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FINGERPRINT IMAGE IDENTIFICATIONS FOR CRIME DETECTION

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Abstract:

Fingerprint image identification plays a critical role in crime detection and forensic investigations. By analyzing the unique patterns present on the friction ridge skin of an individual's fingertips, fingerprints serve as a reliable biometric identifier. This paper provides an overview of the process involved in fingerprint image identification for crime detection. The collection of fingerprint images can be done using various methods, including ink and paper, live scanning devices, or optical scanners. In crime scene investigations, latent fingerprints are often lifted from surfaces using techniques such as dusting or chemical development. Once collected, fingerprint images may undergo enhancement techniques to improve clarity and contrast. The next step involves feature extraction, where distinctive characteristics, such as ridge endings and bifurcations, are identified and recorded. These features are used to generate a fingerprint template, a standardized digital representation of the fingerprint. Comparison is then performed between the captured fingerprint image or latent print and a database of stored fingerprints.

Keywords: Fingerprint, Image Detection, Arduino

I. INTRODUCTION:

Fingerprint image identification is a vital component of crime detection and forensic investigations. Fingerprint patterns, unique to each individual, have long been recognized as a reliable biometric identifier. The analysis and comparison of fingerprint images play a crucial role in linking individuals to crime scenes, identifying suspects, and providing evidence for the prosecution of offenders. The uniqueness and permanence of fingerprints make them valuable in forensic science. The ridges and valleys on the friction ridge skin of fingertips create distinct patterns that remain largely unchanged throughout a person's lifetime. This characteristic has made fingerprints an integral part of law enforcement agencies worldwide. Fingerprint image identification involves several key steps, including collection, enhancement, feature extraction, comparison, and expert analysis. Fingerprint images can be obtained through various techniques such as ink and paper, live scanning devices, or optical scanners. Latent prints, invisible to the naked eye, are often lifted from surfaces at crime scenes using specialized techniques. Enhancement techniques are employed to improve the clarity and contrast of fingerprint images, ensuring better visibility of the ridge details. Feature extraction involves identifying and recording distinctive characteristics, such as ridge endings and bifurcations, which are used to create a standardized digital representation known as a fingerprint template. The comparison process matches the captured fingerprint image or latent print against a database of known fingerprints. Automated algorithms calculate the similarity or dissimilarity between the features, providing a similarity score or rank ordering of potential matches. Expert forensic analysts review and validate the results, considering additional contextual information and evidence.

Accurate and reliable fingerprint image identification is crucial for the successful resolution of criminal cases. It aids in individual identification, corroborates evidence, identifies potential suspects, searches criminal history databases, and supports the prosecution of offenders. Furthermore, maintaining comprehensive fingerprint databases helps in prevention and deterrence by linking individuals to previous offenses. The advancement of technology has brought about significant improvements in fingerprint image identification, including automated

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**

algorithms, sophisticated enhancement techniques, and efficient database management systems. These advancements continue to enhance the accuracy, efficiency, and reliability of fingerprint identification, contributing to the field of forensic science and ensuring justice is served. In this context, this paper explores the techniques, challenges, and advancements in fingerprint image identification for crime detection, highlighting the importance of this field in modern forensic investigations. Fingerprint image identification has been a fundamental tool in the field of forensic science for many decades. The unique patterns present on an individual's fingertips have long been recognized as a reliable means of identification. Fingerprint analysis plays a critical role in crime detection, helping investigators link individuals to specific criminal activities and providing valuable evidence for the legal process. The human fingerprint is characterized by intricate ridge patterns, including loops, whorls, and arches. These patterns are formed during fetal development and remain unchanged throughout a person's lifetime, making fingerprints a highly accurate and stable biometric identifier. This uniqueness and permanence have led to the widespread adoption of fingerprint identification as a primary method for individual recognition. The process of fingerprint image identification involves several stages, starting with the collection of fingerprint samples. This can be done through traditional methods using ink and paper, or through modern live scanning devices and optical scanners.

