Variational Image Processing

Ali Darijani

Contents

Introduction

add the reasons you started to write this book:-)

Unix, Linux, POSIX, and Beyond

Nowadays an applied mathematicians must utilize a computer in order to handle their workflow. Computers must have an operating system(OS) and that is set in the stone. As to what OS is optimal, there are no clear answers obviously. Every OS has its pros and cons. I adopted the Unix-like(Unix, Linux, POSIX) OSs for now as I meticulously observed my mentors during my college years and still continue to do so. This chapter tries to help you determine whether you would benefit from those OSs too and if yes formulate a guideline for its learning process.

Unix or not to Unix!

For now Unix is only a name and not a verb therefore making the heading a failed attempt at making a witty remark. I however, hope that it someday makes its way to the standard dictionaries as a verb like grep or google. During my BSc, MSc, PhD years I observed my mentors and tried to have the same hardware, OS and softwares as a ay of minimizing the initial overhead of having a working workflow for my computing.

BSc Years

I would say that in my BSc years there were only a handful of people that used Unix-like systems. My trust in them however were so solid that I decided to follow their footsteps instead of the more popular windows pathway. Here is a list and a short description of the nature of their computing works:

- Mir Abbas Jalali: Mechanical engineer professor but an applied mathematician at heart mostly doing complex physics simulation. Needed fast, high-performance low-level code(C, Fortran) to perform his computer experiments. Joined the CUDA party really fast back in 2010. Had an Apple, MacBook Pro with Darwin on top as the OS. Was willing to do cluster computing and parallelization if deemed worthy monstrous computations done.
- Saeed Rezaei: A linguist professor that needed a lightweight with a lasting battery daily driver to be able always on the move. Being able to edit essays in different file formats like Markdown, TeX. He wanted to stuff to work out of the box.

MSc Years

- Benjamin Berkels: double commander…jupyter notebook…math vs low level code…SSH…seminar…recording lecture videos..
- Paolo Bientinesi: low level programmerr…architecture aware software…SSH only…reallly realllyy big computing on monsterous machines…
- Goerg May: mathematician…lectures…integrity of the ipad macos…SSH code…

PhD Year

add stuffff

Make a Choice

So look around and see if you make the same choice as I did…

If not to Unix!

It might happen depending on the nature of your computing…then you can skippp the rest of the chapter and carry one with the rest of the book…

If Unix

Relax, Read, and Review

References

General/Offline/Classic Style

- LPI Linux Essentials pdf
- LPI Web Development Essentials pdf
- LPI LPIC-1 Exam 101 pdf
- LPI LPIC-1 Exam 101 pdf

- The LPIC2 Exam Prep pdf
- Practical LPIC-3 300 Link

Details/Online/Wiki Style

- Arch Wiki Link

Important Books/Pdfs/Links

- USB flash installation medium Link
- SSH Key Generation Link
- Linux from Scratch Link
- Filesystem Hierarchy Standard pdf
- DistroWatch Link

Historical/Cultural References

- Unix: A History and a Memoir by Brian Kernighan Link
- Just for Fun by Linus Torvalds Link
- Free Software, Free Society by Richard M. Stallman pdf
- Open Sources by Legends of Open Source pdf
- Open Sources 2.0 by Legends of Open Source Link

My Horsemen of the Apocalypse

- Hardware: Apple
- An Online Linux Terminal Emulator: JSLinux
- Hypervisor: VirtualBox, UTM
- OS: Darwin
- Package Manager: brew
- Terminal Emulator: kitty or Alacritty
- Interactive Shell: zsh Scripting Shell: bash
- Zsh Configuration Framework: ohmyzsh
- Terminal Text Editor: vim GUI Text Editor: Visual Studio Code
- Terminal Multiplexer: tmux
- Modern Linux Tools: Modern Linux

General/Offline/Classic Style

- LPI Linux Essentials pdf

- LPI Web Development Essentials pdf

- LPI LPIC-1 Exam 101 pdf

- LPI LPIC-1 Exam 101 pdf

- The LPIC2 Exam Prep pdf

- Practical LPIC-3 300 Link

- Pro GIT Link

Details/Online/Wiki Style

- Arch Wiki Link

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- Open Sources by Legends of Open Source pdf

