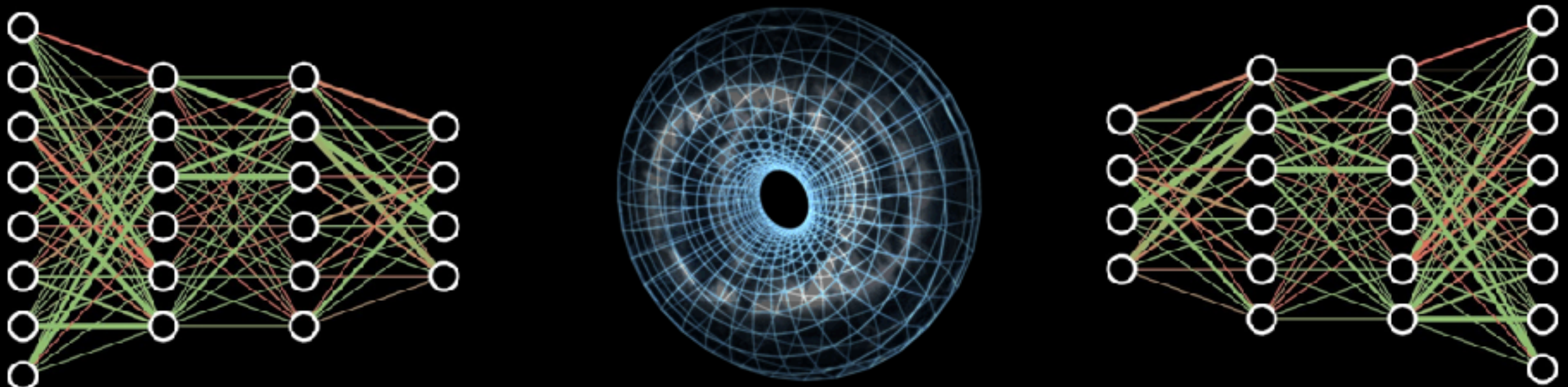
Ubiquitous Machine Learning

deep data representation for next generation applications



SMU O'Donnell Institute Speaker Series, HPC

September 18th, 2024

eric c. larson | eclarson.com

Bobby B. Lyle Endowed Professor in Engineering Innovation

Associate Professor in Computer Science

SMU Lyle School of Engineering

SMU X UTD

Computational Biology & Health Workshop

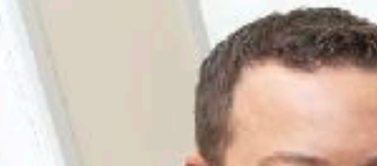
October 3, 2024. 9:00 AM - 1:00 PM.

(3000 Pegasus Park Drive, Dallas, TX 75247)

Light breakfast and lunch will be served.

REGISTER HERE

Questions? Contact
Mary.Moua@smu.edu.



