دانشگاه علوم پزشکی و خدمات بهداشتی، درمانی ایران

Application of Artificial Intelligence in Brain and Spine

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عنوان دوره آنلاین:

هوش مصنوعی در پزشکی با رویکرد بالینی

Online Course: Artificial Intelligence in Medicine with Clinical Approach

Course Topics	عناوین بیست و چهار جلسه	تاریخ جلسات
Artificial Intelligence (AI) in medicine	معرفی هوش مصنوعی در پزشکی	۲۸ بهمن ۱۴۰۲
AI and Fuzzy systems and its applications in medicine	هوش مصنوعی و سیستم های فازی در پزشکی	۵ اسفند ۱۴۰۲
Machine Learning and its applications in medicine	یادگیری ماشین و کاربردهای آن در پزشکی	۱۲اسفند۱۴۰۲
Evolutionary systems and its applications in medicine	الگوریتم های بهینه سازی تکاملی و کاربردهای آن در پزشکی	۱۹اسفند ۱۴۰۲
Neural networks and deep neural networks in medicine	شبکه های عصبی و شبکه های عصبی عمیق در پزشکی	۲۵فروردین ۱۴۰۳
Application of AI in Early Detection of Disease	کاربرد هوش مصنوعی در تشخیص زودهنگام بیماری ها	۱ اردیبهشت ۱۴۰۳
Swarm Intelligence and multi-agent/swarm in medicine	هوش ازدحامی، سیستم های چند عامله/ازدحامی در پزشکی	۸اردیبهشت ۱۴۰۳
Application of AI in Cancer	کاربردهای هوش مصنوعی در سرطان	۲۲اردیبهشت ۱۴۰۳
Application of AI in surgery	کاربردهای هوش مصنوعی در جراحی	۲۹ اردیبهشت ۱۴۰۳
Applications of AI in Neurology	کاربردهای هوش مصنوعی در مغز و اعصاب	۵ خرداد ۱۴۰۳
Application of AI in Internal Medicine	کاربردهای هوش مصنوعی در پزشکی داخلی	۱۲ خرداد ۱۴۰۳
Applications of AI in cardiovascular	کاربردهای هوش مصنوعی در قلب و عروق	۱۹ خرداد ۱۴۰۳
Applications of AI in Breast Disease	کاربردهای هوش مصنوعی در بیماری های پستان	۲۶ خرداد ۱۴۰۳
Application of AI in Ophthalmology	کاربردهای هوش مصنوعی در چشم پزشکی	۲ تیر ۱۴۰۳
Application of AI in Nephrology	کاربردهای هوش مصنوعی در نفرولوژی	۹ تیر ۱۴۰۳
Application of AI in Otorhinolaryngology	کاربردهای هوش مصنوعی در گوش و حلق و بینی	۱۶ تیر ۱۴۰۳
Application of AI in Gynecology and obstetrics	کاربردهای هوش مصنوعی در زنان و مامایی	۲۳ تیر ۱۴۰۳
Application of AI in pediatric medicine	کاربردهای هوش مصنوعی در پزشکی اطفال	۳۰ تیر ۱۴۰۳
Application of AI in anesthesia	کاربردهای هوش مصنوعی در بیهوشی	۶ مرداد ۱۴۰۳
Application of AI in emergency medicine	کاربردهای هوش مصنوعی در پزشکی اورژانس	۱۳ مرداد ۱۴۰۳
Applications of artificial intelligence in orthopedics	کاربردهای هوش مصنوعی در ارتوپدی	۲۰ مرداد ۱۴۰۳
Application of AI in pain management	کاربردهای هوش مصنوعی در مدیریت درد	۲۷ مرداد ۱۴۰۳
Application of AI in pharmacology	کاربردهای هوش مصنوعی در داروسازی	۳ شهریور ۱۴۰۳
Application of AI in dentistry	کاربردهای هوش مصنوعی در دندان پزشکی	۱۰ شهریور ۱۴۰۳

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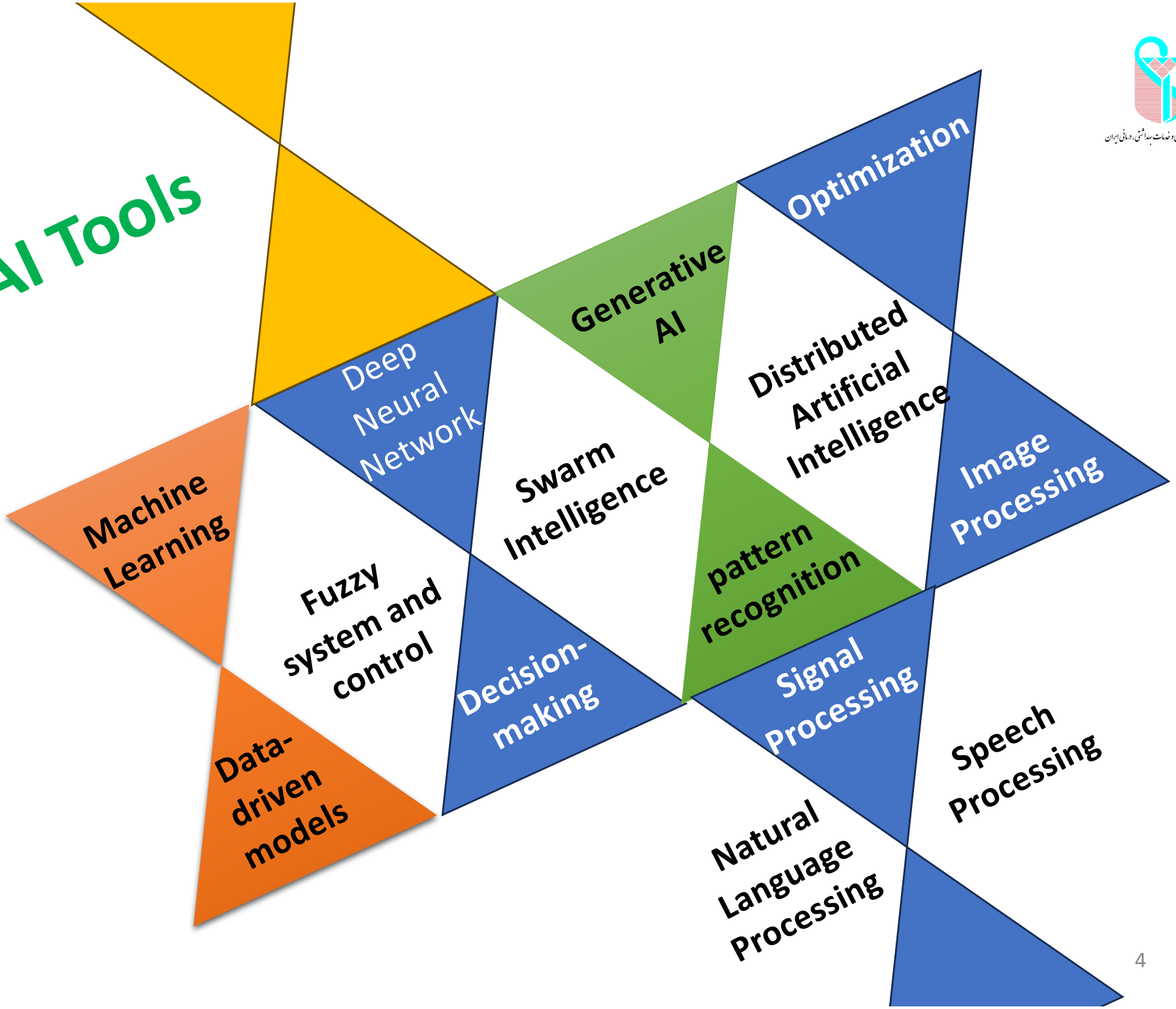
بسم الله الرحمن الرحیم

AI Tools


Machine Learning
Deep Neural Network
Generative AI
Optimization
Fuzzy system and control
Swarm Intelligence
Distributed Artificial Intelligence
Image Processing
Data-driven models
Decision-making
pattern recognition
Signal Processing
Speech Processing
Natural Language Processing

AI can benefit neurosurgeons

- Errors Reduction
- Diagnosis Cost Reduction
- Treatment and prognosis
- Improve accuracy of diagnosis
- Timely pre-, intra- and postoperative care
- Detect abnormalities from clinical data

AI in the pre-operative phase of neurosurgery

AI can assist surgeons in:

- Diagnosing the condition
- Selecting patients for the right treatment
- Helping patients to make the right decisions
- Automatic tumor segmentation
- Epileptogenic zone localization

AI in the pre-operative phase of neurosurgery

AI can assist surgeons in:

- **predicted the glioma**
- **Selecting appropriate candidates for epileptic surgery**
- **Predicting symptomatic cerebral vasospasm after aneurysmal subarachnoid hemorrhage**
- **Predicting tissue damage following acute ischemic stroke**
- **Effective and efficient identification of glioma tissue**

AI in the pre-operative phase of neurosurgery

AI can assist surgeons in:

lumbar disk degeneration detection

Cluster patients suffering from osteoporotic vertebral fracture based on their pain progression helping their management

classifying intra-axial cerebral tumors including high- and low-grade gliomas, metastatic tumors and malignant lymphomas

lateralizing the affected brain hemisphere in the most common pharmacoresistant and surgically remediable type of epilepsy in adults, temporal lobe epilepsy (TLE)

AI and Postoperative Care

predict prognosis

Predict complications

track data for aftercare

identify risk factors

analyse large data sets

cardiac complications

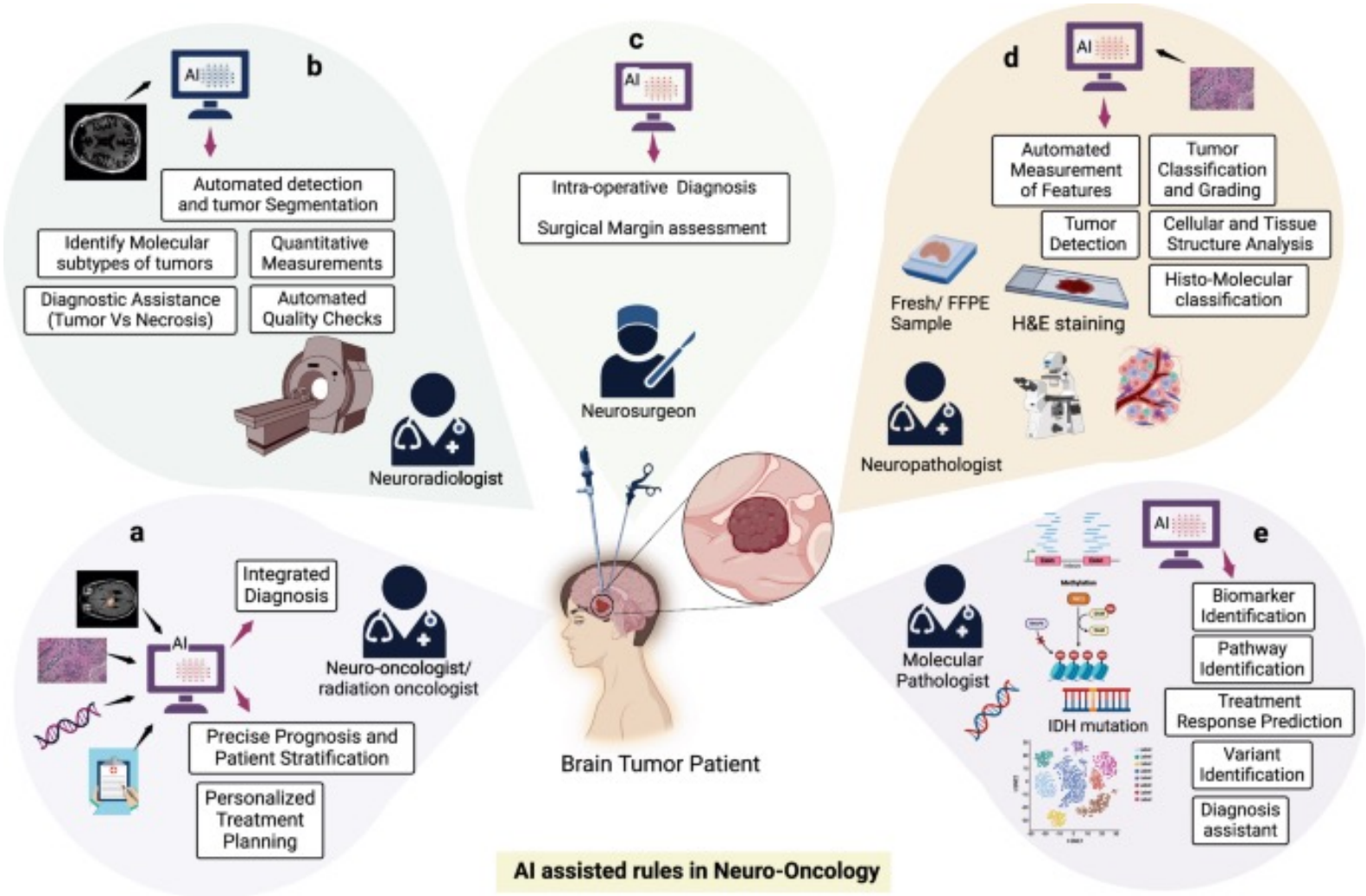
wound complications

mortality

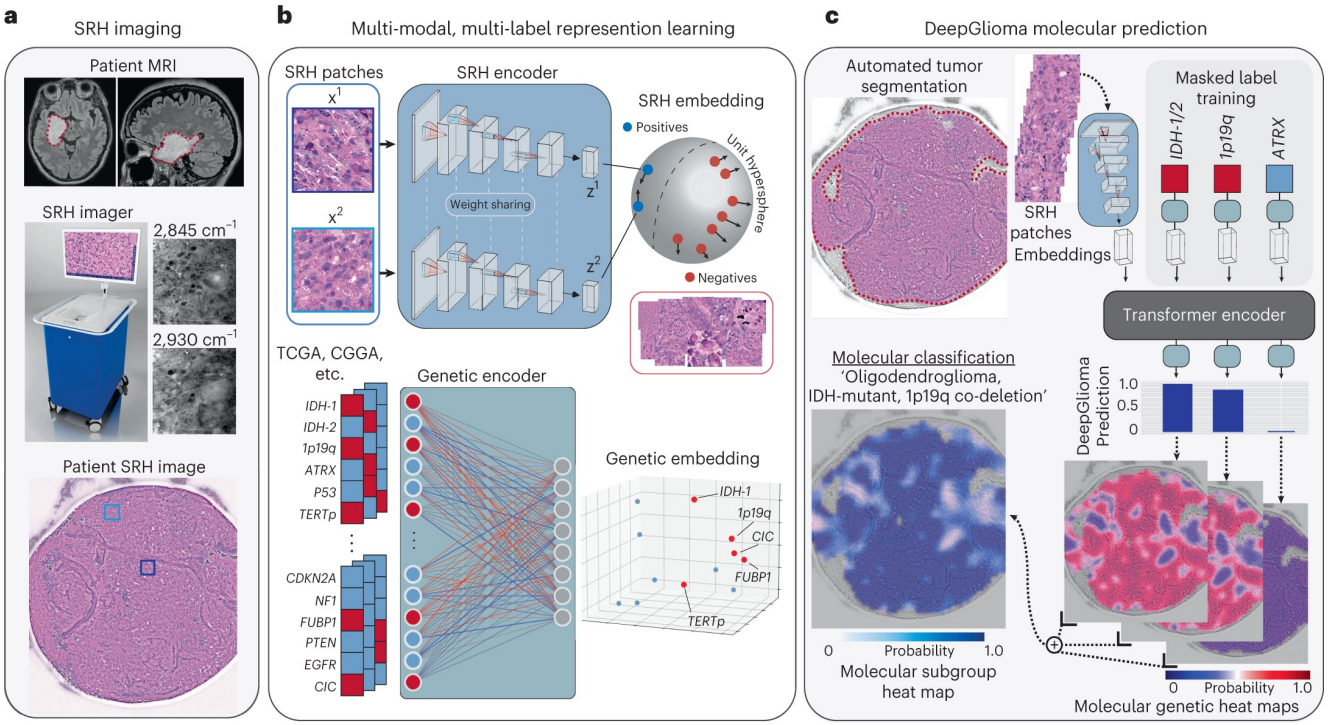
Stroke

Stroke detection	Type of Stroke detection	Stroke CT Score grading
large vessel occlusion detection	Predict imaging and clinical outcomes	triage, quantification, surveillance

