Robert Underwood

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Education

Clemson University **Clemson, SC**
PhD Candidate in Computer Science, GPA 3.92/4.0 *December 2021, expected*
Passed Qualifying Exam: May 2018
Co-Advisers: Dr. Amy Apon, Dr. Jon Calhoun, and Dr. Franck Cappello

Clemson University **Clemson, SC**
Master of Science in Computer Science, GPA 4.0/4.0 *August 2018*
Concentration: Systems and Implementation

Clemson University, Calhoun Honors College **Clemson, SC**
Bachelor of Science, Suma Cum Laude in Computer Science, GPA 4.0/4.0 *December 2016*
Honors Thesis: Automation in the Classroom, Adviser: Dr. Jacob Sorber

Peer Reviewed Publications

[1] Bessac, J., Krasowska, D., Calhoun, J. C., **Underwood, R.**, Di, S., Cappello, F., "Exploring Lossy Compressibility through Statistical Correlations of Scientific Datasets". **Preparation**, target TBD.

[2] Gok, A., Di, S., **Underwood, R.**, Bessac, J., Cappello, F., al, "A Compression Technique for Nanocrystallography Data". **Preparation**, target TBD – Domain Science Journal.

[3] Gok, A., Di, S., **Underwood, R.**, Bessac, J., Cappello, F., al, "A Metric for the Assessment of Derivative Preservation Quality". **Preparation**, target TBD.

[4] **Underwood, R.**, Di, S., Calhoun, J. C., Cappello, F., "Efficient Proxy Models for Metrics on Lossy Compressed Data". **Preparation**, target TBD.

[5] **Underwood, R.**, Di, S., Calhoun, J. C., Cappello, F., "Error Bounded Lossy Compression for Machine Learning and Artificial Intelligence Applications". **Preparation**, target: IEEE Parallel and Distributed Processing Symposium 2021.

[6] **Underwood, R.**, Malvoso, V., Di, S., Calhoun, J. C., Apon, A., Cappello, F., "Productive, Performant, and Parallel Generic Lossy Data Compression with LibPressio". **Submission**, IEEE Transactions on Parallel and Distributed Systems.

[7] Fulp, D., Poulos, A., **Underwood, R.**, Calhoun, J. C., "ARC: An Automated Approach to Resiliency forLossy Compressed Data via Error Correcting Codes". In: *Proceedings of 30th International ACM Symposium on High-Performance Parallel and Distributed Computing*. Co-Author. ACM. June 2021.

[8] Liang, X., Zhao, K., Di, S., Li, S., **Underwood, R.**, Gok, A. M., Tian, J., Deng, J., Tao, D., Calhoun, J., Chen, Z., Cappello, F., "SZ3: A Multi-algorithm, Modular, and Composable Framework for Prediction Based Error-Bounded Lossy Compression".

Submission, target: IEEE Transactions on Parallel and Distributed Systems. July 2021.

[9] **Underwood, R.**, Di, S., Calhoun, J. C., Apon, A., Cappello, F., "OptZConfig: Using Optimization Configure Error Bounded Lossy Compressors". **Submission**, target: IEEE Transactions on Parallel and Distributed Systems. July 2021.

[10] Tian, J., Di, S., Zhao, K., Rivera, C., Hickman, M., **Underwood, R.**, Jin, S., Liang, X., Calhoun, J., Tao, D., Cappello, F., "cuSZ: An Efficient GPU Based Error-Bounded Lossy Compression Framework for Scientific Data". In: *Proceedings of 29th International Conference on Parallel Architectures and Compilation Techniques*. Co-Author. ACM. Atlanta, Georgia (virtual), Oct. 2020.

[11] **Underwood, R.**, Di, S., Calhoun, J. C., Cappello, F., "FRaZ: A Generic High-Fidelity Fixed-Ratio Lossy Compression Framework for Scientific Floating-point Data". In: *proceedings of the 9th international conference on performance engineering*. Presented virtually at IPDPS 2020. IEEE. New Orleans, Louisiana (virtual), May 2020, pp. 1–11.