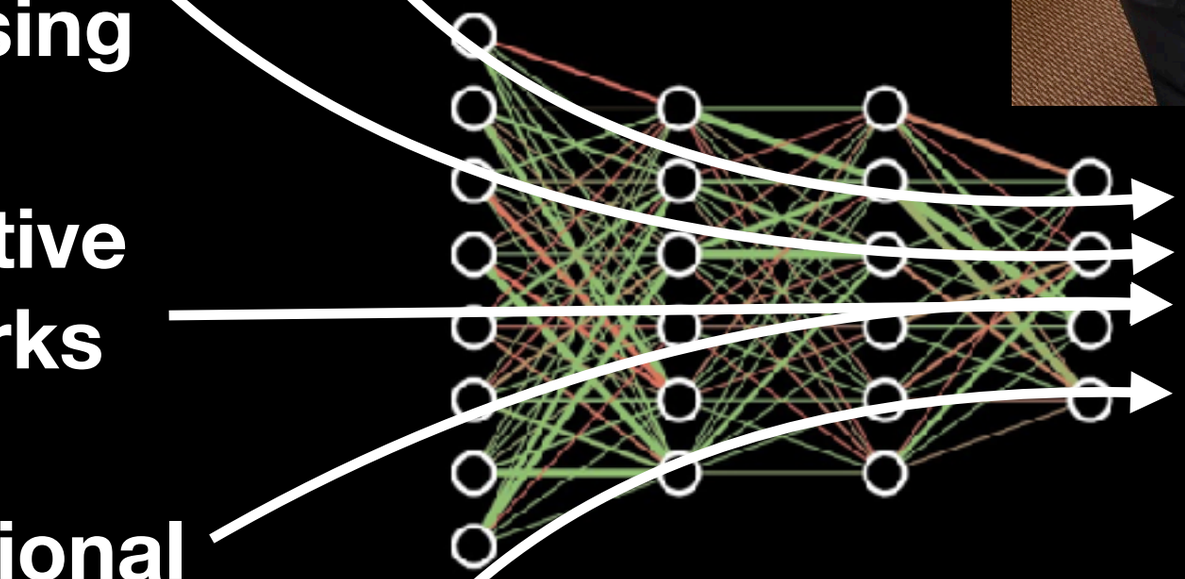
Matrix Factorization

Sequential Processing

Generative Networks

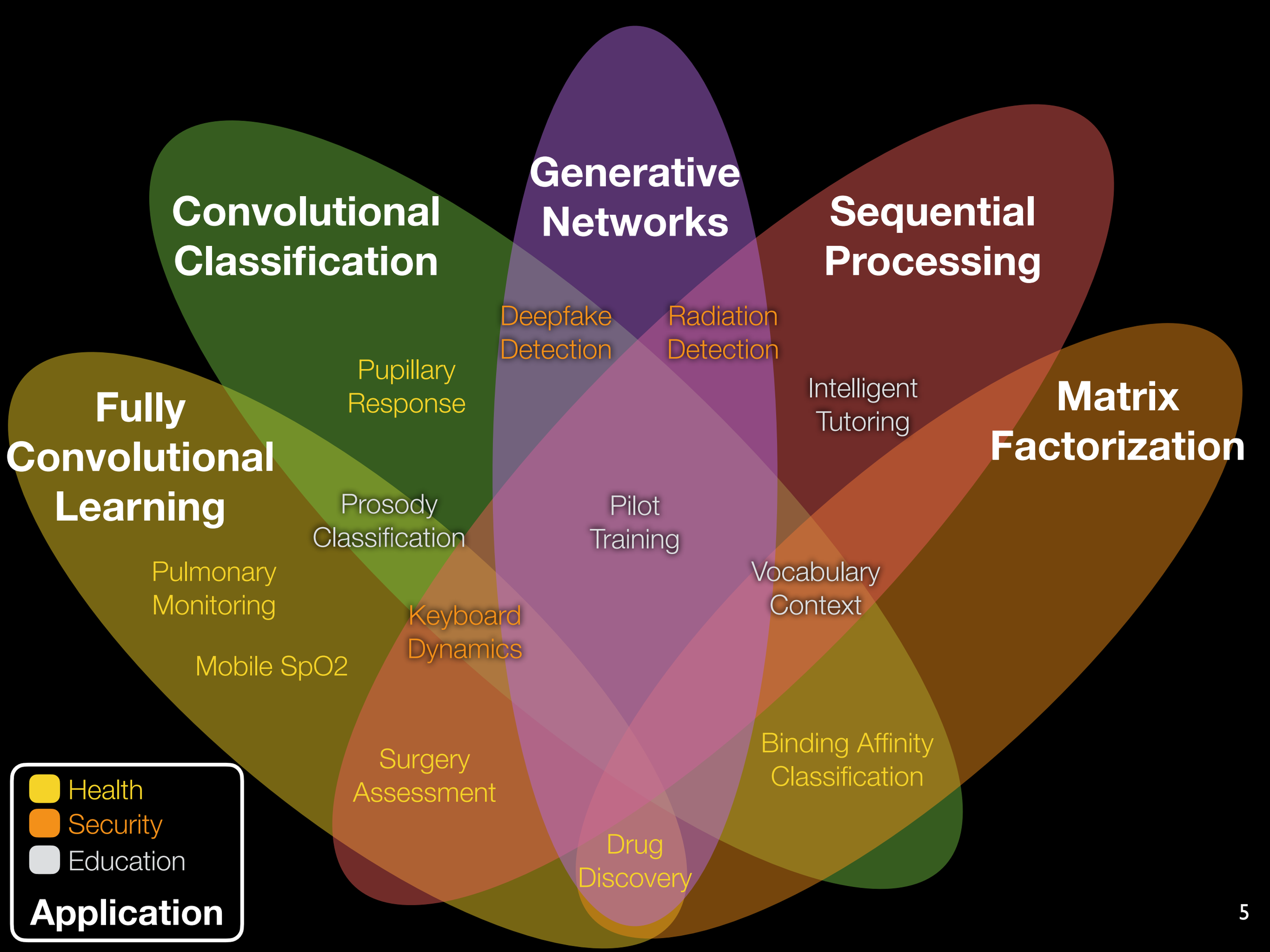
Convolutional Classification

Fully Convolutional Learning

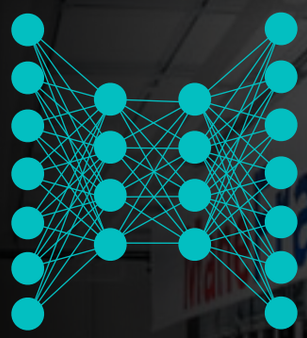


$$p(s \mid k)$$

$$\arg\max_{k} \mathbf{E}_{k \in \mathcal{K}} \left[p(s \mid k) \right]$$


Convolutional Classification
Generative Networks
Sequential Processing
Fully Convolutional Learning
Matrix Factorization
Deepfake Detection
Radiation Detection
Pupillary Response
Intelligent Tutoring
Prosody Classification
Pilot Training
Pulmonary Monitoring
Vocabulary Context
Keyboard Dynamics
Mobile SpO2
Surgery Assessment
Binding Affinity Classification
Drug Discovery
Health
Security
Education
Application

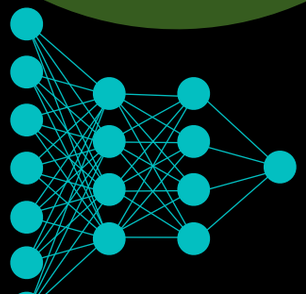
Fully Convolutional Learning



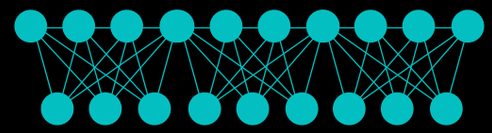
Generative Networks

Matrix Factorization

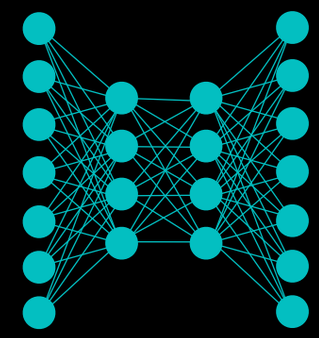
Convolutional Classification

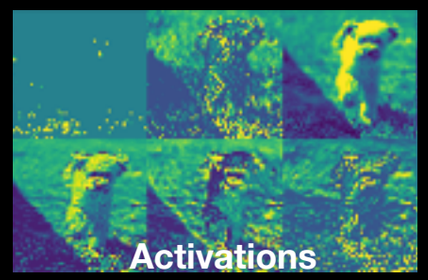


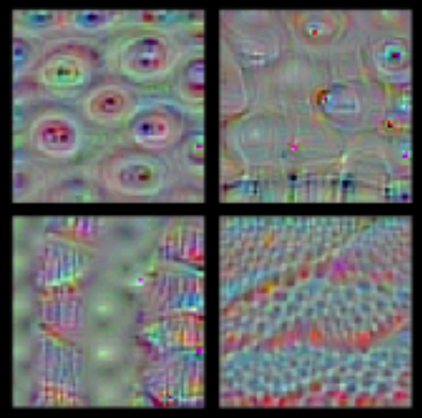
Sequential Processing

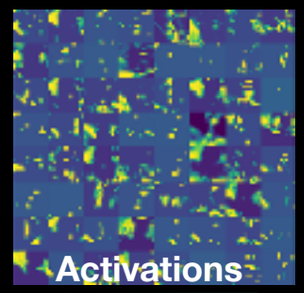


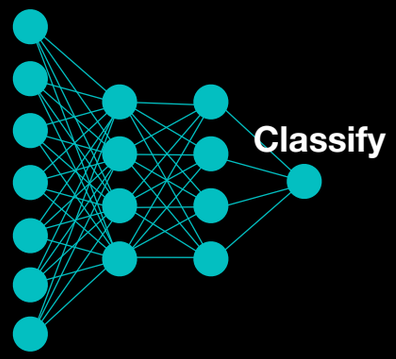
Fully Convolutional Learning

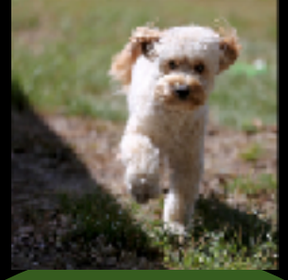


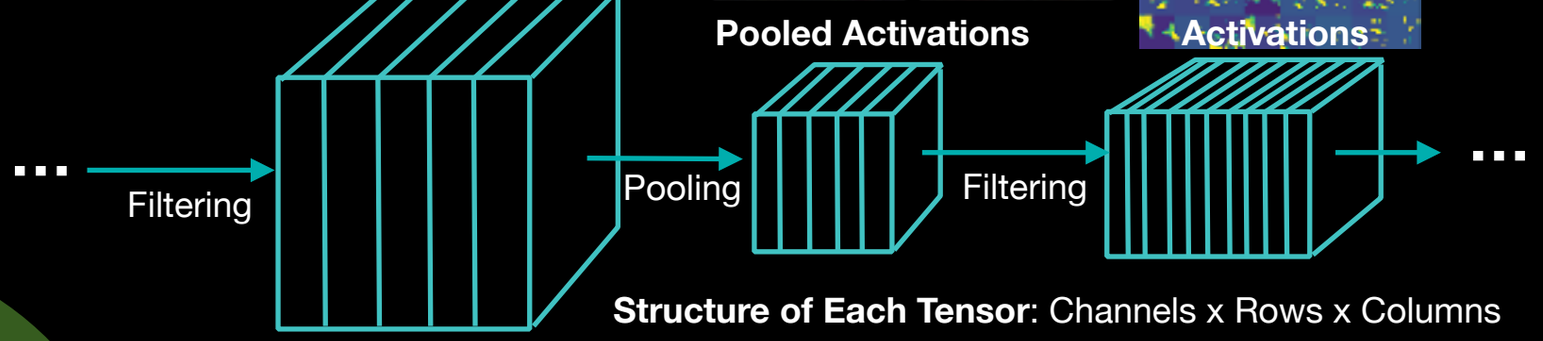












Structure of Each Tensor: Channels x Rows x Columns

Convolutional Classification

Label Errors

Back-propagate to reduce errors
(optimize filter values)

Robotic Partial Nephrectomy Scoring Card

Overall Rubric Scoring

Your GEARS rubric total: **28**

You scored at an **expert** level. Most surgeons score 26 or better.

Your OSATS rubric total: **32**

You scored at an **expert** level. Most surgeons score 32 or better.

Task Specific Rubric Scoring

Surgical Task: **Cut**

Task Time: 9 mins 57 s

Suggested Video Reviews: (Click to navigate)

3 min 12 s

GEARS Total	28
Depth Perception	5
Bimanual Dexterity	5
Efficiency	3
Force Sensitivity	5
Autonomy	5
Robotic Control	5
OSATS Total	32
Respect for Tissue	5
Time & Motion	4
Instrument Handling	5
Inst. Knowledge	5
Assistance	5
Flow of Operation	5
Know. of Procedure	4

Surgical Task: **Reconnection**

Task Time: 19 mins 5 s

Suggested Video Reviews: (Click to navigate)

25 min 36 s

GEARS Total	27
Depth Perception	5
Bimanual Dexterity	4
Efficiency	3
Force Sensitivity	5
Autonomy	5
Robotic Control	5
OSATS Total	31
Respect for Tissue	4
Time & Motion	3
Instrument Handling	5
Inst. Knowledge	5
Assistance	5
Flow of Operation	5
Know. of Procedure	4

