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SCIFI-A Project Proposal

Soft Computing for Identificati Back-propagation Neural Network, Fingerprint, Fingerprint Matching, Fuzzy Logic, Minutia, Neural Network.on of Fingerprint Image

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Abstract— To uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits is called as Biometrics. Biometrics is one of the biggest tendencies in human identification. The fingerprint is the most widely used biometric. However considering the automatic fingerprint recognition a completely solved problem is a common mistake. The most popular and extensively used method is the minutiae-based method (minutia are specific points in a finger image. It is the unique, measurable physical characteristics scanned as input and stored for matching by biometric systems. For fingerprints, minutiae include the starting and ending points of ridges, bifurcations and ridge junctions among other features). There are many different algorithms being used to get this accomplished. Here we have discussed soft computing tools namely fuzzy logic and neural network and how they can be used in fingerprint recognition.

Index Terms— Back-propagation Neural Network, Fingerprint, Fingerprint Matching, Fuzzy Logic, Minutia, Neural Network.

1 Introduction

IDENTITY is to establish the identity of a person, or to ascertain the origin, nature, or definitive characteristics of a particular person. To uniquely identify a person, the recent trend is to use biometric. Fingerprints are the graphical flow-like ridges present on human fingers. Finger ridge configurations do not change throughout the life of an individual except due to accidents such as bruises and cuts on the fingertips. This property makes fingerprints a very attractive biometric identifier. Fingerprint-based personal identification has been used for a very long time. Owning to their distinctiveness and stability, fingerprints are the most widely used biometric features. Nowadays, most automatic fingerprint identification systems (AFIS) are based on matching minutiae, which are local ridge characteristics in the fingerprint pattern.

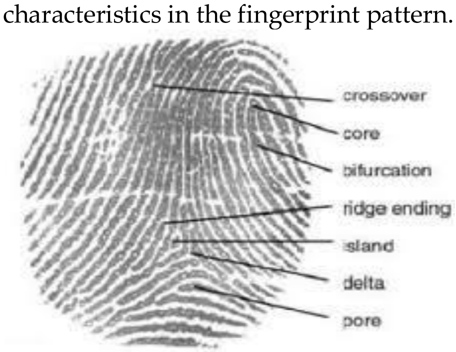

Figure 1: Finger Image

However, a potential ways to improve the algorithms especially on pre-processing steps are still needed to be studied. There have been many algorithms developed for extraction and matching of minutia. Most algorithms found in the literature are somewhat difficult to implement and use a rather heuristic approach.

By introducing soft computing tools we can add intelligence to the recognition system, so that the system can tell the likelihood of the particular image to be on a particular database and other intelligent features can also be introduced.

Figure 2: Different fingerprint patterns

2 Soft Computing

Conventional computing or often called as hard computing, requires a precisely stated analytical model and often a lot of computation time. Many analytical models are valid for ideal cases, and real world problems exist in a non-ideal environment.

Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind. The guiding principle of soft computing is: Exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness and low solution cost. Soft computing may be viewed as a foundation component for the emerging field of conceptual intelligence. Few soft computing tools are: Fuzzy Systems, Neural Networks, Evolutionary Computation, Machine Learning and Probabilistic Reasoning.

3 Fingerprint

Biometrics consists of methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioural traits. Currently Biometrics is one of the biggest tendencies in human identification.

Fingerprints, due to its inimitability, distinctiveness and stability are the most widely used biometrics in recent days.

Fingerprints are the graphical flow-like ridges present on human fingers. Finger ridge configurations do not change throughout the life of an individual except due to accidents such as bruises and cuts on the fingertips. This property makes fingerprints a very attractive biometric identifier. Fingerprint-based personal identification has been used for a very long time.

Most of the automatic fingerprint identification/verification systems adopt the model used by the Federal Bureau of Investigation. The model relies on representing only the two most prominent structures: ridge ending and ridge bifurcation, which are collectively called minutiae.

