Tyler Hayes

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Education

Rochester Institute of Technology — *Rochester, NY*
Doctor of Philosophy in Imaging Science — *Aug. 2016 - May 2022*
- **Advisor**: Dr. Christopher Kanan
- **Thesis**: Towards Efficient Lifelong Machine Learning in Deep Neural Networks

Rochester Institute of Technology — *Rochester, NY*
Master of Science in Applied and Computational Mathematics — *Jan. 2015 - May 2017*
- **Advisor**: Dr. Nathan Cahill
- **Thesis**: Compassionately Conservative Normalized Cuts for Image Segmentation

Rochester Institute of Technology — *Rochester, NY*
Bachelor of Science in Applied Mathematics — *Sept. 2011 - May 2014*
- *Magna Cum Laude*

Appointments

Rochester Institute of Technology — *Rochester, NY*
Graduate Research Assistant — *Aug. 2017 - Present*
- Machine and Neuromorphic Perception Laboratory (kLab)
- **Mentor**: Dr. Christopher Kanan
- **Tasks**: Develop neural network models capable of learning new information incrementally over time, without catastrophically forgetting previous knowledge.

Facebook AI Research (FAIR) — *Virtual*
Research Intern — *May 2021 - Dec. 2021*
- **Mentors**: Dr. Arthur Szlam & Dr. Ludovic Denoyer
- **Tasks**: Developed neural network models for incremental active learning.

U.S. Naval Research Laboratory (NRL) — *Washington, DC*
Graduate Research Intern — *June 2017 - Aug. 2017*
- Naval Research Enterprise Internship Program (NREIP) by the American Society for Engineering Education (ASEE)
- **Mentor**: Dr. Leslie Smith
- **Tasks**: Assessed the validity of the manifold hypothesis within deep neural networks. Utilized dimensionality reduction and intrinsic dimension estimation techniques to characterize feature manifolds.

Rochester Institute of Technology — *Rochester, NY*
Graduate Research Assistant — *Jan. 2016 - May 2017*
- Image Computing and Analysis Laboratory (ICAL)
- **Mentor**: Dr. Nathan Cahill
- **Tasks**: Developed a new cut cost and optimization algorithm for graph-based image segmentation with ties to manifold learning.

UTC Aerospace Systems *Westford, MA*

Image Science Intern *June 2015 - Aug. 2015*

- **Tasks**: Implemented Non-Linear Least Squares optimizer to fit functions to edge spread data. Derived metrics from fitted data to evaluate resolution sharpness metrics of airborne sensors. Quantified confidence estimates using bootstrap resampling.

Liberty Mutual Insurance *Portsmouth, NH*

IT Analyst - Technical Development Program *June 2014 - Sept. 2014*

- **Tasks**: Led case study presentations. Coordinated process improvement project to improve productivity trackers. Created workflow diagrams and traceability matrices for process improvement projects.

Liberty Mututal Insurance *Portsmouth, NH*

Information Technology Intern *May 2013 - Aug. 2013*

- **Tasks**: Researched and compiled presentations on statistical models and statistical software used for predictive analytics. Developed use cases involving loss triangling methods and fraud detection techniques.

Scholarships & Awards

- **Best Library Award:** Workshop on Continual Learning in Computer Vision (CLVision) at CVPR-2021 *2021*
- **Travel Grant:** Women in Computer Vision (WiCV) Workshop at CVPR-2021 *2021*
- **Best Paper Award:** Workshop on Continual Learning in Computer Vision (CLVision) at CVPR-2020 *2020*
- **Travel Grant:** Women in Computer Vision (WiCV) Workshop at CVPR-2020 *2020*
- **Best Poster Award:** Western NY Signal Processing Workshop *2017*
- RIT Graduate Student Scholarship *2016*
- RIT Graduate Student Honor Roll (4.0/4.0 GPA) *2016*
- RIT Student Achievement Honors for **Outstanding Teaching Assistant** *2016*
- RIT Graduate Student Scholarship *2015*
- Alpha Sigma Lambda Honorary Society *2014*
- RIT Student Achievement Honors for **Best Mathematical Modeling Project** *2014*
- RIT Student Achievement Honors for **Best Grader** *2013*
- RIT Named Scholarship *2012*
- RIT Merit Scholarship *2011*