Neuro Oncology



Brain Cancer (AI and optical histology (SRH))



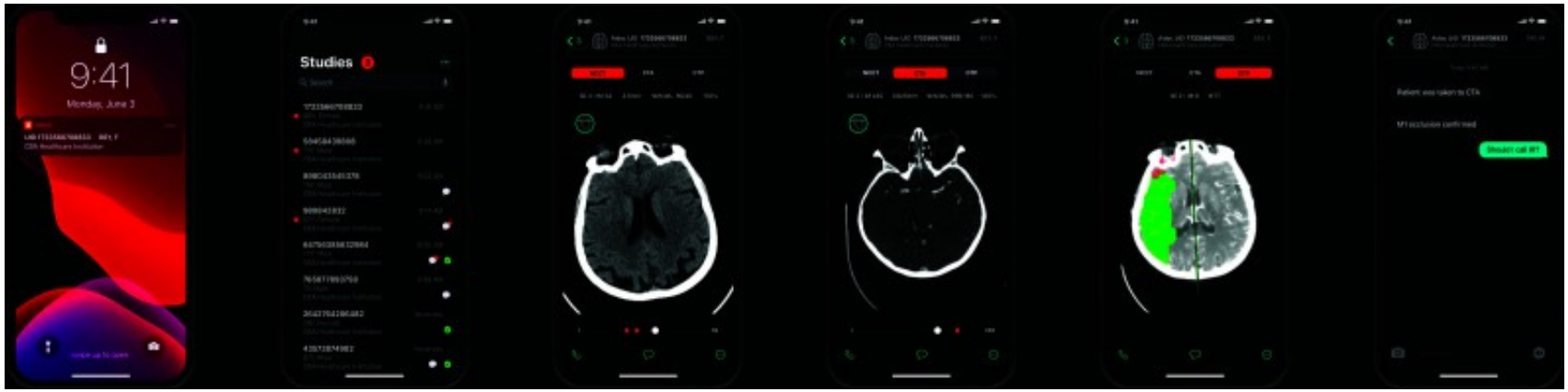
- Molecular classification has transformed the management of brain tumors by enabling more accurate prognostication and personalized treatment.

Artificial-intelligence-based molecular classification of diffuse gliomas using rapid, label-free optical imaging, Nature Medicine volume 29, pages828–832 (2023)

Brain Tumor Diagnosis during Surgery

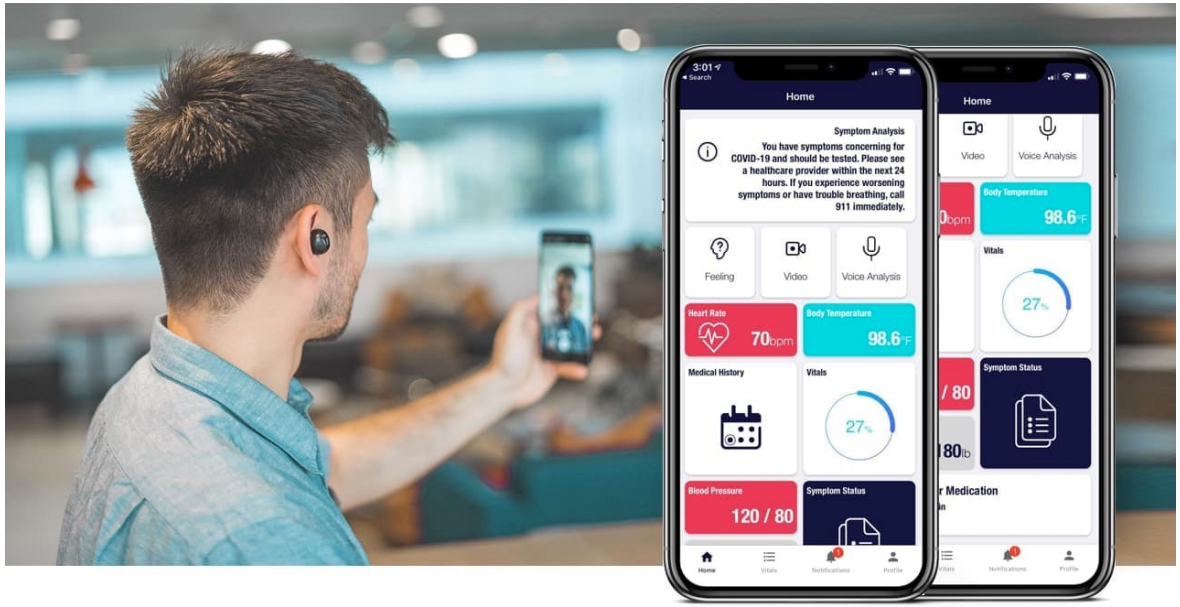
combine an imaging technology called stimulated Raman histology (SRH) with the predictive power of AI to improve current intraoperative pathology practice

Aidoc stroke triage mobile interface



Headache

- AI-based diagnostic model.
- AI assisted triage of headache patients to appropriate clinicians.



A short selfie video: Using Stress, vital signs, such as heart rate, respiration, and blood pressure that infer vital signs from videos using AI.

The role of AI in headache medicine: potential and Peril, American Headache Society, 2023.

Neuromuscular Disorders

- Convolutional neural network model for identifying the **neurological visual disorder**.
- Incremental variance learning-based ensemble classification model for neurological disorders.
- Artificial intelligence-based early detection of neurological disease using **noninvasive methods based on speech analysis**.
- Deep learning for neuroimaging analysis and disease prediction.

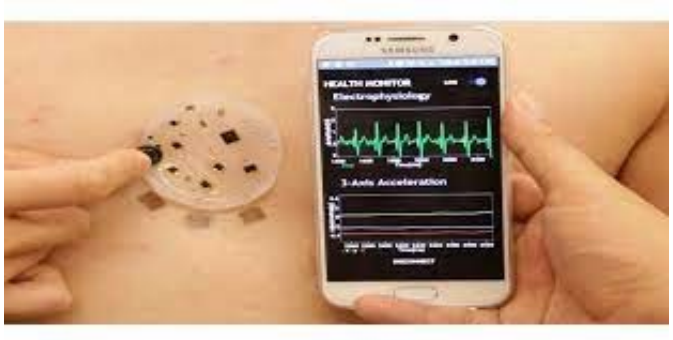
Artificial Intelligence for Neurological Disorders, 1st Edition - Academic Press, 2022

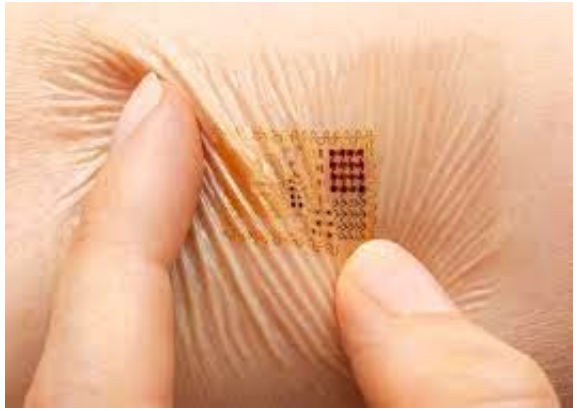
AI in other sections

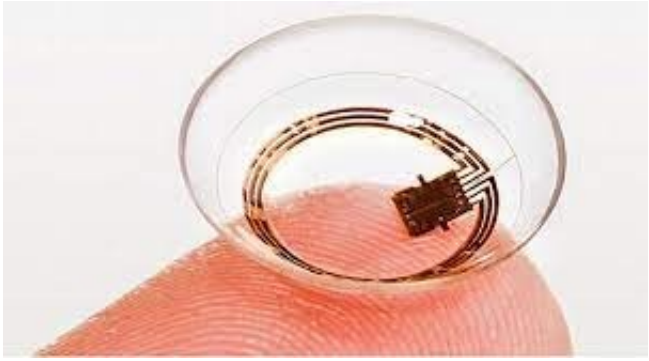
- Pain Management
- Sleep Medicine
- Movement Disorders
- Brain Injury
- Clinical Neurophysiology
- Neurodevelopmental Disabilities
- Neurocritical Care
- Vascular Neurology
- Behavioral Neurology
- Child Neurology
- Multiple Sclerosis
- Neuroimaging
- Neurooncology
- Neurorehabilitation
- Neurodegenerative Disease

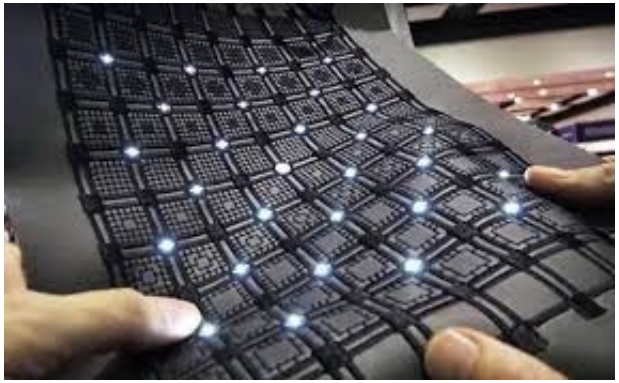
Near-Body Mental Status Monitoring

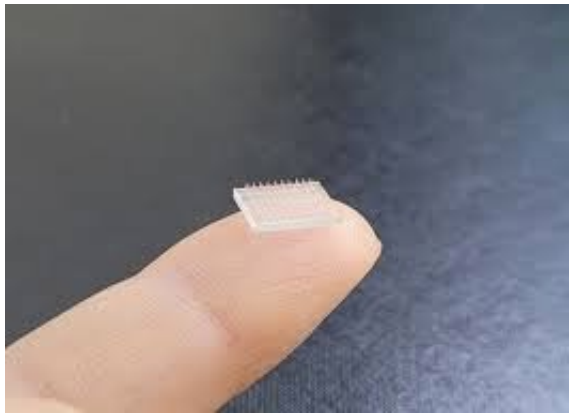
- Combined with AI, the mental statuses of patients can be intervened in time to avoid tragedies.
- E.g. stress monitoring system, where the analyzed data came from the fusion of electroencephalography (EEG) and electromyography (EMG).


HEALTH MONITOR
Electrocardiography
3-Axis Acceleration



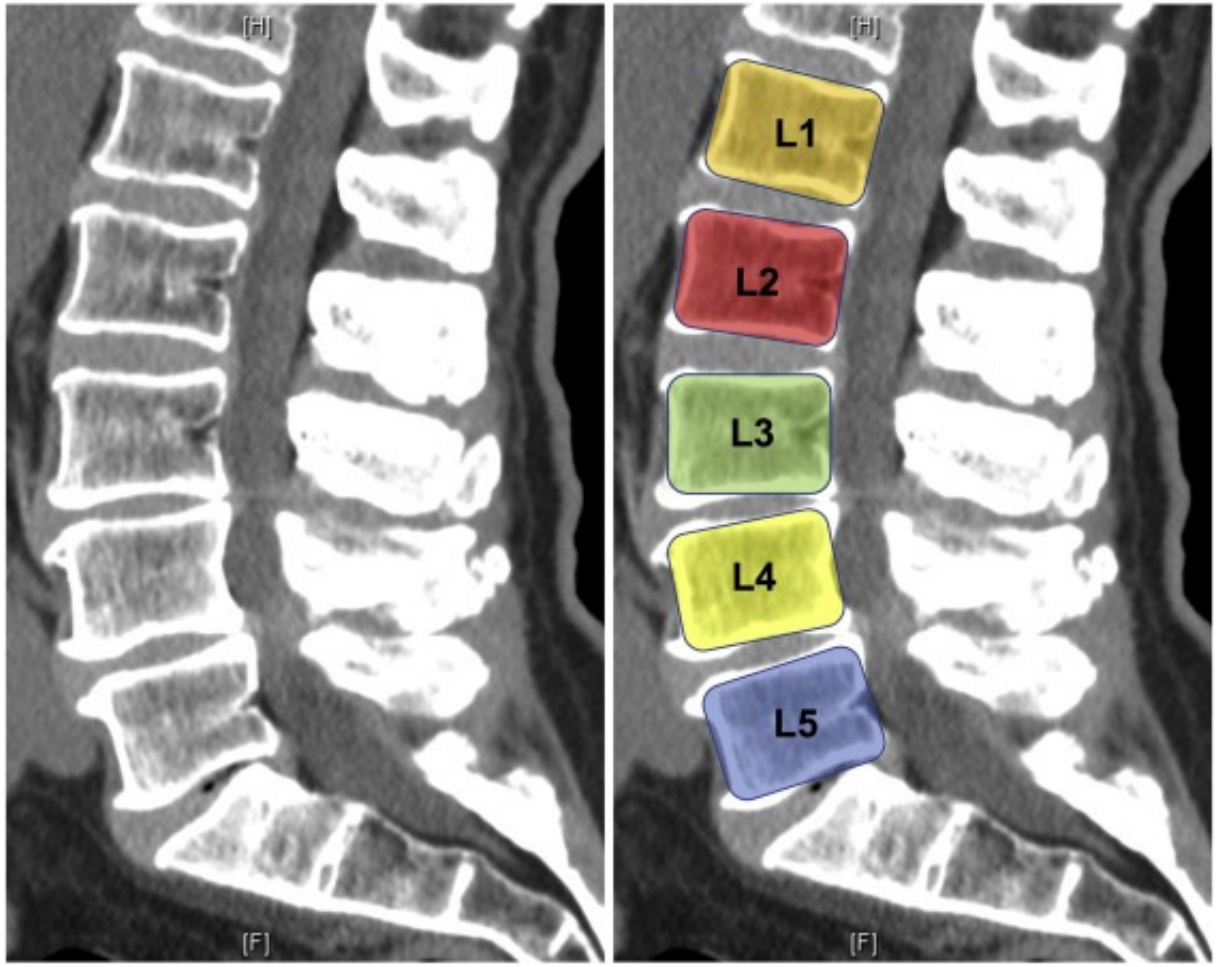






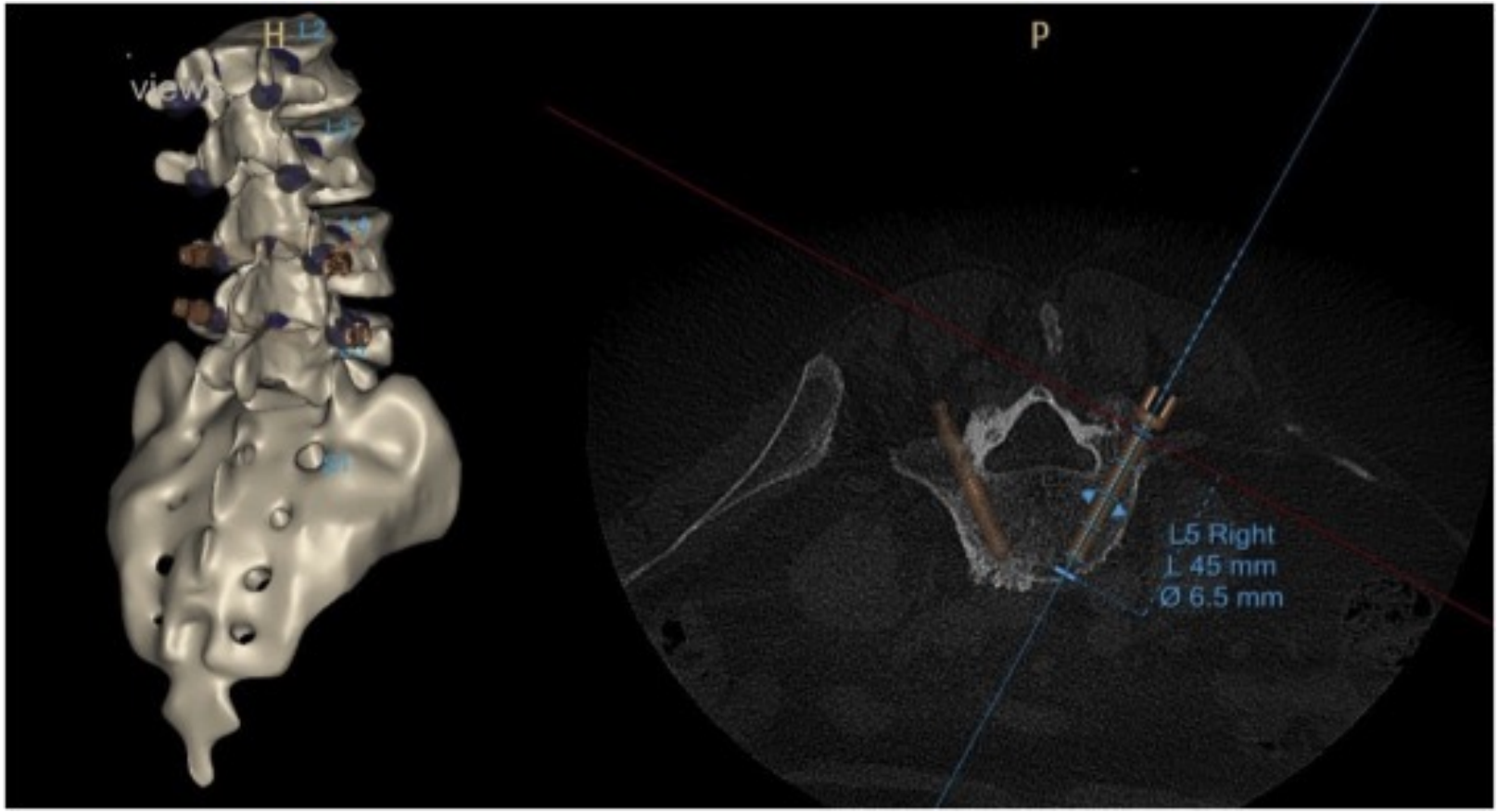
Automatic vertebral segmentation

This technique is particularly useful during surgical navigation for the placement of pedicle screws



