# Satyam Kumar

*Curriculum Vitae*

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## Research Interests

Brain-Computer Interfaces, Machine Learning, Riemannian Geometry, Signal Processing

## Education

2013–2018 **Indian Institute of Technology Kanpur**, *Integrated BTech - MTech Electrical Engineering*, Master's GPA: 8.67/10 | Undergrad GPA: 7/10.

## Publications

1. **Kumar, S.**, Reddy, T., Behera, L., *"EEG based motor imagery classification using instantaneous phase difference sequence"*, **Accepted** for oral presentation at IEEE conference on **Systems, Man and Cybernetics, 2018**
2. Tharun Kumar Reddy, Vipul Arora, **Satyam Kumar**, Laxmidhar Behera, Y K Wang, CT Lin, *"Electroencephalogram based reaction time prediction with Differential Phase Synchrony representations using co-operative multitask learning Deep Neural Networks"* **Accepted** for publication in Special issue on New Advances in Deep-Transfer Learning, **IEEE Transactions on Emerging topics in Computational Intelligence** (Id: TETCI-2018-0173)
3. **Satyam Kumar**, Florian Yger, Fabien Lotte *"Towards Adaptive Classification using Riemannian Geometry approaches in Brain-Computer Interfaces"* **Accepted** at 7th IEEE International Winter Conference On Brain-Computer Interface

## Awards and Honors

Aug'18 **Travel Grant** winner, IEEE conference on Systems, Man and Cybernetics

Aug'17 **Teaching assistant fellowship**, awarded by Ministry of Human Resource Development, India on the basis of academic performance during graduate studies.

Apr'16 **Charpak research scholarship**, one of the 25 recipients from India.

Nov'14 **Overall Best Project award**, *Course project for TA-201*, Received the award for building a windmill driven pump

Jun'13 **JEE Advanced** All India Rank 679, *(top 99.993 percentile)*

Jun'13 **Youngest ever Indian to clear JEE exam** (cleared the exam at age of 13 years)

## Masters Thesis

Aug'17 – Feb'18 **Enhancing the classification accuracy of Motor Imagery Brain-Computer Interface**.
**Prof. Laxmidhar Behera** (*IIT Kanpur*) & **Prof. Roger Gassert** (*ETH Zurich*, Switzerland)

- Analyzed different phase synchrony statistics during motor imagery
- Implemented and compared common spatial pattern (**CSP**) algorithm with **Lasso** regularized sparse filter bank approach (**SFBCSP**) on BCI competition datasets
- Formulated novel approach based on instantaneous phase difference sequences to extract phase synchrony information
- The approach beats published results that use single trial phase locking value on BCI competition IV dataset IIa. When combined with complementary power features, the classification accuracies are further increased

Mar'18 – Jul'18 **Subspace analysis in Motor Imagery Brain-Computer Interface**.
**Prof. Laxmidhar Behera** (*IIT Kanpur*)

- Implemented stationary subspace analysis and divergence based framework of common spatial pattern algorithm for binary class
- Extended the binary class divergence framework to classic One-versus-Rest divergence framework for multiclass motor imagery
- Proposed a novel framework for optimization of stationarity in multiclass motor imagery brain-computer interface using an information theoretic interpretation of Joint Approximate Diagonalization

## Research Experience

Sept'18– Ongoing **Adaptive Riemannian approaches in Brain Computer Interface**.
**Fabien Lotte** (*INRIA Bordeaux, France*) & **Prof. Florian Yger** (*Université Paris-Dauphine, Paris*)

- Implemented state of the art Riemannian geometry algorithms for classification of motor imagery BCIs
- Implemented the classical adaptive algorithms based on CSP for supervised and unsupervised adaptation
- Proposed different frameworks for doing adaptation using Riemannian geometry classifiers. The proposed adaptive frameworks shows as high as 17% increase in average classification accuracy for 3-class mental imagery BCIs over the baseline non-adaptive riemannian geometry classifier.

Aug'16 – Dec'16 **Imagined speech classification Using EEG Signals** .
**Prof. Laxmidhar Behera** (*IIT Kanpur*)

- Designed the experimental paradigm and recorded EEG signals of participants, imagining 2 phonemes: "ba" and "ku"
- Applied two broad approaches for classifying the signals:1) Matricization of the input tensor followed by dimensionality reduction and feature extraction, and 2) **Tensor decomposition** of the input tensor
- Standard classifiers like LDA, SVM, kernel SVM used for binary classification

May'16 – July'16 **Optimization of electrode positions in Brain-Computer Interfaces**.
**Prof. Francesco P. Andriulli** (*Telecom Bretagne, France*)

- Studied different forward and inverse methods deployed for EEG source localization in the human brain model
- Explored epilepsy and epileptic seizures occurring in Human Brain Using **Para-View**, **MATLAB** and learned about different channel selection algorithms.
- Proposed and implemented the **Genetic algorithm** to simultaneously optimize channel selection and classification performance of Motor imagery BCI.

Jan'16 – May'16 **Eye blink classification Using EOG signal** .
**Prof. Laxmidhar Behera** (*IIT Kanpur*)

- Designed the experimental setup and recorded EOG signals of the subjects performing voluntary eye movements
- Performed the feature extraction using spectral and temporal characteristics of EOG signals
- Softmax and SVM's were used for classification

## Relevant Works

Aug'17 **Image generation through Variational Autoencoders** .
Implemented variational autoencoder architecture in tensorflow on MNIST database to generate image of digits

Jun–Jul'17 **Dimensionality reduction using Autoencoders for classification of P300**.
Used Denoising Autoencoders on *EPFL's* publicly available dataset to generate a sparse representation of P300 signals and further classified them using Softmax and LDA classification algorithms

Apr'17 **Classification of handwritten digits using Multi-layer perceptron**, *Prof. Laxmidhar Behera*.
Wrote a MATLAB model of Restricted Boltzmann machine for classification of handwritten digits

Mar'17 **Personalization of HRTF from anthropometric features** , *Prof. Rajesh M. Hegde.*
Compared **Isomap** and **PCA** dimensionality reduction techniques on full and intraconic head related transfer function. Multi-layer perceptron was used for learning the anthropometric features extracted from CIPIC databse

## Teaching Experience

Jan-April'18 **Microelectronics Laboratory, EE381A**

Aug-Oct'17 **Control System Laboratory, EE380A**

## Supervision Experience

Aug-Nov'18 **Shreeshail Hingane***(Junior year undergrad, Electrical Engineering)* on P300 BCI speller together with **Prof. Laxmidhar Behera**

Aug-Nov'18 **Nihir gulati***(Junior year undergrad, Electrical Engineering)* on Motor Imagery BCI together with **Prof. Laxmidhar Behera**

Nov'18-Ongoing **Alyssa Merante***(Biomedical Engineering)* on Motor imagery BCI together with **Prof. Chang Soo Nam**

## Relevant Courses

Electrical Engineering: Neural networks | Speech signal processing | Control systems | Basic of modern control systems | Digital control | Control system laboratory | Signal systems & networks | Digital signal processing | Electromagnetic theory

Mathematics: Fundamental of computing | Probability & statistics | Linear algebra | Complex variables | Detection and estimation theory | Numerical methods in engineering | Bayesian machine learning

Biology: Introduction to biology | Neurobiology | Computational biology and bio-informatics | Human cognitive processes

## Technical Skills

Advanced: MATLAB

Intermediate: Python | LaTeX| AutoDesk Inventor| Paraview | EEG Setup

Basic: C| Tensorflow| Arduino| Android Studio| Microcap