Uniklinikum Würzburg

Wilhelm Conrad Röntgen im digitalen Zeitalter - quo vadis, Radiologie?

Univ.-Prof. Dr. med. Bettina Baeßler

19. September 2022

Institut für Diagnostische und Interventionelle Radiologie
Direktor: Prof. Dr. Thorsten Bley

- Von X-Strahlen und Hounsfield-Einheiten
- Was ist „Künstliche Intelligenz“?
- Was kann „Künstliche Intelligenz“?
- Was kann „Künstliche Intelligenz“ (noch) nicht?
- Ausblick – Quo vadis, Radiologie?

Uniklinikum Würzburg

- Von X-Strahlen und Hounsfield-Einheiten

Wilhelm Conrad Röntgen

Uniklinikum Würzburg

* 27.03.1845 in **Lennep**

Primar- und Sekundarschule
in Apeldoorn, Holland

1864 Schulverweis Techn. Schule Utrecht
ohne Abitur

Maschinenbaustudium Polytechnikum
Zürich

1868 Dipl. Ing., 1869 Dr.

1870 Habilitation in
Würzburg **verwehrt**

Courtesy: Prof. Th. Bley

Wilhelm Conrad Röntgen

Uniklinikum Würzburg

1875 Ruf nach Hohenheim

1876 Ruf nach Strassburg

1879 Ruf nach Gießen

1888 Ruf nach Würzburg

1894 Rektor der Uni Würzburg

8. November 1895
Entdeckung der X-Strahlen

1901 Nobelpreis

Courtesy: Prof. Th. Bley

„Eine neue Art von Strahlen“

Geheimrath Albert von Kölliker

Courtesy: Prof. Th. Bley

Physikalisch Medizinische Gesellschaft zu Würzburg, 23.01.1896

W.C. Röntgens einziger öffentlicher Vortrag:

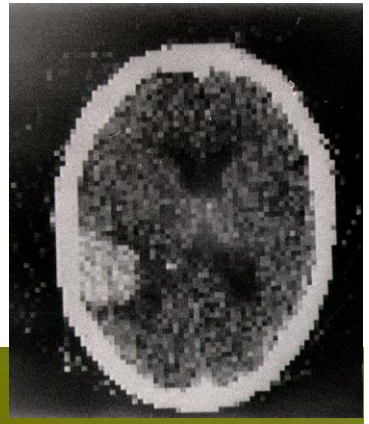
„Eine neue Art von Strahlen“

Von Röntgen zu Hounsfield

Uniklinikum Würzburg

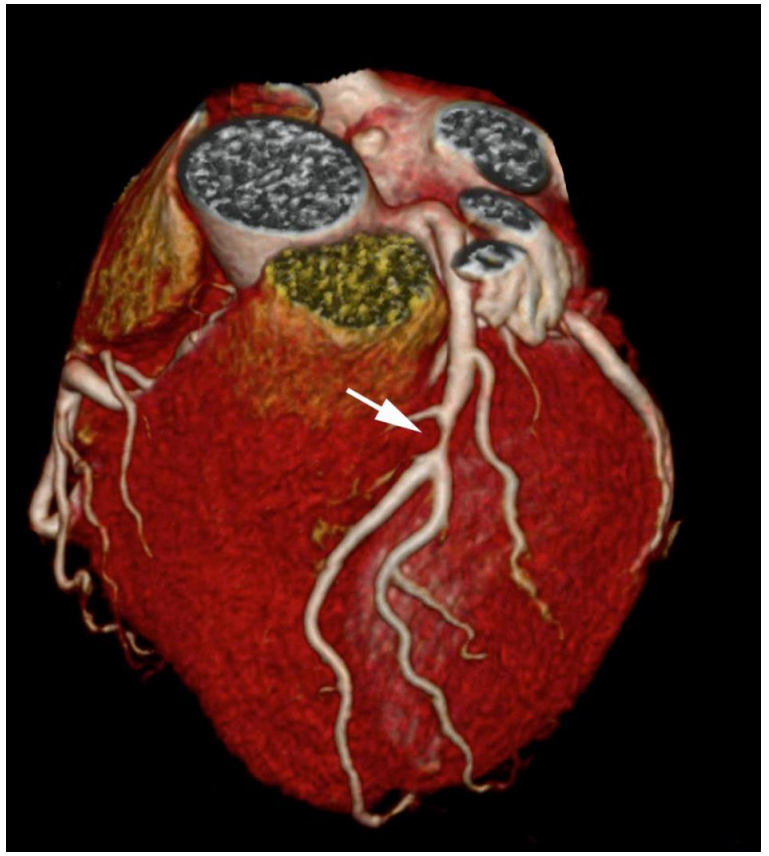
1974

1 Schicht / 7 min.



2016 2 Röhren + 2 Detektoren

1 ganzer Mensch / 5 sek.



Courtesy: Prof. Th. Bley

Radiologie – ein Fach mit „digitaler Tradition“

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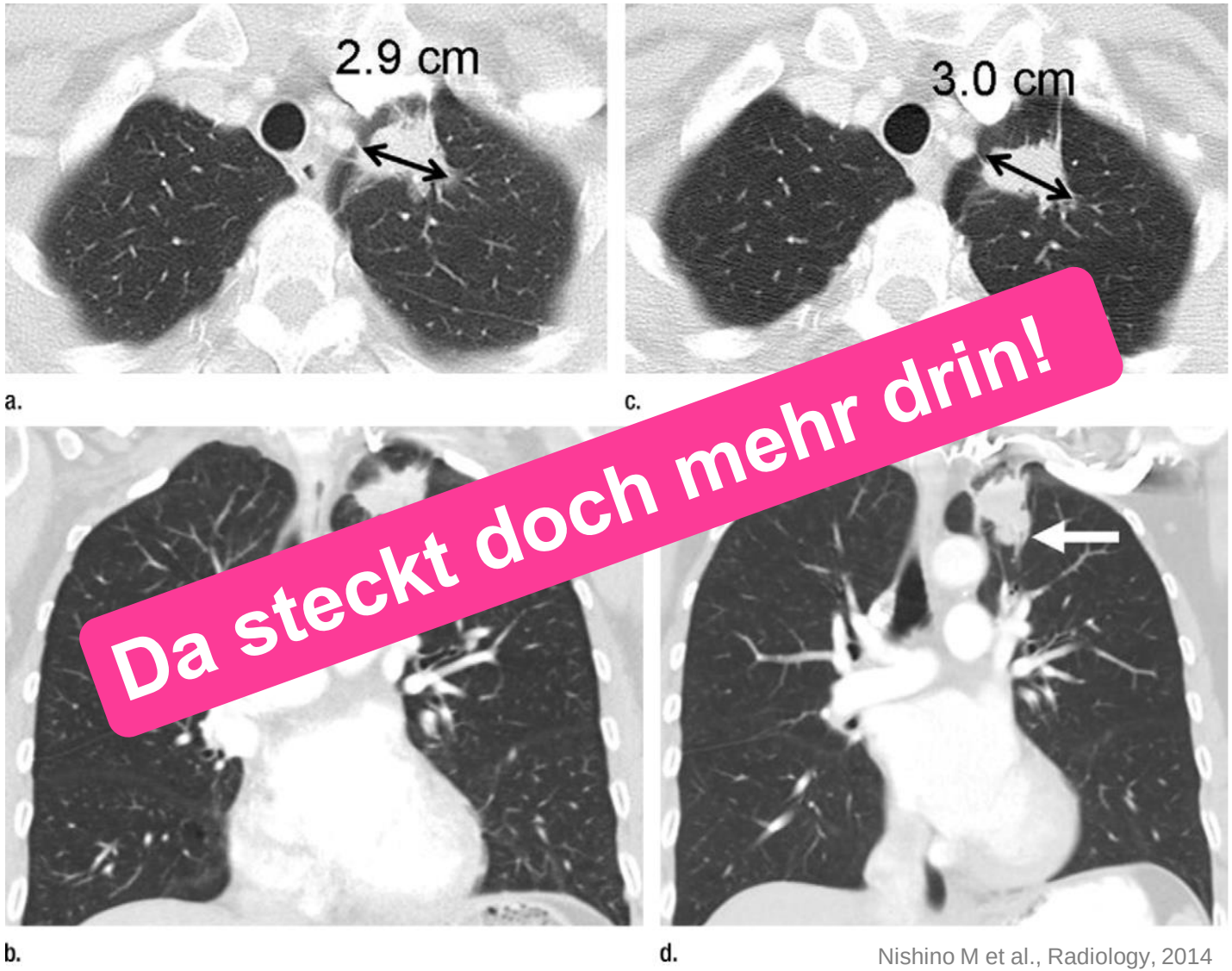
Bildgebung 2022 vs. „Precision Medicine“

Uniklinikum Würzburg



Da steckt doch mehr drin!

Nishino M et al., Radiology, 2014

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- Was ist „Künstliche Intelligenz“?

KI – der Game Changer?

Uniklinikum Würzburg

Artificial Intelligence in Radiology: The Game-Changer on Everyone's Mind

Oct 20, 2017 | Dave Pearson

AI's Impact Will Be Monumental—Will Radiologists Go Along for the Ride or Be Left in the Dust?

One day soon, machines powered by artificial intelligence (AI) will interpret even the most complex clinical images as accurately as today's most experienced radiologists. These robot radiologists will automatically generate final reports, uniformly structured and with no need for preliminary reads. Their interpretations will take

Alltägliche Anwendungen von Künstlicher Intelligenz

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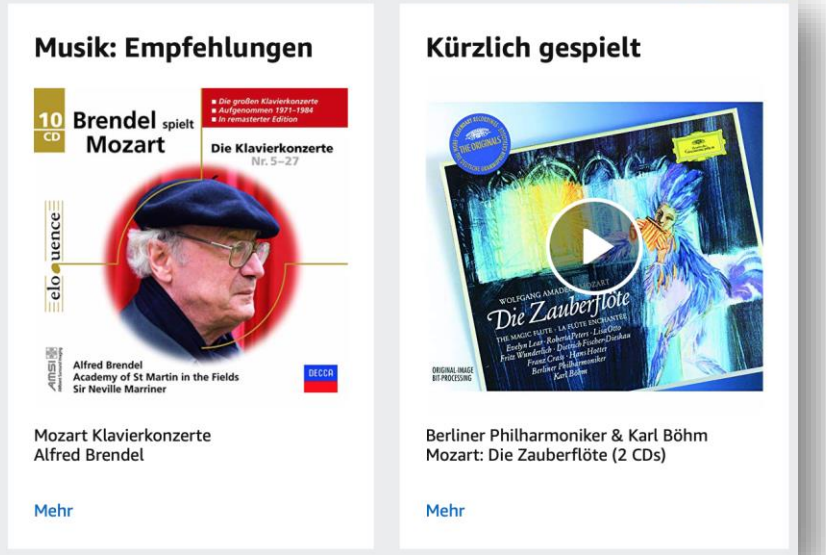
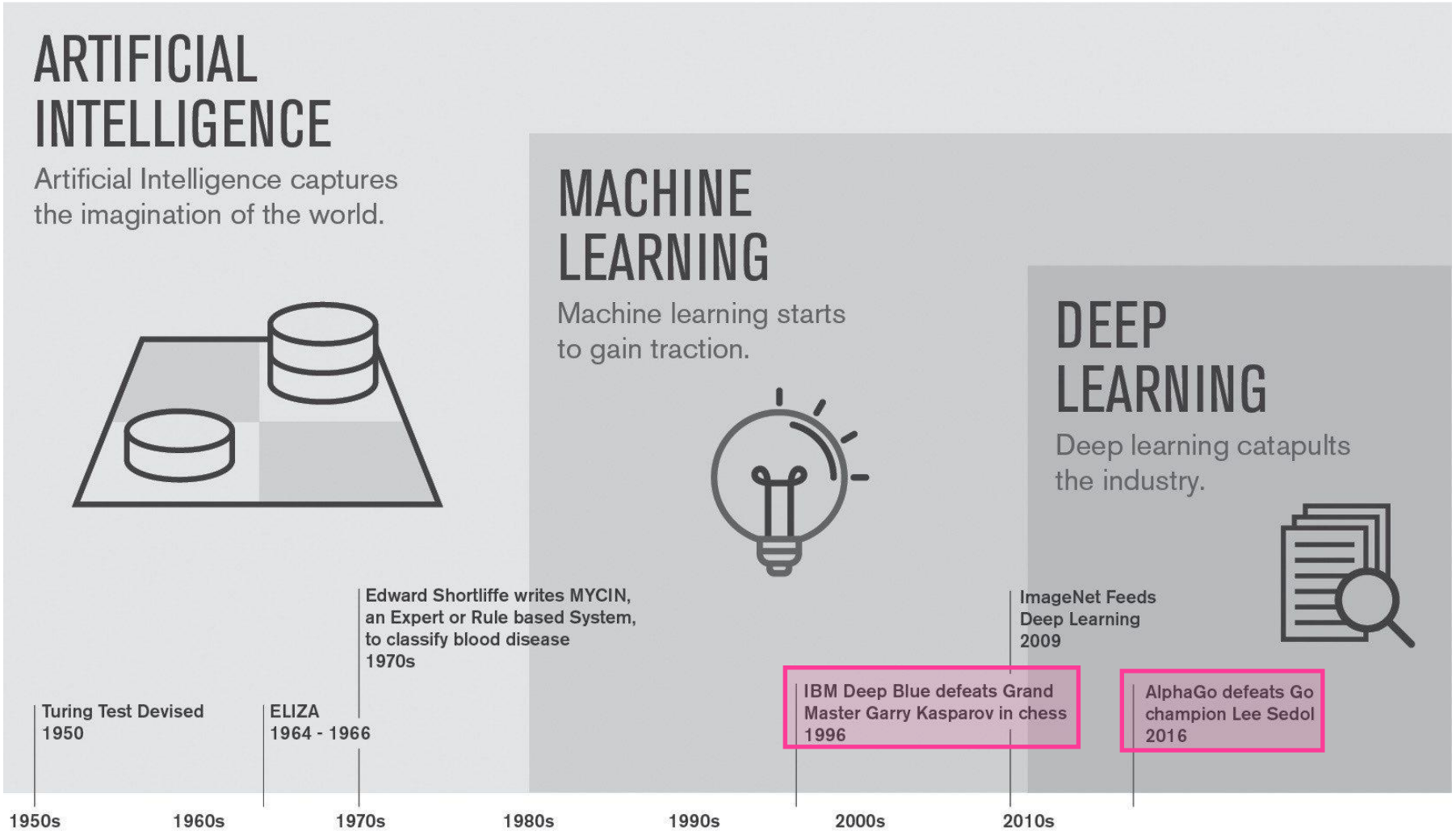
amazon.de prime



Eigentlich nichts Neues…



https://apttus.com/blog/artificial-intelligence-works-intelligent-enterprise/

Sich überlappende Begriffe!

