International Society for Medical Robotics

The Professor Zbigniew Religa Foundation of Cardiac Surgery Development

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

WOJSKOWY INSTYTUT MEDYCZNY
PAŃSTWOWY INSTYTUT BADAWCZY
Military Institute of Medicine - National Research Institute

Nowe technologie, AI, przyszłość robotyki

Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

Nowe technologie, AI, przyszłość robotyki

Zbigniew Nawrat

Fundacja Rozwoju Kardiochirurgii im.prof Zbigniewa Religi
Śląski Uniwersytet Medyczny
Międzynarodowe Stowarzyszenie na rzecz Robotyki Medycznej
Zabrze POLAND

Róbmy roboty

- Kluczem do współczesnej medycyny jest wzrost produktywności i standaryzacja. Nie da się tego zrobić bez automatyzacji i robotyki – od procesów decyzyjnych po terapię i rehabilitację.
- Ze względu na zagrożenia demograficzne, a także wpływ CoVid, ważną zaletą stosowania robotów jest zmniejszenie wymagań dotyczących zatrudnienia – zarówno pod względem liczby, jak i umiejętności czy wykształcenia. Roboty dodają kompetencji i efektywności tam, gdzie ich brakuje.
- Po postępie telekomunikacyjnym – przesyłaniu INFORMACJI na odległość, przyszedł czas na transmisję DZIAŁAŃ na duże odległości. Teleakcja. Do tego potrzebne są roboty.
- Rynek robotów medycznych rośnie o około 20 % rocznie.

Robin Heart

Let's build **Medical Robot**" by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

Let’s make robot

Let's start with medicine

Let’s make robot

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Medical service as a process,

Let’s make robot

Let’s focus on hospital

Hospital

Patient & Disease

Hospital

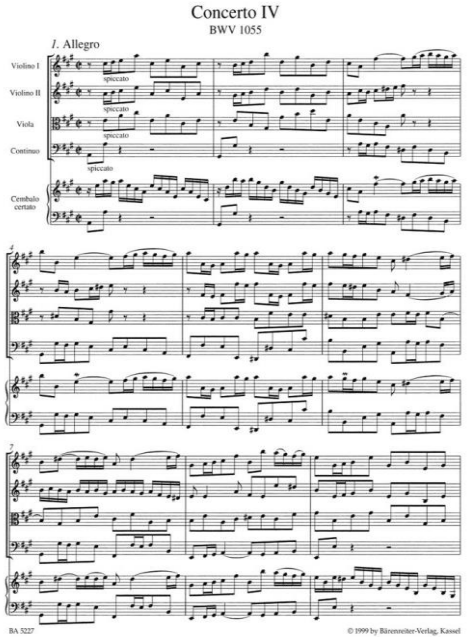
People, a **team**, i.e. a set of specialists

Let's make robot Zbigniew Nawrat

Work **tools**, instruments, devices, equipment

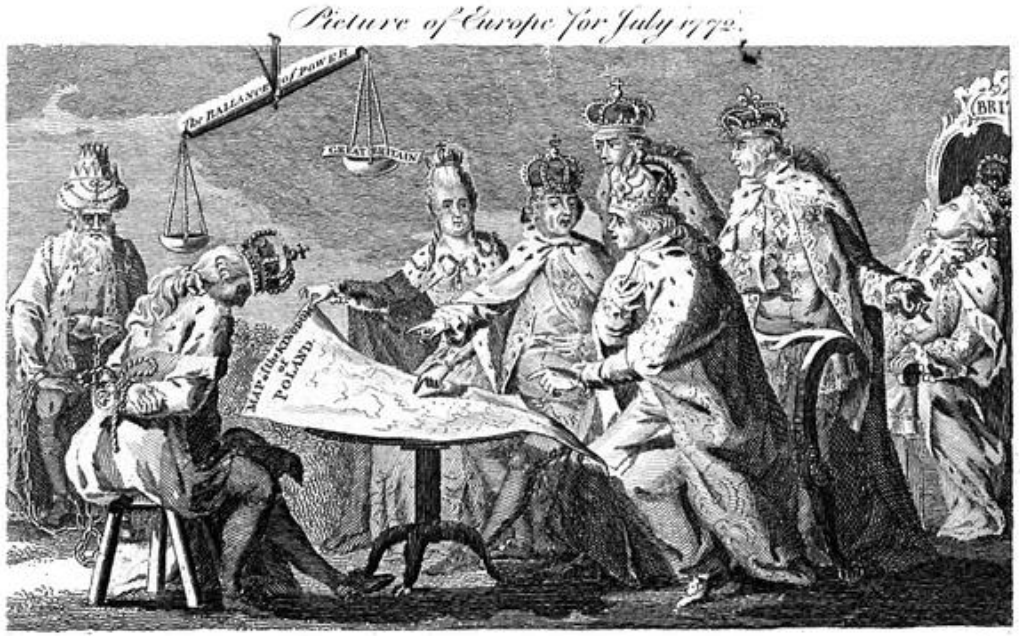
Choreography

Knowledge <> education

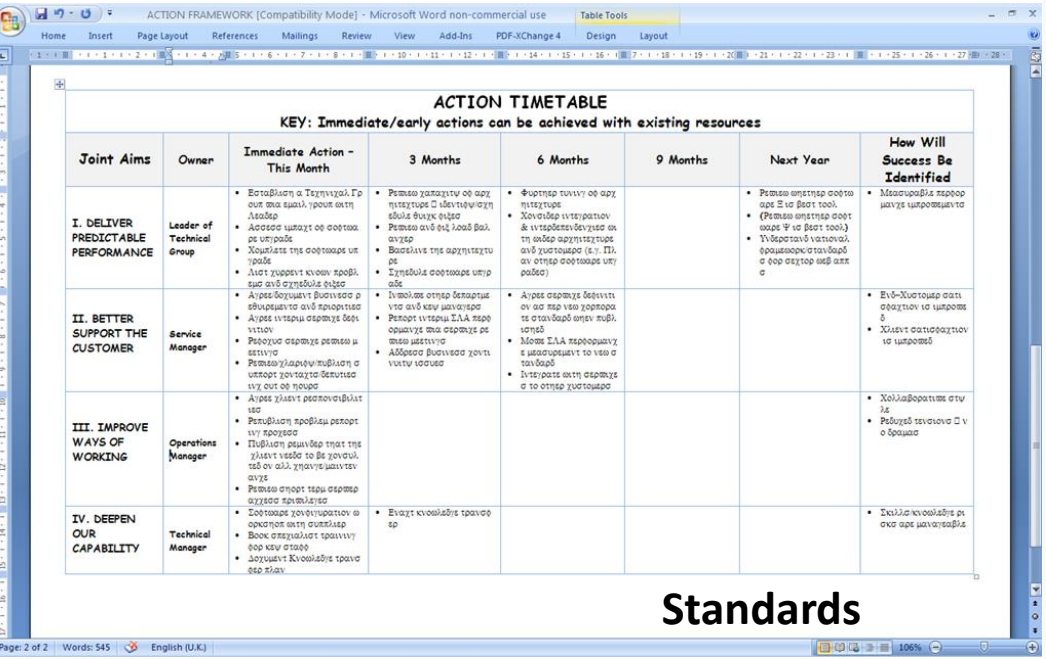


Ergonomy

Strategy> Tactics> Plan> Tasks



Strategy> Tactics> Plan> Tasks



ACTION FRAMEWORK [Compatibility Mode] - Microsoft Word non-commercial use

Table Tools

Home Insert Page Layout References Mailings Review View Add-Ins PDF-XChange 4 Design Layout

