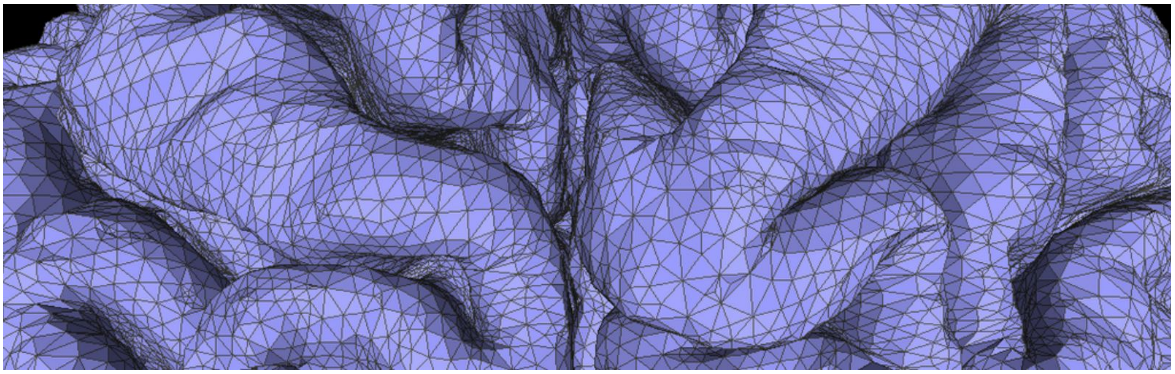


Where AI May Make the Biggest Impact in Healthcare

"There's a global shortage of radiologists.
2/3 of the planet's population - over 4 billion people -
have insufficient access to radiologists. AI can help that."

Andrew Ng, PhD, ML Group Director,
Adjunct Professor, Stanford University

On the entire continent of Africa, if you remove Egypt and South Africa, there are only 6 pediatric radiologists. In Nigeria there are fewer than 60 radiologists for 190 million people. In Mexico there are only about 4,000 radiologists for 130 million people. In Japan there are only 36 radiologists per million people. In Liberia there are only 2 radiologists. Fourteen African countries have no radiologists at all. One hospital in Boston, Massachusetts General Hospital, has 126 radiologists.

AI will help increase access to care in places where radiologists are inaccessible. AI has the potential to enable anyone with a smartphone to have access to healthcare. Researchers are working towards extending the reach of care outside of hospitals and clinics. This is especially important for people living in the developing world and for people working in remote environments such as the 4000 researchers from 40 countries working in Antarctica and the crew on the International Space Station in orbit 250 miles above earth.

Using AI will also help improve workflow and efficiency especially in publicly-funded healthcare systems. Its estimated that in the UK over 300,000 radiographs wait over 30 days to be read by a radiologist. Using AI will greatly reduce delays in identifying and acting on abnormal medical images. This is especially important in chest and brain imaging where time is critical. 40% of all diagnostic imaging performed worldwide are images of the chest.

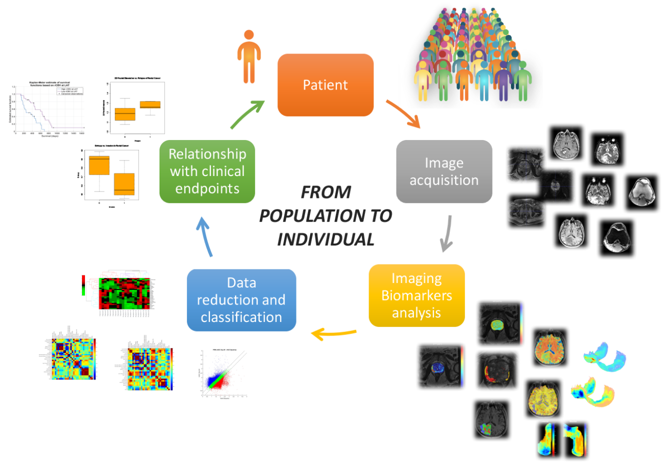
Automated assessments by algorithm are more reproducible and less subjective than human assessments. This could reduce variation and alleviate the sense of subjectivity and inconsistency. According to a paper published in The American Journal of Surgical Pathology, Google's AI powered Lymph Node Assistant LYNA can detect breast cancer metastasis with 99% accuracy. Human pathologists miss metastases as much as 62% of the time but AI algorithms evaluate exhaustively resulting in extremely high accuracy.

