IRACST - International Journal Of Computer Science And Information Technology & Security (Ijcsits), ISSN: 2249-9555
Vol. 2, No.2, April 2012

Classification of Sentiments through Rough Fuzzy Approach

A. Butalia, Dr. A.K. Ramani, Dr. Maya Ingle, Dr. Parag Kulkarni

Abstract— Facial expressions being a part of gesture is a biggest asset for non verbal communication. We are using facial expression of current image as a context to hand gesture which again acts as a context to the next image linking the images in a video to extract unstable sentiments. Facial expression is not precise as beauty. It's a vague concept; hence we have used Rough set. But some facial expressions are universal hence fuzzy set as they definatley belong to that membership set. Ther may be hidden context to every facial expression. We have introduced the intensity levels of facial expressions through fuzzy level factors which improves results in extracting mixed feelings. Bharat Natyam, a renowned Indian Classical Dance is taken as Dataset for test verification.

Index Terms— Facial Expressions, Hand Gestures, Context, Rough Sets, Fuzzy sets, Mudras, Navarasas.

1 Introduction

There is an enormous communication and exchange of information taking place in natural human interactions. Verbal and nonverbal behavior involves the coordination of multiple modalities (facial expression, speech [1] (linguistic and paralinguistic information), gesture, gaze, head movement, and context). Generally, humans consciously or unconsciously use these modalities to express and interpret the emotional behavior in such a way that the interaction can go smoothly. Each of these modalities has unique contribution to exchange the information of human behavior.

Facial expressions [2] convey non-verbal cues, which play an important role in interpersonal relations. Although humans recognize facial expressions virtually without effort or delay, reliable expression recognition by machine is still a challenge. Each one of us analyses the expressions of the individuals we interact with, to understand best their response to us. Even an infant can tell his/her mothers smile from her frown. This is one of the very fundamental communication mechanisms known to humans.

Gesture is a symbolic action by which a thought, a feeling or intention is expressed. Hand gestures are a basic mode of communication. Gestures are not new to us since we use them in our day to day activities also. Just take some time and think of what gesture you would use for situations like to call a person, to point at an object, to show drinking, denote a snake etc.

Facial expression recognition and hand posture recognition technologies have been developed a lot separately for many years [3][4][5]. Also, the face recognition has been used to be the authentication mechanism for security surveillance system [6], robot applications [7] etc. Although there are many researchers efficiently adopted the two recognition systems of facial expressions and hand gesture independently, but the integration is not much highlighted. In this paper, we discuss the benefit to integrate these two recognition systems. Facial expression can add the authenticity to the face recognition system in order to find out the malicious intensions of the thief. Here in this paper basically the dataset used is for story learning which can be used to train the classical dancer as an application. Bharat Natyam Mudras (hand gestures) with Navarasas (facial expressions) are taken as the case study.

The second section defines the Classical dance, Bharat Natyam mudras and Navarasas which are used as parameters for our system. The third section describes the Methodologies used and Outline of the Model. Rough-Fuzzy approach is applied to the proposed model considering the vagueness and uncertainty of emotions for a particular scene. Rough Sets [8] is used for mapping the context of facial expression with the hand gestures using the Decision table. Fuzzy Set [9] membership values are used to map the intensity levels of emotions.

The fourth section explains one of the Dataset used in detail followed by the experimental results as the subsection.

2 Indian Classical Dance: BharatNatyam As A Case Study

Classical dance is closely linked with emotions. A dance depicts a story, which is well highlighted with the help of hand gesture accompanied strongly by facial expressions. 'Nava' means 'nine' and 'Rasa' means 'mood' in Indian classical dance context.

In fact, its objective can be summed up as the creation of different moods in the minds of the spectators. The concept of Abhinaya evolved, whereby through sugges-

Manuscript submitted December 25, 2011. This work was supported by DAVV Indore as part of PhD and MIT College of Engineering Pune (sponsor).
Ayesha Butalia, Associate Professor at MIT College of Engineering Pune(Mobile: 9673102198; e-mail: ayeshabutalia@yahoo.co.in).
Late Dr. A.K. Ramani, Professor at Devi Ahilya Vishwa Vidyalay Indore.
Dr. Maya Ingle, Professor at Devi Ahilya Vishwa Vidyalay Indore. (maya_ingle@rediffmail.com)
Dr. Parag Kulkarni, Director EkLaT Research Centre (paragindia@gmail.com)

tion, the thoughts and feelings of characters in relation to their causes and effects are communicated. The Abhinaya Darpana (mirror of gesture) states that "wherever the hands go, there the eyes should follow. Wherever the eyes go, there the mind follows. Wherever the mind goes, there generates the feelings. Wherever the feelings generates, there the mood (rasa) or flavor is found".

Classical Indian dance comprises of two main components: 'Nritta', the technical aspect and Abhinaya, the emotional aspect. Nritta uses body movements without any meaning to convey. Abhinaya uses a combination of codified hand gestures and facial expressions, sometimes stylized, otherwise natural, to transform the written script into dance. It is the expression of various emotions and moods through the face angas and upa-angas (sublimbs) and through hasthas (hand gestures). Ritualistic gestures, known as Mudras, indicate gestures in dancing and in acting. A Mudra is a very artistic representation of holding the hands and fingers to indicate a particular meaning. Most of the gestures are finger-postures. They form the source of theatrical gesture-language symbolism.

2.1 Mudras

The hand movements can symbolize many things depending on the context they are used in. Bharatnatyam uses these hand gestures to strictly represent something, whereas in other genres that emerged from Bharatnatyam use these mudras to mean anything the dance, song, or dancer wish to portray. For example, the mudra shown in figure 1; Kartarãmukha (the fifth mudra) [10], is used to symbolize or enact holding a garland of flowers, picking flowers, tying a necklace or shooting an arrow. The last mudra is a complete lotus used to symbolize a mirror, long hair, a village, a full-moon, and much more.

Fig. 1. Kartarãmukha mudra

One of the most serious errors a novice in body language can make is to interpret a solitary gesture in isolation of other gestures or circumstances. For example, scratching the head can mean a number of things – sweating, uncertainty, dandruff, fleas, forgetfulness or lying – depending on the other gestures that occur at the same time. Like any spoken language, body language has words, sentences and punctuation. Each gesture is like a single word and one word may have several different meanings. For example, in English, the word 'dressing' has at least ten meanings including the act of putting on clothing, a sauce for food, stuffing for a fowl, an application for a wound, fertilizer and grooming for a horse.