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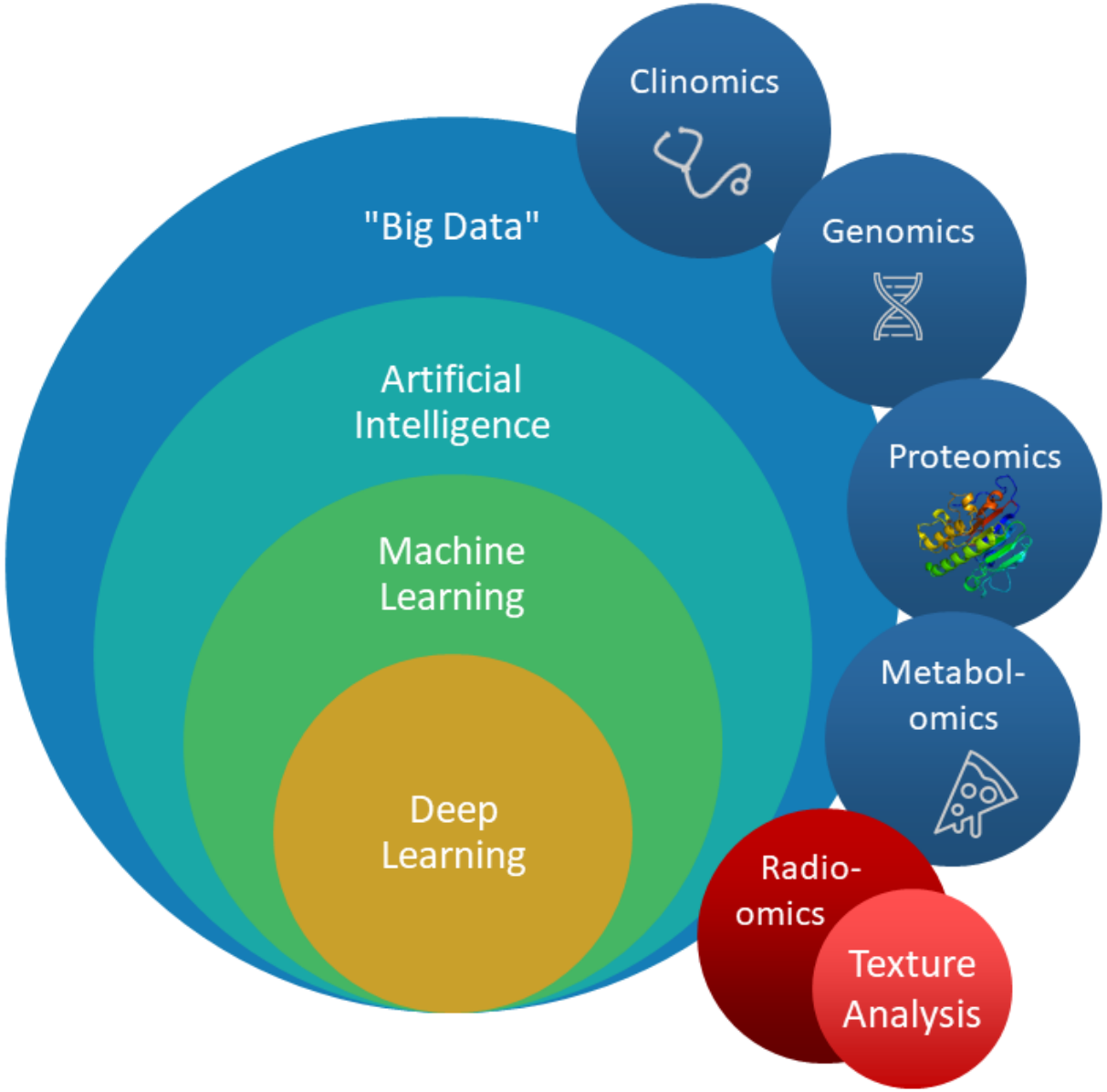
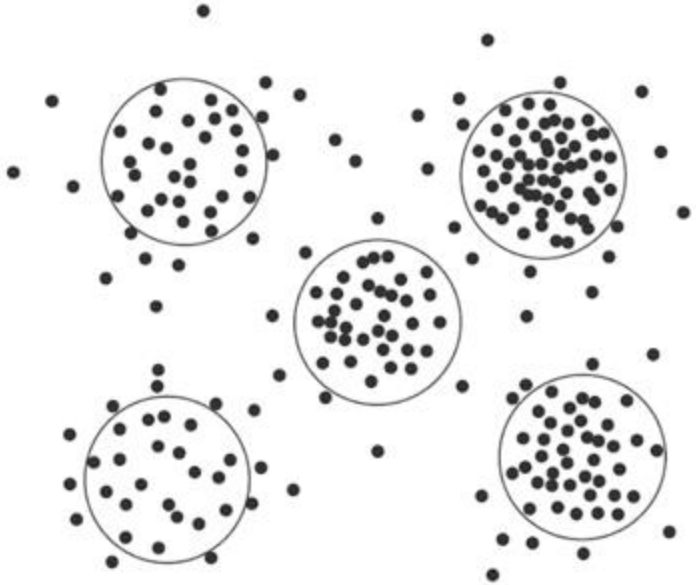