Talks

T.L. Hayes. Replay in deep learning: Current approaches and missing biological elements. *Continual AI Reading Group, Virtual*, 2021 [**Invited Talk**]

C. Kanan and **T.L. Hayes**. Continual learning in deep neural networks: Methods and applications. *Open Data Science Conference East, Virtual*, 2021

T.L. Hayes. Stream-51: Streaming classification and novelty detection from videos. *Continual AI Meetup: Benchmarks and Evaluation for Continual Learning, Virtual*, 2020 [**Invited Talk**]

T.L. Hayes. Remind your neural network to prevent catastrophic forgetting. *Continual AI Meetup: Continual Learning with Sequential Streaming Data, Virtual*, 2020 [**Invited Talk**]

T.L. Hayes. Memory efficient experience replay for mitigating catastrophic forgetting. *RIT AI Seminar Series, Rochester, NY*, 2019 [**Invited Talk**]

T.L. Hayes and N.D. Cahill. Piecewise flat embeddings for hyperspectral image analysis. *SPIE DCS Defense and Security Conference, Anaheim, CA*, 2017

Peer-Reviewed Publications

Y. Zhang, **T.L. Hayes**, and C. Kanan. Disentangling transfer and interference in multi-domain learning. *In: AAAIW: Practical Deep Learning in the Wild*, 2022

J. Gallardo, **T.L. Hayes**, and C. Kanan. Self-supervised training enhances online continual learning. *In: British Machine Vision Conference (BMVC)*, 2021 [36.2% accept rate]

T.L. Hayes, G.P. Krishnan, M. Bazhenov, H.T. Siegelmann, T.J. Sejnowski, and C. Kanan. Replay in deep learning: Current approaches and missing biological elements. *Neural Computation*, 2021

T.L. Hayes and C. Kanan. Selective replay enhances learning in online continual analogical reasoning. *In: CVPRW: Continual Learning in Computer Vision*, 2021 [**Oral Presentation**]

V. Lomonaco, L. Pellegrini, A. Cossu, A. Carta, G. Graffieti, **T.L. Hayes**, M. De Lange, M. Masana, J. Pomponi, G. van de Ven, M. Mundt, Q. She, K. Cooper, J. Forest, E. Belouadah, S. Calderara, G.I. Parisi, F. Cuzzolin, A. Tolias, S. Scardapane, L. Antiga, S. Amhad, A. Popescu, C. Kanan, J. van de Weijer, T. Tuytelaars, D. Bacciu, and D. Maltoni. Avalanche: an end-to-end library for continual learning. *In: CVPRW: Continual Learning in Computer Vision*, 2021 [**Best Library Award**]

R. Roady, **T.L. Hayes**, R. Kemker, A. Gonzales, and C. Kanan. Are open set classification methods effective on large-scale datasets? *PLoS ONE*, 2020

M. Acharya, **T.L. Hayes**, and C. Kanan. Rodeo: Replay for online object detection. *In: British Machine Vision Conference (BMVC)*, 2020 [29.1% accept rate]

R. Roady, **T.L. Hayes**, and C. Kanan. Improved robustness to open set inputs via tempered mixup. *In: ECCVW: Adversarial Robustness in the Real World*, 2020

T.L. Hayes*, K. Kafle*, R. Shrestha*, M. Acharya, and C. Kanan. Remind your neural network to prevent catastrophic forgetting. *In: Proc. European Conference on Computer Vision (ECCV)*, 2020 [27.1% accept rate; * denotes equal contribution]

T.L. Hayes and C. Kanan. Lifelong machine learning with deep streaming linear discriminant analysis. *In: CVPRW: Continual Learning in Computer Vision*, 2020 [**Best Paper Award; Oral Presentation**]

R. Roady*, **T.L. Hayes***, H. Vaidya, and C. Kanan. Stream-51: Streaming classification and novelty detection from videos. *In: CVPRW: Continual Learning in Computer Vision*, 2020 [* denotes equal contribution]