ACTION TIMETABLE

KEY: Immediate/early actions can be achieved with existing resources

Joint Aims	Owner	Immediate Action - This Month	3 Months	6 Months	9 Months	Next Year	How Will Success Be Identified
I. DELIVER PREDICTABLE PERFORMANCE	Leader of Technical Group	• Εσταβλιση α Τεχνιχαλ Γρ ουπ σπαι εμαιλ γρουπ ωιτη Λεαδερ • Ασσεσσ ιμπαχτ οφ σοφτωαρε υπγραδε • Χομπλετε της σοφτωαρε υπγραδε • Λιστ χυρρεντ κνοων προβλεμς ανδ σγηεδυλε φιξεσ	• Ρεσπεσ χαπαχιτψ οφ αρχ ηιτεχτυρε □ ιδεντιφψ/σχη εδυλε θωιχ φιξεσ • Ρεσπεσ ανδ φιξ λοαδ βαλ ανχεσ • Βασελινε της αρχηιτεχτυρε • Σχηεδυλε σοφτωαρε υπγραδε	• Φυρτηερ τυνινγ οφ αρχ ηιτεχτυρε • Χονσιδερ ιντεγρατιον & ιντερδεπενδενχιεσ ακ τη οκδερ αρχηιτεχτυρε ανδ χυστομερσ (ε.γ. Πλ αν οτηερ σοφτωαρε υπγραδεσ)		• Ρεσπεσ ωηετηερ σοφτω αρε □ ισ βεστ τοολ • (Ρεσπεσ ωηετηερ σοφτ αρε Ψ ισ βεστ τοολ) • Υνδερστανδ νατιονάλ φραμεωορκ/στανδαρδ σ φορ σεχτορ ωεβ αππ σ	• Μεασυραβλε περφορ μανχε ιμπροπεμεντσ
II. BETTER SUPPORT THE CUSTOMER	Service Manager	• Αγρεε/δοχυμεντ βυσινεσσ ρ εθυιρεμεντσ ανδ πριορ ιτισε • Αγρεε ιντερμ σερανχε δεφι νιτιον • Ρεβοχυσ σερανχε ρεσπεσ μ εετινγσ • Ρεσπεσ/χλαριφψ/πυβλιση σ υππορτ χοντραχτσ/δεχυτισε ιντψ ουτ οφ ηουρσ	• Ινπολυσε οτηερ δεπαρτμ ντσ ανδ κεψ μανάγερσ • Ρεπορτ ιντερμ ΣΛΑ περφ ορμανχε ττηαι σερανχε ρε ττηαι μεετινγσ • Αδδρεσσ βυσινεσσ χοντι νυιτψ ισσυεσ	• Αγρεε σερανχε δεφινιτι ον ασ περ νεω χορπορα τε σταν δαρδ ωηεν πυβλ ισηεδ • Μοαε ΣΛΑ περφορμανχ ε μεασυρεμεντ το νεω σ ταν δαρδ • Ιντεγρατε ωιτη σερανχε σ το οτηερ χυστομερσ			• Ενδ-Χυστομερ σατι σφαχτιον ισ ιμπροε δ • Χλιεντ σατισφαχτιον ισ ιμπροεδ
III. IMPROVE WAYS OF WORKING	Operations Manager	• Αγρεε χλεαντ ρεσπονσιβιλιτιεσ • Ρετυβλιση προβλεμ ρεπορτ ινγ προχεσσ • Πυβλιση ρεμινδερ τηατ της χλιεντ νεεδσ το βε χονσυλ τεδ ον αλλ χηανγε/μαιντεν ανχε • Ρεσπεσ σηορτ τερμ σερπερ αχχεσσ πριαλαγεσ					• Χολλαβορατιπαε στψλε • Ρεδυχεδ τενσιονσ □ ν ο δραμασ
IV. DEEPEN OUR CAPABILITY	Technical Manager	• Σοφτωαρε χονφιγυρατιον ωορκσηοπ ωιτη συππλιερ • Βοοκ σπεχιαλιστ τραιννγ φορ κεψ σταφφ • Δοχυμεντ Κνοωλεδγε τρανσφερ πλαν	• Εναχτ κνοωλεδγε τρανσφερ				• Σκιλλσ/κνοωλεδγε ρι σκσ αρε μανάγεαβλε

Standards

Page: 2 of 2 Words: 545 English (U.K.) 106%

DEPARTMENT OF HEALTH AND HUMAN SERVICES Health Resources and Services Administration SAMPLE PROJECT WORK PLAN	FOR HRSA USE ONLY Application Tracking Number

Section A - Comprehensive Needs Assessment

Goal A1: Identifying major health issues for the populations to be served, unmet need, barriers to care, etc.

Objective(s)	Key Action Step(s)	Expected Outcome(s)	Data Evaluation and Measurement(s)	Person / Area Responsible(s)	Comment(s) (Maximum 500 characters)
A1.1 Develop protocol and measures for implementing needs assessment within two months of grant award. A.1.2 Establish a team of knowledgeable planning staff to oversee undertaking of needs assessment within one month of grant award. A.1.3. Complete needs assessment for targeted service area within 4 months of award. A2.3 Secure consultant to assist with needs assessment.	1. Identify appropriate tools to use for the needs assessment. 2. Establish Subcommittee of the planning staff to oversee needs assessment. 3. Define roles of planning staff and for the project.	1. Participate in the comprehensive needs assessment elements meeting with area stakeholders. 2. Create tangible targeted assessment protocols and tools for identified populations in collaboration with other health centers. 3. Conduct at least one coordinating meeting every month. 4. Completed needs assessment.	1. The number of planning meetings. 2. Determination made regarding approach. 3. The number of meetings attended. 4. Number of persons at each meeting. 5. Progress against established timeline for completion of assessment.	1. Planning Grant committee 2. CEO 3. Board of Directors 4. Consultant	