Maschinelles Lernen

Uniklinikum Würzburg

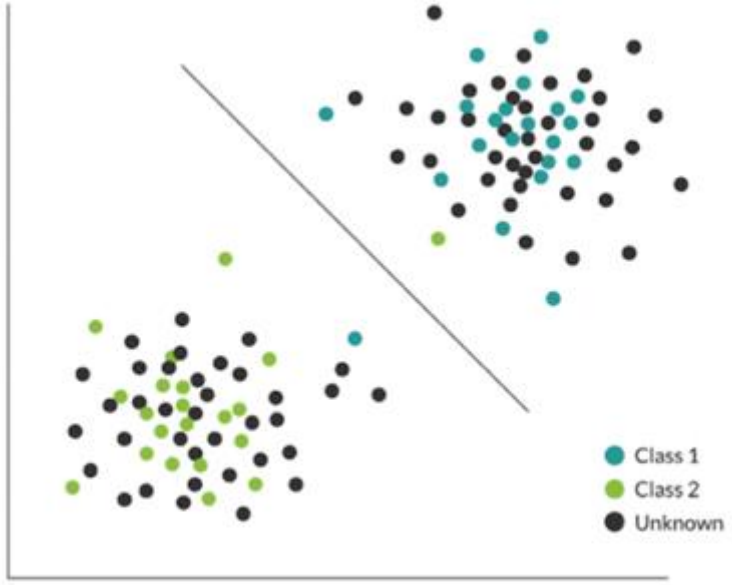
Unsupervised

Clustering von Daten ohne vorgegebene Features



Supervised

Unterteilung in Klassen durch vorgegebene Labels

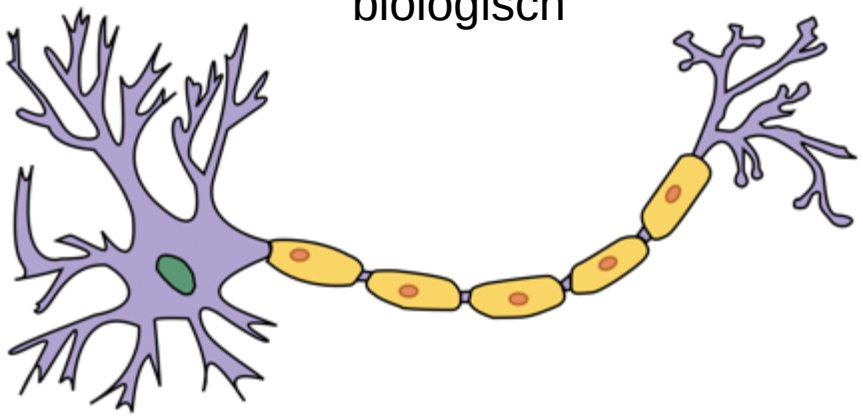


Courtesy: Dr. J Heidenreich

Neuronale Netze

Uniklinikum Würzburg

biologisch



künstlich

Eingabe

Eingabe

Eingabe

Neuron

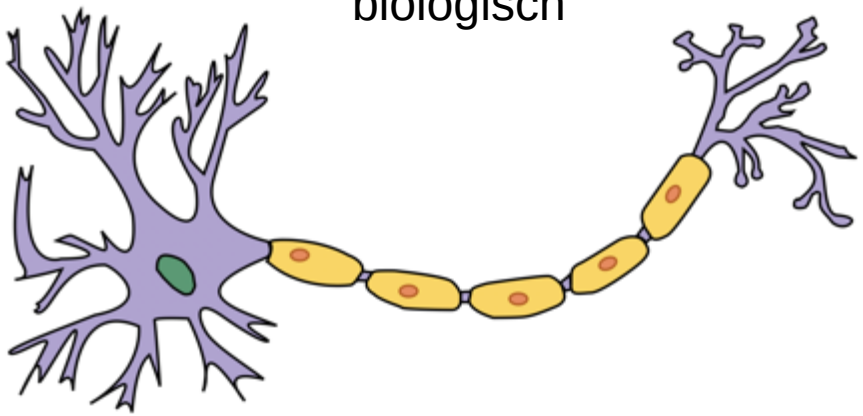
Ausgabe

Courtesy: Dr. J Heidenreich

Neuronale Netze

Uniklinikum Würzburg

biologisch



künstlich

Eingabe

Eingabe

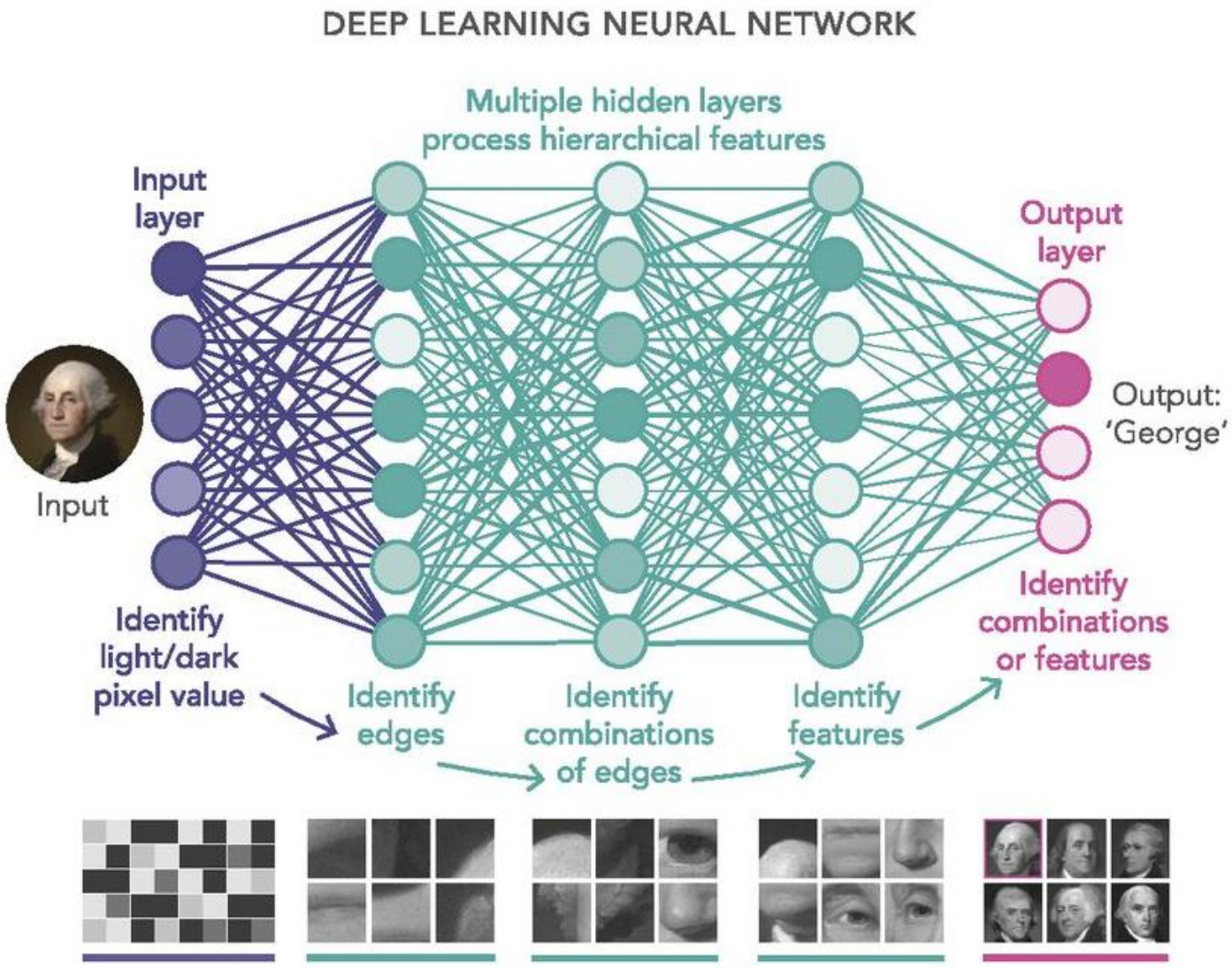
Eingabe

Neuron

Ausgabe

Courtesy: Dr. J Heidenreich

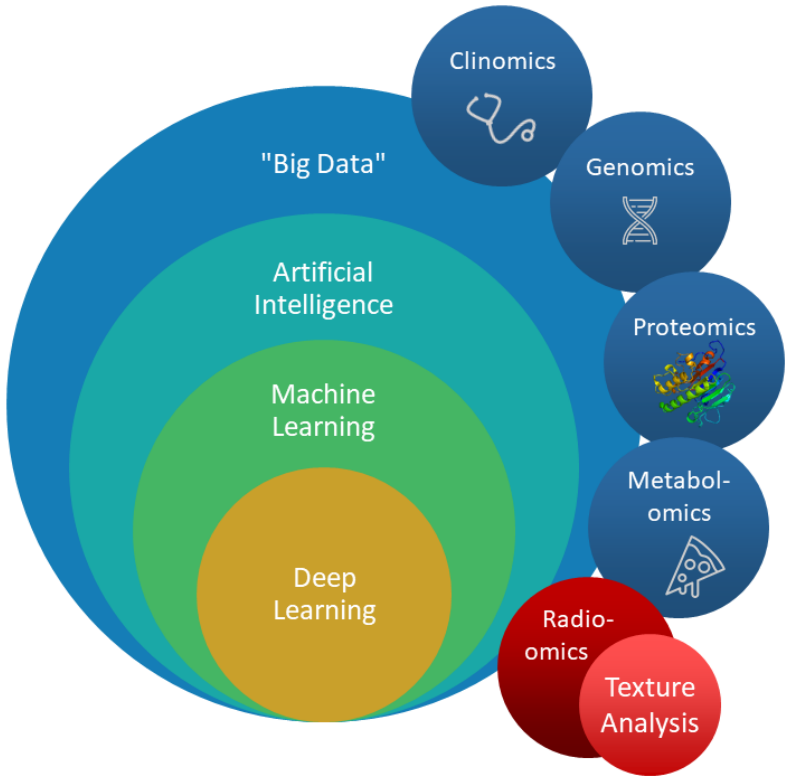
Deep Learning



Waldrop MM, PNAS January 22, 2019 116 (4) 1074-1077

Einzug von Big Data, Machine Learning und Co. in die Radiologie

Uniklinikum Würzburg

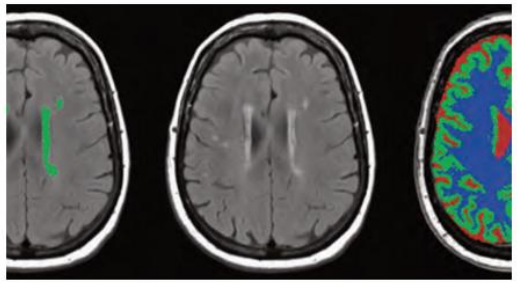


OXIPIT

ChestEye CAD

Automate your reporting

ChestEye CAD is a fully automatic computer-aided diagnosis (CAD) chest X-ray solution. It provides preliminary reports (image in, report out) which then have to be approved by a radiologist. This way it enables the user to save time (internal trial shows >30% savings), increase accuracy (e.g. decrease overlooked secondary findings), optimize screening / triage, and introduce best reporting practices. The solution can be integrated with PACS/RIS/HIS/EHR infrastructure.



Quantib™ Brain

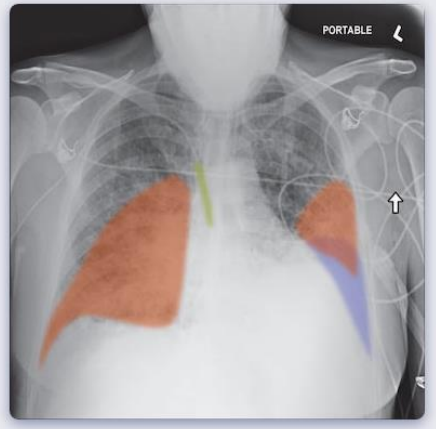
EXAMPLE RESULTS

Findings

- There is volume loss in both lungs. Ill defined opacities are present bilaterally.
- A left sided pleural effusion is seen filling the costophrenic sulcus.
- The hilar area is enlarged.
- The mediastinum is within normal limits.
- Central venous cathether is observed with tip at the superior vena cava.

Impression

Bilateral consolidation. Left pleural effusion.



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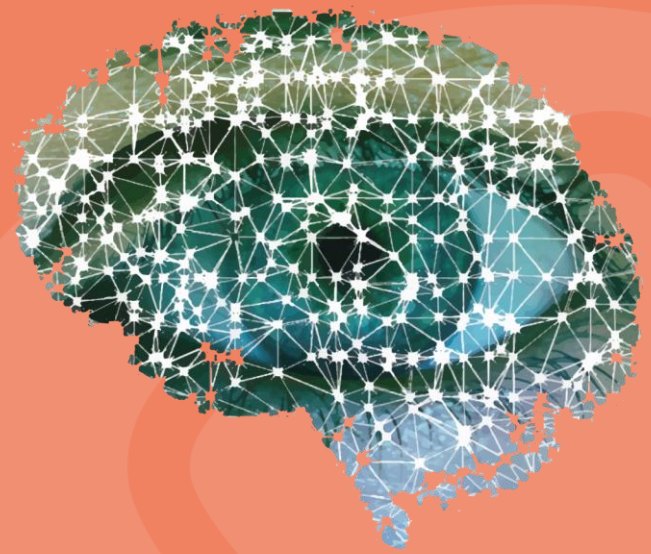
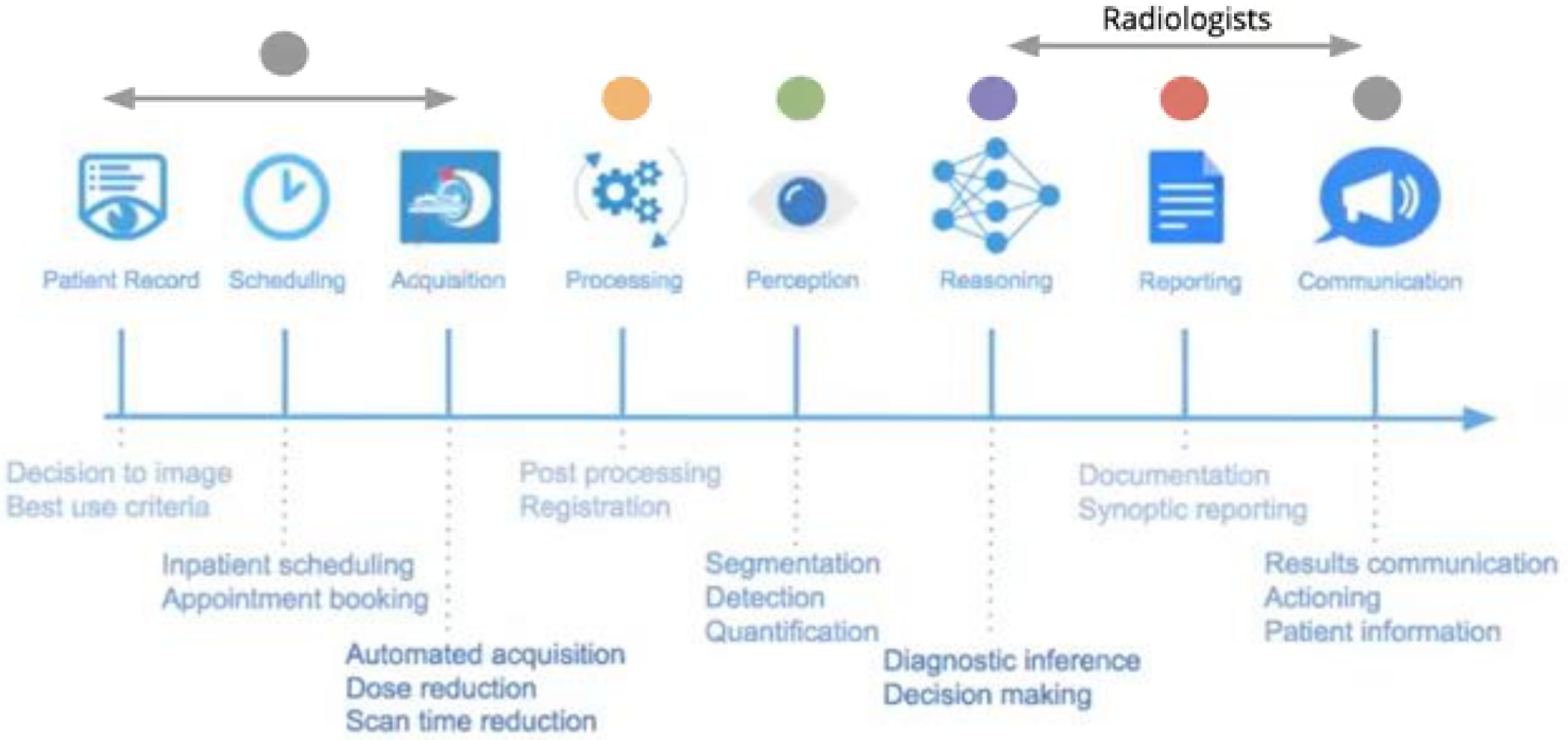


- Was kann „Künstliche Intelligenz“?

Anwendungsbereiche für KI in der Radiologie

Uniklinikum Würzburg



The Radiology AI sector in the EU by Hugh Harvey, EuSoMII Webinar 3.3.2020

KI für die Bildrekonstruktion

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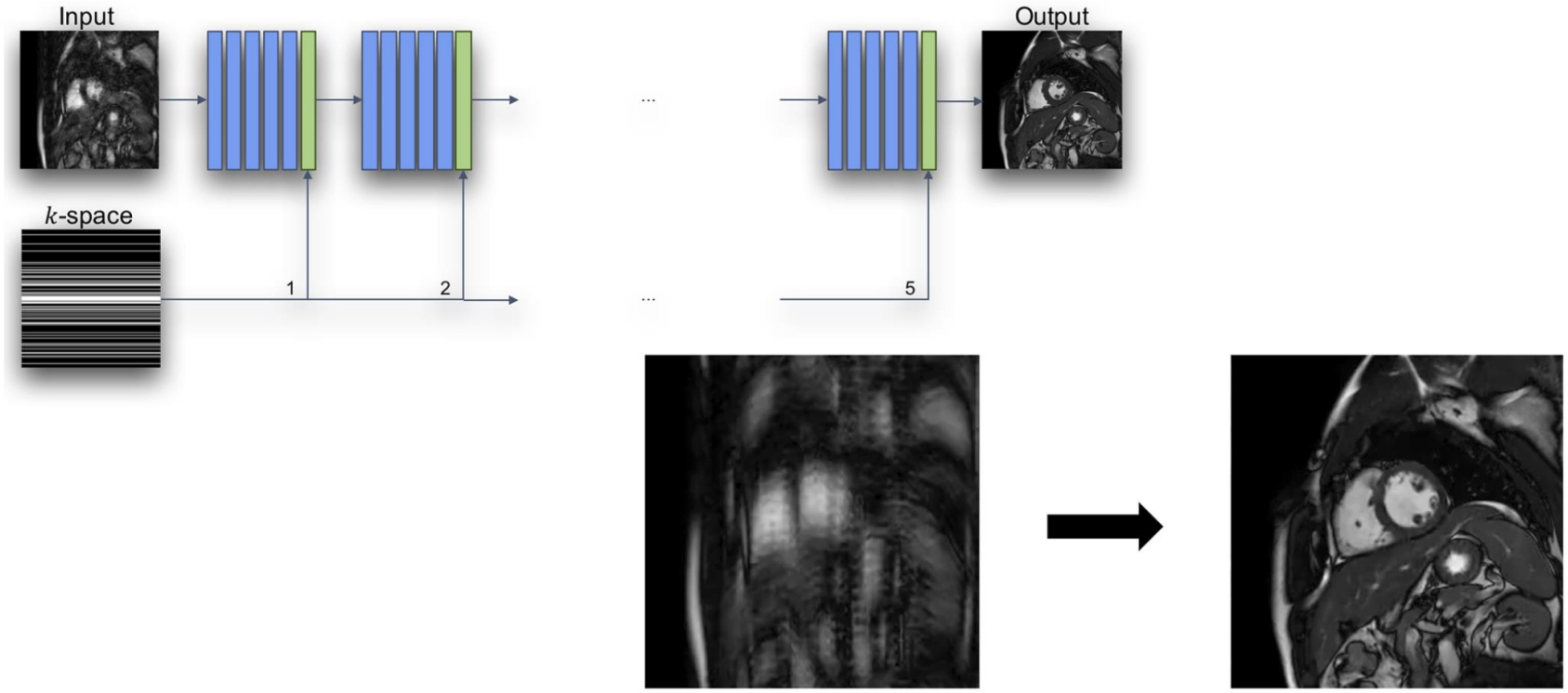
Undersampled MRI reconstruction



Leiner et al., JCMR, 2019

A Deep Cascade of Convolutional Neural Networks for Dynamic MR Image Reconstruction

