RECOGNITION OF SKIN USING FUZZY LOGIC APPROACH

Neural Networks and Fuzzy Systems

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Contents

1. Introduction

Image processing is the most important field of computer science and skin detection is the dominant sub field of image processing which has many applications like cyber-crime pursuit, face detection, gesture recognition, image filtering [1].

As human skin has some specific colors patterns and to detect the exactly those parts of skin from an image is a crucial task, so intelligent fuzzy inferences systems (FIS) are being used to detect the human skin pixels in an image.

Fuzzy logic system is a computational method which is based on degree of truth (Rules) rather than true or false and our aim is to find the highest accuracy rate using this system.

In this report, I have used Mamdani and Sugeno type fuzzy inference systems to provide the best accuracy rate of skin detection. Proposed solution provide the high accuracy as expected.

2. Background

2.1. Data Origin

Data is obtained from UCI machine Learning Dataset and trained on B, G, R values for testing and training purpose. UCI Skin Segmented Dataset uses B, G, R color space and the skin and non-skin data in the dataset is generated from the images of different people with different gender, age and race [2].

Attribute Name	Value
Rows	245057
Columns	7
Source	Real Images' Segments
Missing Values	0

2.2. Fuzzy System's Overview

2.2.1. What is Fuzzy Logic

Fuzzy logic is a logic system of computing which is an addition of multivalued logic. It is based on "degrees of truth" and if-then rules. The fuzzy logic approach resembles the way of reasoning of human brain, and its rule system is provided by calculus of fuzzy rules [3].

2.2.2. Fuzzy Inference System

Fuzzy Inference System introduced by **Ebhasim Mamdani** is the main part of a fuzzy logic system and its primary work is decision making using the "IF-THEN" rules. Fuzzy Inference System has two type of method one is "Mamdani" and other is "Takagi-Sugeno" with different fuzzy rules [4].

Following are the components of FIS:

- Membership Functions
- Fuzzy Logical Operators
- If-Then Rules

2.2.3. Membership Functions

A membership function (MF) is a curve that illustrate how each point in the input space is mapped to a membership value. There are total 11 membership functions in the fuzzy logic toolbox. Every function has its own characteristic, like “trimf”, which is collection of three points forming a triangle [1]. Example figure of MF can be seen below :

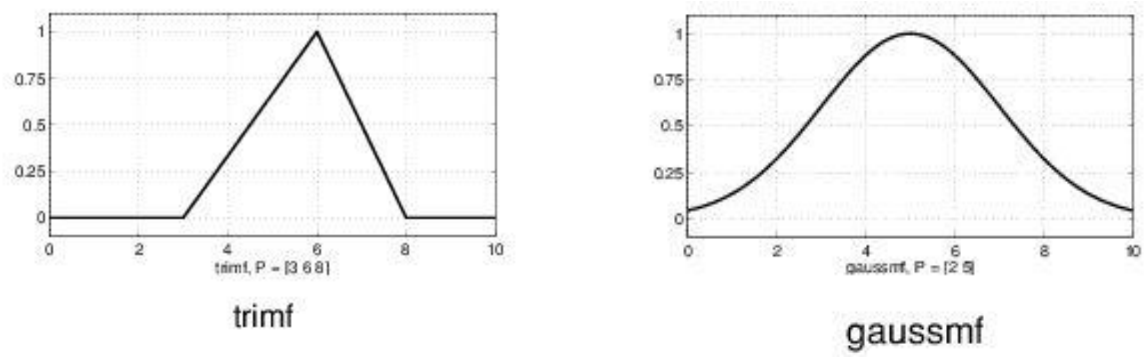

Figure 1member ship functions [5]

2.2.4. Fuzzy Logical Operators

Fuzzy logical operators are the superset of the standard Boolean logic. There are total three fuzzy logical operators available in the fuzzy toolbox [1]. Which are following: First is Min Operation which is the replacement of AND operation in the standard Boolean operators. Second is the Max Operation which is the replacement of OP operator in the standard Boolean operators, and third is the “Not A” Operation.

2.2.5. If-then Rules

If-then rule is also a significant rule of fuzzy inference system. That statement is used to construct the conditional statements that contains fuzzy logic. If-then statement can be expressed as following: If x is A, then y is B Where A and B are the values, which have been defined by the fuzzy sets. In the above example the if-part of the rule "x is A" is called the antecedent, while the consequent is the then-part of the rule "y is B" [5].

