باسمه تعالی

The advanced methods in computational Physics and simulation, spring semester 2024

Lecturer: Prof. Movahed
TA: TBA
Venue: Sunday and Tuesday, 8:30-10:30 am

1) **The course mark includes 10 Points for (Exercises+Project), 9 points for exams, 2 points for Quiz**
2) **Main References:**

1- Landau, Rubin H., Manuel J. Páez, and Cristian C. Bordeianu. Computational physics: Problem solving with Python. John Wiley & Sons, 2015.

2- Gould, Harvey, et al. "An introduction to computer simulation methods: applications to physical systems." Computers in Physics 10.4 (1996): 349-349.

3-Hartmann, Alexander K., and Heiko Rieger. Optimization algorithms in physics. Vol. 2. Berlin: Wiley-Vch, 2002.

4-Hartmann, Alexander K., and Heiko Rieger, eds. "New optimization algorithms in physics." (2004): 134411.

5-Mezard, Marc, and Andrea Montanari. Information, physics, and computation. Oxford University Press, 2009.

6- Bassett, Bruce A., et al. "Fisher matrix preloaded-Fisher4Cast." International Journal of Modern Physics D 20.13 (2011): 2559-2598.

7- Lewis, Antony. "GetDist: a Python package for analysing Monte Carlo samples." arXiv preprint arXiv:1910.13970 (2019).

8- Tejero-Cantero, Alvaro, et al. "SBI--A toolkit for simulation-based inference." arXiv preprint arXiv:2007.09114 (2020).

3) **Other relevant References**

9- Irvine, Kip R., and Lyla B. Das. Assembly language for x86 processors. Prentice Hall, 2011.

10- Giordano, Nicholas J., et al. "Computational physics." Computers in Physics 11.4 (1997): 351-351. Heermann, Dieter W. Computer simulation methods in theoretical physics. Springer Science & Business Media, 2012.

11- My lecture notes available via http://faculties.sbu.ac.ir/~movahed/index.php/courses

12- Pang, Tao. "An introduction to computational physics." (1999): 94 -95.

13- Sirca, Simon, and Martin Horvat. Computational methods for physicists: compendium for students. Heidelberg, New York: Springer, 2012.

14- Gao, Jianbo, et al. Multiscale analysis of complex time series: integration of chaos and random fractal theory, and beyond. John Wiley & Sons, 2007.

15- Williams, Christopher KI, and Carl Edward Rasmussen. Gaussian processes for machine learning. Vol. 2. No. 3. Cambridge, MA: MIT press, 2006.

16- Michael A. Nielsen & Isaac L. Chuang." Quantum Computation and Quantum Information" (2000)

17- Maria Schuld · Francesco Petruccione. "Machine Learning with Quantum Computers ". (2021)

18- Santanu Pattanayak. "Quantum Machine Learning with Python"

4) **Midterm will be held on 20 Farvardin 1403**
5) **Final exam will be held on 6 Tir 1403**
6) **Overall necessities for doing exercises**

- for each set of exercise, it should be a folder titled by the name of student including the set number of exercise.
- The folder must be included the source code and the results. The results must be illustrated in pdf or other type of figure. (Jpeg , eps, pdf is accepted)

7) **Necessary operating system (Windows or Linux) including the relevant things for Python, Mathematica, C++, matlab**
8) **I provided some scripts for plotting available via:**

http://facultymembers.sbu.ac.ir/movahed/attachments/Python_plot.zip
http://facultymembers.sbu.ac.ir/movahed/attachments/Mathematica_plot.zip

Overall time table of training program

Subjects	Date/no.
Introduction, Scientific Methodology and Methods, Computational approach and Simulations مقدمه–جایگاه رویکردهای محاسباتی در روش شناسی علمی و علم داده	Lecture 1
Bash script and SBU-Clusters برنامه نویسی و نوشتن Bash و معرفی سیستم سرمد	Lecture 2
Error estimation 1 تخمین خطا ۱	Lecture 3
Error estimation 2 تخمین خطا ۲	Lecture 4
Probability Distribution 1: PDF Simple estimator PDF Simple estimator تابع توزیع ۱ و	Lecture 5
Probability Distribution 2: Probability Transformation, Joint PDF تابع توزیع ۲، تبدیل تابع چگالی احتمال، تابع چگالی احتمال همبسته	Lecture 6
Correlation functions: Two-point Correlation, Random walk- Simulations تابع همبستگی، تابع دونقطه‌ای، ولگشت تصادفی– شبیه‌سازی	Lecture 7
Langevin Equation and simulation معادله لانژون و شبیه‌سازی آن	Lecture 8
Numerical analysis1: Numerical derivative and Integration, Solving Systems of equations محاسبات عددی ۱: مشتق‌گیری و انتگرال‌گیری عددی، حل دستگاه معادلات	Lecture 9
Numerical analysis 2: Self-consistent method محاسبات عددی ۲: معرفی برخی از روشهای عددی برای حل معادلات دیفرانسیل– روش خودسازگار	Lecture 10
Chaos Theory نظریه آشوب (تولید)، نوسانگرهای جفت شده آشوبی، دیاگرام فاز	Lecture 11
Fractals and numerical algorithm to generation of Self-similar system فراکتالها (تولید)	Lecture 12
Monte-Carlo Simulation 1 اصول شبیه سازی مونته کارلو ۱	Lecture 13
Monte-Carlo simulation 2: Integration and Variational MC Variational MC اصول شبیه سازی مونته کارلو۲: انتگرال گیری،	Lecture 14
Monte-Carlo simulations 3: Markov Chain Monte Carlo and Metropolis Hasting MCMC اصول شبیه سازی مونته کارلو۳: روش متروپولیس، حلقه مارکوف مونت کارلو	Lecture 15
Monte-Carlo simulations 4: Hamiltonian Monte Carlo HMC اصول شبیه سازی مونته کارلو۴:	Lecture 16
Monte-Carlo simulations 5: Ising model Ising model اصول شبیه سازی مونته کارلو۵:	Lecture 17

Genetic Algorithm 1 **الگوریتم ژنتیک ۱**	Lecture 18
Genetic Algorithm 2 **الگوریتم ژنتیک۲**	Lecture 19
Data modeling 1: Bayesian Inference (Bayesian Inference) **مدل کردن داده‌ها ۱:**	Lecture 20
Data modeling 2: Likelihood Analysis **مدل کردن داده‌ها ۲** (Likelihood Analysis)	Lecture 21
Data modeling 3: Numerical Approach **مدل کردن داده‌ها ۳** (Numeric Approach)	Lecture 22
Data modeling 4: Confidence Interval Inference **مدل کردن داده‌ها ۴** (Confidence Interval)	Lecture 23
Data modeling 5: Fisher forecasts **مدل کردن داده‌ها ۵** (Fisher Matrix)	Lecture 24
Simulation Based Inference (SBI)	Lecture 25
Quantum Algorithms الگوریتم‌های کوانتومی	Lecture 26
Topological Based Data Analysis 1	Lecture 27
Topological Based Data Analysis 2	Lecture 28

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