

# Medical AI solutions for bone disease expertise

Enhancing the medical expert



# Our Vision and Strategy

- **Our vision:**

Global leader in image analysis algorithms for orthopedics

- **Strategy:**

Focus on deployment of useful AI to Doctors and Researchers

- **Goal:**

First algorithm FDA approved next year

# | Where is Medical AI today?

“ I predict that within 10 years no medical imaging study will be reviewed by a radiologist until it has been **pre-analyzed by a machine.** ”

President of Radiology association (RSNA)  
Dr. Rick Bryan,  
May 2016

“ Man is the lowest cost, 150 pound, nonlinear, all-purpose **computer system** which can be mass-produced by unskilled labor.

”

NASA 1965, man in space report

# AI for Medical Diagnosis just now maturing

First AI diagnosis FDA approved 11.04.18

 U.S. Department of Health and Human Services

 **U.S. FOOD & DRUG  
ADMINISTRATION**

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S to

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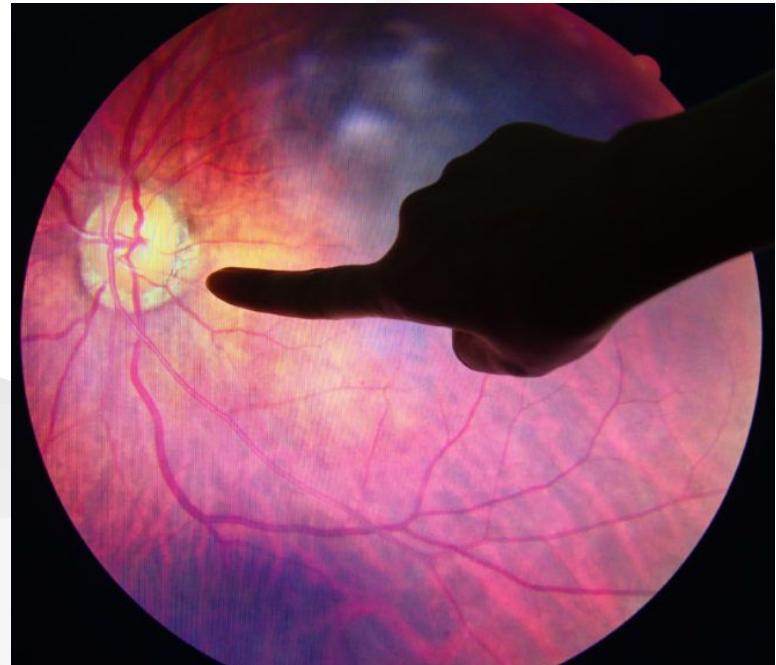
Home > News & Events > Newsroom > Press Announcements

FDA News Release

## FDA permits marketing of artificial intelligence-based device to detect certain diabetes-related eye problems

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For Immediate Release April 11, 2018





+ our FDA  
approved  
Tensorflow  
Model

# AI driven Diagnostics

Lots of problem - each on its own hard to solve



Cercare Medical

4Quant



ai analysis inc.

aидoc



CORSTEM



## Choose a combination:

1. Modality:
  - MRT
  - CT
  - X-Ray
  - Ultrasound
2. Body region
3. Type
  - Diagnosis
  - Measurement
  - Anomaly detection
  - Workflow

# | Our focus: Bone Disease on X-Rays

# Bone diseases are debilitating

Osteodystrophy Multiple Imperfecta fractures hyperostosis  
Osteochondroma Spurs Osteomalacia Hereditary prosthetics Fibromatoses  
condensas Condensing Greenstick Chondromyxoid  
Desmoid Nail-patella

Fibrodysplasia Fracture Osteoma Osteomyelitis cystica cell Ambe  
Extra-Abdominal knee Dysplasia pubis Enchondroma Osteoarthritis  
Osteopenia Paget's myeloma Arthritis spur Osteochondritis  
Giant Osteopetroses Renal

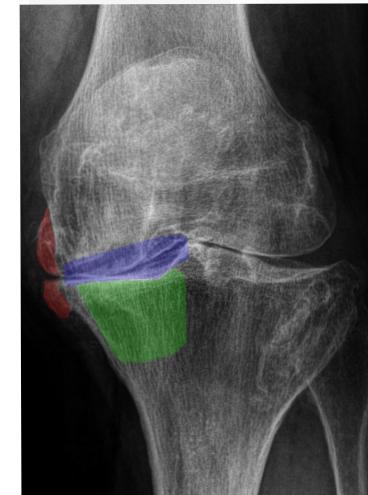
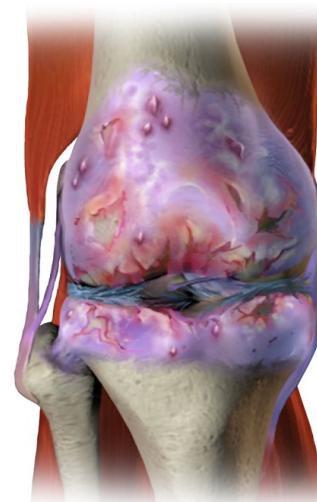
Osteonecrosis Porotic Osteopetrosis  
necrosis Fibrous Gout fibrosa Osteogenesis cancer  
deformans Primary hyperparathyroidism Chondroblastoma  
Dissecans progressive Tumor Tumors

Hypophosphatasia Salter-Harris Fibroma Metabolic Von Osteoporosis  
Osteoid Tumors  
Scoliosis Klippel-Feil Craniosynostosis Disease  
Avascular ossificans exostoses Aggressive

An ageing population demands new solutions!

