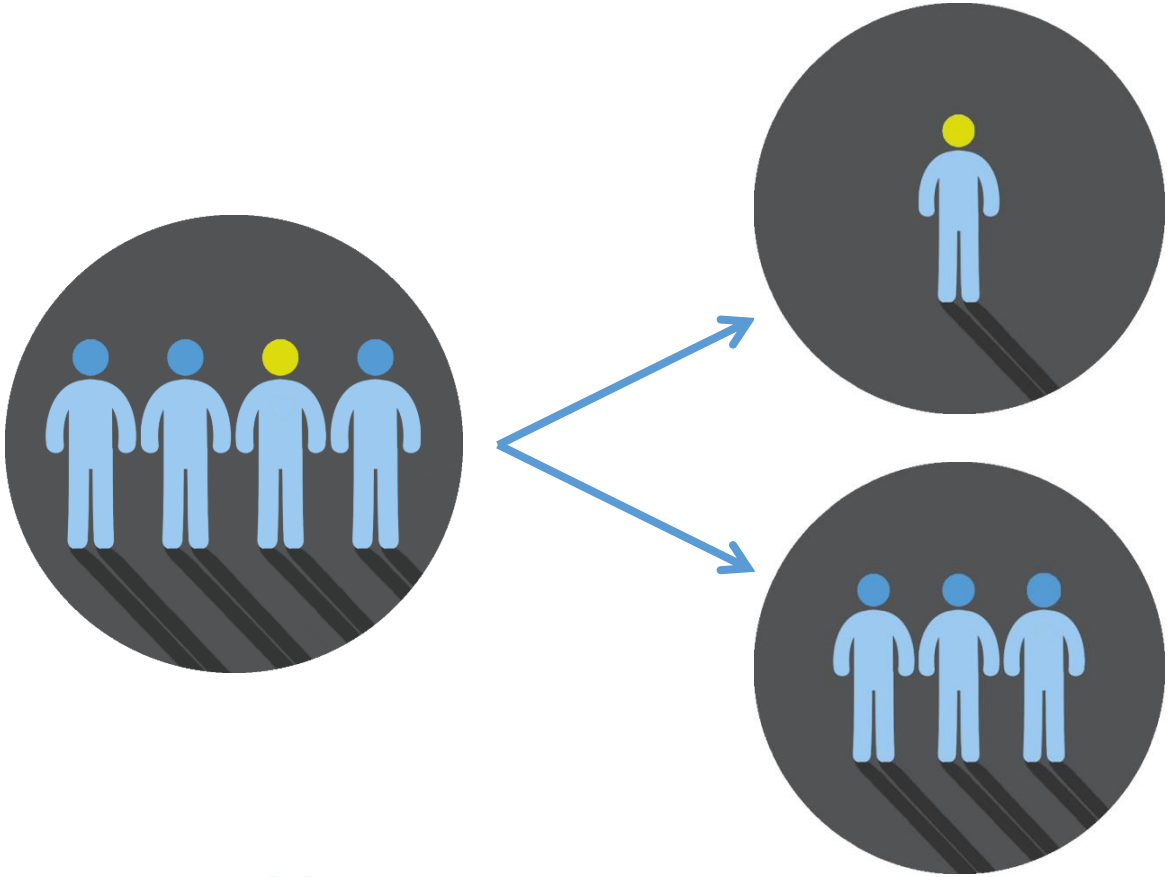
Come l’intelligenza artificiale cambiera’ il nostro lavoro

Prof. Isabella Castiglioni, MSc, MBA

Università degli Studi di Milano-Bicocca

DeepTrace Technologies, spinoff IUSS-Pavia

The challenge: Personalized medicine

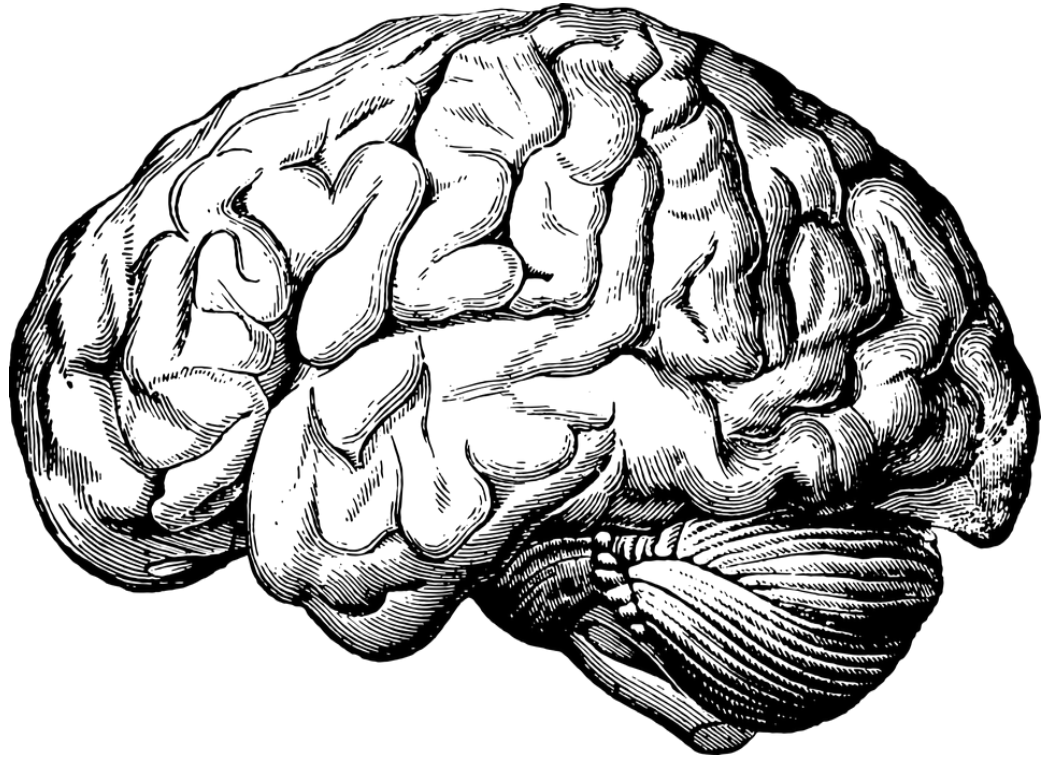


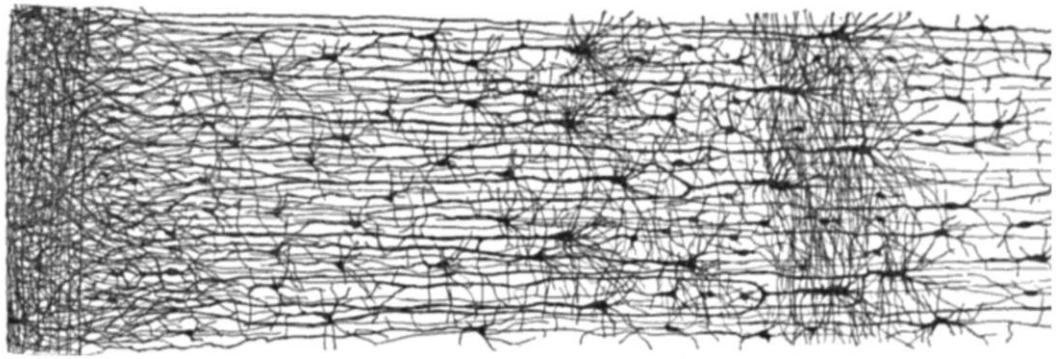
Some will progress or Not, some will respond or not respond to therapy

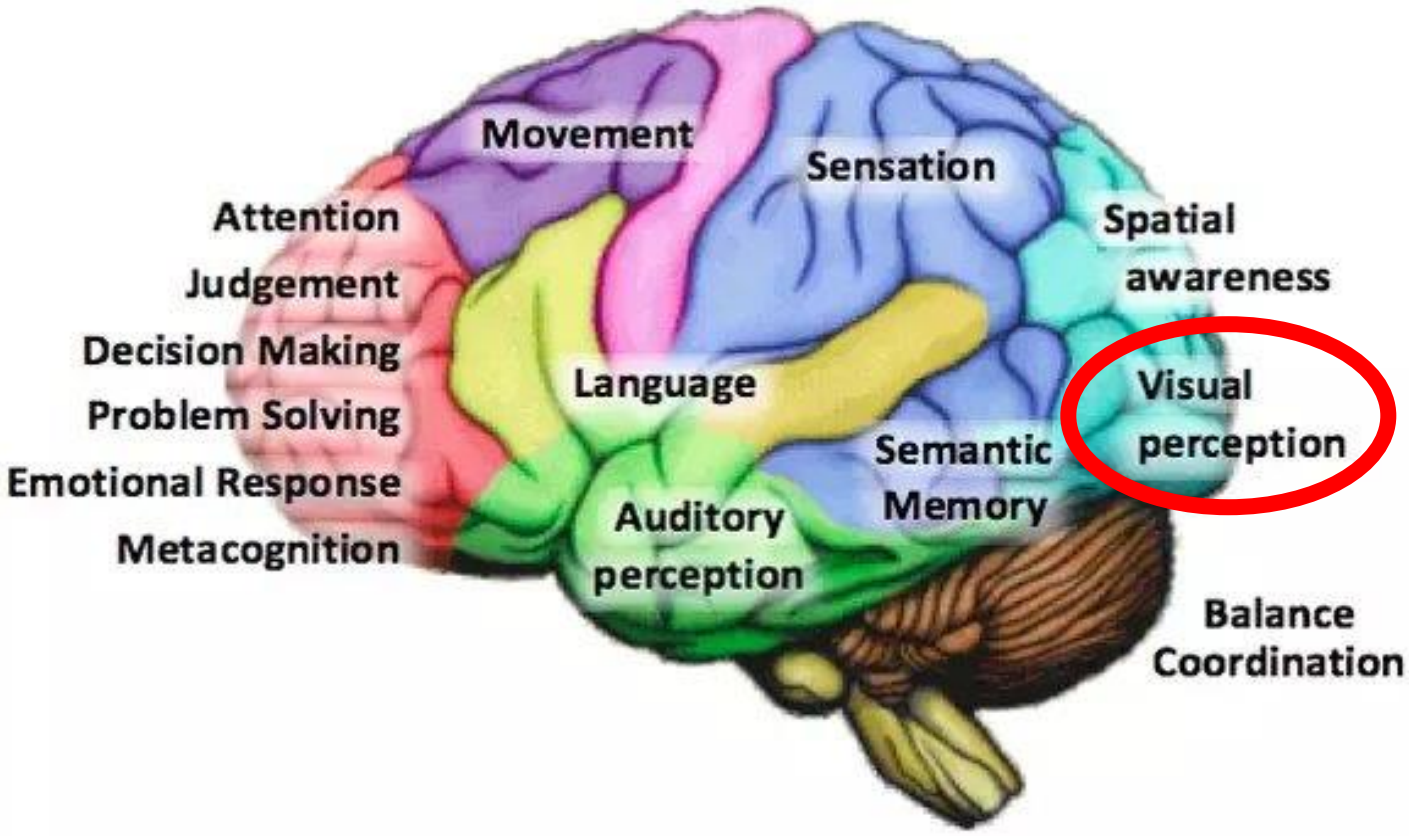
Some subjects among population are at risks of developing diseases

