyday occurrences. It would be wonderful if the Mirror recognized the customer and recalled crucial occasions. The Smart Mirror allows an intimate connection between customers and data. The suggested mirror structure offers positive explanations and music to improve the house party's mood. The suggested mirror architecture socializes the observer and what they view. Index words include the two-way Mirror, Raspberry Mirror, and Haar classifier.

The Reference [15] described the Smart mirror, a Raspberry Pi 3-powered Smart Mirror. The smart Mirror is an information center, personal assistant, and school notice board. Siri can answer simple inquiries as an Alexa. It displays class schedules and campus directions. Connecting to the cloud enables IoT operations like task scheduling, home automation, etc. This essay discusses the future of an IoT-based Smart Mirror with several uses. Raspberry Pi or other microprocessors may be used to develop smart mirrors. Future uses may include athletics, education, and wellness. Smart mirrors employ face or voice recognition.

The Reference [16] proposed that smart mirrors show home artifacts with smart sensors hide technology. Current Smart Homes do not always satisfy tenants' IoT needs. There is a need for a traditional artifact that may be used to create serene and exciting experiences. A total of 22 people were used in a design case study. The first focus groups provided diary studies and conceptual designs. In evaluating our mid-fidelity prototype, it became evident that the author must pay special attention to residents' daily activities to suit their demands. The Smart Mirror offers digital functions and improves bathroom aesthetics. Home technology design extends beyond automation.

III. Proposed Methodology

The proposed system is composed of three layers: Sensors, Detection Unit, and Machine Learning as shown in Figure 1.

This section contains information regarding the research procedure followed to produce this project. The first step in creating a machine learning model is pre-processing the raw data (adjusting the dataset and handling outliers).

The Internet of Things is about improving people's lives (IoT). The world is changing due to the Internet of Things (IoT), as things grow more intelligent and connected. Its widespread usage has enabled a better and more intelligent society in everything from hospitals to shops to banks, offices, and even homes. The primary use of IoT is tracking baked goods in restaurants and bakeries. Sensors are installed to alert blind people of potential threats. The microcontroller directs how the many components of the device work together and acts as their central hub. As a result, a 5V power supply is necessary for each system component. The Arduino synthesizer is utilized to give the user audio input.

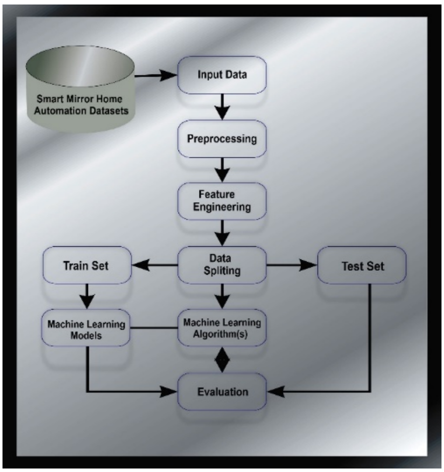


Fig. 1. Proposed framework for implementation of home automation using smart mirror

A. Dataset

The IoT device supplied this data. Both a large number of (independent) variables and a single (dependent) measure are present (Outcome) as shown in Figure 2.

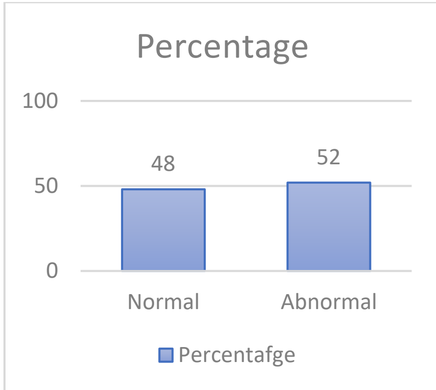


Fig. 2. Results and count are related.

B. Data Pre-processing

Pre-processing is essential in data mining because it may alter or eliminate data before it is used. In machine learning, data pre-processing is the procedure of organizing and cleaning raw data so that it may be used to build and train machine learning models. The input data must undergo careful pre-processing to produce a high-quality dataset. Four pre-processing phases simplify the process, including data cleansing, integration, and reduction. Data must be pre-processed before feeding it into a machine learning algorithm to ensure that model can learn from the data [17].