It's only when you put a word into a sentence with other words that you can fully understand its meaning. Gestures come in 'sentences' called Clusters [11] and invariably reveals the truth about a person's feelings or attitudes. Figure 2 shows different hand gesture, with same expression, depicting different meanings.

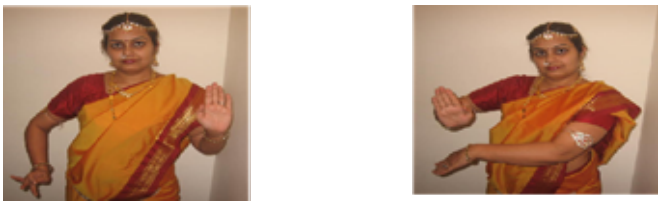

Fig. 2. Same Expression, Different hand gestures- Here the image is of Lord Shiva, and various hand gestures, are showing its various forms.

2.2 Navarasas

Without expression, the hand movements and gestures alone will be unable to bring forth the exact meaning of the situation. For example, anger and love can share the same hand gesture. To differentiate the same mudra, there should be change in the rasa accordingly. Figure 3 distinguishes the same hand gesture øikharàkhya into two different meanings as an act of bravery as depicted in case of Veera [Courage]. Scene: Rama at Sita's Swayamvara by Lord Rama, and in Act of Raudra [Anger]. Scene: Shiva & Manmatha by Lord Shiva with facial expression as subtle and raged repectively.

Fig. 3(a). Facial expression: Subtle – Veera

Fig. 3(b). Facial expression: Anger – Attacking

Rasa is about human state of mind. It's about what the mind feels and the expression of the feeling thereafter. In the Bharata's Natyashastra, Rasa is an emotion experienced by the audience created by the facial expression or the Bhava of the actor. Every Rasa corresponds to a particular Bhava. The Natyshastra has carefully described the Bhavas used to create Rasa. The table 1 states the nine moods (Navarasa) and the corresponding Bhava.

Each such 'bhava' is associated with three distinct processes: an external cause called 'vi bhava', immediate and involuntary reaction called 'anu bhava' and willful, deliberate or conscious reaction called 'vyabhichari bhava'. For example, for 'rati bhava', the stimulus would be season, flower, ornaments or anything beautiful and desirable.

TABLE 1
NAVARASAS-BHAVA

RASA	BHAVA	MEANING
Shanta (Peaceful)	Calm	tranquility
Shringar(Erotic)	Rati	Delight, love
Hasya (Humorous)	Hasa	Laughter
Karuna (Pathetic)	Shoka	Sorrow, Compassion
Raudra (Terrible)	Krodh	Anger
Veera (Heroic)	Utsaha	Heroism
Bhayanaka (Fearful)	Bhaya	Fear
Bibhatsa (Odious)	Jugupsa	Disgust
Adbhuta (Wonderous)	Vismaya	Surprise

The involuntary reaction would be coy glance or sweet words. The 'vyabhichari' bhava would be lassitude, suspicion or jealousy. Similarly, 'adbhuta' bhava starts with seeing unusual things, achieving the desired or magic. The 'anu' bhava is wide or staring eyes, thrill or exclamation and eventually the 'vyabhichari' bhava is standing stunned or overjoyed. Apart from these willful bhavas, there exist thirty-three unstable sentiments: discouragement, weakness, apprehension, weariness, contentment, stupor, joy, depression, cruelty, anxiety, fright, envy, arrogance, indignation, recollection, death, intoxication, dreaming, sleeping, awakening, shame, demonic possession, distraction, assurance, indolence, agitation, deliberation, dissimilation, sickness, insanity, despair, impatience and inconstancy.

The three processes described are quite distinct through Navarasas and mudras but the rest thirty three [10] can be understood by the context which may be identified by previously linked sequences.

Context information characterizes the situation in which an emotion behavior occurs. It includes who is the emotion expresser and receiver, what the expresser are doing, when and where the emotion behavior occurs, and what is the reason for the consequent behaviour.

Generally the reasons of context ('why', 'what', 'when', 'how', 'where' etc) comes from the previously linked situations. The general emotions turn up from the surroundings being developed. For example, one is feeling homesick, because suddenly he or she saw the photos of the mother or some situation of Wedding Bidai (departure of the bride after marriage ceremony) on television etc. The generation of that particular emotion, sadness for this relavant example, comes from the reasons which could be linked up from the previous video.

3 METHODOLOGIES USED: ROLE OF CONTEXT, UNCERTAINTY (ROUGH SETS) AND FUZZINESS:

Adaptation to context means to exploit the potentials, meet the restrictions, and fulfill the requirements so that the user stands to benefit from the multimedia presentation to the best. However, the exhaustive, accurate description of a user's actual situation is extremely complex due to two reasons: (1) No context model is able to fully cover all aspects of the "real world" because of complexity restrictions, and (2) not every aspect of the user's context can be defined and measured exactly. Thus, context attributes may remain unknown, unsure, or are afflicted with uncertainty, or fuzziness. To solve issue (1), the user context description model must be reduced to a trade-off between expressiveness and complexity, which is often done automatically by omitting less relevant attributes for which Reducts are extracted through Brute-force backward elimination algorithm of Relative Attribute Dependency Based on Rough Set Theory[12]. To solve issue (2), the training can be stored as context in RS decision table [13] and decision is made according to that. If boundary region is empty you get exact answer, and rating value 'r' (as defined in equation (12)) is used. If boundary region is not empty, add previous linked feature into table subset, and evaluated 'r' (as defined in equation (13)). The boundary region may not come to zero always but will definitely have less attributes which will definitely assist in resolving the uncertainty especially in situation where precision is not required. The context model may be designed in a way that allows the representation of uncertainty, i.e. the context model may be extended by elements from fuzzy theory.

Shaver et al. (1987) mentioned "degrees of intensity". For example, one can be "slightly embarrassed", and "mortified"; one can be "annoyed", "angry", "enraged", one can be "apprehensive", "frightened", or "terrified". The other reason for creating new emotion words is to indicate something special or specific about the situation in which the emotion arises. For example one could be "disappointed", which implies that one is sad or unhappy about having expected more than reality delivered; one could be "homesick", which implies that one is sad because of being away from home; and so on.

For this, Rough-Fuzzy approach theory is used which is an extension of crisp rough set theory, allowing all memberships to take values in the range [0, 1]. This permits a higher degree of flexibility compared to the strict requirements of crisp rough sets [14] that only deal with full or zero set membership.