In study after study, AI algorithms are more effective and efficient at identifying disease than human experts. AI algorithms can read images in less time (minutes vs. hours) with higher accuracy (up to 99% in some cases). Soon every medical imaging machine will be connected to the cloud where AI algorithms will analyze data and help human doctors screen, assess, and diagnose patients. The potential impact of implementing AI to analyze medical images is huge. Two years ago, AI had already started outperforming human experts. This article is about recent advances and current progress in AI in medical imaging.

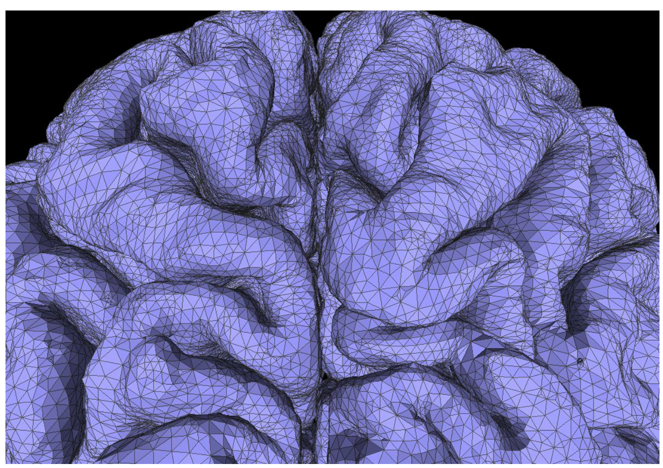
> Over 90% of healthcare data comes from medical imaging and more than 97% of medical images are not analyzed.
>
> GE Healthcare, Beyond Imaging

The AI-PHI

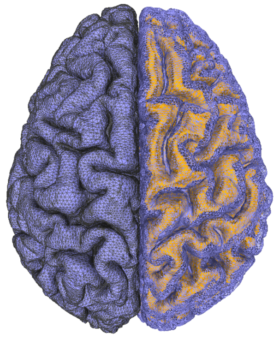
The world's first AI Precision Health Institute at the University of Hawai‘i Cancer Center uses AI to analyze medical images to assess health and predict risk of disease. Recently the AI-PHI partnered with QUIBIM a top tier AI company based in Spain. The AI-PHI is using the QUIBIM Precision Platform to centrally manage, store and quantitatively analyze medical images and algorithms. They are creating large scale imaging repositories with automated extraction of imaging biomarkers to characterize patients status. The QUIBIM platform will be the central repository for the AI-PHI's mammography studies which over time will include mammograms from over 5 million women on 5 continents. The AI-PHI will also use QUIBIM to integrate AI algorithms to detect cancer without the need of radiologists in a first-read.



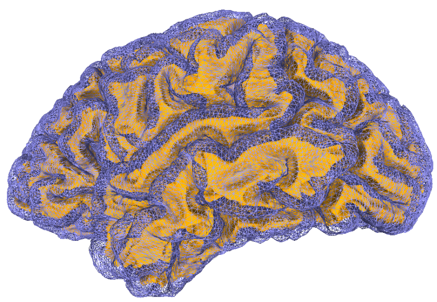
QUIBIM applies AI enhanced methodologies to detect changes produced by diseases and drug treatments and provides accurate quantitative information to doctors, clinicians and researchers. QUIBIM has developed AI algorithms for many types of cancer including brain, breast, and prostate, as well as non-Hodgkin's Lymphoma, and other diseases. The following images of human brains and lungs have been analyzed using QUIBIM's AI algorithms. Next to each image is a short description showing how the AI analysis helps doctors assess, diagnose and treat patients.