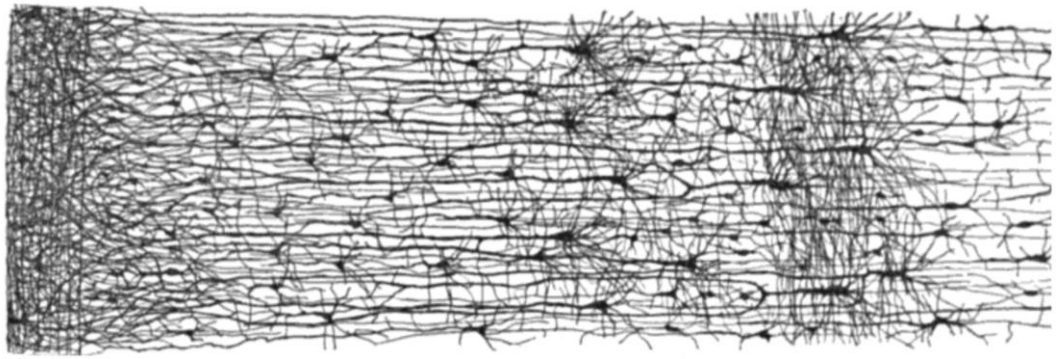
They need a personalized approach

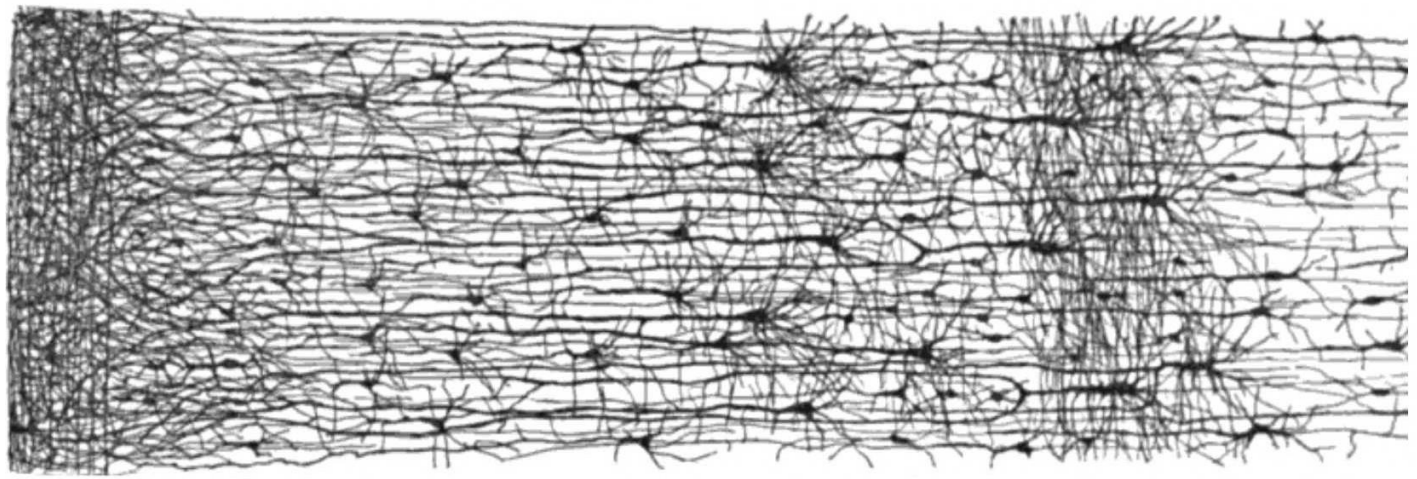
Deep Trace TECHNOLOGIES

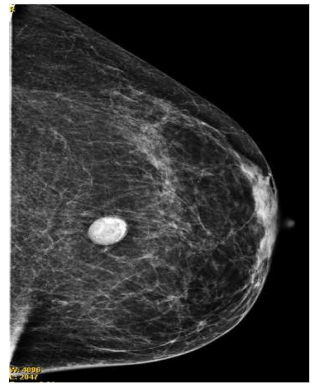





Movement
Sensation
Attention
Judgement
Decision Making
Problem Solving
Emotional Response
Metacognition
Spatial
awareness
Language
Visual
perception
Semantic
Memory
Auditory
perception
Balance
Coordination