Surgical Task: **Bolster**

Task Time: 9 mins 41 s

Suggested Video Reviews: None

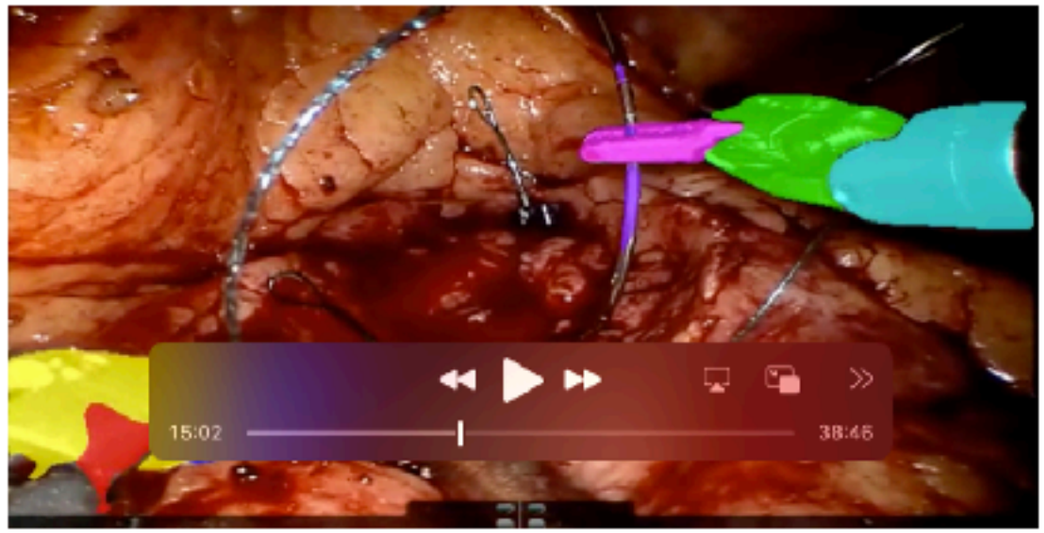
GEARS Total	29
Depth Perception	5
Bimanual Dexterity	5
Efficiency	4
Force Sensitivity	5
Autonomy	5
Robotic Control	5
OSATS Total	30
Respect for Tissue	5
Time & Motion	3
Instrument Handling	4
Inst. Knowledge	5
Assistance	5
Flow of Operation	5
Know. of Procedure	5

GEARS Scoring Explanation

Depth Perception				
1	2	3	4	5
Consistently accesses the target, large movements, flails slowly.		Some failures in reaching the goal, but corrected quickly.		Directs the instruments in the correct plane to the target.
Bimanual skill				
1	2	3	4	5
Use only one hand, ignores the non-dominant hand, poor coordination between the two.		Uses both hands, but the interaction between them is not optimal.		Uses both hands in a complementary manner for optimal exposure.
Efficiency				
1	2	3	4	5
Many redundant movements, frequent changes in the plan to do not progress.		Slow movements, but organized and reasonable.		Confident, efficient, remains focused on the goal.
Force control				
1	2	3	4	5
Jerking, tearing the tissue, damage to structures. Frequent breaking of the suture.		Reasonable handling of tissues, less damage occurs. Occasional rupture of the suture.		Proper handling of tissues, proper tension thereof. Without breaking the suture.
Autonomy				
1	2	3	4	5
Unable to complete the procedure.		This surgeon is able to complete the task safely, with some guidance/tutor.		Able to complete the task alone, without a guide.
Robot Control				
1	2	3	4	5
No optimizes the position of the hands on the console. Frequent collision. The vision is not calibrated.		Occasional collision of hand. Vision is sometimes not optimum.		Adequate control of the camera. Optimal hand position without collision.

OSATS Scoring Explanation

	1	2	3	4	5
Respect for tissue	Frequently used unnecessary force on tissue or caused damage by inappropriate use of instruments	2	Careful handling of tissue but occasionally caused inadvertent tissue damage	4	Consistently handled tissues appropriately with minimal damage
Time and motion	Many unnecessary moves	2	Efficient time/motion but some unnecessary moves	4	Economy of movement and maximum efficiency
Instrument handling	Repeatedly makes tentative or awkward moves with instruments	2	Competent use of instruments although occasionally appeared stiff or awkward	4	Fluid moves with instruments and no awkwardness
Knowledge of instruments	Frequently asked for the wrong instrument or used an inappropriate instrument	2	Knew the names of most instruments and used appropriate instrument for the task	4	Obviously familiar with the instruments required and their use
Use of assistants	Consistently placed assistants poorly or failed to use assistants	2	Good use of assistants most of the time	4	Strategically used assistant to the best advantage at all times
Flow of operation and forward planning	Frequently stopped operating or needed to discuss next move	2	Demonstrated ability for forward planning with steady progression of operative procedure	4	Obviously planned course of operation with effortless flow from one move to the next
Knowledge of specific procedure	Deficient knowledge. Needed specific instruction at most operative steps	2	Knew all important aspects of the operation	4	Demonstrated familiarity with all aspects of the operation



Video Review Portal: See suggested review points shown to the left.

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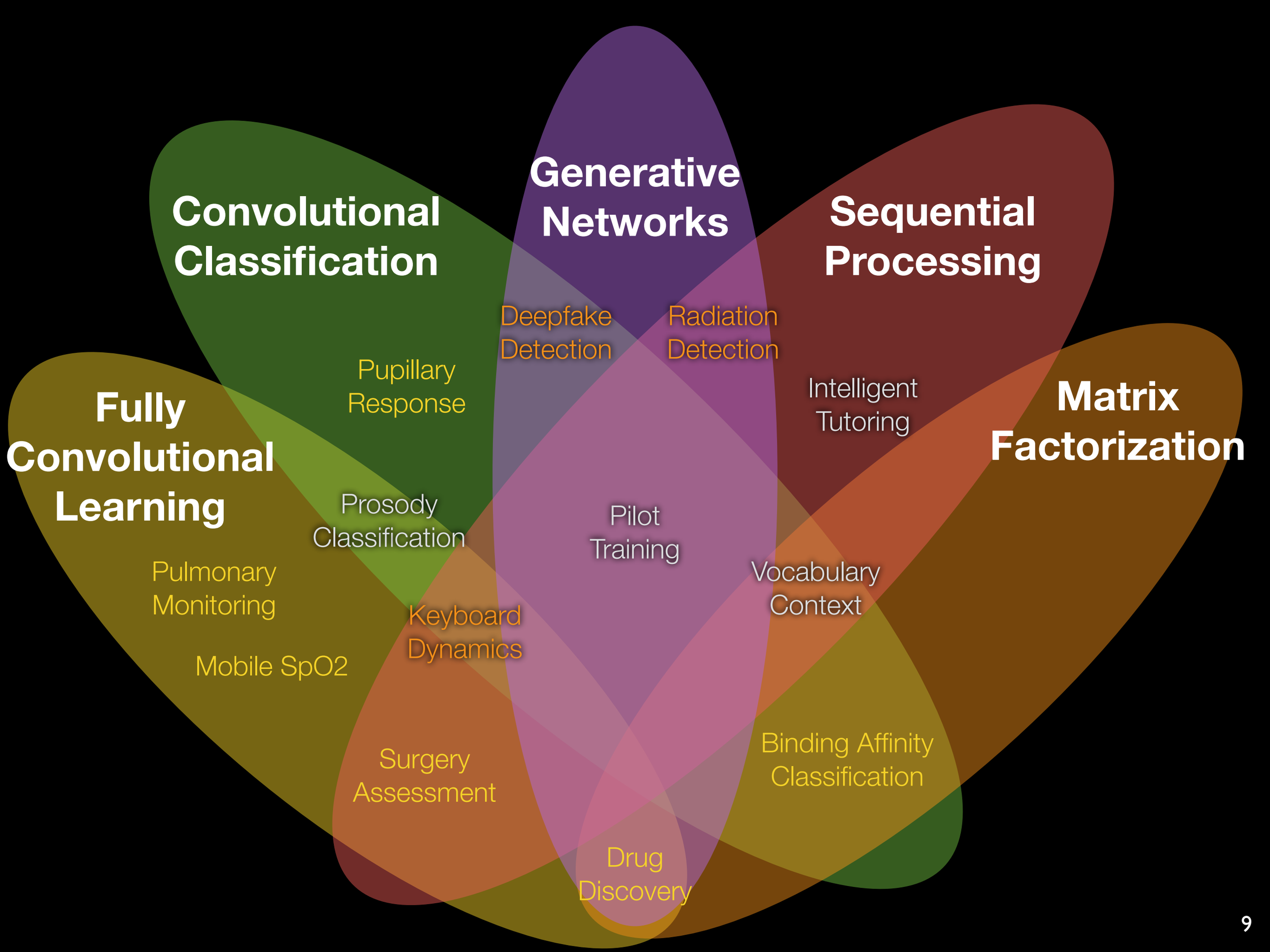
INTUITIVE Foundation