- Open Sources 2.0 by Legends of Open Source Link

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- An Online Linux Terminal Emulator: JSLinux

- Hypervisor: VirtualBox, UTM

- OS: Darwin

- Package Manager: brew

- Terminal Emulator: kitty or Alacritty

- Interactive Shell: zsh Scripting Shell: bash

- Zsh Configuration Framework: ohmyzsh

- Terminal Text Editor: vim GUI Text Editor: Visual Studio Code

- Terminal Multiplexer: tmux

- Modern Linux Tools: Modern Linux

Russian/Eastern European Style 01

- Calculus With Applications by Lax and Terrell Link
- Multivariable Calculus with Applications by Lax and Terrell Link

American Style 01

- Calculus I by Marsden and Weinstein Link
- Calculus II by Marsden and Weinstein Link
- Calculus III by Marsden and Weinstein Link

American Style 02

- Calculus, Volume 1 by Apostol Link
- Calculus, Volume 2 by Apostol Link

Advanced Calculus(Free Style)

- Advanced Calculus by Kaplan Link
- Advanced Calculus by Callahan Link

- Advanced Calculus by Loomis and Sternberg Link
- Advanced Calculus by Buck and Buck Link
- Advanced Calculus by Fitzpatrick Link
- Advanced Calculus by Widder Link
- Advanced Calculus by Taylor and Mann Link
- Advanced Calculus by Edwards Link

- A Course in Advanced Calculus by Borden [Link](#)

Tools for Experimentation

- gnuplot [Link](#)
- GNU Octave [Link](#)
- python [Link](#) scipy [Link](#) numpy [Link](#) matplotlib [Link](#)
- maxima [Link](#)

American Style 01

- Analysis I by Tao [Link](#)
- Analysis II by Tao [Link](#)

Russian Style 01

- Mathematical Analysis I by Zorich [Link](#)
- Mathematical Analysis II by Zorich [Link](#)

Russian Style 02

- Real Analysis (Foundations and Functions of One Variable) by Laczkovich and Sos [Link](#)
- Real Analysis (Series, Functions of Several Variables, and Applications) by Laczkovich and Sos [Link](#)

Tools for Experimentation

- gnuplot [Link](#)
- GNU Octave [Link](#)
- python [Link](#) scipy [Link](#) numpy [Link](#) matplotlib [Link](#)
- maxima [Link](#)

Homepage and the Lecture Videos

- Homepage [Link](#)
- Youtube Playlist [Link](#)

References

- Principles of Mathematical Analysis by Rudin [Link](#)
- The Elements of Integration and Lebesgue Measure by Bartle [Link](#)
- Introduction to Measure and Integration by Taylor [Link](#)
- Measure Theory by Halmos [Link](#)
- Probability and Measure by Billingsley [Link](#)
- Real Analysis by Royden and Fotzpatrick [Link](#)
- Introduction to Measure and Integration by Munroe

Tools for Experimentation

- gnuplot [Link](#)
- GNU Octave [Link](#)
- python [Link](#) scipy [Link](#) numpy [Link](#) matplotlib [Link](#)
- maxima [Link](#)

UNDR CONSTRUCTION

Experimentation Tools

- gnuplot [Link](#)
- python [Link](#) scipy [Link](#) numpy [Link](#) matplotlib [Link](#)
- eigen [Link](#)
- lapack [Link](#)
- Matrix Market [Link](#)

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- GNU Octave [Link](#)
- python [Link](#) scipy [Link](#) numpy [Link](#) matplotlib [Link](#)

- maxima Link

References

- Fourier Analysis by Stein and Shakarchi Link
- – The Mathematics of Signal Processing by Damelin, Miller Link
- to be continued:-)

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
- eigen Link
- lapack Link
- Matrix Market Link

Linear Algebra

- Foundations of Data Science by Blum, Hopcroft, and Kannan pdf

Numerical Optimization

- Convex Optimization by Boyd and Vandenberghe pdf

- to be continued:-)

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
- eigen Link
- lapack Link
- Matrix Market Link

Homepage of the Lecturer and the Lecture Videos

- Homepage Link
- Youtube Playlist Link

References

- Principles of Mathematical Analysis by Rudin Link
- Probability by Breiman Link
- A course in Probability Theory by Chung Link
- Large Deviations Techniques and Applications by Dembo and Zeitouni Link
- Large deviations by Deuschel and Stroock Link
- Probability by Durrett Link
- Introduction to Measure and Integration by Taylor Link
- Large deviations and applications by Varadhan Link
- Probability Theory by Varadhan Link