Let’s make robot

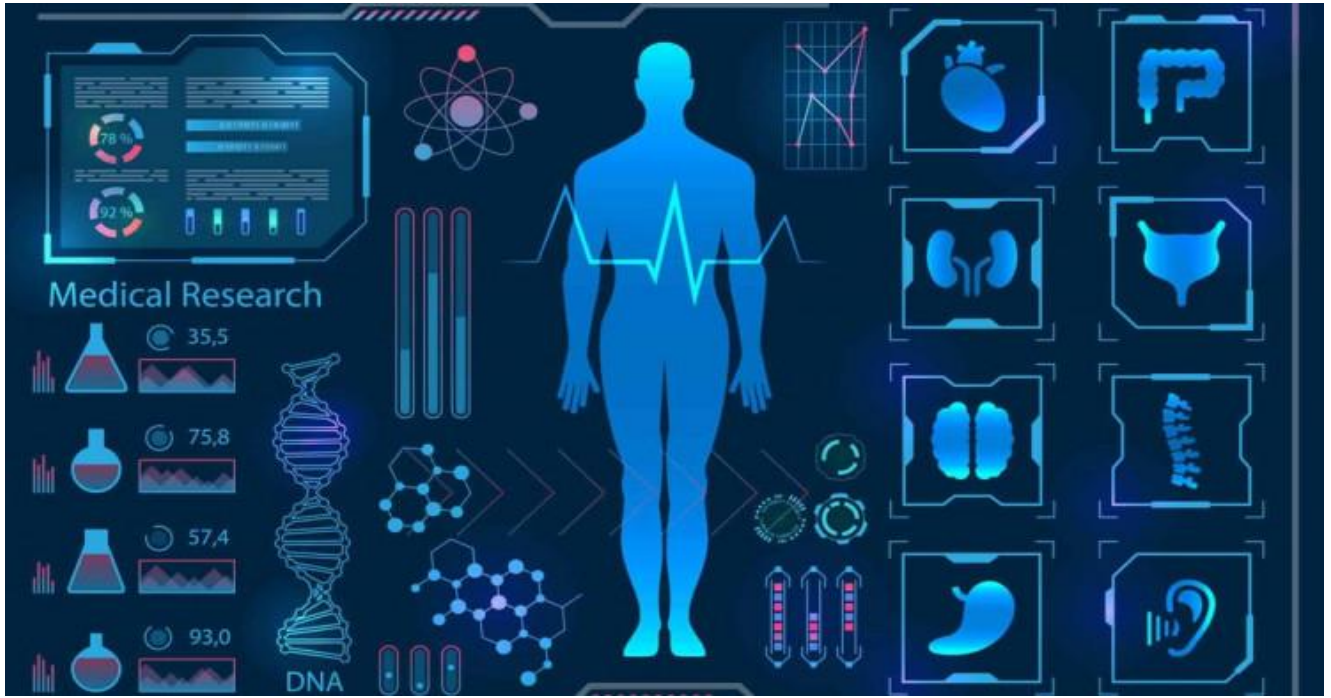
< Hospital, as a **team of people**

Let’s make robot

Medical service as a process,

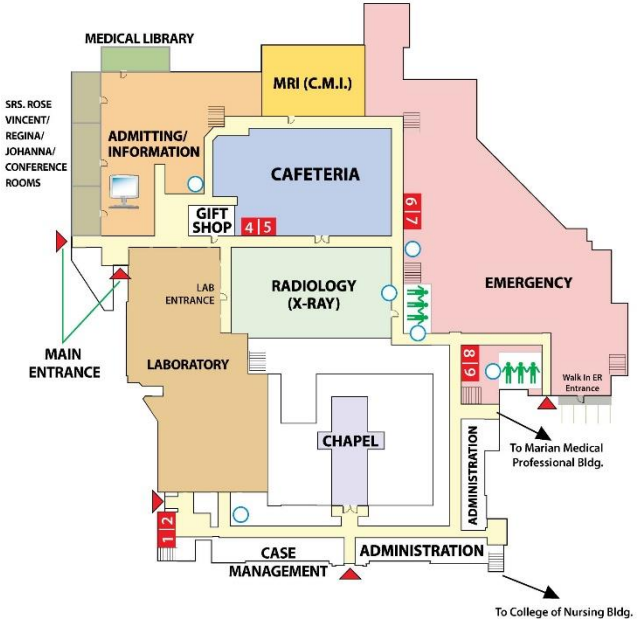
Strategy> Tactics> Plan> Tasks
Virtual Reality Technology - From Imagination to Reality