We have proposed a Rough Fuzzy approach for the linking of images to develop a context. However we are assuming the classification of facial expressions and hand posture recognition [15], the systems proposed in our previous papers. Since rough sets is a powerful mathematical statistics for imprecision and calculating reducts, which can be used for feature selection, images can be inserted as entry in discernibility matrix.

A heuristic approach based on Relative attribute dependency can be applied for reducts [16]. Here since the image is linked with previous history, we have used the rough set [17] approach. Fuzzy sets are for uncertainty, hence will resolve the ambiguity caused by mixed facial expression and hand postures to an extent.

Weights were assigned representing the recognized context state with each facial expression and hand posture [18]. Each of the context states and weights represent as follows:

$$\alpha_f(x) = \int e(x) \quad (1)$$

where x would be the facial expression related to Navarasa e(x).

$$\alpha_h(y) = \int h(y) \quad (2)$$

where $\alpha_f(x)$ is the weighting factor related to facial expression x and $\alpha_h(y)$ is the weighting factor related to

hand posture y.

To calculate these weights, in our research, we recognized emotions through the training data of facial expressions, hand postures and calculated average of emotion values that it comprises of. We extract feature vector through (y) state for learning data.

The function for fusion algorithm is calculated as:

$$F(x,y) = \alpha_f(x)F_x + \alpha_h(y)F_y \quad (3)$$

F_x and F_y are the outputs from RS decision table.

$$S = \langle U, Q, V, Y \rangle \quad (4)$$

where U= {set of hand mudras}

Q={y, x, meaning M[u_i], F(x), F(y)}

V will come from Natya Shastra document defined in [11].

Y is the sentiment [11] which acts as the decision at tribute.

$$F_{xy} = POS_{F(x)}(F(Y)) \quad (5)$$

where

$$POS_A(B) = \cup\langle \underline{AX} \mid X \in IND(B) \rangle \quad (6)$$

where $POS_A(B)$ is dependency of B with A.

$$AX = \{x \in U : [x]A \subset X\} = \bigcup\{Y \in A^* : Y \subset X\} \quad (7)$$

where $\underline{AX}$ is lower approximation, which gives meanings coinciding definitely with that gesture.

$$IND(B) = \{(x,y) \in U \times U : \forall b \in B,\ f(x,b) = f(y,b)\} \quad (8)$$

where IND(B) is equivalence classes of set B.

Considering previous and next image, the system context is

$$O = F(x-1, y-1) \cup F(x+1, y+1) \quad (9)$$

This term can also be related to long term emotional state.

The Rough fuzzy approach is fed for linking to the probabilistic approach. We feed the classification results of the individual facial expressions and hand postures into the decision table of RS as evidences. The decision is made depending upon the AUs and hand posture which will act as condition attributes. The required probability tables are obtained from a performance evaluation of the individual classifiers in an offline training phase based on datasets used. Therefore discernibility matrices of each classifier are tuned into probability tables modeling the dependent observation probabilities of the model. Respective classification performance models are taken into account into the decision level fusion model used in our system.

3.1 Outline of Our Proposed Model

Our main objective is to reduce the ambiguity of the same gesture using the context i.e. Facial expressions and the previous frames. So we can divide our approach is following main modules as diagrammatically represented in figure 4.

1. Dividing video into static frames.

In our approach, the continuous video is given as the input. This video is broken down into number of various static frames. If the conjugative frames are containing the same features then we can eliminates one of them. Then we identify the independent frames. The independent frame means image consists of the hand and face. After

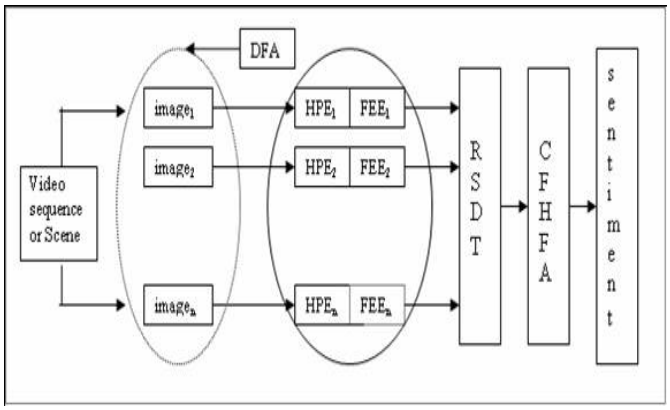

Fig. 4. A general architecture of the proposed system – DFA: Data Flow Diagram, HPE: Hand Posture Extraction, FEE: Facial Expression Extraction, RSDT: Rough Set Decision Table, CFHFA: Context Facial Expression Hand Gesture Fusion Algorithm.

all the independent frames we apply the following steps. When the hand gesture moves in slow motion in the video, there can be various differenet images which will be generated. However, these images are of same context. Hence this problem is solved, ignoring the orientation aspect, which is major challenge in image processing. The state changes when facial expressions changes or hand posture changes or both changes.

2. Hand Feature Extraction.

So, first we have to extract the hand feature [19] from the image. We describe the hand posture in the term of the finger raised and the orientation of the hand posture [20]. So the feature vector can be given by,

$$FHS = \{F_1 \wedge F_2 \wedge F_3 \wedge F_4 \wedge F_5, O_R\} \quad (10)$$

where,

F1 – F5 indicates the positioning of the each finger from thumb to little finger. (i.e. 1 or 0, raised or not raised)

OR indicate the orientation of hand posture.

3. Facial Feature Extraction

A basic top level diagram of the framework is given in figure 4. According to the figure 4; the framework has the following significant modules and roles:

a) Subject stimulation
b) Feature Extraction
c) Feature selection/reduction
d) Classification[21]
e) Decision fusion
f) Information Annotation

To fuse emotional information at the decision level, the proposed system will integrate emotion1, emotion2, emotion3 etc. If the fusion mechanism is reliable enough then the recognition of the detected emotion will have more reliability. This is given by (Paleari and Lisetti 2006)

$$R(\exp r) = f(\exp r_1, \exp r_2, \ldots\ldots \exp r_n) > R(\exp r_i); \forall_i \in [1, n] \quad (11)$$

where R(expr) represents the reliability of the recognition of the emotion $expr_i$. The condition for triggering fusion can take place in two ways based on the technique proposed by Nigay & Coutaz (Nigay and Coutaz 1995). According to their model, when triggered, the system will attempt micro temporal fusion and macro temporal fusion based on the conditions. Micro temporal fusion is used to combine related information units produced in parallel and macro temporal fusion is used to combine related information units produced sequentially by the system, or even delayed by the system. We are considering marcotemporal fusion for our system.