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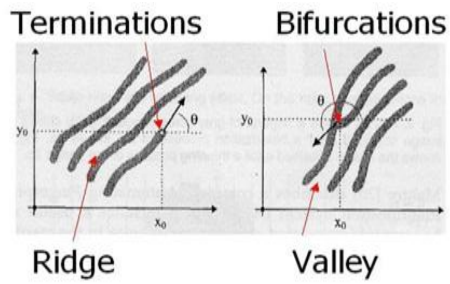


Figure 3: Fingerprints and Minutia

4 Automatic Fingerprint Identification

Identification system recognizes an individual by searching the entire template database for a match. It conducts one-to-many comparisons to establish the identity of the individual. In an identification system, the system establishes a subject's identity (or fails if the subject is not enrolled in the system database) without the subject having to claim an identity.

Large volumes of fingerprints are collected and stored everyday in a wide range of applications including forensics, access control, and driver license registration.

An automatic recognition of people based on fingerprints requires that the input fingerprint be matched with a large number of fingerprints in a database.

Fingerprint matching techniques can be placed into two categories: minutiae-based and correlation based. Minutiae-based techniques first find minutiae points and then map their relative placement on the finger. (However, there are some difficulties when using this approach. It is difficult to extract the minutiae points accurately when the fingerprint is of low quality.)

5 Soft Computing Approach towards Fingerprint Identification

Automatic fingerprint identification system (AFIS) can be further made more accurate using soft computing tools. The most used fingerprint recognition system in current days depends on minutia extraction. Different soft computing tools can be used in different phases of fingerprint feature extraction, classification and matching.

Noise is a big issue in fingerprint extraction and matching. Wavelets can be used in removing noise from the fingerprint image. In the minutia extraction phase only extracting minutia does not help to get enough information about the minutia, so aligning minutia becomes a necessary step. Fuzzy techniques can be used in minutia alignment. For the hierarchical classification of fingerprints neural network can be used. We can set four classes for hierarchical classification i.e. arch, left loop, right loop and whorl [8].

Figure 4: AFIS Pattern Types:(A) Arch; (B) Left Loop; (C) Right Loop; (D) Whorl

In our project proposal, we proposed to use back propagation neural network for fingerprint identification with fuzzy techniques incorporated after hierarchical classification and minutia detection.

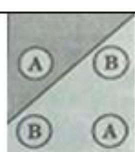
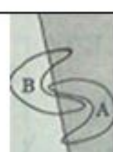
6 Neural Network

The term neural network was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are composed of artificial neurons or nodes. Artificial neural networks are composed of interconnecting artificial neurons (programming constructs that mimic the properties of biological neurons).

Artificial neural networks may either be used to gain an understanding of biological neural networks, or for solving artificial intelligence problems without necessarily creating a model of a real biological system.

The real, biological nervous system is highly complex and includes some features that may seem superfluous based on an understanding of artificial networks.

Real life applications and the tasks to which artificial neural networks include classification, including pattern and sequence recognition; novelty detection and sequential decision making. Figure 5 shows geometrical interpretation of pattern classification and decision regions for different perceptron networks.

Structure	Types of decision region	Exclusive OR problem	Classes with method regions	Most general region shapes
Two-layer network 	Half Plane (Bounded by hyperplane)			

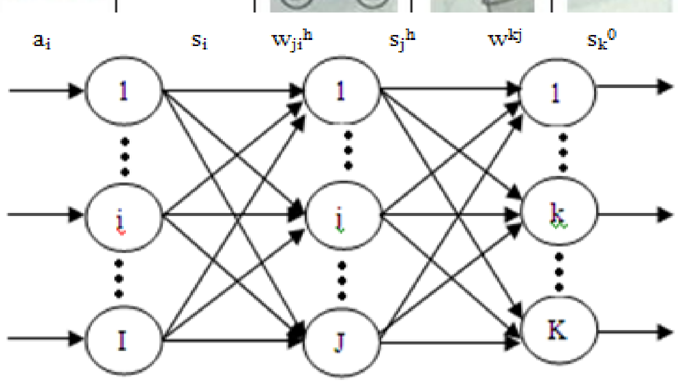


Figure 5: Neural Networks
Figure 6: Simplified view of a 3 layer feed-forward artificial neural network

7 Back-propagation Neural Network

Back-propagation is a common method of teaching artificial neural networks how to perform a given task.

It is a supervised learning method, and is a generalization of the delta rule.

It requires a teacher that knows, or can calculate, the desired output for any input in the training set.

It is most useful for feed-forward networks (networks that have no feedback, or simply, that have no connections that loop).

