2.0 SELF APPRAISAL REPORT ON COGNTIVE SCIENCE

This workgroup involves three related areas, which are

1. Cognitive Cybernetics and Neuro-Rehabilitative Robotics
2. Philosophy of Cognition
3. Cognitive psychology

2.1 Self Appraisal Report on *Cognitive Cybernetics and Neuro-Rehabilitative Robotics*

2.1.1 Contributing Faculty Members

1. **Amit Konar**, Department of Electronics and Tele-Communication Engineering, Jadavpur University, Journal Publications –63, Conference Publications – 250, Patents – 4, H Index –25, Cumulative Impact Factor – 95, Total Citations –3210, Awarded and ongoing doctoral thesis guidance – 15 + 8, Awarded and ongoing Masters thesis guidance –85 + 16.

2. **Aruna Chakraborty,** Visiting Faculty, M.Tech. Course in Intelligent Automation and Robotics, Department of Electronics and Tele-Communication Engineering, Jadavpur University, Journal Publications – 6, Conference Publications – 40, H Index – 6 , Cumulative Impact Factor – 10, Total Citations – 160, Awarded and ongoing doctoral thesis guidance – 1 + 1, Awarded and ongoing Masters thesis guidance – 4 + 4.

2.1.2 Special Achievements

1.**Amit Konar,**
Recipient of 1997-2000 Career Award for Young Teachers, offered by AICTE,
Fellow, West Bengal Academy of Engineering, 2010,
Associate Editor: IEEE Transactions on Fuzzy Systems for the period: 2012-till date,
Associate Editor, IEEE Trans. On Systems, Man and Cybernetics for the period: 2010-2012,
Associate Editor, Neuro-computing, Elsevier for the period: 2009-till date,
Associate Editor Applied Soft Computing, Elsevier for the period 2013 onwards,
Editor-in-Chief Int. J. of Artificial Intelligence and Soft Computing for the period 2009-2012.

2. **Aruna Chakraborty**,
Associate Editor, Int. J. of Artificial Intelligence and Soft Computing for the period 2009-till date.

2.1.3 Relevant Projects in Last 10years including the Ongoing Projects

Project Title	**Sponsoring Agency**	**Members**	**Grant Value (Rs in Lakh)**	**Duration**
UPE-I Project in Cognitive Science	UGC	Amit Konar (Co-PI),	35 lakhs	Year 2008-2012
UPE-II Project in Cognitive Science	UGC	Amit Konar (PI),	2 crores	YEAR 2013-continuing

2.1.4 Relevant Publications in Last 5years

Books

1. Swagatam Das, Ajith Abraham, and Amit Konar, *Metaheuristic Clustering*. Vol. 178. Springer, 2009. **Citation** 42.

2. Aruna Chakraborty and Amit Konar, *Emotional Intelligence: A Cybernetic Approach*, Springer, September 2009. **Citation 18**

3. Amit Konar, and Aruna Chakraborty, (Eds.),*Emotion Recognition: A Pattern Analysis Approach*, Wiley-Blacwell, 2014 (to appear).

4. Amit Konar, and Sumantra Chakraborty, *Abduction: Reasoning with Type-1 and Type-2 Fuzzy Sets*, Springer, Heidelberg, 2014 (to appear)

5. Amit Konar, D. Tibarewala, Suagat Bhattacharyya and Anwesha Khasnobish, *Non-Invasive Human-Computer Interface for Rehabilitative Applications*, Series Title: Biosystems & Biorobotics, Springer, Heidelberg, Germany (Accepted), 2014 (to appear)

Book Chapters

6. Anisha Halder, Amit Konar, Aruna Chakraborty and Rajshree Mandal, "Emotion Recognition from Facial Expressions Using Type-2 Fuzzy Sets", In *Emotion Recognition- A Pattern Analysis Approach*, Wiley-Blackwell, 2014 (to appear).
7. Amit Konar, Aruna Chakraborty and Anisha Halder, "A Review of Pattern Recognition Techniques", In *Advances in Emotion Recognition -A Pattern Analysis Approach*, Wiley-Blackwell, 2014 (to appear).
8. A. Chakraborty and A. Konar, "Stability and Chaos in Cognitive Reasoning," In *The Handbook on Reasoning-Based Intelligent Systems*, J. Nakamatshu (ed.), World Scientific, 2013.
9. R. Kar, A. Konar and A. Chakraborty, "Computing with Word Model for Emotion Recognition Using Interval Type-2 Fuzzy Sets,"In *Synthesizing Human Emotion in Intelligent Systems and Robotics, IGI Global.* (Accepted).
10. R. Kar, A. Konar and A. Chakraborty, "EEG-Analysis for the Detection of True Emotion/Pretension," In *Synthesizing Human Emotion in Intelligent Systems and Robotics, IGI Global.* (Accepted).
11. Anisha Halder, Srishti Shaw, Kanika Orea, Pavel Bhowmik, Aruna Chakraborty, and Amit Konar, "*A Computational Intelligence Approach to Emotion Recognition from the Lip Profile of a Subject*," In *Computational Intelligence in Image Processing*, Springer Amitava Chatterjee and Patrick Siarry (Eds.), 2013.
12. Rajshree Mandal, Anisha Halder, Amit Konar and Atulya K. Nagar, "A Fuzzy Condition Sensitive Hierarchical Algorithm for Approximate Template Matching in Dynamic Image Sequence", In *Computational Intelligence in Image Processing*, Springer Amitava Chatterjee and Patrick Siarry (Eds.), 2013.