T.L. Hayes, N.D. Cahill, and C. Kanan. Memory efficient experience replay for streaming learning. *In: Proc. IEEE International Conference on Robotics and Automation*, 2019 [44.0% accept rate]

T.L. Hayes, R. Kemker, N.D. Cahill, and C. Kanan. New metrics and experimental paradigms for continual learning. *In: CVPRW: Real-World Challenges and New Benchmarks for Deep Learning in Robotic Vision*, 2018

N.D. Cahill, **T.L. Hayes**, R.T. Meinhold, and J.F. Hamilton. Compassionately conservative balanced cuts for image segmentation. *In: Proc. IEEE Conference on Computer Vision and Pattern Recognition*, 2018 [29.6% accept rate]

R. Kemker, M. McClure, A. Abitino, **T.L. Hayes**, and C. Kanan. Measuring catastrophic forgetting in neural networks. *In: AAAI*, 2018 [24.6% accept rate; **Oral Presentation**]

Patent Applications

C. Kanan, **T.L. Hayes**, K. Kafle, and R. Shrestha. Method for training parametric machine learning systems, January 28 2021. US Patent App. 16/938,035

Pre-Prints

T.L. Hayes and C. Kanan. Online continual learning for embedded devices. *arXiv*, 2022

T.L. Hayes, M. Nickel, C. Kanan, L. Denoyer, and A. Szlam. Can I see an example? Active learning the long tail of attributes and relations. *arXiv*, 2022

Z. Qian, **T.L. Hayes**, K. Kafle, and C. Kanan. Do we need fully connected output layers in convolutional networks? *arXiv*, 2020

Conference Papers

T.L. Hayes, R.T. Meinhold, J.F. Hamilton, and N.D. Cahill. Piecewise flat embeddings for hyperspectral image analysis. *In: Proc. SPIE DCS Defense and Security: Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XXIII*, 2017

R.T. Meinhold, **T.L. Hayes**, and N.D. Cahill. Efficiently computing piecewise flat embeddings for data clustering and image segmentation. *In: Proc. IEEE MIT Undergraduate Research and Technology Conference*, 2016

Abstracts & Posters Without Proceedings

T.L. Hayes and C. Kanan. Selective replay enhances learning in online continual analogical reasoning. *Western NY Image and Signal Processing Workshop, Rochester, NY*, 2021

J. Gallardo, **T.L. Hayes**, and C. Kanan. Self-supervised training enhances online continual learning. *Western NY Image and Signal Processing Workshop, Rochester, NY*, 2021

T.L. Hayes and C. Kanan. Selective replay enhances learning in online continual analogical reasoning. *CVPR Workshop: Women in Computer Vision (WiCV), Virtual*, 2021

T.L. Hayes*, K. Kafle*, R. Shrestha*, M. Acharya, and C. Kanan. Remind your neural network to prevent catastrophic forgetting. *CVPR Workshop: Women in Computer Vision (WiCV), Virtual*, 2020 [* denotes equal contribution]

T.L. Hayes and C. Kanan. Lifelong machine learning with deep streaming linear discriminant analysis. *Western NY Image and Signal Processing Workshop, Rochester, NY*, 2019

T.L. Hayes and C. Kanan. Lifelong machine learning with deep streaming linear discriminant analysis. *DARPA L2M PI Meeting, Chicago, IL*, 2019

T.L. Hayes, N.D Cahill, and C. Kanan. Memory efficient experience replay for streaming learning. *Western NY Image and Signal Processing Workshop, Rochester, NY*, 2018

T.L. Hayes, R. Kemker, N.D. Cahill, and C. Kanan. New metrics and experimental paradigms for continual learning. *CVPR Workshop: Real-World Challenges and New Benchmarks for Deep Learning in Robotic Vision, Salt Lake City, UT*, 2018

R. Kemker, M. McClure, A. Abitino, **T.L. Hayes**, and C. Kanan. Measuring catastrophic forgetting in neural networks. *Conference on Data Analysis (CoDA), Santa Fe, NM*, 2018