C. Engineering Features

Both statistical modeling and machine learning use feature engineering as a first step before entering data into a prediction model. It cannot be emphasized how vital feature engineering is to machine learning and data science in general. The main objective of feature engineering is to maximize algorithmic performance. Machine learning feature engineering involves more than just selecting and manipulating features. By ensuring that the dataset is consistent with the algorithm, feature engineering can enhance the performance of machine learning models [18].

D. Feature Scaling

A strategy for normalizing features is feature scaling (Normalization). Here, the data are normalized via "data preparation," often called "data normalization." K-NN and SVM are particularly sensitive to feature changes because they rely on distances or similarities (e.g., in the form of scalar products) between data samples, which makes them dependent on feature scaling. When attempting to solve a challenging set of equations, such as least squares, rounding mistakes can significantly affect the results. It would help if you still rescaled/standardized your data before using techniques invariant to feature scaling (like Fisher LDA or Naive Bayes), such as Decision Trees and Tree-based Ensemble Methods (RF, XGB). On the other hand, XGBoost also uses a linear boosting approach. Therefore, growing the company will be beneficial [19].

IV.Hardware Implementation

A cheap and energy-efficient solution have been developed. The first module manages data collecting, followed by a second module that manages the user interface and data processing.

A. IoT-Based Prototype

IoT devices using Raspberry Pi, Wifi Sensors, Proximity Sensors, Ultrasonic Sensors for Abnormal Movements, and Environmental Sensors for Healthy Environment Detection have been demonstrated in this study. The IoT-based mirror model for home automation is depicted in the Figure 3 below

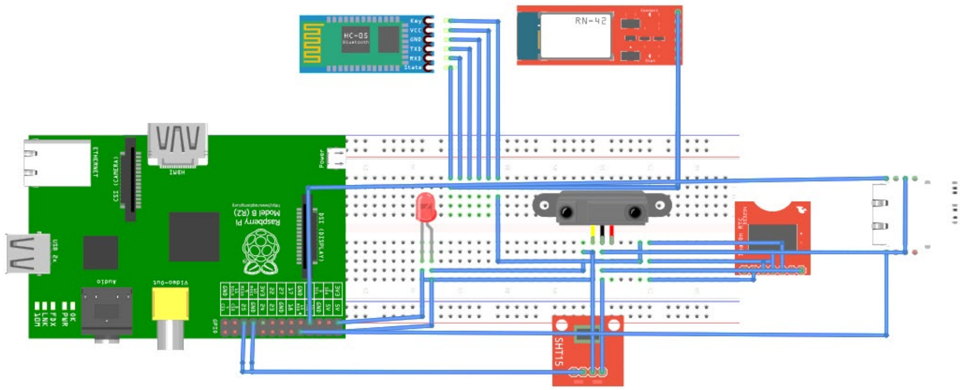


Fig. 3. IoT based prototype

B. Details of Components

1. Proximity Sensor

Because they do not physically contact an object, proximity sensors (shown in Figure 4) do not harm or abrasively detect it. For instance, limit switches detect items by direct physical touch, whereas proximity sensors detect the presence of an object electronically [20].

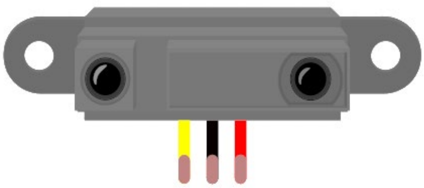


Fig. 4. Proximity sensor

2. Raspberry Pi

The Raspberry Pi (shown in Figure 5) is a low-cost, credit card-sized computer plugged into a monitor or TV and can be used with a standard keyboard and mouse (RPi). On this capable tiny gadget, which is perfect for children and people of all ages, one can learn how to write in Scratch or Python. The Arduino works at 16 MHz, but the Raspberry Pi operates at 1.2 GHz. While Python may be used to program the Raspberry Pi, Arduino is more appropriate for managing motors and LEDs. However, this does not rule out using sensors and LEDs on a Raspberry Pi [21].