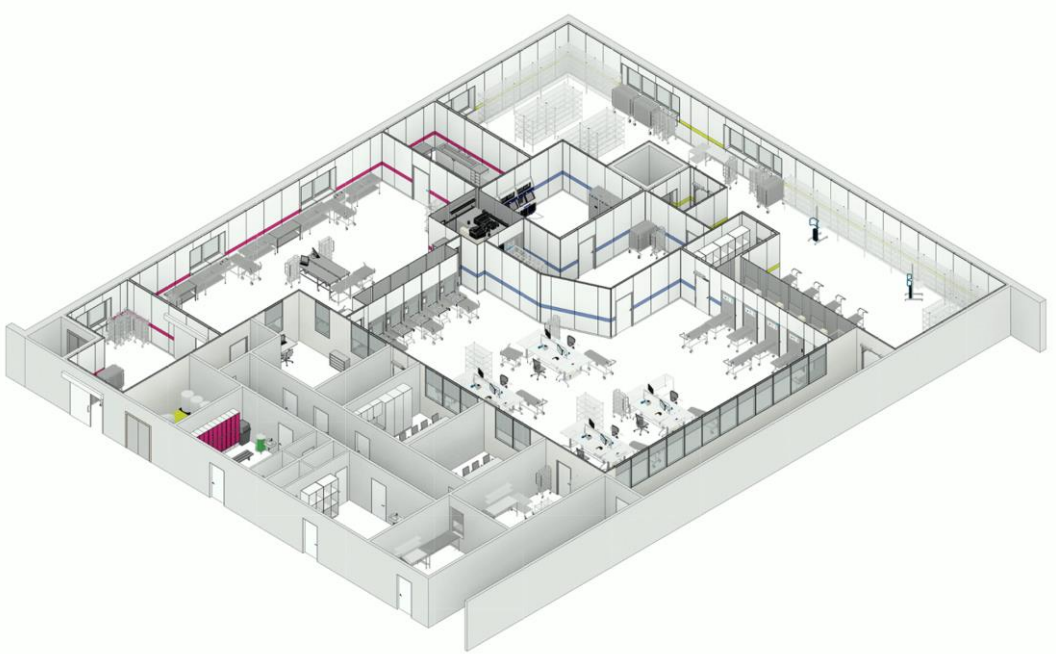
INFORMATION > Patients data



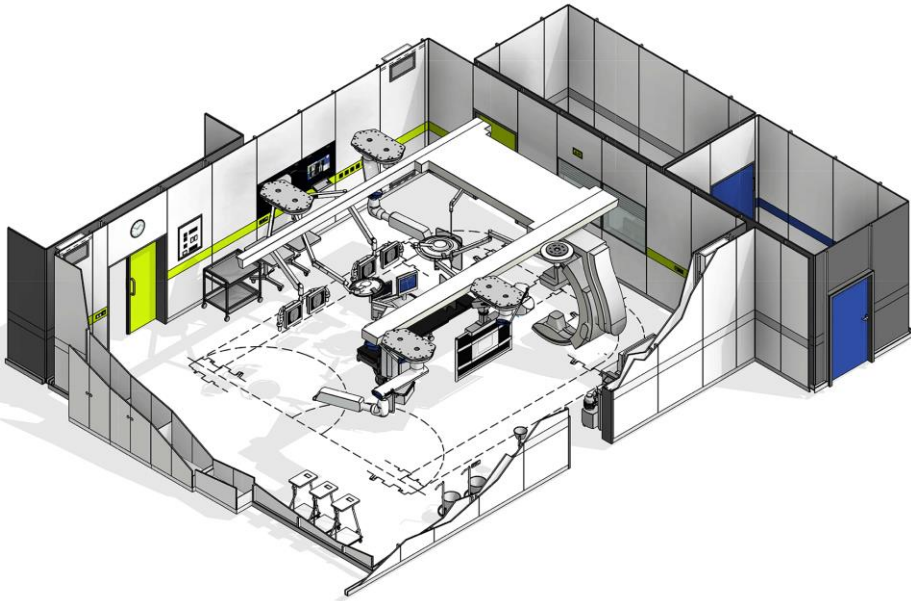
Source: Labmedia

Architectural opportunities and limitations

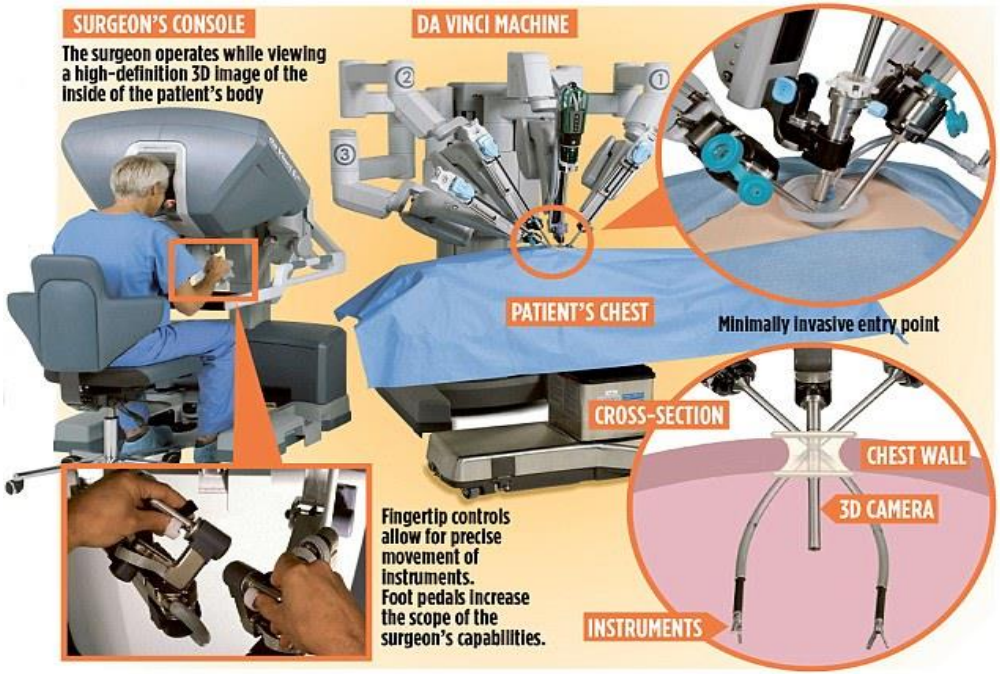


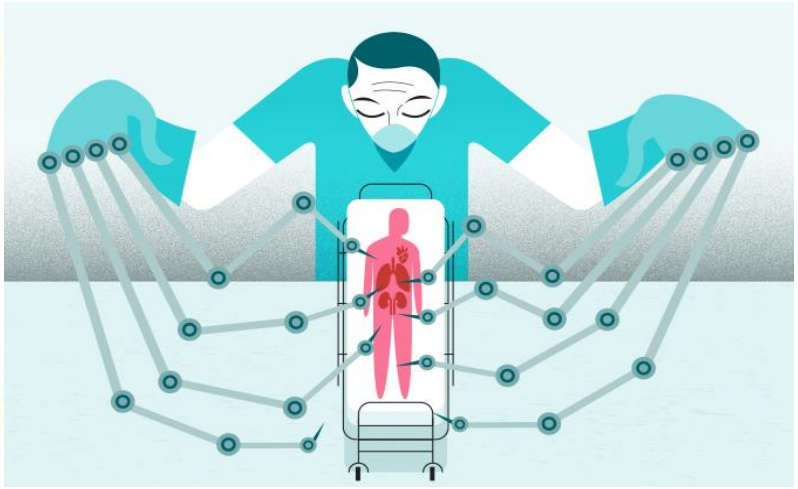


Technical challenges - the environment



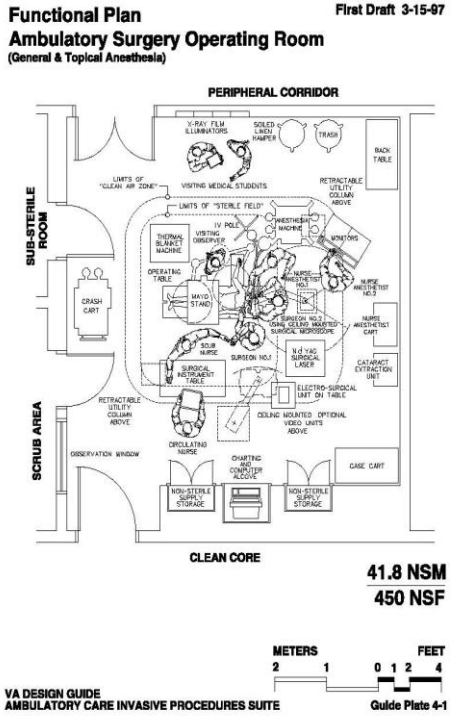
Technical challenges - service / staff





Let's make robot Zbigniew Nawrat

Interaction of people and apparatus - synergy



Healthcare Professionals

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Medical service as a process, or **where** should these **robots** be?

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Medical service as a process, or **where** should these **robots** be?

Everywhere.

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Every pair of hands and brain time of a medical worker **freed** by working robots (including AI) is a benefit for the patient.

This means a higher standard of services

and lower risk, operational certainty

and lower total costs.

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Goal!!

Let’s make robot

Goal!!

hand and automatic washing

Dziewczynka piorąca na tarze (1871 r.)

Pralka z otworem wrzutowym umieszczonym z przodu

Wikipedia

Let's make robot

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Medical service as a process, So **when** should these **robots** be used?

Let's make robot

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Medical service as a process, So **when** should these **robots** be used?

Always.

Let’s make robot

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Commonly. Use the energy and intelligence of machines to save yours for the benefit of those in need, to solve really difficult problems.

There will never be a shortage of challenges

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Goal!!

Let’s make robot

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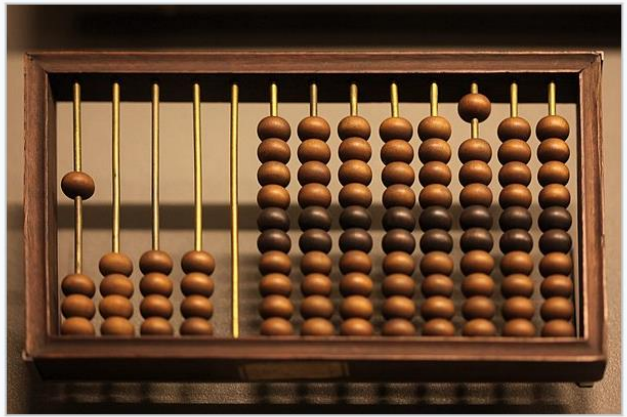
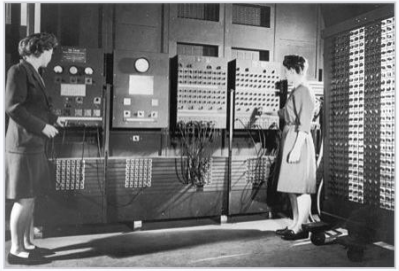
Goal!!



Liczydło

Współczesny prosty kalkulator kieszonkowy firmy Citizen

Wikipedia



Komputer ENIAC wraz z obsługą.

Przykład notebooka firmy IBM

How to make a medical robot?

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Why is a medical robot being made?