13. A. Konar, A. Chakraborty, P. Bhowmick, Souvick Das and A. Halder, “Emotion Recognition from facial expression, voice and EEG signals,” In *Cross-Disciplinary Applications of Artificial Intelligence and Pattern Recognition: Advancing Technologies*, V. K. Mago and N. Bhatia (eds.), IGI Global, 2012.
14. K. Bakshi, S. Chandra, A. Konar and D. N. Tiberawala, “Hand Tremor Prediction and Classification Using Electromyogram Signals to Control Neuro-Motor Instability,” In *Cross-Disciplinary Applications of Artificial Intelligence and Pattern Recognition: Advancing Technologies*, V. K. Mago and N. Bhatia (eds.), IGI Global, 2012.
15. S. Sikdar, A. K. Pal, V. Talukdar and A. Konar, “Biclustering of Gene Microarray Data Using Multi-objective Evolutionary Optimization Algorithms,” In *Recent Trends in Computational Biology and Computational Statistics Applied in Biotechnology and Bioinformatics*, Ajit K. Roy (ed.), New India Publishing Agency, New Delhi, 2012.
16. A. Acharya and A. Konar, “An improved Ant colony optimization algorithm for better speed up and accuracy,” In *Swarm Intelligence Handbook*, L. M. Hiot,Y. Shi and B. K. Panigrahi, (eds.), Springer, 2011.

Journal Publications

1. Pratyusha Rakshit, Amit Konar, Pavel Bhowmik, Indrani Goswami, Swagatam Das, Lakhmi C. Jain, Atulya K. Nagar,“Realization of an Adaptive Memetic Algorithm Using Differential Evolution and Q-Learning: A Case Study in Multirobot Path Planning,”*IEEE T. Systems, Man, and Cybernetics: Systems,* 43(4): 814-831 (2013).**IF=2.183 ,Citation=3.**
2. Anisha Halder, Rajshree Mandal, Amit Konar,“A hierarchical algorithm for fuzzy template matching in emotional facial images,”*Journal of Intelligent and Fuzzy Systems,*24(2): 201-214 (2013). **IF= 0.788,Citation=1.**
3. Rakshit, Pratyusha, Amit Konar, Swagatam Das, Lakhmi C. Jain, and Atulya K. Nagar,"Uncertainty Management in Differential Evolution Induced Multiobjective Optimization in Presence of Measurement Noise,"*IEEE Trans. Systems, Man, and Cybernetics: Systems,* 2014 (to appear).**IF= 2.183.**
4. Saugat Bhattacharyya, Abhronil Sengupta, Tathagata Chakraborti, Amit Konar, D. N. Tibarewala,“Automatic feature selection of motor imagery EEG signals using differential evolution and learning automata,”*Med. Biol. Engineering and Computing,*52(2): 131-139 (2014), 2014.**IF=1.79.**
5. Anisha Halder, Amit Konar, Rajshree Mandal, Aruna Chakraborty, Pavel Bhowmik, Nikhil R. Pal, Atulya K. Nagar,“General and Interval Type-2 Fuzzy Face-Space Approach to Emotion Recognition,”*IEEE T. Systems, Man, and Cybernetics: Systems,*43(3): 587-605 (2013).**IF= 2.183, Citation=1.**
6. Amit Konar, Indrani Goswami, Sapam Jitu Singh, Lakhmi C. Jain, Atulya K. Nagar,“A Deterministic Improved Q-Learning for Path Planning of a Mobile Robot,”*IEEE T. Systems, Man, and Cybernetics: Systems,*43(5): 1141-1153 (2013).**IF=2.183.**
7. A. Chakraborty, Amit Konar, Nikhil R. Pal, Lakhmi C. Jain,“Extending the Contraposition Property of Propositional Logic for Fuzzy Abduction,”*IEEE T. Fuzzy Systems,*21(4): 719-734 (2013).**IF=5.484,Citation=1.**

8. Anisha Halder, Amit Konar, Rajshree Mandal, Aruna Chakraborty, Pavel Bhowmik, Nikhil R. Pal, Atulya K. Nagar,*"General and Interval Type-2 Fuzzy Face-Space Approach to Emotion Recognition,"IEEE T. Systems, Man, and Cybernetics: Systems,*43(3): 587-605 (2013).**IF=2.183,Citation=1.**

9. Anisha Halder, Aruna Chakraborty, Amit Konar and Lakhmi C. Jain, "A New Approach to Emotion Recognition from the Lip Contour of a Subject,"*Journal of Artificial Intelligence and tools,* 2012.**IF=0.25.**

10. V. Talukdar, A. Konar, S. Paria, S. Maity, T. K. Pal, "A new approach to gene prediction, based on the self-organizing map,"*International Journal of Medical Engineering and Informatics,* vol. 2, no. 2, pp. 107 - 121, 2010.

11. Veera Talukdar, Amit Konar, Shibram Paria, Subhasis Maity, Tapas Kumar Pal, "A new approach to gene prediction, based on the self-organising map," *International Journal of Medical Engineering and Informatics,* Volume 2, Number 2,pp. 107 - 121 , October. 2010.

12. Rajshree Mandal, Anisha Halder, Pavel Bhowmik, Aruna Chakraborty, Amit Konar and Nikhil R. Pal, "General and Interval Type-2 Fuzzy Face-Space Approach to Emotion Recognition,"*IEEE Trans. on Systems, Man and Cybernetics,* Mar. 2011.**IF= 2.183, Citation=1.**

13. P.Bhowmik, Souvick Das, A. Konar, D. Nanda and A. Chakraborty, "Emotion Clustering from the Stimulated Electroencephalographic Signals Using a Duffing Oscillator,"*Int. J. of Computers in Healthcare,* vol.1, no.1, 2010. **IF=1.55, Citation=2.**

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List of Conference Publications

1. Saugat Bhattacharyya, Pratyusha Rakshit, Amit Konar, D. N. Tibarewala, Swagatam Das, Atulya K. Nagar,"Differential evolution with temporal difference Q-learning based feature selection for motor imagery EEG data,"*CCMB 2013: 138-145.*

2. A. G. Roy, Pratyusha Rakshit, Amit Konar, Samar Bhattacharya, Eunjin Kim, Atulya K. Nagar,"Adaptive Firefly Algorithm for nonholonomic motion planning of car-like system,"*IEEE Congress on Evolutionary Computation 2013*: 2162-2169.

