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Special Issue on new developments in soft computing and Fuzzy Logic Applications

Guest Editors: [1]Pushpendu Kar,[2]Anandarup Mukherjee,[3]Ramasamy V and [4]Imon Mukherjee
[1]University of Nottingham (China campus)
[2]Institute for Manufacturing (IfM), University of Cambridge, U.K
[3]Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology (Deemed to be University), Chennai, Tamil Nadu, India
[4] Indian Institute of Information Technology Kalyani, India

This special issue of Frontiers focuses on new developments in soft computing and Fuzzy Logic Applications. The ultimate goal of this Special Issue is to offer a platform for MMTC Communication Frontier user who are interested in new developments in fuzzy logic and soft computing uses.

The first paper proposed a model for the quality of the food and the service in restaurants is represented by generating the percentage of tips, indicating that the quality of the food and the service will be determined by the percentage of tips. In essence, fuzzy logic assists in providing judgements about things like hot or cold, good or terrible, etc.

The second paper suggests Deep Fuzzy Clustering, a novel method of consumer segmentation that blends fuzzy clustering and deep neural networks. The suggested approach is intended to get beyond the drawbacks of conventional clustering techniques and produce segmentation results that are more precise and understandable.

The third paper emphasise the key points of the novel algorithm that was put out in their study. To locate the keypoints from sketch faces and gallery photos for the new method, the authors employed SIFT.

Dr. Pushpendu Kar is currently working as an Assistant Professor in the School of Computer Science, University of Nottingham (China campus). Before this, he was a Postdoctoral Research Fellow at the Norwegian University of Science and Technology, the National University of Singapore, and Nanyang Technological University. He has completed all his PhD, Master of Engineering, and Bachelor of Technology in Computer Science and Engineering. He was awarded the prestigious Erasmus Mundus Postdoctoral Fellowship from the European Commission, ERCIM Alain Bensoussan Fellowship from the European Union, and SERB OPD Fellowship from the Dept. of Science and Technology, Government of India. He has received the 2020 IEEE Systems Journal Best Paper Award. He has received four research grants for conducting research-based projects, three of them as a Principal Investigator (PI). He also received many travel grants to attend conferences and doctoral colloquiums. Dr. Kar has more than 12 years of teaching and research experience, a few of which are from highly reputed organizations around the world. I also worked as a software professional at IBM for one and a half years. He is the author of more than 50 scholarly research papers, which have been published in reputed journals and conferences, and in IT magazines. He has also published two edited books. He is also an inventor of four patents. He has participated in several conference committees, worked as a team member to organize short-term courses, and delivered a few invited talks as well as Keynote Lectures at international conferences and institutions. He is a Senior Member of IEEE and a Fellow of the Higher Education Academy (FHEA), UK. Dr. Kar has been recognized as a High-Level Talent by Ningbo Municipal Government, China.

Dr. Anand holds a Ph.D. in Computer Science and Engineering from the Indian Institute of Technology (IIT) Kharagpur, India, and a Master's degree in Microelectronics & VLSI Design from West Bengal University of Technology, India. His Ph.D. focused on conceptualizing, designing, and implementing various data and computation offloading and run-time optimizing solutions for UAVs and UAV networks. Many of his systems and works have been covered in print and televised media. Also, Anand works with the Distributed Information and Automation Laboratory (DIAL) of the Institute for Manufacturing at the University of Cambridge, UK. He is a Research Associate at the Institute for Manufacturing (IfM) and PdRA member at Trinity Hall, University of Cambridge, UK. He is a member of IEEE and ACM, and also serves as the Vice-chair of IEEE-P1954 Standards Committee of the IEEE Standards Association, Associate Editor of Springer Nature's PPNA and is an Area expert in IEEE ComSoc SIG on IoT for e-Health.

Dr. Ramasamy V is currently working as an Associate Professor in the Department of Computer Science and Engineering at Vel Tech Rangarajan Dr.Sagunthala R&D Institute of Science and Technology (Deemed to be University), Chennai, Tamil Nadu, India. His area of interest includes Mobile Cloud Computing, IoT, Machine Learning, Data Science, Artificial Intelligence and Data mining. He is the author of several scholarly research papers in international journals and conferences. He is the Organizing Chair of International Conference on Advanced Computing and Intelligent Engineering (ICACIE) and International Conference on Advanced Communications and Machine Intelligence (MICA).