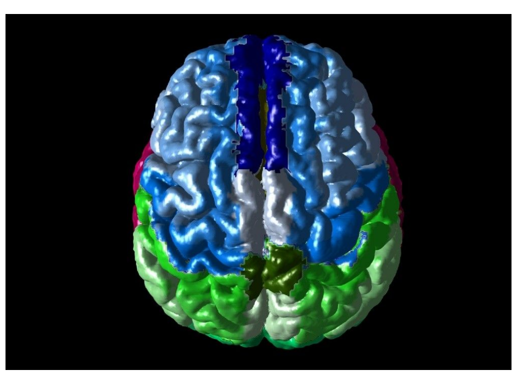
This is a close-up image of human brain sulci, reconstructed in 3D after processing a T1 MRI brain scan with QUIBIM Precision platform. This allows us to extract volumes from different brain regions and calculate the thickness of the gray matter cortex. With the surface extraction of gray matter, we can analyze important aspects such as neuronal density and gray matter thickness which are related to neurodegeneration. Since many neurodegenerative diseases occur as a result of these processes, this analysis can help to diagnose diseases such as Alzheimer's, Multiple Sclerosis, Parkinson's, and Amyotrophic Lateral Sclerosis.



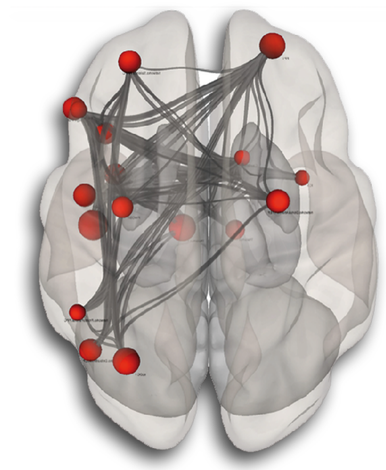
This is a superior view of a human brain, reconstructed in 3D after processing a T1 MRI brain scan with QUIBIM Precision platform. Gray matter in the right hemisphere has been made transparent to visualize white matter in orange. This allows us to extract volumes from different brain regions, including white matter regions and calculate the thickness of the gray matter cortex. This can help to diagnose several neurodegenerative diseases such as Alzheimer's, Multiple Sclerosis, Parkinson's, and Amyotrophic Lateral Sclerosis.



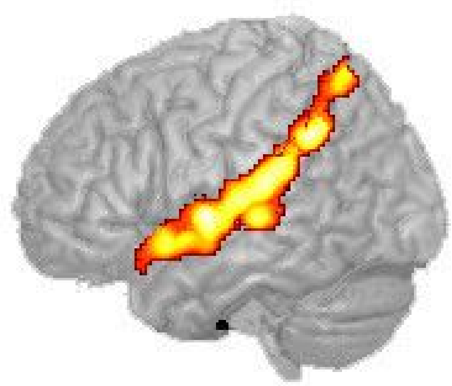
This is a lateral view of a human brain, reconstructed in 3D after processing a T1 MRI brain scan with QUIBIM Precision platform. Gray matter in this hemisphere has been made transparent to visualize white matter in orange. This allows us to extract volumes from different brain regions, including white matter regions and calculate the thickness of the gray matter cortex. This can help to diagnose several neurodegenerative diseases such as Alzheimer's, Multiple Sclerosis, Parkinson's, and Amyotrophic Lateral Sclerosis.