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EXAMPLE

Surgery

Important question

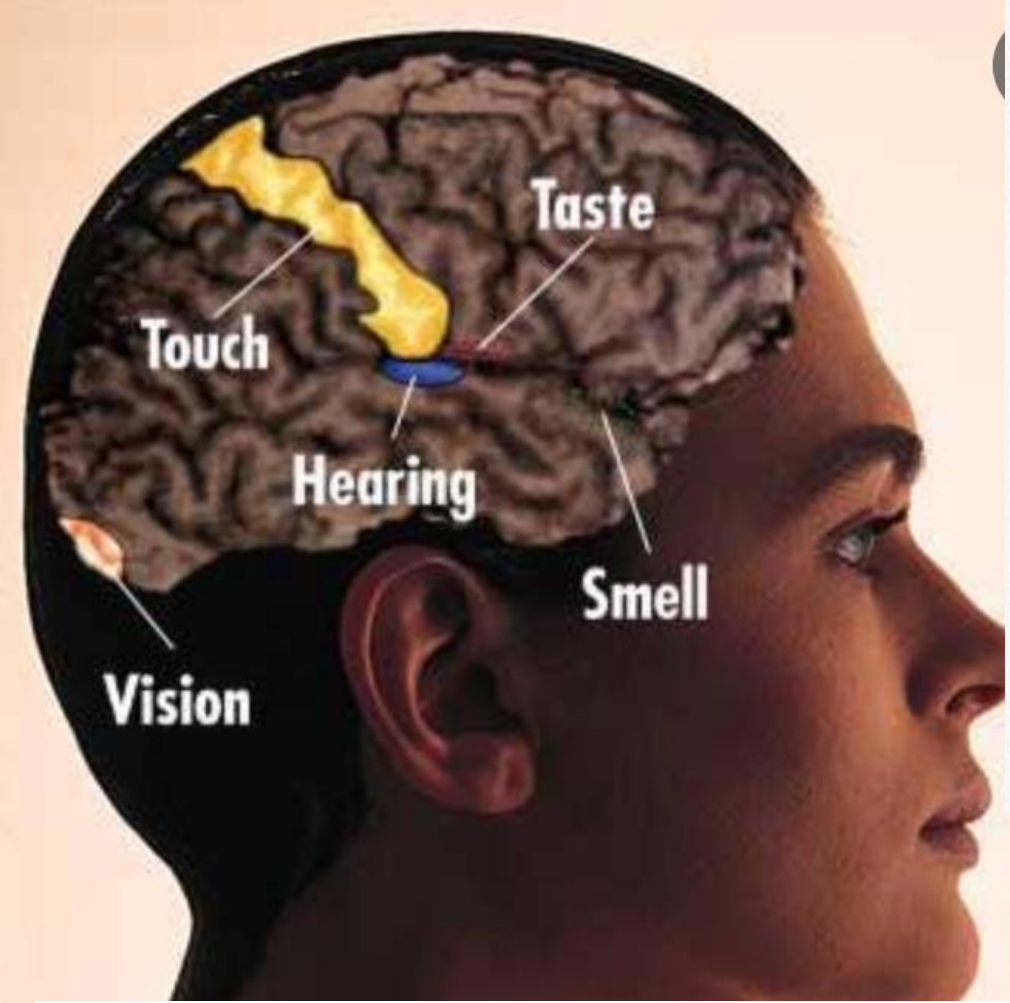
https://upload.wikimedia.org/wikipedia/commons/8/83/De_anatomische_les_van_Dr._Frederick_Ruysch.jpg

Your team can create answer:

HOW?

to do it

Surgeon



brain + sensors = measurement / information> decision

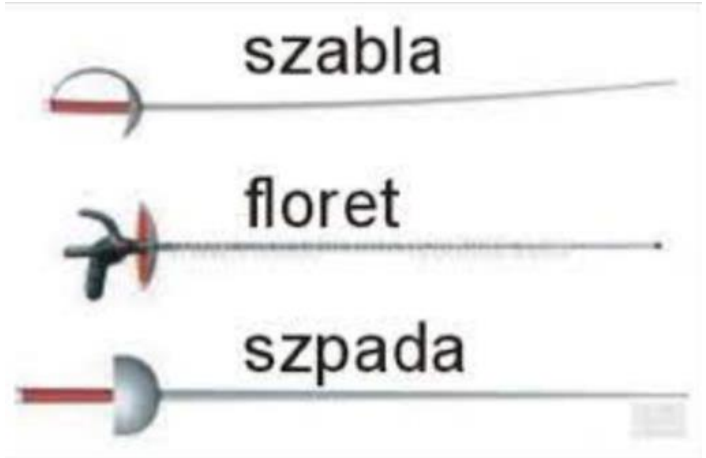
VISION = 85% Information

2D

3D

Surgery is teamwork

The surgeon needs **tools** to work



tool> special shape / handle / technique of application> purpose of the operational activity

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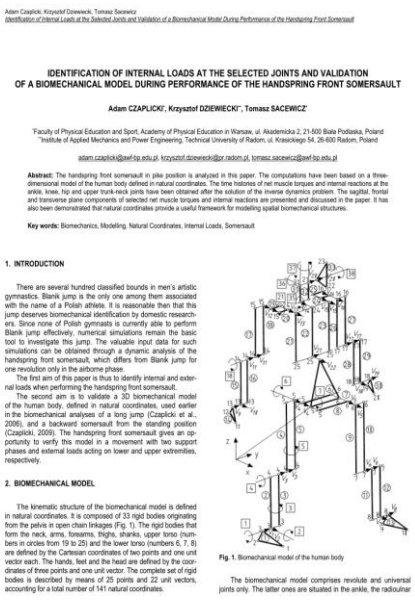
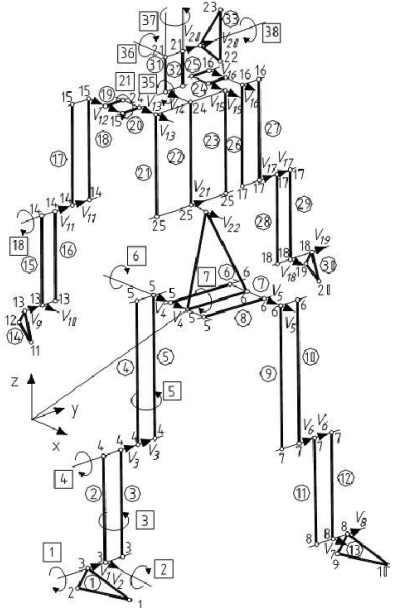
The surgeon changes into a **special outfit** for the operation

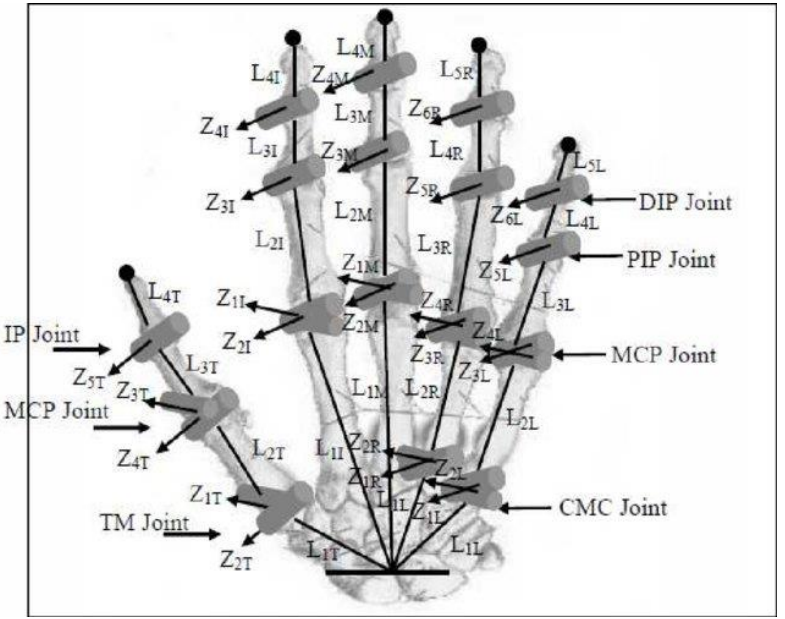
The way the **surgeon** works depends on his **construction, kinematics, dynamics**.
Improvement through learning and exercise.