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
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- lapack Link
- Matrix Market Link

Abbreviations and Acronyms

- ASCII: American Standard Code for Information Interchange
- GNU: GNU's Not Unix
- pip: Pip Installs Packages

References(Websites)

Unix, Linux, POSIX, and Beyond

- https://www.lpi.org/
- https://learning.lpi.org/en/learning-materials/learning-materials/
- https://wiki.archlinux.org/
- https://git-scm.com/
- https://about.gitlab.com/
- https://github.com/
- https://www.linuxfromscratch.org/
- https://distrowatch.com/

My Horsemen of the Apocalypse

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- Zsh Configuration Framework: ohmyzsh
- Terminal Text Editor: vim GUI Text Editor: Visual Studio Code
- Terminal Multiplexer: tmux
- Modern Linux Tools: Modern Linux

List of References

- A First Course in Numerical Methods by Ascher and Greif Link
- Numerical Mathematics by Quarteroni, Sacco, and Saleri Link
- to be continued

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
- eigen Link
- lapack Link
- Matrix Market Link

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Introductory Texts

- Bostock, D. Philosophy of Mathematics: An Introduction (2009)
- Brown, J. R. Philosophy of Mathematics, 2nded (2008)
- Colyvan, M. An Introduction to the Philosophy of Mathematics (2011)
- George, A. and D. Velleman Philosophies of Mathematics (2002)
- Körner, S. The Philosophy of Mathematics: An Introductory Essay (1960)
- Linnebo, Ø. Philosophy of Mathematics (2017)
- Shapiro, S. Thinking about mathematics: The philosophy of mathematics (2000)

General Collections of Essays

- Aspray, W. and P. Kitcher History and Philosophy of Modern Mathematics (1988)
- Benacerraf, P. and H. Putnam Philosophy of Mathematics: Selected Readings, 2nded (1983)
- Ewald, W. From Kant to Hilbert: A Source Book in the Foundations of Mathematics (1996)
- George, A. Mathematics and Mind (1994)
- Hart, W. The Philosophy of Mathematics (1996)
- Hersch, R. 18 Unconventional Essays on the Nature of Mathematics (2006)

- Irvine, A.D. Philosophy of Mathematics (2009) Leng, M., et al Mathematical Knowledge (2007)
- Lindström, S., et al Logicism, Intuitionism and Formalism: What has become of them? (2009)

- Mancosu, P. The Philosophy of Mathematical Practice (2008)
- Marcus, R. and M. McEvoy An Historical Introduction to the Philosophy of Mathematics: A Reader (2016)
- Shapiro, S. The Oxford Handbook of the Philosophy of Mathematics and Logic (2005)
- Schirn, M. The Philosophy of Mathematics Today (1998)

- Tymoczko, T. New Directions in the Philosophy of Mathematics (1985)
- Van Heijenoort, J. From Frege to Gödel: A Source Book in Mathematical Logic (1967)

