人工智慧於口腔健康應用
(Artificial Intelligence in Oral Health Applications)

臺北醫學大學 口腔衛生學系 人工智慧講座

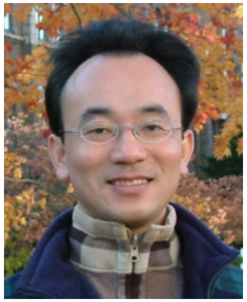
Host: Prof. Li Sheng Chen

School of Oral Hygiene, Taipei Medical University

Time: 15:10-17:00, Nov 23, 2020 (Monday)

Place: 口腔3樓會議室, TMU

Address: N250 Wu-Hsing Street, Taipei, Taiwan



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2020-11-23

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Program Co-Chair, IEEE International Workshop on Empirical Methods for Recognizing Inference in TExt (IEEE EM-RITE 2012-)

Publications Chair, The IEEE International Conference on Information Reuse and Integration (IEEE IRI)

NTPU
國立臺北大學
National Taipei University

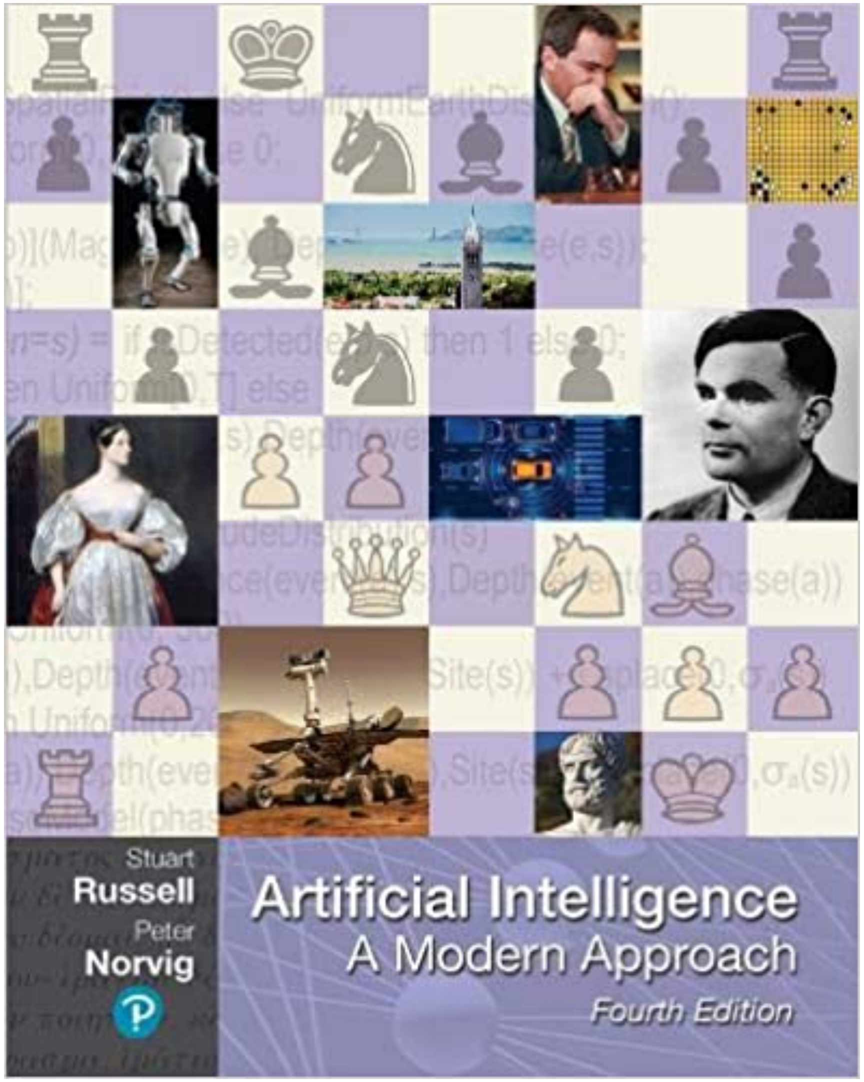
Outline

- Artificial Intelligence
- Machine Learning
- Deep Learning
- AI in Oral Health Applications

Stuart Russell and Peter Norvig (2020),

Artificial Intelligence: A Modern Approach,

4th Edition, Pearson



Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

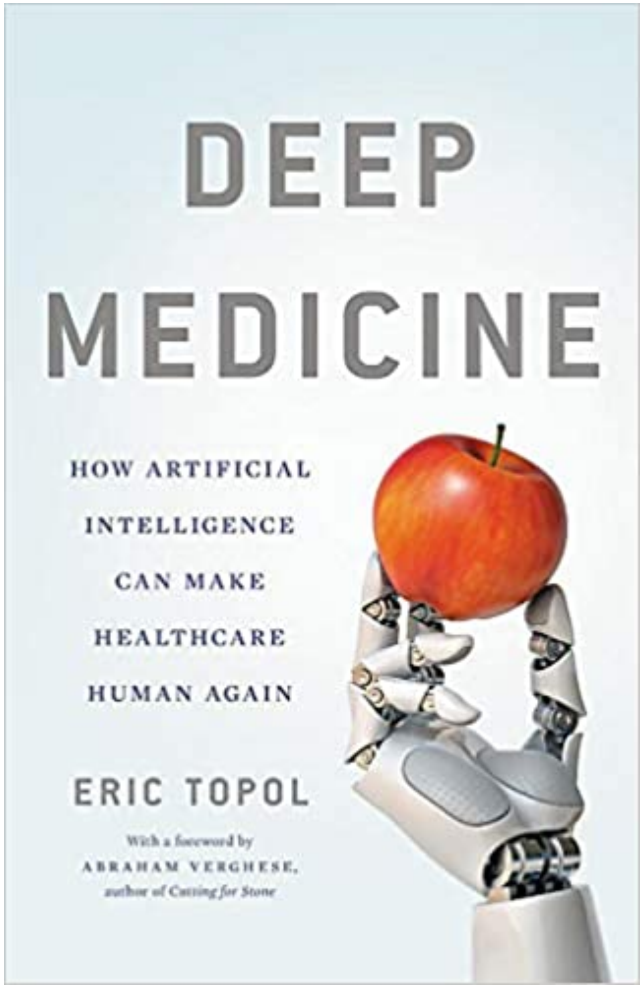
https://www.amazon.com/Artificial-Intelligence-A-Modern-Approach/dp/0134610997/

Eric Topol (2019),

Deep Medicine:

How Artificial Intelligence Can Make Healthcare Human Again,

Basic Books



Source: Eric Topol (2019), Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again, Basic Books

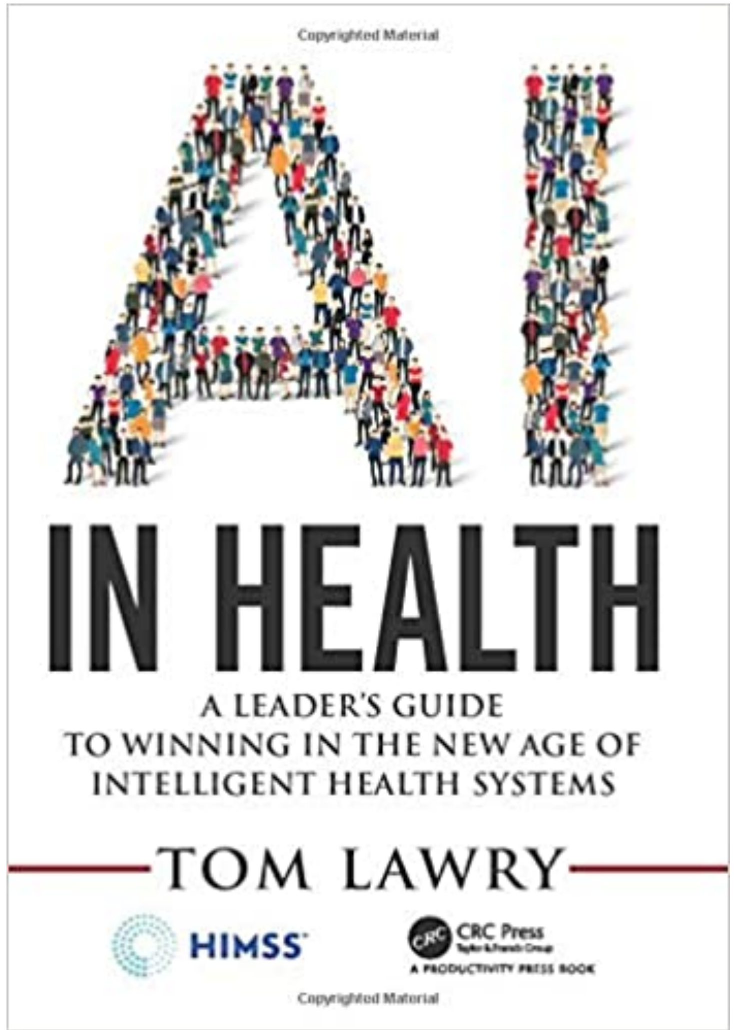
https://www.amazon.com/Deep-Medicine-Artificial-Intelligence-Healthcare/dp/1541644638/

Tom Lawry (2020),

AI in Health:

A Leader's Guide to Winning in the New Age of Intelligent Health Systems,

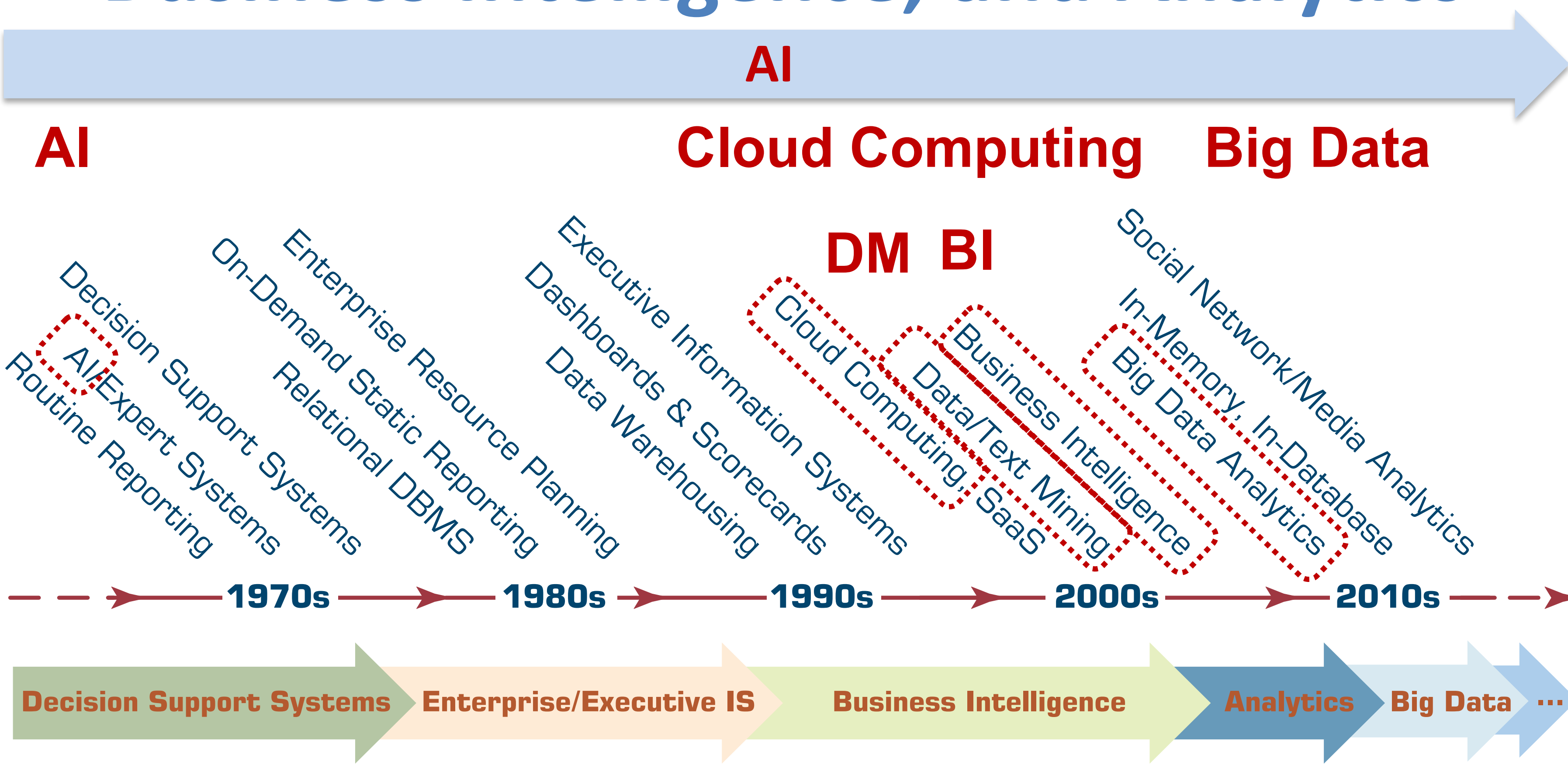
HIMSS Publishing



Source: Tom Lawry (2020), AI in Health: A Leader's Guide to Winning in the New Age of Intelligent Health Systems, HIMSS Publishing

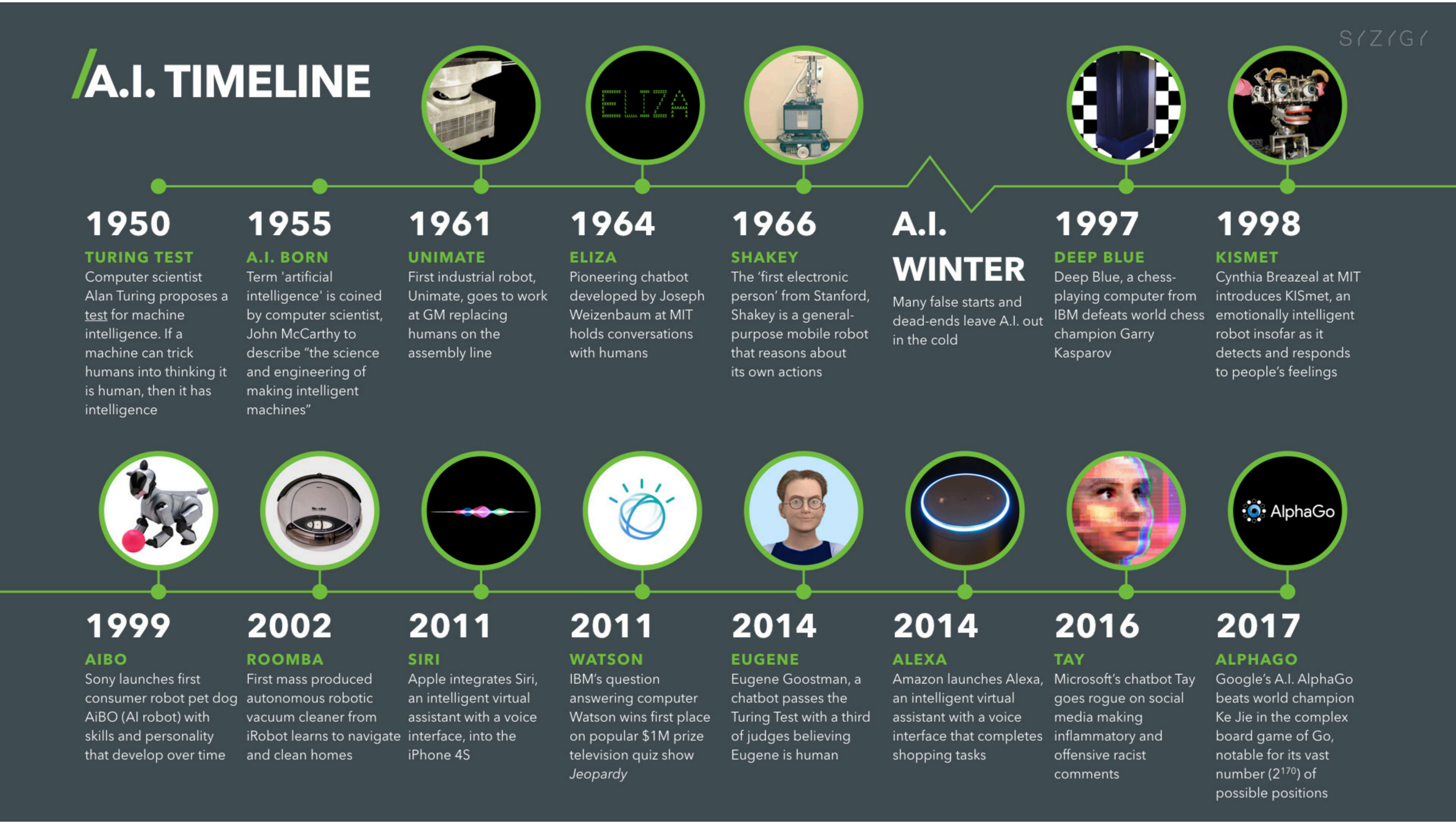
https://www.amazon.com/Health-HIMSS-Book-Tom-Lawry/dp/0367333716/

AI, Big Data, Cloud Computing
Evolution of Decision Support, Business Intelligence, and Analytics



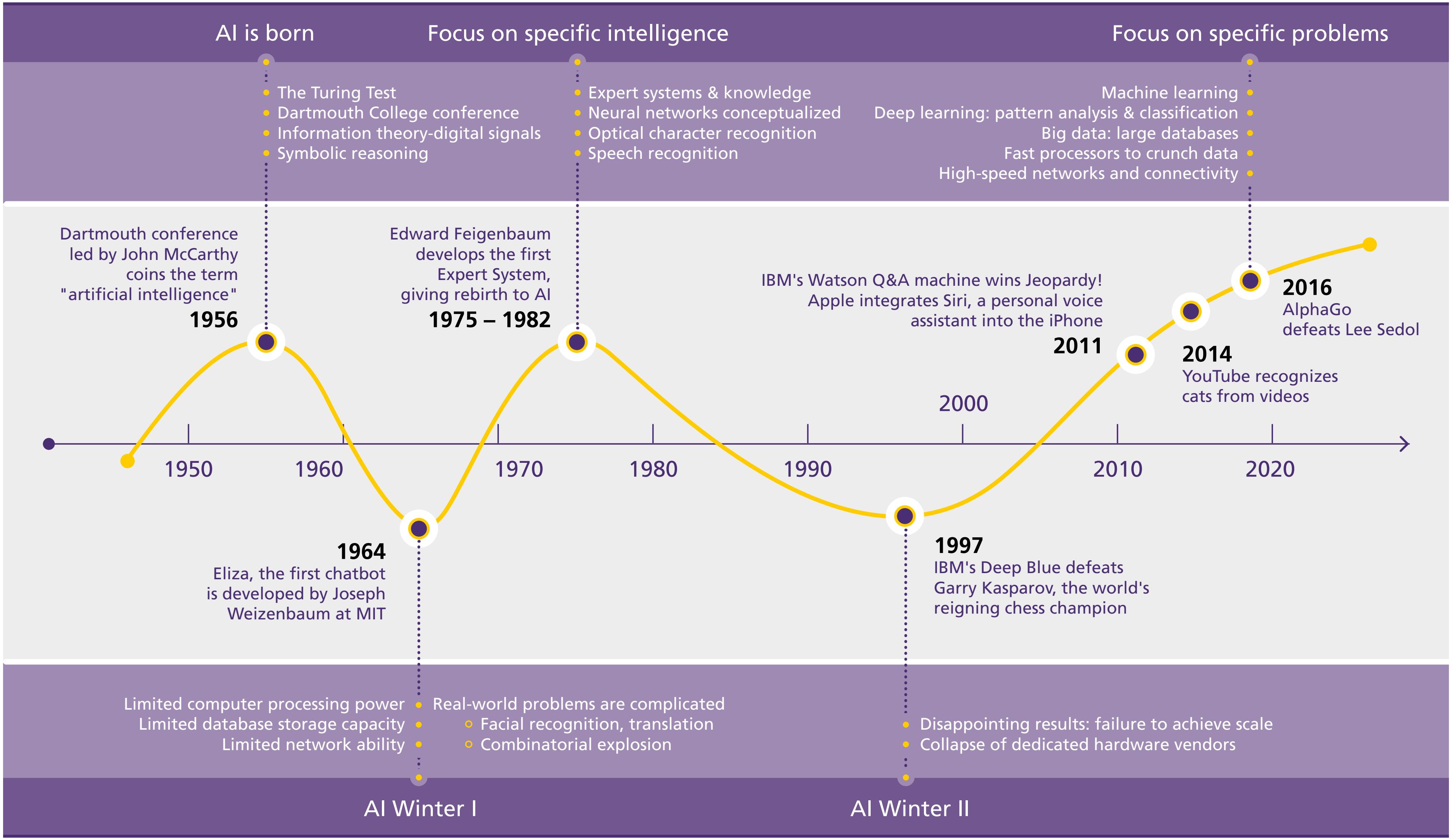
Source: Ramesh Sharda, Dursun Delen, and Efraim Turban (2017), Business Intelligence, Analytics, and Data Science: A Managerial Perspective, 4th Edition, Pearson