# Osteoarthritis (OA): a degenerative joint disease

- Affects 15% of population
- Greatest cause of disability
- 3.5 B\$ burden on society

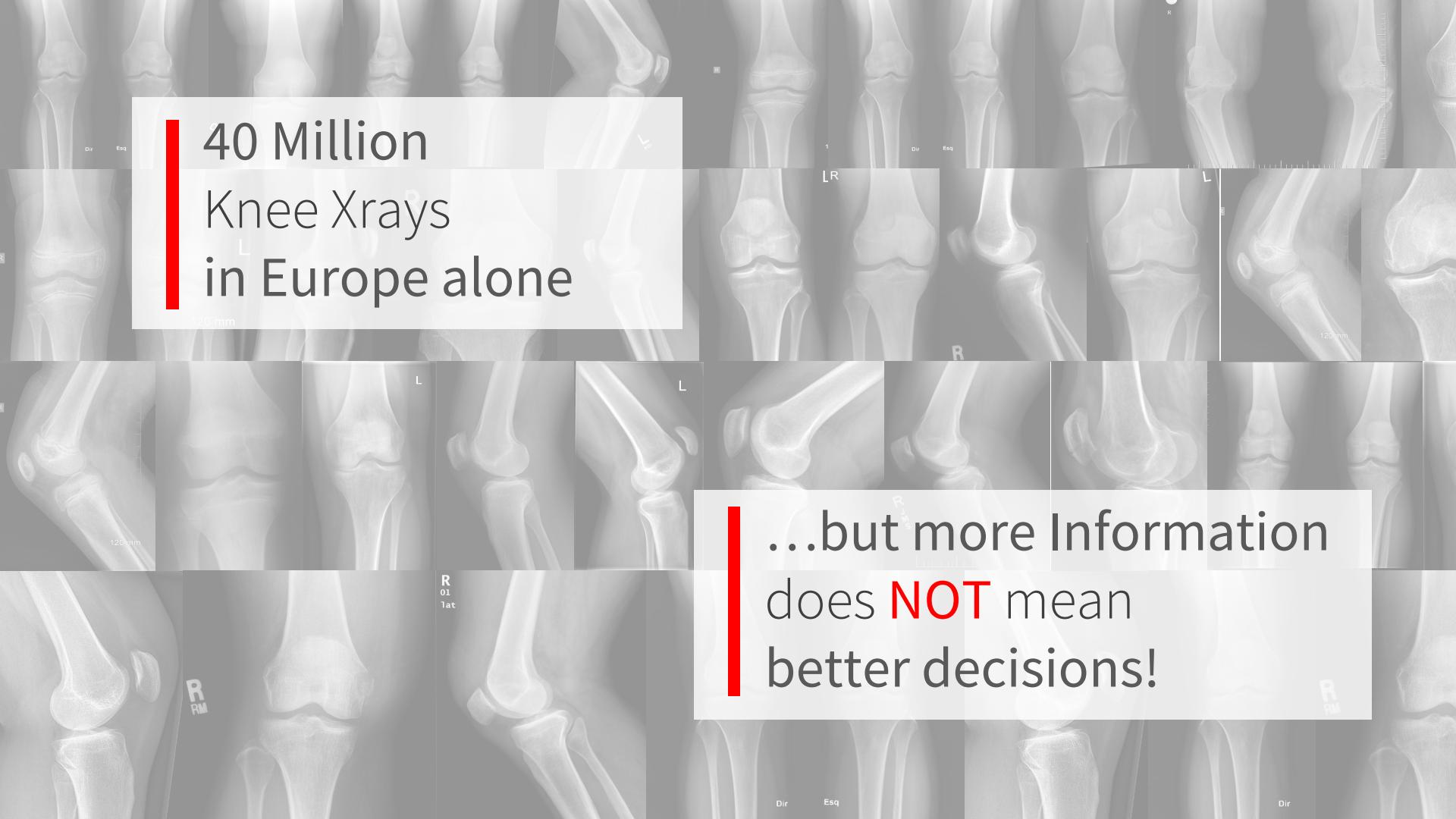


## Early diagnosis is crucial for patients

# Early diagnosis can stop progression

Difficult to assess early stage





40 Million  
Knee Xrays  
in Europe alone

...but more Information  
does **NOT** mean  
better decisions!



More images, more errors (+16%\*)

\*American College of Radiology, Vol 12, Issue 9, Sept 2015



Automated image analysis  
saves time **and** enables  
better decisions!