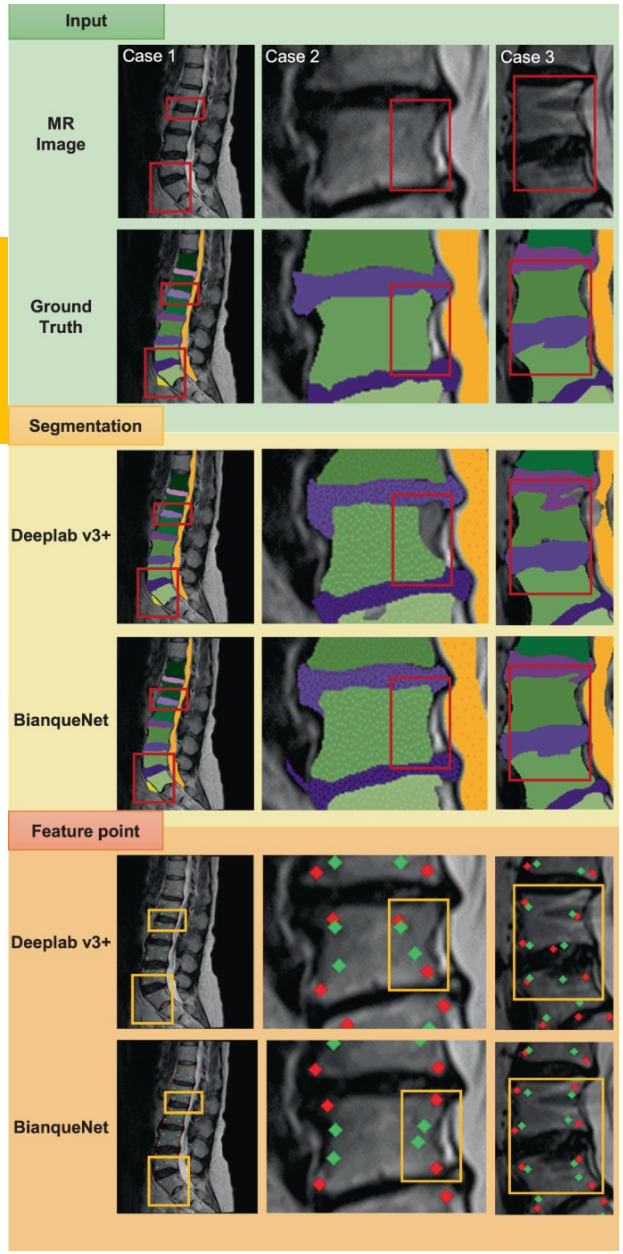
Vertebral segmentation on CT scan using convolutional neural networks

Segmentation of the lumbosacral spine based on intraoperative images from cone beam computed tomography (CBCT) for the planning of pedicle screw placement using surgical navigation.

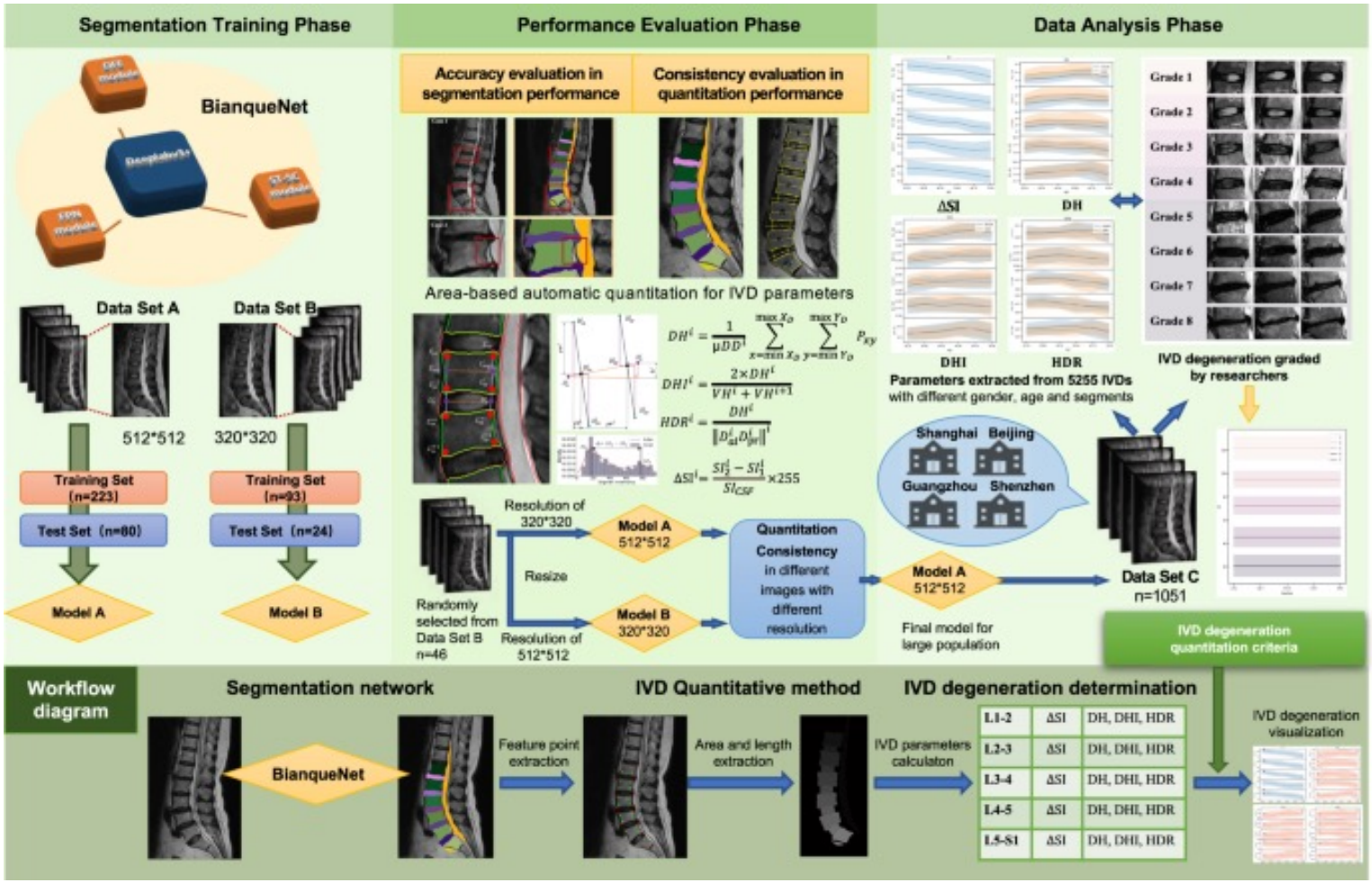


Classification of intervertebral disc degeneration

automatic recognition of degenerative stages and certain morphological changes such as disc protrusion or disc herniation

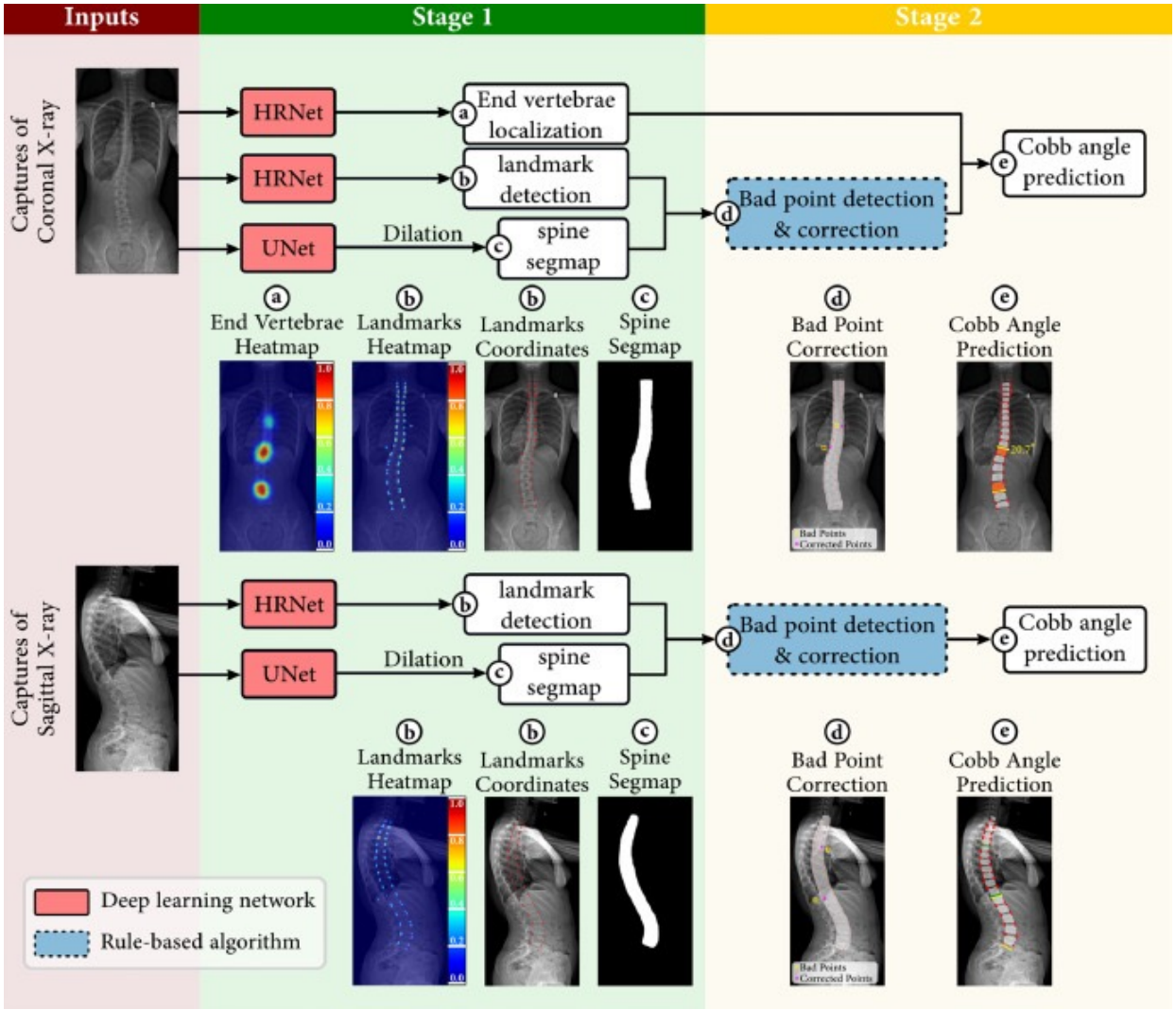


Deep learning-based high-accuracy quantitation for lumbar intervertebral disc degeneration from MRI



Nature Communications **volume 13**, Article number: 841 (2022)

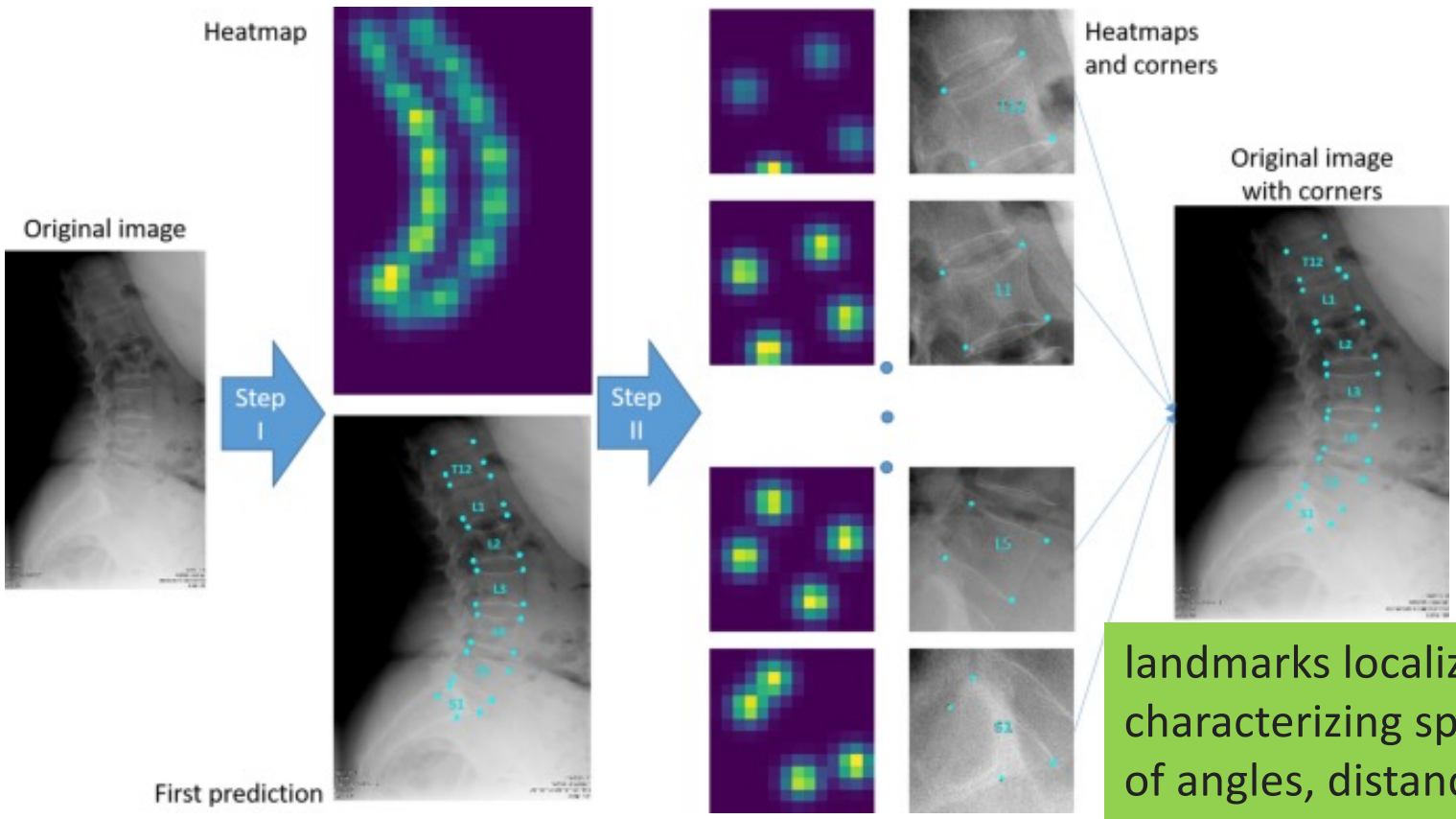
AI based auto-analyses of spine alignment irrespective of image quality with prospective validation