SMU Artificial Intelligence

UTSW Urology

Convolutional Classification

- X. Qu, M. El-Saied, J. Gahan, R. Steinberg, and E.C. Larson (2019). “Machine Learning using a Multi-task Convolutional Neural Networks Can Accurately Provide Robotic Skills Assessment.” 2019 World Congress of Endourology.
- Y. Wang, J. Dai, T. Morgan, M. Elsaid, A. Garbens, X. Qu, R. Steinberg, J. Gahan, and E.C. Larson (2021). "Evaluating Robotic-Assisted Surgery Training Videos with Multi-task Convolutional Neural Networks." Journal of Robotic Surgery (JORS), 2021. Doi: 10.1007/s11701-021-01316-2
- Zhongjie Wu, Yihao Wang, Jessica Dai, Tara Morgan, Alaina Garbens, Hal Kominsky, Jeffrey Gahan, & Eric C. Larson (2023) Evaluating Robotic Partial Nephrectomy Surgeons with Fully Convolutional Segmentation and Multitask Attention Networks. JORS 10.1007/s11701-023-01657-0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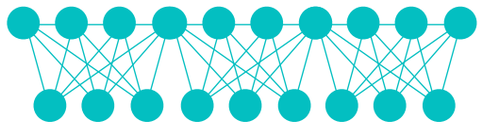
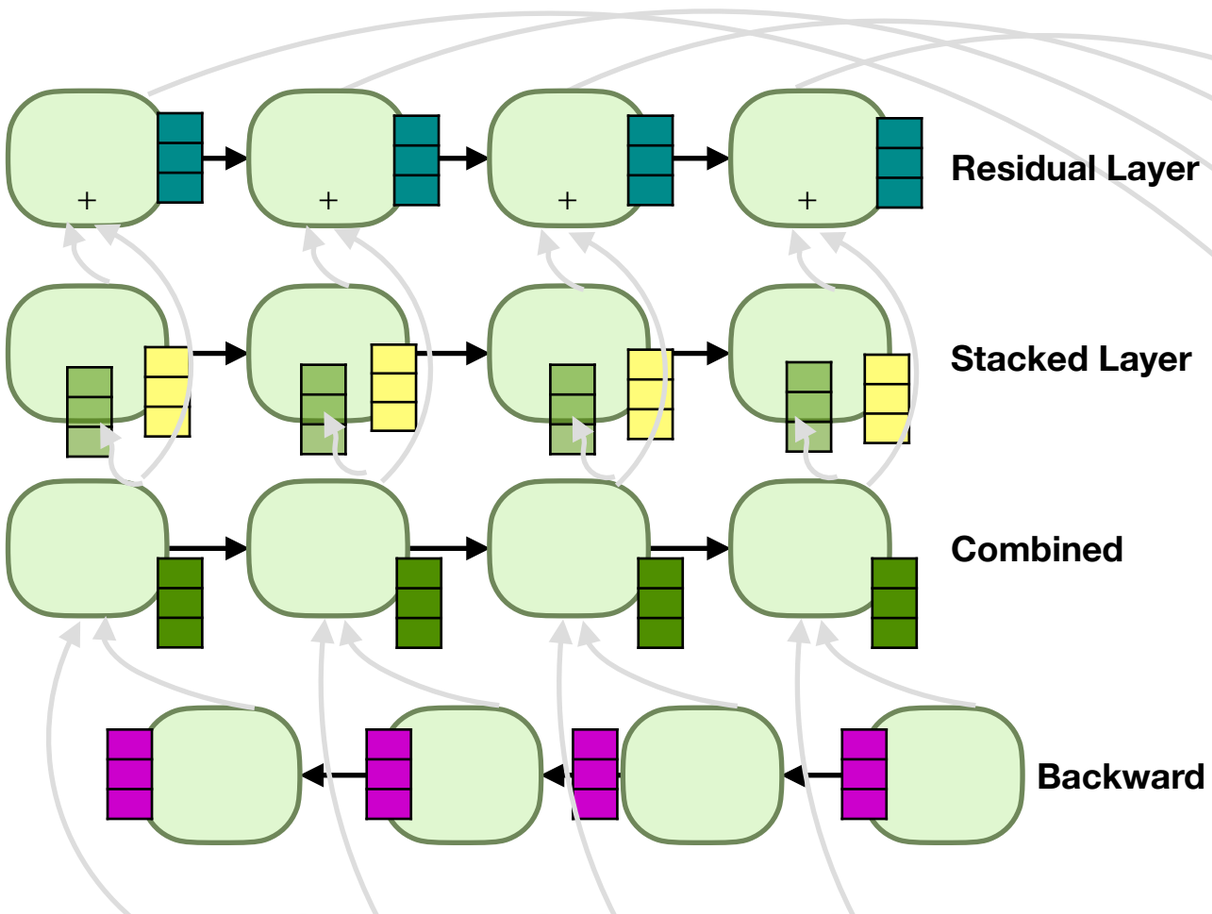
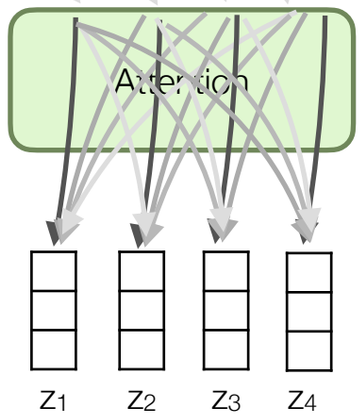
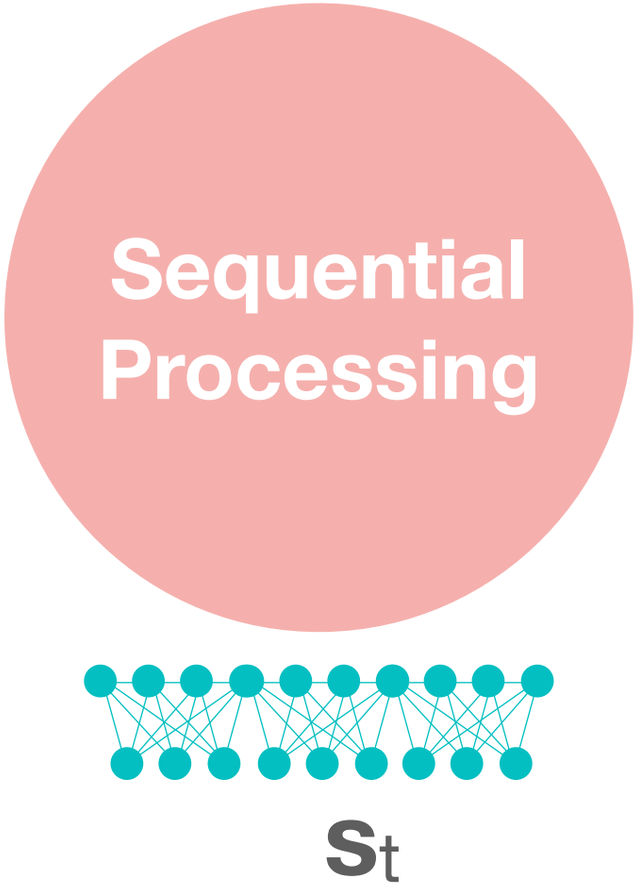
Pilot Training
Pulmonary Monitoring
Vocabulary Context
Keyboard Dynamics
Mobile SpO2
Surgery Assessment
Binding Affinity Classification
Drug Discovery