R. Kemker, M. McClure, A. Abitino, **T.L. Hayes**, and C. Kanan. Measuring catastrophic forgetting in neural networks. *Western NY Image and Signal Processing Workshop, Rochester, NY*, 2017 [**Best Poster Award**]

Teaching Experience

Rochester Institute of Technology *Rochester, NY*

Guest Lectures

- **Guest Lecturer for RIT's Graduate Level Deep Learning for Vision Course (2021)**: Lectured on lifelong machine learning.
- **Guest Lecturer for RIT's Graduate Level Deep Learning for Vision Course (2020)**: Lectured on lifelong machine learning.
- **Guest Lecturer for RIT's Graduate Level Image Processing and Computer Vision Course (2017)**: Lectured on clustering techniques and background subtraction.

Rochester Institute of Technology *Rochester, NY*

Graduate Teaching Assistant *Aug. 2016 - May 2017*

- Chester F. Carlson Center for Imaging Science
- **Classes**: Deep Learning for Vision (Graduate Level), Image Processing and Computer Vision (Graduate Level)
- **Tasks**: Graded and assisted students with homework, proposals, projects, and presentations.

Rochester Institute of Technology *Rochester, NY*

Graduate Teaching Assistant *Jan. 2015 - May 2016*

- School of Mathematical Sciences
- **Classes**: Calculus (B, C, I, II)
- **Tasks**: Assisted students with in-class workshops and graded homework assignments.

Rochester Institute of Technology *Rochester, NY*

Learning Assistant *Jan. 2014 - May 2014*

- School of Mathematical Sciences
- **Class**: Mathematics of Graphical Simulation
- **Tasks**: Created notes and graded group worksheets. Held recitation sessions for assistance with homework and class concepts.

Rochester Institute of Technology *Rochester, NY*

Grader *Sept. 2012 - Dec. 2013*

- School of Mathematical Sciences
- **Classes**: Multivariable Calculus, Differential Equations, Probability and Statistics
- **Tasks**: Graded homework assignments.

Service

Women in Machine Learning (WiML) Workshop at the Neural Information Processing (NeurIPS) Conference *Virtual*

Volunteer *2021*

- **Help Desk Volunteer**: Provided answers to general workshop questions and helped troubleshoot technology issues.

Women in Machine Learning (WiML) Workshop at the Neural Information Processing (NeurIPS) Conference *Virtual*

Volunteer *2020*

- **Poster Mentor**: Attended my mentee's poster session to discuss her work. Provided constructive feedback on her poster and presentation.
- **Help Desk Volunteer**: Provided answers to general workshop questions and helped troubleshoot technology issues.

Rochester Institute of Technology *Rochester, NY*

GRADUATE DIVERSITY OUTREACH *2018 - 2019*

- Spoke to RIT's Pathways to Graduate School classes and LSAMP/McNair students on differences between undergraduate and graduate schooling and how to be successful in graduate school.

Students Supervised

- Yipeng Zhang: BS Student at University of Rochester [co-authored a paper together] *2020-2021*
- Hitesh Vaidya: MS Student at Rochester Institute of Technology [co-authored a paper together] *2019*
- Xuexun Xiao: MS Student at University of Rochester *2019*
- Michael Geraci: HS Student *2018*

Technical Skills

Deep Learning Frameworks	PyTorch, TensorFlow, Keras
Scientific Computing Packages	Numpy, Scipy, Scikit-learn
Programming (Proficient)	Python, MATLAB
Programming (Basic)	Java
Applications	Git, Bash Scripting, LaTeX, Microsoft Office, Word, Excel, Outlook

Reviewer

- IEEE Conference on Computer Vision and Pattern Recognition (CVPR) *2022*
- Frontiers in Neurorobotics *2021*
- IEEE Access *2020*
- British Machine Vision Conference (BMVC) *2020, 2021*
- CVPR Workshop on Continual Learning in Computer Vision (CLVision) *2020, 2021*
- IEEE Transactions on Neural Networks and Learning Systems *2020, 2021*
- Neural Networks (Elsevier) *2020*
- IEEE International Symposium on Biomedical Imaging (ISBI) [Delegate Reviewer] *2018*
- IEEE International Conference on Image Processing (ICIP) *2017*