Dr. Imon Mukherjee received his Ph.D. from Jadavpur University, Kolkata, India, in 2015 respectively. Currently, he is associated with Dept. of Computer Science & Engineering, Indian Institute of Information Technology Kalyani, India (an Institute of National Importance under MHRD, Govt. of India) since 2016. Earlier, he was an Assistant Professor in the dept. of Computer Science and Engineering of Institute of Technology & Marine Engineering, now The Neotia University, West Bengal, India from August, 2006 to December, 2011. Then from January, 2012, he was associated with the Dept. of Computer Science and Engineering, St. Thomas' College of Engineering & Technology, Kolkata, India, with same designation. His research focuses on Information Security and Data Analytics. He is associated as Guest Editor, Reviewer, PC member, Track Session Chair of many reputed conferences and journals like IEEE Transactions on Circuits and Systems for Video Technology, etc. He has supervised many Ph.D. students at IIIT Kalyani. He has acted as PI of many projects funded by DRDO (Govt. of India), SERB-CRG (Govt. of India), MeitY (Govt. of India), and, DST (Govt. of W.B.), etc.

A FUZZY INFERENCE SYSTEM FOR DETERMINING THE QUALITY OF THE FOOD AND SERVICE IN RESTAURANTS TO GET TIP PERCENTAGE

Sankha Subhra Debnath[1], Prasad Mahudapathi[2]
Department of Computer Science and Engineering, Techno College of Engineering, Agartala
[2]IOOF, Melbourne, Australia
Corresponding email address: - sankhasubhradebnath@gmail.com[1]

ABSTRACT:

On the basis of concepts like high, old, hot, cold, and so forth, fuzzy logic can be utilised to express obscurity. The range of truth values can be expanded via fuzzy logic to include all real integers between 0 and 1. The range of numbers here indicates the likelihood that the stated fact is either "true" or "false." Fuzzy logic has several applications in daily life, including those in the domains of engineering, agriculture, transportation, environmental science, and economics and business. It was applied in this study to determine the appropriate amount of "tips" for restaurant servers based on their level of service. The fuzzy inference system, as opposed to the traditional true or false categories like poor, average, hot, cold, high, elderly, etc., somewhat illustrates the approach based on the grade of truth [1]. In essence, fuzzy logic assists in providing judgements about things like hot or cold, good or terrible, etc. In this work, the quality of the food and the service in restaurants is represented by generating the percentage of tips, indicating that the quality of the food and the service will be determined by the percentage of tips [1,3].

KEYWORDS:

Fuzzy Inference System, skfuzzy module in Python, Tipping problem in restaurants.

1. INTRODUCTION:

Dr. Lotfi Zadeh from the University of California first invented fuzzy logic in 1965, therefore it has been around for a while. Because fuzzy logic is frequently used in the present world in all-automatic technologies, its application has grown more well-known over time. Based on words like high, old, hot, chilly, etc., fuzzy logic can be utilised to express obscurity. Boolean logic is improved by fuzzy logic, which introduces the idea of partial truth [1]. According to classical logic, everything can be expressed in binary terms (i.e., yes or no, zero or one), however fuzzy logic offers Boolean truth with the level of truth [1].

2. METHODOLOGY:

Fuzzy inference is the process of using fuzzy logic to translate an input into an output [3]. The mapping then provides a basis for making decisions or identifying patterns. Fuzzy inference makes use of all the elements that are covered in Membership functions, logical operations, and If-Then Rules. The two-input, one-output, three-rule tipping dilemma from the Basic Tipping Problem is used as an example to teach the fuzzy inference process. For this task, the service and meal quality are inputs into the fuzzy inference system, which subsequently calculates a tip% by following the guidelines below:

- Only in the event that the service and/or food quality was excellent, will the tip be high.
- If the service was ordinary, the tip will be medium.
- If the meal and service were poor, the tip would be low.

2.1. PROCESS TO FIND THE TIPPING PROBLEM IN RESTAURANTS USING FUZZY INFERENCE SYSTEM:

The "tipping problem" is frequently presented as an example of how fuzzy logic principles can be utilized to produce complicated behavior from a small, clear set of expert rules. I rate the service and food quality on a scale of 0 to 10 before tipping. Here, I utilize it to leave a tip that ranges from 0 to 25%.