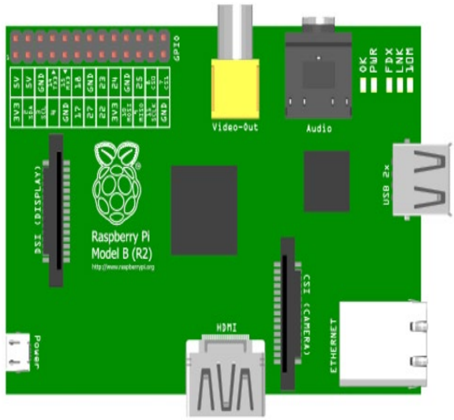


Fig. 5. Raspberry Pi microcontroller

1. Humidity Sensor Specs

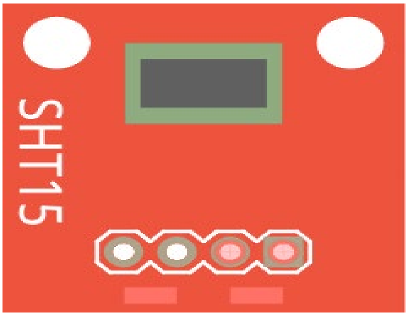


Fig. 6. Humidity sensor SHT 11x series

The SHT11 (shown in Figure 6) is a standard version of the relative humidity and temperature sensor IC in a surface-mountable LCC package. This sensor has a tiny footprint, yet it includes all the sensor parts and signal processing needed to generate a calibrated digital output [22]. The DHT-22 is a temperature, relative humidity, and digital output sensor (also known as AM2302). The capacitive humidity sensor and a thermistor, which gauges ambient air temperature, transmit data through the data pin. Pin information is as follows:

- 3-5V
  - 2.5mA is the maximum current.
  - Temperatures between 40 and 80°C, with a 0.5°C precision. c) Humidity ranges from 0% to 100%, with a precision of two to five percent.
  - The DHT22 sensor board has four pins (VCC, DATA, NC, and GND) that are utilized to connect to the sensor.
- The GND and DATA pins on the Arduino board are wired to Vcc and GND, respectively.
- A 10k ohm resistor is needed between the Vcc and DATA pins (pull-up resistor).

3. Ultrasonic Sensor

When an ultrasonic burst strikes an object, the echo is detected. The obstacles are pinged by ultrasound. The Arduino board emits a brief pulse to initiate the detection process and then uses the pulse in () approach to watch for a subsequent pulse on the same pin. Ultrasonic sensors (shown in Figure 7) generate waves at high frequencies for the human ear to hear. The sensor's transducer may receive and send ultrasonic sound waves by acting as a microphone and transducer. Our ultrasonic sensors, like many others, transmit a pulse and receive the echo with a single transducer [23].

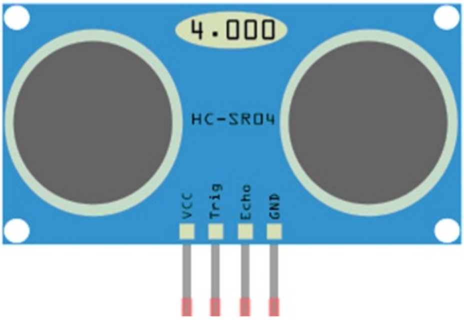


Fig.7. Ultrasonic sensor

4. *Bluetooth*

With the help of the HC-05 Bluetooth Module (shown in Figure 8), a Bluetooth SPP (Serial Port Protocol) module, setting up a wireless serial connection is made simple. It uses serial transmission for communication, which makes connecting to a controller or a personal computer straightforward. It works between 2.45GHz and 2.47GHz. The data transfer rate may cover 1Mbps to 10 meters. The working voltage for the HC-05 module is between 4-6V. The baud rate, for instance, can be changed to any value between 9600 and 19200 [24].

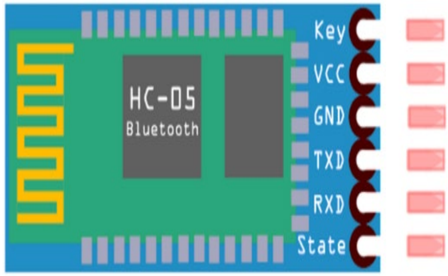


Fig. 8. HC-05 Bluetooth

V. Experiments and Results

A new methodology has been created due to the Internet of Things (IoT). A smart mirror for home automation has been suggested as one such idea. A piece of theft-detection electronic equipment may be used by those alone at home. The hardware is shown schematically in the following in Figure 9..