2.3. Architecture

The fuzzy inference system has four major parts, which are given below:

1. Fuzzification Interface

Which change the crisp values into its parallel fuzzy value [3].

2. Knowledge Base

That contains fuzzy if-then rules which are provided by specialist [3].

3. Inference Engine

It makes the fuzzy inference on the given inputs and rules by simulating human reasoning process [3].

4. Defuzzification Module

The defuzzification module converts the fuzzy sets got from the inference engine, into crisp values [3]

2.4. Previous Methodologies

By the time, different methods have been adopted to deduce the skin related pixels in the image. In these methods different models had been developed to detect skin which were based on Pixel Base Recognition or Region Based Recognition. Some previous methods are discussed below:

An efficient model for skin segmentation had been developed by Iraji and Yavari [6], they used the color space 'YCbCr' for skin classification along with Mamdani fuzzy inference. They set some rules for all three (Y, Cb, Cr) input's possible values, high and low. Input range was set according to the min and max input value. Their work is very useful for finding skin pixels in an image.

In the same way a dynamic threshold approach has also been adopted for the purpose of skin detection. Fixed threshold values methodology can also be used to detect skin but many times it does not work, because any skin may be classified as non-skin. Then skin related value can be mistakenly classified as non-skin if that skin colors do not belong to fixed threshold value [7]. To address that issue dynamic threshold approach has been adopted, which provide better results.

Similarly, Rajen B.Bhatti proposed a more advanced method of skin region segmentation using low complexity fuzzy decision tree based on BGR colour space [8]. In that solution they used dataset generated by various textures got from face images of various people. That technique is majorly based on the few rules [8].

2.4.1. Mamdani Fuzzy Inference Method

In 1975, Ebrahim Mamdani proposed Fuzzy Inference System to the solution of the problem to control the steam engine by using linguistic rules. Fuzzy Inference System works on the set of rules to map the inputs and outputs [9].

2.4.2. Sugeno Fuzzy Model

This model was proposed by Takagi, Sugeno, and Kang which resulted into a systematic approach to have fuzzy rules generated from the give input-output dataset [10]. The only difference in the Mamdani and Sugeno is that the Sugeno's output membership functions are either linear or constant [10] and Mamdani system is based on pre-fed rules and Sugeno shows the results by using ANFIS function and dataset.

3. Main Part

This part is about adopted methodologies which we use to solve the given problem. The problem has been solved using two fuzzy inference systems, Mamdani Inference System and Sugeno Inference System.

3.1. Dataset Overview

The sample data which has been obtained from the UCI Machine Learning Repository [8], which can on the data which represent skin and non-skin.

3.1.1. Given Data:

- Total Instances = 245057
- Total Attributes in one row = 3
- Skin Samples = 50859
- Non-Skin Samples= 194198
- Column 1-3 = Input Data (In the form of BGR values)
- Column 4 = Output Data

3.2. Data Preprocessing

Data was copied from website and saved as text file then using load command, it is loaded to Matlab.

3.2.1. Dataset randomization

In order to get high accuracy, Matlab built in function “randperm” is used to make the dataset random.

```
data = data (randperm (size (data, 1)), :);
```

3.2.2. Read fuzzy inference system

Reading the pre developed Mamdani inference system using this command

```
fis = readfis('mamdanifuzzylogic.fis');
```

3.2.3. Input output data

In given data first three columns are input data and last column is output data, so they are separated by following commands:

```
dataInput = data(:,1:3); % given input values

dataOutput = data(:,4);  % given output values
```

3.2.4. BGR TO RGB Conversion

The given data was in the BGR colour space format, while it was recommended from instructor to use RGB colour space. Thus for that purpose the colour space has been converted from BGR to RGB.

```
rgbData = fliplr(data(:,1:3));  %BGR to RGB
```

3.3. Proposed Solutions

After the processing of the data, the fuzzy inference systems have been developed in order get the desired accurate results.

3.3.1. Mamdani Fuzzy Inference System

Mamdani Inference System uses the YCBCR color space, so first of all according to research paper RGB colour space has been converted into YCBCR colour space by using below built in function of Matlab.

```
ycbcr=rgb2ycbcr(data(:,1:3));
```

Two membership functions “high” and “low” have been used in Mamdani methodology, similarly, y, cb and cr were used as inputs and “trimf” has been used as membership function, which has triangular shape.