Publisher: IEEE

5 Author(s) Jo Schlemper ; Jose Caballero ; Joseph V. Hajnal ; Anthony N. Price ; Daniel Rueckert **View All Authors**

KI in der kardialen MRI: Automatische Segmentierung

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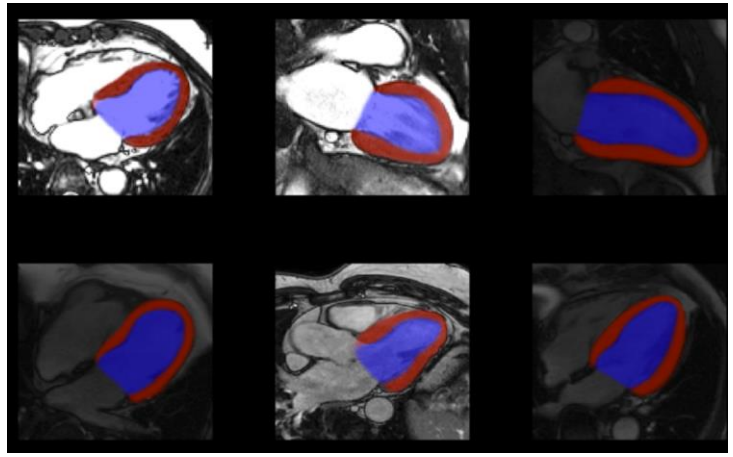
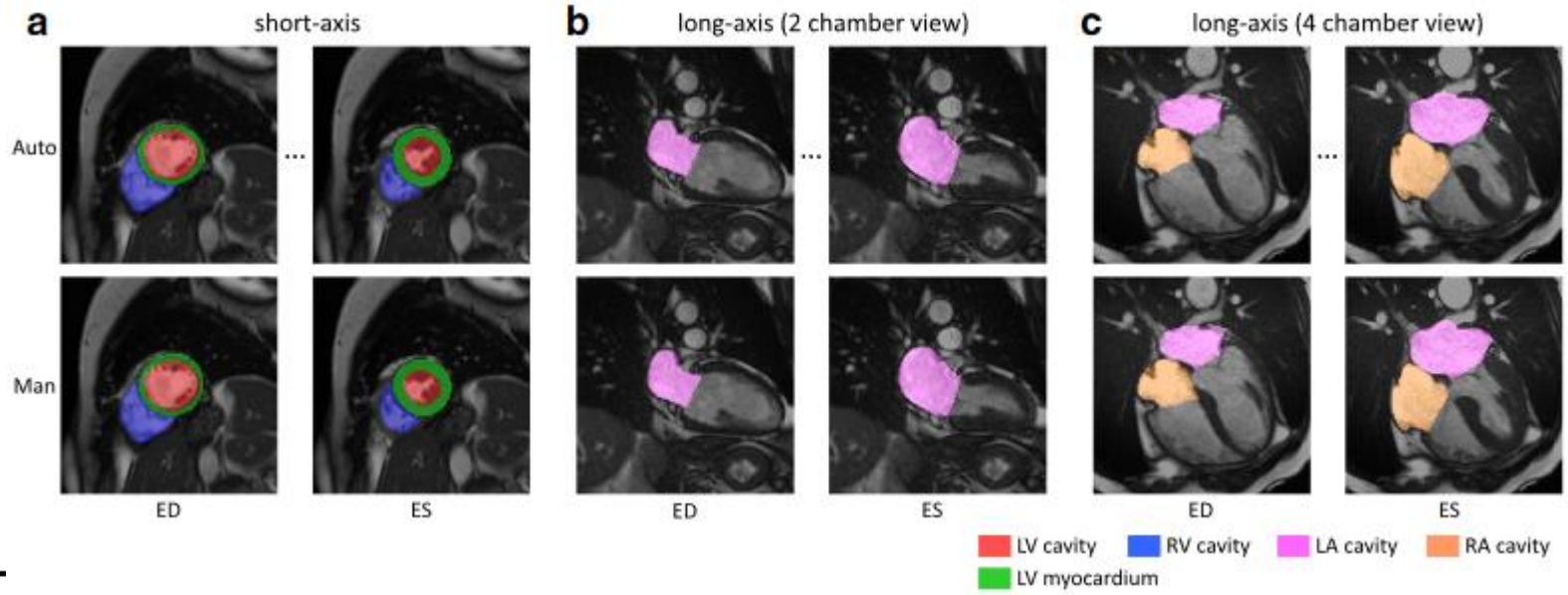


Leiner et al., JCMR, 2019



Bai *et al. Journal of Cardiovascular Magnetic Resonance* (2018) 20:65
https://doi.org/10.1186/s12968-018-0471-x

Journal of Cardiovascular Magnetic Resonance

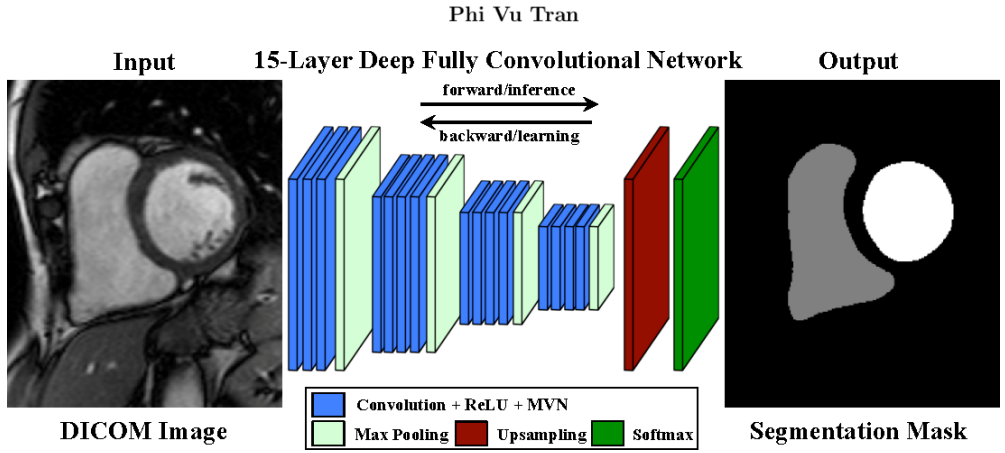
RESEARCH Open Access

Automated cardiovascular magnetic resonance image analysis with fully convolutional networks

Wenjia Bai[1*], Matthew Sinclair[1], Giacomo Tarroni[1], Ozan Oktay[1], Martin Rajchl[1], Ghislain Vaillant[1], Aaron M. Lee[2], Nay Aung[2], Elena Lukaschuk[3], Mihir M. Sanghvi[2], Filip Zemrak[2], Kenneth Fung[2], Jose Miguel Paiva[2], Valentina Carapella[3], Young Jin Kim[3], Hideaki Suzuki[4], Bernhard Kainz[1], Paul M. Matthews[4], Steffen E. Petersen[2], Stefan K. Piechnik[3], Stefan Neubauer[3], Ben Glocker[1] and Daniel Rueckert[1]

A Fully Convolutional Neural Network for Cardiac Segmentation in Short-Axis MRI

Phi Vu Tran



KI für die Segmentierung von Narbengewebe

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Self-configuring nnU-net pipeline enables fully automatic infarct segmentation in late enhancement MRI after myocardial infarction

Julius F. Heidenreich [a,*], Tobias Gassenmaier [a], Markus J. Ankenbrand [b,c], Thorsten A. Bley [a], Tobias Wech [a]

[a] Department of Diagnostic and Interventional Radiology, University Hospital Würzburg, Germany
[b] Department of Cellular and Molecular Imaging, Comprehensive Heart Failure Center, University Hospital Würzburg, Germany
[c] Center for Computational and Theoretical Biology, University of Würzburg, Germany

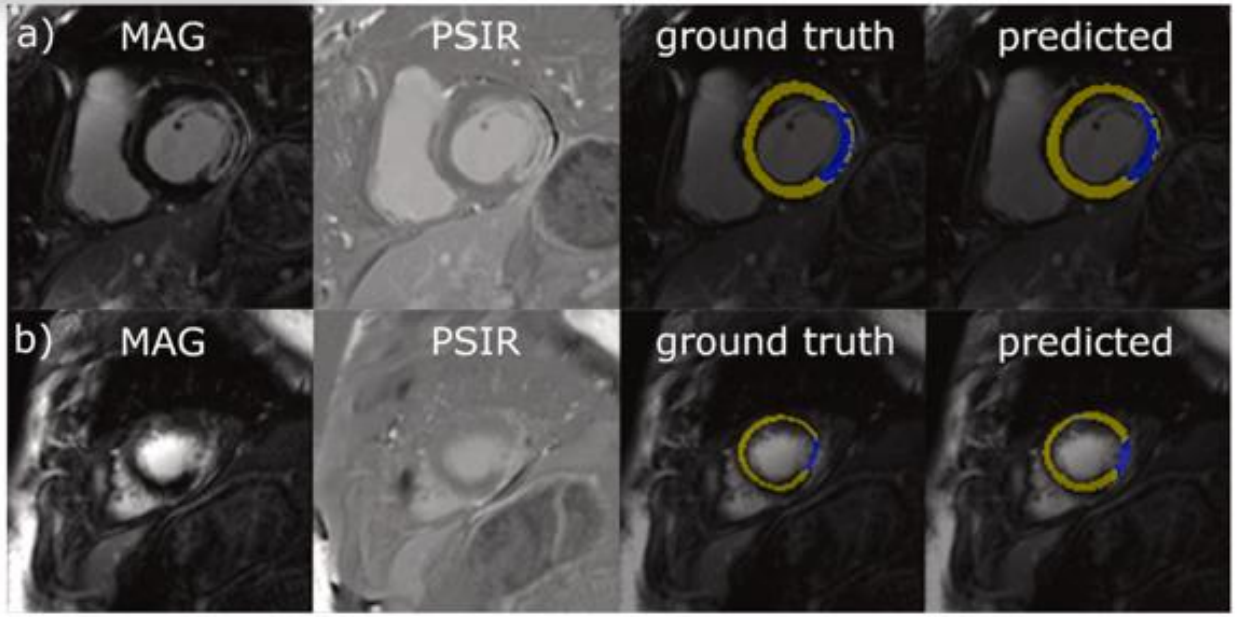

Fig. 2. Exemplary illustration of automatic segmentation performed by nnU-net for the DUAL group. In a) an example with good performance (DSC_{myo} = 0.89, DSC_{scar} = 0.89) is depicted. No reflow areas were added to infarct zone as labelled in the training data. The second example (b) shows a specimen with lower performance of the trained model as measured by the DSC (DSC_{myo} = 0.67, DSC_{scar} = 0.33). Myocardium was interpreted thicker as in the manual reference, which both affected the results form myocardium and infarct zone. MAG, magnitude reconstruction; PSIR, phase sensitive inversion recovery.

Heidenreich et al. Eur J Radiol 2021 Aug;141:109817. doi: 10.1016/j.ejrad.2021.109817.

KI in der Neuroradiologie: Multiple Sklerose und Demenz

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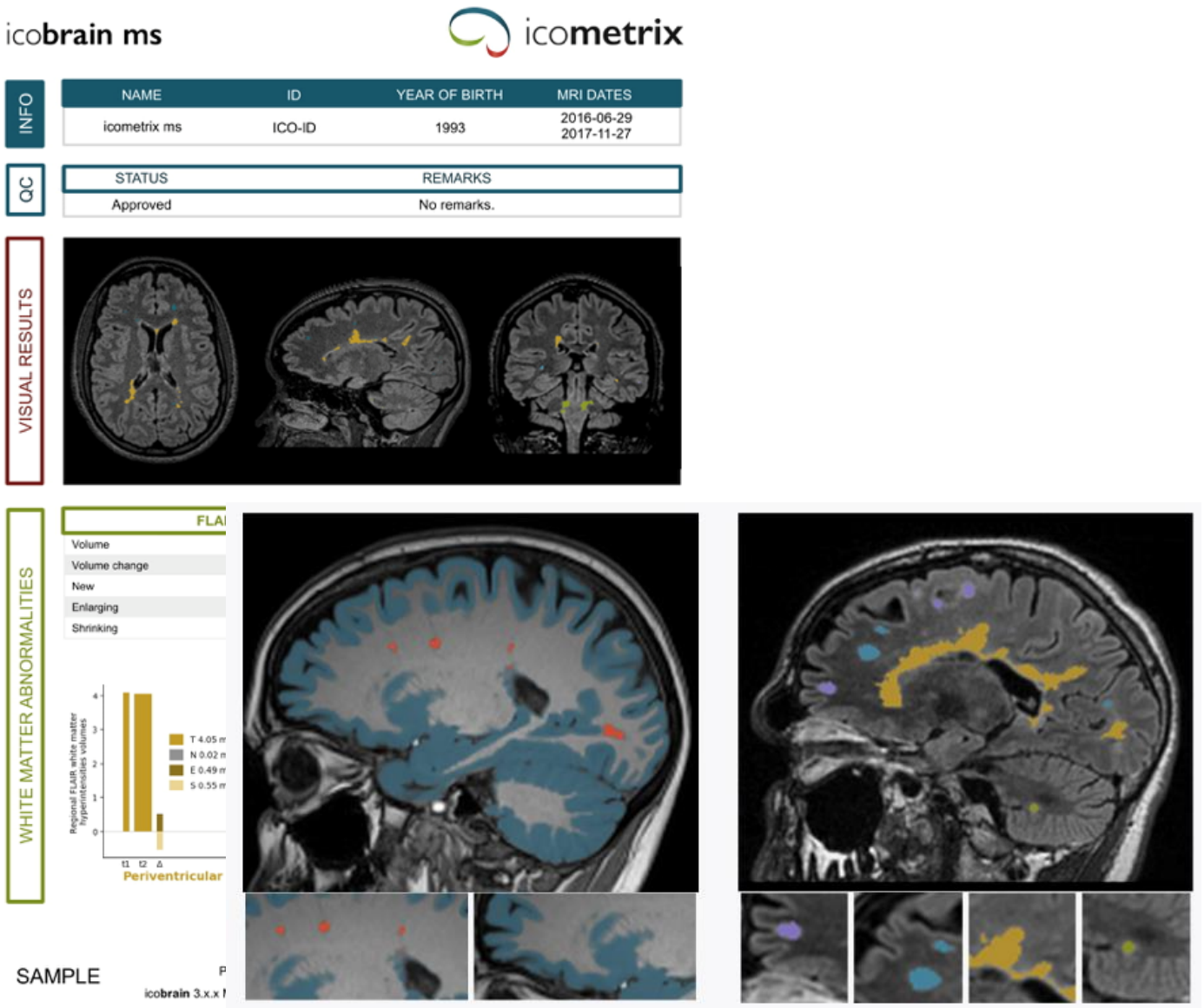
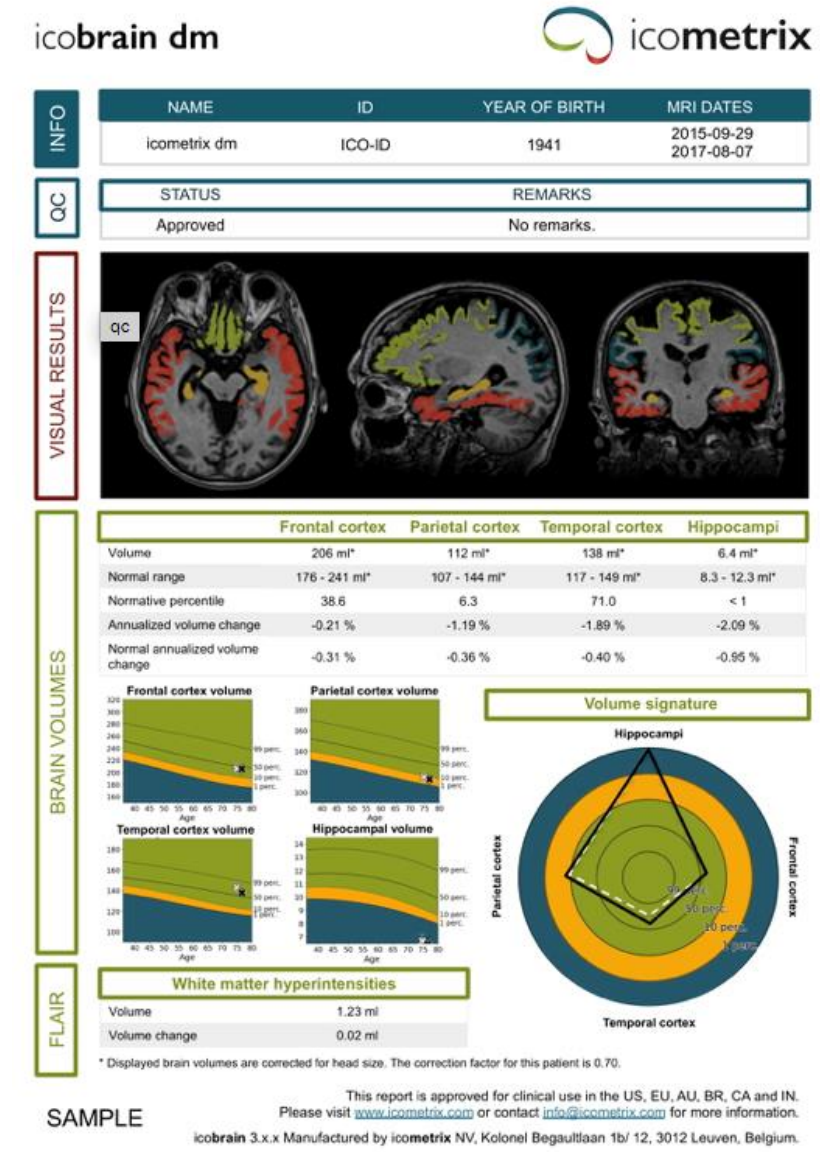