2.LITERATURE REVIEW:

In criminal investigations, latent fingerprints left behind at crime scenes are often recovered and processed using specialized techniques such as dusting or chemical development. Once collected, fingerprint images may undergo enhancement procedures to improve their quality and increase the visibility of ridge details. Enhancement techniques can include contrast adjustment, noise reduction, and ridge orientation estimation, all aimed at producing clear and legible fingerprint images for analysis. The next step is feature extraction, where unique characteristics of the fingerprint, known as minutiae, are identified and recorded. These minutiae include ridge endings, bifurcations, and other ridge characteristics that form the basis of fingerprint comparison and matching. Comparison is performed by matching the extracted minutiae from the captured fingerprint image or latent print against a database of known fingerprints. Automated algorithms employ various matching algorithms and similarity scoring methods to determine the degree of similarity between the fingerprints and rank potential matches. While automated algorithms play a significant role in fingerprint identification, human expertise is indispensable. Forensic experts with specialized training and experience analyze the results, validate the matches, and provide expert opinions and testimony in legal proceedings. The combination of automated algorithms and expert analysis ensures accurate and reliable identification outcomes. Fingerprint image identification has revolutionized the field of forensic science, enabling law enforcement agencies to solve countless crimes and bring offenders to justice. The advent of computerized fingerprint databases has facilitated rapid and efficient searches, significantly enhancing the speed and effectiveness of investigations. However, challenges remain in the field of fingerprint image identification. The analysis of latent prints can be particularly complex due to the often partial, distorted, or degraded nature of the prints. Developing robust techniques for latent print enhancement and matching is an ongoing area of research. Privacy and data security are also critical concerns in fingerprint identification systems. Safeguarding the integrity of fingerprint databases, ensuring secure access, and protecting individuals' privacy rights are essential considerations that must be addressed. In conclusion, fingerprint image identification is a powerful tool in crime detection and forensic investigations. Its unique and stable nature, coupled with advancements in technology and automated algorithms, have greatly enhanced the accuracy and efficiency of fingerprint identification systems. With continued research and development, fingerprint image identification will remain a cornerstone of forensic science, aiding in the pursuit of justice and the maintenance of law and order.

3.BLOCK DIAGRAM:

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**

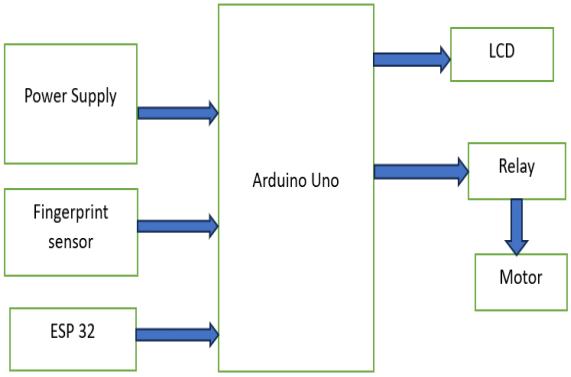
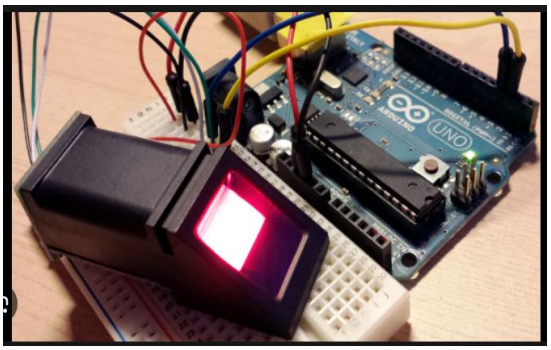


Fig1. block diagram for fingerprints images.