Fig 1: Structure of the tipping problem in restaurants using fuzzy inference system

2 On a scale of 0 to 10, rate the quality of the wait staff's service in universe for antecedent 1. Similarly, rate the quality of the meal in universe for antecedent 2.

3 The universe of the consequent means: From 0% to 25%, how much should we tip.

4 In order to calculate the output as a tipping %, I have divided the rates for the service and the quality of the food into (service: 9.8 and quality: 6.5).

3. RESULT AND DISCUSSION:

Here, I've modelled this using the skfuzzy control system API. Let's define fuzzy variables first:

```
import numpy as np
import skfuzzy as fuzz
from skfuzzy import control as ctrl

# New Antecedent/Consequent objects hold universe variables and membership
# functions
quality = ctrl.Antecedent(np.arange(0, 11, 1), 'quality')
service = ctrl.Antecedent(np.arange(0, 11, 1), 'service')
tip = ctrl.Consequent(np.arange(0, 26, 1), 'tip')

# Auto-membership function population is possible with .automf(3, 5, or 7)
quality.automf(3)
service.automf(3)

# Custom membership functions can be built interactively with a familiar,
# Pythonic API
tip['low'] = fuzz.trimf(tip.universe, [0, 0, 13])
tip['medium'] = fuzz.trimf(tip.universe, [0, 13, 25])
tip['high'] = fuzz.trimf(tip.universe, [13, 25, 25])
```

So here I have imported the basic library of python as “numpy as np” and as I have done this coding for fuzzy so that I have imported “skfuzzy as fuzz” and also from skfuzzy I have imported “control as ctrl”.

when someone has gone for a restaurant then he/she should give the tips over there So, basically tips in a restaurant depends on quality of the food and service in the restaurant. Here I set the range of quality and service as (0 – 10) and the tip percentage as (0% - 25%).

So, there are two inputs (Antecedents) quality and service and one output (Consequent) which is tip. There are three parameters which are assembled in the coding “np. arrange” are start, stop and step. For the quality which is our 1st input, where start is our 0, then stop is 11 and step is 1 (0, 11, 1). Here stop is in 11 because I have set the range for the quality and service as (0 – 10) respectively. So, basically the step is defined how the series will extend like step 1 in the series will be like 0,1,2,3,4,5,6,7,8,9, 10 and if the step is 2 then the series will be 0,2,4,6,8,10. Then in the same way our service was coded. Then the output as tip has also the parameters as (0, 26, 1).

After that I have assigned the membership functions. So, for quality and service I have used “automf" that is automatically it will assign the membership values. Here I have assigned the parameter for quality and service as “automf (3)” because there are three regions in quality and service as poor, average and good. But for tip it was written explicitly like in tip there are three regions which are low, medium and high where I have used the triangular membership function which is “fuzz. trimf”.

4. CONCLUSION:

The tipping % used in this article, which serves to raise the proportion of return customers, is used to evaluate the quality of the food and service. With the aid of this essay, we will be able to analyse the notion in a variety of professions and sectors, such as weather forecasting. This procedure can be used in a variety of fields, including electrical, electronics, and mechanical.

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Mr. Sankha Subhra Debnath, Asst. Prof., Techno College of Engineering Agartala has been working in TCEA since Feb’ 2018. He has more than 10 years of teaching experience in several institutes, organizations and colleges. Before TCEA he worked at ICFAI UNIVERSITY, AGARTALA for two years. He did his B.Tech in CSE from MANAV BHARTI UNIVERSITY and M.Tech in CSE from Visvesvaraya Technological University. He has expertise in Computer Graphics and Multimedia, Data Structure and Algorithm, Cloud Computing and many such important subjects. He has published more than 20 research papers in different referred international journals, conferences and book chapters. Mr. Debnath has been awarded the best paper award by several renowned international conferences. He has been invited keynote speaker and panelist in multiple global conferences and panel discussions. He has also received numerous prestigious travel grants to attend conferences, workshops, and meetings around the world.