KI in der Kinderradiologie: Automatische Skelettalterbestimmung

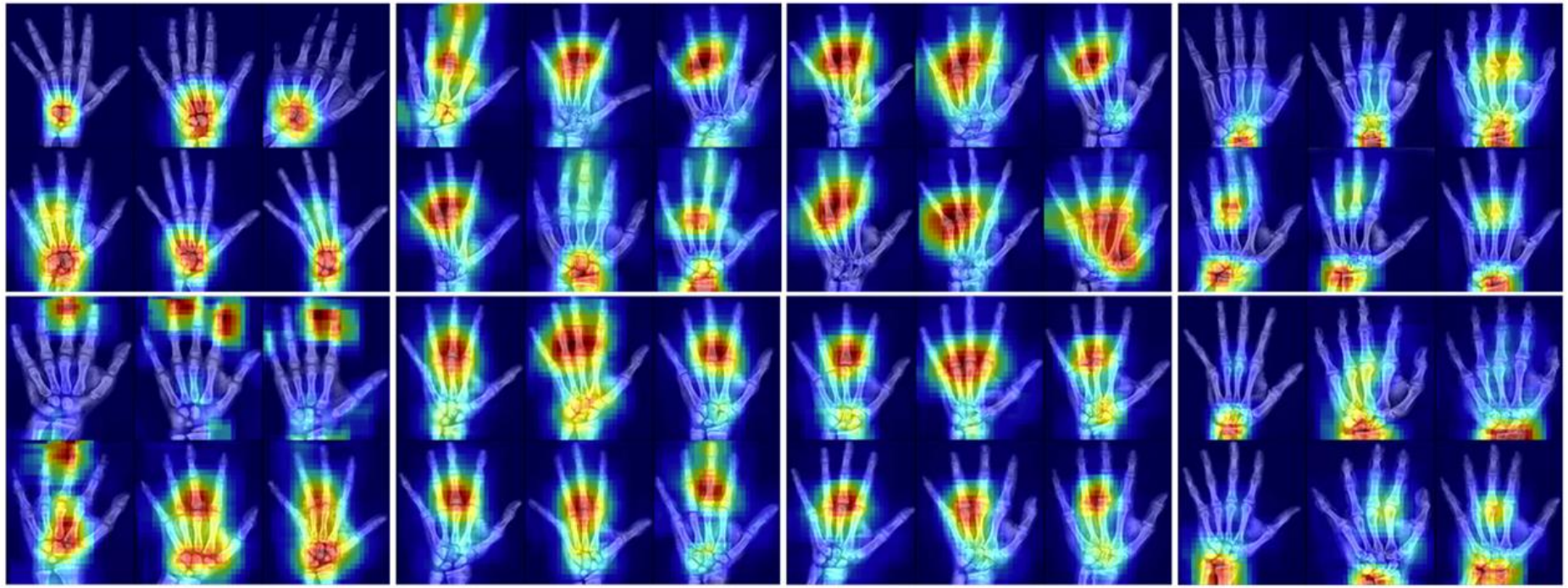
Uniklinikum Würzburg

J Digit Imaging (2017) 30:427–441
DOI 10.1007/s10278-017-9955-8

CrossMark

Fully Automated Deep Learning System for Bone Age Assessment

Hyunkwang Lee[1] · Shahein Tajmir[1] · Jenny Lee[1] · Maurice Zissen[1] · Bethel Ayele Yeshiwas[1] · Tarik K. Alkasab[1] · Garry Choy[1] · Synho Do[1]



KI-Start-Ups in Europa

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The Radiology AI sector in the EU by Hugh Harvey, EuSoMII Webinar 3.3.2020

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- Was kann „Künstliche Intelligenz“ NICHT?

  - oder: Werden wir Ärzte in Zukunft überflüssig?

Prognose Geoffrey Hinton, 2016

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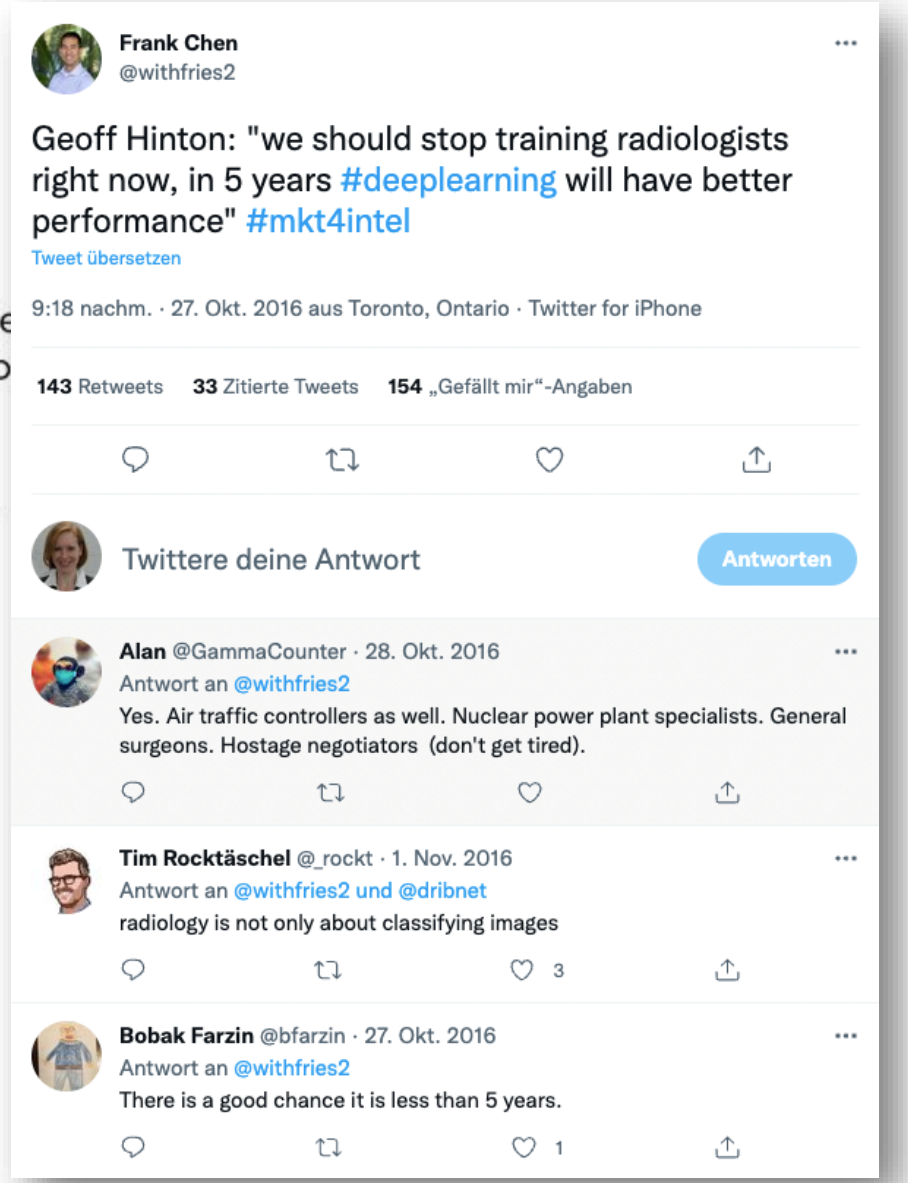
"I think that if you work as a radiologist, you are like Wile E. Coyote in the cartoon. You're already over the edge o the cliff, but you haven't yet looked down. There's no ground underneath. People should stop training radiologists now. It's just completely obvious that in five years deep learning is going to do better than radiologists."

Nov 24, 2016

Geoffrey Hinton, University of Toronto



…oder: Muss der Pathologe Angst vor Tauben haben?!

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Pigeons (*Columba livia*) as Trainable Observers of Pathology and Radiology Breast Cancer Images

Richard M. Levenson, Elizabeth A. Krupinski, Victor M. Navarro, Edward A. Wasserman

Published: November 18, 2015 • https://doi.org/10.1371/journal.pone.0141357

„Pigeons spot cancer as well as human experts.“

https://youtu.be/flzGjnJLyS0?t=10 http://www.sciencemag.org/news/2015/11/pigeons-spot-cancer-well-human-experts

Wichtige Limitation: Fehlende Standardisierung

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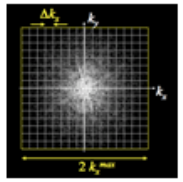
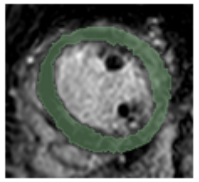
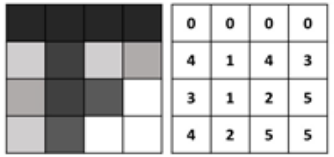
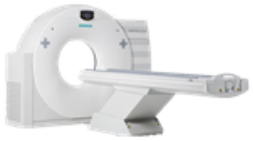
	Robustness		Reproducibility	Classification performance	
	Image acquisition	Reconstruction	Segmentation	Post-processing	Feature extraction
					

 MRI	• Field strength
	• Sequence design
	• Matrix size (acquired)
	• Field of view
	• Slice thickness
	• Acceleration techniques
	• Vendor
	• Contrast timing
	• Movement
		• Matrix size (reconstructed)
		• Reconstruction technique
			• Manual 2D
			• Manual 3D
			• Semi-automated 2D
			• Semi-automated 3D
			• Automated 2D
			• Automated 3D
			• Size of the ROI
				• Image interpolation ('resampling' / 'rescaling')
				  • Grid alignment
				  • Pixel sizing
				• Intensity discretisation ('rebinning')
				• Normalisation
					• Mathematical formula
					• Post-processing platform

 CT	• Tube voltage
	• Miliamperage
	• Pitch
	• Field of view / pixel spacing
	• Slice thickness
	• Acquisition mode
	• Vendor
	• Contrast timing
	• Movement
		• Reconstruction matrix
		• Slice thickness
		• Reconstruction kernel
		• Reconstruction technique
			• Manual 2D
			• Manual 3D
			• Semi-automated 2D
			• Semi-automated 3D
			• Automated 2D
			• Automated 3D
			• Size of the ROI
				• Image interpolation ('resampling' / 'rescaling')
				  • Grid alignment
				  • Pixel sizing
				• Intensity discretisation ('rebinning')
				• Normalisation
					• Mathematical formula
					• Post-processing platform

van Timmeren JE, … Baessler B. Radiomics in medical imaging—"how-to" guide and critical reflection. Insights Imaging. 12/2020;11:91.

Limitationen: das Chihuahua-Muffin-Problem

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https://medium.freecodecamp.org/chihuahua-or-muffin-my-search-for-the-best-computer-vision-api-cbda4d6b425d

Auch KI kann sich irren...