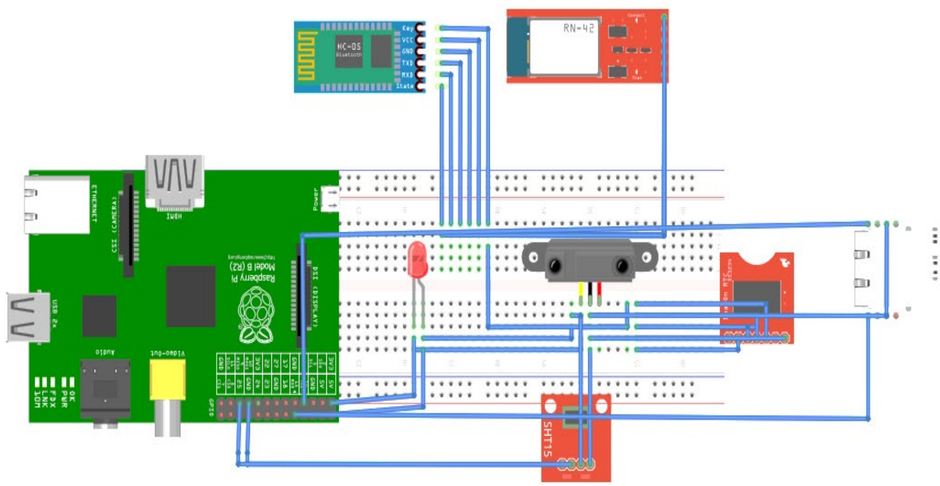


Fig. 9. Produced product for visually impaired persons

An SD card, an Arduino microcontroller, and ultrasonic sensors are used to construct the system. The Arduino uses the signals to make decisions about signal delivery and management. These sensors produce high-frequency sound waves and examine the echoes that are reflected. The distance between a signal's source and destination can be determined by timing the signal's transmission and reception. Both centimeters and inches may be measured with a high-frequency ultrasonic sensor

A. Models for Machine Learning

$$Accuracy = \frac{TP}{TP + TN} \quad (1)$$

$$Precision = \frac{TP}{TP + FP} \quad (2)$$

$$Recall = \frac{TP}{TP + FN} \quad (3)$$

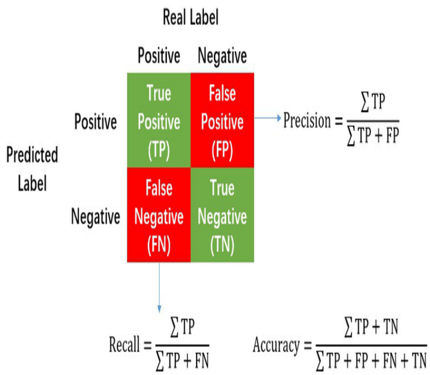
$$F1\ Score = \frac{Recall}{PRecision} \quad (4)$$

For ML purposes, IoT data collection is transformed into CSV files. The machine learning model's main objective was to validate the accuracy tests based on sensor data. The following observations were discovered in datasets:

B. Model Assessment Parameters

Metrics including Accuracy, Precision, Recall, and F1 Score have been used to evaluate how well the various approaches work. As the confusion matrix demonstrates, it has been correctly and incorrectly categorized. The table below displays the metrics used in this investigation:

1. Confusion Matrix



C. Logistic Regression

Two accuracy estimates were obtained: one from the training data and the other from the test data. If the training set accuracy is much higher than the test set accuracy, comparing the two may show overfitting. The correctness of the test set is particularly crucial when assessing the performance of anonymous data since it is unbiased. The obtain ROC curve and confusion matrix shown in Figures 10, 11 respectively.

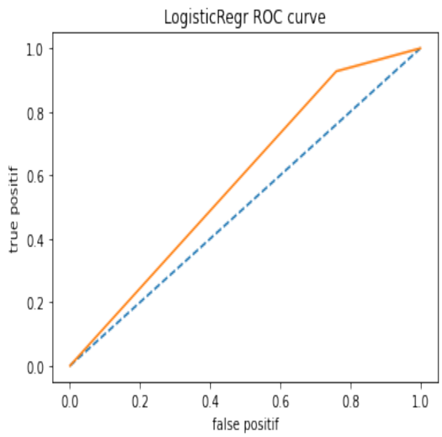


Fig. 10. LR default ROC

Classification report can be obtained as a text or a dictionary by using the classification report.