Prasad Mahudapathi is a Goal-Oriented and Collaborative Consultant with over 13 years of enterprise-level technical experience as a Solution Implementation, VMware Consultant, Solution Design, Consulting, Automation, IT Transformation and Operations, Server Consolidation, Business Continuity, and Disaster Recovery in alignment with ITIL processes establishing Change, Incident, and Problem Management.

Deep Fuzzy Clustering for Customer Segmentation using Neural Networks

Debnarayan Khatua[1*], Sayantan Mandal[2*]

[1]School of Sciences, Woxsen University, Hyderabad, India
[2]Department of Mathematics, Amrita School of Engineering, Amrita Viswa Vidyapeetham
Amaravati, A.P., India

Abstract

Abstract Customer segmentation is a critical task for businesses to understand the behavior and preferences of their customers and develop targeted marketing strategies. Although commonly utilised, traditional segmentation techniques like k-means clustering and hierarchical clustering have drawbacks when dealing with complicated and high-dimensional customer data. Recent research has looked into the application of deep learning methods for customer segmentation, such as neural networks. Deep learning approaches can automatically extract high-level features and nonlinear correlations between features from raw consumer data. Moreover, fuzzy clustering, which enables users to belong to numerous clusters with varying degrees of participation, can deliver results for segmentation that are more precisely defined and easier to understand. In this context, we suggest Deep Fuzzy Clustering, a novel method of consumer segmentation that blends fuzzy clustering and deep neural networks. The suggested approach is intended to get beyond the drawbacks of conventional clustering techniques and produce segmentation results that are more precise and understandable.

Keywords: Neural Network; Fuzzy Clustering; Deep Learning; Segmentation; Conventional Clustering

1. Introduction

Customer segmentation is a widely studied topic in the field of marketing and has traditionally been addressed using clustering techniques. E-commerce, a new type of retailing, has advanced quickly throughout time. In contrast to the offline customer market, e-commerce allows for the simultaneous service of thousands of customers online. In order to create effective marketing strategies and increase customer loyalty, online client segmentation is essential for customer relationship management [1, 2].

Consumers are accustomed to providing verbal feedback that incorporates subjectivity [3, 4, 5]. Many research published recently claimed that type-2 fuzzy sets are adaptable in handling uncertainties, particularly linguistic uncertainty [6, 7, 8, 9]. Power customers were categorised by Hu and Zhao [10] using a crude clustering algorithm. For location clustering and customer segmentation, Oner and Oztaysi [11] presented an interval valued hesitant fuzzy clustering technique. Many application studies on client segmentation exist in addition to theoretical research [12, 13, 14]. Based on a sizable amount of actual transaction data from Taobao.com, Liu et al. [12] investigated Chinese online purchaser segmentation. Based on data from a sample of 597 consumers, Calvo-Porral and Levy-Mangin [13] concentrated on the speciality food customers segmentation. Gucdemir and Selim [14] combined clustering analysis and multi-criteria decision making techniques for dividing up commercial clients of a global original equipment manufacturer. It is crucial for the effective implementation of consumer segmentation theory.

In this context, we propose a new approach for customer segmentation called Deep Fuzzy Clustering, which combines deep neural networks with fuzzy clustering. The proposed method is designed to overcome the limitations of traditional clustering methods and provide more accurate and interpretable segmentation results.

2. Aims and Motivation

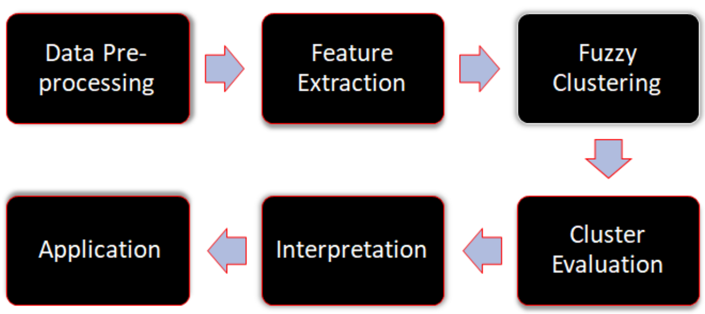
The aim of this research is to develop a new approach for customer segmentation that combines deep neural networks with fuzzy clustering. The proposed method, called Deep Fuzzy Clustering, is designed to overcome the limitations of traditional clustering methods and provide more accurate and interpretable segmentation results.