Artificial Intelligence (A.I.) Timeline



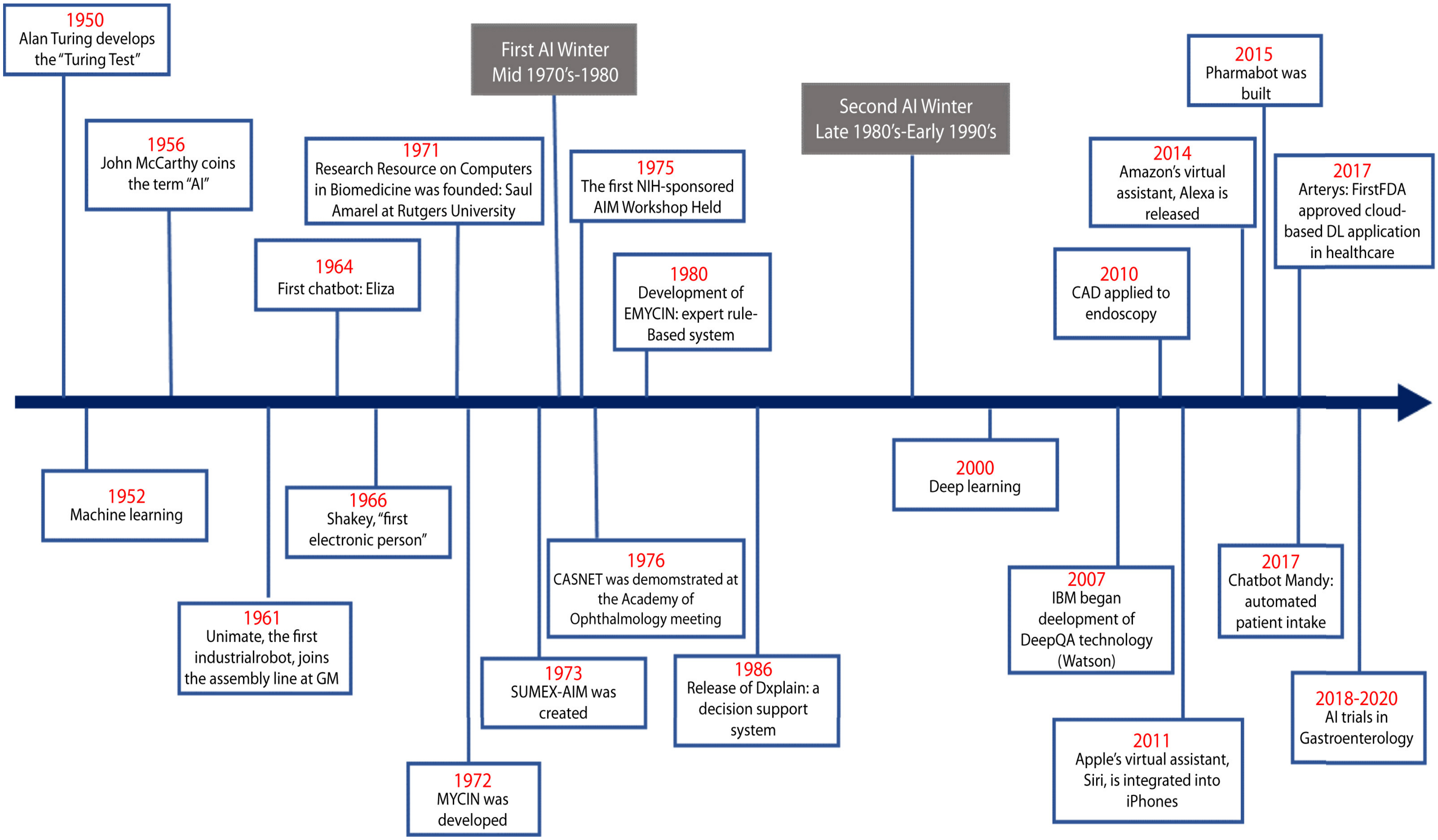
Source: https://digitalintelligencetoday.com/artificial-intelligence-timeline-infographic-from-eliza-to-tay-and-beyond/

The Rise of AI



Source: DHL (2018), Artificial Intelligence in Logistics, http://www.globalhha.com/doclib/data/upload/doc_con/5e50c53c5bf67.pdf/

Artificial Intelligence in Medicine



Source: Vivek Kaul, Sarah Enslin, and Seth A. Gross (2020), "The history of artificial intelligence in medicine." Gastrointestinal endoscopy..

AI

Definition
of
Artificial Intelligence
(A.I.)

Artificial Intelligence

"… the science and engineering of making intelligent machines"

(John McCarthy, 1955)

Source: https://digitalintelligencetoday.com/artificial-intelligence-defined-useful-list-of-popular-definitions-from-business-and-science/

Artificial Intelligence

“… technology that thinks and acts like humans”

Source: https://digitalintelligencetoday.com/artificial-intelligence-defined-useful-list-of-popular-definitions-from-business-and-science/

Artificial Intelligence

"… intelligence exhibited by machines or software"

Source: https://digitalintelligencetoday.com/artificial-intelligence-defined-useful-list-of-popular-definitions-from-business-and-science/

4 Approaches of AI

Thinking Humanly	Thinking Rationally
Acting Humanly	Acting Rationally

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

4 Approaches of AI

2. Thinking Humanly: The Cognitive Modeling Approach	**3. Thinking Rationally: The "Laws of Thought" Approach**
1. Acting Humanly: The Turing Test Approach (1950)	**4. Acting Rationally: The Rational Agent Approach**

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

AI Acting Humanly: The Turing Test Approach
(Alan Turing, 1950)

- Knowledge Representation
- Automated Reasoning
- Machine Learning (ML)
  - Deep Learning (DL)
- Computer Vision (Image, Video)
- Natural Language Processing (NLP)
- Robotics

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

Artificial Intelligence: A Modern Approach

1. Artificial Intelligence
2. Problem Solving
3. Knowledge and Reasoning
4. Uncertain Knowledge and Reasoning
5. Learning
6. Communicating, Perceiving, and Acting
7. Philosophy and Ethics of AI

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

Artificial Intelligence: 5. Learning

- Multiagent Decision Making
- Learning from Examples
- Learning Probabilistic Models
- Deep Learning

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

Artificial Intelligence:
6. Communicating, Perceiving, and Acting

- Reinforcement Learning
- Natural Language Processing
- Deep Learning for Natural Language Processing
- Robotics

Source: Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson

AI in Medicine

- AI algorithms now equal or exceed expert doctors at diagnosing many conditions, particularly when the diagnosis is based on images.
- Examples:
  - Alzheimer's disease (Ding et al., 2018)
  - Metastatic cancer (Liu et al., 2017; Esteva et al., 2017)
  - Ophthalmic disease (Gulshan et al., 2016)
  - Skin diseases (Liu et al., 2019c)