IDENTIFICATION OF INTERNAL LOADS AT THE SELECTED JOINTS AND VALIDATION OF A BIOMECHANICAL MODEL DURING PERFORMANCE OF THE HANDSPRING FRONT SOMERSAULT

Adam CZAPLICKI*, Krzysztof DZIEWIECKI**, Tomasz SACEWICZ**





https://www.researchgate.net/publication/270723380_Design_and_Analysis_of_a_Multifingered_Robot_Hand/figures?lo=1

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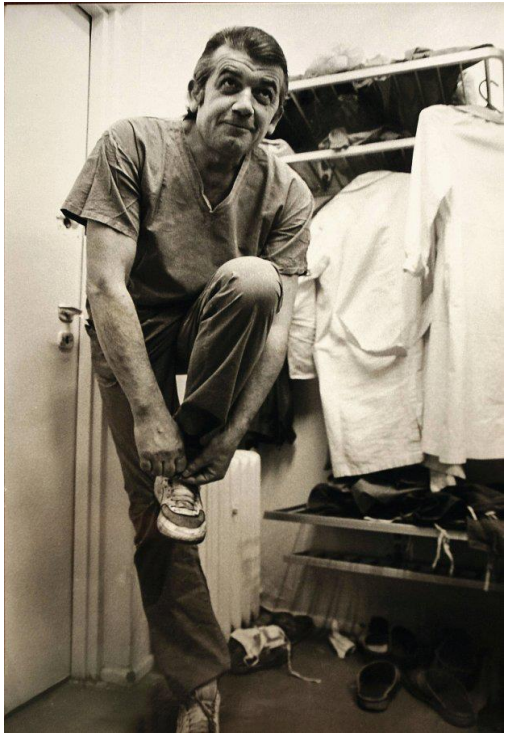
Robots for surgeon - example

From Heart to Robin Heart

Let's start with the doctor

From Heart to Robin Heart

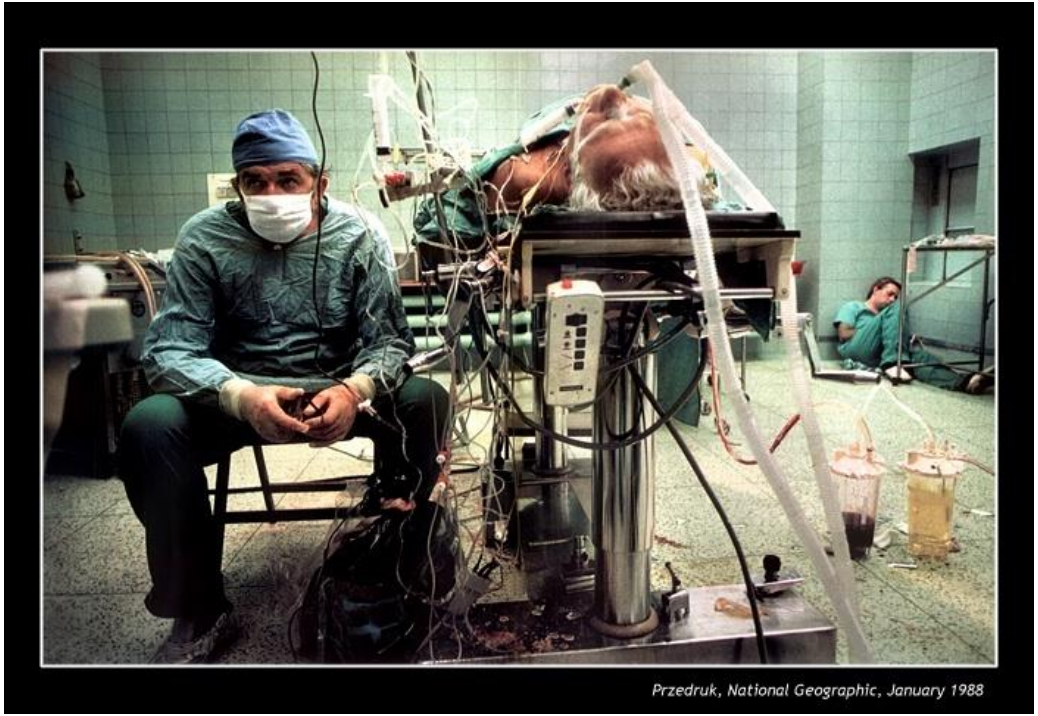
Prof. Zbigniew Religa



From Heart to Robin Heart

Let's start with the patients

From Heart to Robin Heart



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From Heart to Robin Heart

Heart

From Heart to Robin Heart

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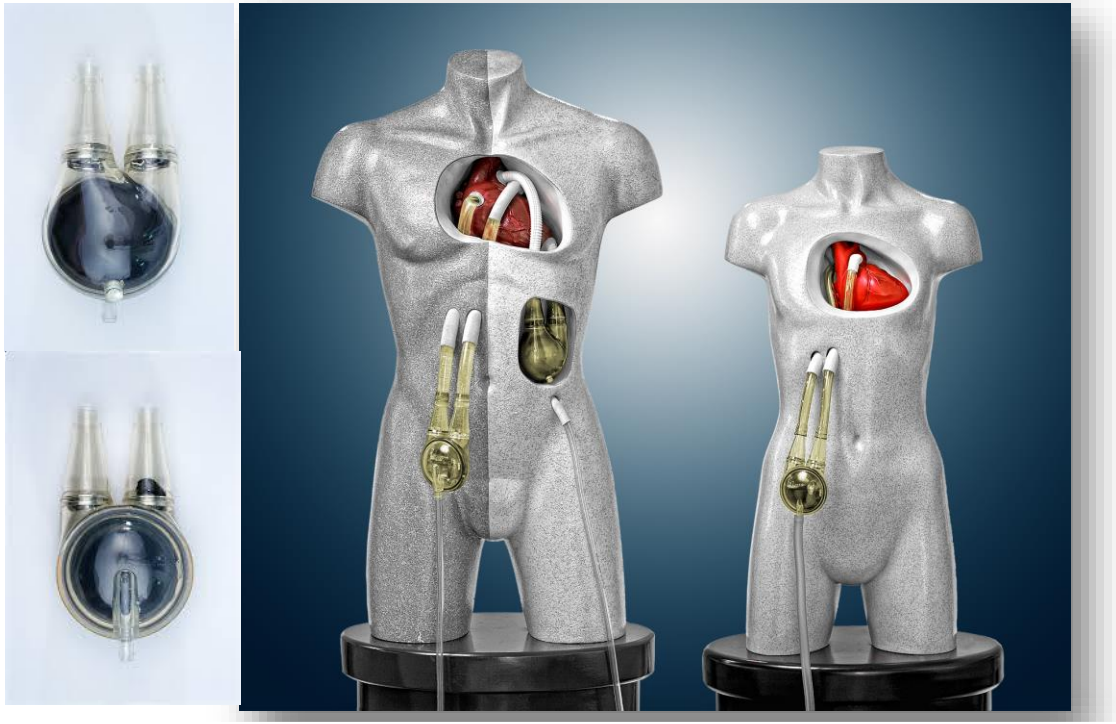