The motivation for this research comes from the growing need for businesses to understand their customers' behavior and preferences in order to provide more personalized and effective marketing strategies. However, traditional clustering methods have limitations in terms of accuracy and interpretability, which can lead to suboptimal segmentation results.

Deep learning and fuzzy clustering are two promising approaches that can potentially address these limitations and provide more accurate and interpretable segmentation results. Combining these two approaches can potentially leverage their respective strengths and improve the accuracy and interpretability of customer segmentation results.

The proposed approach can have practical applications in a variety of industries, including retail, e-commerce, and marketing. By accurately segmenting customers based on their behavior and preferences, businesses can better tailor their marketing strategies and improve customer satisfaction and retention.

3. Pipeline of the Proposed Method



Preprocess the customer data first to make sure it is in a format that is appropriate for clustering. This could entail processing missing numbers, scaling the data, and removing outliers. After that, take the customer data and extract high-level features using a deep neural network. This could entail learning features that are important for clustering using methods like autoencoders or convolutional neural networks.

Then, use fuzzy clustering to group the customer data using the retrieved features. This entails giving each data point a membership value to show the extent to which it belongs to each cluster.

Afterward, assess the quality of the clustering outcomes using measures like the Dunn index or the silhouette score. This stage is crucial for figuring out the ideal number of clusters and making sure the clustering outcomes are precise and understandable.

After that, examine the traits of each cluster to comprehend the results of the clustering. This entails identifying the fundamental characteristics that set each cluster apart from the others and using this knowledge to learn more about the underlying customer preferences and behaviour.

Finally, use the results of the clustering to create customised marketing plans for each customer category. This could entail customising pricing plans, advertising campaigns, or product suggestions to better suit the requirements and preferences of each consumer category.

4. Future Direction

The field of deep fuzzy clustering for customer segmentation using neural networks is a rapidly evolving area, and there are several potential directions for future research. Here are a few possible future research directions:

- Integration of interpretability: While deep learning techniques have shown promising results in various applications, their black-box nature can make it difficult to interpret the results. Future research could explore ways to integrate interpretability into the deep fuzzy clustering method to provide better insights into the factors driving customer behavior and preferences.
- Incorporation of domain knowledge: Domain knowledge can provide valuable insights into the factors that influence customer behavior and preferences. Future research could investigate ways to incorporate domain knowledge into the deep fuzzy clustering method to improve the accuracy and interpretability of the results.
- Multi-objective optimization: Customer segmentation often involves multiple objectives, such as maximizing customer satisfaction, minimizing marketing costs, and maximizing profits. Future research could explore ways to incorporate multiple objectives into the deep fuzzy clustering method to provide a more comprehensive view of customer segmentation.
- Scalability: The size of customer data is increasing rapidly, and it is becoming increasingly important to develop clustering algorithms that can scale to large datasets. Future research could investigate ways to improve the scalability of the deep fuzzy clustering method to handle large datasets in a reasonable amount of time.
- Online learning: In many applications, customer data is collected in real-time, and it is important to develop clustering algorithms that can adapt to new data quickly. Future research could investigate ways to incorporate online learning into the deep fuzzy clustering method to enable real-time customer segmentation. Overall, the future research direction in deep fuzzy clustering for customer segmentation using neural networks is expected to lead to more accurate, efficient, and interpretable clustering algorithms with practical applications in various fields.

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Dr. Debnarayan Khatua obtained his Ph.D. in Mathematics from the National Institute of Technology Durgapur in 2019, where he worked on Models on Dynamical System in Different Environments (Production Inventory, Fuzzy Mathematics). He is an active researcher, with a focus on fuzzy inference system, Mathematical Modelling, Machine Learning, Natural Language Processing, Biomathematics, Fuzzy Mathematics etc. In addition, He has published numerous papers in academic journals like soft computing, IJFS, COAM, etc. Recently his research collaborations are IIT Kharagpur, NIT Durgapur, XIM University, etc. He has secured third place in the Mathematics at the university in 2010. I have qualified in GATE in the year 2015. He received the best poster award in Mathematics at the 4th international conference organized by World Scientific Congress, India, 2014. Now he is an assistant professor of Mathematics, at School of Sciences at Woxsen University, Hyderabad.