3. Pratyusha Rakshit, Amit Konar, Eunjin Kim, Atulya K. Nagar: DEMO-TDQL,"An adaptive multi-objective optimization algorithm,"*IEEE Congress on Evolutionary Computation 2013,* 3095-3102.

4. Pratyusha Rakshit, Amit Konar, Archana Chowdhury, Eunjin Kim, Atulya K. Nagar,"Muti-objective evolutionary approach of ligand design for protein-ligand docking problem,"*IEEE Congress on Evolutionary Computation 2013,* 237-244.

5. Kingshuk Chakravarty, Diptesh Das, Ankur Sinha, Amit Konar,"Feature selection by Differential Evolution algorithm - A case study in personnel identification,"*IEEE Congress on Evolutionary Computation 2013,* 892-899.

6. Sriparna Saha, Shreya Ghosh, Amit Konar, Atulya K. Nagar,"Gesture Recognition from Indian Classical Dance Using Kinect Sensor,"*CICSyN 2013,* 3-8.

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11. Ramadoss Janarthanan, Aruna Chakraborty, Amit Konar, Atulya K. Nagar,"Ad hoc reasoning in chained fuzzy systems realized with Diens-Rescher implication,"*FUZZ-IEEE 2013,* 1-6.

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15. Soumyadip Chatterjee, Saugat Bhattacharyya, Amit Konar, D. N. Tibarewala, Anwesha Khasnobish, Ramadoss Janarthanan,"Performance Analysis of Multiclass Common Spatial Patterns in Brain-Computer Interface.," *PReMI 2013,* 115-120.

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2.1.5 Relevant Patents in Last 5years

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2.1.6 Facilities Available

a) **JACO Robot Arm**, Year of Installation-2012, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

b) **Functional Near Infrared Spectroscopy Machine**, Year of Installation-2013, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

c) **Kinect Sensor and Xbox-360,** Year of Installation-2012, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

d) **Affectiva Q-Sensor (Galvanic Skin Resistance Meter):** Year of Installation-2012, Place of installation- School of Cognitive science, JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

e) **Emotive Research Edition EEG System (Two):** Year of Installation-2012, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

f) **PPS Tact Array Sensor (Tactile array Sensor):** Year of Installation-2012, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

g) **Tekscan Palm Pressure Sensor:):** Year of Installation-2013, Place of installation- Control Engineering Lab, ETCE Dept., JU, Purchased under UGC-UPE-II Program, Departments within the University and outside served- ETCE dept, School of Cognitive Science and School of Bioscience and Engineering, Jadavpur University.

2.1.7 Ongoing Work under UPE II – 2012-14

1. Title: ***General and Interval Type-2 Fuzzy Face-Space Approach to Emotion Recognition.***
Authors: Amit Konar, Aruna Chakraborty and Anisha Halder

Abstract: Facial expressions of a person representing similar emotion are not always unique. Naturally, the facial features of a subject taken from different instances of the same emotion have wide variations. In the presence of two or more facial features, the variation of the attributes together makes the emotion recognition problem more complicated. This variation is the main source of uncertainty in the emotion recognition problem, which has been addressed here in two steps using type-2 fuzzy sets. Both interval and general type-2 fuzzy sets (GT2FS) have been used separately to model the fuzzy face space. The interval type-2 fuzzy set (IT2FS) involves primary membership functions for m facial features obtained from n-subjects, each having l-instances of facial expressions for a given emotion.

The uncertainty management policy adopted using GT2FS has resulted in a classification accuracy of 98.333% in comparison to 91.667% obtained by its interval type-2counterpart. A small improvement (approximately 2.5%) in classification accuracy by IT2FS has been attained by pre-processing measurements using - the well-known interval approach.

Conclusions

- The IT2FS-based recognition scheme takes care of the inter subject level uncertainty in computing the maximum support of individual emotion class.
- The GT2FS-based recognition scheme, however, takes care of both the inter- and intra-subject level uncertainty, and thus offers higher classification accuracy for the same set of features. Using three data sets, the classification accuracy obtained by employing GT2FS is 98.333%, by IT2FS is 91.667%, and by IA-IT2FS is 94.167%.
- The more the number of subjects used for constructing the fuzzy face space, the better would be the fuzzy face space, and thus better would be the classification accuracy.

2. Title: A Deterministic Improved Q-Learning for Path Planning of a Mobile Robot
Authors: Amit Konar and Sapam Jitu Singh

Abstract: This paper provides a new deterministic Q-learning with a presumed knowledge about the distance from the current state to both the next state and the goal. This knowledge is efficiently used to update the entries in the Q-table once only by utilizing four derived properties of the Q-learning, instead of repeatedly updating them like the classical Q-learning. Naturally, the proposed algorithm has an insignificantly small time complexity in comparison to its classical counterpart. Furthermore, the proposed algorithm stores the Q-value for the best possible action at a state and thus saves significant storage. Experiments undertaken on simulated maze and real platforms confirm that the Q-table obtained by the proposed Q-learning when used for the path-planning application of mobilerobots outperforms both the classical and the extended Q-learning with respect to three metrics: traversal time, number of states traversed, and 90° turns required. The reduction in 90° turnings minimizes the energy consumption and thus has importance in the robotics literature.