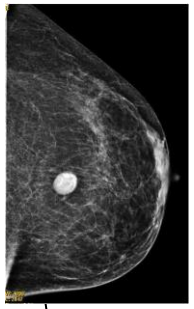


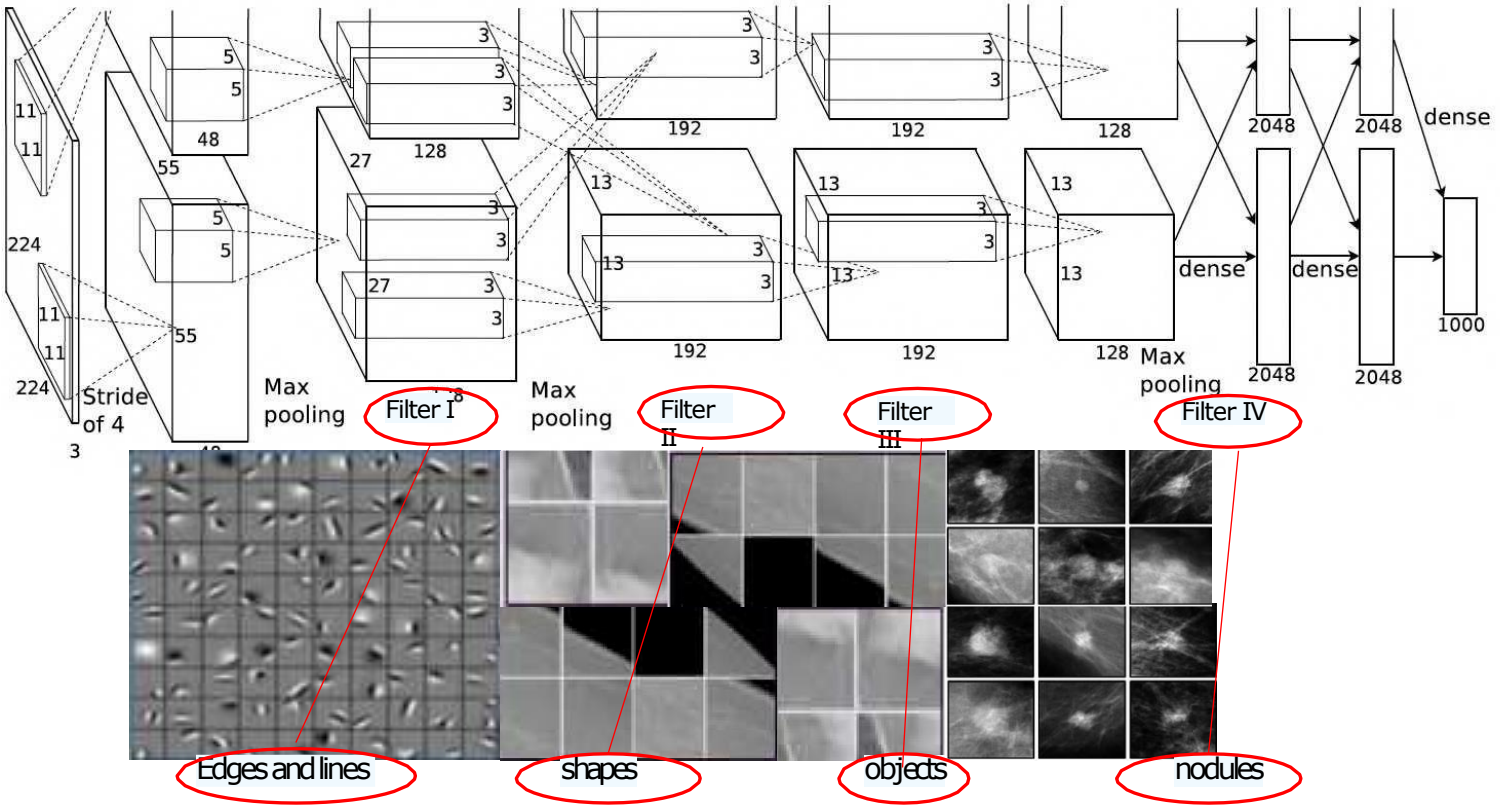


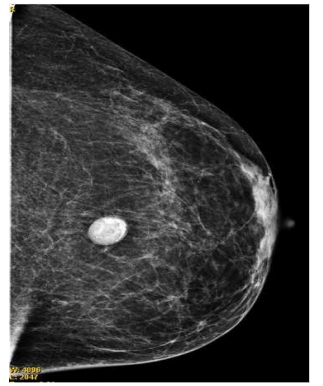


Human vision and association by time experience

AI







Artificial vision and association by accelerated experience from time series

TASKS associated to the human (intelligent) vision

- Segmentation
- Detection
- Classification
- Quantification

Radiomics: a new approach for the study of cancer

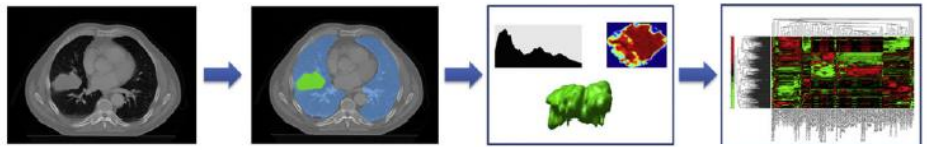
Published in final edited form as:
Eur J Cancer. 2012 March ; 48(4): 441–446. doi:10.1016/j.ejca.2011.11.036.

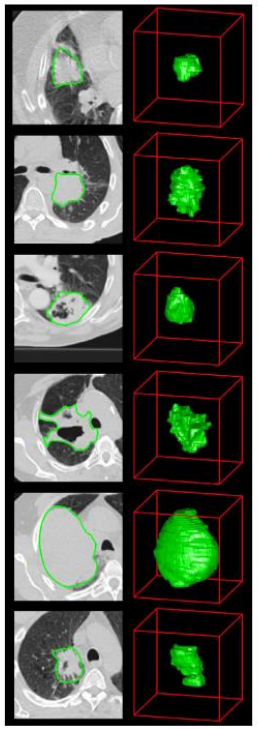
Radiomics: Extracting more information from medical images using advanced feature analysis

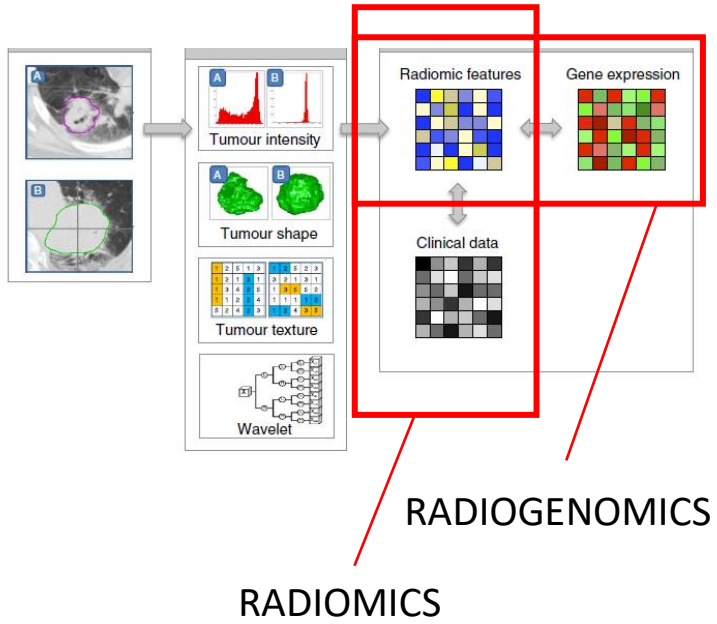
Philippe Lambin[a,*,e,f], **Emmanuel Rios-Velazquez**[a,e], **Ralph Leijenaar**[a,e], **Sara Carvalho**[a,e], **Ruud G.P.M. van Stiphout**[a,e], **Patrick Granton**[a,e], **Catharina M.L. Zegers**[a,e], **Robert Gillies**[b,e], **Ronald Boellard**[c,e], **André Dekker**[a,e], and **Hugo J.W.L. Aerts**[a,d,e]

[a]Department of Radiation Oncology (MAASTRO), GROW – School for Oncology and Developmental Biology, Maastricht University Medical Center, Maastricht, The Netherlands [b]H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA [c]U University Medical Center, Department of Nuclear Medicine & PET Research, Amsterdam, The Netherlands [d]Computational Biology and Functional Genomics Laboratory, Department of Biostatistics and Computational Biology, Dana-Farber Cancer Institute, Harvard School of Public Health, USA

Comprehensive quantification of disease phenotypes by applying a large number of quantitative image features representing lesion heterogeneity and correlating with omics and clinical data







Predictive personalized medicine by radiomics

www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

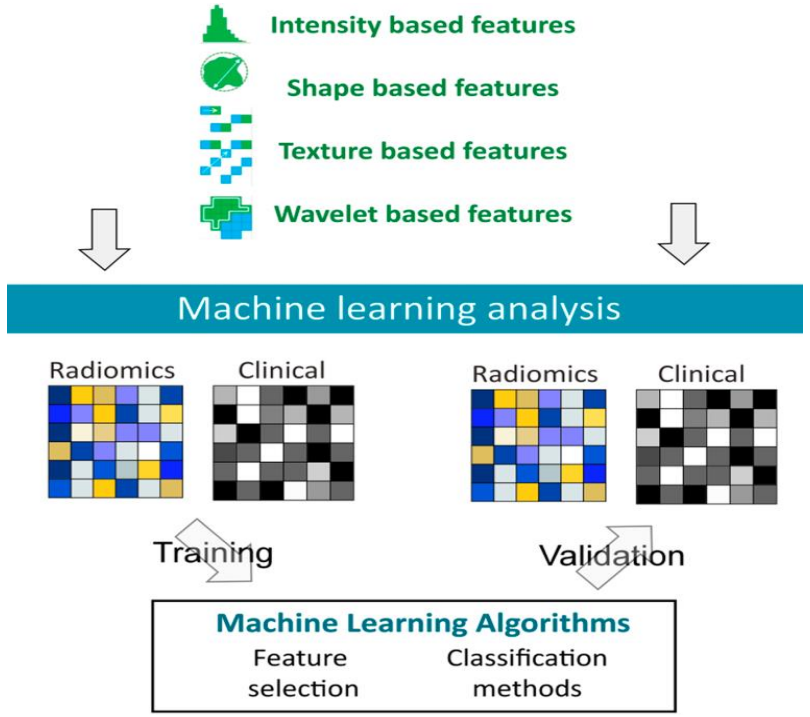
Machine Learning methods for Quantitative Radiomic Biomarkers

Chintan Parmar[1,3,4,*], Patrick Grossmann[1,5,*], Johan Bussink[6], Philippe Lambin[3] & Hugo J. W. L. Aerts[1,2,5]

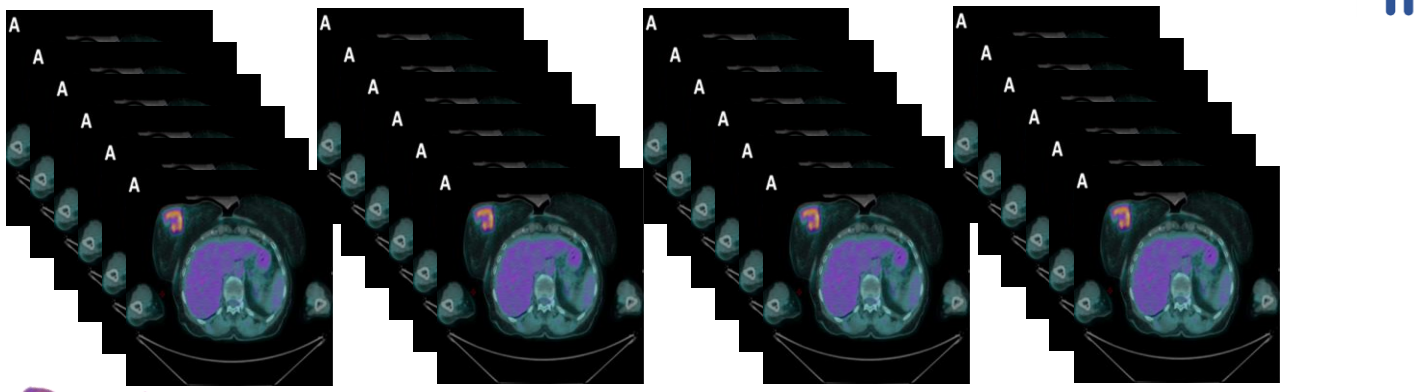
Received: 02 April 2015
Published: 17 August 2015