The first stage involves the face and the facial feature detection, the points to be eliminated or discarded related to ambiguity. FACS and FAP parameters can be used for doing this. Then the features are extracted and can be stored in database which can further help us decreasing processing time, and various processing can be done on this data. The AU table in [22] can be used to convert them into two dimensional data. The features are to be reduced in order to remove indispensable attributes. The rough set reduct [23] approach based on entropy can be used for that. The facial expression recognition system will classify seven different emotions by Ekram [24], named anger, disgust, fear, and happiness, neutral, sad and surprise. There will be ambiguity in the recognition system, due to human unpredictable behavior. There are mixed emotions. However humans can show different emotions which may not be pertaining to the same context. To resolve this, a sequence of images is linked wherein each image has its own emotional state which may lead to ambiguity, but the linking will lead to a long term emotional state. However the mood here will be the output of the system proposed. Each image here will have facial expression which will be enhanced more by adding hand posture as the context [25]. The mood however will develop a useful context from the information annotation system, which can help in further decision making.

4. Expert domain knowledge is employed to rank the criteria of emotions and hand gestures.

We can't conclude the meaning of same hand posture in various contexts. To reduce this ambiguity regarding interpretation face feature extraction is done as next step.

Action units are used as face features. Action unit includes the variation of eyebrows, mouth and chick from original look, showing the reaction.

a) Mudras → hand gestures and their meanings[11].
b) Mapping with expressions.
c) Database of emotional evaluation attribute is mapped with hand gesture (mudras and their meanings) and established according to the results obtained.
d) Using previous frames as context.

Some ambiguities are still remaining though facial expressions are used as a context. To reduce these ambiguities we are using the information from previous frames as a new context. Every state contains information regarding all the considered previous states. Current frame is interpreted by new context and information within current frame. Similar procedure is repeated until video get completed.

Emotion is a complex matter. It is neither a Boolean rating nor single directed. There are multiple dimensions of emotion like worry/control, anxiety/relaxation and so on, as defined by the comfort zone theory. The algorithm first designed was a single value for one dimension. However Emotion cannot be extracted from a single feature. Hence, we have formulated it as follows –

$$r = \sum i\alpha_i f_i(x) \quad (12)$$

to have rating r where i is the current image, α ∈ R(unstable sentiment table), x is an input (normally sequence of images, taken from video or clip of art), f is a function which maps the input to a value between zero and one (amount of detected emotion by the i-th rating function) and α is the factor to weight the model. f(x) is the expression of current static image x. α_i is computed through 3DM[26] where inputs can be hand gestures[27] as context and through rough sets co-relation factor, weighing factor can be decided.

As the rating is only approximation and therefore would result in a value oscillating, we further extended previous model. For a rating value we also include the previous values.

$$r(x) = (\sum i^n \alpha_i r(x-i)) / (\sum i^n \alpha_i) \quad (13)$$

where the α's are the weighting factor which equal to $\alpha_i = 1 - i/n$ while i is the starting at 0 for the last frame and n is the amount of history values used.

When emotional and hand gesture [28] interpretation evaluate on is based upon multiple criteria, trade-offs are necessarily involved in the selection process. Different criteria may be applied for the hand gesture interpretation. The relative importance of the criteria depends on the previous section in the new emotional context.

We define threshold value α as α(0) → meditation to α(1) →to raudra as shown in table 2.

To calculate unstable sentiment (output) through context information:

$$Oi, i(1-2) = \alpha, i(x) \quad (14)$$

$$Oi, i(3-4) = \beta, i-2(y) \quad (15)$$

We term this O(x) as r for the i[th] current image for simplicity.

'α' is the fuzzy membership value of expression and 'β' is the fuzzy factor generated for sentiment.

Rule I: For 0th image

$$r = 0 \quad (16)$$

Rule II: for 1 to n-1 images,

$$r_i = r_i + \exp r[im_l] + \exp r[im_{l+1}] \quad (17)$$

where $\exp r[im_l]$ is the α–value associated to expression of i[th] image

For find h () we use RS decision table.

TABLE 2
EXPRESSIONS AND THEIR 3DM VALUE

i	Expressions	MEANING m[i]	α[i]
0	Gyan mudra	meditation	0
1	Shanta (Peaceful)	tranquility	0.1
2	Shringar(Erotic)	Delight, love	0.2
3	Hasya (Humorous)	Laughter	0.3
4	Adbhuta (Wonderous)	Surprise	0.4
5	Veera (Heroic)	Heroism	0.5
6	Karuna (Pathetic)	Compassion	0.6
7	Shoka (Sadness)	Sorrow	0.7
8	Bhayanaka (Fearful)	Fear	0.8
9	Bibhatsa (Odious)	Disgust	0.9
10	Raudra (Terrible)	Anger	1

Rule III:

$$if\ (\exp r[im_i] == \exp r[im_{i+1}])increment_i$$

$$r_i = r_{i-1} \quad (18)$$

4 EXPERIMENT RESULTS AND DISCUSSION

As modeled by our system in figure 4, the given dataset is synthesized accordingly as given in figure 6.

The node structure defined by us in figure 6 is generalized as in figure 5.

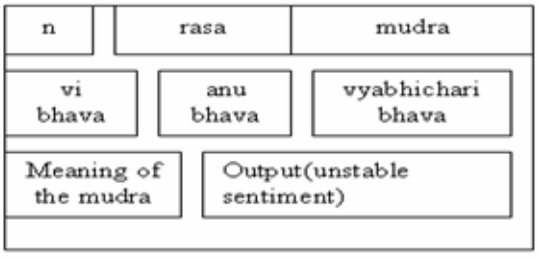

Fig. 5. Generalized Structure for node of DFA

where,

n is the n[th] number of image in the sequence.

Rasa is the expression out of the nine Navarasas.

'vi bhava' is an external cause

'anu bhava' is immediate and involuntary reaction

'vyabhichari bhava' is willful, deliberate or conscious reaction.

'vi bhava' is always 0 for first frame

'vyabhichari bhava' is always 0 for last frame.

4.1 Experiments For CFHFA on Dataset: Act - Sringara [Love]

For every story [29], we define Deterministic Finite Automata. When expression changes, state changes. In a story there should be a twist, for which expression may be the hint for twist in the story.