Conclusions

- The paper proposed an alternative algorithm for deterministic Q-learning, presuming that the background knowledge about the distance from the current state to both the next state and the goal state are available.
- The proposed algorithm updates the entries of the Q-table only once unlike the CQL, where the entries in the Q-table were updated many times until convergence was ensured. This results in a significant saving in the time complexity of the order of mn in comparison to the CQL, where n and m are the number of states and number of actions at each state, respectively.

3. **Title: Uncertainty Management in Differential Evolution Induced Multiobjective Optimization in Presence of Measurement Noise**

Authors: Pratyusha Rakshit and Amit Konar

Abstract: This paper aims at designing new strategies to extend traditional multi objective optimization algorithms to efficiently obtain Pareto-optimal solutions in presence of noise on the objective surfaces. The first strategy, referred to as adaptive selection of sample size, is employed to balance the tradeoff between quality measure of fitness and run-time complexity. The second strategy is concerned with determining statistical expectation, instead of conventional averaging, of fitness samples as the measure of fitness of the trial solutions. The third strategy attempts to extend Goldberg's method to compare slightly worse trial solutions with its competitor by a more statistically viable comparator to examine possible placement of the former solution in the Pareto optimal front. The traditional differential evolution for multi-objective optimization algorithm has been modified by extending its selection step with the proposed strategies. Experiments undertaken to study the performance of the extended algorithm reveal that the extended algorithm outperforms its competitors with respect to three performance metrics, when examined on a test suite of 23 standard benchmarks with additive noise of three statistical distributions. The extended algorithm has been applied on the well-known box-pushing problem, where the forces and torques required to shift the box by two robots are evaluated to jointly satisfy the conflicting objectives on task-execution time and energy consumption in presence of noise on range estimates from the sidewalls of the workspace.

Conclusions

- The adaptive selection helps in optimizing run-time complexity of the noisy MOO algorithm without losing qualitative solutions.
- The expected value of sample fitness offers a better measure of the fitness for a given trial solution than the averaged value.

4. Title: Realization of an Adaptive Memetic Algorithm Using Differential Evolution and Q-Learning: A Case Study in Multirobot Path Planning.

Authors: Pratyusha Rakshit and Amit Konar

Abstract: Memetic algorithms (MAs) are population-based meta-heuristic search algorithms that combine the composite benefits of natural and cultural evolutions. An adaptive MA (AMA) incorporates an adaptive selection of memes (units of cultural transmission) from a meme pool to improve the cultural characteristics of the individual member of a population-based search algorithm. This paper presents a novel approach to design an AMA by utilizing the composite benefits of differential evolution (DE) for global search and Q-learning for local refinement. Four variants of DE, including the currently best self-adaptive DE algorithm, have been used here to study the relative performance of the proposed AMA with respect to runtime, cost function evaluation, and accuracy (offset in cost function from the theoretical optimum after termination of the algorithm). Computer simulations performed on a well-known set of 25 benchmark functions reveal that incorporation of Q-learning in one popular and one outstanding variants of DE makes the corresponding algorithm more efficient in both runtime and accuracy. The performance of the proposed AMA has been studied on a real-time multi robot path-planning problem. Experimental results obtained for both simulation and real frameworks indicate that the proposed algorithm-based path-planning scheme outperforms the real-coded genetic algorithm, particle swarm optimization, and DE, particularly its currently best version with respect two standard metrics defined in the literature.

Conclusions

- A relative comparison of the proposed technique with four variants of DE algorithms, including Sa DE (the currently known best performing DE), envisages that the proposed DE-TDQL algorithm outperforms all its competitors with respect to accuracy and runtime required for convergence. A set of 25 CEC'2005 benchmark functions proposed by Suganthan has been used to arrive at the foregoing conclusions.
- Besides the foregoing, one more fundamental claim of this paper is that if TDQL is used to select scaling factors of any variants of DE, the modified algorithm would outperform its fundamental counterpart in both accuracy and convergence time.
- The experiments undertaken reveal that the DE-TDQL-based AMA outperforms the classical DE and PSO, real-coded GA, and SaDE algorithms with respect to two parameters AUTD and ATPD. The experiments performed with Khepera II mobile robots also indicate that DETDQL- based AMA outperforms other realizations in a real environment, thereby satisfying the efficacy of the proposed algorithm.

5. **Title: Extending the Contraposition Property of Propositional Logic for Fuzzy Abduction.**
Authors: Aruna Chakraborty and Amit Konar

Abstract: Abduction deals with assumption-based reasoning to explain an observation. In the context of fuzzy reasoning, abduction attempts to determine the membership function of the fuzzy propositions present in the antecedent of a rule when the membership functions for the propositions in the consequent of the rule are given. Currently available models of fuzzy abduction are capable of inferring the membership function of the antecedent clause accurately when the antecedent includes single fuzzy proposition. However, when the antecedent clause of a rule contains multiple fuzzy propositions, these models fail to determine the independent membership function of the individual propositions present in the antecedent.

This paper presents a new formulation to handle the above problem by fuzzy extension of the well known contraposition property of propositional logic. Several interesting properties dueto the fuzzy extension of the classical contraposition have been derived. An algorithm for automated abduction using the extended contraposition property has been developed to demonstrate the principle of abduction with rules containing one or more fuzzy propositions in the antecedent/consequent. The time complexity of the proposed fuzzy abduction for a sequence of n-chained rules, where each rule has m fuzzy propositions, is O (mn), considering a uniform cost for composition operation and t-norm computation of the antecedent.

Conclusions

- The extensive computations required in evaluating fuzzy inverse relations (with respect to max-min composition operator) to obtain abductive inferences can be avoided by the proposed approach.
- Special emphasis is given here to retrieval of MFs due to abduction. Conditions for abductive retrieval for simple rules with single fuzzy proposition in both antecedent and consequent and complex rules with multiple propositions in the consequent have been derived.
- A complexity analysis reveals that for n rules each with m fuzzy propositions, we need to evaluate (m × n) number of relational matrices. Consequently, time complexity of the abductive reasoning algorithm is O(mn), presuming a uniform cost for composition operation and t-norm computation for the antecedent.