The term is an abbreviation for "backward propagation of errors".

Back-propagation requires that the activation function used by the artificial neurons (or "nodes") be differentiable.

8 Back-propagation Neural Network Algorithm

- Given a set of input-output patterns (a_l, b_l), $l = 1, 2, \dots L$, where the lth input vector $a_l = (a_{l1}, a_{l2}, \dots, a_{lI})^T$ and the lth output vector $b_l = (b_{l1}, b_{l1}, \dots, b_{lI})^T$.
- Assume only one hidden layer and initial settings of weights to be arbitrary.
- Assume input layer with only linear units.
- Then the output signal is equal to the input activation value for each of these units. Let η be the learning rate parameter.
- Let $a = a(m) = a_l$ and $b = b(m) = b_l$.
- Activation of unit i in the input layer, $x_i = a_i(m)$.
- Activation of unit j in the hidden layer, $x_j^h = \sum_{i=1}^{I} w_{ji}^h x_i$
- Output signal from the jth unit in the hidden layer, $s_j^h = f_j^h(x_j^h)$
- Activation of unit k in the output layer, $x_k^o = \sum_{j=1}^{J} w_{kj} s_j^h$
- Output signal from the kth unit in the output layer, $s_k^o = f_k^o(x_k^o)$
- Error term for the kth output unit, $\delta_k^o = (b_k - s_k^o) f_k^o$
- Updates weights on output layer, $w_{kj}(m+1) = w_{kj}(m) + \eta\, \delta_k^o s_j^h$
- Error term for the jth hidden unit, $\delta_j^h = f_j^h \sum_{k=1}^{K} \delta_k^o w_{kj}$
- Updates weights on the hidden layer, $w_{ji}^h(m+1) = w_{ji}^h(m) + \eta\, \delta_j^h a_j$
- Calculate the error for the lth pattern, $E_l = ½ \sum_{k=1}^{K} (b_{lk} - s_k^o)^2$

$$\sum_{l=1}^{L}$$

- Total error for all patterns, $E = \quad E_l$

  Apply the given patterns one by one, may be several times, in some random order and update the weights until the total error reduces to an acceptable value.

9 Fuzzy Logic

Fuzzy logic is a form of many-valued logic derived from fuzzy set theory to deal with reasoning that is fluid or approximate rather than fixed and exact. In contrast with "crisp logic", where binary sets have two-valued logic, fuzzy logic variables may have a truth value that ranges in degree between 0 and 1. In simple words we can say fuzzy logic is a super set of conventional (boolean) logic that has been extended to handle the concept of partial truth--the truth values between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific functions.
Because fingerprint patterns are fuzzy in nature integrating the fuzzy encoder with back-propagation neural network (BPNN) as a recognizer which has variable fault tolerances for fingerprint recognition can help recognition in huge.

10 Neuro-Fuzzy Network

In the field of artificial intelligence, neuro-fuzzy refers to combinations of artificial neural networks and fuzzy logic. Human brain recognition system for biometric works neuro-fuzzily.
Neuro-fuzzy hybridization results in a hybrid intelligent system that synergizes these two techniques by combining the human-like reasoning style of fuzzy systems with the learning and connectionist structure of neural networks. Neuro-fuzzy hybridization is widely termed as Fuzzy Neural Network (FNN) or Neuro-Fuzzy System (NFS) in the literature.
Both neural networks and fuzzy systems have some things in common. They can be used for solving a problem (e.g. pattern recognition) if there does not exist any mathematical model of the given problem. They solely do have certain disadvantages and advantages which almost completely disappear by combining both concepts.
Neural networks can only come into play if the problem is expressed by a sufficient amount of observed examples. These observations are used to train the black box. On the one hand no prior knowledge about the problem needs to be given. On the other hand, however, it is not straightforward to extract comprehensible rules from the neural network's structure.
On the contrary, a fuzzy system demands linguistic rules instead of learning examples as prior knowledge. Furthermore the input and output variables have to be described linguistically. If the knowledge is incomplete, wrong or contradictory, then the fuzzy system must be tuned. Since there is not any formal approach for it, the tuning is performed in a heuristic way. This is usually very time consuming and error-prone.