# Introduced 2018: IB Lab Analyzer™

standardized real-time knee-OA imaging biomarker



Automated

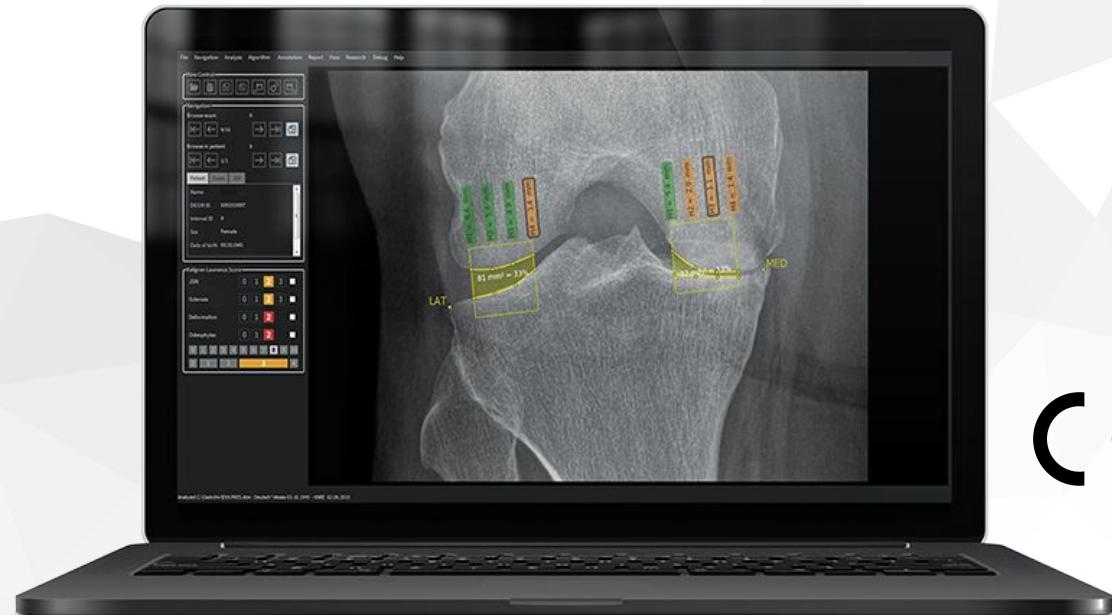


Standardized



Real-time

1 sec vs 6 min



# Better comparison and care

## Automated Clinical Decision Support

**Software supported assessment of Osteoarthritis based on Kellgren & Lawrence\***

(cf. Kellgren J. H., Lawrence J. S., Radiological assessment of osteoarthritis. Ann Rheum Dis, 1957, 16, 492-501)

**PATIENT DATA**

Patient Name	KneePat_20142527
Patient ID	5
Date of Birth	11.07.1936
Height (cm)	0
Sex	F
Weight (kg)	0

**EXAM DATA**

Study ID	S
Date of Capture	30.01.2013
Laterality	L
Instrument	Knee Studie
Analyst	ak
Device Type	Fluorospot Compact FD

**KNEE OSTEOARTHRITIS STATUS**

<b>SCLEROSIS</b>	<b>JSW</b>
<b>1</b>	<b>3</b>
0 = none 1 = mild 2 = moderate 3 = severe with cyst formation	0 = no visible narrowing 1 = slight narrowing 2 = definite narrowing 3 = joint space collapsed

<b>DEFORMATION</b>	<b>OSTEOPHYES</b>
<b>2</b>	<b>2</b>
0 = none 1 = slight 2 = obvious	0 = none or doubtful 1 = slight 2 = big

**KELLGREN & LAWRENCE SCORE TOTAL: 8**

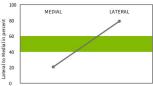
**MEASURED JOINT SPACE WIDTH (JSW)**

	MEDIAL	LATERAL
H1 (mm)	0.7	5.1
H2 (mm)	1.9	8.2
H3 (mm)	3.0	10.3
H4 (mm)	4.2	13.4



**MEASURED JOINT SPACE AREA (JSA)**

	MEDIAL	LATERAL
JSA (mm²)	41.7	157.6
Distribution (%)**	22%	79%
JSA (ROI) (%)***	34%	55%



**PHYSICIANS REMARKS**

**\*Kellgren & Lawrence Score**

The KLS is a scoring system to classify Osteoarthritis (OA) from X-ray images. This classification has been commonly used in clinical practice to grade the severity of OA. It provides a reference for healthcare providers with a treatment algorithm to guide clinical decision-making. In this method the X-ray image is examined by using four distinct parameters. These parameters are as follows: Osteophytes, Sclerosis, Deformity and Joint space width.

Each parameter is scored independently. The total score of all parameters defines the OA-grade. The following table displays the grading system:

**Kellgren & Lawrence Score Board**

Parameter	Result	Score (Points)
Osteophytes	None or doubtful	0
	Obvious	1
	Obvious and big	2
JSW	Not narrowed or doubtful narrowed	0
	Obvious narrowed	1
	Progressed narrowed	2
Sclerosis	Joint space partially collapsed	3
	No sclerosis	0
	Mild sclerosis	1
Deformity	Mild sclerosis with cyst formation	2
	Sclerosis with cyst formation	3
	No deformity	0
Deformity	Weak deformity	1
	Obvious deformity	2

After each parameter has been graded, the addition of all four single scores leads to the total score and grade of OA. There are five grades of OA which are defined by the total score that ranges from 0 to 10 (see table below).

**Kellgren & Lawrence Grade**

Grade	Total Score	Description
0	0	No signs of OA
1	1-2	Doubtful narrowing of joint space and possible osteophytic lipping
2	3-4	Definite osteophytes, definite narrowing of joint space, mild sclerosis
3	5-9	Moderate multiple osteophytes, definite narrowing of joint space, mild sclerosis with cyst formation and weak deformity of the bone
4	10	Big osteophytes, definite narrowing of joint space, severe sclerosis and definite deformity of the bone