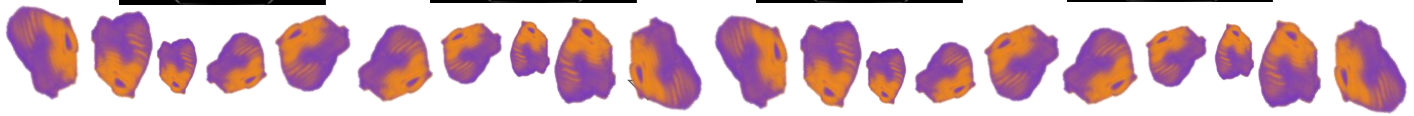
Radiomics extracts and mines large number of medical imaging features quantifying tumor phenotypic characteristics. Highly accurate and reliable machine-learning approaches can drive the

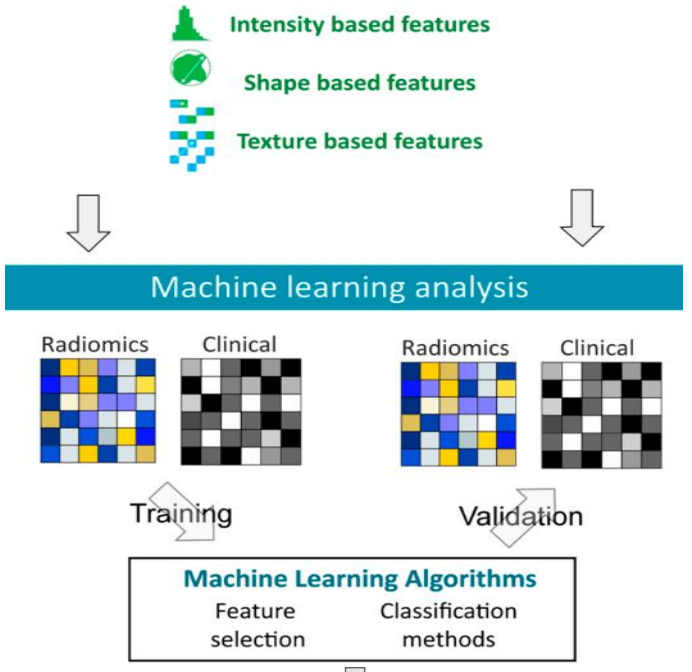
To predict clinical outcome by applying artificial intelligence models to radiomics features



BIG DATA Imaging & Artificial Intelligence







Predictive models based on Radiomics

PREDICTIVE PERSONALIZED MEDICINE

Personalization of the screening, diagnosis and therapy based on the predicted subject risk

Review

Contributions of Artificial Intelligence Reported in Obstetrics and Gynecology Journals: Systematic Review

Ferdinand Dhombres[1,2], MD, PhD; Jules Bonnard[3], MSc; Kévin Bailly[3], PhD; Paul Maurice[1], MD, MSc; Aris T Papageorghiou[4], MD, PhD; Jean-Marie Jouannic[1,2], MD, PhD

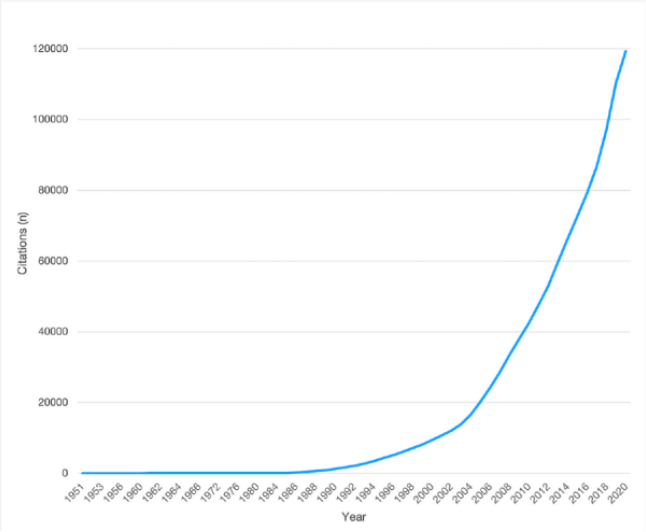
[1]Fetal Medicine Department, Armand Trousseau University Hospital, Sorbonne University, Paris, France

[2]Laboratory in Medical Informatics and Knowledge Engineering in e-Health, Institut National de la Santé et de la Recherche Médicale, Sorbonne University, Paris, France

[3]Institute for Intelligent Systems and Robotics, Sorbonne University, Paris, France

[4]Oxford Maternal & Perinatal Health Institute, Green Templeton College, Oxford, United Kingdom

Figure 1. Trend of the 119,325 citations in PubMed indexed with the MeSH (Medical Subject Heading) term "artificial intelligence" between 1951 and 2020.



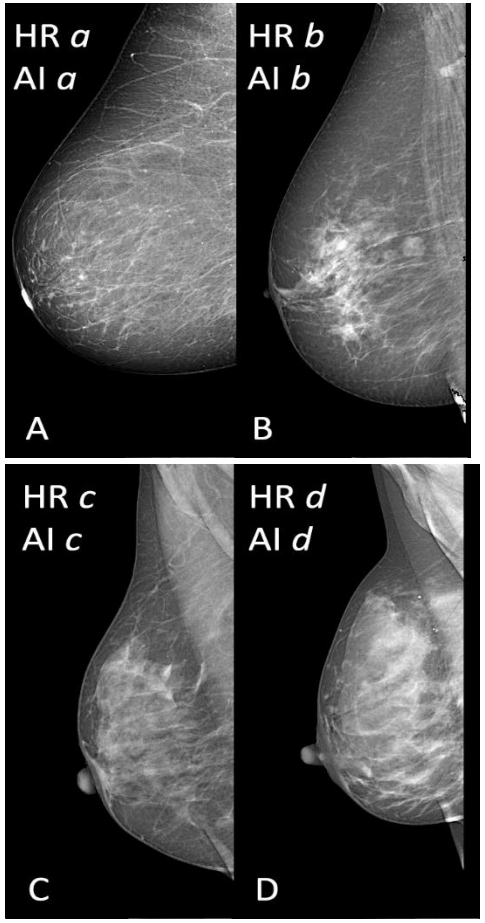
PREDICTS BREAST CANCER INDIVIDUAL RISK

Radiology: Artificial Intelligence

AI IN BRIEF

Development and Validation of an AI-driven Mammographic Breast Density Classification Tool Based on Radiologist Consensus

Veronica Magni, MD • Matteo Interlenghi, MSc* • Andrea Cozzi, MD • Marco Alì, MSc, PhD • Christian Salvatore, MSc, PhD • Alcide A. Azzena, MD • Davide Capra, MD • Serena Carriero, MD • Gianmarco Della Pepa, MD • Deborah Fazzini, MD • Giuseppe Granata, MD • Caterina B. Monti, MD, PhD • Giulia Muscogiuri, MD • Giuseppe Pellegrino, MD • Simone Schiaffino, MD • Isabella Castiglioni, MSc, MBA • Sergio Papa, MD • Francesco Sardanelli, MD*



AI → low risk

AI → high risk

SUPPLEMENTAL EXAMINATION

PREDICTS BREAST CANCER CALCIFICATION RISK

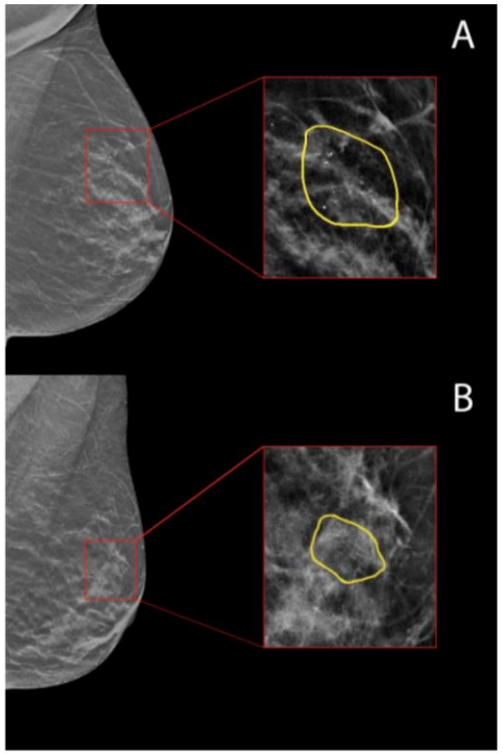
applied sciences

MDPI

Article

A Decision Support System Based on BI-RADS and Radiomic Classifiers to Reduce False Positive Breast Calcifications at Digital Breast Tomosynthesis: A Preliminary Study

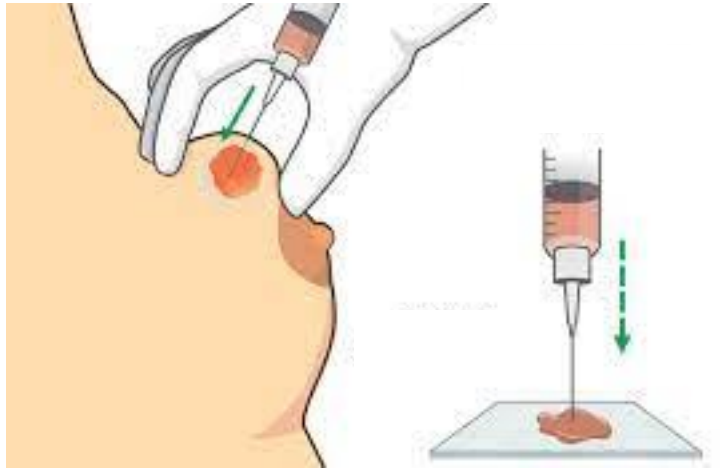
Marco Alì [1,†], Natascha Claudia D'Amico [1,2,†], Matteo Interlenghi [3,†], Marina Maniglio [1], Deborah Fazzini [1], Simone Schiaffino [4], Christian Salvatore [3,5,*], Isabella Castiglioni [6,7] and Sergio Papa [1]