After that according to [6], rules has been designed for the fuzzy inference system which are shown in the below fig.

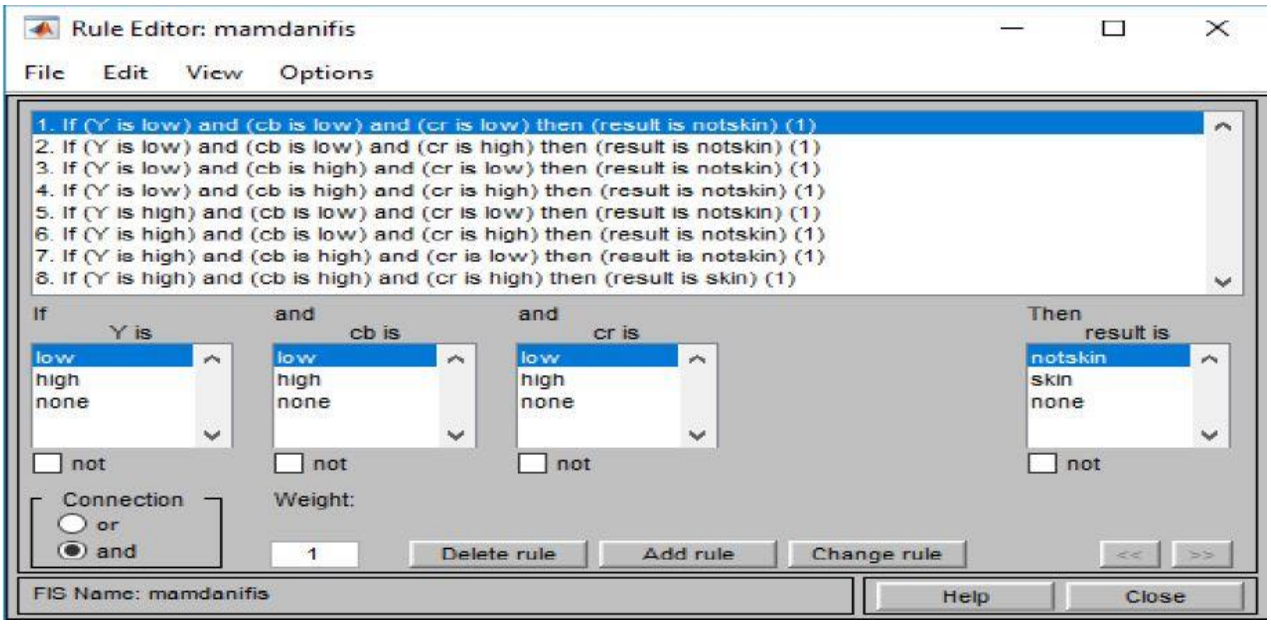

Figure 2 Mamdani Rules model

After that following results have been acquired

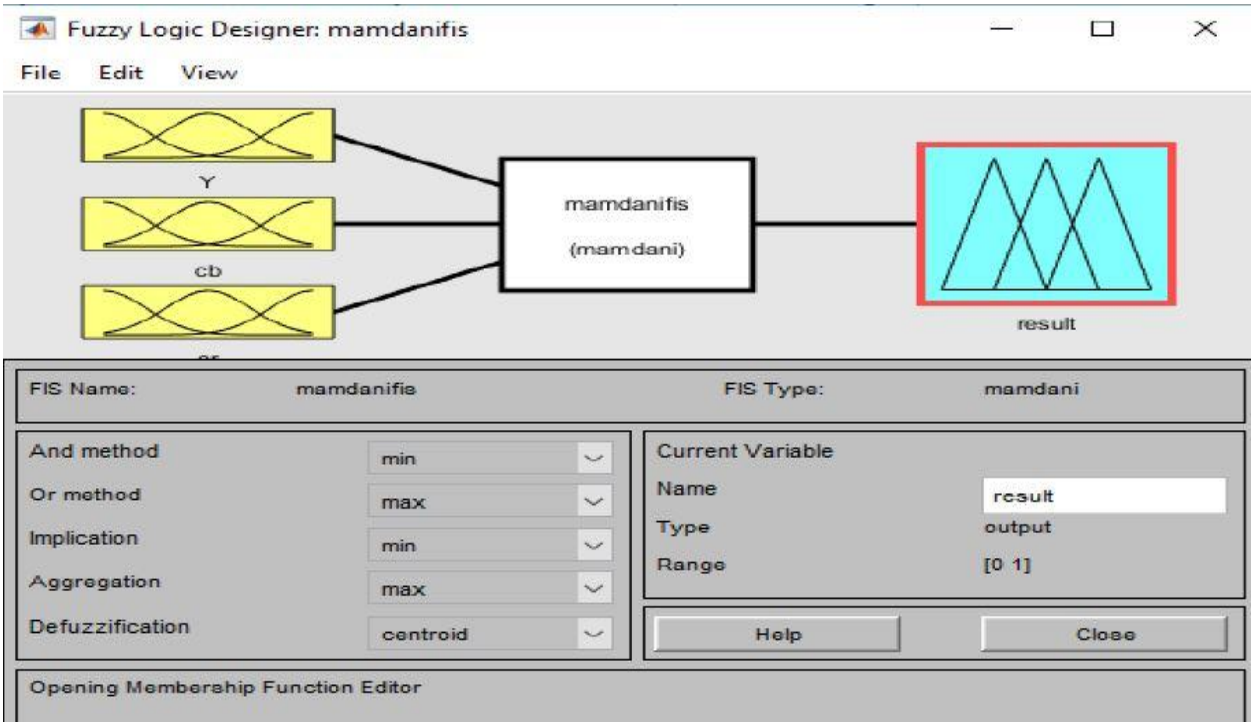

Figure 3 FIS Model of mamdani

3.3.2. Sugeno Fuzzy Inference System:

Sugeno Fuzzy Inference System has also been designed to get high accuracy in skin detection problem. The Sugeno FIS model is also very similar to Mamdani FIS model like, two parts of the fuzzy inference process, fuzzyfying the inputs and applying the fuzzy operator are same. The one main difference between Mamdani and Sugeno FIS model is that in Sugeno FIS model we use linear or constant membership functions.

To implement Sugeno Fuzzy Inference System, eight “if-then” rules have been build, with three inputs. While in the inputs the membership function named as `'gbellmf'`. Range of inputs has been set 0 to 255, while the range for the output has been kept as (0,1). Then system has been trained on the dataset provided in the UCI machine learning repository.

4. Experimental Results and Analysis

After all the pre-processing and system design done, the experiments were conducted on both Mamdani and ANFIS model. The results of the experiments are mentioned below.

4.1. Mamdani Fuzzy Inference System Experiment

Before starting the experiment, the Fuzzy Inference System was created with all the required rules fed in its knowledge base. There were 8 rules used in the knowledge base of this system. Following table shows the experiment's key statistics.

Training Data	Testing Data	Output Threshold	Recognition Rate
N/A	245057	0.5	77.216%
Analysis			