6. **Title: Bypassing the Natural Visual-Motor Pathway to Execute Complex Movement Related Tasks Using Interval Type-2 Fuzzy Sets**
Authors: Anwesha Khasnobish and Amit Konar

Abstract: The human brain processes visual stimuli representative of complex motion-related tasks at the occipital lobe to generate the necessary neuronal signals for the parietal lobe, which in turn generates smart movement related plans to excite the motor cortex to execute the actual tasks. The paper introduces a novel approach with an aim to provide rehabilitative support to patients suffering from neurological damage in their parietal and/or motor cortex regions. An attempt to bypass the natural visual-motor pathway is undertaken using interval type-2 fuzzy sets to generate the approximate EEG response of the damaged parietal/motor cortex from occipital EEG signals. The approximate EEG response is used to trigger a pre-trained junction coordinate generator to obtain

three different junction coordinates of the task-planner. A robot arm is employed to move each link end-points to the desired locations in the reference coordinate system by appropriately activating its links using the well-known inverse kinematics approach. The mean-square positional errors obtained for each link is found within acceptable limits for all experimental subjects, indicating a possible impact of the proposed approach in rehabilitative robotics. Subjective variation in EEG features over different sessions of experimental trials is modeled here using interval type-2 fuzzy sets for its inherent power to handle uncertainty. Experiments undertaken confirm that interval type-2 fuzzy realization outperforms its classical type-1 counterpart and back-propagation neural approaches in all experimental cases.

Conclusion:

- Experiments undertaken confirm that although the neural approach has comparable performance in occipital to parietal/motor cortex feature mapping, it performs poorly in presence of noise in the EEG features.
- The proposed type-2 fuzzy logic based feature prediction in the motor cortex (or parietal) lobe from the EEG features in occipital lobe makes sense for its better performance in both feature mapping and prohibiting the infiltration of noise in the predicted feature space.
- The proposed scheme thus has immense scope in the next generation rehabilitation engineering.

7. **Title: Motor Imagery and Error Related Potential Based Position Control System for a Robot Arm**

Authors: Saugat Bhattacharyya and Amit Konar

Abstract: The paper proposes three novel schemes for EEG-driven position control of a robot arm by utilizing motor imagery and error-related potentials of the subject for respective actuation of the robotic links and their necessary alignment with desired target positions. The architectural difference in the proposed three schemes is introduced to maintain a trade-off between user-freedom and design complexity. In the first scheme, the subject imagines desired movements of the robotic links in a fixed (given) order. The scheme has the least design complexity as it requires decoding of motor imagery and error-related potentials only, but need not decode link addresses. In the second scheme, the subject randomly plans movements of any links in any order; consequently we require a link address classifier (decoder) along with motor imagination and error-related potential classifiers as used in the first scheme. The second scheme thus has more complexity than the first scheme to provide better user-freedom in random link selection. In the third scheme, the subject plans his own limb movements, and a robot is commanded to copy the actions of the subject by moving its corresponding links as planned by the subject. A support vector machine classifier is used for decoding of motor imagination and error-related potential with high classification accuracy above 85% in all the three schemes. A radial basis function neural net is used to decode link address from motor imagination with above 90% classification accuracy. The decoding and execution of control intentions for the complete movement of three links of a robot is performed within 57, 35.5 and 29.45 seconds for the proposed three schemes respectively.

Conclusions

- Experiments undertaken indicate that SVM classifiers yield an average classification accuracy of 96.45 %, 97.62 % and 98.96 % respectively for the first, second and the third schemes,

when used in motor imagery classification. It offers a high accuracy over 85% in error classification.

- The controller performance has been measured using settling time, steady-state error and peak overshoot, and their respective values for the third scheme are 28 seconds, 0.024% and 2.5% respectively.
- The third scheme is designed for rehabilitative applications, and experiments undertaken reveal that it serves real-time applications for its fast reaction time (of the order of 1 second).

8. **Olfaction Recognition by EEG Analysis Using Differential Evolution Induced Hopfield Neural Net**
AuthorsAnuradha Saha and Amit Konar

Abstract*:*The paper proposes a novel approach to recognize smell stimuli from the electroencephalogram (EEG) signals acquired during the period of inhalation. The main contribution of the paper lies in feature selection by an evolutionary algorithm and pattern classification by Differential Evolution induced Hopfield neural network. One additional merit of the work lies in data point reduction by Principal component analysis. Experiments undertaken on 25 subjects with 10 smell stimuli indicate that the proposed scheme of feature selection, data point reduction and classification outperforms the traditional approach by a wide margin. Experimental results confirm that the smell stimuli excites the pre frontal lobe of the human brain and is responsible for a special type of brain rhythms (EEG signal) in alpha-band, theta-band and delta-band.

Conclusions

- Experimental instances for 10 different smell stimuli have been used to validate the proposed olfaction recognition scheme.
- The wavelet coefficients and PSD features have been found to give best results of classification accuracy irrespective of classifier. Further, the above two features when fed to the proposed Hopfield-DE classifier yields the best classification accuracy, indicating the best performance of the composite feature-classifier system.
- Statistical testing realized by McNemar's test also supports the above statement of multiple patterns describing the smell stimuli.