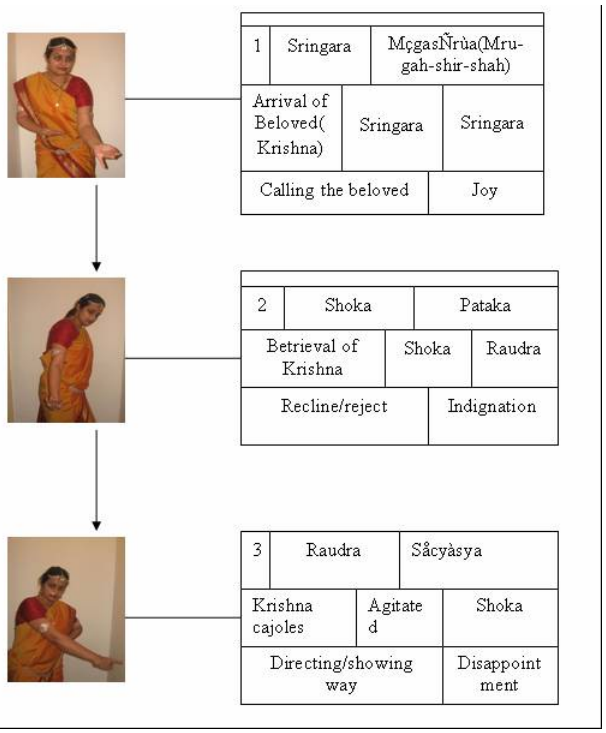

Fig. 6. Scene: Radha. Unyielding Radha shows Krishna his way out. [Radha Waits for his beloved Krishna in anticipation. When Krishna arrives late Radha's delight turns into anger as finds marks of other women on him. When Radha confronts him, Krisha tries to cajole her. Unyielding Radha shows him his way out.]

The DFA and its corresponding State Chart Diagram is as shown in figure 5 and table 3 respectively.

Here the context information will be the facial expression related to discharge of arrows, as the same hand gesture denotes attack as well as veera, as described in previous section. This information will be stored in Decision table of RS.

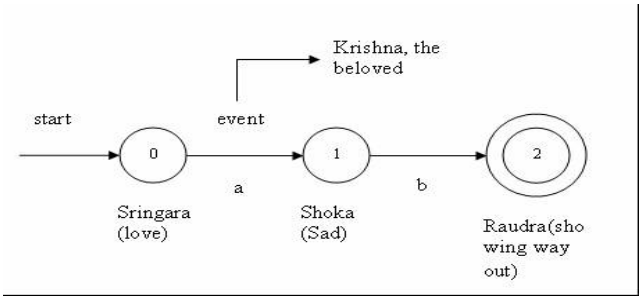

Fig. 7. DFA for the Dataset: Act Sringara

TABLE 3
STATE TRANSITION TABLE FOR THE DFA OF THE DATASET: ACT SRINGARA

STATE	Input Symbol	
	a	b
0	{0}	{1}
1	-	{2}

a → Krishna
b → Radha

For 0th image

$$r = 1.4(>1) = Distracted \quad (19)$$

Rule IV:

if $(r > 1)$

$$AddRule() : r = \exp r(i_{(m-1)}(m[small])) + \exp r(i_m(m[l \arg e])) \quad (20)$$

else

$$AddRule() : r = \exp r(i_{(m-1)}(m[l \arg e])) + \exp r(i_m(m[small])) \quad (21)$$

The intermediate states have been proved through reduct of RS [30], that it has to be evaluated first and then calculated.

$$O_j(n) = v_n = \sum_0^{i-1} v_i \quad (22)$$

n is total number of static frames.

where Oj is the total 'vi bhava', the why cause and answer. The intermediate context for the frame is calculated as

$$Output(ri) = m[i-1] + anubhava(i) + vyabhichari(i+1) \quad (23)$$

For the current frame i, the what clause is:

$$O_k(i) = r_i \quad (24)$$

where $O_k(I)$ is the final action state which comes from the last frame n.

The final Context State is proposed as:

$$C('vi\ bhava', 'anu\ bhava', 'vyabh\ bhava') = (O_j(I), F(n), O_k(I)) \quad (25)$$

For experimentation, we tested our system on short videos narrating the epics. The Navarasas along with the moods (bhavas) were the highlights of each story which will evaluate the system for all expressions.

As the dataset (Act: Sringara) discussed in previous section, the Rough Set Decision table was calculated by our system as shown in table 4:

There rasas and expressions *(marked in italic)* are repeating, hence causing ambiguity, which the first problem. The second problem is that most of the unstable sentiments are still in question mark state. In this particular case however, the first problem is solved, but the second problem x is not solved. Our fusion algorithm discussed in the dataset used evaluates the value x as distracted and disappointed. However both the issues are solved through context fusion algorithm proposed in this paper for other datasets.

TABLE 4
THE ROUGH SET DECISION TABLE

Hand Posture	Mudra	Meanings	Rasa	Expr	Additional context	Orientation	Sentiment
		women	*sringara*	*delight*	*sama*	*hand bent*	
		cheek	*shanta*	*peace*		*near the cheek*	
		traditional manners	veera	courage			
		fear	bhibhatsa	disgust			
		discussion	*shanta*	*peace*		*near the mouth*	
		costume of an actor	*shanta*	*peace*		*near the costume*	
		place of residence	*shanta*	*peace*		*near the hip*	
	MçgasÑrùa (Mru-gah-shir-shah)	tete-a-tete	adbhuta	surprise		?	intamacy
		drawing three lines	shoka	sad			worry
		on the brow					
		patterns on the ground	*shanta*	*peace*		*pointing the ground*	
		massage of the feet	*shanta*	*peace*		*near the feet*	
		combining	*shanta*	*peace*		*both hands*	
		holding an umbrella	*shanta*	*peace*		*near the head*	
		stair	raudra/	anger			raged/
			adbhuta	surprise		?	astonishment
		calling the beloved	*sringara*	*delight*		*hand stretched*	love
		roaming	karuna	compassion			bored

Hand Posture	Mudra	Meanings	Rasa	Expr	Additional context	Orientation	Sentiment
		beginning dance	sringara	delight		position on head	welcome
		cloud	bhayanaka	fear		hands stretched up	
		forest	shoka	sad			
		forbidding things/depicting				pointing upwards	
		bosom	hasya	happy			
		night	bhayanaka	fear		hands side	
		river	karuna			hands wave	
		world of the gods	karuna			hand up	
		cutting	raudra	anger	?	fingers together	
		wind	adbhuta	surprise			
		reclining	raudra	anger	?		denying
		walking	neutral	neutral		zig zag	
		graciousness	sringara		?		
		moonlight	hasya		Ullokita		
		stop	raudra/shoka				
	Pataka	wave	hasya		?		
		entering a street	adbhuta				
		equality	shanta		sama		
		one's self			avalokita	hand towards one's self	
		taking an oath	veera	heroic			determination
		silence	shanta	tranquility			insanity
		benediction					
		a good king	veera			on head	
		slap	raudra			hands upwards	
		touching	karuna			hands in front	
		going in front				tilted showing in front	
		the form of a sword	veera followed by raudra				
		month year			tilting hands		
		rainy season				from upwards to downwards	
		day			tilting hand once		
		giving blessings	sringara	delight		position side	blessing