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From Heart to Robin Heart

Polish System of Mechanical Heart Support

POLVAD

1993

Still in clinical usage.. About 500 patients. Longest suport abot 2 years

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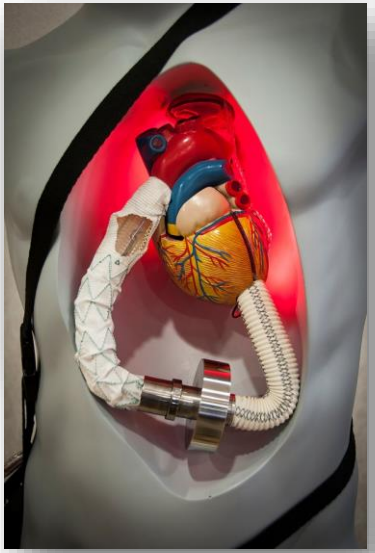
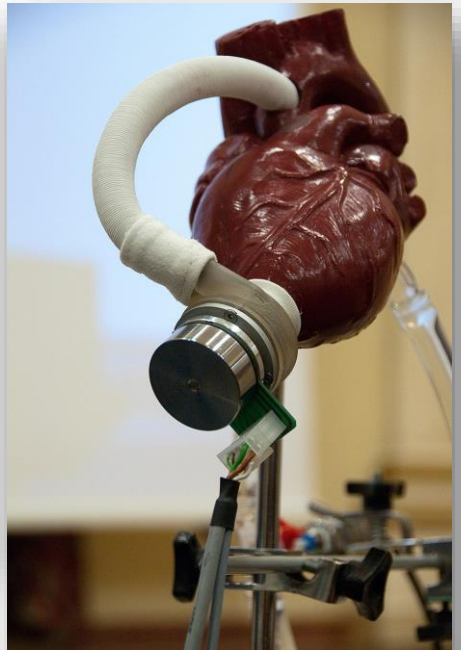
From Heart to Robin Heart

Polish centrifugal and axial rotary blood pumps

Pompa odśrodkowa
Konstrukcja: FRK; Zabrze



Pompa osiowa
Konstrukcja: CTO Gdańsk



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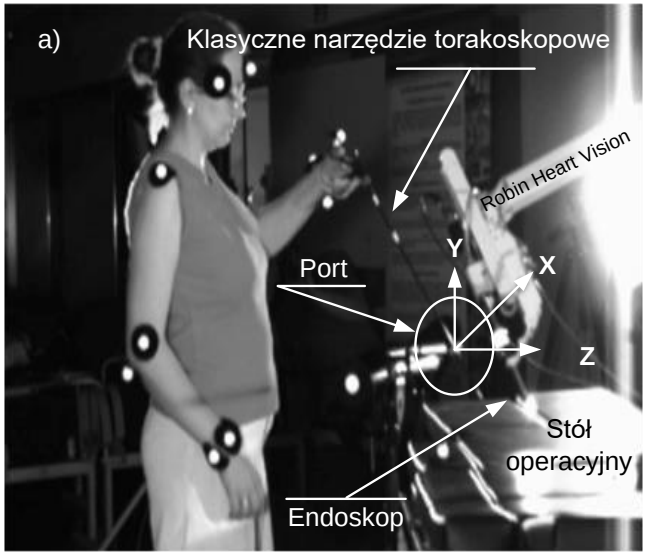
From Heart to Robin Heart

NEED

New tools

From Heart to Robin Heart

Research



Kinematic analysis of the surgeon and dynamic tool-tissue reaction

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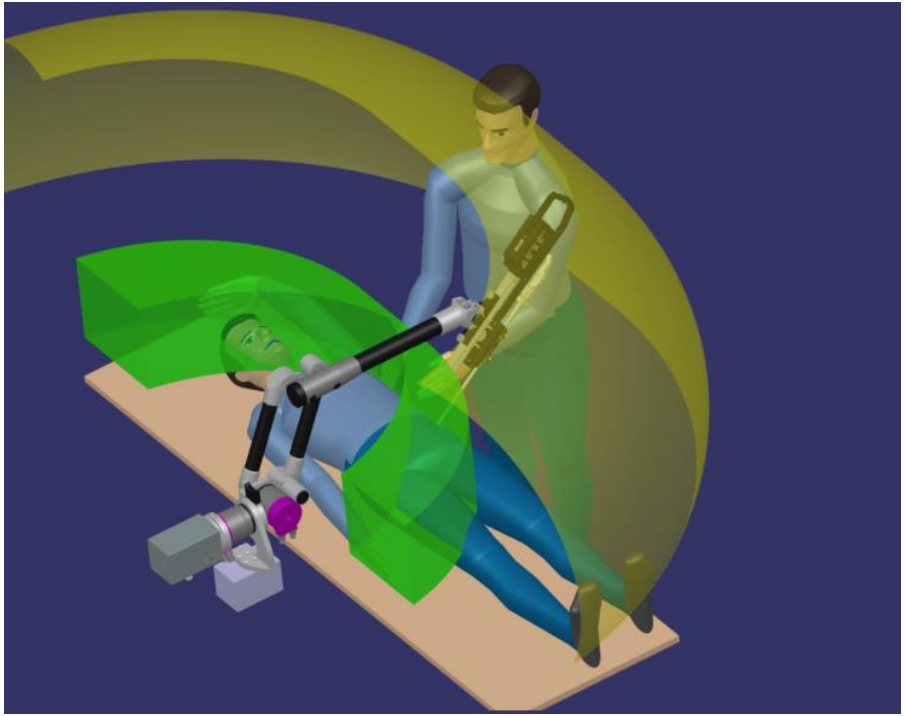
Ergonomy



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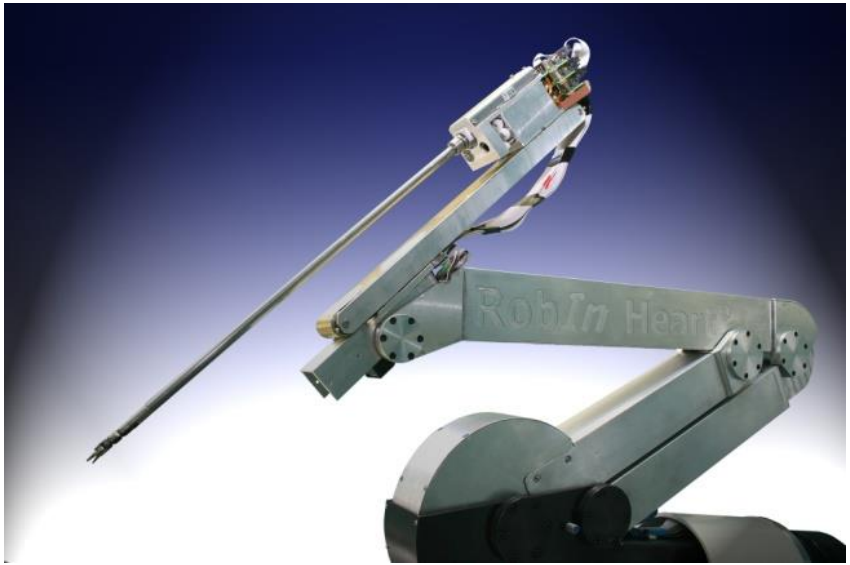