[12] **Underwood, R.**, Anderson, J., Apon, A., "Measuring Network Latency Variation Impacts to High Performance Computing Application Performance". In: *Proceedings of the 9th International Conference on Performance Engineering*. presented at ICPE 2018. ACM/SPEC. Berlin, Germany, Apr. 2018, pp. 1–12.

Significant Software

LibPressio

`https://github.com/robertu94/libpressio` *2019-present*

- High-performance generic abstraction for compression of dense tensors
- Supports 45+ of plugins for compressors and analysis in collaboration with 6 institutions
- Significant plugins include: LibPressio-Opt (automatic configuration of compression), a parallel compression runtime, and the external metrics framework
- Significant integrations include: Python bindings, HDF5-filters, R bindings, ADIOS2, Spack, Z-checker

SZ

`https://szcompressor.org/` *2019-present*

- One of the leading open and transparent Lossy Compression Frameworks for scientific data
- Contributed an early design of SZ for GPUs and the modular SZ-3
- Implemented the python bindings for SZ

Peer-Reviewed Academic Poster Presentations

Approachable Error Bounded Lossy Compression **Virtual**
Supercomputing 2021 *November 2021*
Robert Underwood

Predicting Optimal E.B.L.C. Configuration for Sampled Data **Spokanne, WA**
S.I.A.M. Conference on Computer Science and Engineering *February 2019*
Robert Underwood, Jon Calhoun, and Amy Apon

Academic Presentations

LibPressio **Virtual**
Part of a session entitled "Lossy Data Reduction for ECP Applications" *April 2021*
Exascale Computing Project Annual Meeting

Approachable Error Bounded Lossy Compression **Virtual**
An Interface, Automated Tuning, and analysis for lossy compression *November 2020*
Super Computing 2020, Doctoral Showcase

Lossy Compression for AI **Virtual**
An overview of how to use lossy compression to reduce storage needs for AI *September 2020*
Joint Laboratory for Extreme Scale Computing

FRaZ **Virtual**
A Generic High Fidelity Fixed Ratio Lossy Compression Framework *May 2020*
for Floating Point Scientific Data; IPDPS 2020

LibPressio: A Generic Abstraction for Compression **Huston, TX**
Part of a session entitled "Lossy Data Reduction/Compression for ECP Applications"February 2020
Exascale Computing Project Annual Meeting

Approachable Error Bounded Lossy Compression **Lemont, IL**
Overview of tools and techniques for using error bounded lossy compression *December 2019*
Argonne National Laboratory Mathematics and Computer Science Devision Seminar

Predicting Optimal Error-Bounded-Lossy-Compression Configuration **Huston, TX**
Techniques for predicting error bounded lossy compression ratios *November 2018*
Supercomputing 18 Student Volunteer Talks

Research Experience

Clemson University **Clemson, SC**
Clemson Data Intensive Computing Environments *2016-2021*

- Applications and modeling of reliability and performance of error-bounded lossy compression
- Designed experiments to analyze performance of high performance computing systems
- Build models to improve reliability computer infrastructure.

Argonne National Laboratory **Lemont, IL**
Under Dr. Franck Cappello *Summer-Fall 2019*

- Researched the design of optimization based techniques for enforcing user-level error bounds
- Designed and implemented libpressio – a generic abstraction between compression libraries
- Contributed to the design and implementation of SZ a lossy compression framework

Clemson University **Clemson, SC**
Clemson PERSIST Lab *2015-2016*

- Designed and developed an automated grading framework using Python, C, Raspberry Pi, and Docker.
- System used modular design, supports process isolation, and multiple test formats.

Teaching and Mentoring Experience

Clemson University **Clemson, SC**
Mentoring *Summer 2021*

- Mentored one female and one male, undergraduate student on projects that led to two ACM student research poster submissions and later journal submission.
- Provided training on git, python, C++, lossy compression, and scientific experiment design

Clemson University **Clemson, SC**
CPSC/ECE 3220: Operating Systems *Fall 2018*

- Graduate Teacher of Record, produced all lectures and most materials
- Junior/Senior level course - 50 Students enrolled, Completed (78%), Course GPA (2.42)
- Course materials `https://robertu94.github.io/cpsc3220-f18/`
- Anonymous Student Assessment Responses:
  - Response Rate (92.3%), Would Recommend (72.2%)
  - Median Results: Effective Instructor (4/5), Helpful Feedback (4/5), Relative Difficulty (5/5)
  - Selected Student Comments:
    - "Definitely. One of the best professors I've had at Clemson.",
    - "Yes. He is very knowledgeable and works very hard to impart that knowledge to others.",
    - "Yes, it is obvious that Mr. Underwood is passionate about operating systems and is extensively knowledgable about computer science in general. This course felt overwhelming at times, but I definitely learned a lot through it."