Existing systems: Fingerprints in the crime scene plays an important role to identify the criminal involved in the crime. Crime scene images (CSI) are images taken from the crime spot. When crime is occurred, the investigator takes both latent and patent sample of fingerprints left behind. The patent fingerprints are visible by naked eye, so they are simply photographed. But latent fingerprints are invisible and these samples are more difficult to perceptible. These samples can be lifted through different techniques. The use of cyanoacrylate vapours which sticks to prints and make them visible in the present of normal light. This method is much difficult, so normally incrime scene, the investigators apply a fine dusting powder (aluminium dust or black granular) to the surface in which fingerprints to be extracted. The dust actually sticks to the fingerprint then they use clear tape to lift the fingerprint. After the lifting the fingerprints, the prints are scanned and saved in the digital image form. The fingerprints taken from the crime scene is unintentionally made and these images are noisy or partial prints and difficult to identify.



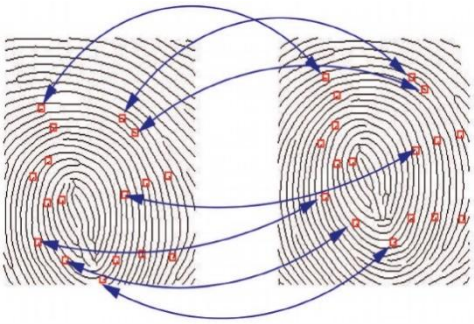


Fig2. Minutiae matching

Proposed System: The CNN uses successive convolutional layers with a non-linear ReLu function for storing the features of an image having a specific dimension.

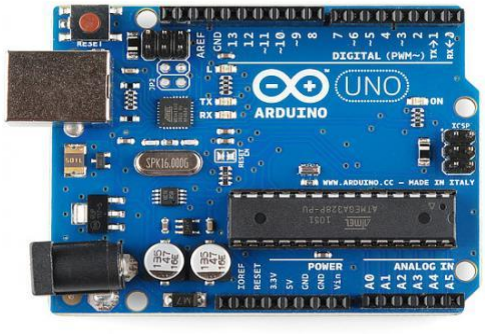
Maxpooling layers are used for down sampling. The fully connected layer multiplies the input by a matrix with sigmoid activation function and adds to a bias vector which contains the feature map. The images obtained from the crime scene are called crime scene images (CSI). These images play important role and used as evidence in criminal cases. The fingerprint information contained in the images collected directly from the crime scene may be partial or tough to identify. This can lead to fingerprint images of bad or low quality. Due to the low quality of fingerprint image to another systematic image feature, the early fingerprint image quality may be of exterior value of identification. To moderate this problem, the fingerprint allows to perform image pre-processing, to feature mark up and identification

ISSN PRINT 2319 1775 Online 2320 7876
Research paper Volume 12, Iss 4, 2023

analysis. Segmentation is a first step in image enhancement which converting low-level image processing transforming a gray scale image into high-level image description in terms of features, objects and scenes. It partitions an image into distinct region containing each pixel with similar characteristics. Fingerprint skeletonization is used to reduce ridges until one pixel wide. The fingerprint features like minutiae are extracted from the skeleton images. The ROI is extracted using open and close operation by discarding the image areas without effective ridges and terminates. The remaining effective area is divided into two areas, to determine bound the white area used and to represents the inner area the gray area used.

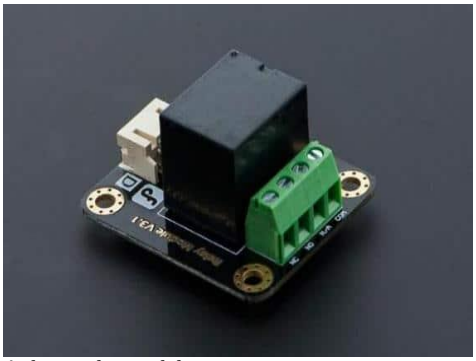
3.1 COMPONENTS:

- Arduino:The Arduino is a family of microcontroller boards to simplify electronic design, prototyping and experimenting for artists, hackers, hobbyists, but also many professionals. People use it as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standard Arduino Uno) are built around an ATmega microcontroller — essentially a complete computer with CPU, RAM, Flash memory, and input/output.