Sequential Processing

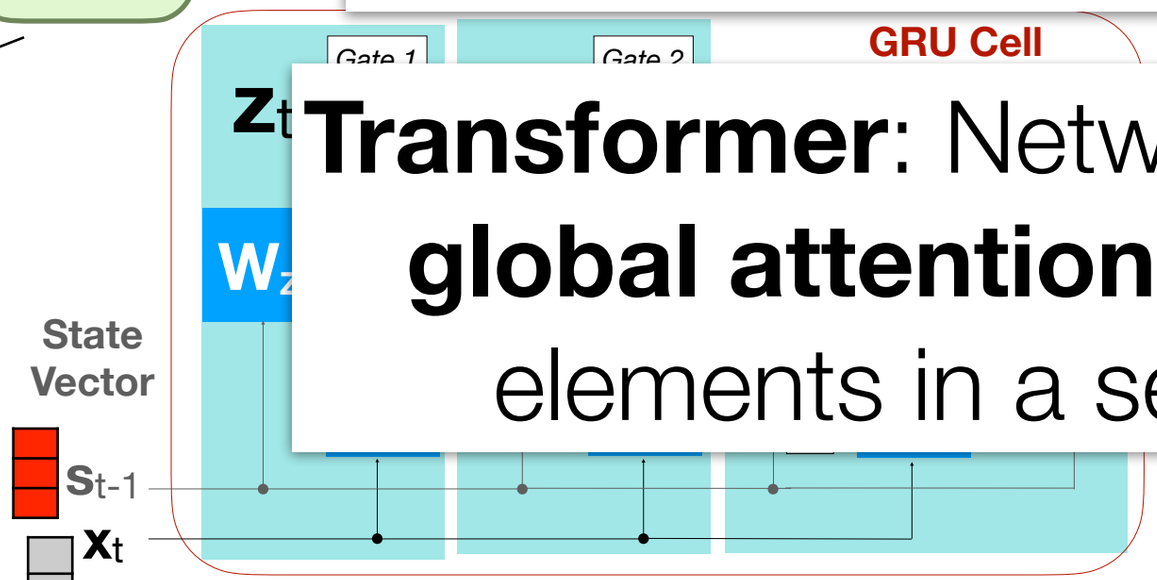






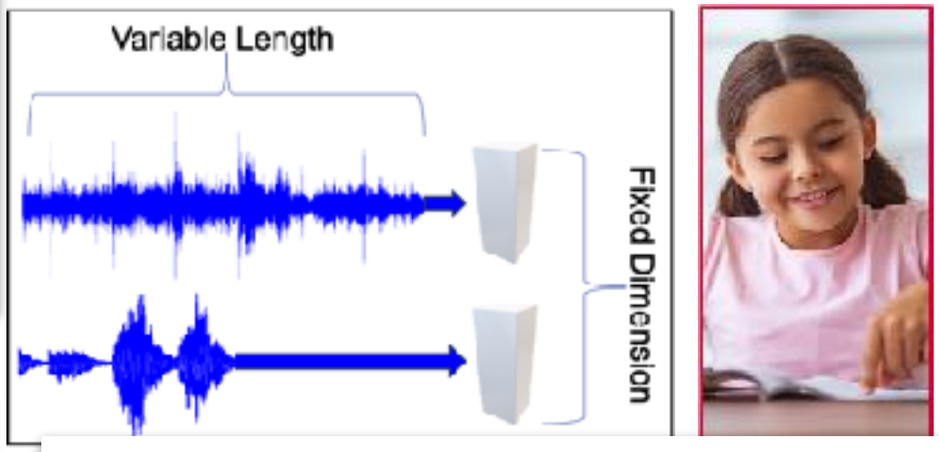


Recurrent: Network "Learns" **state** representation & how to **track/interpret**



Transformer: Network "Learns" **global attention** among all elements in a sequence

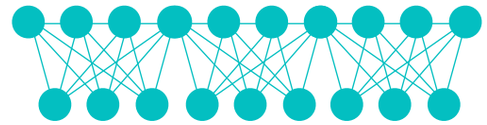
Vocabulary Acquisition Assessment

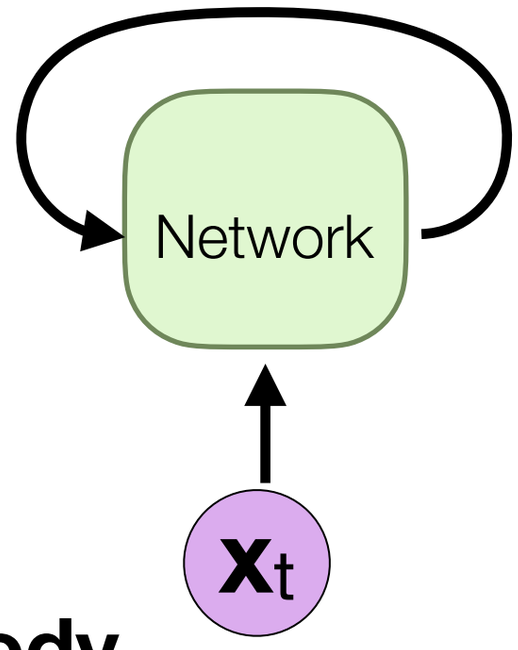


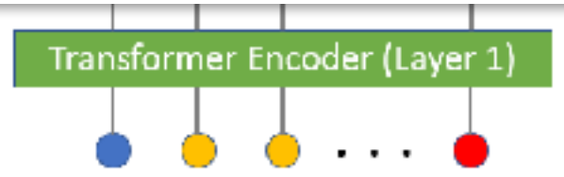
Sequential Processing

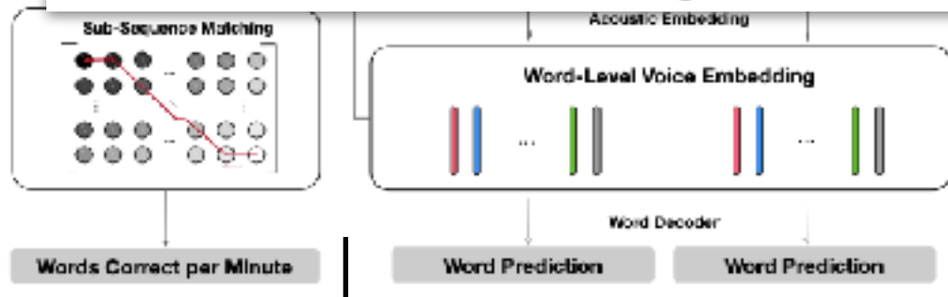
0.78 Model κ with human raters, approaching human level

Achieved 86% correctness compared to human rated prosody and 97% correctness of Oral Reading Fluency







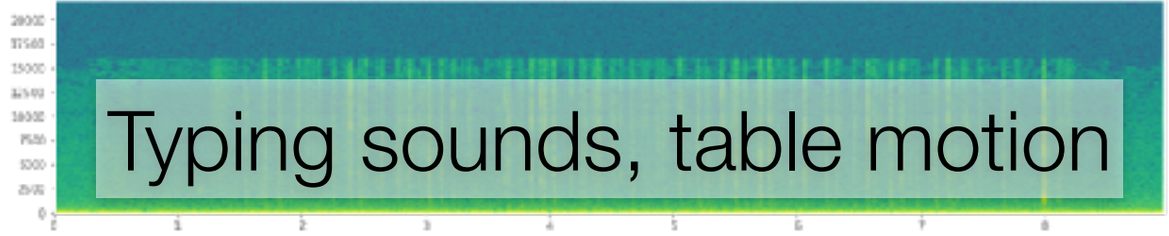


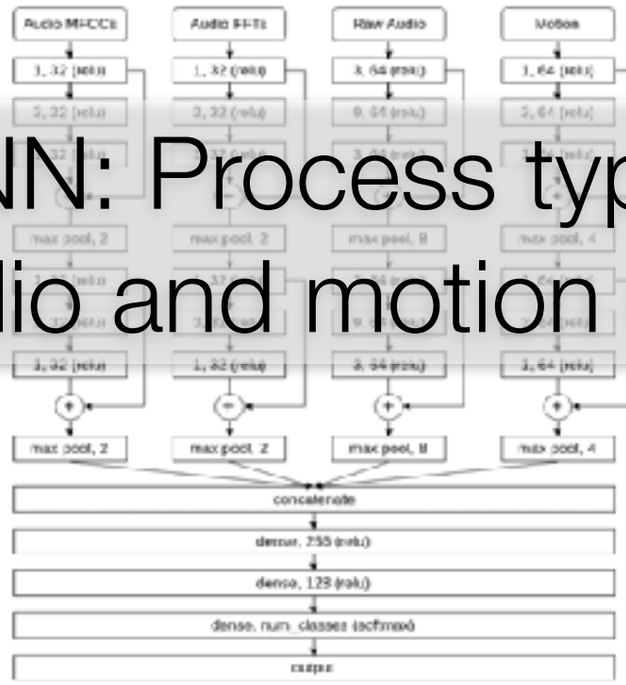
Oral Reading Fluency
Words correct per Minute

Prosody
NAEP Socring

- G. Sammit,* Z. Wu,* Y. Wang,* Z. Wu,* A. Kamata, J. Nese, and E. C. Larson (2022). Automated Prosody Classification for Oral Reading Fluency with Quadratic Kappa Loss and Attentive X-vectors. International Conference on Acoustics, Speech, and Signal Processing (ICASSP 2022).
- Yihao Wang, Zhongdi Wu, Akihito Kamata, Joseph Nese, Vedant Nilabh, & Larson, E. (2024) Improving Oral Reading Fluency Assessment through Sub-sequence Matching of Acoustic Word Embeddings. (ICASSP 2024)
- Z. Wu, EC Larson, M. Sano, A. Kamata, N. Gage, and D. Baker (2023). Towards Scalable Vocabulary Acquisition Assessment with BERT. Learning at Scale 2023.