Work Experience

The Boeing Company **Charleston, SC**
Information Technology Intern *Summer 2016, 2017*

- Developed improvements for a web based portal system in HTML, Python, and JavaScript
- Developed the user interface for a materials database using HTML and JavaScript
- Designed, developed, and led development on a resource management tool using C#, HTML, and JavaScript.
- Worked on the Network Automation, Tooling, and Standards Integration Team

Unitrends, Inc **Columbia, SC**
Software Development Intern *2014-2016*

- Developed GPU offloading for AES encryption using Nvidia CUDA.
- Designed and developed automated configuration scripts for testing environments using Ansible.
- Designed and developed new cloud infrastructure using LVM, Linux, and Docker
- Designed and developed a Dynamic Alert System in Python
- Worked on the Alerts System in PHP, BASH, C, PERL, SQL
- Worked on the internal Customer Incident Analysis web portal using Django, Postgreql, HTML, CSS, and JavaScript

Professional Affiliations

Association for Computing Machinery: Student Member 2014-2021

Professional Service

Reviewer: ICPE 2017, ICCCN 2017, PABS 2017, SC17, IEEE CLOUD 2018, IEEE TSE 2018, IPDPS 2018, IPDPS 2019, IEEE CLUSTER 2020

Honors

- Clemson Outstanding Ph.D. in Computer Science Award, 2021
- Graduate Student Research Lighting Talk Competition Faculty Award, 2020
- Department of Energy Office of Science Graduate Student Research Award, 2019
- Fellowship, National Research Traineeship: Resilient Infrastructure Systems 2017-2020
- National Science Foundation Graduate Research Fellowship Honorable Mention 2017
- Faculty Scholarship Award, Clemson University 2016
- Benefitfocus Scholarship 2015-2016
- McAlister Scholarship 2015-2016
- Palmetto Fellows Recipient 2013-2016
- President's List at Clemson University 2013-2016
- Outstanding Sophomore in Computer Science at Clemson University 2015
- Order of the Arrow, Vigil Honor 2013
- Eagle Scout 2010

Extracurricular Activities

Clemson University **Clemson, SC**
Clemson School of Computing Graduate Student Organization, Secretary *2017-2019*

- Keep minutes and assist with program and logistics
- Coordinate with other student organizations and School of Computing staff

Clemson University **Clemson, SC**
Clemson University Cyber Security Team *2015-2018*

- Primary developer for the Cyber Security reference material, 2016
- Competed in Collegiate Cyber Defense Competition 2015-2016 and Palmetto Cyber Defense Competition, 2015
- Designed and developed scripts to aid in auditing and administration of contest environments, 2016
- Lead training on Mitigating Exploitable patterns in software design and Observability tools

Clemson University **Clemson, SC**
Clemson Association for Computing Machinery Vice President *2014-2016*

- Planned and help found the Clemson Association for Computing Machinery Technology Seminar, Fall 2016
- Prepared and presented 4 seminars per semester on Git, Linux, Vim, Firewalls, Unix tools, and other topics, 2014-2016
- Coordinated with President to set up professional development and social events, 2014-2016

Clemson University **Clemson, SC**
Clemson Association for Computing Machinery Programming Team *2013-2016*

- Competed in competitions to design efficient algorithms to solve problems
- Team placed 1^{st} at the Mercer Spring Programming Competition in 2014 and 2015
- Team placed 3^{rd} at Association for Computing Machinery Southeast Regional Competition 2015
- Invited to participate in the National Invitational Programming Competition 2015, 2016
- Primary developer for the Clemson Hackpack algorithms reference
- Student apprentice judge at Mercer Programming Competition February 2016.