Assessment of spine alignment in the management of scoliosis, using AI.

eClinicalMedicine, Volume 43, January 2022, 101252

2-step deep learning model for landmarks localization in spine radiographs

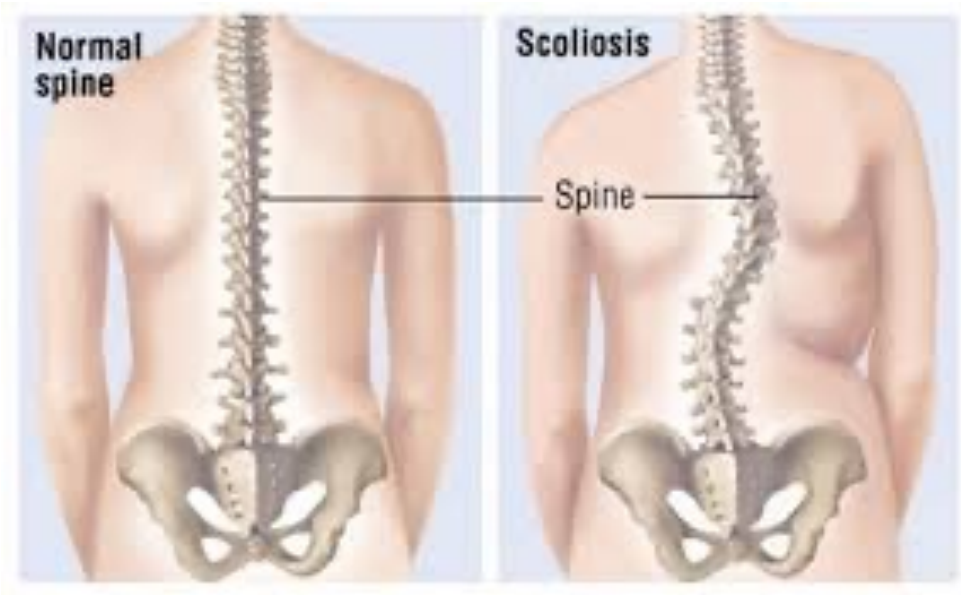


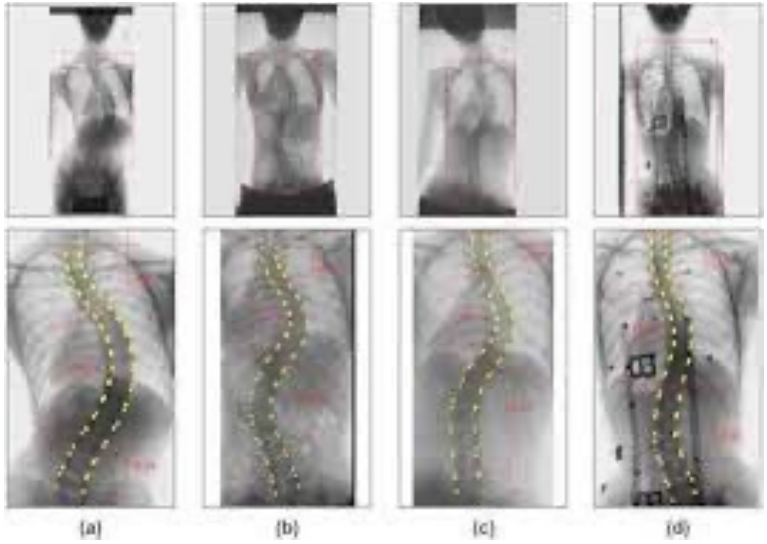
landmarks localization is used to allows characterizing spine alignment in term of angles, distances and shape that could be useful e.g. for surgical planning or monitoring the progression of deformities

Scientific Reports **volume 11**, Article number: 9482 (2021)

Calculation of spinal deformity parameters

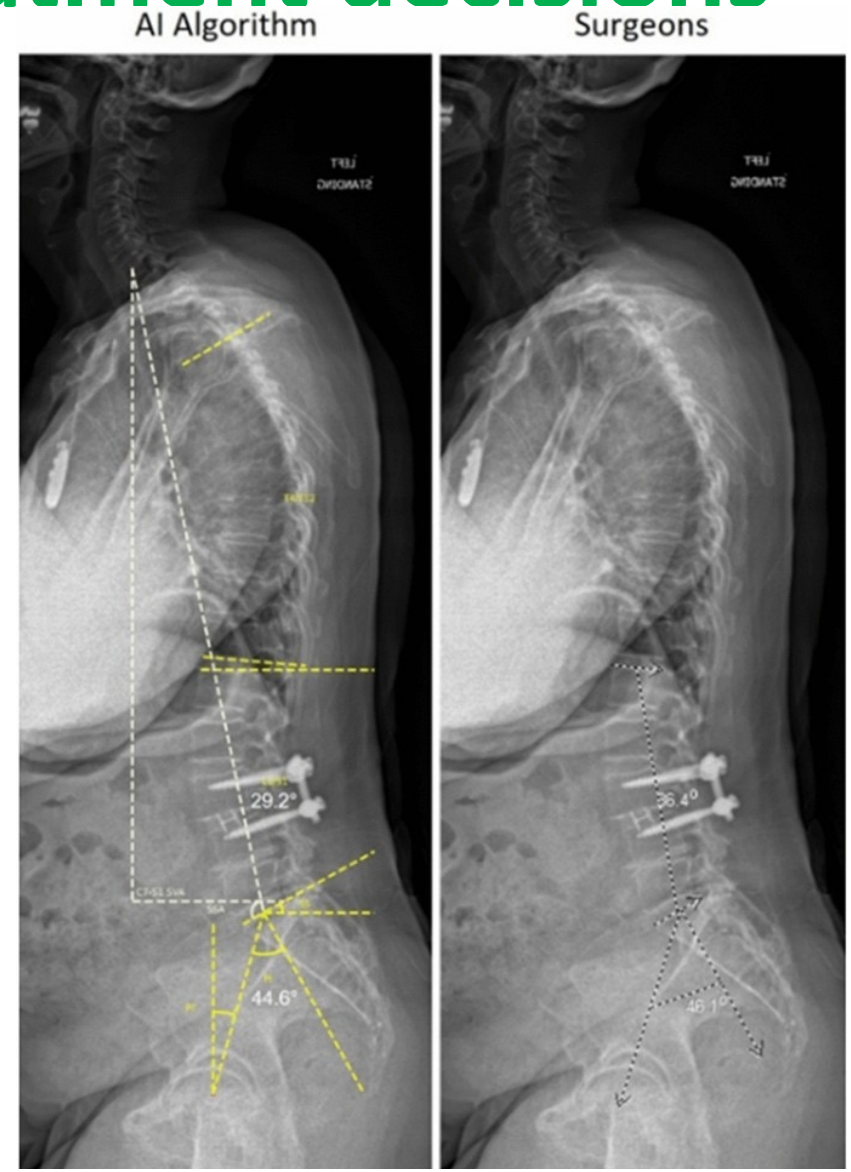
The initial ML algorithms were also tested for automatic determination of landmarks and the acquisition of sagittal alignment measurements on full-spine radiographs.



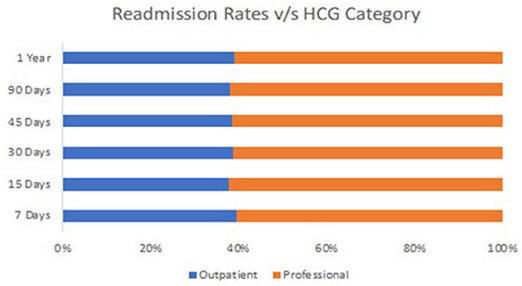


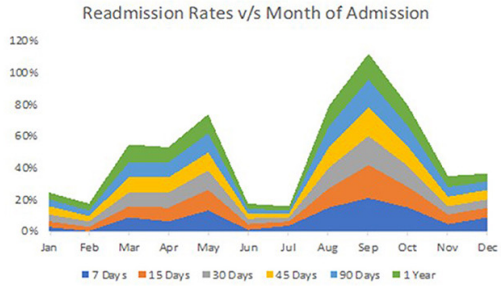
AI for making treatment decisions

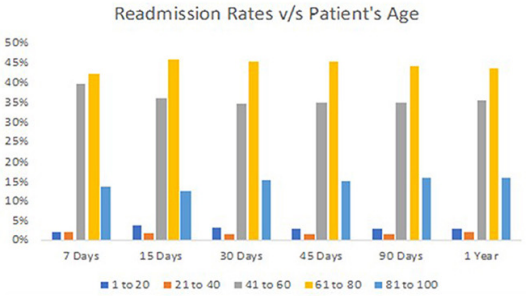
The diagnostic process and the treatment decision for a spinal pathology is generally established by the surgeon based on scientific data, good practice recommendations and his/her clinical experience.
adult spinal deformity is an area that requires multicenter analysis of several hundreds of medical records to be able to draw conclusions that are significant for clinical practic

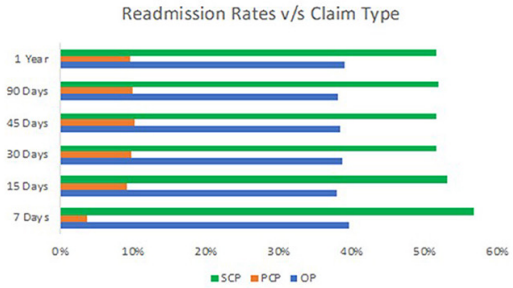


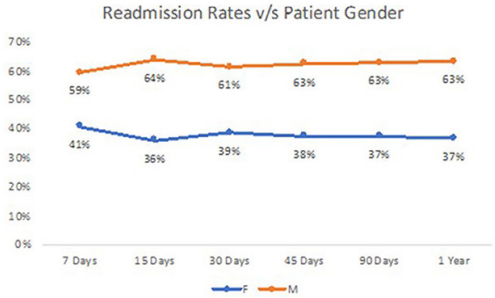
predict the risk of postoperative complications and unplanned readmission in surgically





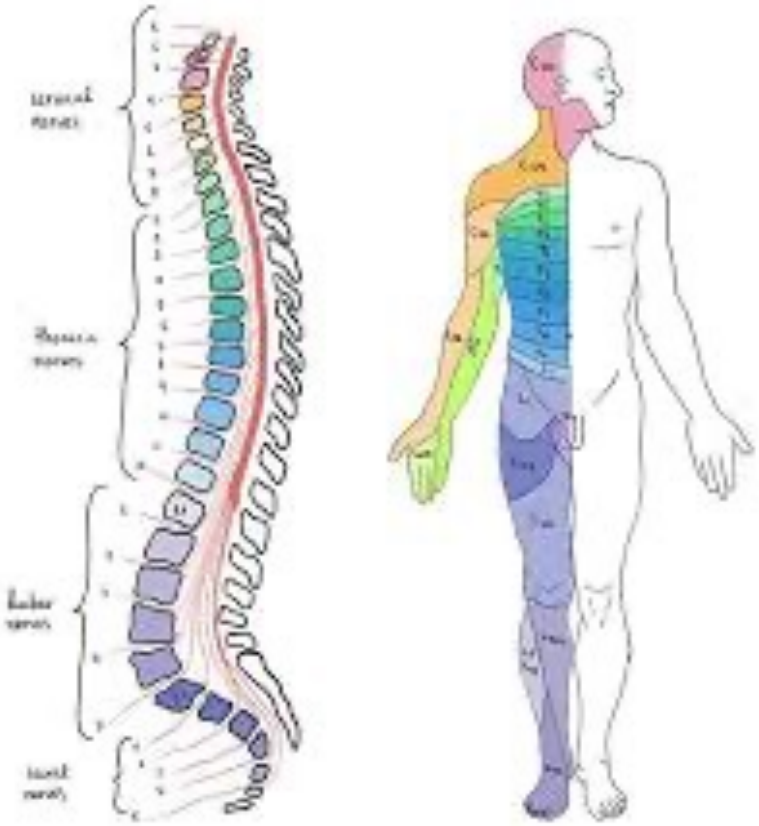




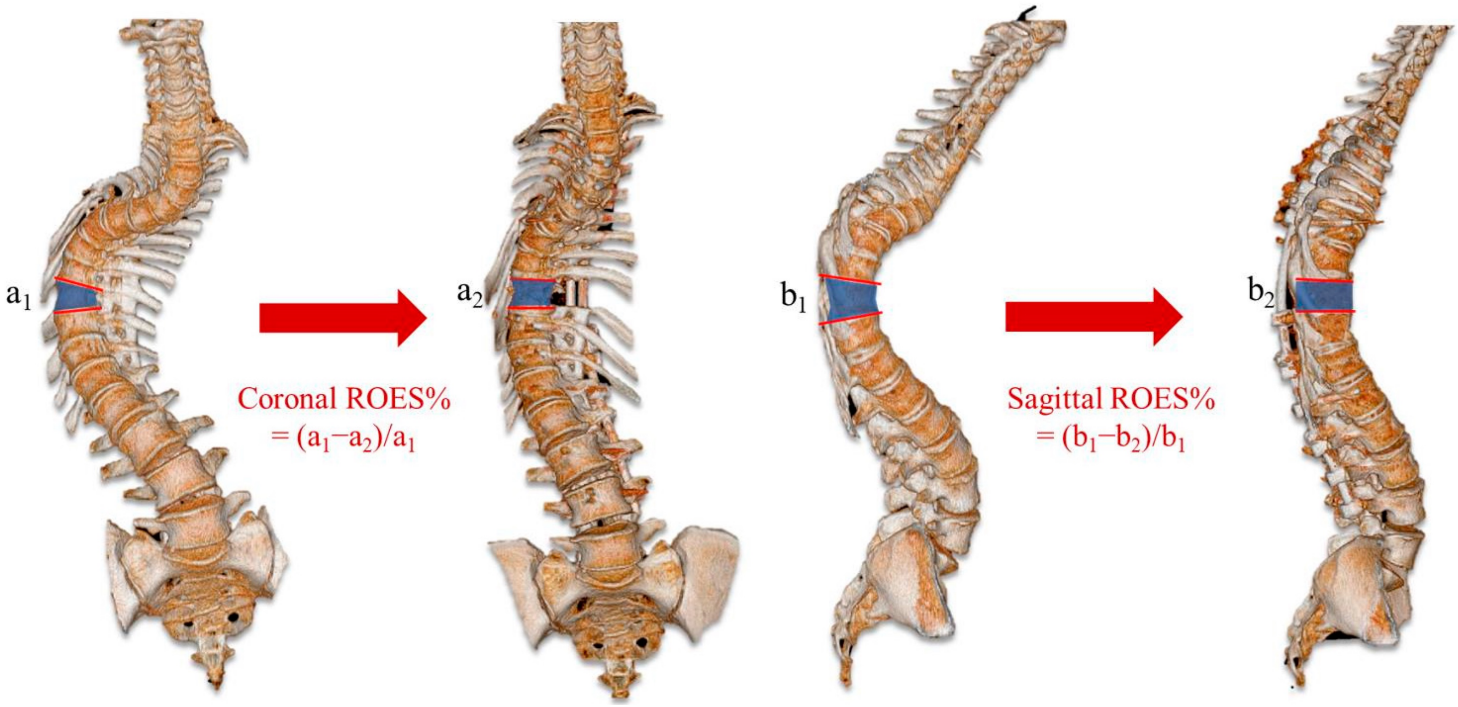


combination of factors such as the type of deformity, age, sex, patient comorbidities, paraspinal muscle atrophy, bone mineral density, sagittal and coronal balance parameters, along with the type of surgical treatment.