AI → high risk

AI → low risk

SUPPLEMENTAL EXAMINATION



REDUCTION OF 30% of INEFFECTIVE BIOPSIES

REDUCTION OF 30% of RADIOLOGIST ERROR (from 50%)

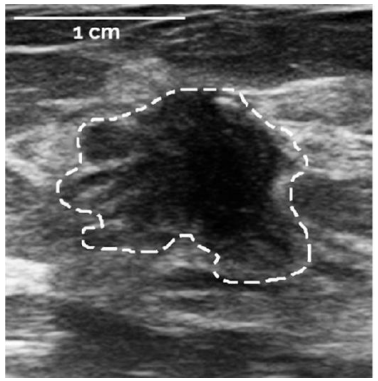
AI PREDICTS BREAST CANCER MASS RISK

diagnostics MDPI

Article

A Machine Learning Ensemble Based on Radiomics to Predict BI-RADS Category and Reduce the Biopsy Rate of Ultrasound-Detected Suspicious Breast Masses

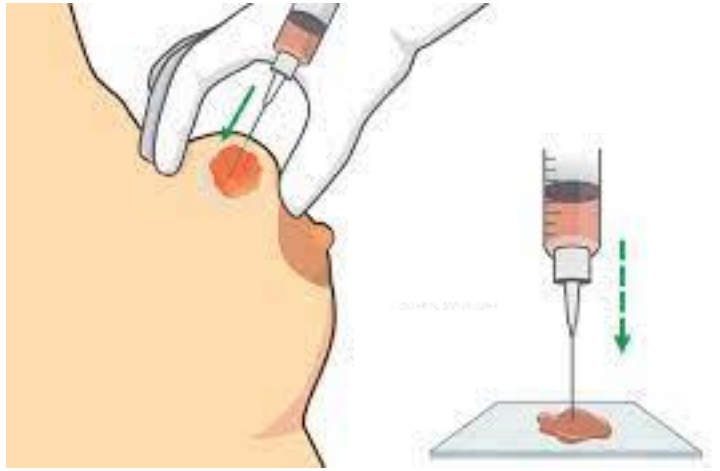
Matteo Interlenghi [1,†], Christian Salvatore [1,2,†], Veronica Magni [3], Gabriele Caldara [2], Elia Schiavon [1], Andrea Cozzi [3], Simone Schiaffino [4], Luca Alessandro Carbonaro [5,6], Isabella Castiglioni [7,8,*] and Francesco Sardanelli [3,4]



AI → high risk

AI → low risk

SUPPLEMENTAL EXAMINATION



REDUCTION OF 20% of INEFFECTIVE BIOPSIES

REDUCTION OF 20% of RADIOLOGIST ERROR (from 50%)

AI PREDICTS OVARIAN CANCER MASS RISK

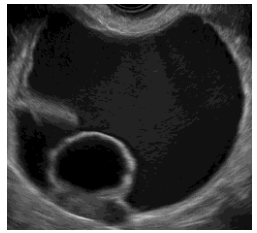
Chiappa *et al. European Radiology Experimental* (2021) 5:28
https://doi.org/10.1186/s41747-021-00226-0

European Radiology Experimental

ORIGINAL ARTICLE Open Access

A decision support system based on radiomics and machine learning to predict the risk of malignancy of ovarian masses from transvaginal ultrasonography and serum CA-125

Valentina Chiappa[1†], Matteo Interlenghi[2†], Giorgio Bogani[1], Christian Salvatore[2*], Francesca Bertolina[1], Giuseppe Sarpietro[1], Mauro Signorelli[1], Dominique Ronzulli[3], Isabella Castiglioni[4] and Francesco Raspagliesi[1]



AI → Very low risk

AI → high risk

SECOND-LEVEL MRI IMAGING OR SURGERY

REDUCTION OF 30% of INEFFECTIVE BIOPSIES

REDUCTION OF 30% of RADIOLOGIST ERROR (from 50%)

HIGH SENSITIVITY (99%)

PREDICTS NODAL STAGING OF ENDOMETRIAL CANCER RISK

Original research

INTERNATIONAL JOURNAL OF GYNECOLOGICAL CANCER

Combining positron emission tomography/computed tomography, radiomics, and sentinel lymph node mapping for nodal staging of endometrial cancer patients

Cinzia Crivellaro,[1] Claudio Landoni,[1,2] Federica Elisei,[1] Alessandro Buda,[3] Manuela Bonacina,[4] Tommaso Grassi,[3] Lavinia Monaco,[4] Daniela Giuliani,[3] Irene Gotuzzo,[4] Sonia Magni,[4] Giampaolo Di Martino,[3] Martina Delle Marchette,[4] Luca Guerra,[1,2] Fabio Landoni,[2,3] Robert Fruscio,[2,3] Cristina Messa,[4,5] Elisabetta De Bernardi[2]

Table 4 Ability of volume-density to discriminate metastatic tumors in Group B patients (n=28; 14 with metastatic nodes, 14 without metastatic nodes)

Result	PET visual detection (n)	PET radiomics
TP	0	6
TN	14	13
FP	0	1
FN	14	8

FN, false-negative; FP, false-positive; PET, positron emission tomography; TN, true-negative; TP, true-positive.

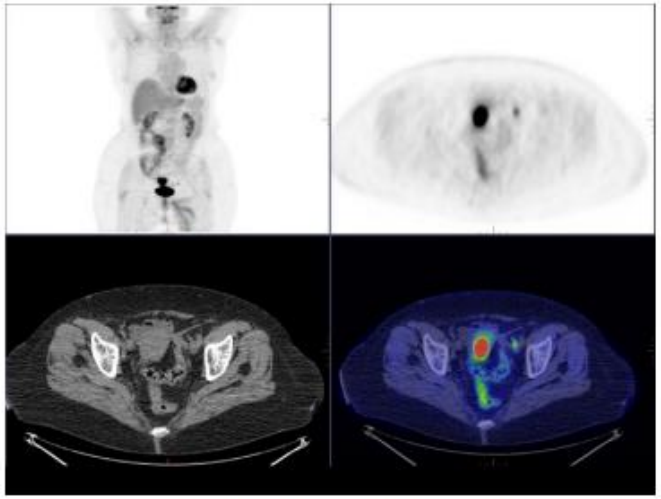


Figure 1 True-positive PET/CT finding. Pathologic ^{18}F-labeled fluoro-2-deoxyglucose (18-FDG) uptake in a small left external iliac lymph node, confirmed at histology.

AI → Very low risk

AI → high risk → DIFFERENT TREATMENT

REDUCTION OF 50% of FALSE NEGATIVES

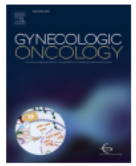
PREDICTS SARCOMA vs MIOMA MASS RISK

Gynecologic Oncology 161 (2021) 838–844

Contents lists available at ScienceDirect

Gynecologic Oncology

journal homepage: www.elsevier.com/locate/ygyno



Using rADioMIcs and machine learning with ultrasonography for the differential diagnosis of myometRiAL tumors (the ADMIRAL pilot study). Radiomics and differential diagnosis of myometrial tumors

V. Chiappa [a,*], M. Interlenghi [b], C. Salvatore [b], F. Bertolina [a], G. Bogani [a], A. Ditto [a], F. Martinelli [a], I. Castiglioni [c,1], F. Raspagliesi [a,1]

[a] Gynecologic Oncology, Fondazione IRCCS Istituto Nazionale Tumori di Milano, Italy
[b] DeepTrace Technologies S.R.L., Milan, Italy
[c] Dipartimento di Fisica G. Occhialini, University of Milan-Bicocca, Milan, Italy

Mioma risk

Sarcoma risk

SECOND-LEVEL MRI IMAGING OR SURGERY

In the uncertain cases (30%), the AI provided correct malignant answer in 83% respectively, and benign answer in 78% of cases

PREDICTS CERVICAL CANCER TISSUE RISK

Computer Methods and Programs in Biomedicine 164 (2018) 15–22

Contents lists available at ScienceDirect

Computer Methods and Programs in Biomedicine

journal homepage: www.elsevier.com/locate/cmpb

A review of image analysis and machine learning techniques for automated cervical cancer screening from pap-smear images

Wasswa William[a,*], Andrew Ware[b], Annabella Habinka Basaza-Ejiri[c], Johnes Obungoloch[a]

[a] Department of Biomedical Sciences and Engineering, Mbarara University of Science and Technology, Uganda
[b] Faculty of Computing, Engineering and Science, University of South Wales, UK
[c] College of Computing and Engineering, St. Augustine International University, Uganda

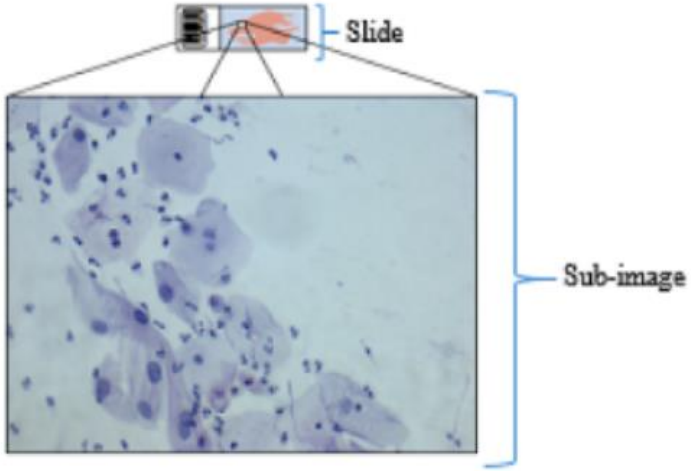
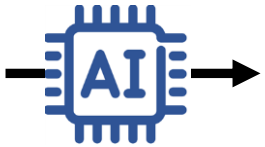


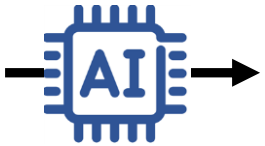
Fig. 1. A typical pap-smear image (slide) and a high-resolution field of view (sub-image). Approximately 10,000 sub-images are needed to cover the whole slide.