Hand Posture	Mudra	Meanings	Rasa	Expr	Additional context	Orientation	Sentiment
		evening				pointing down	?
		Parabrahma	shanta		sama		
		demonstration	sringara	happy			excited/joy
		one hundred				tilting	
		sun				pointing up	
		city					
		world	karuna			rotating	power
						pointing up	
		saying "Thus" or "What?"	adbhuta				anxiety
		He	sringara				demonstrating
							man
		fan	?				
	Sâcyàsya	threatening	raudra			pointing towards	fright
		pining away	hasya				arrogance
		rod			sama		?
		the body			avalokita		
		astonishment	adbhuta	surprise			?
		braid of hair					
		umbrella	bhayanaka	fear			
		capability	veera	heroic/pride			assurance
		down				pointing down	
		beating the drum	raudra	anger		beating both hands	
		wheel				rotating	
		circle				rotating	
		explanation	shoka	sad/worry		near the mout	anxiety

4.2 Experiments For FEA, HGA, FHFA and CFHFA on Navarasas datasets.

We divided our result table in two parts:

a) Positive rasas with α ranging from 0 to 0.6 (refer table 2).
The result tables and their graphs are shown in table 5(A) and figure 8(a) respectively.

b) Negative rasas with α ranging from 0.7 to 1 (refer table 2).
The result tables and their graphs are shown in table 5(B) and figure 8(b) respectively.

The nine datasets were taken from Sijith, "Navarasas- Expressions in BharatNatyam", and Reflections in the Mind's Eye, & Views. Through The Lens, Journeys & the Joie de Vivre!, December 09, 2007 [29].

1. Sringara [Love]. Scene: Radha &Krishna.
2. Hasya [Laughter]. Scene: Shoorpanakha, Rama & Lakshmana.
3. Karuna [Compassion].
Scene: Story of Nandanar (from a song in Tamil literature)
4. Raudra [Anger]. Scene: Shiva & Manmatha
5. Veera [Courage]. Scene: Rama at Sita's Swayamvara
6. Bhayanaka [Fear]. Scene: Vyasa, Ambika, Ambalika.
7. Beebhatsa [Disgust]. Scene: Vyasa, Ambika, Ambalika.
8. Adbhuta [Wonder]. Scene- Vamana & Mahabali.

TABLE 5(A)
EXPERIMENTAL RESULTS FOR POSITIVE EXPRESSION

Dataset on which experimentation is done.	% per FEA	% per HGA	% per FHFA	% per CFHFA
Strategy	I	II	III	IV
Dataset 1 related to Shanta	80.01	45.17	82.11	95.13
Dataset 2 related to Shringar	71.33	30.75	85.21	92.65
Dataset 3 related to Hasya	81.54	49.21	86.73	94.78
Dataset 4 related to Adbhuta	70.98	43.25	82.49	95.11
Dataset 5 related to Veera	86.99	40.83	89.98	94.92
Dataset 6 related to Karuna	64.22	25.45	75.45	92.24

9. Shanta [Tranquility/Peace]. Scene: Enacting the song Shanti Nilavu Vendum, which calls for peace and harmony, as preached by Mahatma Gandhi, in his world of sorrow and turmoil. Radha waits for her beloved Krishna in anticipation. When Krishna arrives late Radha's delight turns into anger as she finds marks of other women on him. When Radha confronts him, Krishna tries to cajole her. Unyielding Radha shows him his way out. Realizing the depth of her sorrow, Krishna professes his true love for her and seeks Radha's forgiveness.

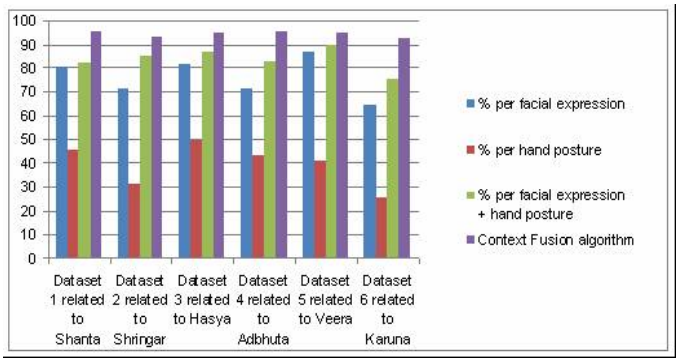

Fig. 8(a). Comparative Results of FEA, HGA, FHFA and CFHFA on Positive Rasas.

FEA is Facial Expression Algorithm considering only facial expression as the parameter. HGA is Hand Gesture Algorithm considering only hand gesture as the parameter. FHFA is Facial expression Hand gesture Fusion Algorithm which is the first stage of our proposed model (refer figure 4). CFHFA is Context Facial expression Hand gesture Fusion Algorithm which is the second stage and the highlight of this paper.

There can be 'n' number of sentiments that can be attached with a single facial expression. Facial expressions can only resolve detection of emotions. There can be 'm' number of meanings of same hand gesture. The response for the detection of sentiment has rather negative impact.

TABLE 5(B)
EXPERIMENTAL RESULTS FOR NEGATIVE EXPRESSION

Dataset on which experimentation is done.	% per FEA	% per HGA	% per FHFA	% per CFHFA
Strategy	I	II	III	IV
Dataset 7 related to Shoka	62.89	26.76	74.56	90.29
Dataset 8 related to Bhayana	60.26	28.67	74.43	93.11
Dataset 9 related to Bibhatsa	72.25	31.57	80.16	94.78
Dataset 10 related to Raudra	74.22	52.91	87.87	94.78

Our novel approach resolves the ambuiguity of identifying sentiment out of the expression taking into consideration some major complexities of image processing. By reducing the orientation aspect (as discussed in section 3.1), it also improves time complexities to certain extent. The remarkable observation from the results is that the β-value associated to any sentiment is constant and related with the summation of two different lower α–value expressions. Hence now the sentiment is a mathematical constant and many processing can be done to it further.