11 Characteristics of Neuro-Fuzzy Network

Compared to a common neural network, connection weights and propagation and activation functions of fuzzy neural networks differ a lot.
Although there are many different approaches to model a fuzzy neural network most of them agree on certain characteristics such as the following:

- A neuro-fuzzy system based on an underlying fuzzy system is trained by means of a data-driven learning method derived from neural network theory. This heuristic only takes into account local information to cause local changes in the fundamental fuzzy system.
- It can be represented as a set of fuzzy rules at any time of the learning process, i.e., before, during and after. Thus the system might be initialized with or without prior knowledge in terms of fuzzy rules.
- The learning procedure is constrained to ensure the semantic properties of the underlying fuzzy system.
- A neuro-fuzzy system approximates a n-dimensional unknown function which is partly represented by training examples. Fuzzy rules can thus be interpreted as vague prototypes of the training data.
- A neuro-fuzzy system is represented as special three-layer feedforward neural network as it is shown in Figure 6.
  - The first layer corresponds to the input variables.
  - The second layer symbolizes the fuzzy rules.
  - The third layer represents the output variables.
  - The fuzzy sets are converted as (fuzzy) connection weights.
  - Some approaches also use five layers where the fuzzy sets are encoded in the units of the second and fourth layer, respectively. However, these models can be transformed into a three-layer architecture.

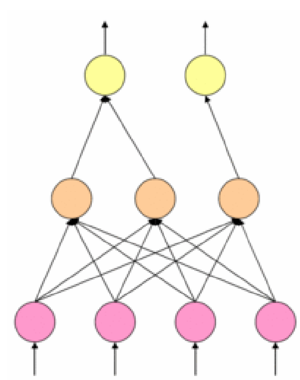


Figure 7: The architecture of a neuro-fuzzy system

12 Proposal

There are many methods in the literature for fingerprint identification using minutia as a feature.

But there is not much work done using soft computing tool such as neural network.

We are proposing a new method of fingerprint identification system where the minutia will be taken as feature to train the neural network system.

As a three layer neural network may not be useful enough to map a fingerprint image perfectly to a certain user, we are planning to implement a four (or even more) layer neural network.

And then finally add fuzzy logic to make the system more flexible.

13 Proposed Algorithm

- Cut effective area of a fingerprint image
- Block-wise divide the image
- Extract minutia of each block
- Calculate the number of minutia for each block and gradient for each minutia
- Use this number and the respective gradient values as a feature to train the back propagation neural network
- Use 40% data (fingerprint image of a same person of same finger) to train the system

Later on incorporate fuzzy logic with this system to decrease error rate.

We are planning to use fuzzy logic in input as well as output layer, and so making the system at least a 5 layer network (input fuzzy layer, input of actual neural network, hidden layer, output layer of neural network, output layer of fuzzy logic)

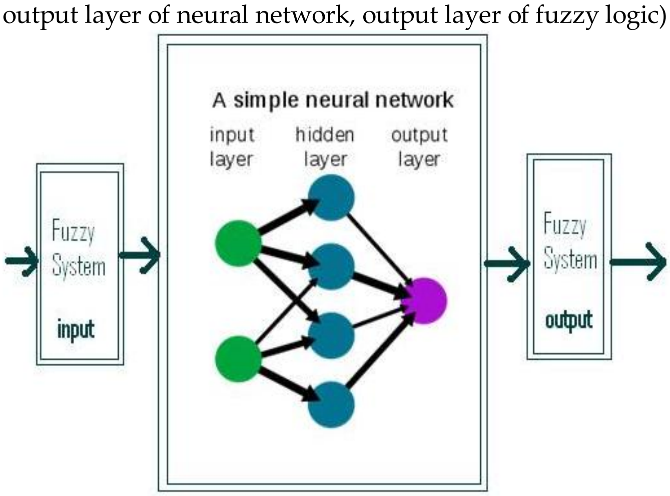


Figure 8: Simplified version of our proposed algorithm

14 Discussion and Conclusion

Most of the fingerprint recognition systems rely on minutiae matching algorithms. Although minutiae based techniques are widely used because of their temporal performances, they do not perform so well on low quality images and in the case of partial fingerprint they might not be used at all. Therefore, when comparing partial input fingerprints to pre-stored templates, a different approach is needed. Soft computing can help to achieve better result for these types of case. Different soft computing tools can be applied in different phases of preprocessing also.

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