2.1.8 Work plan during 2014-17

- ***Designing strategies and algorithms for multi-agent Q-learning for Multi-robot Cooperation*** *by Arup K. Sadhu and Amit Konar, Work in progress and paper under preparation.*
- ***EEG-FNIRS Correlation Study for Cognitive Task Analysis Applications*** *by Saugat Bhattacharyya and Amit Konar, Work in progress and paper under preparation.*
- ***Cognitive Failure Detection in Driving by EEG-FNIRS Analysis*** *by Anuradha Saha and Amit Konar, Work in progress and paper under preparation.*
- ***Determining the Brain-Connectivity for Emotion Arousal*** *by Reshma Kar, Amit Konar and Aruna Chakraborty, Work in progress and paper under preparation.*

2.2 Self Appraisal Report on *Philosophy of Cognition*

2.2.1 SELF APPRAISAL REPORT ON *Philosophy of Cognition*

2.1.1 Contributing Members

This group consists of the following members.

1. Professor Emeritus Amita Chatterjee, School of Cognitive Science, Awarded and ongoing doctoral thesis – 4 ongoing, 1 awarded
2. Professor Mihir K. chakraborty
3. Dana sugu
4. Srimoyi Bhattacharya

2.1.2 Special Achievements

1. Professor Emeritus, Amita Chatterjee

1. National Fellow for 2012-2013, Indian Council of Philosophical Research (ICPR).

2. Adviser to the School of Cognitive Science, Jadavpur University (2011 - 2012).

Editor, Journal of Indian Council of Philosophical Research, 2014-2017

2.1.3 Relevant Publications in Last 5years

1. Professor Emeritus Amita Chatterjee

Forthcoming:

1. ‘Brajendranath Seal: A Disenchanted Hegelian’, to be published in an anthology by IIAS, Shimla.
2. ‘What is it like to be a moral being’ in Value and Values: Economics and Justice in an Age of Global Interdependence, eds. Roger T. Ames and Peter D. Hershock, University of Hawaii Press, Honolulu.
3. “From self-ascription to self-knowledge’, to be published in an anthology by the Department of Philosophy, Decent Publications, New Delhi, 2012.
4. ‘Embarrassing suffering, Karma, and Causation’, to be published in an anthology by the Central, Routledge, New Delhi, 2012.
5. Emotion and Affective deficit in patients with Dyshyponoia: A Review, co-authored with Madhushree Chakraborty, Atanu Biswas, Pradeep Chakraborty, Sandip Pal, and Malay Ghosal, CEA 2013, IIT Gandhinagar, 2013.
6. "Naturalism in Classical Indian Philosophy", The Stanford Encyclopedia of Philosophy (Spring 2012 Edition), Edward N. Zalta (ed.), URL =
7. <http://plato.stanford.edu/archives/spr2012/entries/naturalism-india/>.
8. 'Affective Information Processing and Representations', co-authored with Dana Sugu, M.K. Kundu et al. (Eds.): PerMIn 2012, LNCS 7143, pp. 42–49 (2012).

9. ‘Funes and Categorization in an abstraction-free world’, in the Proceedings of the International Conference on Apoha Semantics and Human Cognition, Columbia University Press, USA, 2011, pp. 247-257.
10. ‘Nyaya- Vaisesika Philosophy’, The Oxford Handbook of World Philosophy, eds. J. Garfield and W. Edelglass, Oxford University Press, New York, 2011, pp.112-126.
11. ‘Gärdenfors’ Conceptual Spaces and Affective Representations’, co-authored with Dana Sugu, in International Journal on Humanistic Ideology, Vol. 4 No. 1, Spring-Summer 2011, pp. 11-18
12. ‘Navya-Nyaya Logic’, jointly with Prabal K. Sen, in a special issue on Logic and Philosophy Today, Journal of Indian Council of Philosophical Research, vol xxvii, no.1, 2010, pp.77-99.
13. ‘Where is the knowledge we have lost in information’, in International Journal on Humanistic Ideology, Vol. III, No. 1, Spring-Summer 2010, pp. 49-58.
14. ‘Flashback: Reshuffling Emotions’, co-authored with Dana Sugu, in International Journal on Humanistic Ideology, Vol. III, No. 1, Spring-Summer 2010, pp. 109-134.
15. ‘Assessment of Dyshyponoia in Multicultural Plurilingual Setup’, co-authored with Madhushree Chakraborty, in International Journal on Humanistic Ideology, Vol. III, No. 1, Spring-Summer 2010, pp. 167-180.
16. ‘Introduction’, in The Dawn and Dawn Society, Volume XIV (reprint), ed. Madhabendra Nath Mitra, Jadavpur University in association with National Council of Education Bengal, 2010.
17. ‘Is Belief in Free Will a Cultural Universal?’, co-authored with Shaun Nichols, Joshua Knobe, Smita Sirker, et al., in Mind & Language, Vol. 25, No. 3 June 2010, pp. 346–358.
18. ‘Dinnāga and Mental Models: A Reconstruction’, co-authored with Smita Sirker, to be published in Philosophy East and West, University of Hawai‘i Press, 60:3, July 2010, pp. 315-340.
19. ‘Naturalism in Linguistic Theory’ in International Journal on Humanistic Ideology, Vol. II, No. 1, Spring-Summer 2009, pp. 43-57.
20. An introduction to the chapter on ‘Indian Logic’, co-authored with J. N. Mohanty, in The Development of Modern Logic, ed. Leila Haaparanta, Oxford University Press, USA, April, 2009, pp. 903-905.
21. ‘Emotion Detection from Facial Expressions Using Fuzzy Logic, jointly with Amit Konar et al., IEEE Transactions on Systems, Man and Cybernetics.
22. ‘Buddhist Logic’, in The Development of Modern Logic, ed. Leila Haapranta, Oxford University Press, USA, April, 2009, pp. 916-928.
23. ‘Consciousness: Dominant Metaphors and Research Methods’, in Understanding Consciousness: Recent Advances, Ramakrishna Mission Institute of Culture, Golpark, January, 2009, pp. 225-245.
24. “Marry your daughter to a handsome person”: The Nyaya technique of precisifcation’, co-authored with Mihir. K. Chakraborty, in Logic, Navya-Nyaya & Applications: Homage to Bimal Krishna Matilal, Studies in Logic 15, eds. M. K. Chakraborty, B. Lowe, M. N. Mitra and S. Sarukkai, College Publications, London, UK, 2008, pp. 65-79.
25. ‘How did the Faculty of Language Evolve: A Debate between Chomsky and Pinker’, in Language, Science and Cognition, D. K. Print World, New Delhi, 2009.
26. ‘Navya Nyaya Langauge as a Medium of Science’, in Art, Literature and Aesthetics, PHISPC, Centre for Studies in Civilizations, New Delhi, 2009...