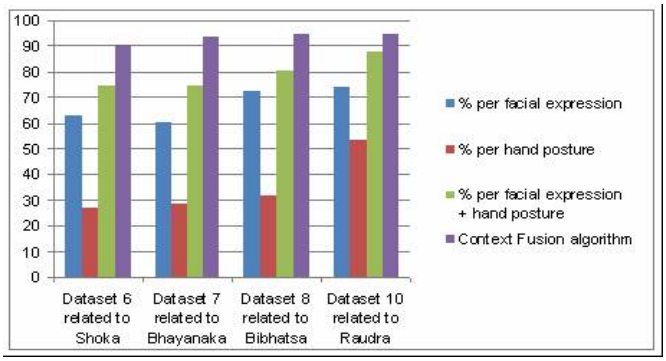

Fig. 8(b). Comparative Results of FEA, HGA, FHFA and CFHFA on Negative Rasas.

CFHFA, when applied on the dataset, not only improves in the output of sentiment, but also helps in extracting the narration from it which can be the extension to this paper. The mathematical constant of sentiment can be played with 'n' number of strategies to give various outputs.

Rule V: For the negative emotions-

Sentiment can be also termed positive or negative based on the α-value.

$$if\ (r > 1.1) \tag{18}$$

(Considering 0.6(heroism) +0.5(compassion)), then it is negative sentiment. α-value in equation (20) is greater that 0.6 (as negative emotions starts from 0.7), we have also proved that r value generated in equation (20) will always be negative.

4.3 Towards Fuzzification of intensity values to facial expressions

Each facial expression can be again rated according to the intensity with which they are expressed. There is a concept of mixed feelings which still a major challenge. Rating the nearest expression intensity will definaltely help in identifying the Sentiment which will be closest to the real life situation.

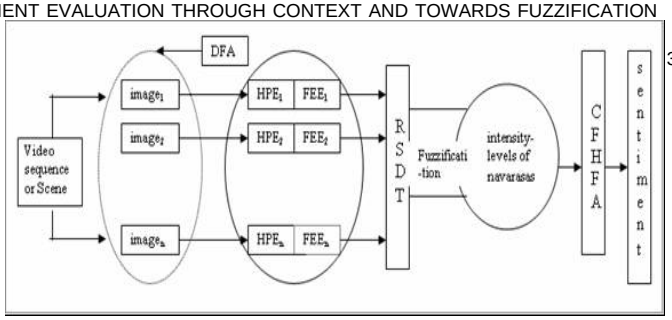

Fig. 4. Revised version of Model proposed. An Architecture to intensify the levels of expressions in order to extract unstable feelings. DFA: Data Flow Diagram, HPE: Hand Posture Extraction, FEE: Facial Expression Extraction, RSDT: Rough Set Decision Table, CFHFA: Context Facial Expression Hand Gesture Fusion Algorithm.

In our next paper we have proposed the revised model as shown in figure 4 where we are trying to fuzzify the intensity of each facial expression. We are calling this as intensity levels of each rasa expressed by the dancer. This will resolve the ambuity to extract more sentiments and also resolve the problem of usage of mudra to depict that narration.

7 Conclusion

From the datasets used in the experimentation, it is clear that the second strategy degrades the result from the first. To compare, there is improvement through the FHFA model (Strategy 3) which is first stage of our model by 9.24%. However, the result improves greater by 12.26% with respect to Strategy 3 from the CFHFA (Strategy 4), which acts as the output of the proposed model.

This Model can be used by Bharat Natyam Gurus to evaluate their student's proper usage of mudra and its expressions while Strategy 4 can be used for proper coordination of the entire dance sequence narrating the scene. It can also be used for phycatric evaluation to judge the intensity (fuzzy) of an expression for same scenario. If all gestures included, it can give amazing results for Parkinson's patient.

This approach if extended with audio effects can be used in the interpretation of behavior of an infant baby and in many such artificial intelligent exclusive applications.

Acknowledgment

This is the research work associated to the PhD work going on Under Devi Ahilya University, Indore, and College of Engineering, Pune. My sincere thanks the centre and their faculty for their extensive support.

References

[1] M. Pantic, L.J.M. Rothkrantz, "Facial gesture Recognition in face image sequences: A study on facial gestures typical for speech articulation", Delft University of Technology.

[2] Ayesha Butalia, A.K Ramani, Parag Kulkarni, "Facial Expression Recognition", [6] Ahmad Rabie, Britta Wrede, Thurid Vogt, Marc Hanheide, Evaluation and Discussion of Multi-modal Emotion Recognition, 978-0-7695-3925-6/ 2009 IEEE DOI 10.1109/ICCEE.2009.192.

[3] Turk, M. A. and A. P. Pentland, "Face recognition using eigenfaces", in Proc. IEEE Conf. CVPR, June 3-6, 1991, pp.586-591.

[4] Brunelli, R. and T. Poggio, "Face recognition: features versus templates," IEEE Trans. Pattern Analysis and Machine Intelligence, Vol.15, No.10, pp.1042-1052, 1993.

[5] W. T Freeman and M. Roth, "Orientation histograms for hand gesture recognition", Tech. Rep. TR-94-03a, Mitsu Mitsubishi Electric Research Laboratories, Cambridge Research centre, Cambridge, Mass, USA, 1995.

[6] A.M. Burton, S. Wilson, M. Cowan, V. Bruce, "Face recognition in poor-quality video: Evidence from Security S urveillance", Psychological Science, Vol. 10, No. 3, May 1999, pp. 243-248.

[7] Triesch J. and Malsburg C. V. D, "A Gesture Interface for Human-Robot Interaction", Proc. of 3th IEEE Intl. Conf. on Automatic Face and Gesture Recognition, pp. 546-551. 1998.

[8] Z.Pawlak, "Rough Sets", International Journal of Computer and Information Sciences, Vol.11, 341-356(1982).

[9] P. Pramod Kumar, Prahlad Vadakkepat, Loh Ai Poh, "Hand Posture And Face Recognition Using A Fuzzy-Rough Approach", International Journal of Humanoid Robotics, Vol. 7, No. 3 (2010) 331–356.

[10] Lakshmi Amman, Homepage, Mudras, Hastàbhinaya (Hah-stah-bin-a-yah), Hand Gestures, Febraurary 2002.
http://www.generalism.net/lakshmi/Dance/mudras.html

[11] Allan, Barbara, The Definitive Book of 'Body Language', ISBN 978-81-8322-014-9.

[12] Prof. Ayesha Butalia, Dr. A.K. Ramani, Dr. Parag Kulkarni, Emotion Recognition System at NCICT'10, National conference on Information and Communication Technology organized by NYSS College of Engg and Research during 23rd -24 Dec. 2010.