Convolutional Classification

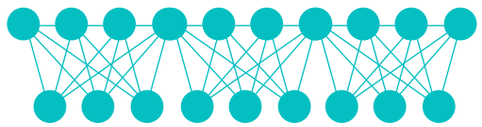


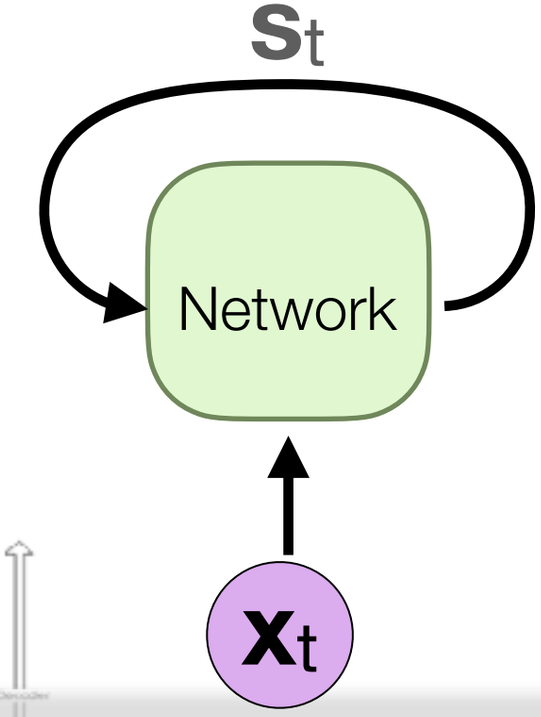


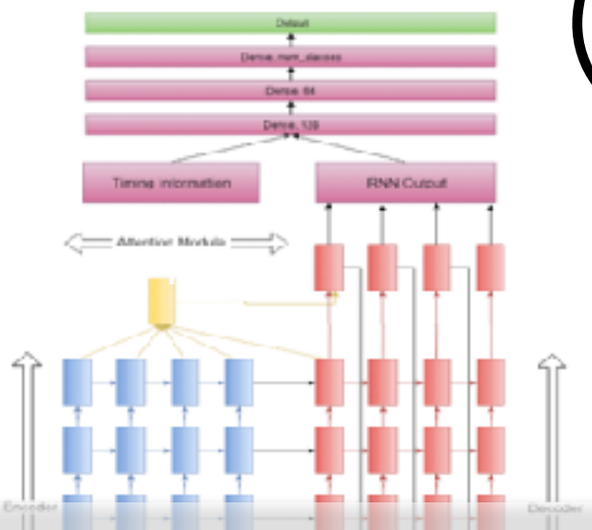
CNN: Process typing audio and motion data

>90% Typing Accuracy

Sequential Processing

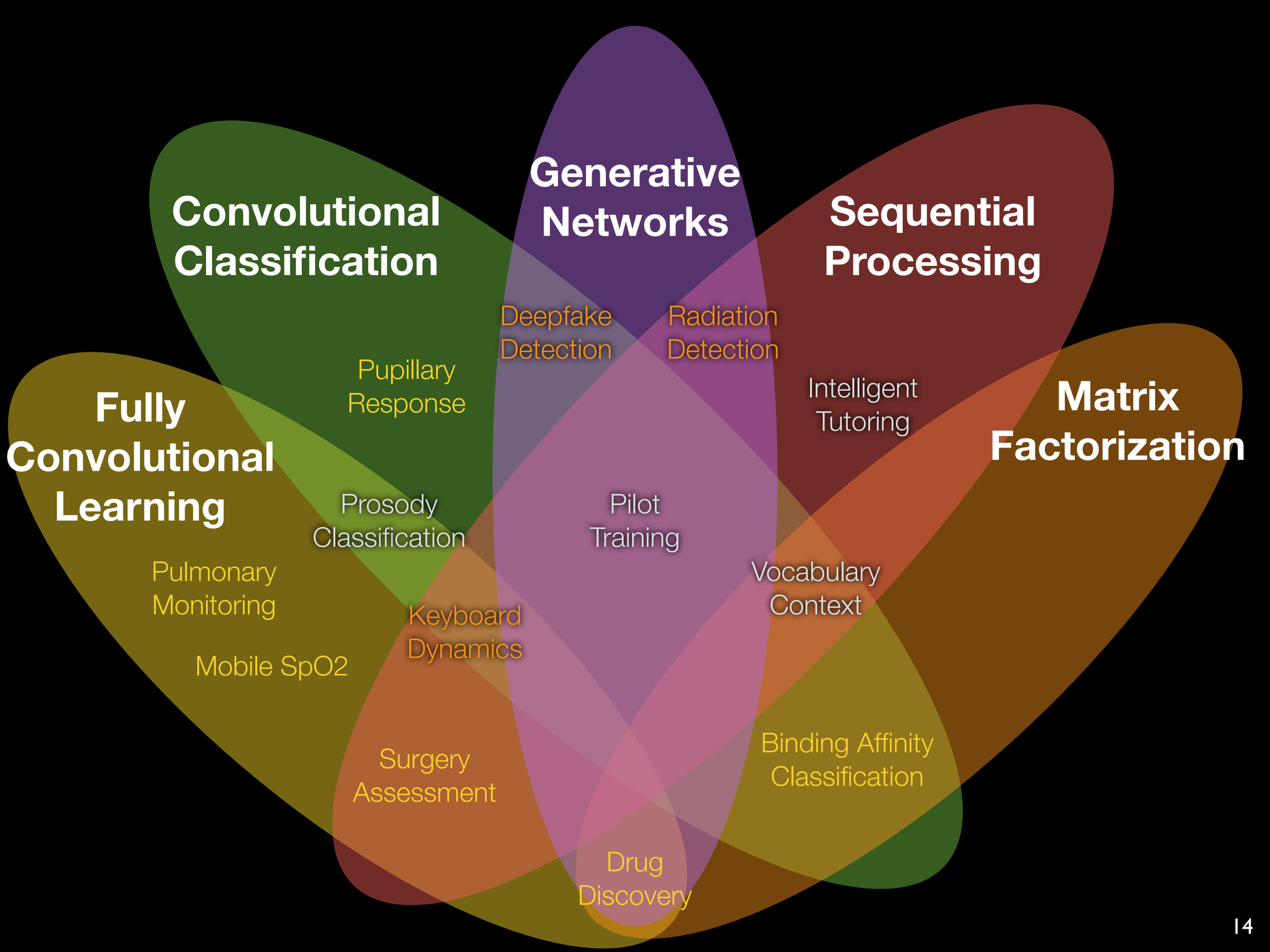






Transformer: Aggregate CNN Typing Sequence to form phrases

- T. Giallanza*, T. Siems*, E. Sharp*, I. Johnson*, E. Gabrielsen*, M. Thornton, and E.C. Larson (June 2019). Keyboard Snooping via Mobile Phones: Threats of Device Arrays. Journal of Interactive, Wearable, and Ubiquitous Technology (IMWUT). 2019.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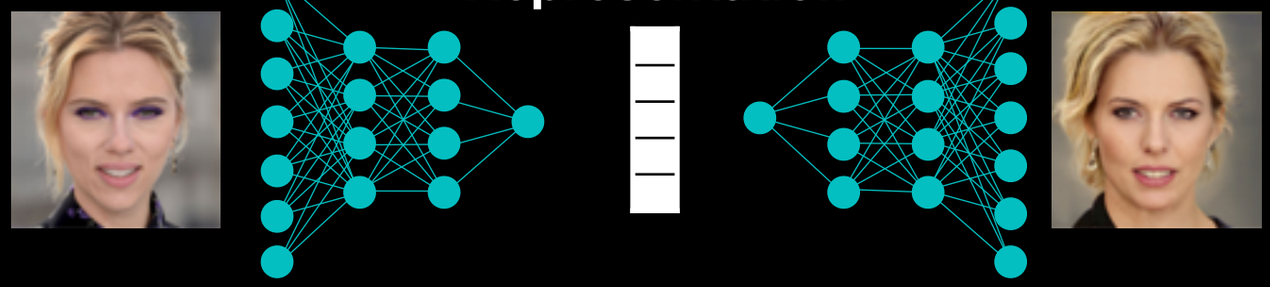
Prosody Classification
Pilot Training
Pulmonary Monitoring
Vocabulary Context
Keyboard Dynamics
Mobile SpO2
Surgery Assessment
Binding Affinity Classification
Drug Discovery

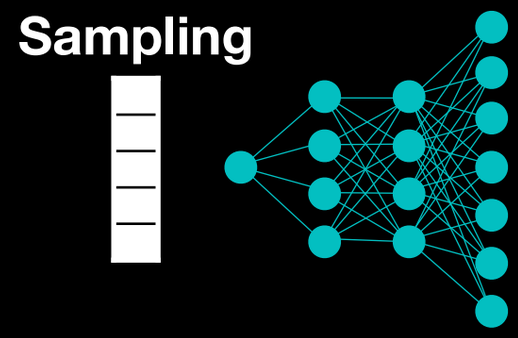
Pidhorskyi, Stanislav, Donald A. Adjeroh, and Gianfranco Doretto. "Adversarial latent autoencoders." IEEE/CVF Conference on Computer Vision and Pattern Recognition, pp. 14104-14113. 2020.