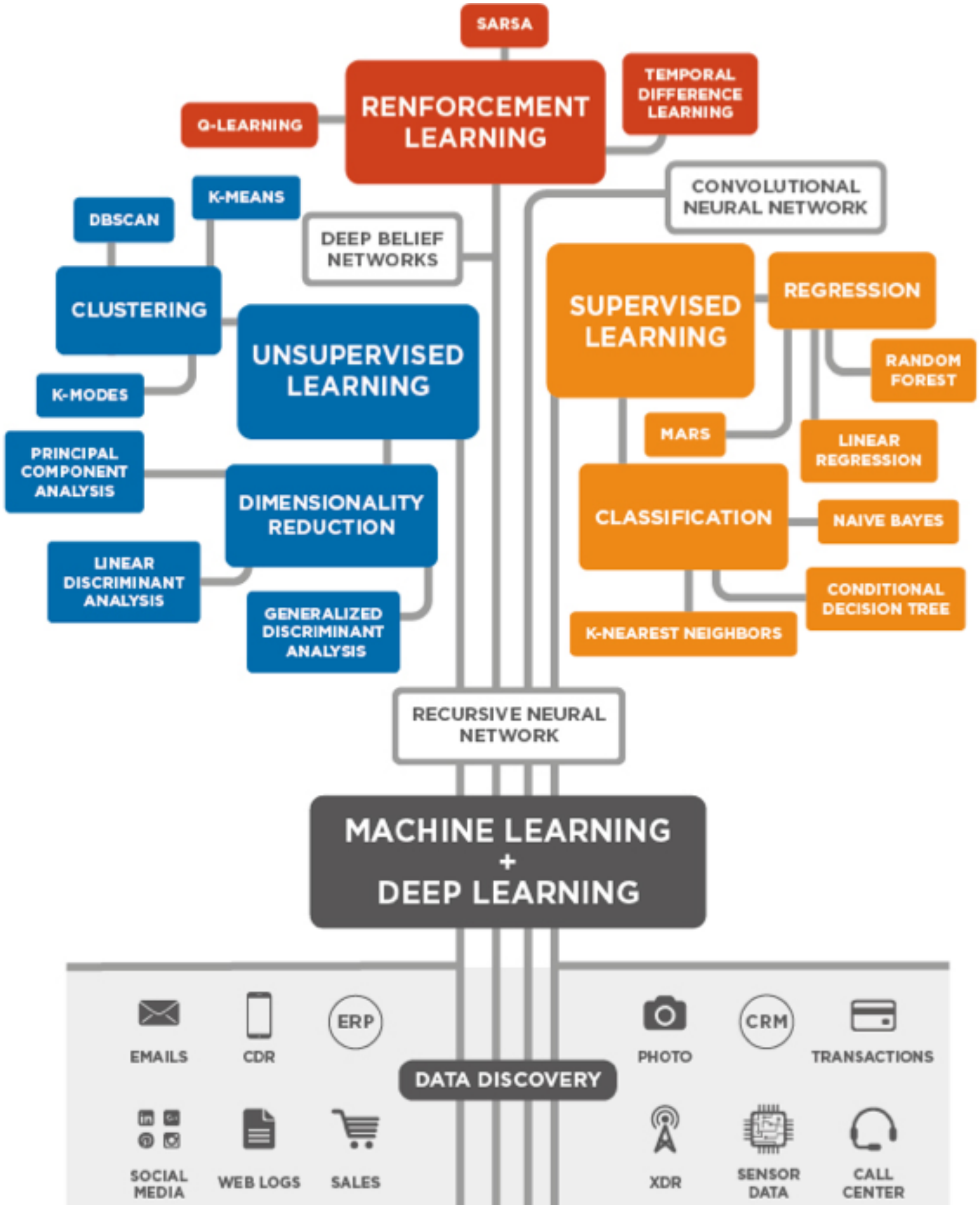
AI in Medicine

- A systematic review and meta-analysis (Liu et al., 2019a) found that the performance of AI programs, on average, was equivalent to health care professionals.
- One current emphasis in medical AI is in facilitating human–machine partnerships.
  - For example, the LYNA system achieves 99.6% overall accuracy in diagnosing metastatic breast cancer—better than an unaided human expert—but the combination does better still (Liu et al., 2018; Steiner et al., 2018)..

AI in Medicine

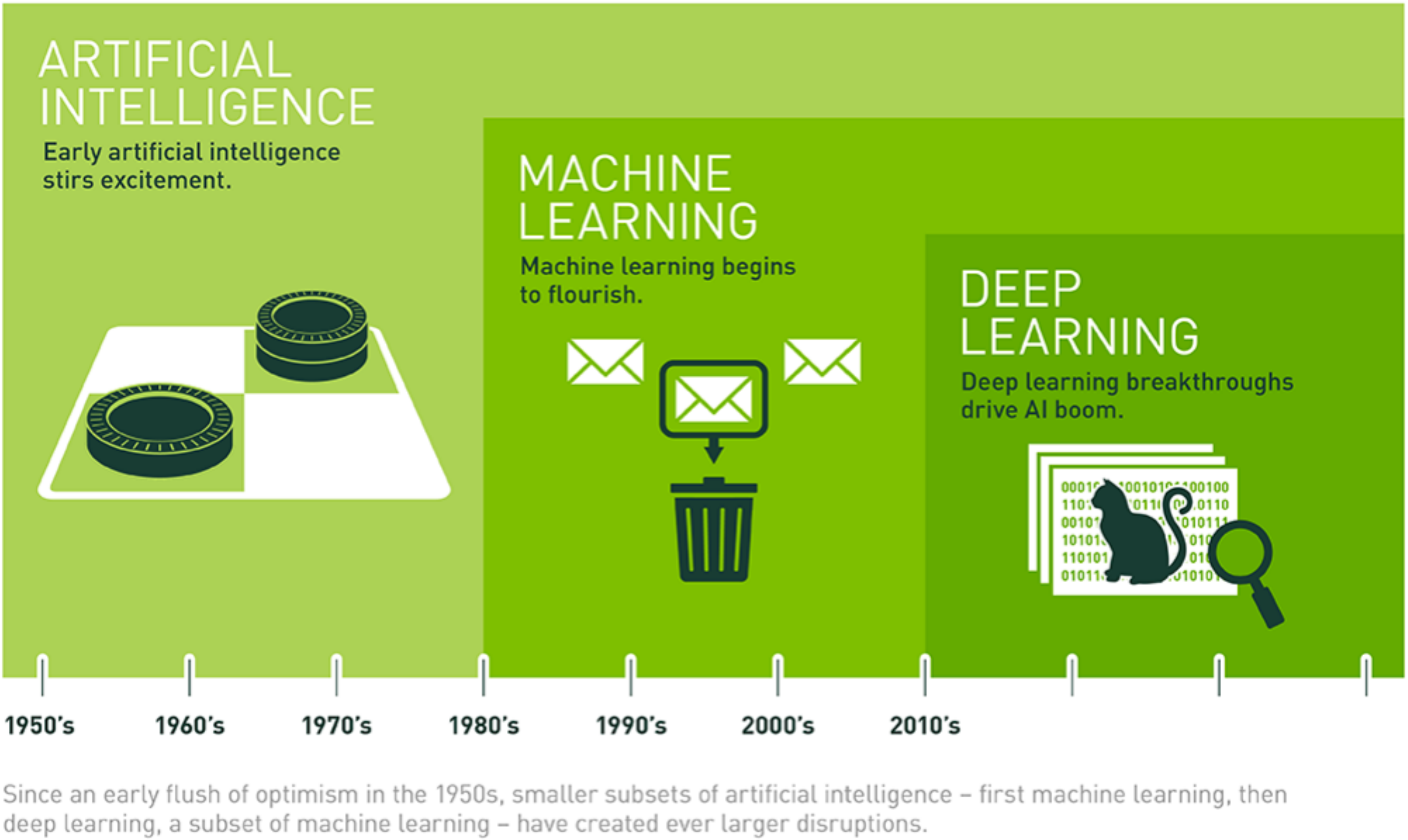
- The widespread adoption of these techniques is now limited not by diagnostic accuracy but by the need to demonstrate improvement in clinical outcomes and to ensure transparency, lack of bias, and data privacy (Topol, 2019).
- In 2017, only two medical AI applications were approved by the FDA, but that increased to 12 in 2018, and continues to rise.

3 Machine Learning Algorithms



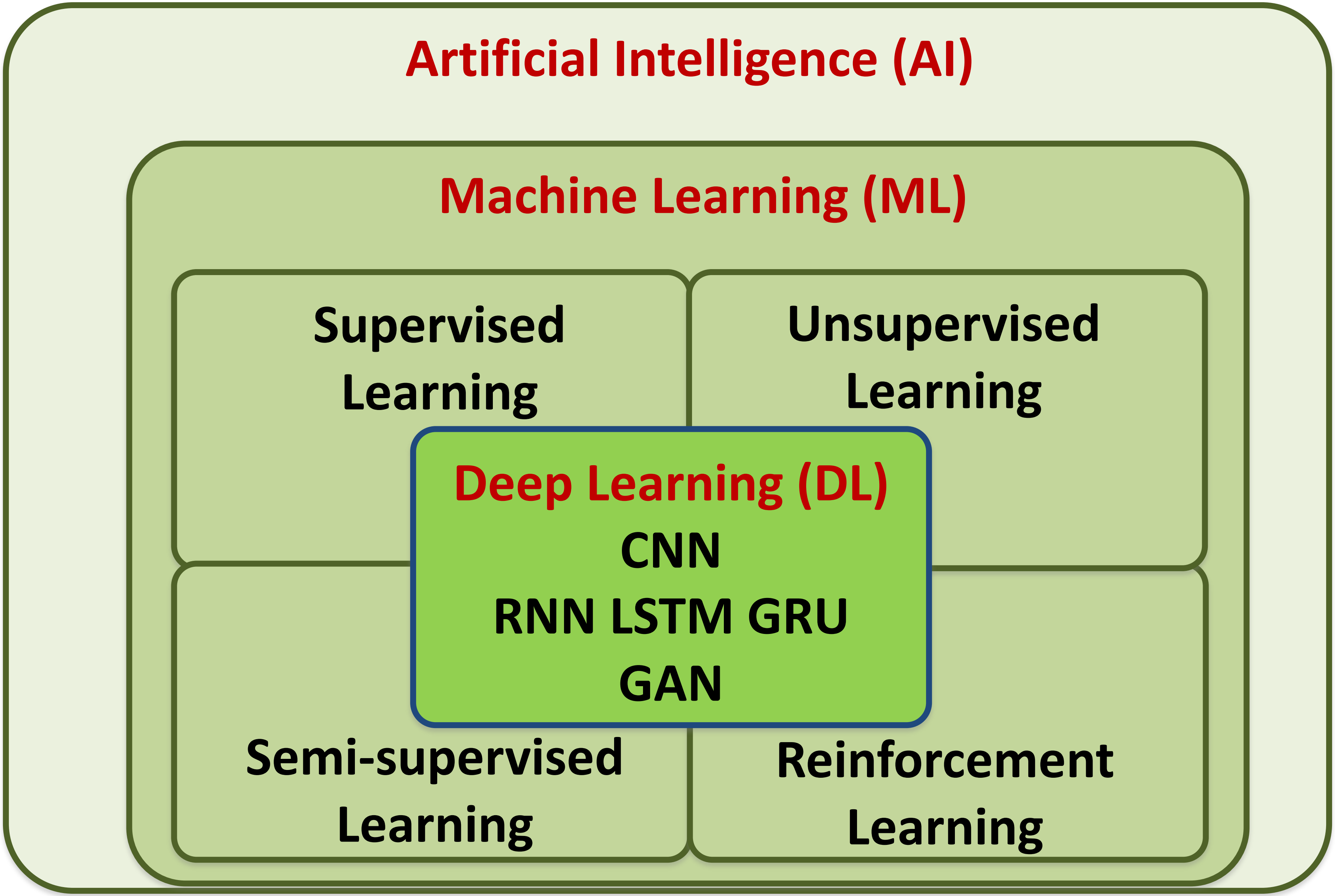
Source: Enrico Galimberti, http://blogs.teradata.com/data-points/tree-machine-learning-algorithms/