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- Ayer, A. Language, Truth and Logic (1947) Balaguer, M. Platonism and Anti-Platonism in Mathematics (1998)
- Bishop, E. and D. Bridges Constructive Analysis (1985)
- Bostock, D. 'Aristotle's Philosophy of Mathematics' in Oxford Handbook of Aristotle (2012)
- Brittan, G. Kant's Theory of Science (1978)
- Burgess, J. and G. Rosen A Subject with No Object (1997)
- Connes, A., et al Triangle of Thoughts (2000)
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- Demopoulos, W. Frege's Philosophy of Mathematics (1997)
- Diamond, C. Wittgenstein's Lectures on the Foundations of Mathematics, Cambridge 1939 (1975)
- Dummett, M. Elements of Intuitionism (1977)
- erreirós, J. Mathematical Knowledge and the Interplay of Practices (2016)
- Field, H. Science without numbers: a defense of nominalism (1980)
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- Giaquinto, M. The Search for Certainty: A Philosophical Account of the Foundations of Mathematics (2002)
- Hahn, H. Empiricism, Logic and Mathematics: Philosophical Essays (1980)
- Jost, J. Bernhard Riemann: On the Hypotheses Which Lie at the Bases of Geometry (2016)
- Kitcher, P. The Nature of Mathematical Knowledge (1984)
- Koetsier, T. Lakatos' Philosophy of Mathematics (1991)
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- Lawvere, F.W. and R. Rosebrugh Sets for Mathematics (2003)
- Leng, M. Mathematics and Reality (2010)
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- Maddy, P. Realism in Mathematics (1990)
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- Manin, Yu. Mathematics and Physics (1981)
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- McKeon, R. (editor) The Basic Works of Aristotle (1941)
- Parsons, C. Mathematics in Philosophy: Selected Essays (1983)
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- Ramsey, F. The Foundations of Mathematics, in Philosophical Papers, ed. D. Mellor (1990)
- Rashed, R. The Development of Arabic Mathematics: Between Arithmetic and Algebra (1994)
- Rashed, R. Classical Mathematics from Al-Khwarizmi to Descartes (2005)
- Rashed, R. and B. Vahabzadeh Omar Khayyam, the Mathematician (2000)
- Russell, B. The Principles of Mathematics (1903)
- Sieg, W. Hilbert's Programs and Beyond (2013)
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- Tietzen, R. Mathematical Intuition: Phenomenology and Mathematical Knowledge (1989)
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- Wittgenstein, L. Remarks on the Foundations of Mathematics (1956)

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- LPI Web Development Essentials pdf
- LPI LPIC-1 Exam 101 pdf
- LPI LPIC-1 Exam 101 pdf
- The LPIC2 Exam Prep pdf
- Practical LPIC-3 300 Link
- Pro GIT pdf

Calculus

- Calculus With Applications by Peter D. Lax , Maria Shea Terrell Link
- Multivariable Calculus with Applications by Peter D. Lax , Maria Shea Terrell Link

ONLY A REDIRECTION

UNDER CONSTRUCTION AND STUFF ARE BEING INCREMENTALLY ADDED

Caution!

The HPC is a rapidly changing field. I only update the materials in every iteration I do and therefore it is best to consult multiple sources.

Linux

The world of High-performance computing is dominated by Supercomputers that have a Linux OS therefore a bit of Linux is kind of a De facto standard.

I suggest that you check some materials beforehand to save yourself from the agony and suffering of not knowing it during the High-performance computing course.

General References

- Introduction to Parallel Programming by Pachaeco and Malensek Link

- Introduction to High Performance Computing for Scientists and Engineers by Hager and Wellein Link

Computer Architecture

- Computer Organization and Design by Patterson and Hennessy Link

- Computer Architecture by Patterson and Hennessy Link

Exercise 00

- SSH wiki *** SSH man page

- cp wiki *** cp man page

- rsync wiki *** rsync man page

- FastX GUI based remote desktop session client

- Tar wiki *** Tar man page

- Slurm Workload Manager wiki *** Slurm Workload Manager

Exercise 01

Exercise 02

Exercise 03

Exercise 04

Exercise 05

Exercise 06

Plan

So my plan is to self-taught myself an MBA. I am gonna use the Stanford Business School Course List and get on them.

Financial Accounting

- Financial Accounting by WEYGANDT, KIMMEL, and KIESO Link
- to be continued:-)

I Have NO Idea of What Comes Next :-)

construction

ONLY A REDIRECTION

References

- Nonlinear Continuum Mechanics of Solids by Başar and Weichert Link
- Tensor Algebra and Tensor Analysis for Engineers by Itskov Link
- Non-Linear Elastic Deformations by Ogden Link
- Continuum Mechanics and Theory of Materials by Haupt Link
- The Mechanics and Thermodynamics of Continua by Gurtin Link

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
- eigen Link
- lapack Link
- Matrix Market Link
- FEniCS Link
- deal.II Link

References

- Mathematical Image Processing by Bredies and Lorenz Link
- Digital Image Processing by Gonzalez and Woods Link
- A Wavelet Tour of Signal Processing by Mallat Link
- Mathematical Problems in Image Processing by Aubert, Kornprobst Link
- The Mathematics of Signal Processing by Damelin, Miller Link

Tools for Experimentation

- ImageMagick Link
- OpenCV Link
- scikit-image Link
- SciPy Link
- ImageJ Link
- TensorFlow Link
- Keras Link
- NumPy Link