By using the 8 rules of YCBCR input values with membership functions, obtained recognition rate is good but we can still improve it by adding the more rules. Similarly, with increase in membership functions and output threshold recognition rate will also be increase accordingly.			

Training Data	Testing Data	Output Threshold	Recognition Rate
N/A	245057	0.6	78.725%
Analysis			
Increment in recognition rate is very slow but it could be increase by increasing more threshold and result with be more accordingly.			

Training Data	Testing Data	Output Threshold	Recognition Rate
N/A	245057	0.7	79.225%
Analysis			
As we have obtained a very little increment in rate, so there is one possibility to increase more is by increasing more rules which is beyond the scope of paper.			

4.2. ANFIS Fuzzy Inference System

In ANFIS Fuzzy Inference System, we have to set the percentage of training data and remaining data can be used to produce the SUGENO inference system. So recognition rate is calculated accordingly. Following table shows the different experiments.

Training Data	Testing Data	Output Threshold	Recognition Rate
70%	30%	2.3	98.5405%
Analysis			
Best recognition rate obtained by using 70/30 ration of data.			

Training Data	Testing Data	Output Threshold	Recognition Rate
80%	20%	2.3	98.305%
Analysis			
As we have obtained a very little decrement in rate, so there is one possibility to increase more is by increasing more rules.			

Training Data	Testing Data	Output Threshold	Recognition Rate
90%	10%	2.3	98.225%
Analysis			
Again we have obtained a very little decrement in rate which shows that data should be moderate.			

5. Conclusion

Hence it is proved that the ANFIS Fuzzy Inference System gives the best performance because it is trained on the data and ANFIS derives the rules after the neural networks' training. Mamdani can be perform better but if we add more rules.

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