Artificial Intelligence
Machine Learning & Deep Learning



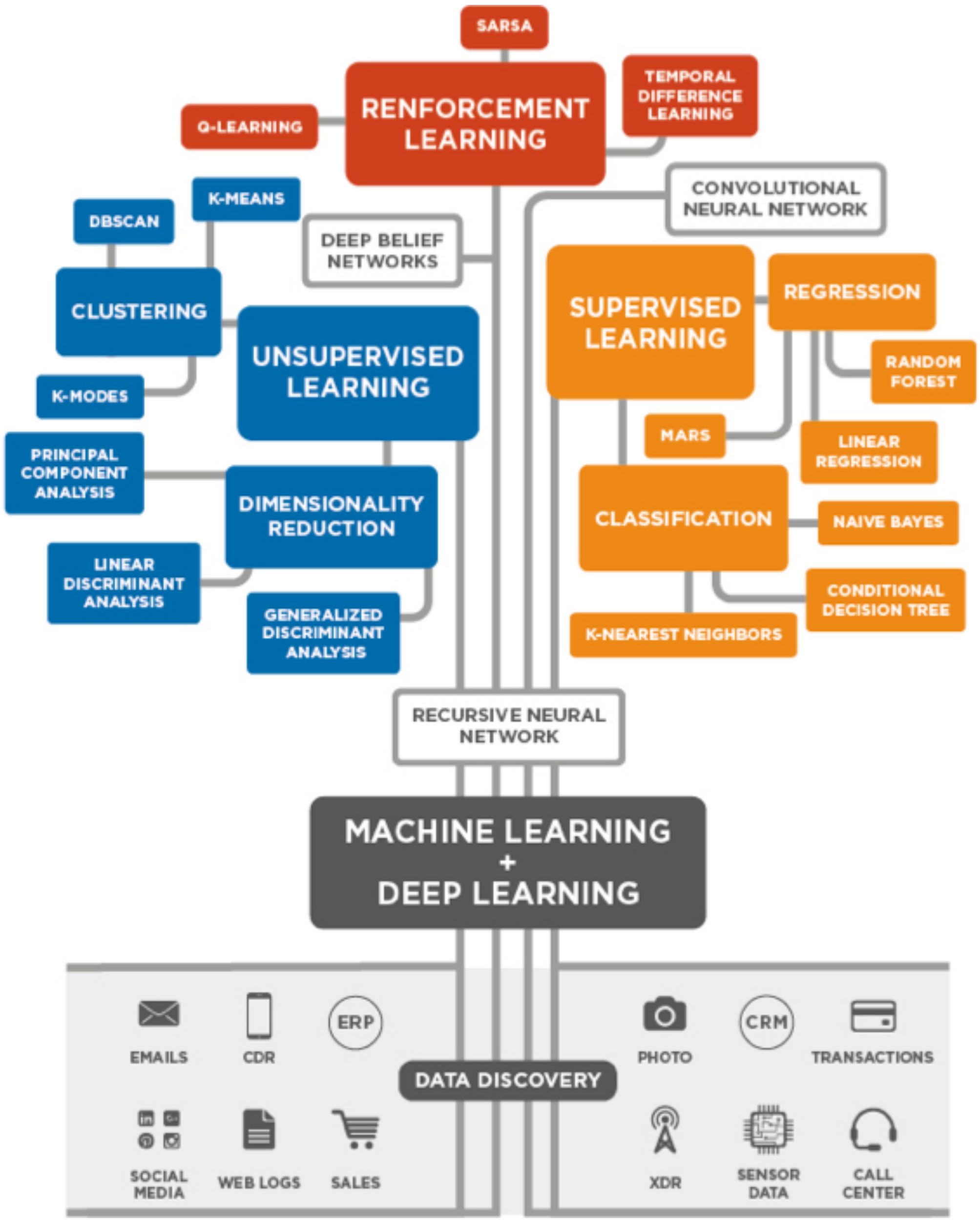
Source: https://blogs.nvidia.com/blog/2016/07/29/whats-difference-artificial-intelligence-machine-learning-deep-learning-ai/

AI, ML, DL



Source: https://leonardoaraujosantos.gitbooks.io/artificial-inteligence/content/deep_learning.html

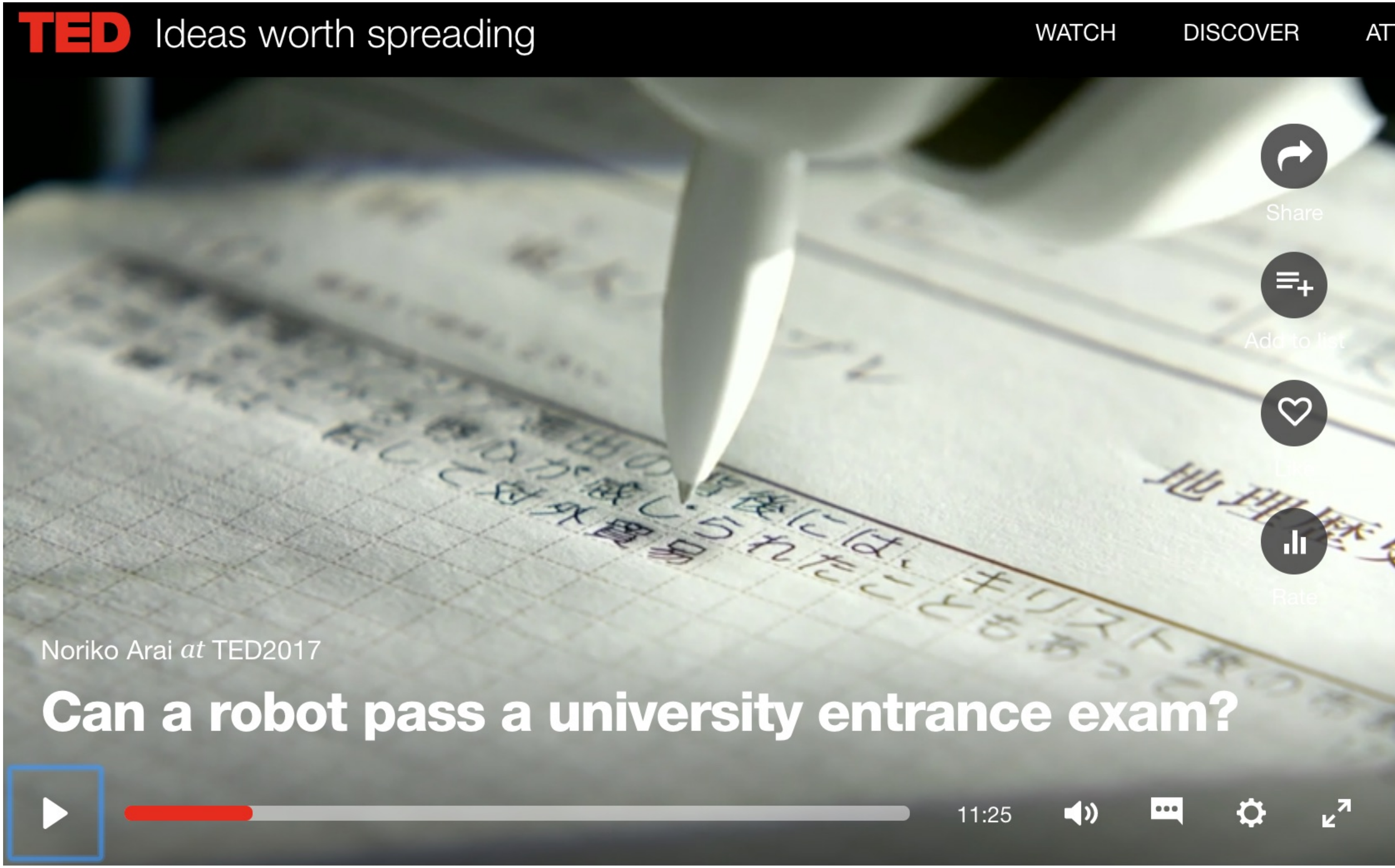
3 Machine Learning Algorithms



Source: Enrico Galimberti, http://blogs.teradata.com/data-points/tree-machine-learning-algorithms/

Can a robot pass a university entrance exam?