Professional Presentations

Systemd Tools **Clemson, SC**
Overview of useful, but lesser know `systemd` features *November 2017*
CU Cyber

C++ Templates: Staring into the Abyss **Clemson, SC**
Advanced talk on C++11-17 templates and uses *April 2017*
Clemson ACM Technology Seminar, Guest talk

Dockerize all the Things! **Clemson, SC**
Introduction to container technology and uses *Feburary 2017*
Clemson ACM Technology Seminar, Guest talk

Exploitable III: Reverse Engineering **Clemson, SC**
Overview of binary analysis, user and kernel level tracers, and debuggers *September 2016*
CU Cyber and Clemson ACM Crossover Seminar

Automation in the Classroom **Clemson, SC**
Motivation and demonstration of classroom automation *April 2016*
School of Computing Seminar, Spring 2016 Seminar Series

Python: A Parser Tongue Primer **Clemson, SC**
Introduction to idiomatic Python programming *April 2016*
Clemson ACM Seminar

Exploitable II: Application Design **Clemson, SC**
Overview of writing secure software *March 2016*
CU Cyber and Clemson ACM Crossover Seminar

Provisioning At the Speed of Thought **Clemson, SC**
Evaluation and Uses of Ansible, Salt and Puppet *October 2016*
Clemson ACM Technology Seminar

Writing Semantic Code **Clemson, SC**
Using refactoring and design patterns for better code *August 2016*
Clemson ACM Technology Seminar

Think Different **Clemson, SC**
Introduction to approaching computer science projects *Feburary 2016, et al*
Clemson ACM Various Venues, Also titled "Perfecting Your Projects"

Linux is Scary **Clemson, SC**
Introduction to Linux for new computer science students *Feburary 2016, et al*
Clemson ACM Seminar

Thou Shall Not Pass **Clemson, SC**
Introduction to open source firewalls *Feburary 2016*
Clemson ACM Seminar

Exploitable: Ethical Hacking **Clemson, SC**
Introduction to ethical software penetration testing *October 2015*
CU Cyber and Clemson ACM Crossover Seminar

Git Well Soon **Clemson, SC**
Introduction to the Git distributed version control system *September 2015, et al*
Clemson ACM Various Venues, Also titled "Git Thee to a Version Control System"

Intermediate Vim **Clemson, SC**
Advanced seminar on using the Vim text editor *Feburary 2015*
Clemson ACM Seminar

N Unix Tools in $O(N)$ Minutes **Clemson, SC**
Overview of scripting tools for POSIX platforms *March 2015*
Clemson ACM Seminar

NMAP **Clemson, SC**
Overview of network mapping with NMAP *October 2015*
CU Cyber

Relevant Coursework

Clemson University **Clemson, SC**
EES 883: Resilient Infrastructure Systems *Spring 2018*

- Constructed and quantified uncertainty in a queuing theory and population based model of Infrastructure systems
- Designed experiments for statistical model validation
- Prepared a NSF grant proposal submitted by my adviser to NSF and funded by NSF

Clemson University **Clemson, SC**
CPSC 820: Parallel Architecture *Fall 2016*

- Researched and presented on the design and implementation of Linux Bridge, OpenVSwitch, DPDK, SRIOV, and MACVLAN
- Designed and conducted experiment to quantify latency variation in RDMA using InfiniBand layers 1, 2, and 4

Clemson University **Clemson, SC**
CPSC 840: Design and Analysis of Algorithms *Spring 2016*

- Analyzed and designed amortized, randomized, and approximation algorithms to solve problems.
- Designed time and space efficient data structures

Computer Skills

Advanced: Bash, Bourne Shell, C, C++, Docker, Linux Kernel and Userspace, Python, Vim

Intermediate: Ansible, Git, Hadoop, JAVA, JavaScript, LaTeX, SaltStack, Systemd, SQL, OpenMP, MPI

Basic: ARM assembly, C#, FreeBSD, MPI, PHP, Perl, Puppet, SNMP, SVN, Apache Spark, Rust, Julia, Haskell, RCpp/RInside, HTML5, CSS3