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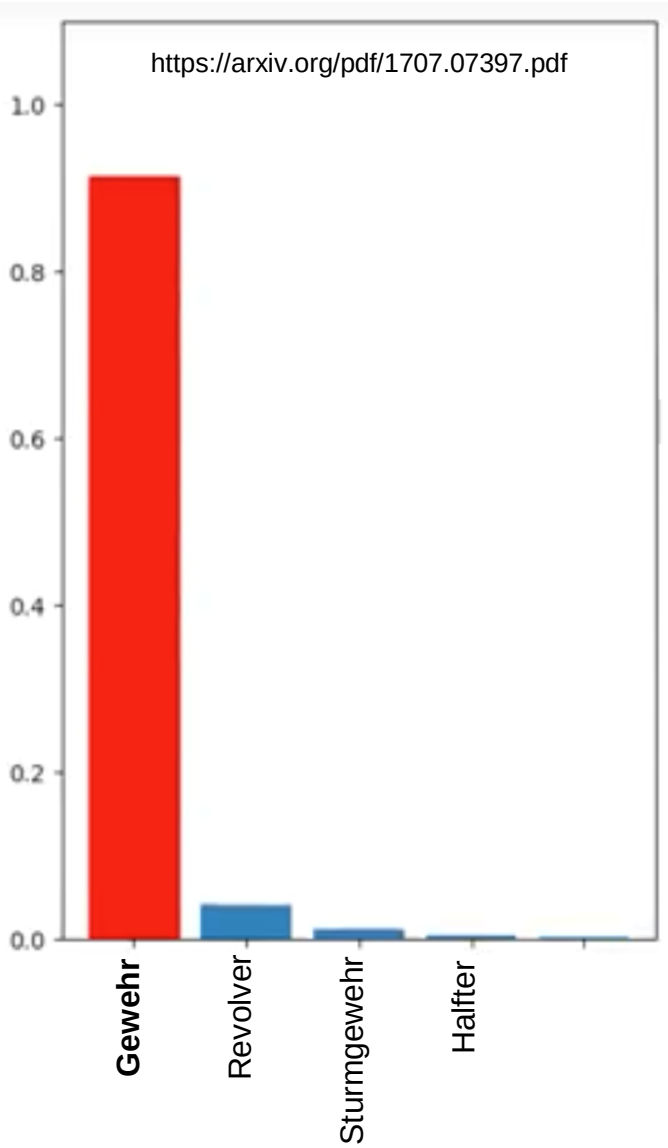
Synthesizing Robust Adversarial Examples

Anish Athalye [*12] Logan Engstrom [*12] Andrew Ilyas [*12] Kevin Kwok [2]

Gewehr !

https://arxiv.org/pdf/1707.07397.pdf



Nur eine (1!) korrekte Klassifikation

https://arxiv.org/pdf/1707.07397.pdf

„One pixel attack for fooling deep neural networks“

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HORSE

FROG(99.9%)

SHIP

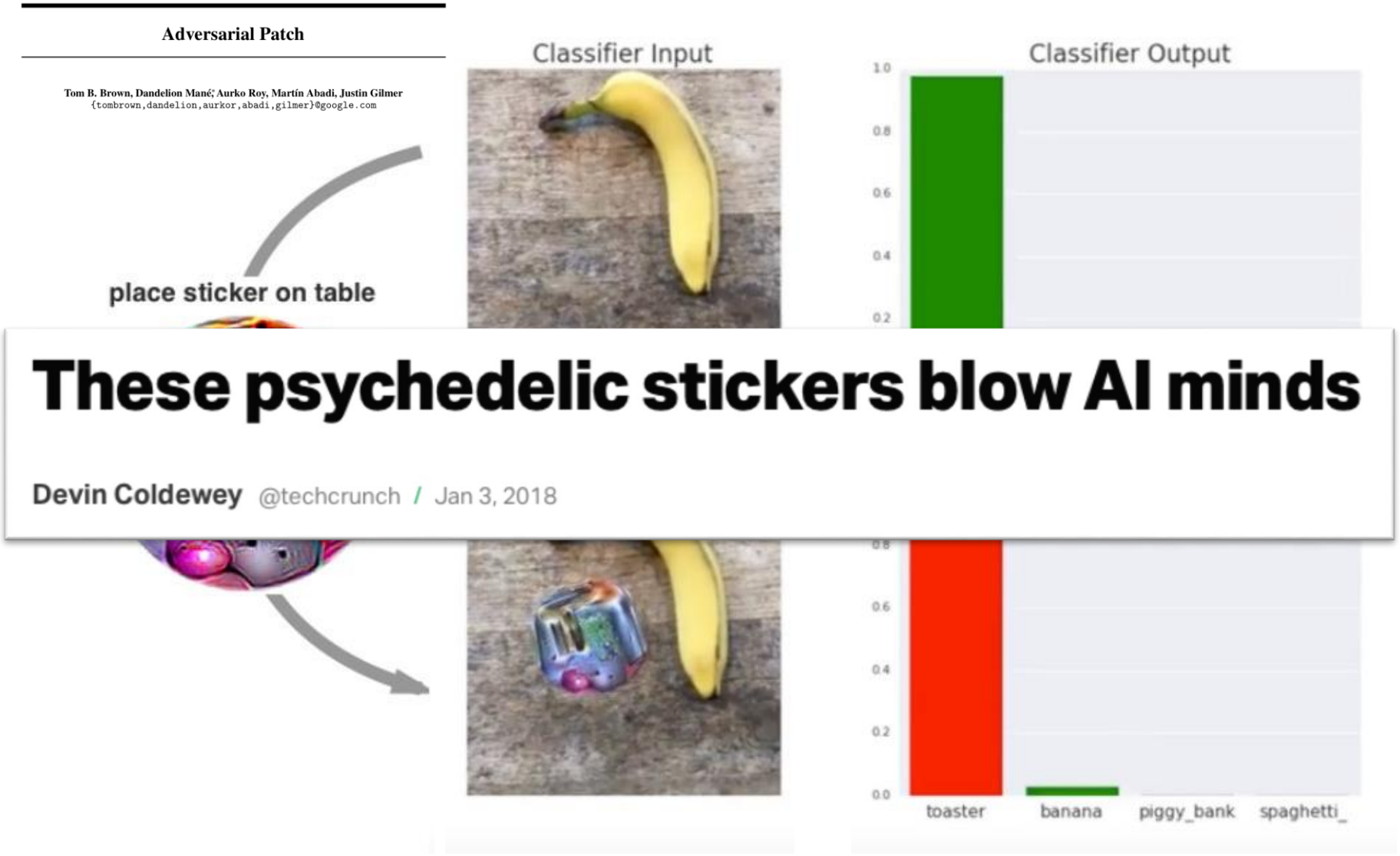
AIRPLANE(62.7%)

CAT

BIRD(66.2%)

Andere Verwirrungsstrategien...

Uniklinikum Würzburg



… und immer wieder neue Varianten von Problemen

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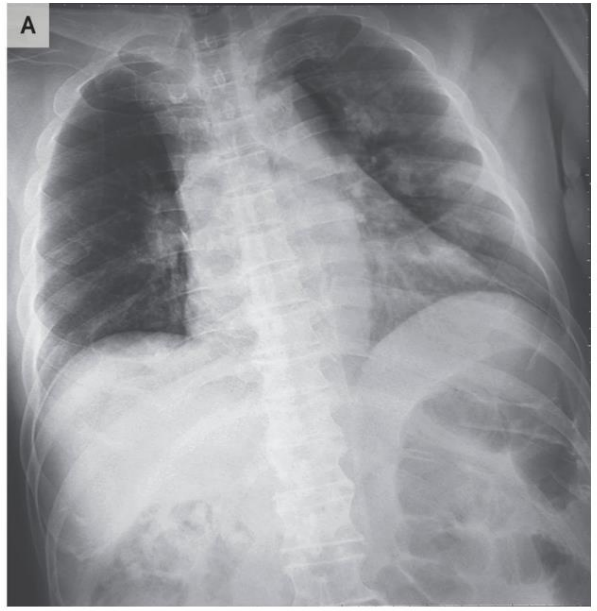
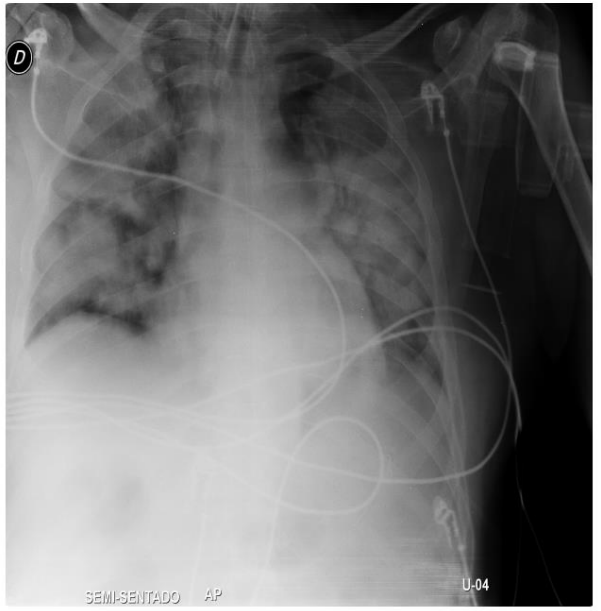
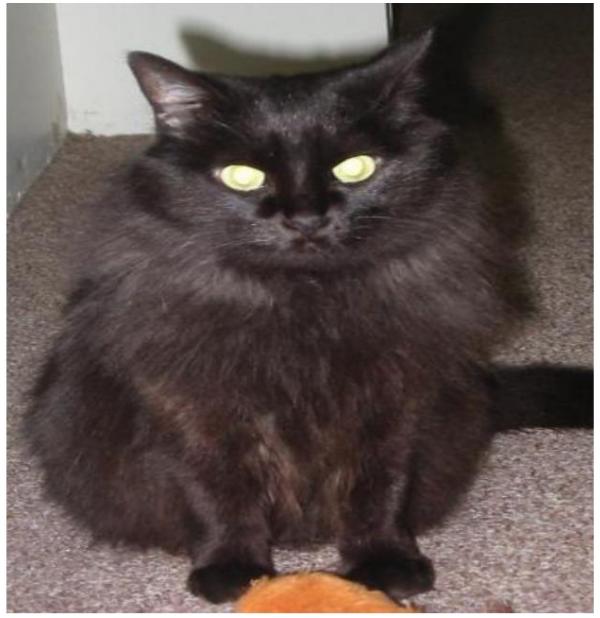
True Label	COVID-19 (Training Data)	COVID-19 (Unseen Data)	Cat (Unrelated Data)
			

Model	Prediction	Confidence	Prediction	Confidence	Prediction	Confidence
DNN	COVID-19	99.7%	Non-COVID	75.1%	COVID-19	100%
BNN	COVID-19	95.5%	COVID-19	67.1%	COVID-19	99.8%
Ours	COVID-19	99.9%	COVID-19	69.0%	COVID-19	50.1%

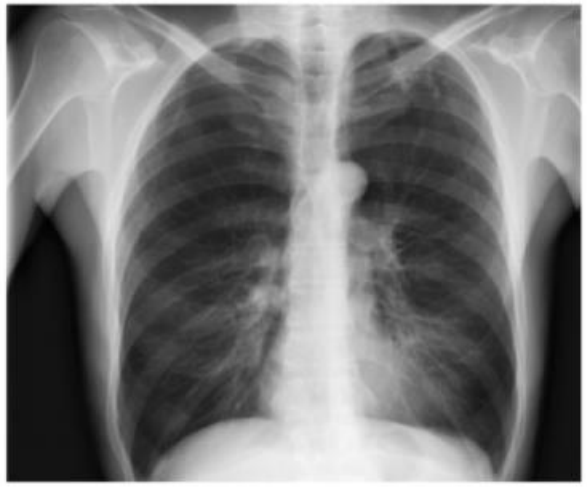
https://api.deepai.org/publication-download-pdf/can-your-ai-differentiate-cats-from-covid-19-sample-efficient-uncertainty-estimation-for-deep-learning-safety

„Garbage in, garbage out.“

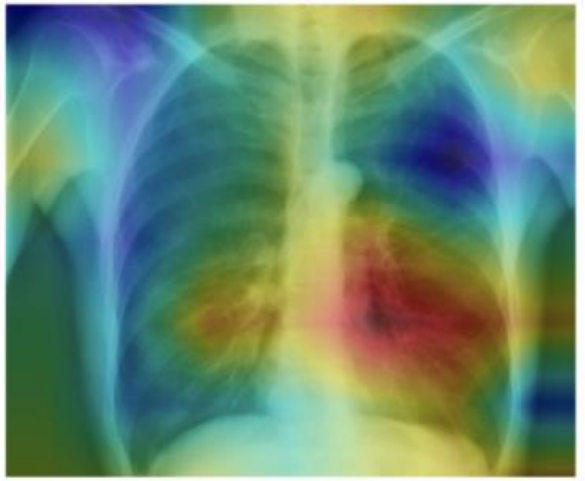
Uniklinikum Würzburg

CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning

Pranav Rajpurkar [*1] Jeremy Irvin [*1] Kaylie Zhu [1] Brandon Yang [1] Hershel Mehta [1]
Tony Duan [1] Daisy Ding [1] Aarti Bagul [1] Robyn L. Ball [2] Curtis Langlotz [3] Katie Shpanskaya [3]
Matthew P. Lungren [3] Andrew Y. Ng [1]



Input
Chest X-Ray Image



Output
Pneumonia Positive (85%)

- Ausblick – Quo vadis, Radiologie?