Table 1
Some of the cell features used for cervical cancer classification [19].

Feature	Cervical cancer class			
	Normal	Degree of dysplasia		
		Mid	Moderate	Severe
Nucleus area(μm^2)	20–50	50+	50+	50+
Nucleus intensity	dark	light	dark	Dark
Cytoplasm intensity	light	light	dark	Dark
Nucleus/Cytoplasm - ratio	1–2%	10–20%	20–50%	50% +



Low risk

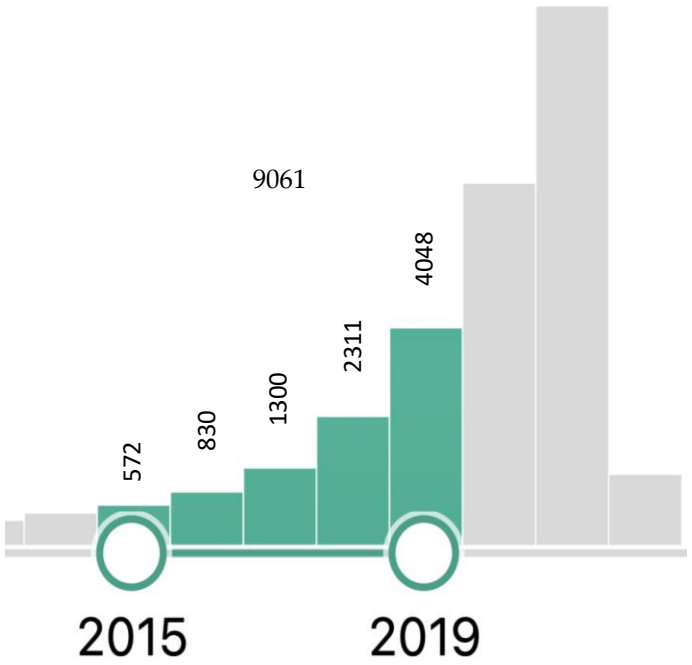


Moderate/severe risk

SUPPLEMENTAL EXAMINATION

THE CHALLENGE of AI in MEDICINE…

Publication of artificial intelligence and machine learning-based research papers applied to medicine (2015-20)



Approval of artificial intelligence and machine learning-based medical devices in the USA and Europe (2015–20): a comparative analysis

Urs J Muehlematter, Paola Daniore, Kerstin N Vokinger

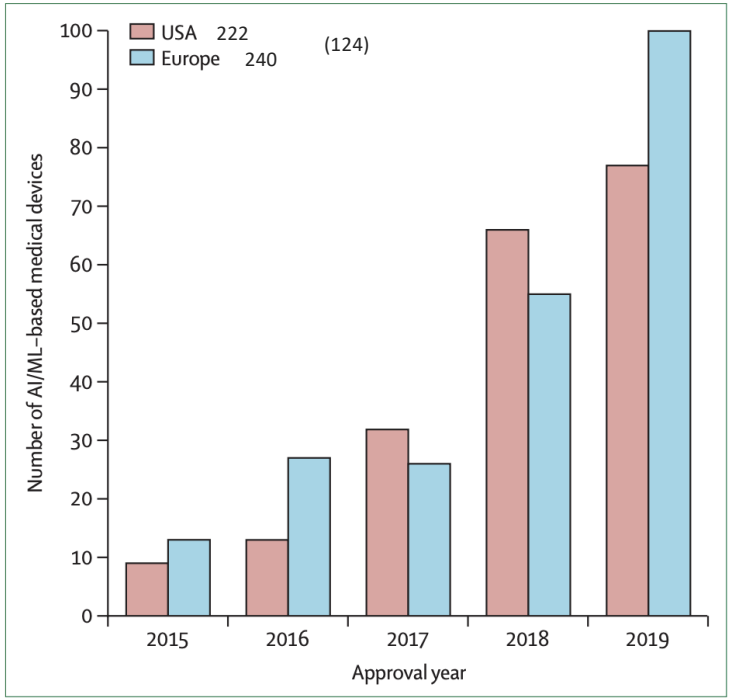


Figure 2: **Number of approved (USA) and CE-marked (Europe) AI/ML-based medical devices between 2015 and 2019**
The CE-mark year is considered the approval year for devices in Europe. AI/ML=artificial intelligence and machine learning. CE=*Conformité Européenne*.

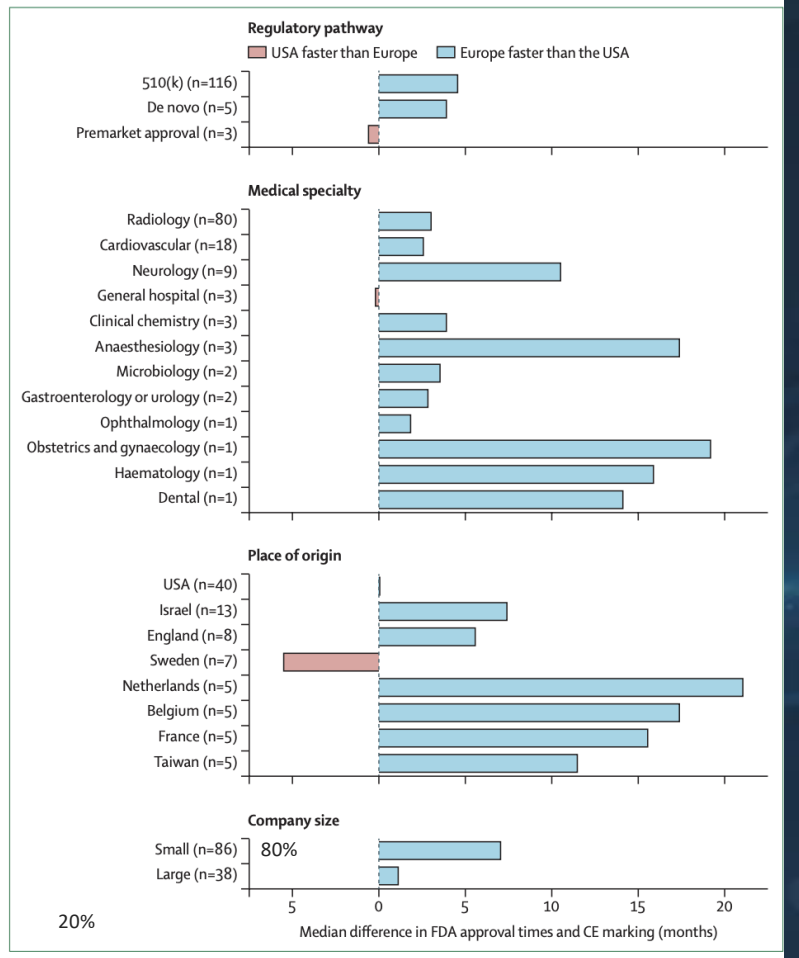


Figure 4: **Median time between AI/ML-based medical devices that have been CE marked in Europe and also approved by the FDA in the USA**
AI/ML=artificial intelligence and machine learning. CE=*Conformité Européenne*. FDA=US Food and Drug Administration.