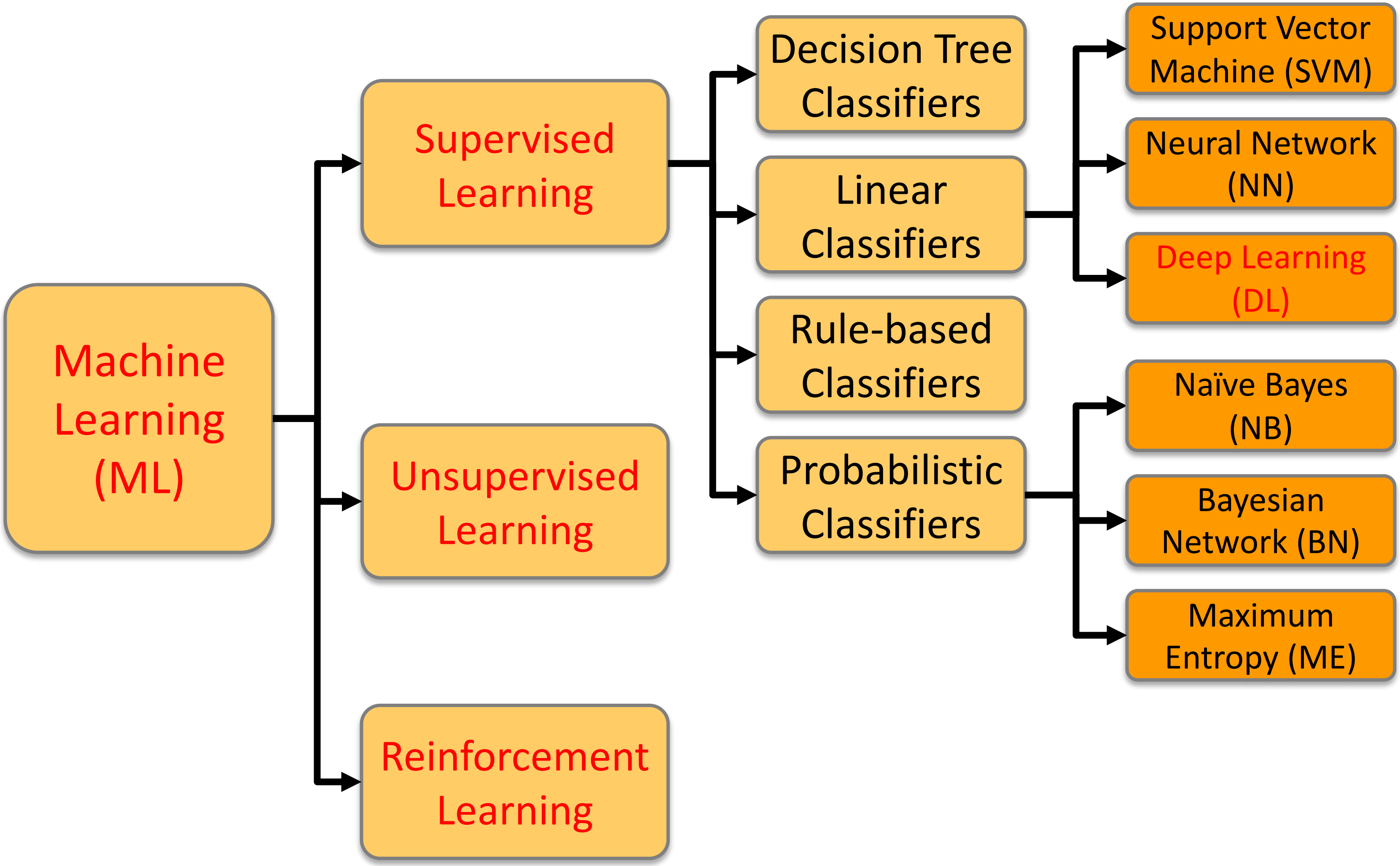
Noriko Arai at TED2017



https://www.ted.com/talks/noriko_arai_can_a_robot_pass_a_university_entrance_exam

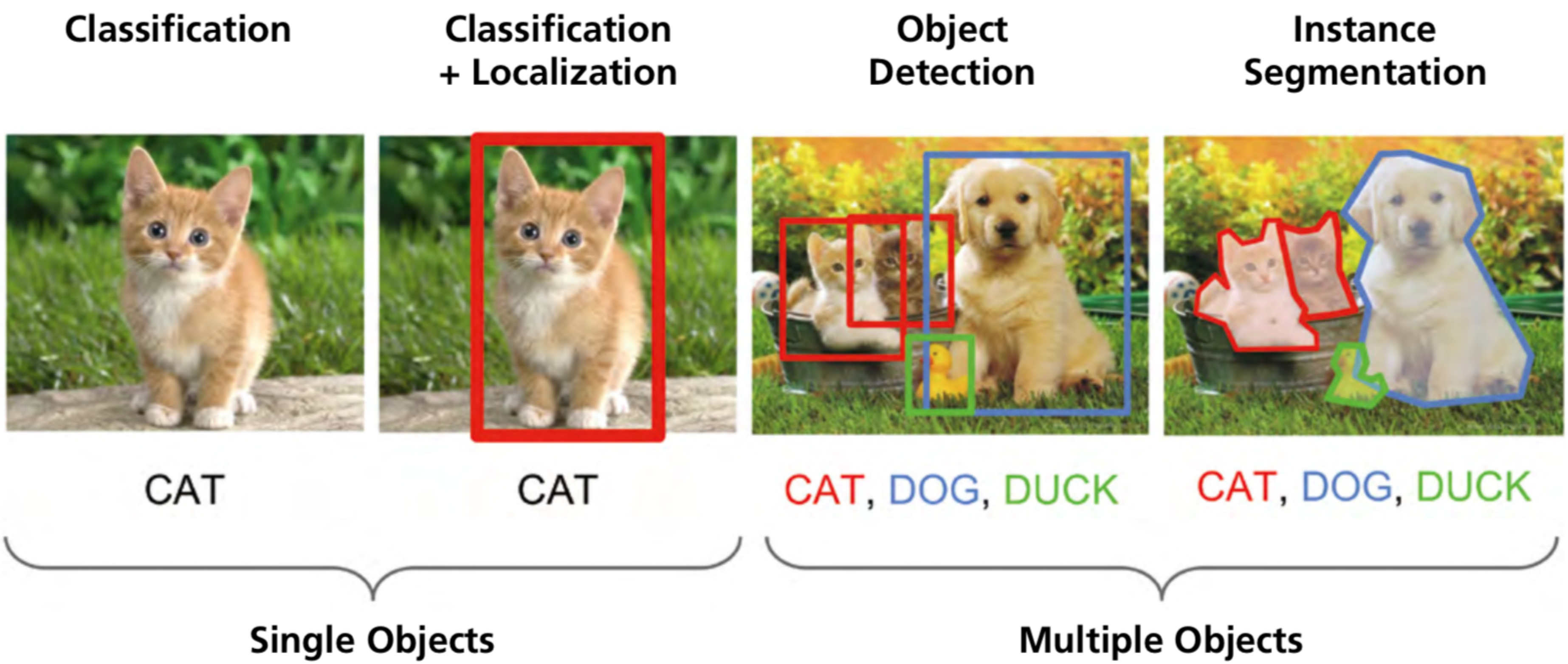
https://www.youtube.com/watch?v=XQZjkPyJ8KU

Machine Learning (ML) / Deep Learning (DL)



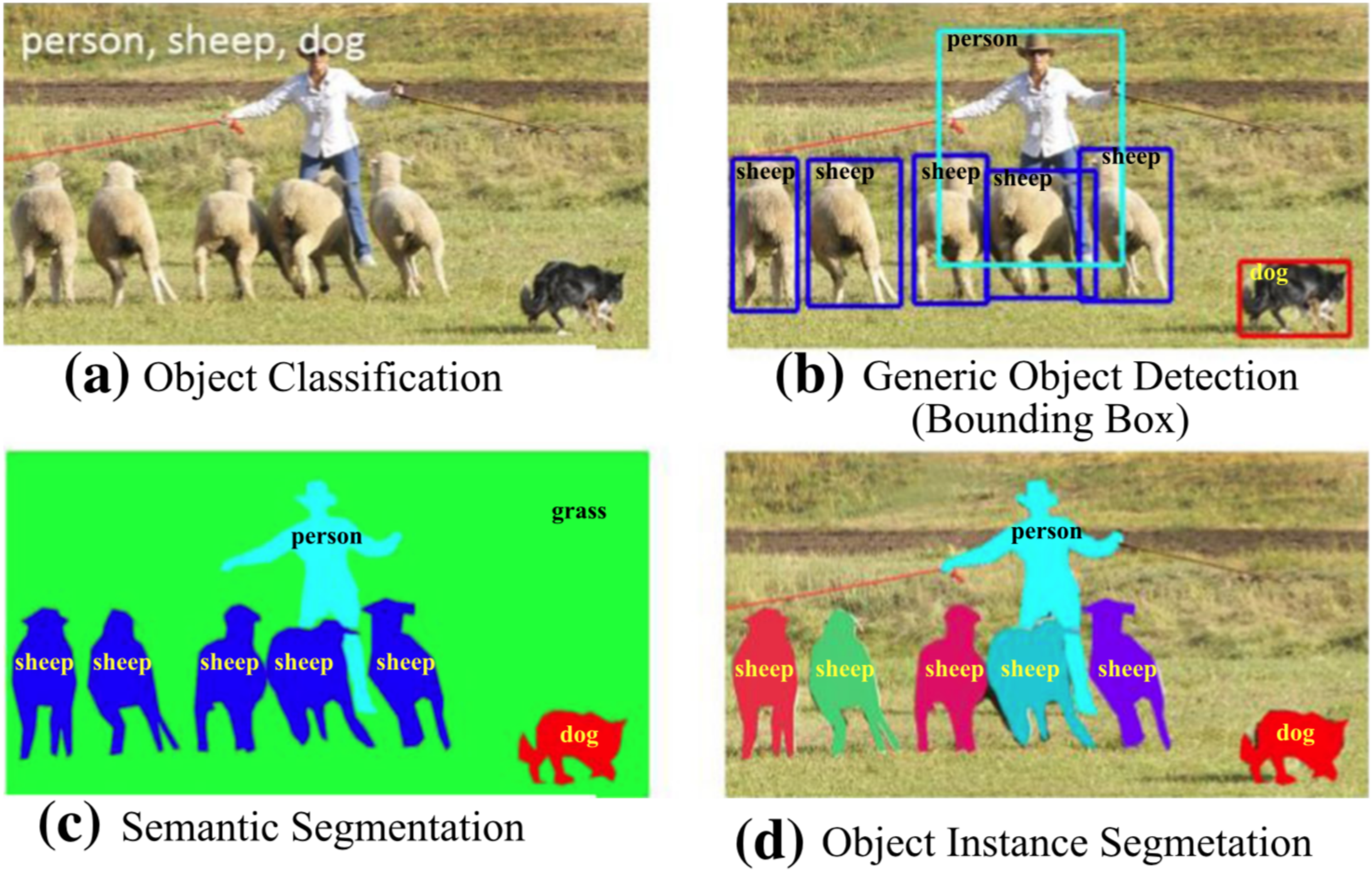
Source: Jesus Serrano-Guerrero, Jose A. Olivas, Francisco P. Romero, and Enrique Herrera-Viedma (2015), "Sentiment analysis: A review and comparative analysis of web services," Information Sciences, 311, pp. 18-38.