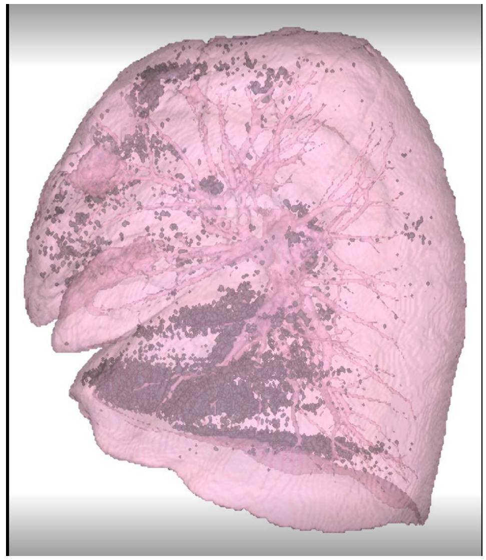
This is a superior view of a human brain, reconstructed in 3D after processing a T1 MRI brain scan with QUIBIM Precision platform. Colors of gray matter are related to different brain regions, after the application of an anatomical atlas. This allows us to extract volumes from different brain regions and study abnormal volumes when compared to age and gender. This can help to diagnose several neurodegenerative diseases such as Alzheimer's, Multiple Sclerosis, Parkinson's, and Amyotrophic Lateral Sclerosis.



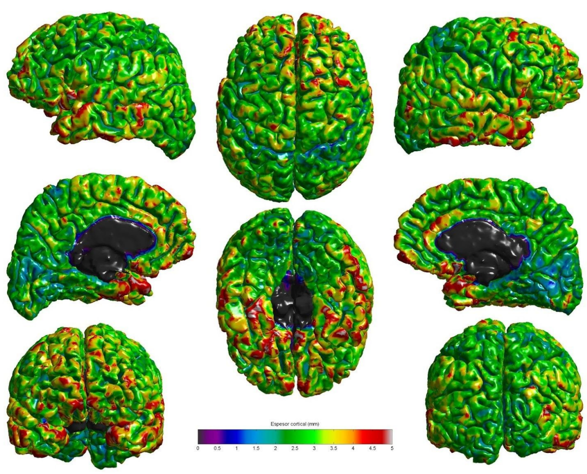
This is the result of a functional analysis of a human brain while the person is in a resting state. Functional MRI allows us to detect how brain regions activate in similar patterns when resting, activating the default mode network. This methodology was recently applied by the QUIBIM team to brain stroke patients in acute phase. In this study, a functional connectivity pattern was detected which allowed us to predict which patients would have a bad functional outcome after three months. This information helps clinicians to make important decisions in terms of alternative treatments.



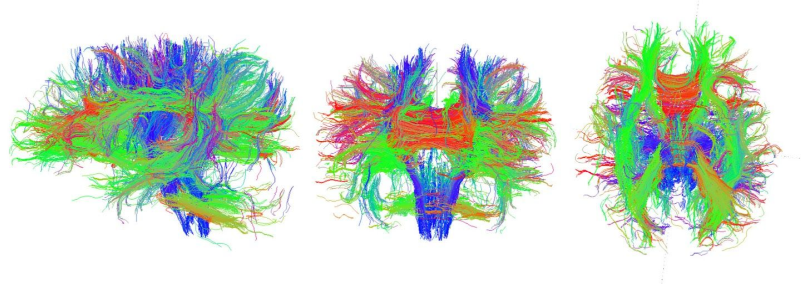
This is a visualization of brain activated regions after the application of auditory stimuli when performing a functional MRI examination. This image was created after detecting which brain voxels had a significant signal correlation with the input activation-rest paradigm. This allows psychiatrists to evaluate abnormal activations in diseases like schizophrenia.



This is a lateral view of a human lung reconstructed in 3D, showing some concentrations of lung emphysema. This was obtained after applying AI segmentation algorithms to Computed Tomography images. The information extracted is synthesized in the emphysema percentage and in the 15th percentile of lung densities. These imaging biomarkers allow pneumologists to diagnose and monitor treatment in COPD patients.