MEDICAL DEVICE

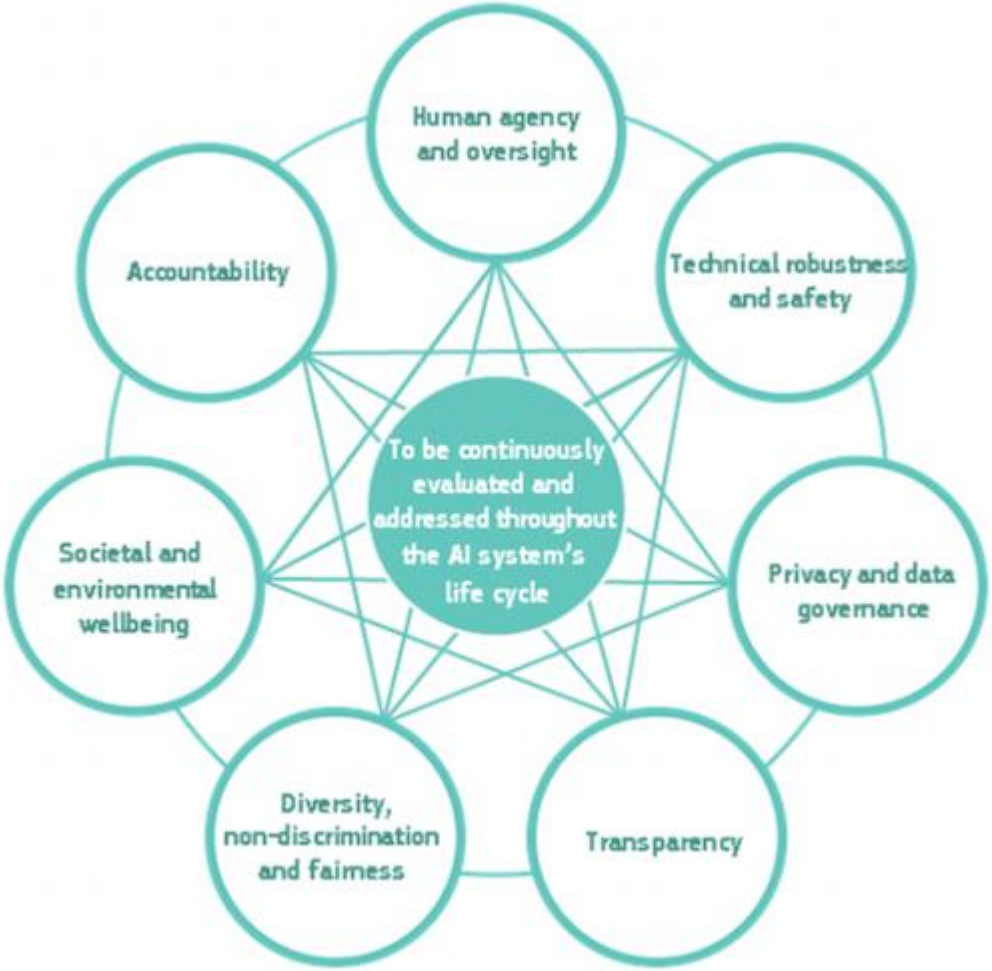
- QUALITY MANGEMENT
- RISK MANAGEMENT
- SAFETY
- PERFORMANCE
- USABILITY

DIFFERENCES FOR AI

- DATA QUALITY
- DATA REPRESENTATIVENESS
- ROBUSTNESS
- EXPECTANCY
- EXPLAINABILITY
- TRANSPARENCY
- PREDICTABILIYT

Safety, privacy, security and trust

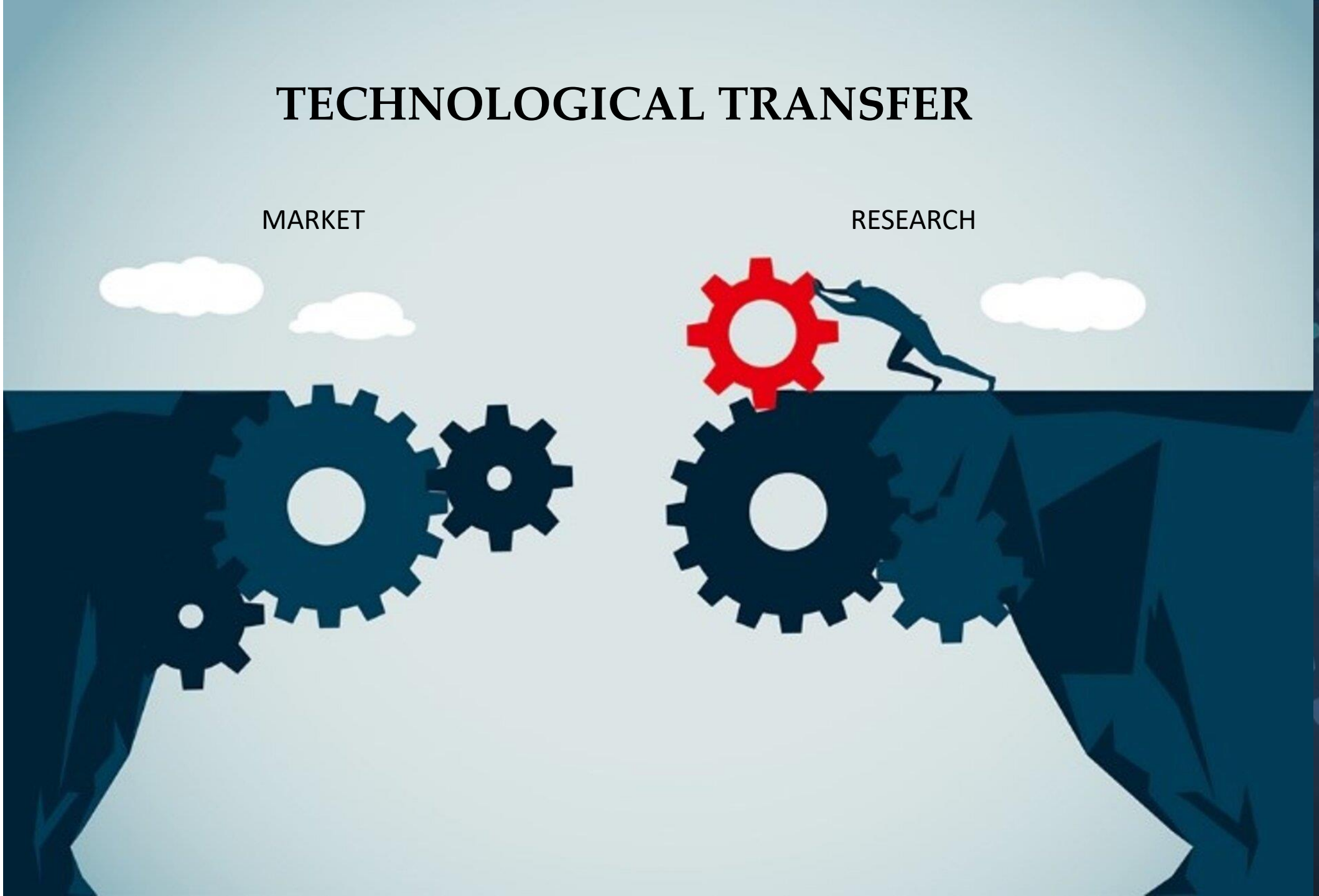
according to ethical, legal and societal issues related to AI supporting the implementation of the European Strategy on Artificial Intelligence (published by EC High-Level Expert Group on Artificial Intelligence)



in full respect of the General Data Protection Regulation (GDPR), as well as security standards