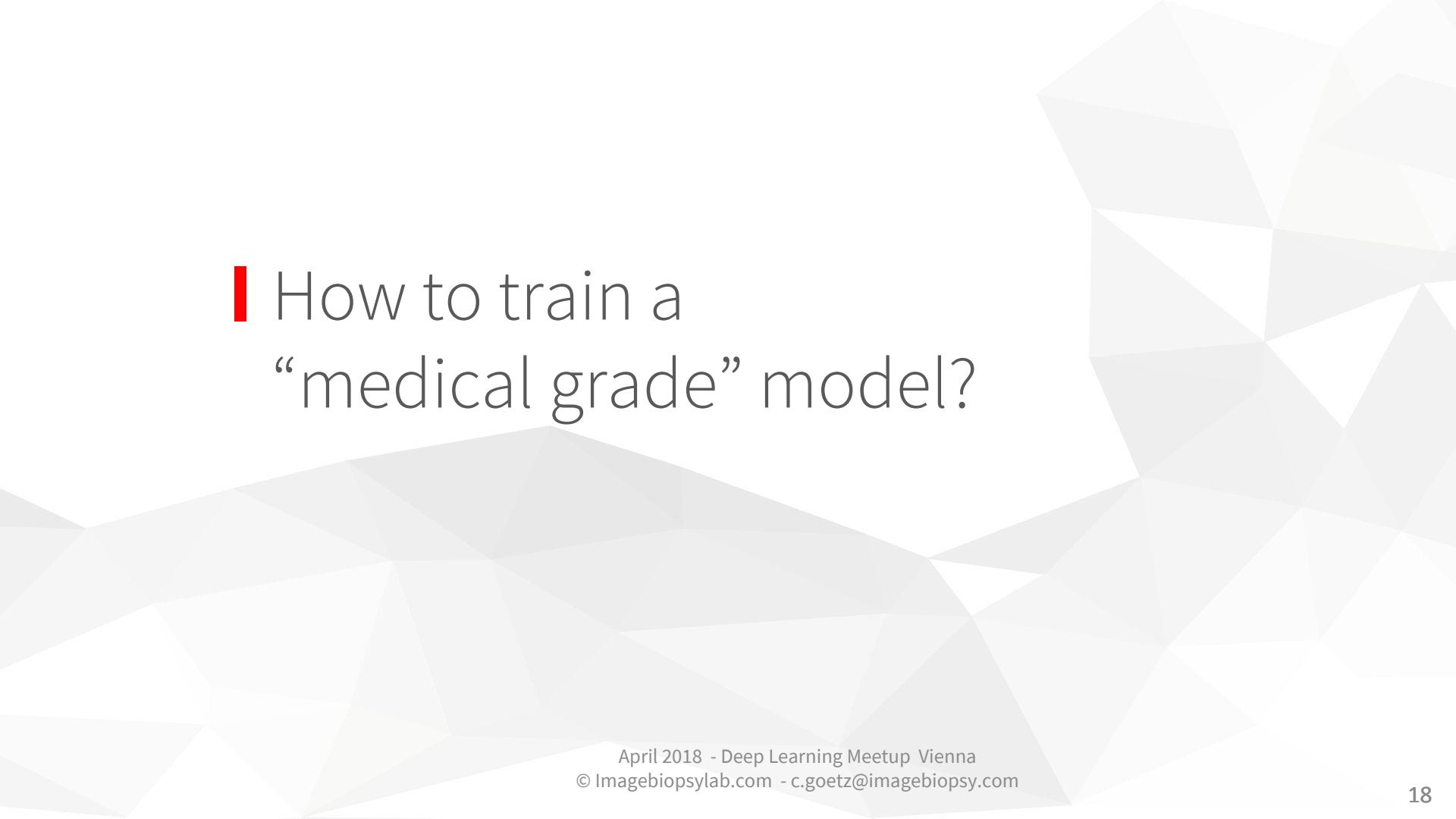
\*Lateromedial proportion of the measured total joint space area in percent. This allows a quantitative assessment of joint space area changes.

\*\* Proportion of the measured joint space area in comparison to the total lateromedial JSa area. The size of the JSa bows is proportional to the width of the tibia. This allows a direct comparison of knees of different widths (for example a comparison between men and women).

**Image biopsy lab**  
www.imagebiopsy.com

Image biopsy lab V 1.1229914 v3254.2

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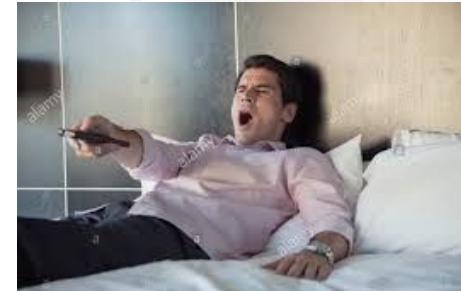
# I How to train a “medical grade” model?

# The problem

Death by overfitting

**NETFLIX**

Wrong prediction



Wrong prediction



# Why so difficult?

Death by overfitting

Few images, low information content

Ambiguous labels,  
domain expertise needed

Hard to obtain data

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Precise and robust medical benefit

Quick, local inference on CPU

You can prove you won't kill anyone

# Why so difficult?

Death by overfitting

Few images, low information content

Ambiguous labels,  
domain expertise needed

Hard to obtain data



# Training AI on X-Rays is challenging

Limited image information, small numbers of images, ambiguous labels

## Normal Images

- Rich in features, RGB, 2D
- Pretrained Models
- Huge annotated databases,  
easy to label



# Training AI on X-Rays is challenging

Limited image information, small numbers of images, ambiguous labels

## Medical X-Ray

- Featureless, Grayscale, 3D→2D
- Transfer learning challenging
- Restricted access to few images,  
labels only by experts



Agreement Rate  
for image grading  
among physicians\*:

30%

Limited use of X-rays for disease  
management and treatment decisions

\*Based on a classification according to Kellgren & Lawrence scoring, 600 x-rays, 2 groups of 2 orthopedics and 3 radiologists



# How to succeed: AI + feature engineering

Divide and conquer: Ensure local training and diagnosis

Object detection +  
Landmarking



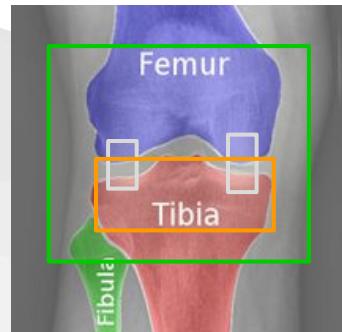
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Segmentation and  
Bounding boxes