These are all views of a human brain reconstructed in 3D after processing T1 MRI images. The cortical thickness was calculated and it has been plotted on the surface. Red colors illustrate gray matter regions with a high thickness while blue-purple colors express a decreased cortex thickness in a specific point.



These are sagittal, coronal and axial view of white matter fiber bundles after the analysis of Diffusion Tensor Imaging MRI images by the application of a tractography algorithm. Red colors indicate fibers orientation in right-left direction, blue color indicates inferior-superior orientation, and green anterior-posterior fibers orientation.

> "Usually, we see AI algorithms that can detect a brain hemorrhage or a wrist fracture — a very narrow scope for single-use cases. But here we're talking about 14 different pathologies analyzed simultaneously, and it's all through one algorithm."
>
> Matthew Lungren, MD, MPH, Professor of Radiology, Pediatric Radiology, Stanford University Medical Center

Recent Advances

- In a study at Stanford one algorithm named CheXNeXt read chest X-rays for 14 different pathologies. In this study the algorithm matched expert radiologists in accuracy and was much more efficient. The radiologists took an average of 4 hours to read an image, the algorithm read them in less than 2 minutes with the same level of accuracy.

- In China, NovaVision Group used AI to screen for over 1,000 diseases by analyzing one image of the eye. They are able to find disease with 97% accuracy.

- Researchers at University of Warwick have developed an AI algorithm that can reduce the processing time for abnormal chest X-rays from 11 days 3 days. The study "Automated Triaging of Adult Chest Radiographs with Deep Artificial Neural Networks," was published in Radiology on Jan 22 2019.

- In a study, published in Radiology, AI was able to detect Alzheimer's disease in brain scans 6 years prior to diagnosis with 98% accuracy. Radiologists have used brain scans to try to detect Alzheimer's by looking for reduced glucose levels across the brain. However, because the disease is a slow progressive disorder, the changes in glucose are very subtle and difficult to spot with the naked eye.

- In this study on cervical cancer by the National Cancer Institute's Division of Cancer Epidemiology and Genetics, AI was more accurate at identifying pre-cancer than a human expert reviewer of Pap tests under the microscope. The AI performed better than all standard screening methods at identifying cases of cervical cancer.

- Researchers at Osaka University used AI to analyze microscopic images to identify cancer cell types. Using a convolutional neural network based system they were able to automatically distinguish between different types of cancer cells. Being able to accurately identify cancer cells helps doctors choose the most effective treatment.

- In a study led by researchers at UCSF and Mayo Clinic, computers equalled radiologists in assessing breast cancer risk. This study was published May 1, 2018, in the Annals of Internal Medicine.

- CardioLogs is a Paris-based startup building deep learning algorithms to analyze ECGs. Emergency room doctors used Cardiolog's algorithm and it outperformed the conventional algorithm for emergency department electrocardiogram interpretation.

- Google has developed an AI system that can grade prostate cancer cells with 70% accuracy. This is important because human pathologists who grade prostate cancer cells disagree up to 53% of the time. According to the paper Development and Validation of a Deep Learning Algorithm for Improving Gleason Scoring of Prostate Cancer, the AI was 70% accurate whereas human pathologists were only 61% accurate.

- Scientists at Stanford have developed a deep learning algorithm that can diagnose 14 types of heart rhythm defects, called arrhythmias, better than cardiologists. The algorithm, detailed in an arXiv paper, performs better than trained cardiologists, and has the added benefit of being able to sort through data from remote locations where people don't have access to cardiologists.

- Researchers at USC applied machine learning to measure changes linked to cardiovascular disease. Their study was published in Nature Scientific Reports.

- In a study published in Clinical Cancer Research, deep learning was used to analyze a large set of mammograms to distinguish images with malignant diagnosis from benign lesions. Deep learning distinguished recalled-benign mammograms from malignant and negative images. This study showed that there are imaging features unique to recalled-benign images that deep learning can identify to help radiologists in decision making to help reduce unnecessary recalls.