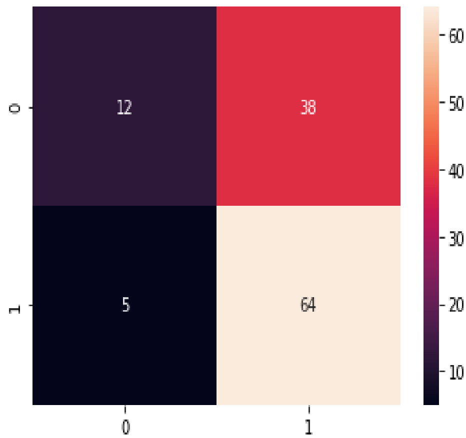


Fig. 11. Confusion matrix with default parameters

D. K-Nearest Neighbours

Primary goals in this part are to comprehend the KNN algorithm and its parameters. Understanding how KNN hyper parameters tweaking influences the model's accuracy, using a variety of techniques to increase it, and choosing the appropriate model to utilize to get the best outcomes

The K-nearest neighbors (KNN) method, a supervised machine learning algorithm, may be used to forecast difficulties with classification and regression. However, it is primarily used in the industry for categorizing and predicting issues. These two traits serve as a decent summary of KNN. KNN is a lax technique for machine learning since it uses all available data in the classification process without a specialized training phase. KNN is a non-parametric learning method since it does not make assumptions about the underlying data.

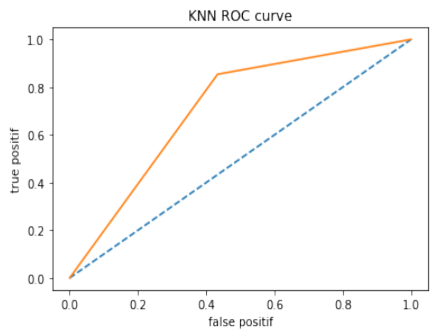


Fig. 12. KNN ROC default

Prior to adjusting the KNN algorithm's parameters (K's value, metrics), it makes sense to adjust the ideal random state. We will continue using the approach we have so far since it returns the "ideal state," which increases accuracy while raising the F1 score. Instead of specifying KNN hyperparameter tweaking at this point, the model will be evaluated to see how KNN hyperparameters impact it.

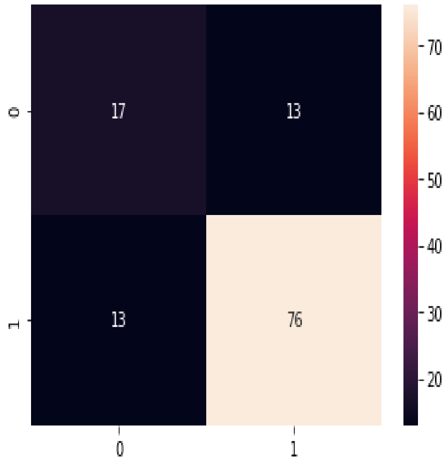


Fig. 13. Confusion matrix of KNN default

It can be seen that 71027464, which has a 78 percent accuracy, is the best random state. To test this model and evaluate the impact of the KNN parameters, a roc curve, a confusion matrix, and an f1 score is employed. With this model, 78% accuracy level was obtained. The f1 rating is 70%, and the wishes are correct.

E. Support Vector Machine

Any classifier will be assessed using the ROC curve, f1, accuracy, training duration, ROC score, and confusion matrix. It is being started by talking about the variables that will be adjusting C. How much it is desired to prevent misclassifying each training sample is specified by the C parameter, which is used in SVM optimization. If $h = 0 + 1.x1$, $h = 0 + 1.x1$ is the hypothesis without polynomial features, then $h = 0 + 1.x1 + 2.x21$, $h = h0 + 1.x12$ is the new hypothesis with polynomial features and d = 2.