predict the functional outcomes and the quality of life

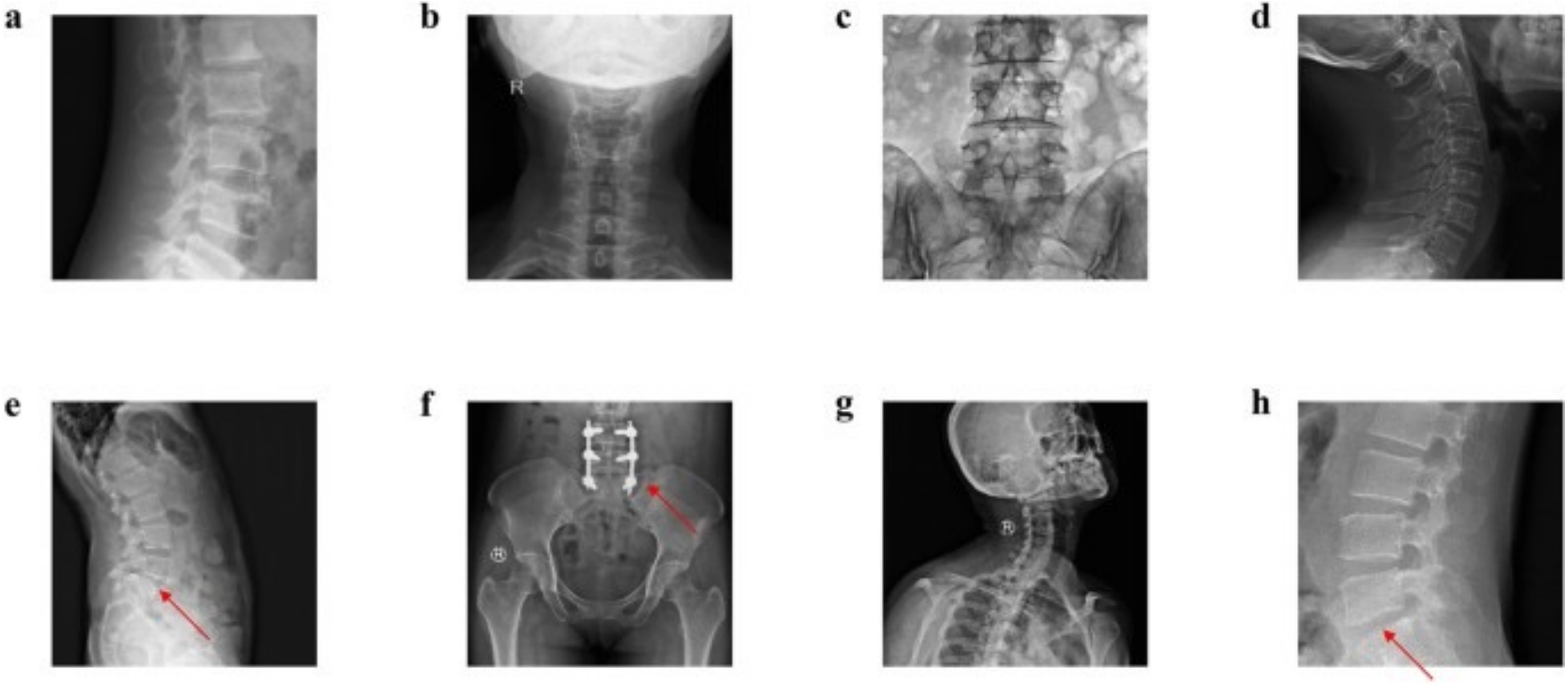


Planning of spinal deformity corrections



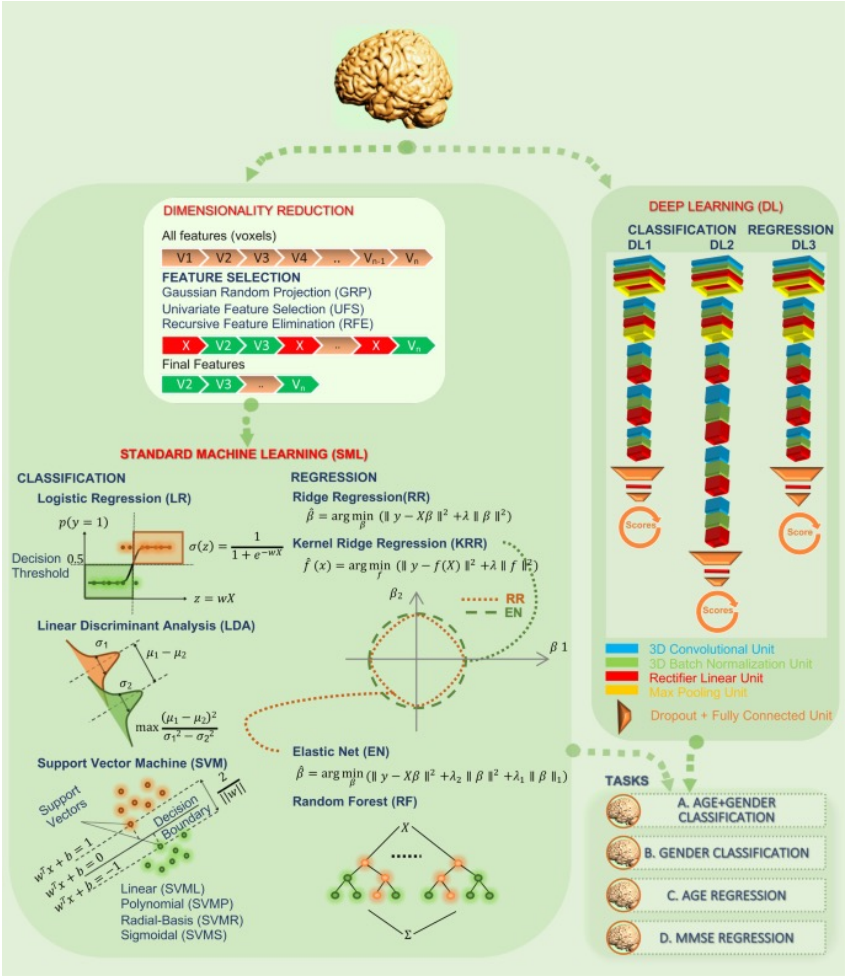
Demonstrating the successful application of synthetic learning in spine surgery for training multi–center models with increased patient privacy

classification of spine radiographs as abnormal or normal.



Scientific Reports **volume 13**, Article number: 12481 (2023)

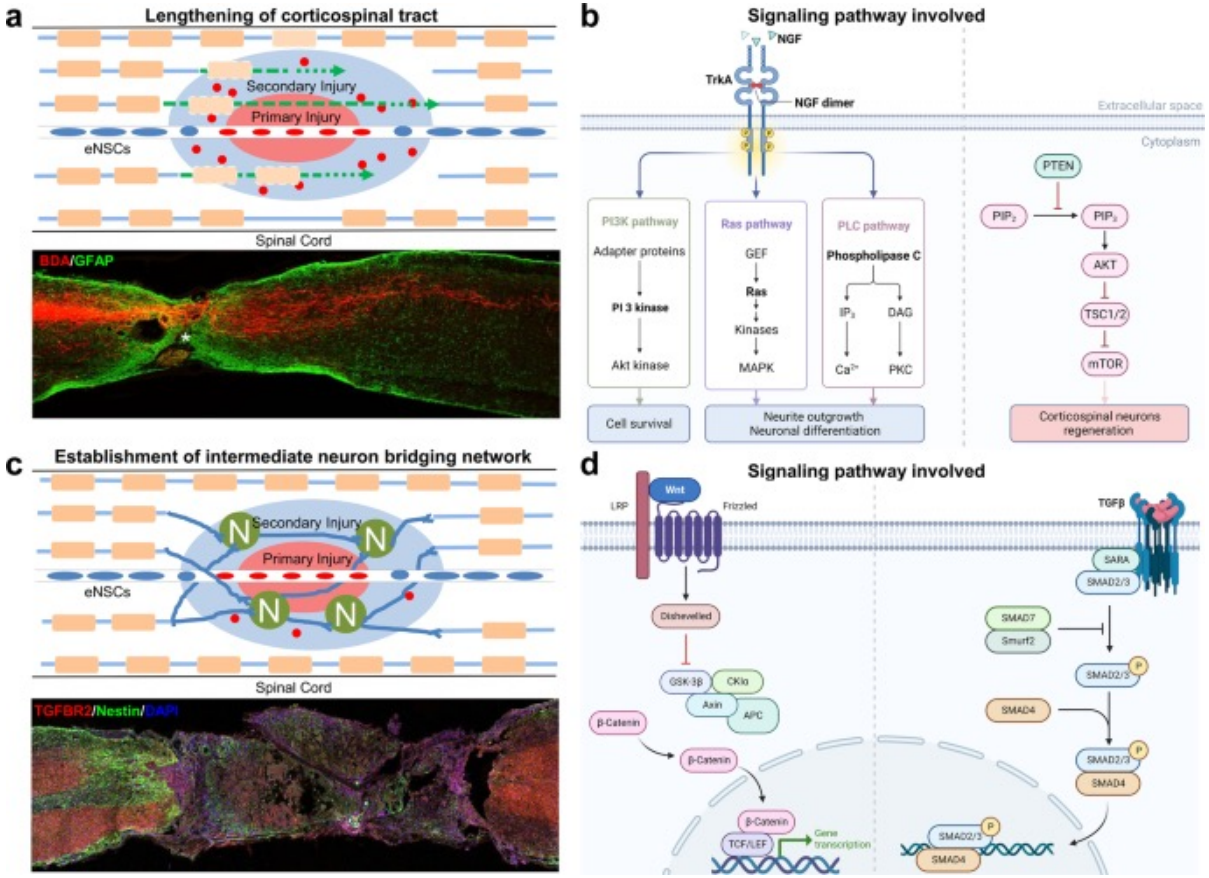
Deep learning encodes robust discriminative neuroimaging representations to outperform standard machine learning



Nature Communications **volume 12**, Article number: 353 (2021)

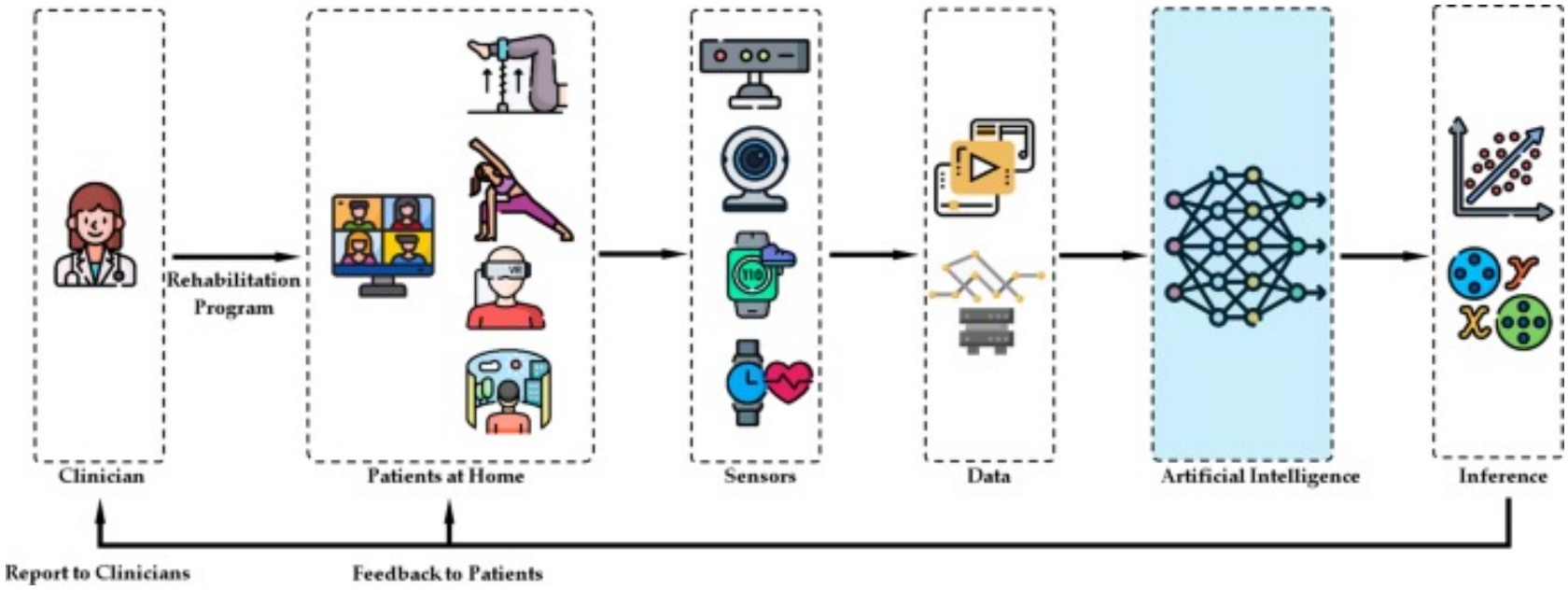
Spinal cord injury: molecular mechanisms and therapeutic interventions

- axon regeneration and neural circuit remodeling, but the results have not been ideal.



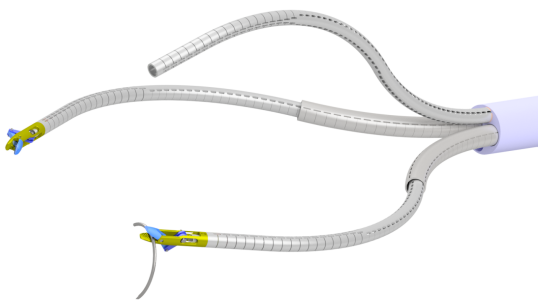
Artificial intelligence-driven virtual rehabilitation for people living in the community

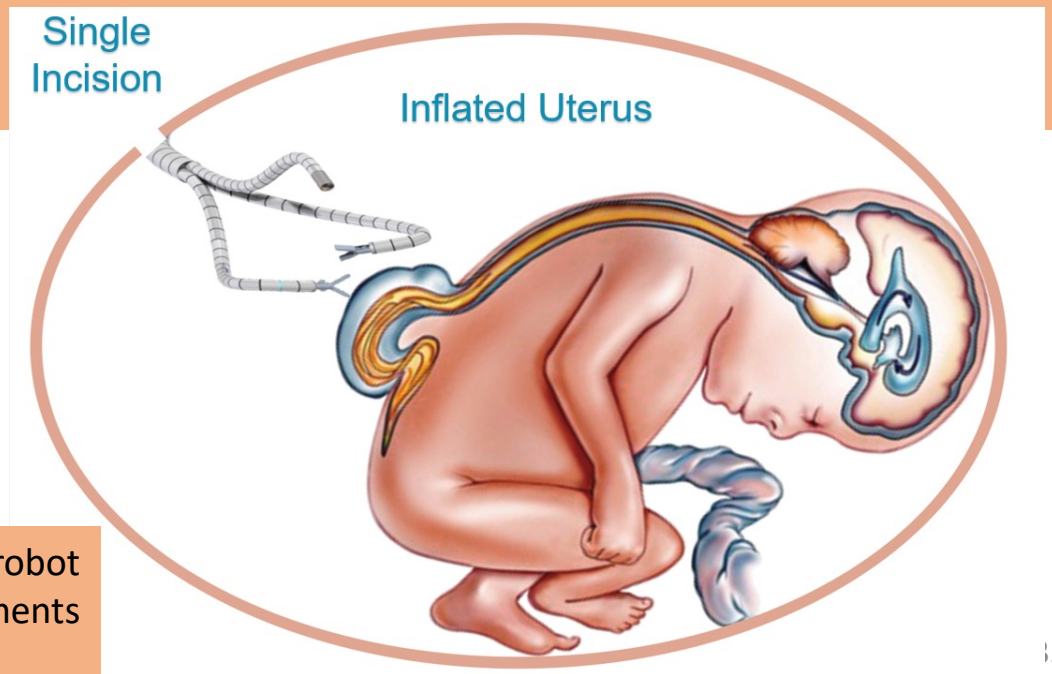
- Virtual Rehabilitation (VRehab)