Verlernen der medizinischen Fertigkeiten

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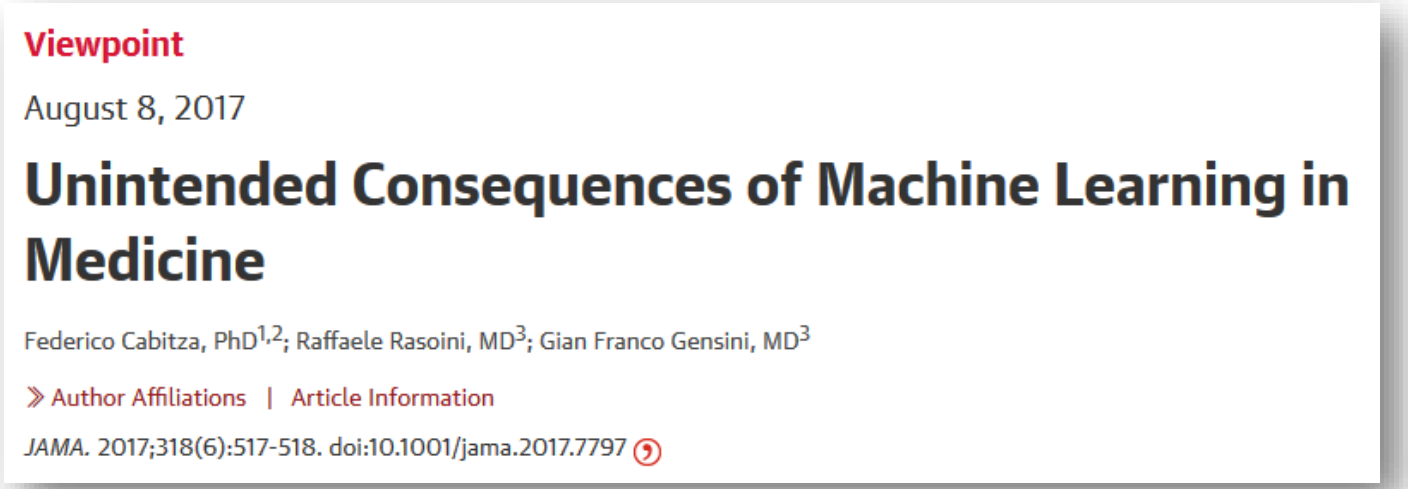


Viewpoint

August 8, 2017

Unintended Consequences of Machine Learning in Medicine

Federico Cabitza, PhD[1,2]; Raffaele Rasoini, MD[3]; Gian Franco Gensini, MD[3]

» Author Affiliations | Article Information

JAMA. 2017;318(6):517-518. doi:10.1001/jama.2017.7797

Original Investigations JAMIA

Research Paper ■

Computer Decision Support as a Source of Interpretation Error: The Case of Electrocardiograms

Theodore L. Tsai, MD, Douglas B. Fridsma, MD, Guido Gatti, MA

„Deskilling“

Anonymisierung im Zeitalter von KI fraglich

Uniklinikum Würzburg

THE WALL STREET JOURNAL.

BUSINESS | HEALTHCARE | HEALTH

Facial-Recognition Software Was Able to Identify Patients From MRI Scans

Study calls attention to a privacy threat that is set to grow as technology improves and medical-imaging data increases

Researchers used actual MRI scans, similar to a simulated scan seen at left, to generate facial reconstruction images, like the one at right, and then applied facial-recognition software to compare with photos. PHOTO: MAYO CLINIC

Anonymisierung im Zeitalter von KI fraglich

Uniklinikum Würzburg

CORRESPONDENCE

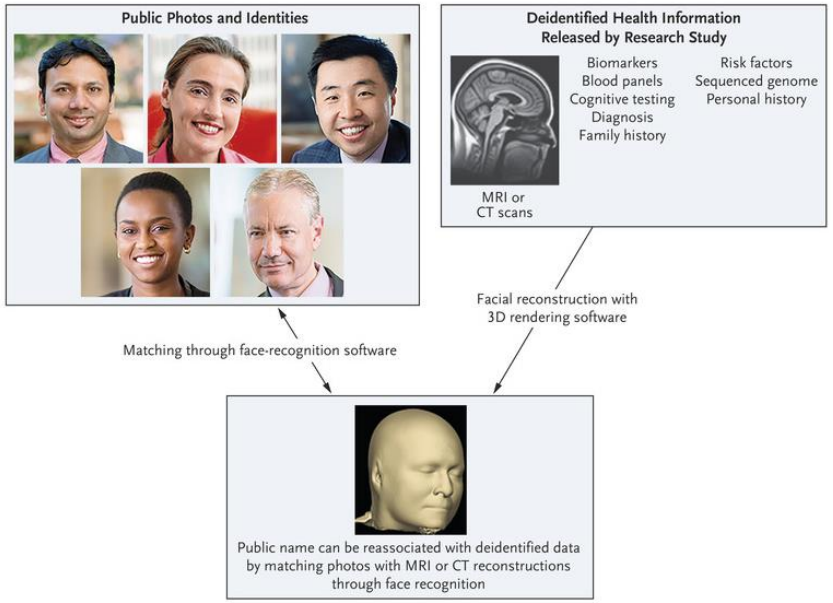
Identification of Anonymous MRI Research Participants with Face-Recognition Software

October 24, 2019
N Engl J Med 2019; 381:1684-1686
DOI: 10.1056/NEJMc1908881
Metrics

The NEW ENGLAND JOURNAL of MEDICINE

TO THE EDITOR:

Public sharing of research data is being widely promoted. Medical image files contain "metadata" such as the name of the participant, the date of the scan, and the identification number. Such data are typically removed (deidentified) before data sharing, but images of the face in magnetic resonance imaging (MRI) scans remain accessible.



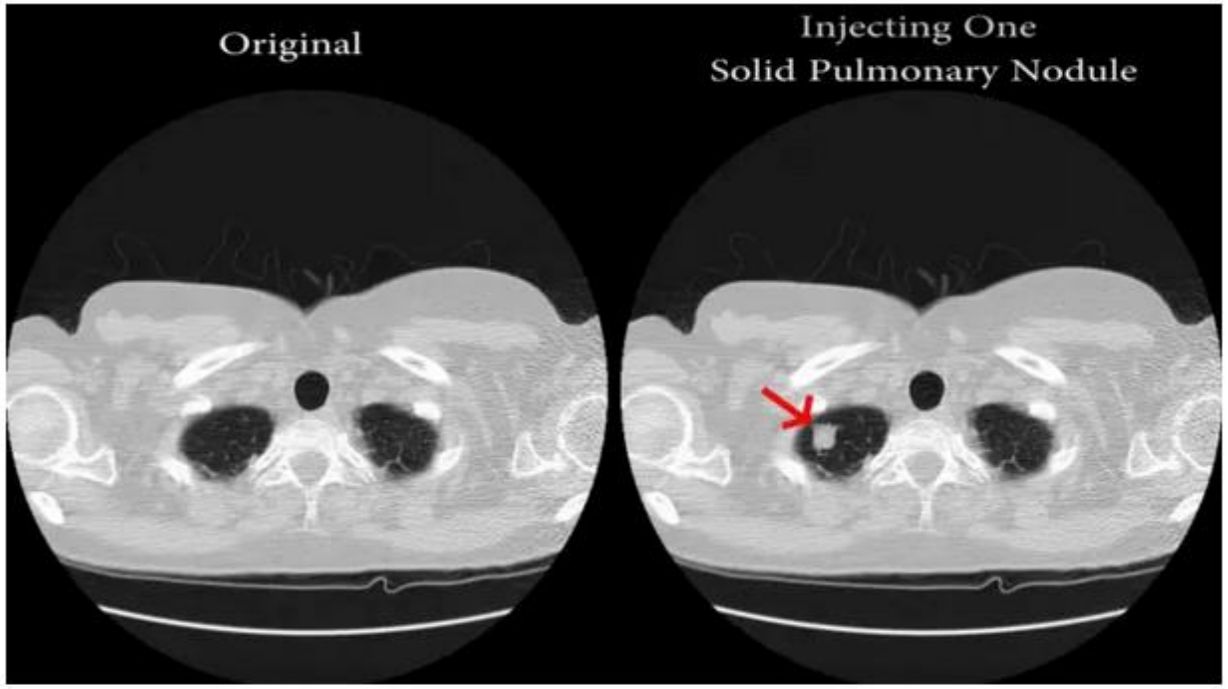
Cybersecurity (?)

Uniklinikum Würzburg

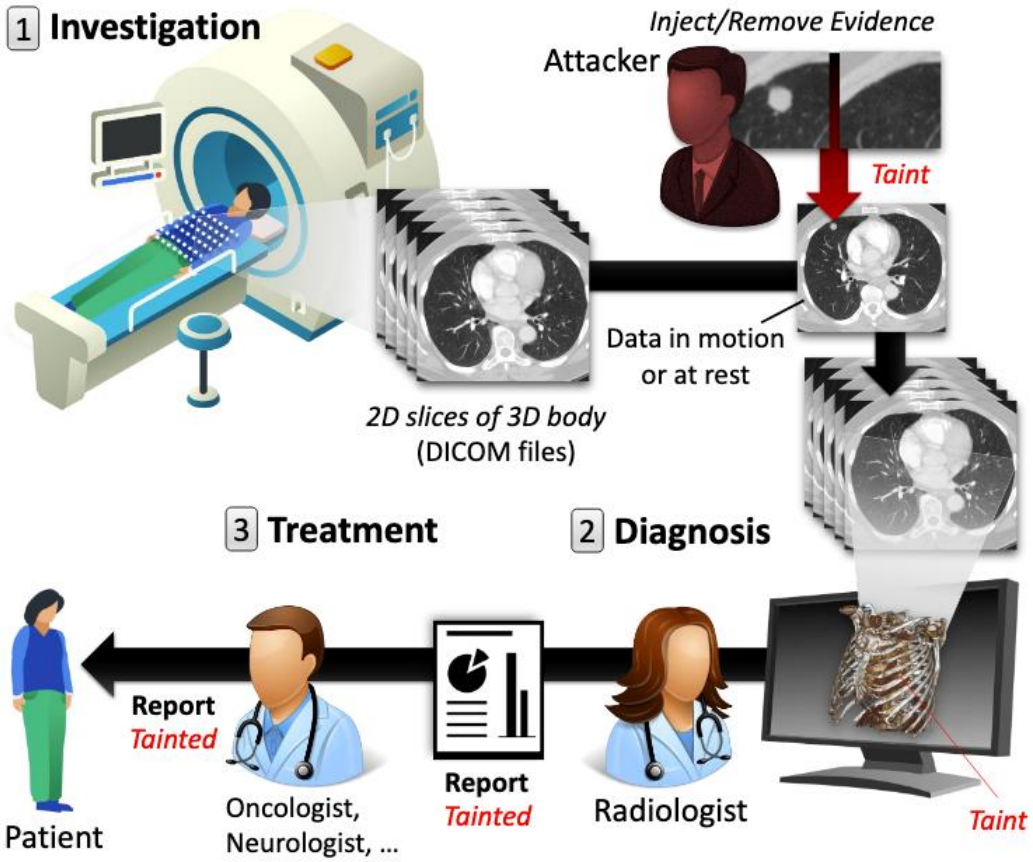
CT-GAN: Malicious Tampering of 3D Medical Imagery using Deep Learning

Yisroel Mirsky[1], Tom Mahler[1], Ilan Shelef[2], and Yuval Elovici[1]
[1]Department of Information Systems Engineering, Ben-Gurion University, Israel
[2]Soroka University Medical Center, Beer-Sheva, Israel
yisroel@post.bgu.ac.il, mahlert@post.bgu.ac.il, shelef@bgu.ac.il, and elovici@bgu.ac.il

arXiv:1901.03597v2 [cs.CR] 3 Apr 2019



(Bild: YouTube / Ben Gurion University)



Cybersecurity im Krankenhaus: DIE Herausforderung der Zukunft?

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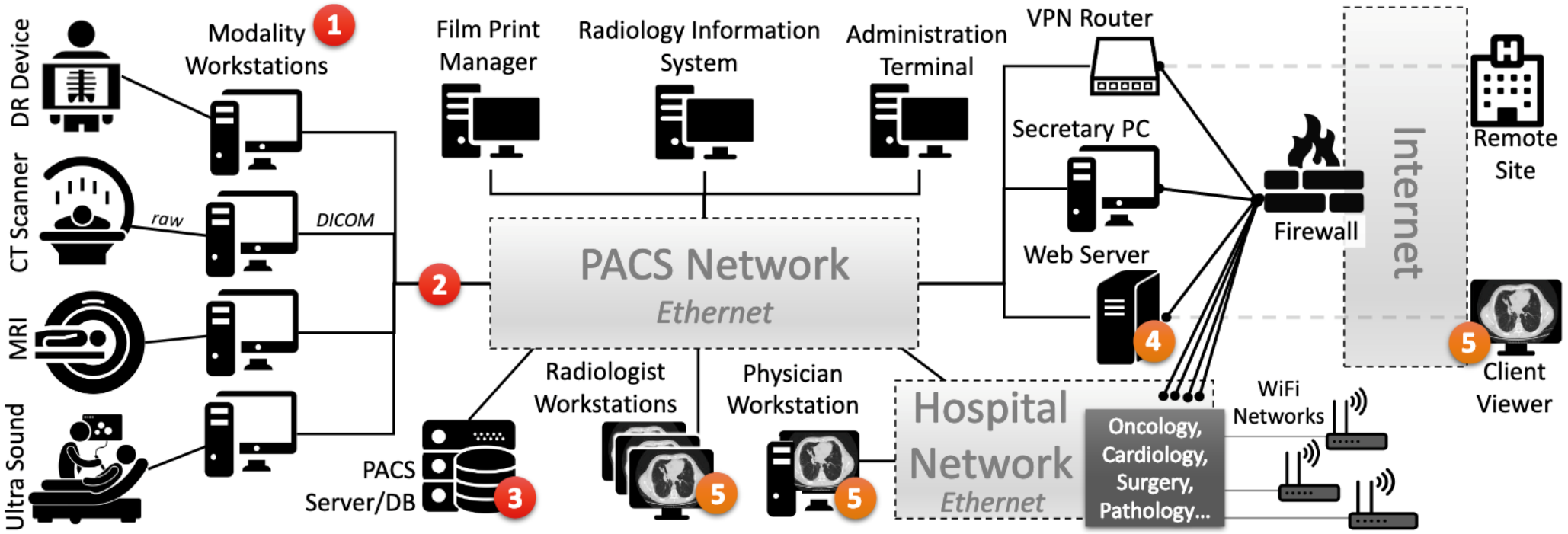

Figure 3: A network overview a PACS in a hospital. 1-3: points where an attacker can tamper with all scans. 4-5: points where an attacker can tamper with a subset of scans.

arXiv:1901.03597v2 [cs.CR] 3 Apr 2019

Rassistische KI?!