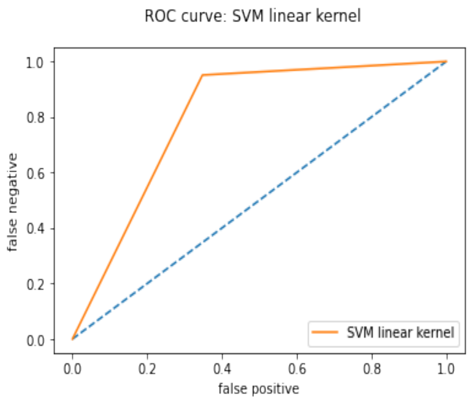


Fig. 14. SVM linear ROC curve

The data will be divided at random, and the split that performs the best will be chosen. Whether or whether it is tweaked, this is entirely up to us. A range of SVM parameters will be tested to achieve the best results and choose the ones that will incur the lowest cross-validation costs. Using this function, outcome of three kernels is visualized that were trained. All the hyperparameters have already been iterated and determined their optimum values; therefore, it will not be done so again. However, suppose it is desired to fine-tune any of the hyperparameters. In that case, it can be done so by setting the max iteration to 2000, for instance, and commenting on the line where it determined the optimum split random state value.

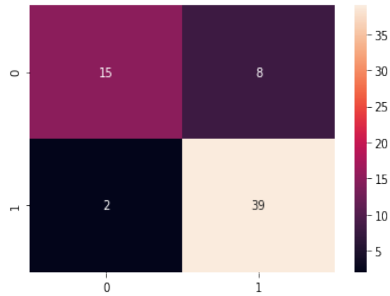


Fig. 15. Confusion matrix of SVM with linear kernel

These circumstance fits with an accuracy of 84%, and the confusion matrix demonstrates that the linear kernel SVM classifier correctly classifies your data.

VI. Comparatively Analysis

As observed in the graphic, the support vector machine classifier has a high accuracy of 84% and a confusion matrix that is often diagonal, indicating that it can accurately classify data. For instance, our F1 score of 0.82 implies that there are a few false positives and false negatives, which is a favorable development.

VII. Conclusions

The development of internet-enabled gadgets has increased the demand for internet access. This makes an IoT platform more critical.

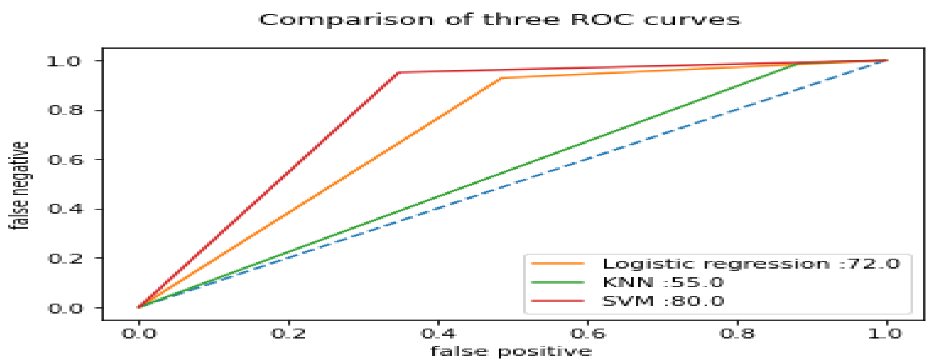


Fig. 16. Algorithmic comparisons

According to this research, this IoT-based smart Mirror combines interactive information services and makes them available via an integrated user interface. The framework provides customizable meteorological data, time and date, and news feeds. In addition, it will turn lights on and off, pause throughout daily activities, cast mobile apps to a mirror screen, and monitor lost phones. Foldable

Demand-based Smart Mirror uses IoT technologies (Internet of Things). The Mirror may also display reminders, voice-activated notifications, daily tasks, weather updates, breaking news, and other smartphone-sent information. Smart Mirror and Raspberry Pi network are connected over Wi-Fi. Raspberry-Pi mainboards paired with two-way mirrors or acrylic mirror sheets disguise the Mirror's rear end. This accomplishes the goal. Modules can be written in any language that supports C programming. When Python is the primary programming language, software and hardware restrictions must be accounted for. This article describes how the Mirror was conceptualized and built.

This approach is cheaper and more predictable than DIY. Smart mirrors can increase people's capacity to interact with and obtain information. This strategy benefits all ages, including individuals with disabilities, elders, and toddlers. Anyone can utilize this approach, even if they are going about their everyday business. They can live independently and comfortably as a result. Future goals include user authentication using a camera module attached to a smart mirror and hand gesture control of the mirror.

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