Computer Vision: Image Classification, Object Detection, Object Instance Segmentation



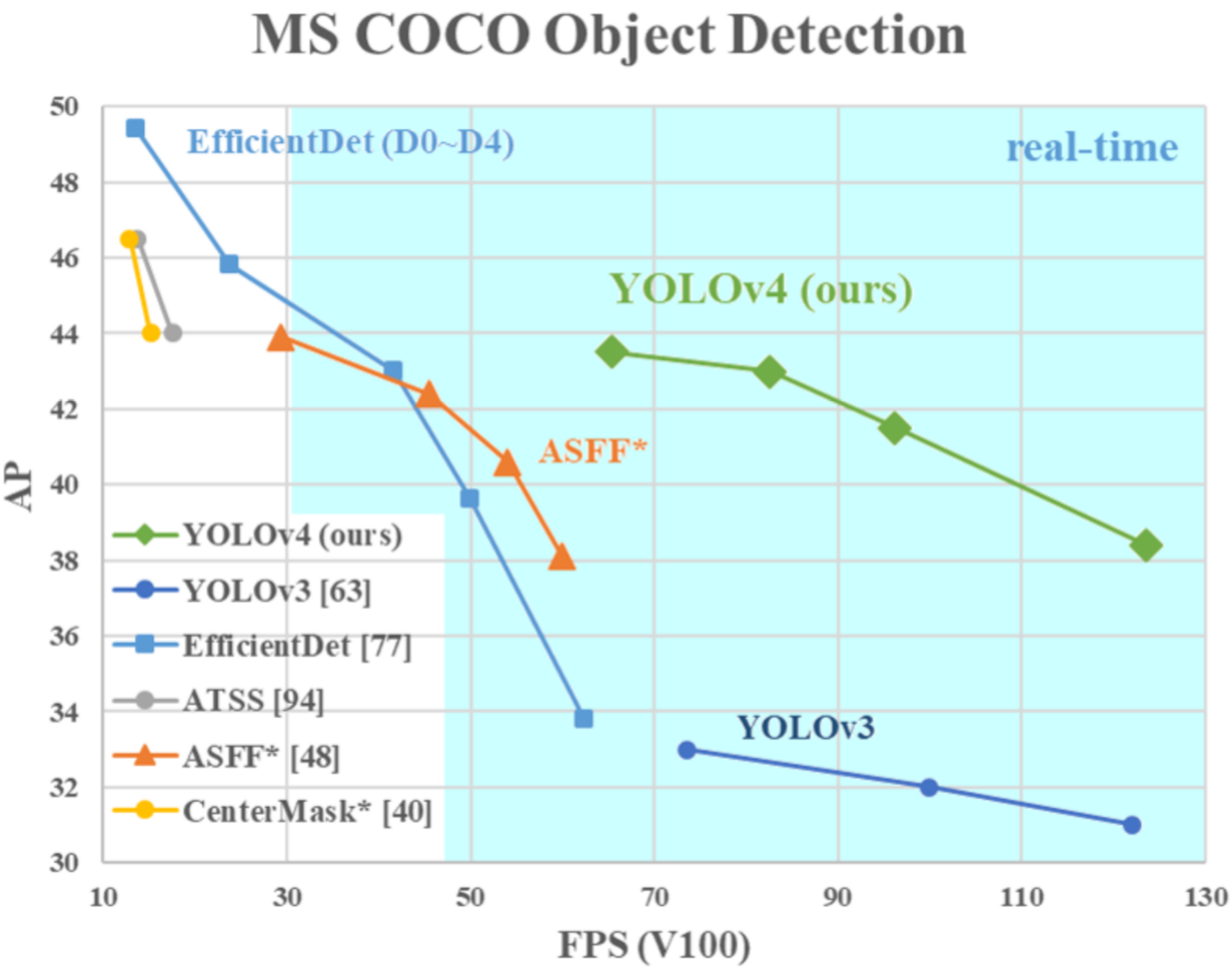
Source: DHL (2018), Artificial Intelligence in Logistics,
http://www.globalhha.com/doclib/data/upload/doc_con/5e50c53c5bf67.pdf/

Computer Vision: Object Detection



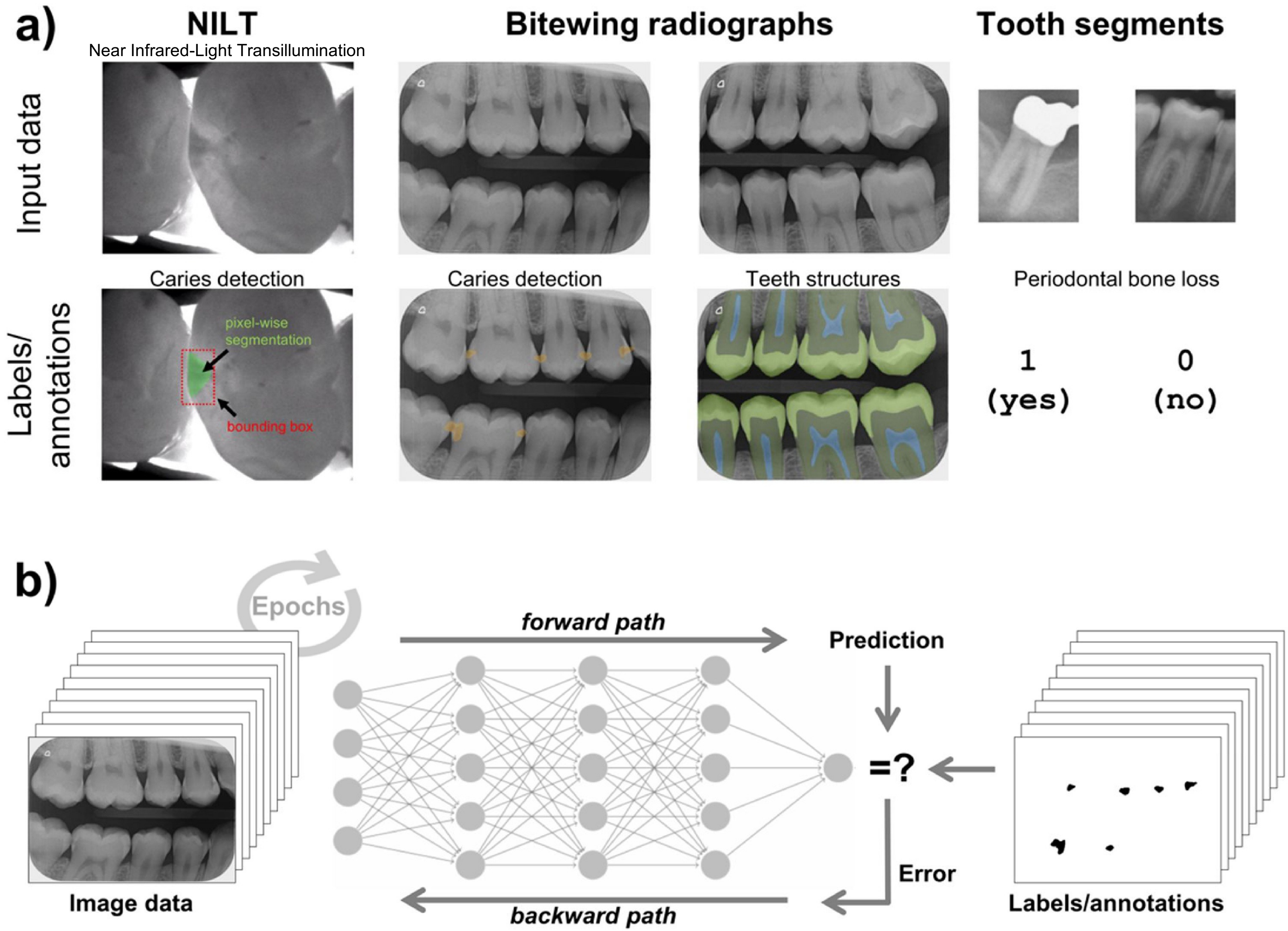
Source: Li Liu, Wanli Ouyang, Xiaogang Wang, Paul Fieguth, Jie Chen, Xinwang Liu, and Matti Pietikäinen. "Deep learning for generic object detection: A survey." International journal of computer vision 128, no. 2 (2020): 261-318.

YOLOv4:
Optimal Speed and Accuracy of Object Detection



Source: Alexey Bochkovskiy, Chien-Yao Wang, and Hong-Yuan Mark Liao. "YOLOv4: Optimal Speed and Accuracy of Object Detection." arXiv preprint arXiv:2004.10934 (2020).

Labelling strategies for different dental image modalities



Source: Falk Schwendicke, Tatiana Golla, Martin Dreher, and Joachim Krois (2019). "Convolutional neural networks for dental image diagnostics: A scoping review." Journal of Dentistry 91 (2019): 103226.