2.1.4 Ongoing Work under UPE II – 2012-14

1. Activity Title: Understanding vagueness in perception, based on experimental studies.
Contributing Persons: Professor Amita Chatterjee and Srimoyi Bhattacharyya.
Target Beneficiaries: This study has no direct benefits to subjects and society, however, otherresearchers may benefit in the future from the information learned in this study.
Abstract: The purpose of this study is to bring out the fuzzy zones in our language and visual perceptions. Based on Bonini et.al's study on the use of vague predicates by Italian people, this study, tests if there is a changed perception of a question by the addition/subtraction of a persuasive/emphatic word, among English and Bengali speakers in India. Whether an additional use of modified predicates will bring about a difference in response will be looked into in this human- participant experiment based study. An element of novelty in this study lies in incorporating questions on the fuzzy areas of visual perception by mean of using transitions of colour gradients.

2. Activity Title: Affective information processing and the special cases of fear and surprise experiences as related to cognitive processes
Contributing Persons: Professor Amita Chatterjee, Dana Sugu
Target Beneficiaries: Academic research on the influences of affective experiences upon cognitive states
Abstract: Not incorporating available behavioral evidence from human studies and the cross-special evidence for primary emotions in all mammals has brought affective science into a stage where the emotional experiences cannot be fully understood. The understanding of complexity of emotional experience has to be based on the understanding of each emotional component and their evolutionary layering of the non-human and human brain. We focus on the primary processes and analyze the neurological basis for innate emotions. These innate emotions form the basis for more complex emotions that are involved in the secondary and tertiary processes which accommodate learning and conscious emotional experiences.
Most significant conclusion(s):

1. A framework for affective information processing has to accommodate recent research work which includes subcortical areas of the brain, specially researched on non-humans
2. A three-layer hierarchical framework has been used which includes the affective processes ranging from non-conscious to conscious experiences
3. Such a framework could explain the diversity of human experience while still allowing the existence of universal basic emotional systems

Publications and Conferences:

1. Sugu, D., Chatterjee, A., Bhattacharjee, A., "On Cultural Differences in Emotion Processing of Visual Stimuli," *paper accepted at International Conference on Cognition, Emotion, and Action, IIT Gandhinagar,* 6-8 December 2013.
2. Sugu, D., Chatterjee, A., A Descriptive Model of Affective Consciousness, paper accepted at the National Conference on Brain and Consciousness, 20-21 September 2013, Indian Statistical Institute, Kolkata
3. Chatterjee, A. and Sugu, D., A Framework for Understanding the Relation between Music and Emotions. Ninãd, Journal of the ITC-SRA, 26, 2013
4. Sugu, D., Chatterjee, A.: Affective Information Processing and Representations. M.K. Kundu et al. (Eds.): PerMIn 2012, LNCS 7143, pp. 42–49 (2012)

2.3 SELF APPRAISAL REPORT ON Cognitive Psychology

This group consists of the following related subgroups.

1. Brain localization study of Deductive /Abductive reasoning

2. Study of Perception and Cognition of the visually impaired from cortical response

2.3.1 Contributing Faculty Members

1. **Lopamudra Choudhury**, Director School of Cognitive Science. Journal Publications – 4, Conference Publications –6, Patents – number, Policy Documents – number, H Index – number, Cumulative Impact Factor – number, Total Citations – number, Awarded and ongoing doctoral thesis guidance – 10, Awarded and ongoing MPhil thesis guidance – 14. ***The decision of non-inclusion of any of these numbers is left to the discretion of the individual member***

2.3.2 Relevant Publications in Last 5years

1. Lopamudra Choudhuryjointly with S. Aditya and B.B. Chaudhuri, "Effect of combining Müller-Lyer and horizontal-vertical illusions," Int. J. Computational Vision and Robotics,Vol. 1, No. 1, 2009, pp.59-70.
2. Lopamudra Choudhury, "Medical ethics: dilemma between reason and emotion," *Journal of the Dept of Philosophy, University of North Bengal*, Vol VII,2010, pp 34-37.
3. Lopamudra Choudhury co-authored by Mihir Chakraborty, *"History of the reasoning with diagramsin,"the Proceedings of the National Seminar on History and Philosophy of Science on the occasion of late Prof. M.C. Chaki's 99th birth anniversary at Calcutta Mathematical Society, SaltLake.* Kolkata 64, 3rd July 2011.
4. Lopamudra Choudhury coauthored with Bharat Malakar, "*Chid-paramanu osnayubijnanerchetanarsambandha: kichumaulikbhavana*(in Bengali)," *DarshanBiksha,* Vol 21, No II , 2011, Jadavpur University, Kolkata.
5. Lopamudra Choudhury jointly with Mihir Chakraborty, "*On representing Open Universe, Studies in logic*, Vol 5, No 1(2012), pp 96-112.
6. Lopamudra Choudhury, *Mental image and its Relevance in Human Cognitive System*, Mind and Cognition: An Interdisciplinary Sharing, ed Kuntala Bhattacharya, Madhuchhanda Sen, Smita Sirker, D.K.Printworld, New Delhi, 2012(forth coming publication)
7. N. Bhattacharya and L. Choudhury, "An Effort to Understand the Concept Formation in the Visually challenged," *IJDL,* Vol. 42, No. 2, June, pp. 137-149, 2013.
8. Lopamudra Choudhury, "Sustainability and Individual Development," In *Sustainable Development: Ethics and Economics,Ed Bharat Malakar, Readers Service,* 2013, pp.33-3