Deep Trace TECHNOLOGIES

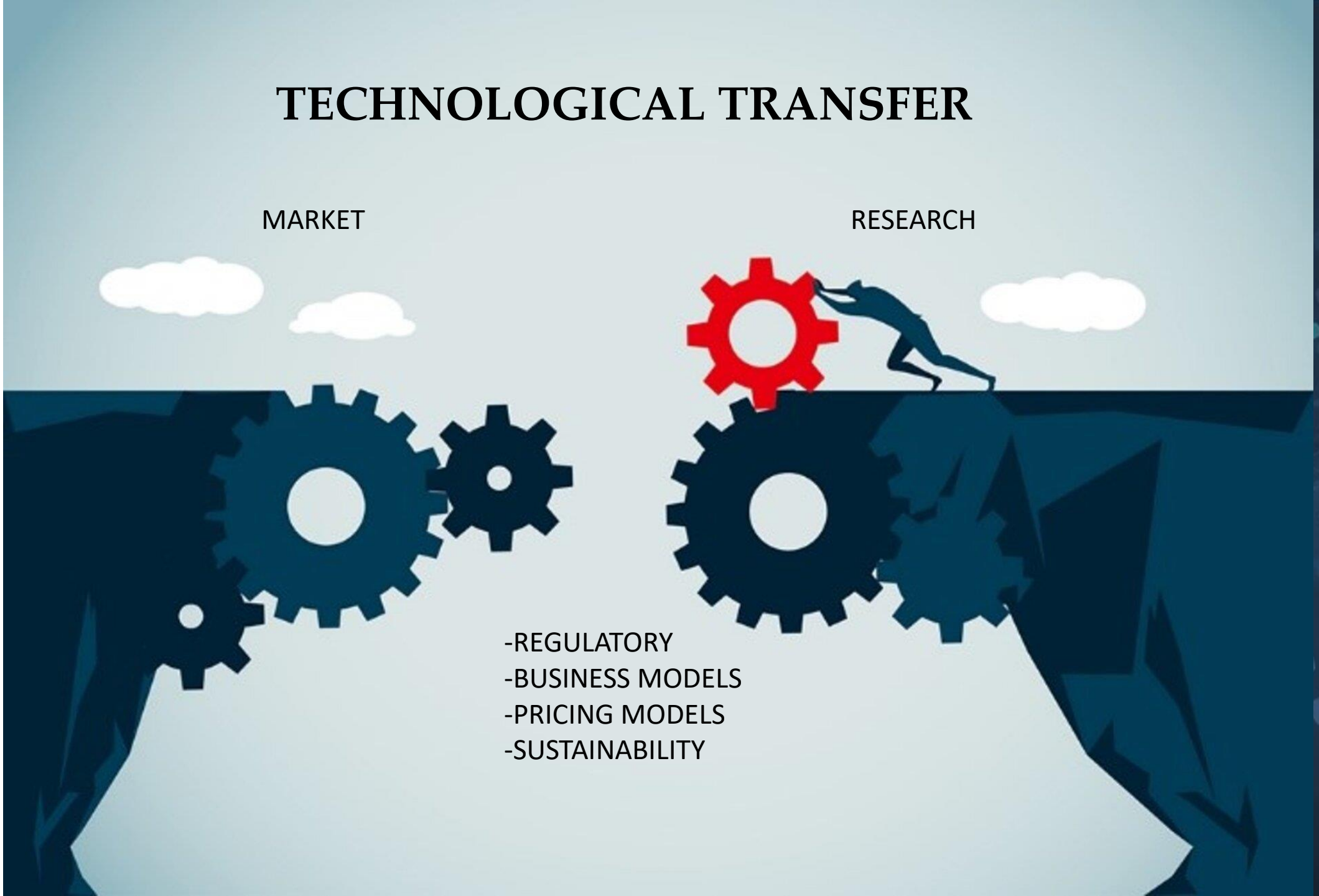
TECHNOLOGICAL TRANSFER



TECHNOLOGICAL TRANSFER

MARKET

RESEARCH



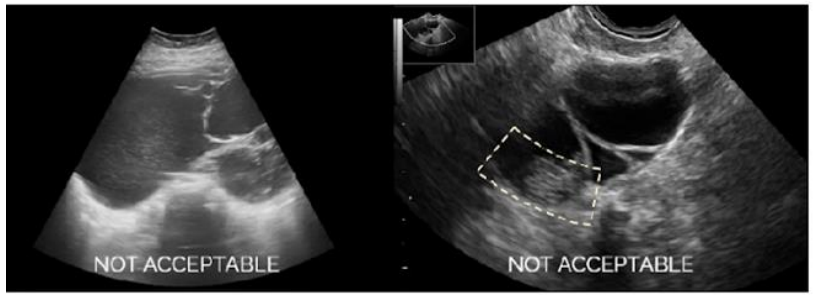
-REGULATORY
-BUSINESS MODELS
-PRICING MODELS
-SUSTAINABILITY

Trace4OC©

Ultrasound machine and Pelvis US imaging

ULTRASONOGRAPHER

TRASVAGINAL ULTRASOUND STUDY



Deep Trace TECHNOLOGIES

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How it works

INPUTS

PROCESS

OUTPUT

10 min

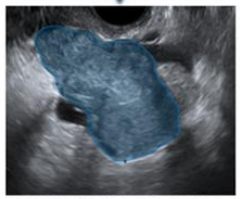
ULTRASOUND MACHINE

DICOM EXPORT

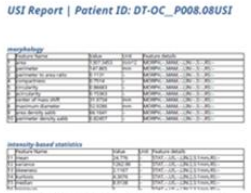
PELVIS ULTRASONOGRAPHY (US) IMAGING

COMBINED WITH

SERUM LEVEL TEST FOR CA-125 AND CURRENT WOMAN'S MENOPAUSAL STATE



SEGMENTED US IMAGE



RADIOMIC FEATURES

MACHINE LEARNING

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PREDICT THE RISK OF OVARIAN CANCER

CE

FULLY-AUTOMATIC REPORT

2 min

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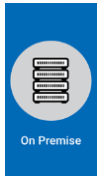
STAND-ALONE SW



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Machine Learning Model

subjects with some adnexial masses
)

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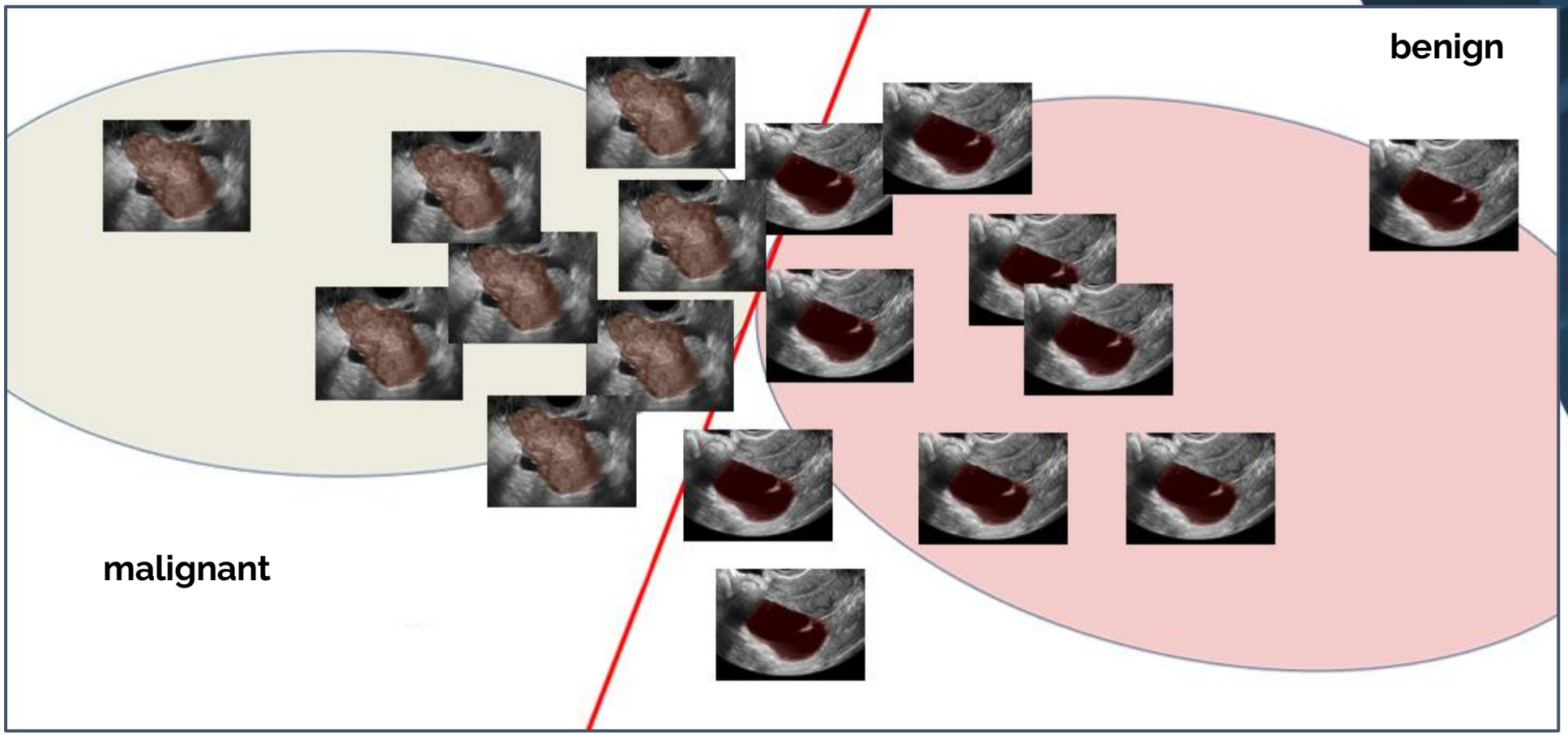
Machine Learning Trained Model



TRACE4OC decreases of about one third false positives with respect to HUMAN OPERATORS

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Report for gynecologist report (final)

File-creation date: 02-Sep-2021 13:13:14

TRACE4OC | Report DTT-OC_P001.01USI

The USI image has been classified as MEDIUM-HIGH risk of MALIGNANCY

File-creation date: 11-May-2022 17:04:53

TRACE4OC | Report DTT-OC_P004.04USI

The adnexal mass has been classified as VERY LOW risk of MALIGNANCY

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Scientific publications
PIVOTAL STUDIES

Journal of Ultrasound
https://doi.org/10.1007/s40477-020-00503-5

ORIGINAL PAPER

The Adoption of Radiomics and machine learning improves the diagnostic processes of women with Ovarian MAsses (the AROMA pilot study)

Valentina Chiappa[1] · Giorgio Bogani[1] · Matteo Interlenghi[2] · Christian Salvatore[3] · Francesca Bertolina[1] · Giuseppe Sarpietro[1] · Mauro Signorelli[1] · Isabella Castiglioni[4] · Francesco Raspagliesi[1]

Received: 8 May 2020 / Accepted: 24 June 2020

Chiappa *et al. European Radiology Experimental* (2021) 5:28
https://doi.org/10.1186/s41747-021-00226-0

European Radiology Experimental

ORIGINAL ARTICLE Open Access

A decision support system based on radiomics and machine learning to predict the risk of malignancy of ovarian masses from transvaginal ultrasonography and serum CA-125

Valentina Chiappa[1†], Matteo Interlenghi[2†], Giorgio Bogani[1], Christian Salvatore[2*], Francesca Bertolina[1], Giuseppe Sarpietro[1], Mauro Signorelli[1], Dominique Ronzulli[3], Isabella Castiglioni[4] and Francesco Raspagliesi[1]

SENSITIVITY 99%

SPECIFICITY 77%

ACCURACY 88%

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Benefits

STANDARDIZED CLINICAL EVALUATION

-STANDARDIZED IMAGE PROTOCOL AND ANALYSIS

-STANDARDIZED BLOOD TEST PROTOCOL AND ANALYSIS

-STANDARDIZED ANALYSIS AND REPORTS

EFFICIENT ANALYSIS

-10 MIN GYNECOLOGY EVALUATION

-10 MIN US STUDY

-10 MIN BLOOD TEST

-2 MIN ANALYSIS AND REPORTS

32 min

DIAGNOSIS OF OC, ADDRESSMENT TO OC TREATMENT

The model, classifying patients into two classes (very low risk and medium-high risk) overcomes the problem of the "uncertain" OM class: the current recommendations for the "uncertain" class problem are to assess the OMs by second-level imaging (*e.g.*, magnetic resonance imaging) or to address directly to surgery, with a high number of false positives. With our predictive model, the masses in the very low class can be managed conservatively, while the masses in the medium-high risk class can be assessed by second-level imaging (*e.g.*, magnetic resonance imaging) or surgery, with a reduction of about one third in false positives and false negatives. This dichotomy certainly represents an important decision support for less experienced examiners in OMs triage.

Come l'intelligenza artificiale cambiera' il vostro lavoro?

Personalization of the screening, diagnosis and therapy based also on an AI-based predicted subject risk

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