Fetal Surgery

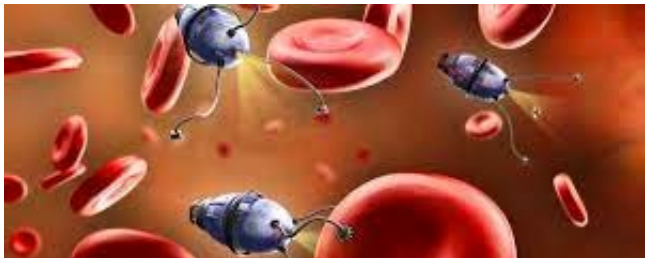
- Spina bifida is one of the most common birth defects, affecting 4 babies for every 10.000 pregnancies.
- It is due to incomplete closing of the neural tube and often results in severe motor and neuro-developmental impairment.
- Fetal surgery has shown promising results compared to standard post-natal surgery, as earlier repair prevents potential or additional nerve damage. However, open fetal surgery is associated with high rates of maternal complications.
- A multi-arm robot is under development to render minimally-invasive surgery easier

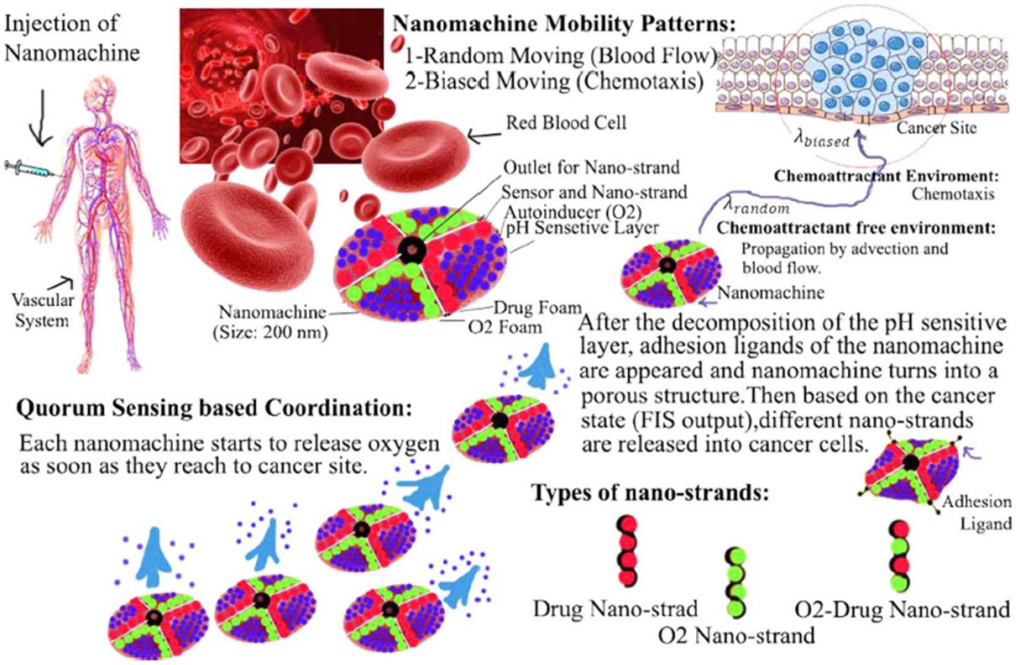


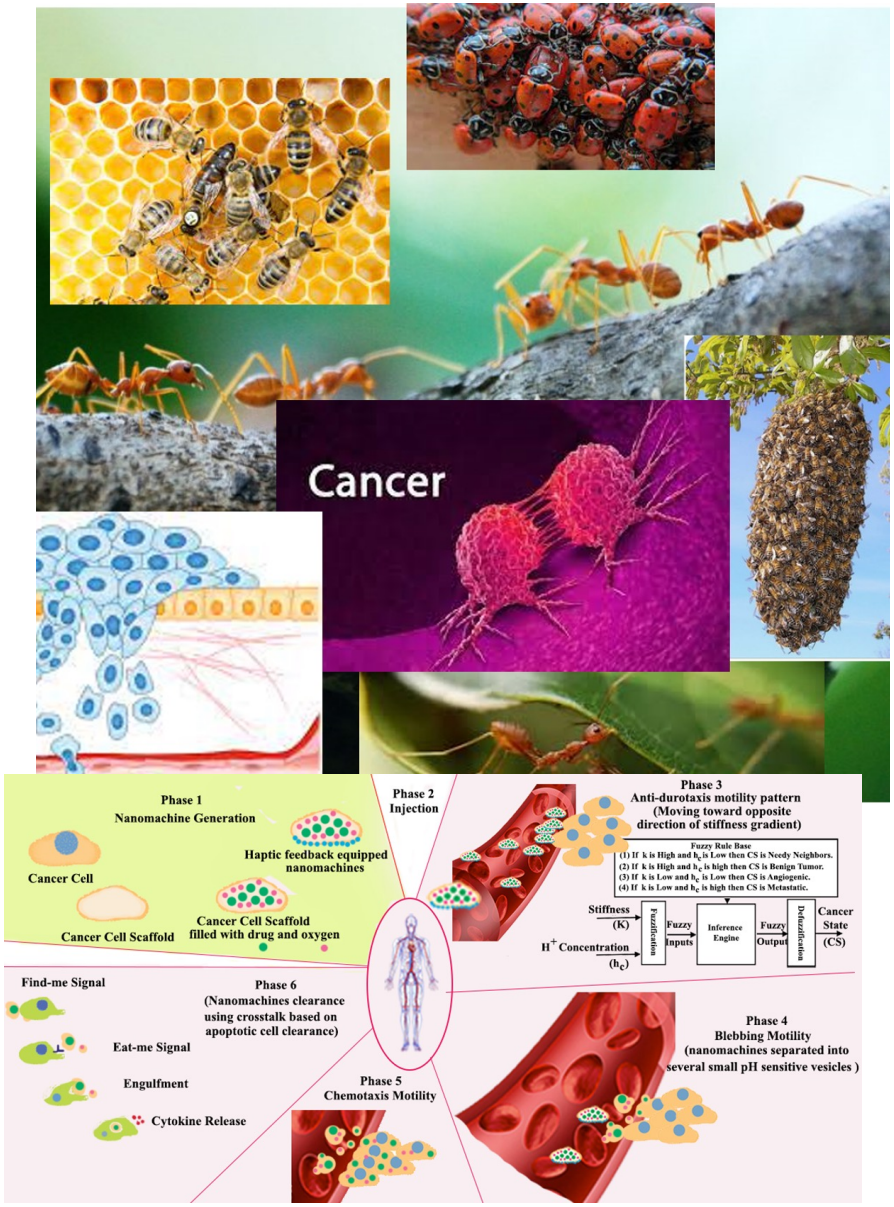


The 11mm outer-diameter multi-arm robot possesses 4 arms; one camera, two instruments and one suction/irrigation channel.

Swarm robotics and micro – nano robotics in medicine





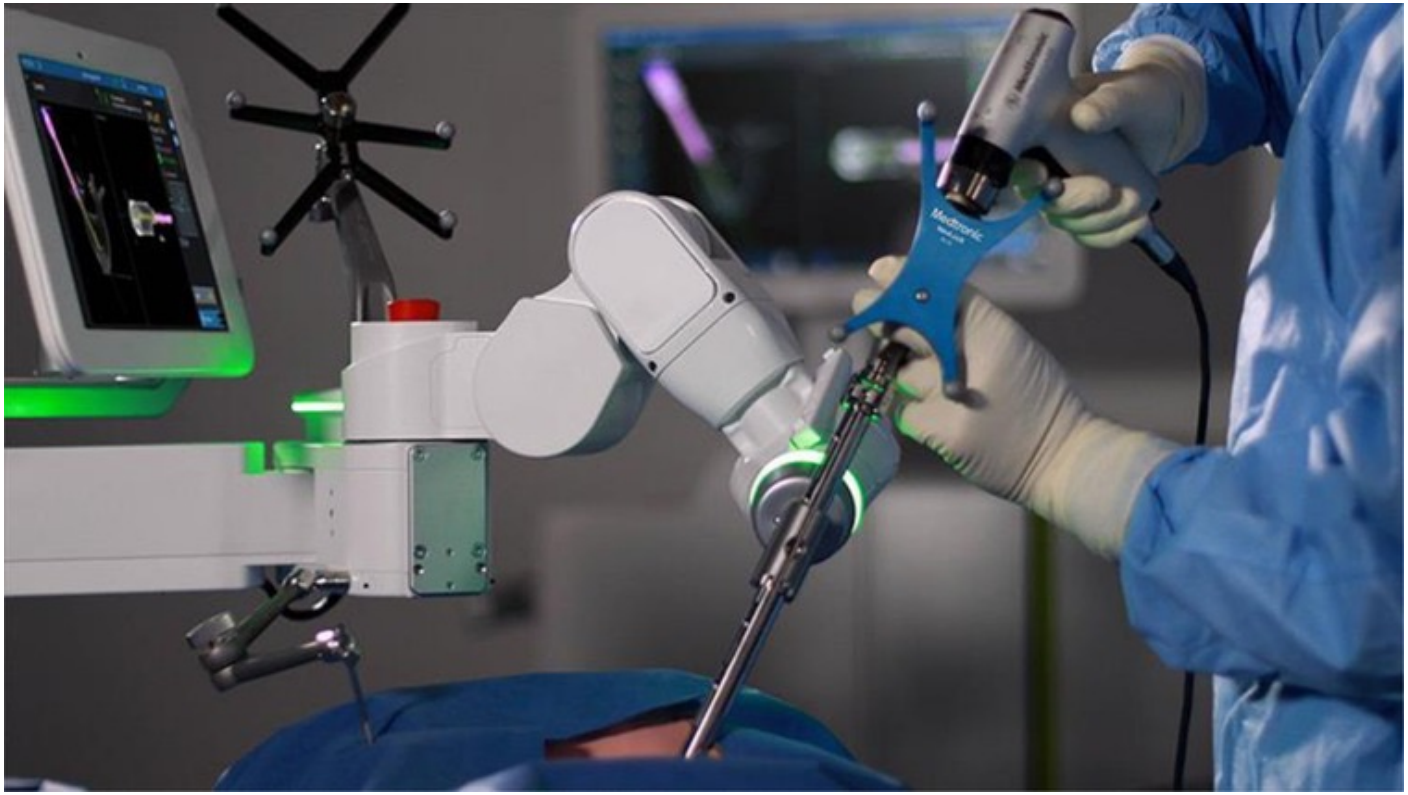


Robotic thread for brain's blood vessels

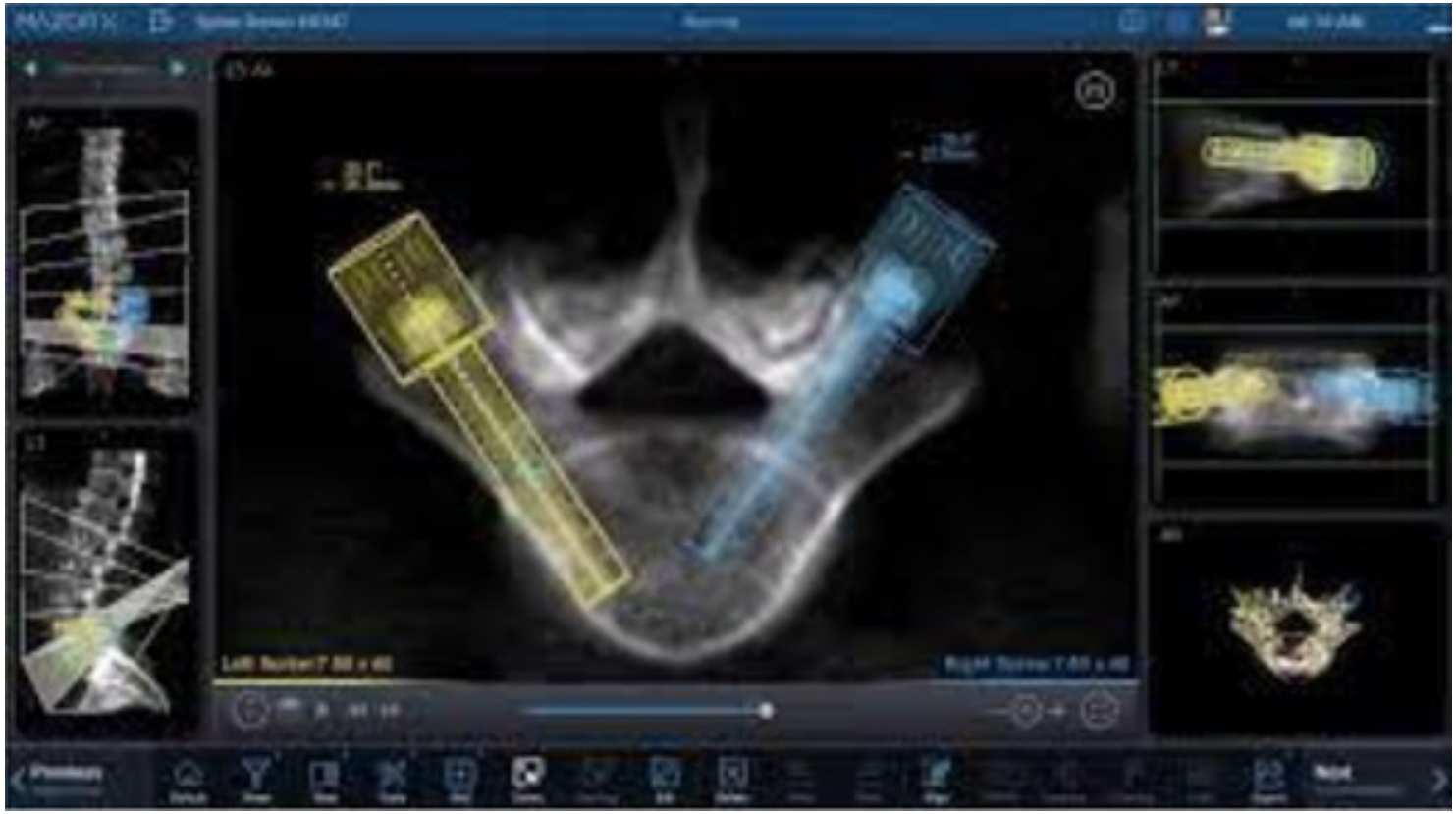
https://news.mit.edu/2019/robot-brain-blood-vessels-0828

Mazor X

The **Mazor**™ robotic guidance system combines surgical navigation with pre- and interoperative planning so you can perform spinal surgery more efficiently.



Software interaction with Mazor X, including pedicle screw selection along with optimization of construct definition. Proper pedicle screw diameter and length can be selected to conform to the patient's individual anatomy based on pre-operative imaging using the work-station.