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MEDIZINSOFTWARE

Forscher finden "rassistische Vorurteile" in Algorithmus

Ein in den USA gebräuchlicher Algorithmus stuft Patientenbedürfnisse nach den Arztrechnungen ein. Aufgrund der sozialen Verhältnisse im Land führt das zu einer Bevorzugung weißer Patienten bei der Behandlung. Eine Änderung des Algorithmus ist möglich, die Forscher halten sie ohne gesetzlichen Zwang aber nicht für wahrscheinlich

25. Oktober 2019, 15:21 Uhr, Oliver Nickel

(Bild: Pixabay.com/Montage: Golem.de/CC0 1.0)

Algorithmen werden schnell tendenziös.

RESEARCH ARTICLE

Dissecting racial bias in an algorithm used to manage the health of populations

Ziad Obermeyer[1,2,*], Brian Powers[3], Christine Vogeli[4], Sendhil Mullainathan[5,*,†]

+ See all authors and affiliations

Science 25 Oct 2019:
Vol. 366, Issue 6464, pp. 447-453
DOI: 10.1126/science.aax2342

Science

Vol 366, Issue 6464
25 October 2019

Ethische Aspekte: enorme Bedeutung für KI in der Medizin

Uniklinikum Würzburg

ORIGINAL RESEARCH • SPECIAL REPORT

Radiology

Ethics of Artificial Intelligence in Radiology: Summary of the Joint European and North American Multisociety Statement

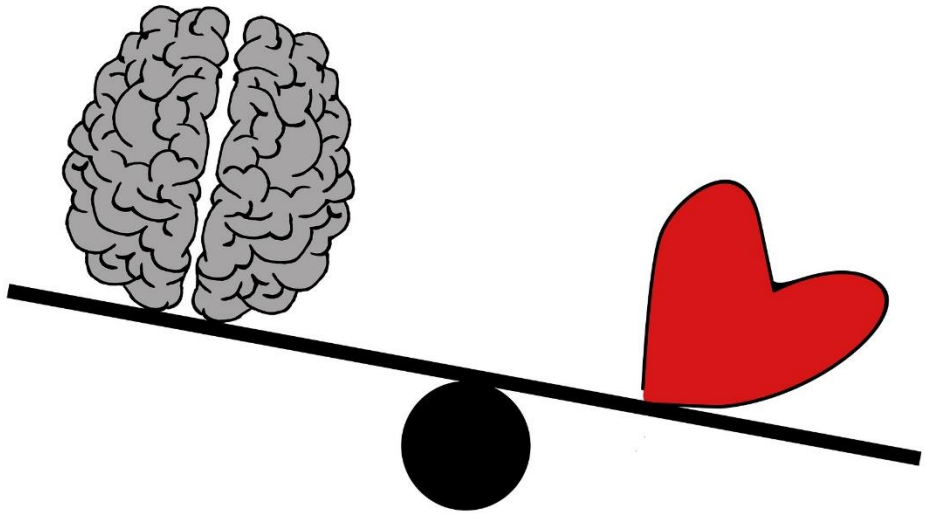
J. Raymond Geis, MD • Adrian P. Brady, MB, FFRRCSI • Carol C. Wu, MD • Jack Spencer, PhD • Erik Ranschaert, MD, PhD • Jacob L. Jaremko, MD, PhD • Steve G. Langer, PhD • Andrea Borondy Kitts, MS, MPH • Judy Birch, BEd • William F. Shields, JD, LLM • Robert van den Hoven van Genderen, PhD, MSc, LLM • Elmar Kotter, MSc, MD, MBA • Judy Wawira Gichoya, MBChB, MS • Tessa S. Cook, MD, PhD • Matthew B. Morgan, MD, MS • An Tang, MD, MSc • Nabile M. Safdar, MD, MPH • Marc Kohli, MD

From the American College of Radiology Data Science Institute, Reston, Va (J.R.G.); Department of Radiology, National Jewish Health, 3401 Shore Rd, Fort Collins, CO 80524 (J.R.G.); Mercy University Hospital, Cork, Ireland (A.B.); University of Texas MD Anderson Cancer Center, Houston, Tex (C.C.W.); MIT, Department of Linguistics and Philosophy, Cambridge, Mass (J.S.); Netherlands Cancer Institute, Amsterdam, the Netherlands (E.R.); Department of Radiology and Diagnostic Imaging, University of Alberta, Edmonton, Alberta, Canada (J.L.J.); Radiology Department-Mayo Clinic, Rochester, Minn (S.G.L.); Lahey Hospital & Medical Center, Burlington, Mass (A.B.K.); Pelvic Pain Support Network, Poole, UK (J.B.); General Counsel, American College of Radiology, Reston, Va (W.F.S.); Center of Law and Internet, Vrije Universiteit Amsterdam, Amsterdam, the Netherlands (R.v.d.H.v.G.); Department of Radiology, University Medical Center, Freiburg, Germany (E.K.); Department of Interventional Radiology, Oregon Health & Science University, Portland, Ore (J.W.G.); Department of Radiology and Imaging Sciences, Emory University, Atlanta, Ga (J.W.G., N.MS.); Department of Radiology, University of Pennsylvania, Philadelphia, Pa (T.S.C.); Department of Radiology and Imaging Sciences, University of Utah, Salt Lake City, Utah (M.B.M.); Centre de Recherche du Centre Hospitalier de L'Université de Montréal, Quebec, Canada (A.T.); and Department of Radiology and Biomedical Imaging, UCSF, San Francisco, Calif (M.K.). Received July 16, 2019; final version accepted August 9. **Address correspondence to** J.R.G. (e-mail: *raym.geis@gmail.com*).

Conflicts of interest are listed at the end of this article.

Radiology 2019; 293:436–440 • https://doi.org/10.1148/radiol.2019191586 • Content codes: IN HP

Psychologische Aspekte (Angst)



Wichtige Voraussetzungen für die Zukunft von ML, KI & Co.

Uniklinikum Würzburg

- Forschung zu Standardisierung und Workflow-Optimierung
- Qualitätssicherung
- Ethische Standards
- Interdisziplinäre und interprofessionelle Konsensbildung
- Aus- / Weiterbildung
- Nutzerordnungen

„Artificial Intelligence“ vs. „Augmented Intelligence“?

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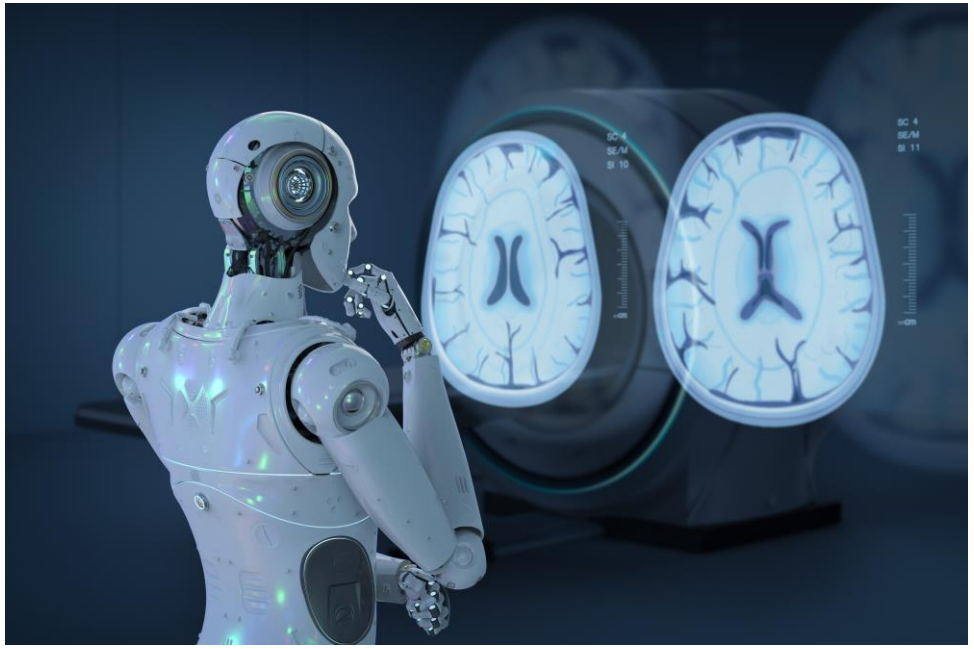

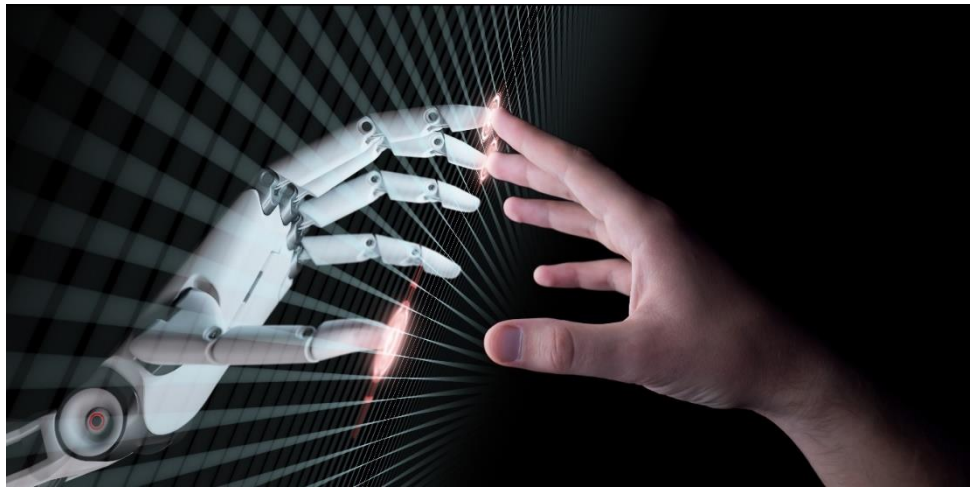

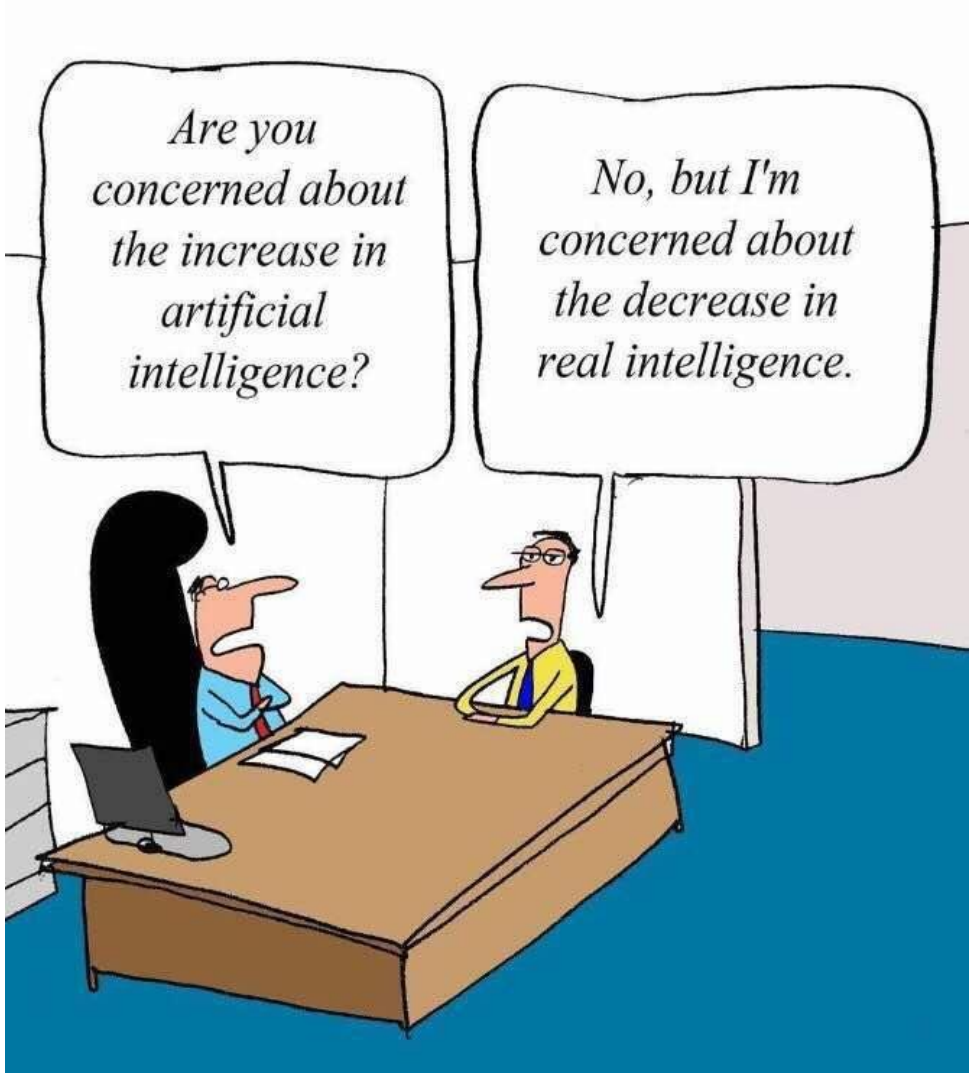

Will it replace radiologists? The answer is no, but I do think that radiologists who use AI will replace radiologists who don't.

—Curtis Langlotz, MD, PhD

DIRECTOR, AIMI LAB, STANFORD

Vielen Dank!

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