- Researchers at the Lawrence J. Ellison Institute for Transformative Medicine are developing a platform leveraging machine learning to analyze tissue samples to diagnose breast cancer and assess response to treatment.

- Samsung has applied its AI algorithms to assist diagnosis in each of its imaging modalities increasing the accuracy of diagnosis from 83% to 87% for doctors with four years or less experience.

- A team at Stanford University used deep learning convolutional neural networks to reduce the dosage of gadolinium, a heavy metal used in contrast material for MRI that is often left in the body after an MRI exam.

- In Mexico they are using an AI solution by Lunit INSIGHT for chest radiography and mammography. It has an accuracy level of 97-99% for chest x-rays and and 97% for mammography.

- Zebra Medical Vision AI algorithms help identify patients at risk of osteoporotic fractures and AI algorithms to help identify patients at risk of cardiac events.

- In November 2018, the FDA cleared MaxQ AI Accipio Ix intracranial hemorrhage detection software. This software uses AI to detect brain bleeds.

- In April 2018 the FDA approved marketing of the first medical device to use AI to detect the eye disease in adults who have diabetes. The software uses an AI algorithm to analyze images of the eye.

- The NIH and Nvidia are developing AI tools to support clinical trials. The AI tools will provide precision medicine to patients with brain and liver cancers.

- A team at Stanford developed an AI algorithm to help radiologists accurately diagnose MRI scans of knee injuries. Doctors diagnosed fewer false positives using the algorithm.

- Bayer and Merck have won a breakthrough device designation from the FDA for software they are jointly developing. The software uses AI to analyze image findings from cardiac, lung perfusion and pulmonary vessels.

- Researchers at Imperial College London and Bayer Pharmaceuticals have formed a partnership to research using machine learning to analyze 3D heart imaging, genetic information, and health data to accelerate drug discovery for heart disease.

- A team at Massachusetts General Hospital in Boston is using AI to diagnose and classify brain hemorrhages using small image data sets. This AI system is as accurate in detecting and classifying intracranial hemorrhages as human radiologists.

- The FDA has cleared IDx-DR, an AI diagnostic system used at the University of Iowa Hospitals and Clinics to AI to analyze images of the retina for signs of diabetic retinopathy. When the AI detects signs of diabetic retinopathy, the AI recommends a follow-up with an ophthalmologist. If it detects no signs of the condition, the system recommends a follow-up screening in one year. Another AI based diagnostic system for detecting of diabetic retinopathy, detailed in Nature, achieved 87.2% sensitivity and 90.7% specificity in the detection of diabetic retinopathy.

This article was written by Margaretta Colangelo, Ángel Alberich-Bayarri PhD, and John Shepherd, PhD.

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Ángel Alberich-Bayarri, PhD is Founder and CEO of QUIBIM. Dr. Alberich-Bayarri is a leading expert worldwide in the application of AI to medical images and the development of algorithms for Imaging Biomarkers. He is a member of the board of the European Society of Medical Imaging Informatics and of the e-Health and Informatics

Subcommittee of the European Society of Radiology. Dr. Alberich-Bayarri is author of more than 40 publications in the field of imaging biomarkers, author of 13 book chapters and editor of one book on Imaging Biomarkers. He received the MIT Innovators Under 35 award in 2015. He is based in Spain.

John Shepherd, PhD is Founder and Director of the AI Precision Health Institute. Dr. Shepherd is known worldwide for his expertise in quantitative X-ray imaging using ML and the use of AI and DL to extract more cancer risk information from various forms of medical imaging including dual-energy X-ray absorptiometry, digital mammography, tomosynthesis, MRI, and 3D optical images. He has over 200 peer reviewed papers and has been cited in other publications over 10,000 times. He is based in Hawaiʻi .

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