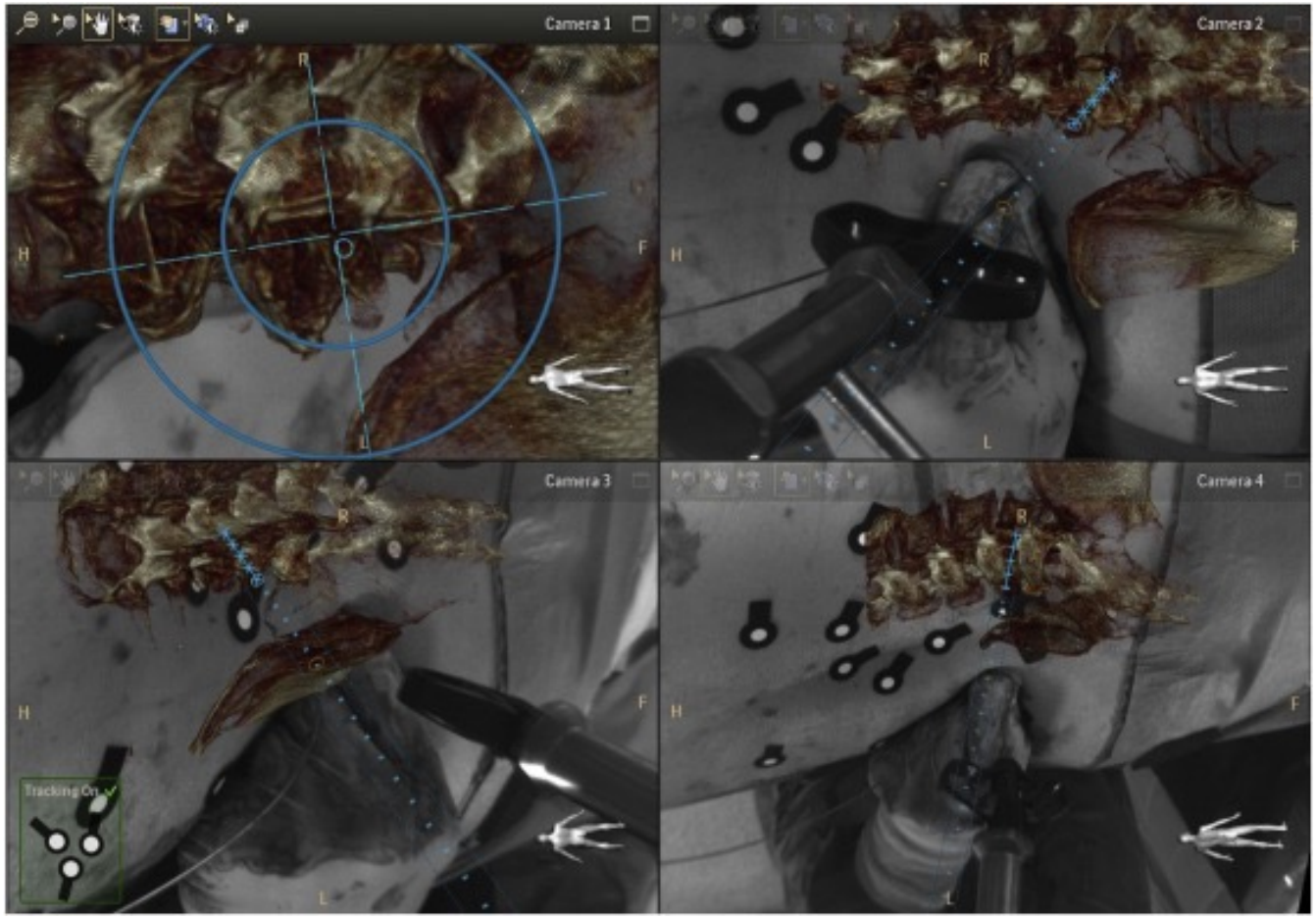


Rosa System Robotic

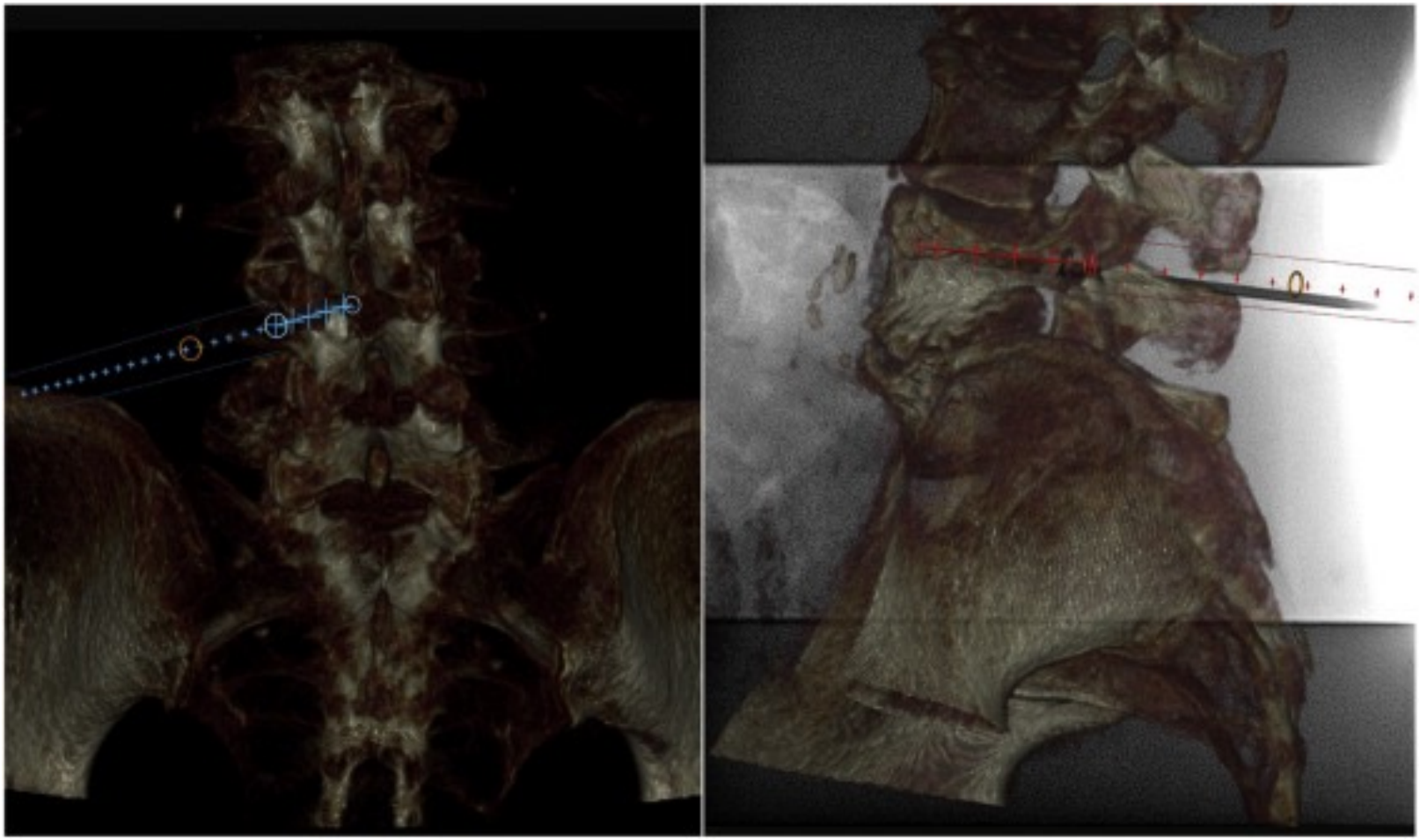
Augmented reality surgical navigation

- Augmented reality surgical navigation (ARSN) is a technique in which images and additional information are projected virtually in the surgical field. This is a new type of surgical navigation that is used to guide the surgeon in pedicle screw placement and to increase the accuracy.

Virtual projection of 3D reconstruction of CBCT images in the surgical field.

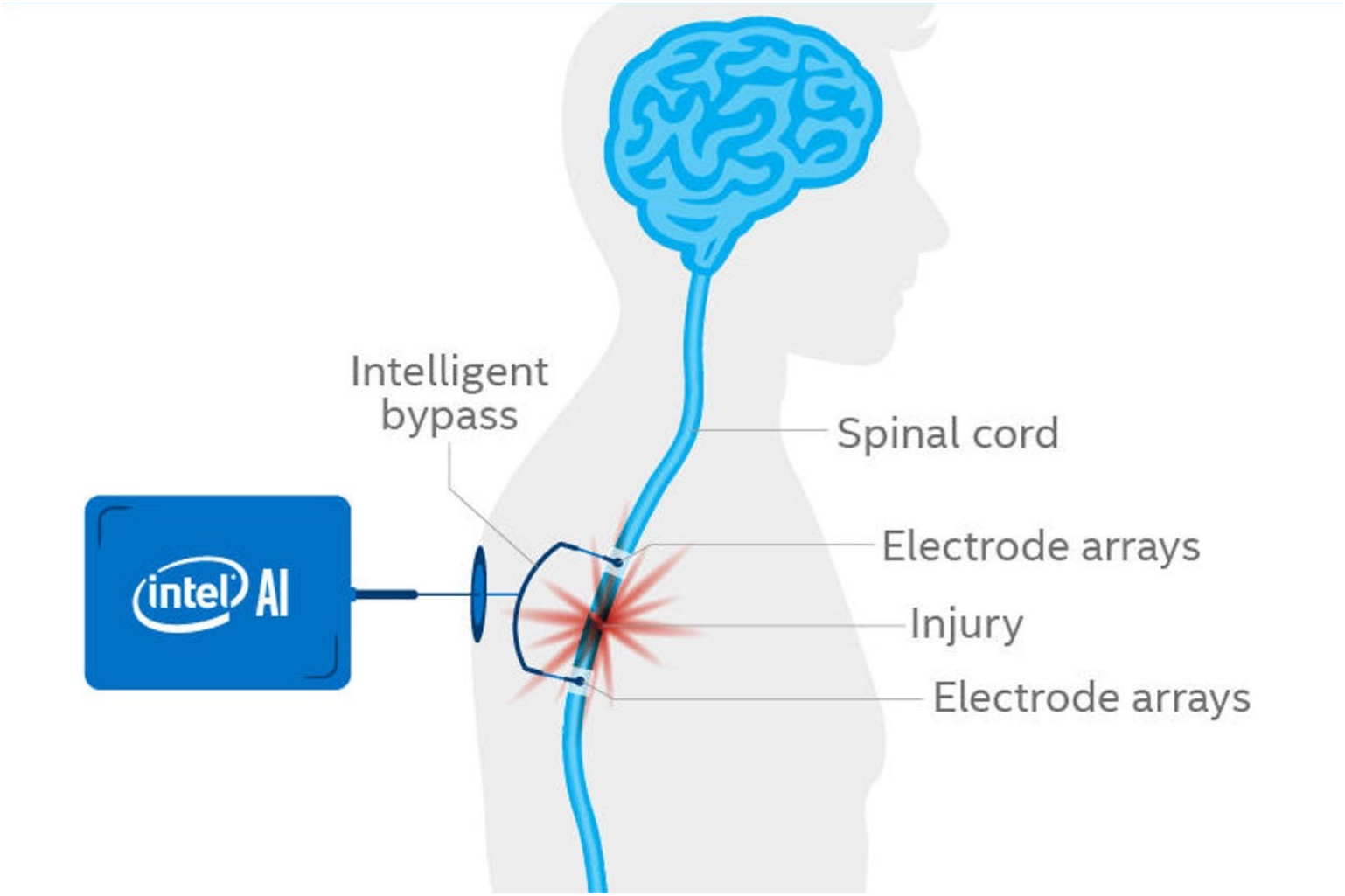


Verification of the true Jamshidi™ needle trajectory compared to the planned screw trajectory.