Dr. Sayantan Mandal is working as a Assistant Professor in Mathematics, School of Engineering, Amrita Vishwa Vidyapeetham Amaravati. His area of interest is Bandler-Kohout Subproduct Inference Mechanisms, Fuzzy Relational Equations, Fuzzy Relational Inference Mechanisms, Similarity Based Reasoning, Suitability of Different Types of Inference Mechanism, TSK Fuzzy Systems.

Hybrid Approach for Face Recognition and Face Detection

Bibek Majumder[1], Senthilkumar Piramanayagam[2]

[1]M.B.B Unibersity, Agartala, India, bibekmajumder6@gmail.com
[2]Senthilkumar Piramanayagam, Alten-UK, Coventry, England,

1. Introduction

Because of all the challenges and limitations, face identification techniques have always been a particularly difficult subject for academics. The characteristics of human faces are not constant; rather, during short periods of time (from one day to the next) and over a long period of time, a person's face can change significantly (a difference of months or years). It is necessary to perform a distinguishing job because one issue with face recognition is the possibility that different faces could appear to be extremely similar. On the other hand, many traits may not be present when we look at the same face repeatedly. One of the main issues arises from lighting, variations in facial expression, the presence of accessories (such as beards, glasses, etc.), and lastly, the rotation of a face may isolate numerous facial features.

2. Preliminaries

2.1 Wavelet Transformation (WT):

Wavelet Transformation [1, 2] is a very effective face identification technique. Wavelet Transformation (Haar) keeps the original properties of the image while reducing the dimension by deleting abundances. When an image is transformed using the 2D-Discrete Wavelet Transform (2D-DWT) [3], several frequencies of four sub-band images [4]—namely, (1) HH, (2) HL, (3) LH, and (4) LL—are produced instead of only one. Here, low-pass and high-pass filtering are indicated by the letters L and H, respectively. After down-sampling, the LL band closely resembles the original image. The HL band frequently recognises vertical characteristics in the original input image, while the LH band frequently recognises horizontal features. Last but not least, the HH band typically identifies concentrated high-frequency point structures in the image.

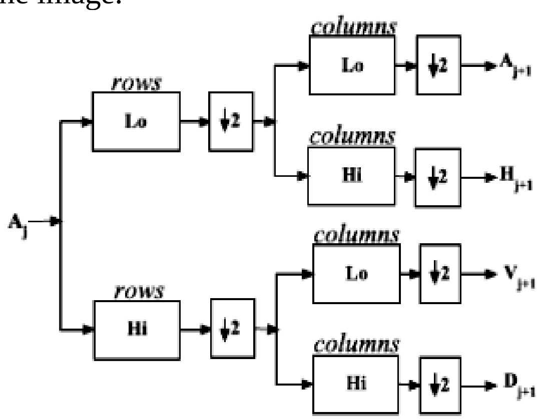

Figure 1: 2D-DWT decomposition.

2.2. Scale Invariant Feature Transformation (SIFT):

The algorithm for finding the keypoints using SIFT was skillfully described by David G. Lowe in [5]. The discipline of face recognition has made substantial use of SIFT in the previous 13 years. It primarily observes and represents local features in images that are translation, scale and rotation invariant. It is employed as a keypoints descriptor in face recognition. As a result, the image would yield about the same amount of keypoints (keypoints interpreted as feature coordinates) after being enlarged; this is what we mean when we say that an image is scale invariant. It would provide approximately the same amount of keypoints even for rotated photos (It is another benefit which this algorithm facilitates).

2.3. Two tasks: Unsupervised Learning and Supervised Learning:

Unsupervised and supervised learning both include two general tasks that is machine learning and pattern recognition. Whether the label for each training sample is known or unknown is the main distinction between these two jobs. When the label is known, we attempt to represent the relationship between the feature vectors and the labels they are linked with during the learning phase of pattern recognition. This process is known as supervised learning. Our goal is to comprehend how to handle the several feature vector classes that could be included in the training data set despite the fact that we don't know what each training sample's labels would be. This learning process is referred to as unsupervised learning.