[13] A. Skowron, N. Zhong, and N. Cercone Computational Intelligence, An International Journal, Special Issue on Rough Sets, Data Mining, and Granular Computing.

[14] Prof. Ayesha Butalia, Dr. A.K. Ramani, Dr. Parag Kulkarni, Emotional Recognition and towards Context based Decision, International Journal of Computer Applications (IJCA), USA, November2010 issue Volume 9, number 3/1362-1838.

[15] Prof. Ayesha Butalia, Dr. A.K. Ramani, Dr. Parag Kulkarni, Ms. Manjari Bangali, Improving interaction using context in gesture recognition system at National Conference NCGIT'11 at Truba COE, Indore during 28-29th April 2011.

[16] J. Grzymala-Busse, R. Swiniarski, N. Zhong, and Z. Ziarko International Journal of Applied Mathematics and Computer Science, Special Issue on Rough Sets and Its Applications.

[17] Z. Ziarko Fundamental Informaticae, An International Journal, Vol.27, No. 2-3, Special Issue on Rough Sets (1996).

[18] H. S Nguyen and S.H Nguyen, "Discretization Methods in Data Mining", Vol.1, 451-482, Physica-Verlag (1998).

[19] Prof. Ayesha Butalia, Guesture Recognition System at International Conference on Futuristic Computer Applications is to be held in IISc Bangalore tied up with ACM, USA, on 20-21 March, 2010.

[20] Prof. Ayesha Butalia, Agricultural Data analysis through Reduct Entropy Method at International Journal on Futuristic Computer Applications is to be held in IISc Bangalore tied up with ACM, USA, on 20-21 March, 2010.

[21] T.Y Lin, Journal of Intelligent Automation and Soft Computing, Vol.2, No. 2, Special Issue on Rough Sets (1996).

[22] Caroline Hummels, Pieter Jan Stappers, Meaningful Gestures for Human Computer Interaction: Beyond Hand Postures, Third IEEE International Conference on Automatic Face & Gesture Recognition (FG'98). April 14-16, 1998 in Nara, Japan. Los Alamitos: IEEE Computer Society Press. Copyright 1998 IEEE, pp. 591-596.

[23] Sijith, "Navarasas-Expressions in BharatNatyam", Reflections in the Mind's Eye, & Views. Through The Lens, Journeys & the Joie de Vivre!, December 09, 2007.

[24] B. Stenger P. R. S. Mendonc¸a R. Cipolla, "Model-Based 3D Tracking of an Articulated Hand", In proc. British Machine Vision Conference, Manchester, UK, September 2001.

[25] Bernard Boulay, Francois Bremond, Monique Thonnat, "Human Posture Recognition in Video Sequence", INRIA Sophia Antipolis, France.

[26] Xu Xu, Jie Lin and Dongming Xu, "Mining Pattern of Supplier with the Methodology of Domain-Driven Data Mining", FUZZ-IEEE, Korea, August 20-24, 2009.

[27] Deng, Lawrence Y. Dong-Liang Lee Huan-Chao Keh Yi-Jen Liu," Shape context based matching for hand gesture recognition", Frontier Computing. Theory, Technologies and Applications, 2010 IET International Conference on, 4-6 Aug. 2010

[28] Elena Sánchez-Nielsen, Luis Antón-Canalís, Mario Hernández-Tejera, "Hand Gesture Recognition for Human-Machine Interaction".

Ayesha Butalia She is persuing PhD from Devi Ahilya University, Indore. She has been the University Topper in Masters for Computer Science and Engineering, specialization in Information Technolgy from VIT, Pune in 2008. She holds Junior Diploma in French language from Nagpur University. She also holds Certification of IBM-ACE, DB2, RSA, Rational Rose and many more.

She is currently working as a Associate Professor in Maharashtra Institute of Technology, College of Engineering, Pune. She has around twelve years of experience in teaching, training, and also a research associate in an Export Oriented Unit of Research and Computing firm. Effecitve teaching of seventeen different subjects related to engineering in Computer and Information technology. Area of specialization includes data base management, distributed systems, machine learning, artificial intelligence, Data mining and software engineering. She is recipient of Best paper presentation award in two conferences organized by IEEE.

Ayesha has authored two books with international publication. She has authored more than 50 research papers. She has practiced Bharat Natyam and Kuchipudi for around 11 years under the Gurus Mrs. Ratnam Janardhan and Mrs. Usha Keswan, Nagpur. The images for the dataset prepared are of the author itself.

Late A.K Ramani He was Professor & Head SCS, Chair Planning Committee at Devi Ahilya Vishwa Vidyalay Indore. Before that he was in R & D at ISRO, Associate Professor at UPM (1995-99). He was invited as keynote speaker in different conference in India and abroad. He had held workshop on Assessment & Accreditation. He is author of a book on Advance Computer Architecture. He was incharge of the project which were executed based on Information Systems for Hospital, Muncipal Corporation, Police etc. He was recipient of Dr. Radhakrishnan Award for best research paper (1993), and SICE Scholarship, Japan.

Maya Ingle Currently working as Professor at Devi Ahilya Vishwa Vidyalaya, Indore.

Parag Kulkarni Received Ph.D. degree in Computer Science and Engineering from IIT, Khargpur in 2001. He holds Masters Certification in strategic management–from IIM Calcutta. He received D.Sc. – Higher doctorate for his research and professional achievements from Monarch – Switzerland in 2010.
He is CEO and Chief Scientist at EKLaT Research, Pune. He has close to two decades of teaching, research and Management experience. During this period he headed research labs/groups at product companies like Capsilon, Siemens, IDeaS and worked as CEO, principal scientist, and senior scientist. His areas of interest and research include machine learning, AI, IT Strategy, IT Security, Text Mining, Knowledge Management, systemic learning, forecasting, distributed computing and document management. He is recipient of several awards including Oriental Foundation Scholarship, Research Contribution awards.
He is/was associated as adjunct professor, visiting researcher and

Visiting Professor at Pune University, IIM, Masaryk University and many other Technical Schools and B-schools of repute. Parag co-authored two books and his three books are in press. He co-authored more than 100 research papers. He is/was member of editorial board of SCIT – Technical Journal, International journal for advanced computing and knowledge discovery (IJACKD) and member of program and technical committees for various international and national conferences and boards including IICAI, NCDC, Conference on AI Tools, IASTED, WSEAS, etc. Dr. Parag Kulkarni Director EkLaT Research Centre and also as Adjunct Professor at College of Engineering Pune, and Pune Institute of Computer Technology.