Generative Networks

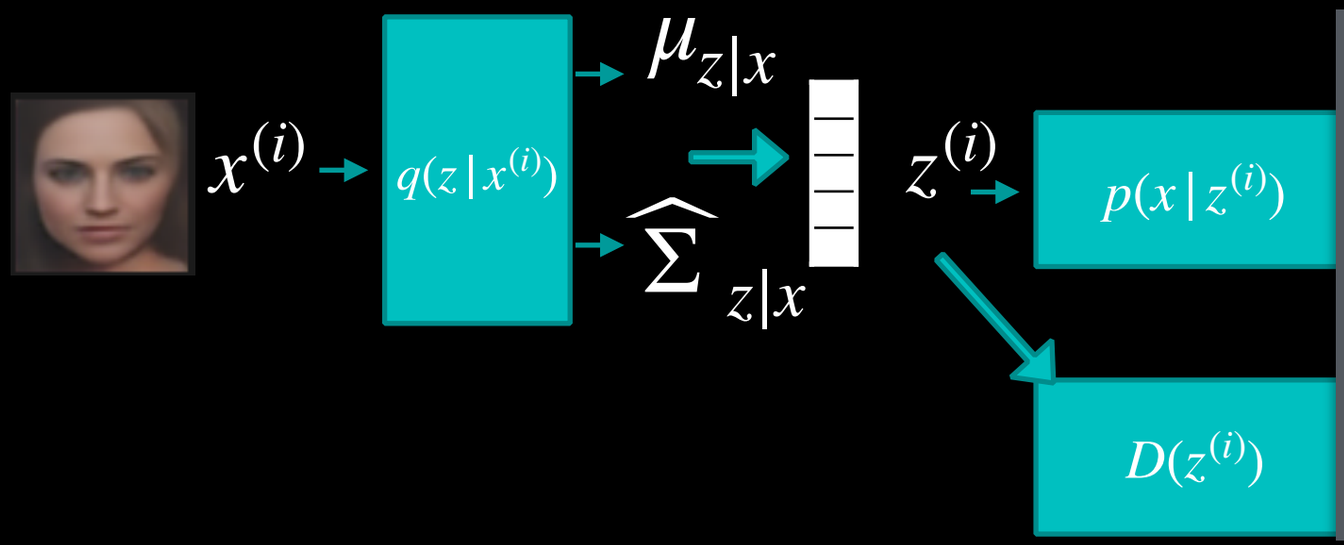
Swapped Face Detection using Deep Learning and Subjective Assessment

Xinyi Ding[1*], Zohreh Raziei[2], Eric C. Larson[1], Eli V. Olinick[2], Paul Krueger[3] and Michael Hahsler[2]





Generated Images (Fake)



Advantage: Allows training of deep networks with fewer labels

Convolutional Classification

Generative Networks

Sequential Processing

Predict pilot cognitive load & situational awareness, 85% (or better) accuracy

Eye Scan Patterns

Ratings Domain

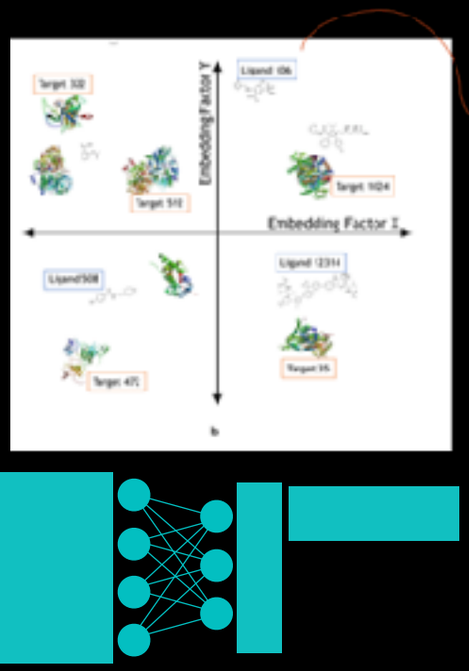
Wrist Biometrics

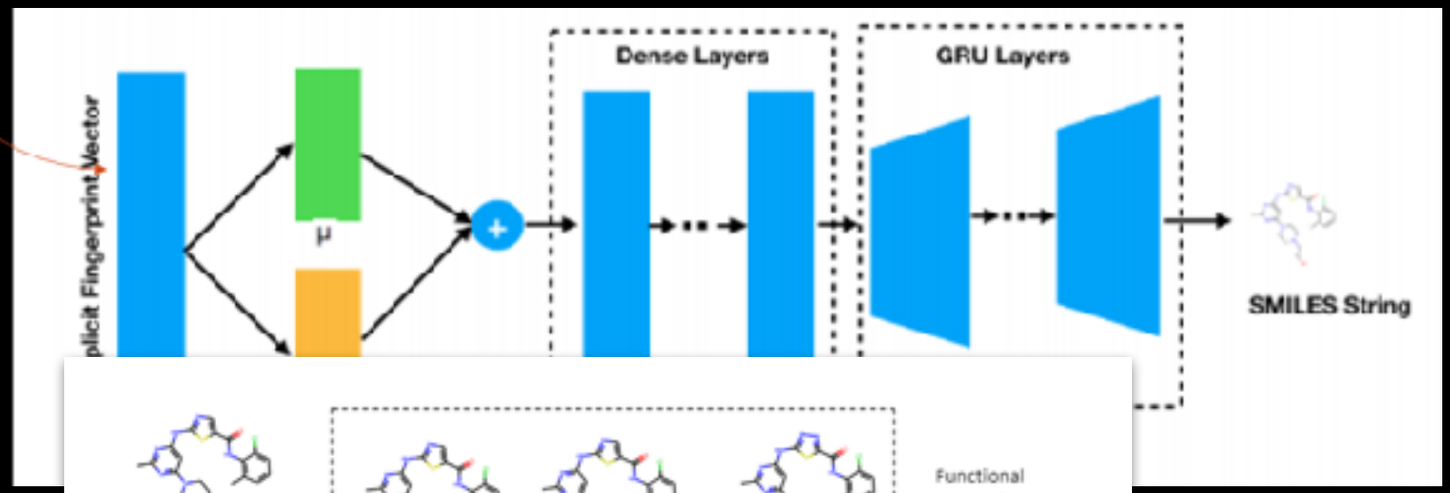
- J. Wilson*, S. Nair, S. Scielzo, and E.C. Larson (August 2020). Automatic Gaze Classification for Aviators: Using Multi-task Convolutional Networks as a Proxy for Flight Instructor Observation. International Journal of Aeronautics, Aviation, and Aerospace (IJAAA).
- J. Wilson*, S. Nair, S. Scielzo, and E.C. Larson (March 2021). Cognition-Aware Computing: Objective Measures of Cognitive Load Using Deep Multi-Modal Learning: A Use-Case in Aviation. Proceedings of the ACM Journal on Interactive Mobile Wearable, and Ubiquitous Technology. Vol. 5, Issue. 1, Article 40 (March 2021), 35 pages. https://doi.org/10.1145/3448111
- S. Scielzo, J. Wilson*, and E.C. Larson (June 2020). “Towards the Development of an Automated, Real-Time, Objective Measure of Situation Awareness for Pilots.” Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC).
- N. Crothers*, Y. Sinha*, S. Scielzo, and E.C. Larson (2022). “Real-Time Situation Awareness Assessment for Pilots via Machine Learning: Constructing an Automated Classification System.” Modeling & Simulation (MODSIM) World 2022.
- S. Gibbs, V. Tanner, A. Abrham, S. Scielzo, and E.C. Larson (2024). “Towards the Development of an Automated Trust Classifier.” Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC).