Patent in US/GB/GER/FR

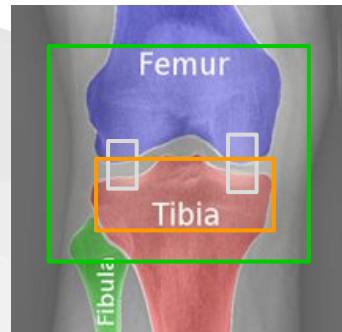
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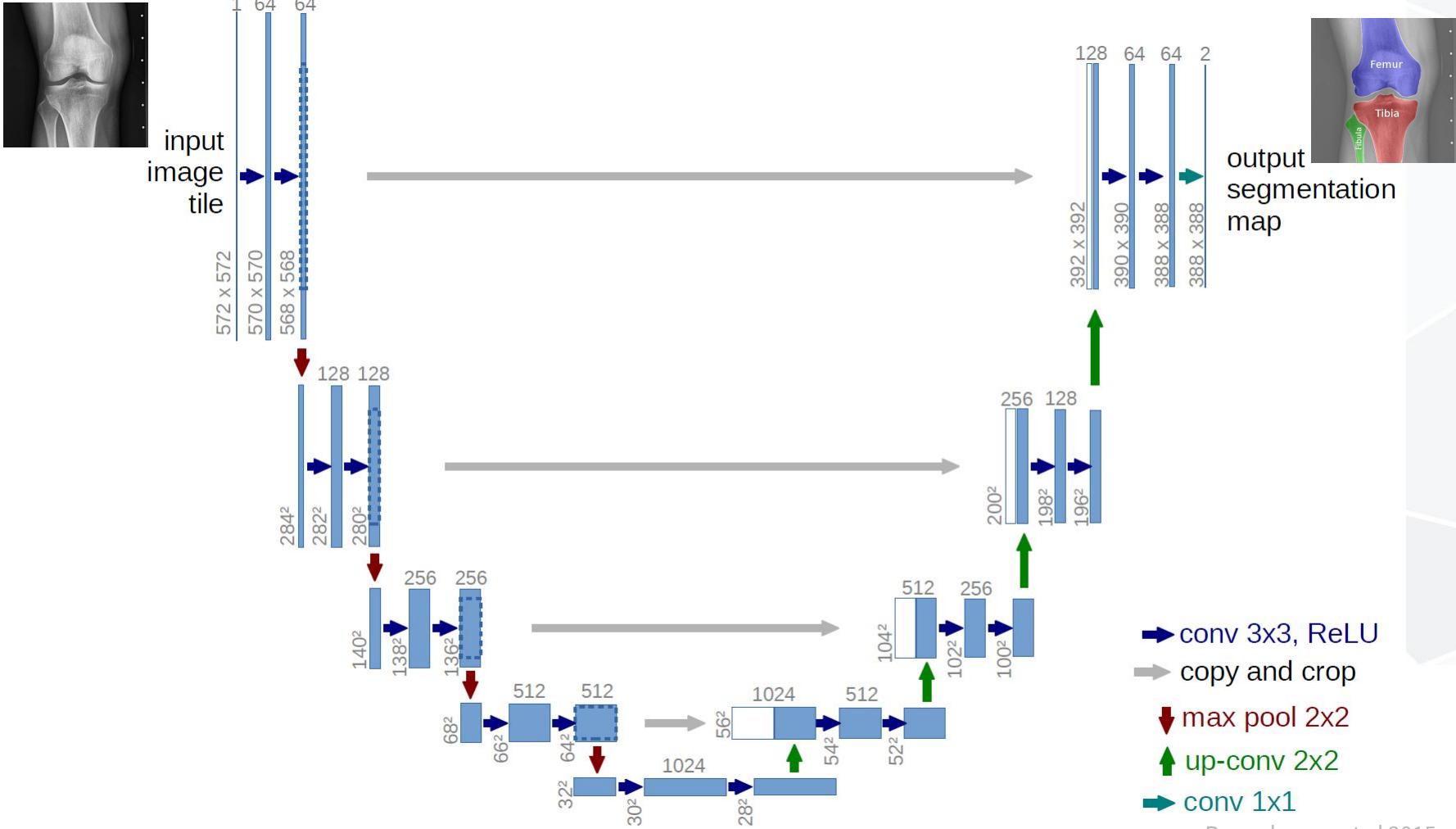


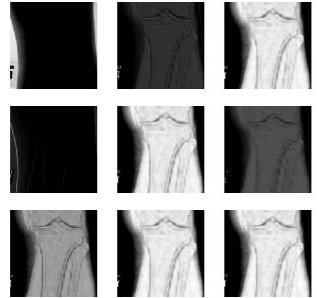
Patent in US/GB/GER/FR

For each sub-problem:  
custom networks,  
features and losses

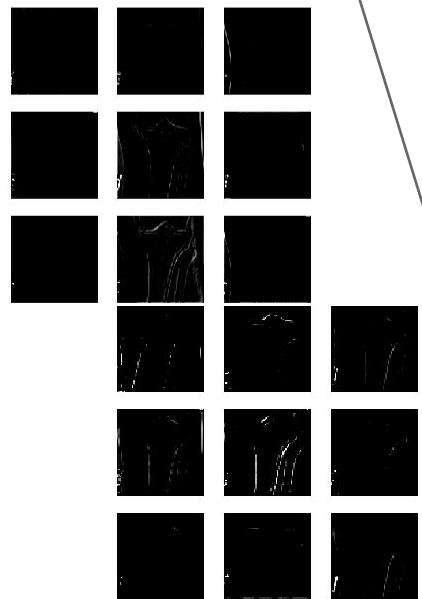
- Redundancy
- Ensembles
- custom losses
  - minimize disagreement
  - Dice-score