Math Related References

- Fundamentals of Machine Learning for Predictive Data Analytics by Kelleher, Namee, and D'Arcy Link
- Data Mining by Han, Kamber, and Pei Link

Programming Frameworks

- python Link
- conda Link
- ipython Link
- numpy Link
- pandas Link
- matplotlib Link
- TensorFlow Link
- Keras Link

Elliptic

- Numerical Methods for Elliptic and Parabolic Partial Differential Equations by Knabner and Angermann Link
- Elliptic Differential Equations by Hackbusch Link
- Finite Elements by Braess Link
- Partial Differential Equations by Evans Link
- Numerical Treatment of Partial Differential Equations by Grossmann, Roos, and Stynes Link

Hyperbolic

- Numerical Approximation of Hyperbolic Systems of Conservation Laws by Godlewski and Raviart Link
- Numerical Methods for Conservation Laws by LeVeque Link
- Finite Volume Methods for Hyperbolic Problems by LeVeque Link
- Partial Differential Equations by Evans Link
- Numerical Treatment of Partial Differential Equations by Grossmann, Roos, and Stynes Link

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- gnuplot Link
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Classic Linear Algebra

- Linear Algebra Done Right Link
- Linear Algebra by Petersen Link
- Applied Linear Algebra and Matrix Analysis by Shores Link
- Applied Linear Algebra by Olver and Shakiban Link
- Advanced Linear Algebra by Roman Link

Numerical Linear Algebra

- Numerical Linear Algebra by Allaire and Kaber Link
- Numerical Linear Algebra by Wendland Link
- Numerical Linear Algebra by Beilina, Karchevskii, and Karchevskii Link
- Numerical Linear Algebra by Layton and Sussman pdf
- Iterative Solution of Large Sparse Systems of Equations by Hackbusch Link
- Iterative Methods for Sparse Linear Systems by Saad pdf
- Hierarchical Matrices by Hackbusch Link
- Tensor Spaces and Numerical Tensor Calculus by Hackbusch Link

Experimentation Tools

- gnuplot Link
- python Link scipy Link numpy Link matplotlib Link
- GNU Octave Link
- eigen Link
- lapack Link
- Matrix Market Link

Comparison of Numerical Linear ALgebra Libraries

Matrix types and operations

- ''Real'' – general (nonsymmetric) real
- ''Complex'' – general (nonsymmetric) complex
- ''SPD'' – symmetric positive definite (real)
- ''HPD'' – Hermitian positive definite (complex)
- ''SY'' – symmetric (real)
- ''HE'' – Hermitian (complex)
- ''BND'' – band

Operations: - ''TF'' – triangular factorizations (LU, Cholesky) - ''OF'' – orthogonal factorizations (QR, QL, generalized factorizations) - ''EVP'' – eigenvalue problems - ''SVD'' – singular value decomposition - ''GEVP'' – generalized EVP - ''GSVD'' – generalized singular value decomposition

	Real	Complex	SPD	HPD	SY	HE	BND	TF	OF	EVP	SVD	GEVP	GSVD
ALGLIB	YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	NO
ATLAS	YES	YES	YES	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO
Dlib	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	NO	NO
GNU Scientific Library	YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	YES
ILNumerics.Net	YES	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	NO
IMSL Numerical Libraries	YES	YES	YES	YES	NO	NO	YES	YES	NO	YES	YES	YES	NO
LAPACK	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
MKL	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
NAG Numerical Library	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
NMath	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO
SciPy (Python packages)	YES	YES	YES	NO	NO	NO	YES	YES	YES	YES	YES	NO	NO
Eigen	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO
Armadillo	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	NO

References

- The Markdown Guide by Cone Link
- GitHub flavored Markdown short *** long
- AsciiDoc Link
- Introducing Markdown and Pandoc by Link
- The Not So Short Introduction to LaTeX Link
- Markdown Link
- Pandoc Link
- AsciiDoc Link
- Asciidoctor Link
- LaTeX Link
- TeX Link
- MacTeX Link

References

- Linear Functional Analysis by Alt Link
- Mathematical Image Processing by Bredies and Lorenz Link
- Partial Differential Equations by Evans Link
- Functions of Bounded Variation and Free Discontinuity Problems by Ambrosio, Fusco, and Pallara Link

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