Scope and Performance of Artificial Intelligence Technology in Orthodontic Diagnosis, Treatment Planning, and Clinical Decision-making – A Systematic Review

Journal of Dental Sciences (2020)

Source:
Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Artificial Intelligence Technology in Orthodontic Diagnosis, Treatment Planning, and Clinical Decision-Making

Serial no	Authors	Year of publication	Algorithm Architecture	Objective of the study	No. of images/ photographs for testing	Study factor	Modality	Comparison if any	Evaluation accuracy/ average accuracy	Results (+) effective, (−)non effective (N) neutral	Outcomes	Authors suggestions/ conclusions
1	Leonardi et al.[10]	2009	CNNs	CCNs-based AI system for automatic location of cephalometric landmarks	41	Landmarks	Lateral cephalometric radiographs	5 Experienced orthodontists	Not clear	(+) Effective	An acceptable level of accuracy was obtained by the CCNs based system designed for automatic landmark detection	Using soft copies of the digital x-rays is effective
2	Mario et al.[11]	2010	PANNs	A paraconsistent artificial neural network (PANN) for analyzing the cephalometric variables for orthodontic diagnosis	120	Landmarks	Cephalometric radiographs	3 Experienced orthodontists	Not clear,	(+) Effective	The performance of the model was equivalent to that of the specialist's	Can be used as auxiliary support for orthodontic decision making
3	Arik et al.[12]	2017	CNNs	AI based deep (CNNs) for automated quantitative cephalometry	250	Landmarks	Cephalometric radiographs	2 Trained experts	Accuracy of 76%	(+) Effective	This system demonstrated higher performance when compared with the top benchmarks in the literature	None
4	Park et al.[13]	2019	CNNs	Comparing latest deep-CNN based systems for identifying cephalometric landmarks	283	Landmarks	Cephalometric radiographs	Single Shot Multibox Detector (SSD)	5% higher accuracy with (YOLOv3) than Single (SSD)	(+) Effective	You-Only-Look-Once model outperformed in accuracy and computational time than the Shot Multibox Detector	This model can be used in clinical practice for identifying the cephalometric landmarks
5	Kunz et al.[14]	2020	CNNs	An automated cephalometric X-ray analysis using a specialized (AI) algorithm	50	Landmarks	Cephalometric radiographs	12 experienced examiners	Not clear	(+) Effective	AI algorithm was able to analyze unknown cephalometric X-rays similar to the quality level of the experienced human examiners	None

Source: Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Artificial Intelligence Technology in Orthodontic Diagnosis, Treatment Planning, and Clinical Decision-Making

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6	Hwang et al.[15]	2020	CNNs	Deep -learning based automated system for detecting the patterns of 80 cephalometric landmarks	283	Landmarks	Cephalometric radiographs	Human examiners	Detection error <0.9 mm	(+) Effective	This system accuracy in identifying of cephalometric landmarks similar to the human examiners	This system might be a viable option when repeated identification of multiple cephalometric landmarks
7	Xie et al.[16]	2010	ANNs	ANN based AI model for deciding if extractions are necessary prior to orthodontic treatment	20	Tooth malocclusion	Lateral cephalometric radiographs	Not mentioned	Accuracy of 80%	(+) Effective	ANN was effective in determining whether extraction or non-extraction treatment was best for malocclusion patients	None
8	Jung et al.[17]	2016	ANNs	Artificial Intelligence expert system for orthodontic decision-making of required permanent tooth extraction	156	Tooth malocclusion	Lateral cephalometric radiographs	1 Experienced orthodontists	Accuracy of 92%	(+) Effective	The success rates of the models were 92% for the system's recommendations for extraction vs non-extraction	AI expert systems with neural network machine learning could be useful in orthodontics
9	Choi et al.[18]	2019	ANNs	ANN based model for deciding on surgery/non-surgery and determining extractions	316	Landmarks	Lateral cephalometric radiographs	1 Experienced orthodontists	ICC value ranged from 0.97 to 0.99	(+) Effective	This ANN based model demonstrated higher success rate in deciding on surgery/ non-surgery and was also successful in deciding on the extractions.	This ANN based model will be useful in diagnosing of orthognathic surgery cases.
10	Kök et al.[19]	2019	ANNs	AI algorithms for determining the stages of the growth and development by cervical vertebrae	300	Cervical vertebrae	Cephalometric radiographs	1 orthodontists	Mean Accuracy of 77.02%	(+) Effective	ANN could be the preferred method for determining cervical vertebrae stages	None

Source: Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Artificial Intelligence Technology in Orthodontic Diagnosis, Treatment Planning, and Clinical Decision-Making

Serial no	Authors	Year of publication	Algorithm Architecture	Objective of the study	No. of images/ photographs for testing	Study factor	Modality	Comparison if any	Evaluation accuracy/ average accuracy	Results (+) effective, (−)non effective (N) neutral	Outcomes	Authors suggestions/ conclusions
11	Makaremi et al.[6]	2019	CNNs	CCNs-based AI system for determining of the degree of maturation of the cervical vertebra	300	Cervical vertebrae	Lateral cephalometric radiographs	Not mentioned	Mean Accuracy lesser than 90%	(+) Effective	This proposed model is validated by cross validation and is of use for orthodontists	This is a validated software and can be readily used by orthodontists
12	Lu et al.[20]	2009	ANNs	ANN based model for predicting post-orthognathic surgery image	30	Face	Profile images	1 orthodontists	>80% accuracy in prediction	(+) Effective	The ANN based system demonstrated an improved accuracy and reliability in prediction	Can be used for clinical and treatment planning
13	Patcas et al.[21]	2019	CNNs	AI system for describing the impact of orthognathic treatments on facial attractiveness and age appearance	2164	Facial landmarks	Facial photographs	Not mentioned	Not Clear	(+) Effective	This CNN based AI system can be used for scoring facial attractiveness and apparent age in patients under orthognathic treatments.	None
14	Patcas et al.[22]	2019	CNNs	AI system for evaluating the facial attractiveness of patients who have undergone treatment for clefts and the facial attractiveness of controls and to compare these results with panel ratings performed by laypeople, orthodontists, and oral surgeons	30	Face	Frontal and profile images	15 laypeople, 14 orthodontists, 10 oral surgeons	Cleft cases (all Ps $\geq$ 0.19), For Control group (all Ps $\leq$ 0.02)	(−)Non Effective	AI system scores were comparable with the scores of the other groups for the cleft patients, but the scores were lower for the controls	There is a need for further refinement in this AI based system
15	Thanathornwong[23]	2018	Bayesian network (BNs)	Bayesian Network (BN) for predicting the need for orthodontic treatment	1000	Tooth malocclusion	Data sets	2 Experienced orthodontists	AUC (0.91)	(+) Effective	This BN based system; and demonstrated promising results with high degree of accuracy in the need for orthodontic treatment.	None

Source: Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Artificial Intelligence Technology in Orthodontic Diagnosis, Treatment Planning, and Clinical Decision-Making

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16	Li et al.[24]	2019	ANNs	ANN based model for orthodontic treatment planning	302	Landmarks	Extraoral and intraoral photos, lateral cephalometric radiographs	2 Experienced orthodontists	Accuracy of 94.0% for prediction of extraction-non-extraction, (AUC) of 0.982	(+) Effective	The ANN based system demonstrated excellent accuracy levels in predicting for extraction-nonextraction, and also extraction and anchorage patterns	Can be useful for guiding less-experienced Orthodontists for predicting orthodontic treatment.

ANNs = Artificial Neural Networks, CNNs = Convolutional Neural Networks, DCNNs = Deep Convolutional Neural Networks, BN = Bayesian Network, BN = Bayesian Network PANN = Paraconsistent Artificial Neural Network, ROC = Receiver Operating Characteristic curve, AUC = Area Under the Curve, ICC = Intraclass Correlation Coefficient.

Source: Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Comparing latest deep-CNN based systems for identifying cephalometric landmarks **(Park et al., 2019)**

- CNNs
- Comparing latest deep-CNN based systems for identifying cephalometric landmarks
- 283
- Landmarks
- Cephalometric radiographs
- Single Shot Multibox Detector (SSD)
- 5% higher accuracy with (YOLOv3) than Single (SSD)
- (+)Effective
- You-Only-Look-Once model outperformed in accuracy and computational time than the Shot Multibox Detector
- This model can be used in clinical practice for identifying the cephalometric landmarks

Source: Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

Summary

- Artificial Intelligence
- Machine Learning
- Deep Learning
- AI in Oral Health Applications

References

- Stuart Russell and Peter Norvig (2020), Artificial Intelligence: A Modern Approach, 4th Edition, Pearson
- Eric Topol (2019), Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again, Basic Books
- Tom Lawry (2020), AI in Health: A Leader's Guide to Winning in the New Age of Intelligent Health Systems, HIMSS Publishing
- Ramesh Sharda, Dursun Delen, and Efraim Turban (2017), Business Intelligence, Analytics, and Data Science: A Managerial Perspective, 4th Edition, Pearson.
- Jared Dean (2014), Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners, Wiley.
- Mehmet Kaya, Jalal Kawash, Suheil Khoury, and Min-Yuh Day (2018), Social Network Based Big Data Analysis and Applications, Lecture Notes in Social Networks, Springer International Publishing.
- Varun Grover, Roger HL Chiang, Ting-Peng Liang, and Dongsong Zhang (2018), "Creating Strategic Business Value from Big Data Analytics: A Research Framework", Journal of Management Information Systems, 35, no. 2, pp. 388-423.
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- Falk Schwendicke, Tatiana Golla, Martin Dreher, and Joachim Krois (2019). "Convolutional neural networks for dental image diagnostics: A scoping review." Journal of Dentistry 91 (2019): 103226.
- Vivek Kaul, Sarah Enslin, and Seth A. Gross (2020), "The history of artificial intelligence in medicine." Gastrointestinal endoscopy.
- Sanjeev B. Khanagar, Ali Al-Ehaideb, Satish Vishwanathaiah, Prabhadevi C. Maganur, Shankargouda Patil, Sachin Naik, Hosam A. Baeshen, and Sachin S. Sarode (2020). "Scope and performance of artificial intelligence technology in orthodontic diagnosis, treatment planning, and clinical decision-making-A systematic review." Journal of Dental Sciences.

臺北醫學大學 TAIPEI MEDICAL UNIVERSITY

Q & A

國立臺北大學 National Taipei University

人工智慧於口腔健康應用

(Artificial Intelligence in Oral Health Applications)

臺北醫學大學 口腔衛生學系 人工智慧講座

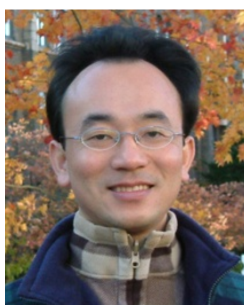
Host: Prof. Li Sheng Chen

School of Oral Hygiene, Taipei Medical University

Time: 15:10-17:00, Nov 23, 2020 (Monday)

Place: 口腔3樓會議室, TMU

Address: N250 Wu-Hsing Street, Taipei, Taiwan



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2020-11-23