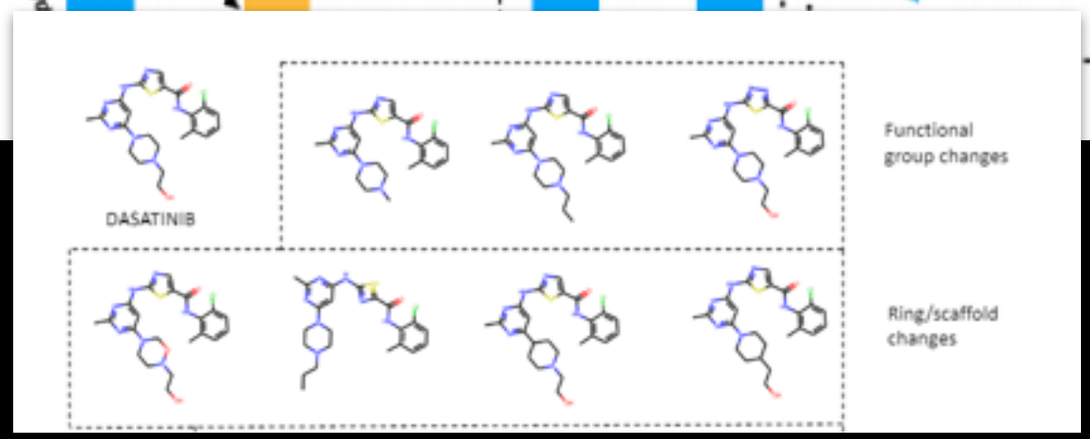
Convolutional Classification

Generative Networks

Sequential Processing







- R. Srinivas*, P. Klimovich*, and E.C. Larson. Implicit-descriptor ligand-based virtual screening by means of collaborative filtering. Journal of Cheminformatics. 10, no. 1 (2018): 56.
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Matrix Factorization

Convolutional Classification

Generative Networks

Sequential Processing

Fully Convolutional Learning

Matrix Factorization

Pupillary Response

Deepfake Detection

Radiation Detection

Intelligent Tutoring

Prosody Classification

Pilot Training

Vocabulary Context

Pulmonary Monitoring

Keyboard Dynamics

Mobile SpO2

Surgery Assessment

Binding Affinity Classification

Drug Discovery

Health
Security
Education

Application

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SMU's O’Donnell Data Science and Research Computing Institute mission is to **perform multi-disciplinary research** in data science, **high performance computing**, AI/ML, and **future technologies**. We serve as a gateway to SMU's HPC, **developing connections** between our faculty affiliates and government agencies, industry, and nonprofit organizations.

Fairness-aware Multimodal AI for Healthcare Data (DSI FRAG)

Adapting Electronic Health Record Analysis with Fair Input Modalities

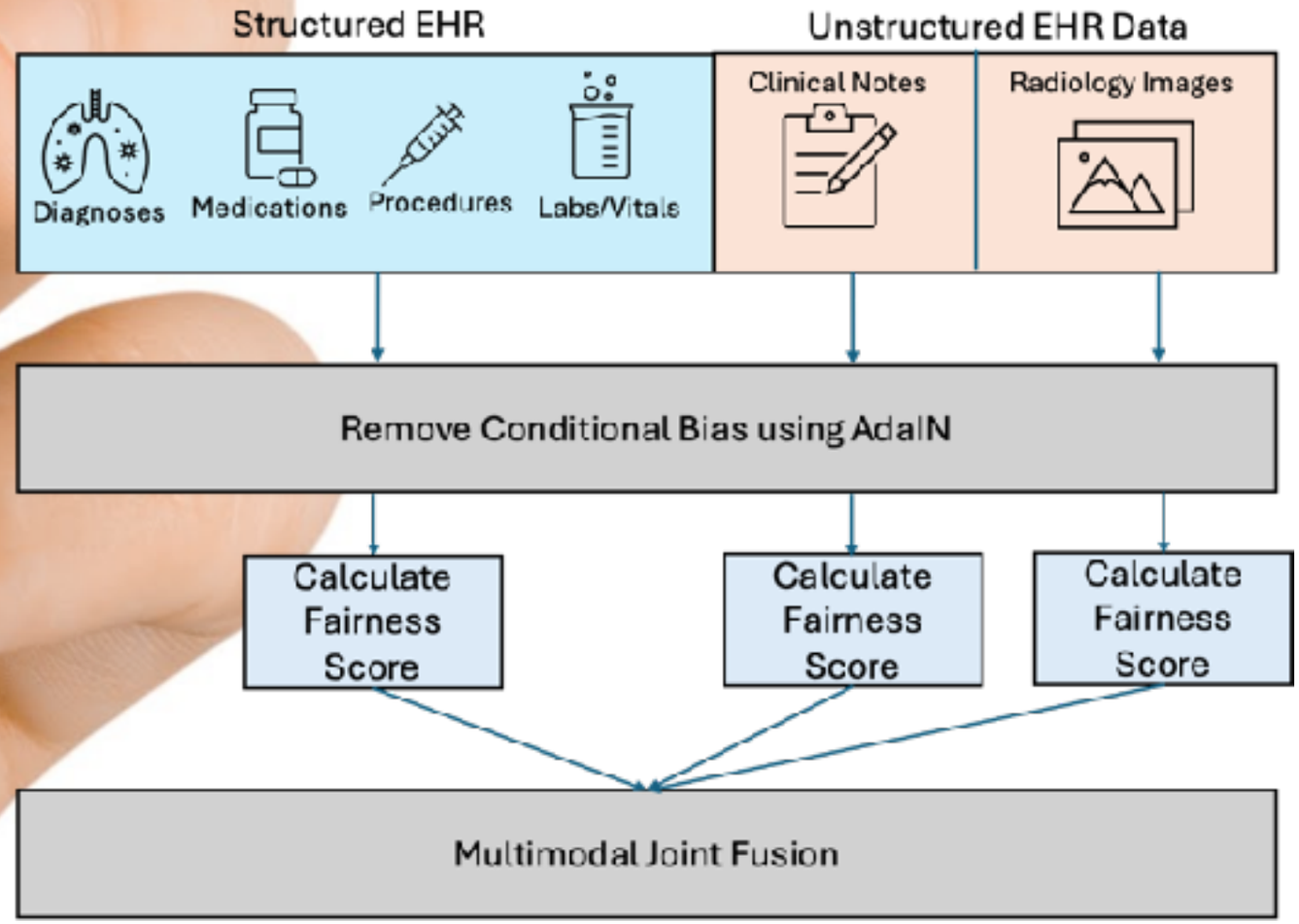
O'Donnell Data Science and Research Computing Institute

Mehak Gupta
Assistant Professor in Comp. Sci.

Fairness-aware fusion
(+) Fairness modality scoring
(+) Joint weighted fusion

Non-linear refinement
(+) Train bimodal ➡ trimodal models by refining residual losses

Fairness Evaluation
(+) Error Distribution Disparity Index

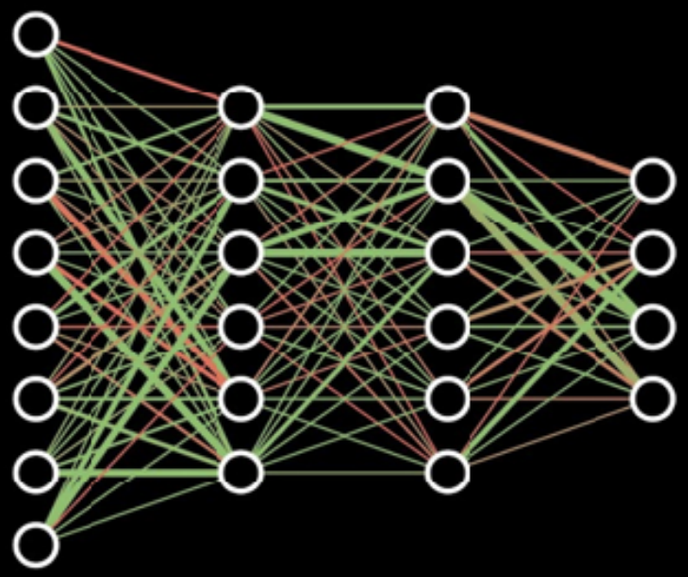


Thank You!

Ubiquitous Machine Learning

deep data representation for next generation systems

Thank You!



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