# I Common Architectures

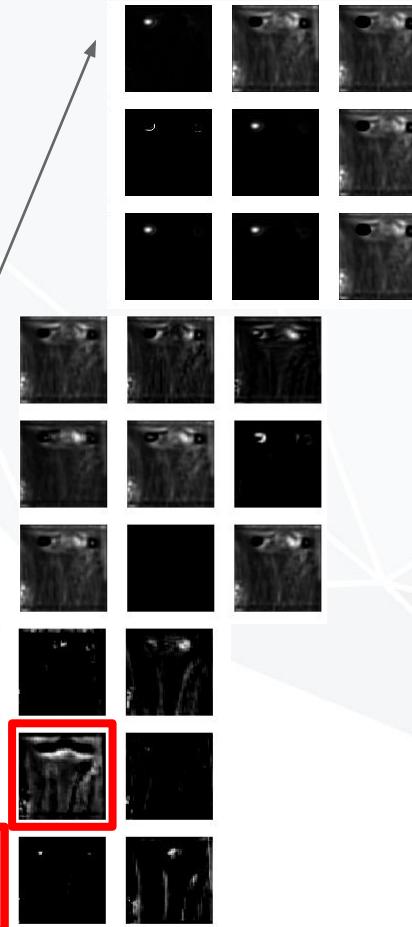




Local detail



Abstraction,  
context



# Anomaly Detection

Training a network to detect **unhealthy** things ONLY



Really good at spotting everything **healthy** as anomaly

# Tensorflow model =! Medical AI Product

Sadly not enough



AI / Computer Vision

**Medical AI  
Product**

# | How to make a Product?

# Interdisciplinary expertise needed for Medical AI

High market-entry barriers, high returns