3. Proposed Methods:

3.1. Sketch to photo Recognition Using Fuzzy and Intuitionistic Fuzzy (IF) m_x Oscillation in the SIFT and Facial Landmark Domain:

The 6-point facial landmark (fig. 2), SIFT, IF and Fuzzy m_X oscillation make up the new approach that we introduced. We recommend a fuzzy-based similarity assessment method called IF and Fuzzy m_X oscillation to improve the precision of face recognition. Apply SIFT on digital photos and sketches to locate keypoints and then choose the keypoints for feature extraction. These values are classified using IF m_X oscillation and fuzzy m_X oscillation after feature extraction. It's now feasible that we are receiving many images as an output. We therefore employ a 6-point facial landmark detector—a modified version of a 68-point facial landmark detector—to solve this problem. We created two distinct regions (fig. 3) for further verification using these six locations. As a result, by utilizing the provided method, matching a facial sketch to a photo will make it straightforward to recognise the right picture. Our method's accuracy explains how IF and Fuzzy m_X oscillation are applied in the field of facial recognition-based drawing.

(a) (b)

Figure 2: The 68-point face landmarks are in (a), while the 6-point facial landmarks are in (b).

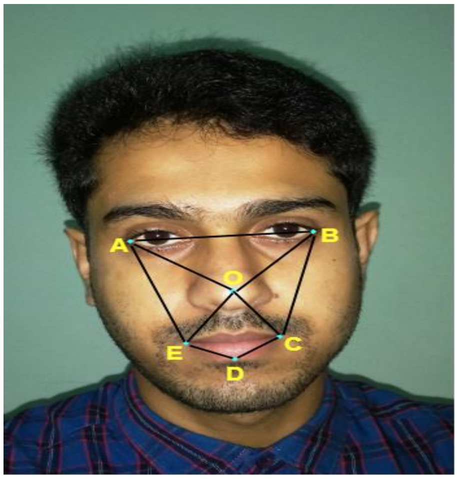

Figure 3: Indicates the landmark points A, B, O, C, D, and E and the region AOB indicates as a triangle and OCDE as a quadrilateral.

3.2. Face Detection Model In-Plane And Out-of-Plane Rotation Based Support Vector Machines (SVM) and golden ratio (ϕ):

With the use of SVM and the golden ratio, we have developed a quicker method of accessing facial detection algorithms. We require the frontal faces training dataset to train SVM specifically for skin filtering in order to run our algorithm. The suggested algorithm involves applying colour histogram equalisation first (if the face detection algorithm fails to recognise any faces), that can quickly resolve the skin filter error. Next, we apply SVM to remove anti-skin a colour, i.e., a skin filter algorithm is designed using SVM. The golden ratio is then used to properly identify the facial images. The experimental findings show that the suggested strategy not just works better, but also executes significantly faster.

3.3. Skin Filter Using SVM:

For human faces, skin tone is a particularly noticeable characteristic. The chromatic colour space's distribution of skin tones is concentrated in a constrained area. Color is processed more quickly than other facial aspects. To reduce the computational complexity, skin colour identification is therefore initially performed on the input colour image. Choosing a good colour space for skin colour identification is crucial since the accuracy of skin colour detection impacts the results of face detection systems. Since RGB colour space is one of many colour spaces and is susceptible to intensity variations, using simply RGB colour space to determine skin complexion is insufficient. From the dataset, a small number of are initially chosen. The SVM is then trained in Lab colour space to filter out non-skin colour pixels using a skin filter. The SVM's training phase conditions the hyper-parameters of the skin filter.

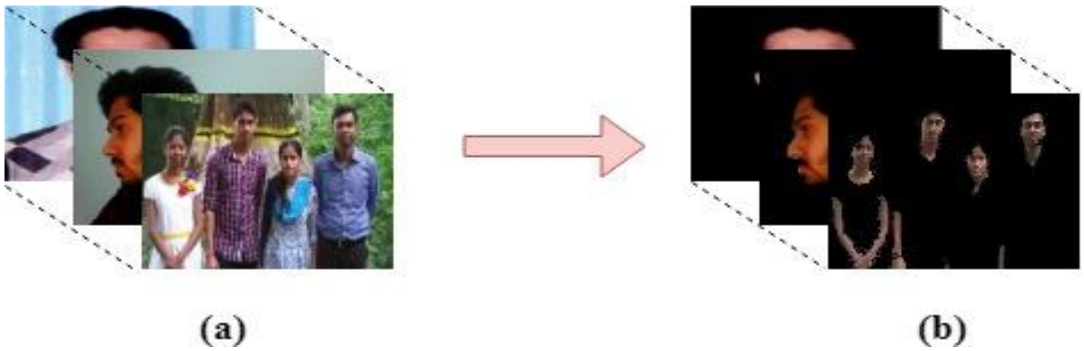

Figure 4. The gallery image is shown in (a), and the skin filtering result is shown in (b).