- Arduino Software:Launch the Arduino application
  - If you disconnected your board, plug it back in
  - Open the Blink example sketch by going to: File > Examples > 1.Basics > Blink
  - Select the type of Arduino board you're using: Tools > Board > your board type
  - Select the serial/COM port that your Arduino is attached to: Tools > Port > COMxx
  - If you're not sure which serial device is your Arduino, take a look at the available ports, then unplug your Arduino and look again. The one that disappeared is your Arduino.
  - With your Arduino board connected, and the Blink sketch open, press the 'Upload' button
  - After a second, you should see some LEDs flashing on your Arduino, followed by the message 'Done Uploading' in the status bar of the Blink sketch.
  - If everything worked, the onboard LED on your Arduino should now be blinking! You just programmed your first Arduino!
- Relay:Relay modules are simply circuit boards that house one or more relays. They come in a variety of shapes and sizes, but are most commonly rectangular with 2, 4, or 8 relays mounted on them, sometimes even up to a16relays.

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**



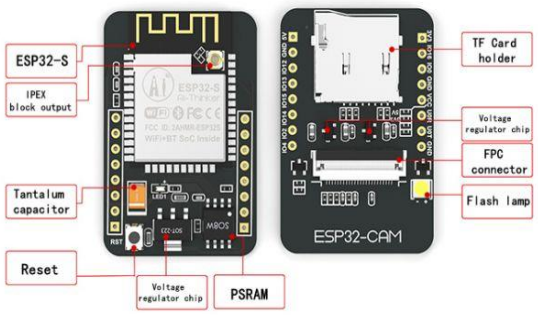
Arduino relay module

Hobbyists often use a relay module with Arduino in their projects. An Arduino is a micro contoller board that is widely popular in DIY electronics projects. The relay module, when paired with an Arduino, can control various apply.

- Motor: A DC motor (Direct Current motor) is the most common type of motor. DC motors normally have just two leads, one positive and one negative. If you connect these two leads directly to a battery, the motor will rotate. If you switch the leads, the motor will rotate in the opposite direction.

Dc motor

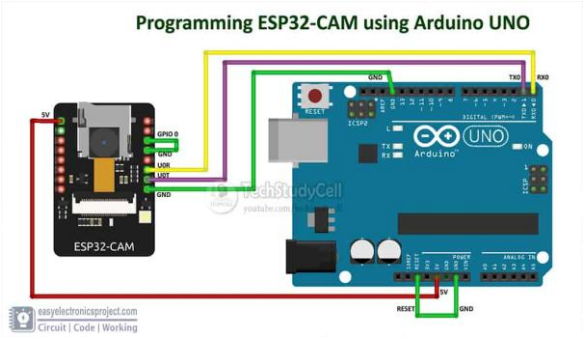
- ESP32:



It is a figure that what is there in ESP32

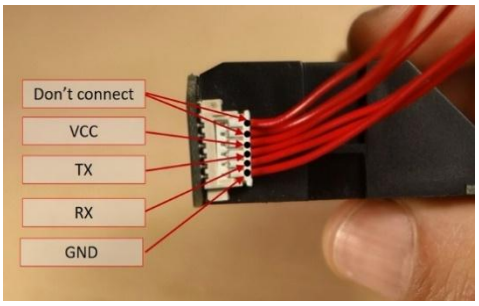
Also connection with the Arduino as shown in below figure,

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**



- Fingerprint: fingerprint sensor modules,like the one in the following figure, made fingerprint recognition moreaccessible and easy to add to your projects. This means that is super easy to make fingerprint collection, registration, comparison and search.

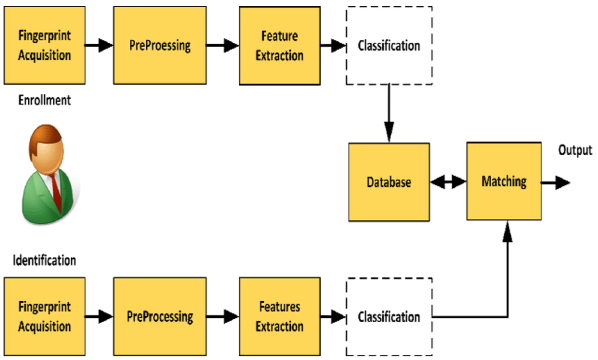
These modules come with FLASH memory to store the fingerprints and work with any microcontroller or system with TTL serial. These modules can be added to security systems, door locks, time attendance systems, and much more.