Medical Expertise

**Medical AI  
Product**

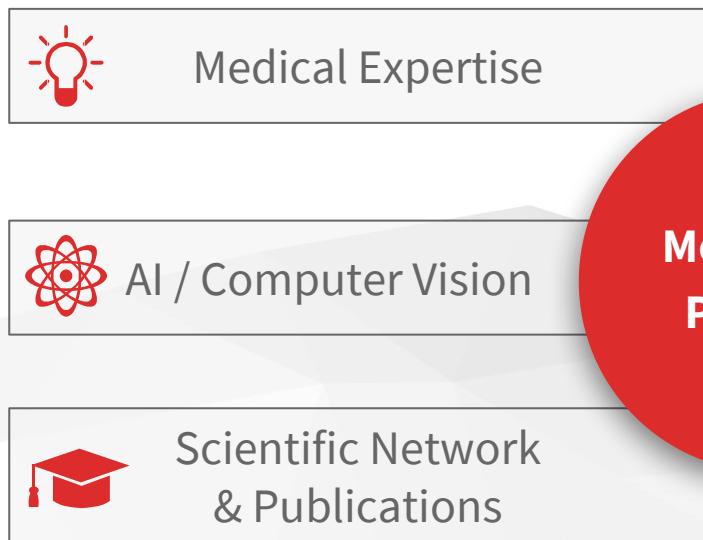
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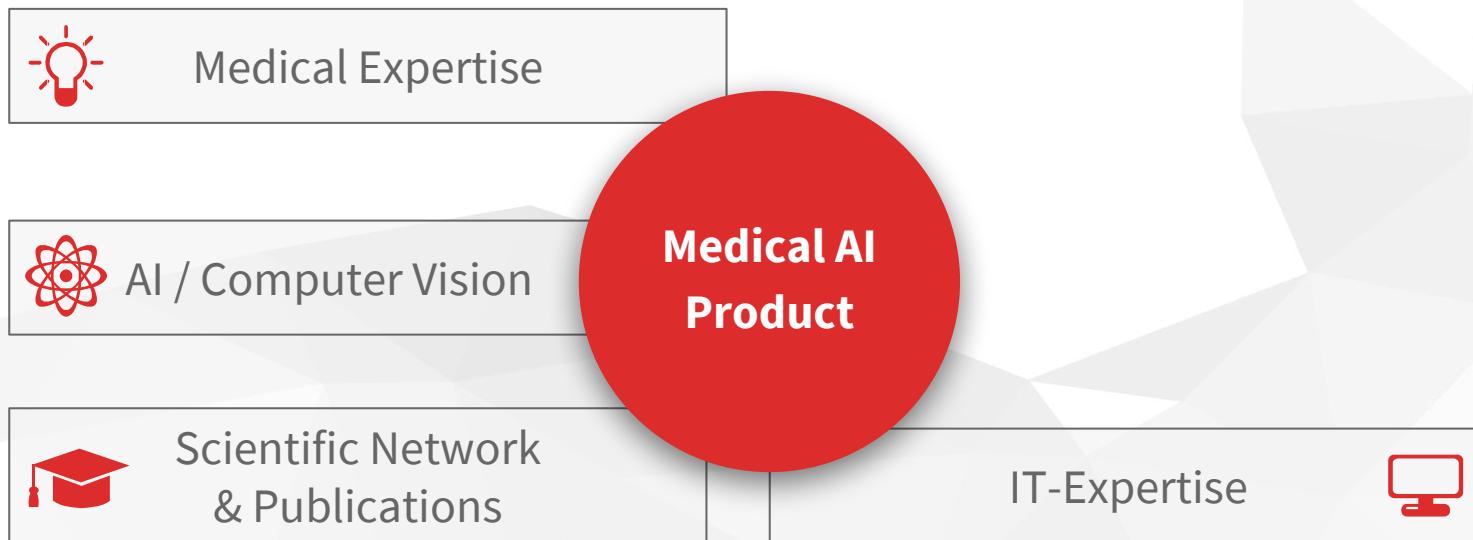
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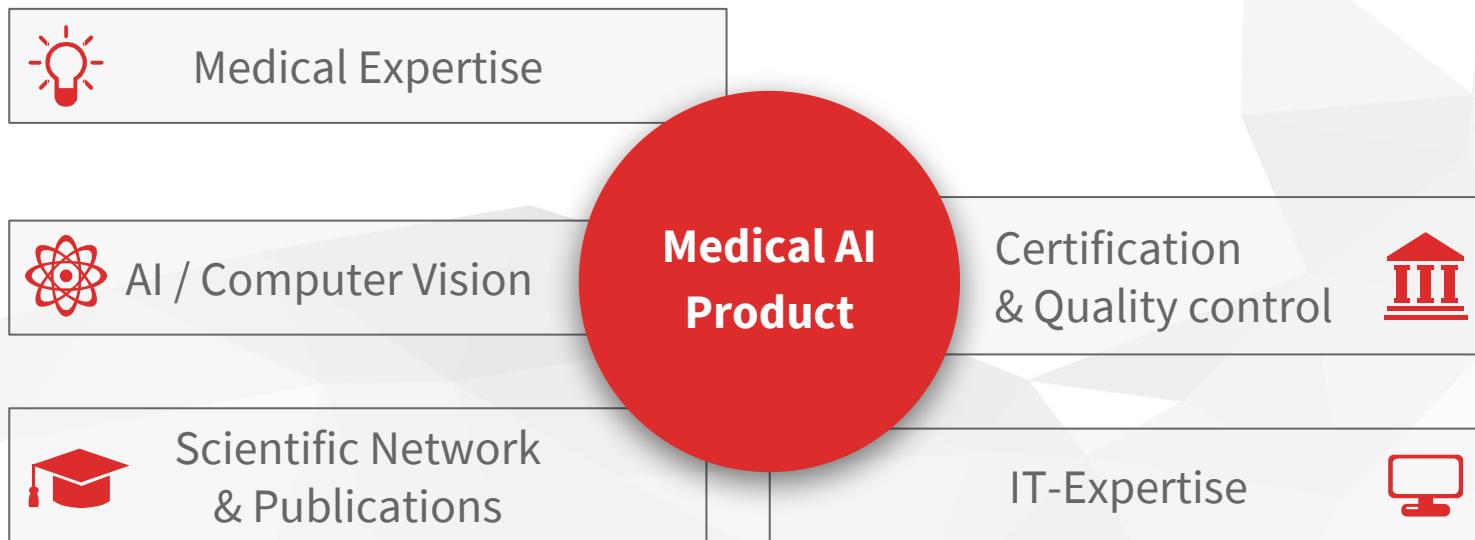
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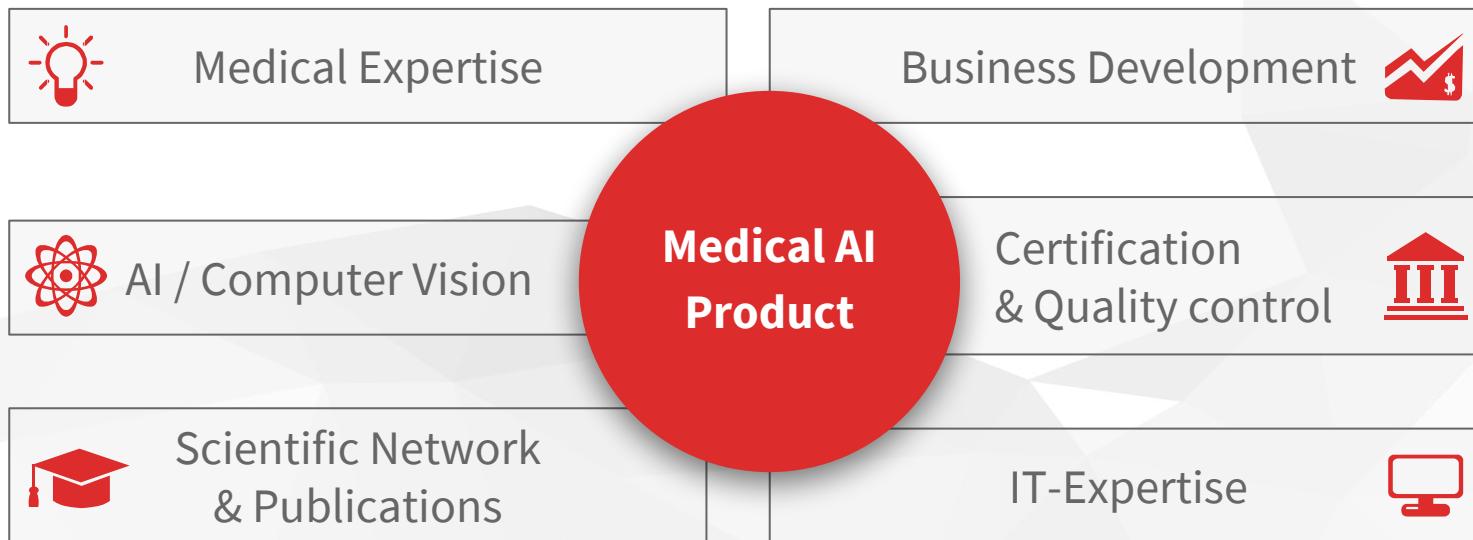
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# | How to earn money with AI?