2.3.3 Facilities Available

64 channel EEG machine (Neuroscan) installed in 2011 funded partly by the University and partly by DIT Govt of India

2.3.4 Ongoing Work under UPE II – 2012-14

I. Brain localization study of Deductive /Abductive reasoning

Contributing scholar: Prof. Mihir Kumar Chakraborty

1. ***Title:*** **Singular Propositions and their Negations in Diagrams**, Lopamudra Choudhury and Mihir Kumar Chakraborty accepted for publication in the proceedings of Diagrams Logic and Cognition 2013 in the online journal CEUR.

Abstract: This paper deals with the visual representation of negation involving particular propositions. The underlying consideration depends on the three basic desirable aspects of visual representation viz. simplicity, visual clarity and expressiveness [9]. For incorporation of constants in diagrams we discuss Venn-i (2004), Swoboda's diagrams (2005) and Spider diagrams with constants (2005). We also discuss representation of negation in these diagrams. To depict negation in Venn-i the concept of absence is brought in from the conceptual schema of Indian philosophy. The advantage of Venn-i over spider diagram is discussed. The notion of absence naturally calls for the concept of an open universe. A brief discussion on open universe is presented at the end.

Contributing scholar for the following three papers: Mr Arindam Bhattacharjee, UPEII Project Fellow.:

Title: Deductive Reasoning and Other Parallel Cognitive Functions, *A Survey Supported by Neuro-Physiological Evidences* *Indian Journal of Applied Psychology.* (submitted)

Authors: Lopamudra Choudhury and ArindamBhattacharjee

Abstract: Deductive reasoning is the cognitive ability to search new information on the basis of already given information. With the advancement of different neurological techniques it is possible to understand neural activities during deductive reason in details. In last decades few meta-analyses were popular especially, GoelVinod (2007) and Jérôme Prado, AngadChadha, and James R. Booth(2011). Review based literature helps in understanding area wise activation during deductive reasoning. But the possible cognitive roles of those activated areas are not clearly described. Thus, here our attempt is to fill in the gap by identifying the possible role of those areas during deductive reasoning. Majority of studies indicate memory would be possible parallel process during reasoning.

2. **Title:** ***A Search for Cognitive Dimension of Everyday Life Activities,"Accepted for publication in ACADEMICIA: An International Multidisciplinary*** **Research Journal (Proposed online publication January 2014 edition).**

Authors: *Lopamudra Choudhury and Arindam Bhattacharjee*

Abstract: The aim of this paper to determine the Cognitive dimension of Everyday Life ctivities. For measuring everyday life activities, an attempt has made to construct a scale. The scale named as Daily Life Cognitive Efficiency scale. Initially 45 statements were taken concerning 6 conceptual fields. These conceptual subscales are i) systematic, ii) target fulfillment, iii) self-affordance, Iv) evaluation of task v) object placement and vi) multitasking. Each dimensions further consisted of several key cognitive features. In particular, the paper reported the responses of 100 Bengali students (both UG and PG) from different departments of Jadavpur University .The results of the present study provide the final scale, which consists of all the 37 items of the initial Daily Life Cognitive Efficiency scale (DLCES) and for which strong evidence was ascertained. The result reveals that, our daily life activities encompass several cognitive abilities which are rooted in categorization.

3. ***Title: Explanation of Leaning Disorder from Cognitive Perspective," Accepted for Publication In International Journal of Computer Science (IJCS).(Proposed online publication January 2014 edition).***
Authors: *Lopamudra Choudhury and Arindam Bhattacharjee*

Abstract: Learning Disorder generally considers children or adolescent with under achievement in academic field. Poor intellectual capacity or health related issues are not the sole cause of this academic under achievement. Different researchers from the biological or social perspectives trying to explain causes of learning disorder in their own way but those explanations are not enough. Over all difficulty arise due to nature of the disorder itself. Actually learning disorder is a group of disorders with several dimensional differences like verbal, visual, abstract, symbolic etc. In this analysis we are trying to make an explanation of learning disorder from cognitive perspective. Another approach which is viewed as learning disorder is not typically related with children and adolescents rather acquired at any stage of life due to psychosocial or physiological causes. Overall findings suggests short term memory and attention deficits played important role in peripheral dyslexia whereas central dyslexia is caused by higher level of cognitive processing. Deep dyslexia is exclusively related with concept formation and categorization.
Key words: dyslexia, cognition, learning disorder, semantic, reasoning.

II. Study of Perception and Cognition of the visually impaired from cortical response

Publication
Name of the contributing scholar: Nairrita Bhattacharya

An Effort to Understand the Concept Formation in the Visually challenged, N. Bhattacharya & L. Choudhury, IJDL, Vol. 42, No. 2, June, pp. 137-149, 2013.

Workshop
Conducted a two day workshop on the Cognition of the Visually Challenged at Ramakrishna Mission Blind Boys' Academy, Narendrapur on 22nd and 23rd January 2014.

Most significant conclusion(s):

- Diagrammatic reasoning facilitate visual thinking
- Reasoning and memory work in parallel and is also supported by neuro-physiological evidences
- Everyday activity is governed by categorization and cognition

2.3.5 Work plan during 2014-17

- Determine experimentally a probable relation between reasoning and memory especially working memory
- Explore the logical aspect of bringing in constants and open universe in diagram logic as an alternative system of reasoning
- Develop test batteries to assess cognitive abilities both for the sighted and the visually challenged
- Tactile informationand knowledge formation among the visually challenged