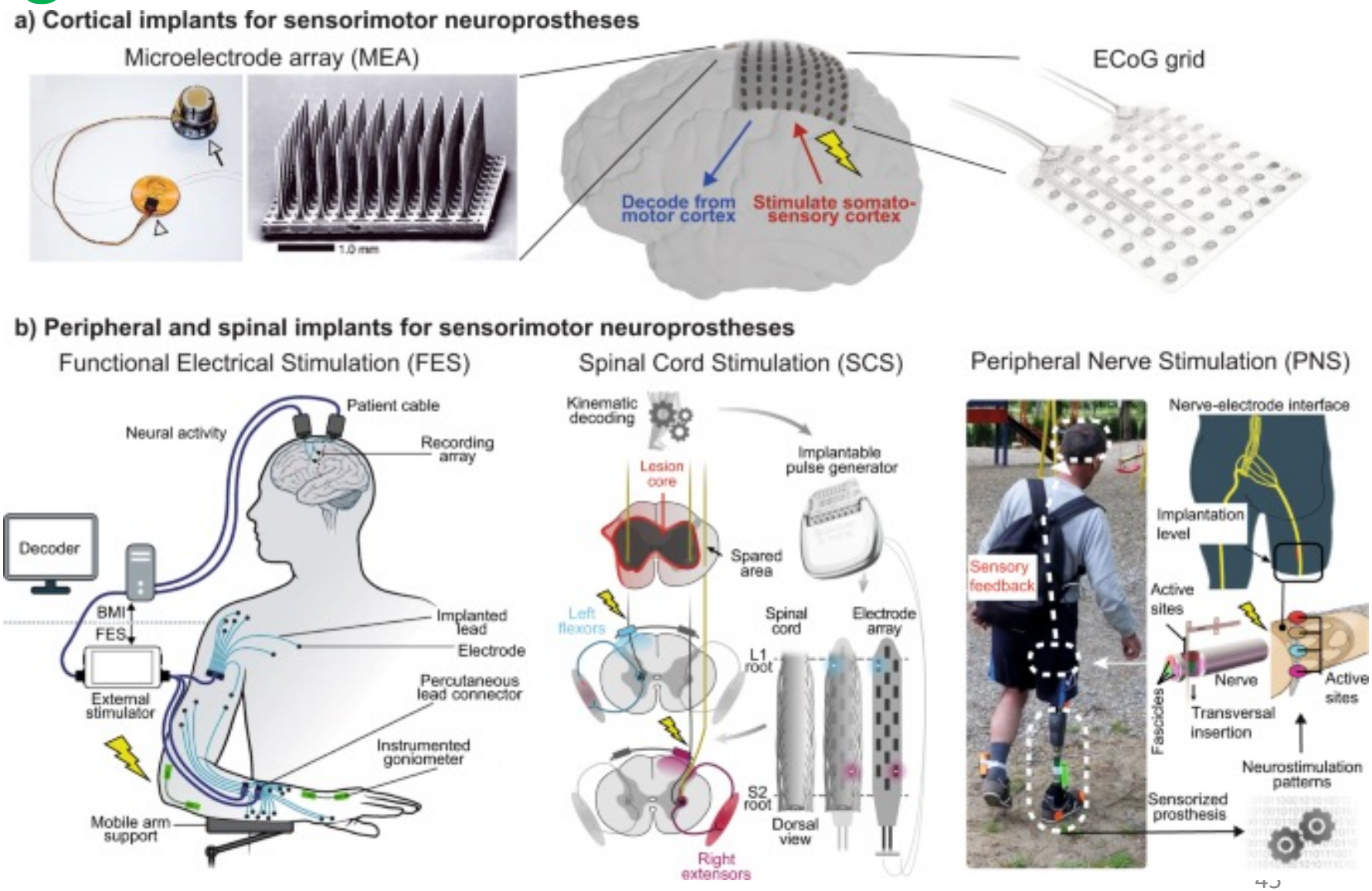


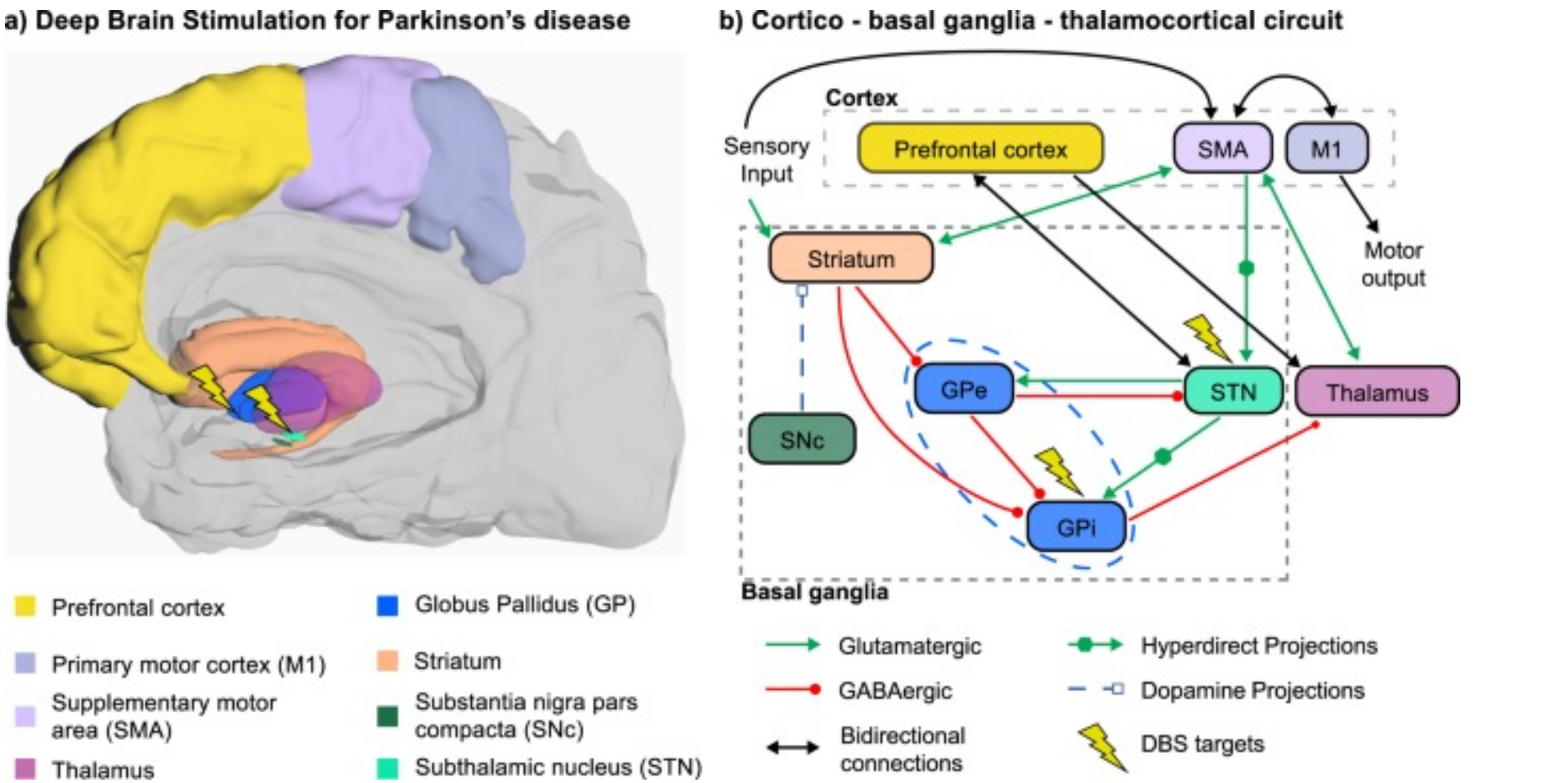
Artificial intelligence and treatment algorithms in spine surgery, Orthopaedics & Traumatology: Surgery & Research و Volume 109, Issue 1, Supplement, February 2023, 103456

Intelligent Spine Technology

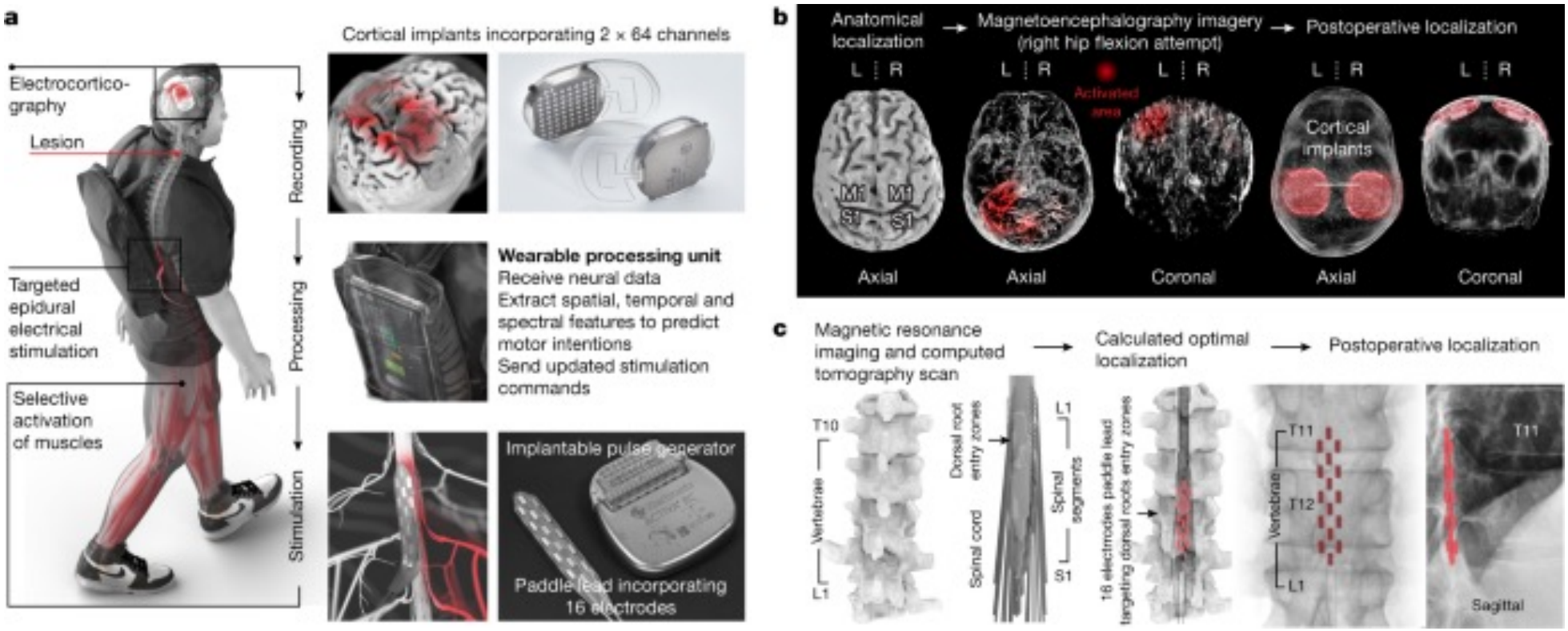


Neuroprosthetics: from sensorimotor to cognitive disorders




a) Deep Brain Stimulation for Parkinson's disease
Prefrontal cortex
Primary motor cortex (M1)
Supplementary motor area (SMA)
Thalamus
Globus Pallidus (GP)
Striatum
Substantia nigra pars compacta (SNc)
Subthalamic nucleus (STN)
b) Cortico - basal ganglia - thalamocortical circuit
Cortex
Sensory Input
Prefrontal cortex
SMA
M1
Motor output
Striatum
GPe
STN
Thalamus
SNc
GPi
Basal ganglia
Glutamatergic
GABAergic
Bidirectional connections
Hyperdirect Projections
Dopamine Projections
DBS targets

Walking naturally after spinal cord injury using a brain–spine interface



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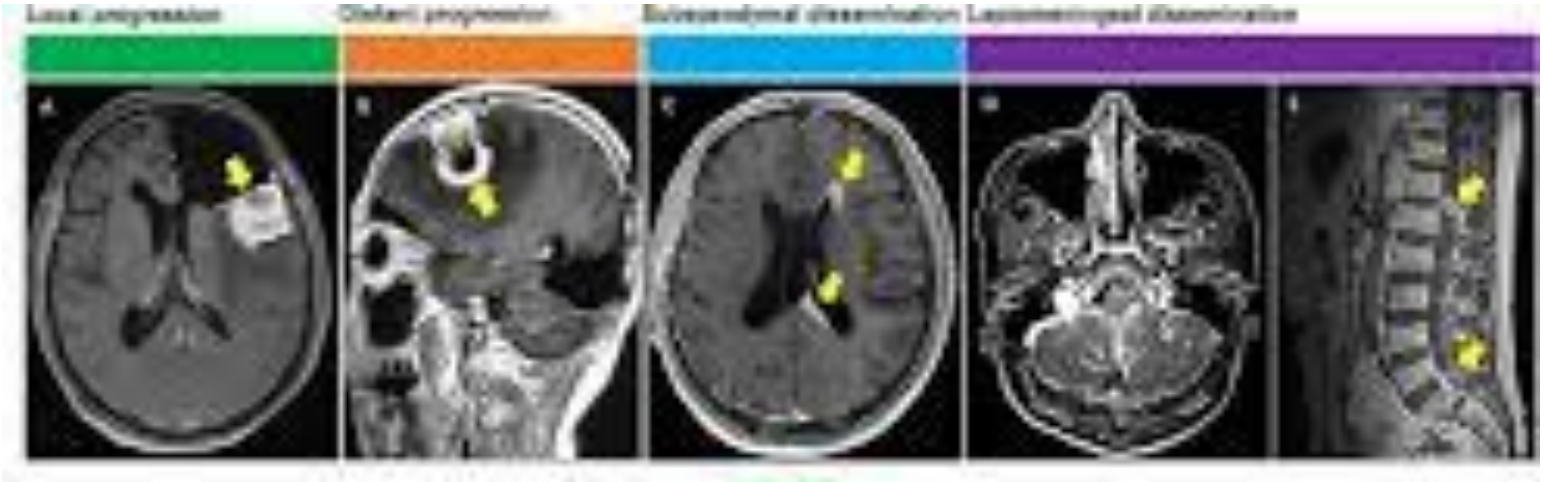
AI can predict the progression of a disease



Innovation through collaboration

Challenges and Questions

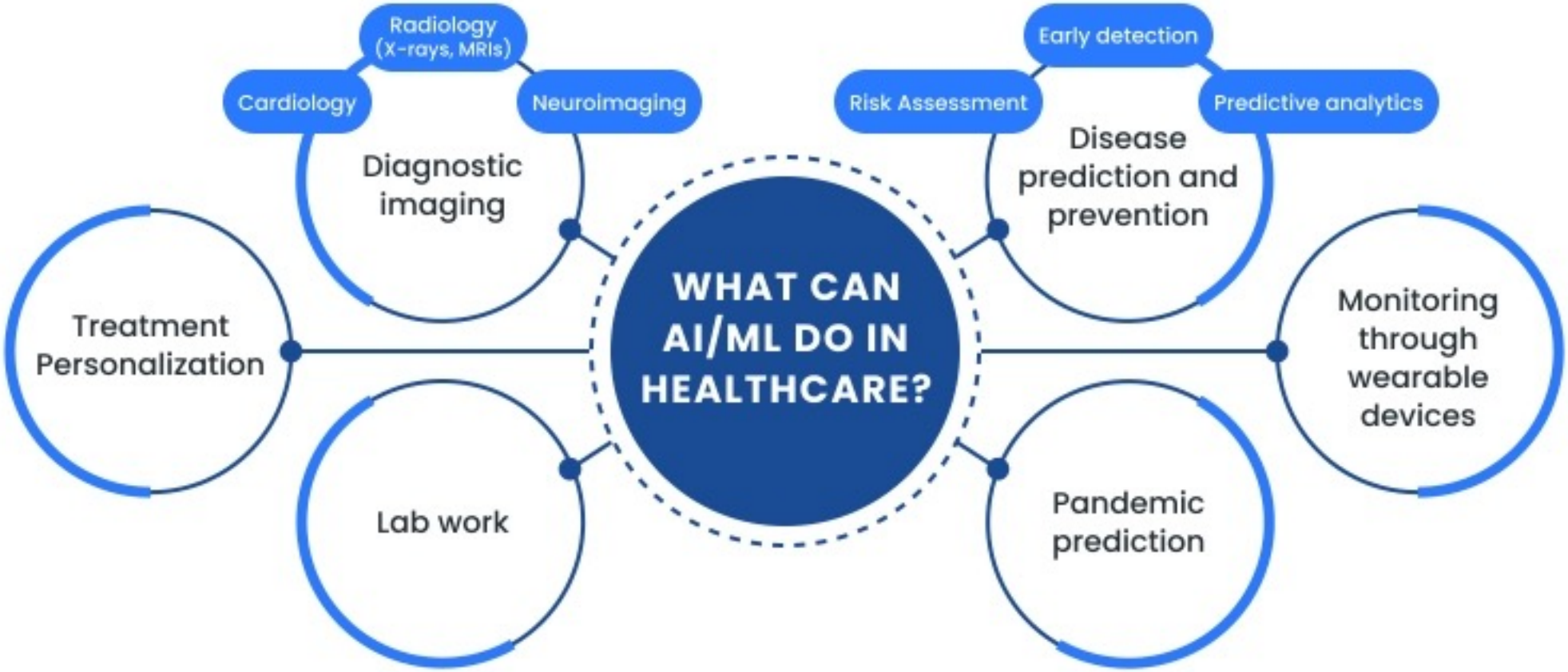
- How do we ensure the ethical use of AI in healthcare?
- What are the regulatory frameworks that need to be in place for the safe and effective use of AI?
- How do we measure the quality and accuracy of AI in healthcare?

Challenges and Ethical Considerations

data privacy,

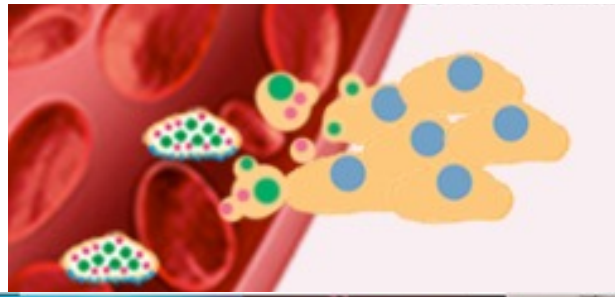
potential biases in datasets

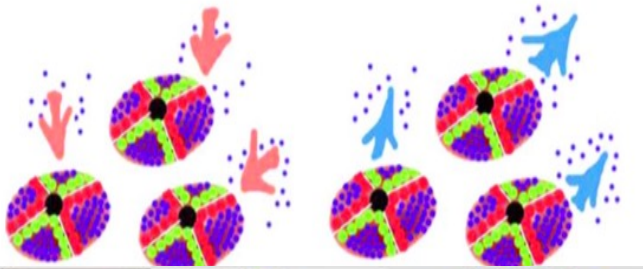
interpretability of algorithms,

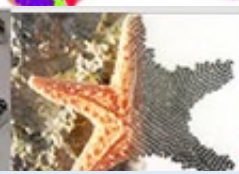


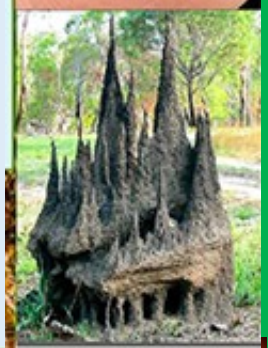
Note that!!

- AI may not replace human doctors.
- Since doctors are trained to not only diagnose and treat diseases but also to provide emotional support to patients.
- AI cannot replace the empathy and compassion that doctors bring to their work.









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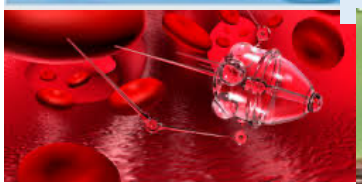
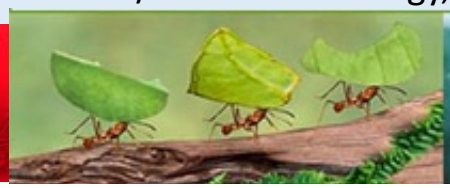
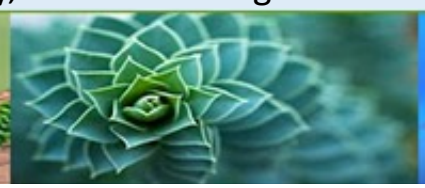
Research Interest:

Artificial Intelligence, Artificial Intelligence in Medicine, Complex Systems, Biomimicry, Cognitive Science, Swarm Intelligence, Nanomedicine, Targeted Drug Delivery, Early Detection of Disease, Swarm Nano Robotics, Cancer Research, Fuzzy Logic and Control, Soft Computing, Neural Networks, Machine Learning, Multi-agent Systems, Distributed Decision Making, Biomarkers, Biophysics, Nature Inspired Algorithms, Computational Cellular/Molecular Biology, Protein Folding







Artificial Intelligence for Good (AI for Good)