3.3. Proposed Method Using Golden Ratio:

The Phi number, which equals 1.618, defines the divine proportion, often known as the golden ratio [6]. As a result, the size of the face can be calculated using the golden ratio using the width between the centres of the eyes as a reference. We have use this location as the centre of our face box because we know the pixel values for the nose tip. The provided technique will therefore correctly identify a twisted face if it occurs.

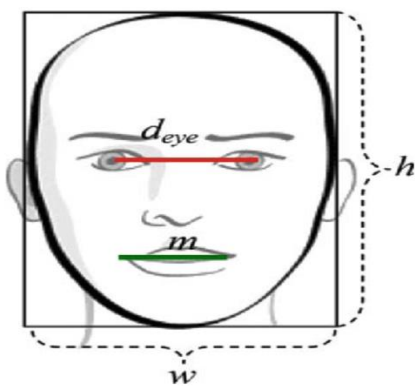

Fig. 5 The perfect face is determined by using golden ratios between the various facial features.

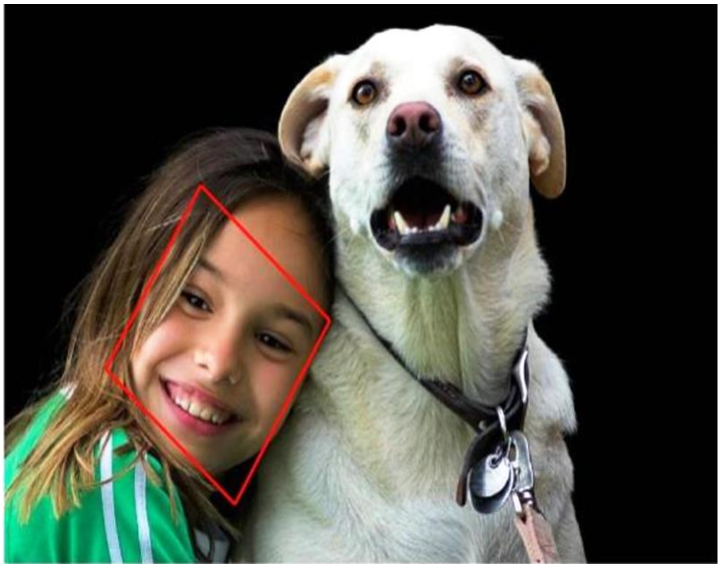

Fig. 6 Perfectly detect face region.

4. Conclusion

As we get to a conclusion, we will emphasise the key points of the novel algorithm that was put out in this study. In order to locate the keypoints from sketch faces and gallery photos for the new method, we employed SIFT. We then chose the keypoints for feature extraction, using IF m_X oscillation and fuzzy m_X oscillation. For a better outcome, we ultimately used a modified 6 point facial landmark detector. By creating a Matlab language programme and testing it against several face datasets that are currently available; we have validated the suggested technique. Results were generally what we had anticipated. And the new algorithm's accuracy will rise as the quantity of training sets and feature coordinates does.

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Bibek Majumder was born in India, 1992. Received his B.Sc. and M.Sc. degree in Mathematics major from M.B.B College and Tripura University in the year 2014 and 2016, respectively. In 2016 he joined as a Research Scholar in the Dept. of Mathematics, Tripura University. Now he is working as a visiting faculty in the Dept. of Mathematics, M.B.B University. His research interests in Image processing and optimization.

Senthilkumar Piramanayagam has over 14 Years of experience in the Automotive industry. He has exposure to all phases of the SW and System development life cycle. He has experience in project management experience with different teams. He has experience in SIL validation, Coding & Verification, and the Quality & Safety team. He has exposure to working & handling Tier 1 suppliers and OEMs in different geographic locations. He is a Certified ISO26262 Functional Safety Level 1 & ASPICE 3.0 Provisional Assessor.

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