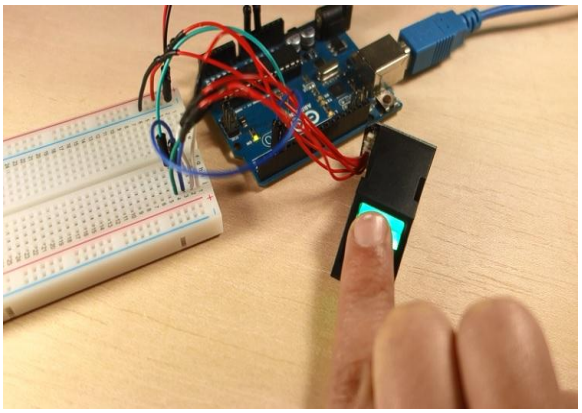
- This sensor has six pins to connect to
  - Bred board and Arduino.
- The fingerprint sensor module used in this project came with really thin wires, so soldering breadboard-friendly wires was needed. We recommend using different colors according to the pin function. In our case:
- DNC – white wires
- VCC – red wire
- TX – blue wire
- RX – green wire
- GND – black wire

4.DESIGN FLOW:

ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**



- Turn on the power supply.
- There are two categories enrollment and identification.
- The first thing we had to do is fingerprint acquisition, to collect all the fingerprint data.
- Next thing is to do preprocessing.
- In the next step is feature extraction.
- Then we have to classify the fingerprints like details etc.
- After above step go for the matching of the fingerprints of suspect and innocent.
- Then we are getting the output of fingerprint who had committed crime.
-



5.RESULT:

- Fingerprint images in crime scene are important clues to solve serial cases. In this paper we present a complete crime scene fingerprint identification system using deep machine learning with Convolutional Neural Network (CNN). Images are acquired from crime scene using methods ranging from precision photography to complex physical and chemical processing techniques and saved as the database. The images collected from the crime scene are usually incomplete and hence difficult to categorize. Suitable enhancement methods are required for pre-processing the fingerprint images. Minutiae are extracted from the fingerprint images. The features of preprocessed data are fed into the CNN as input to train and test the network.

6.CONCLUSION:

- Fingerprint image identification is a critical component of crime detection and forensic investigations. The uniqueness and permanence of fingerprint patterns make them a reliable biometric identifier for individual recognition. The existing system of fingerprint image identification has significantly contributed to solving crimes and bringing offenders to justice. The proposed system builds upon the existing system by incorporating advancements in technology, methodologies, and data management. Through advanced fingerprint collection

ISSN PRINT 2319 1775 Online 2320 7876
 Volume 12, Iss 4, 2023

techniques, enhanced latent print analysis, robust feature extraction algorithms, and intelligent matching algorithms, the proposed system aims to improve the accuracy, efficiency, and reliability of fingerprint identification.

- Processes, Additionally, the

proposed system addresses challenges such as large-scale database management, integration with other biometric technologies, and enhanced data security and privacy measures. By continuously researching and developing new techniques and technologies, the proposed system aims to stay at the forefront of advancements in the field of fingerprint image identification. Overall, fingerprint image identification plays a crucial role in establishing the identity of individuals, corroborating evidence, identifying suspects, searching criminal history databases, and supporting the prosecution of offenders. The existing and proposed systems contribute to the field of forensic science, ensuring the fair administration of justice and the maintenance of law and order. As technology continues to advance, it is essential to continually improve fingerprint image identification systems, address challenges, and adapt to evolving needs. By doing so, law enforcement agencies can leverage the power of fingerprint analysis to enhance crime detection capabilities, solve complex cases, and ensure the safety and security of society.

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ISSN PRINT 2319 1775 Online 2320 7876
Research paper **Volume 12, Iss 4, 2023**

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