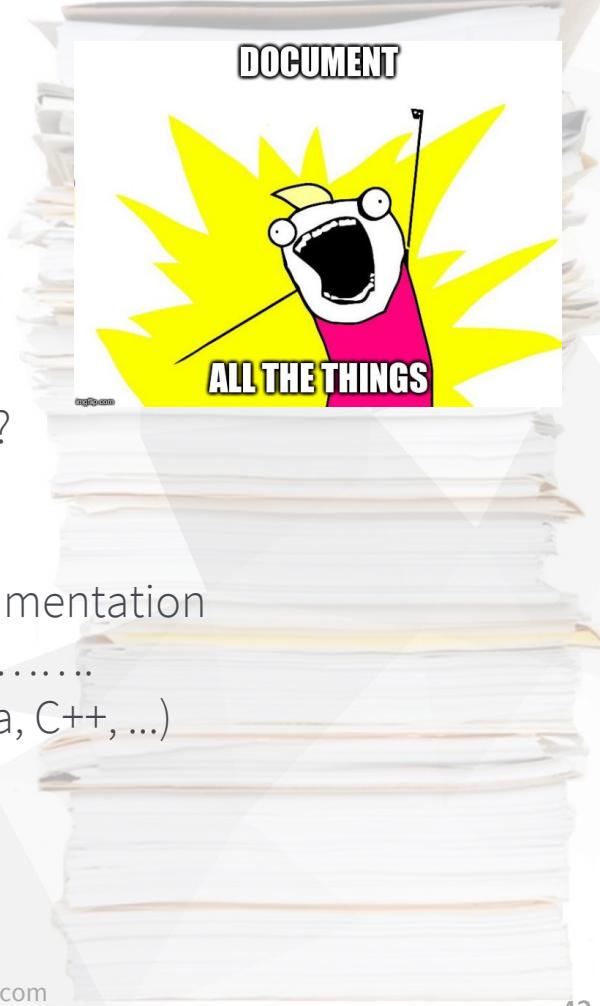
# Certification

Success measured in Kilos of printed paperwork

Some of the Fun activities:

- Harm of each of the 1300 bugs of Tensorflow for patient?
- Harm of unknown bugs?
- Document on how to document
- Document on the process of how to document the documentation
- Person who monitors process on how to document the .....
- Repeat for everything else you use (Numpy, Python, Java, C++, ...)

**Motivation:** Health expenditure OECD = 4300 B\$



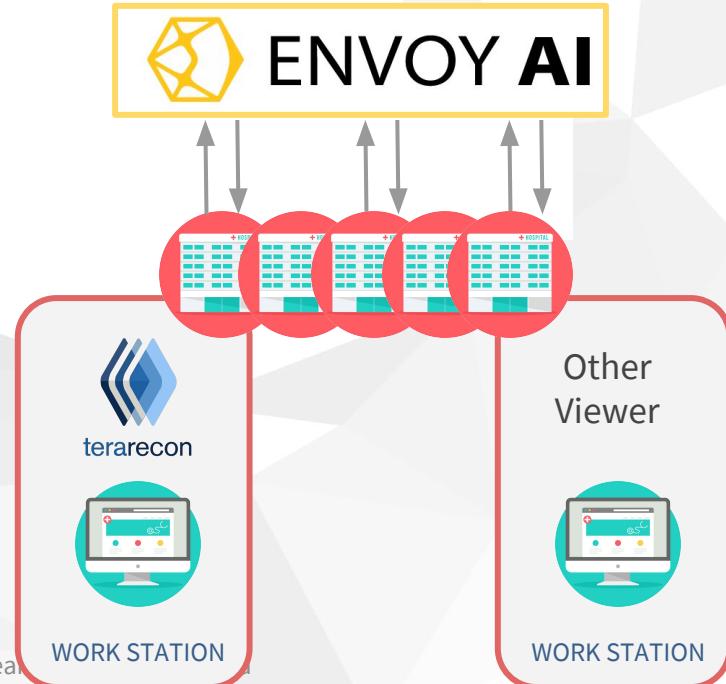
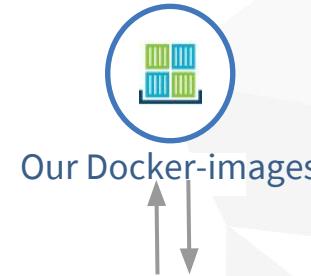
# Last-mile delivery to doctor

Amazon for AI - accelerated access to US

Platform for AI-algorithms

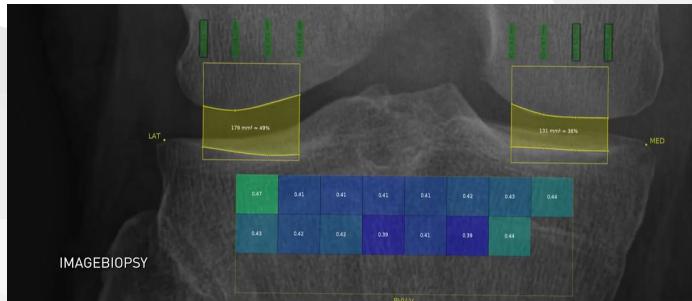
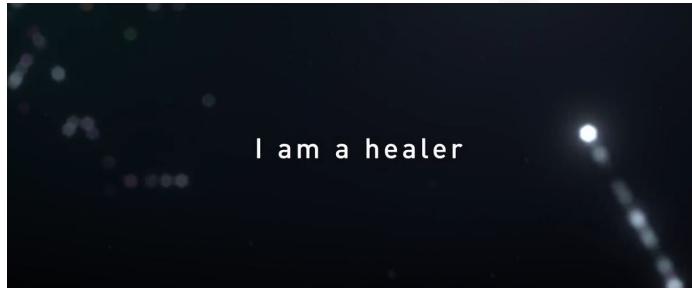
- Docker images deployed on AWS
- Developer portal
- Reaches 2,000 major US hospitals

Contracts signed 12/2017



# Featured on Nvidia GTC conference 03/18

(Obviously) in a league with NASA and Airbus!



Watch on [www.ImageBiopsy.com](http://www.ImageBiopsy.com)

April 2018

# Meet the Team: Diverse set of skills

Caffeine driven success + 180 scientific Publications

**6x in a row “Employee of the month”: Ulf (Titan X)**



Help fellow humans with AI!

**We are hiring**

r.ljuhar@imagebiopsy.com

c.goetz@imagebiopsy.com

Contact us, if you are up for a challenge!



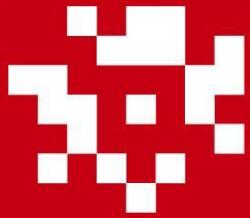


image  
biopsy  
lab

Richard Ljuhar, Christoph Götz |

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