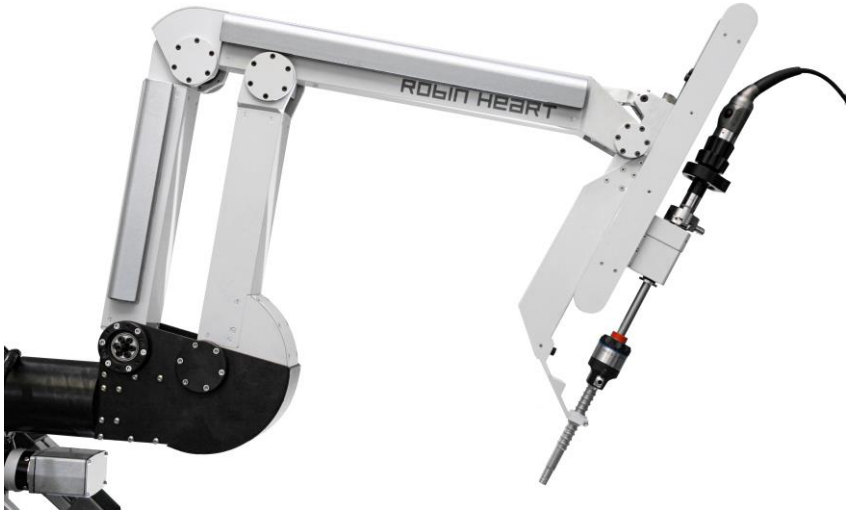

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From Heart to Robin Heart

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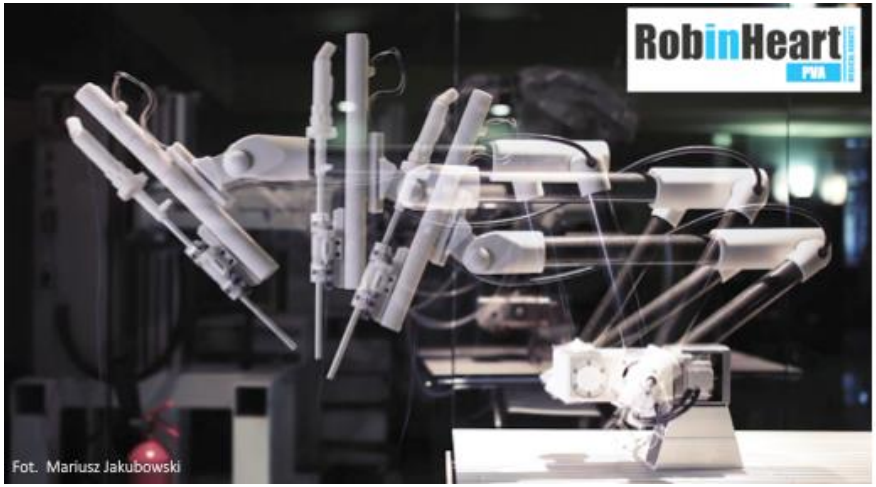
From Heart to Robin Heart



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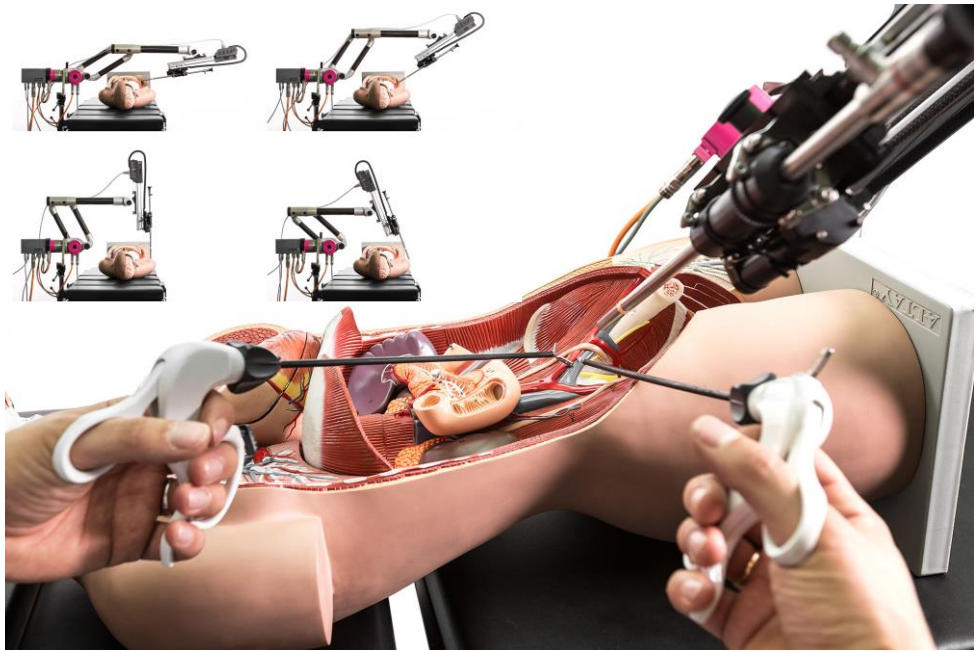

Robin Heart

Port Vision Able

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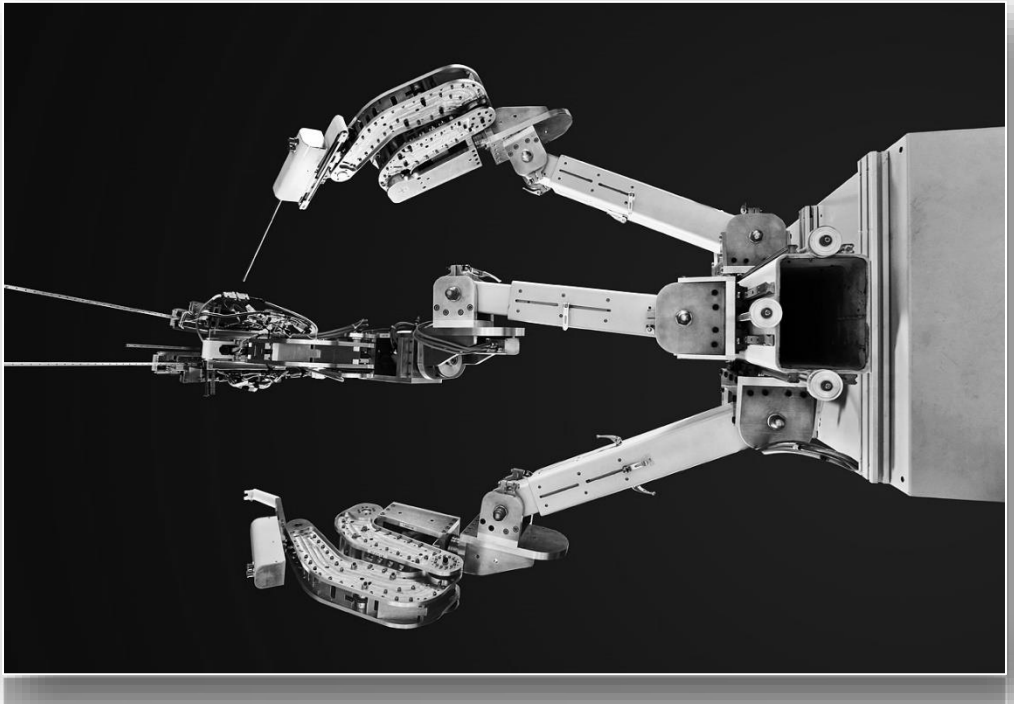
From Heart to Robin Heart

RobInHeart MC²



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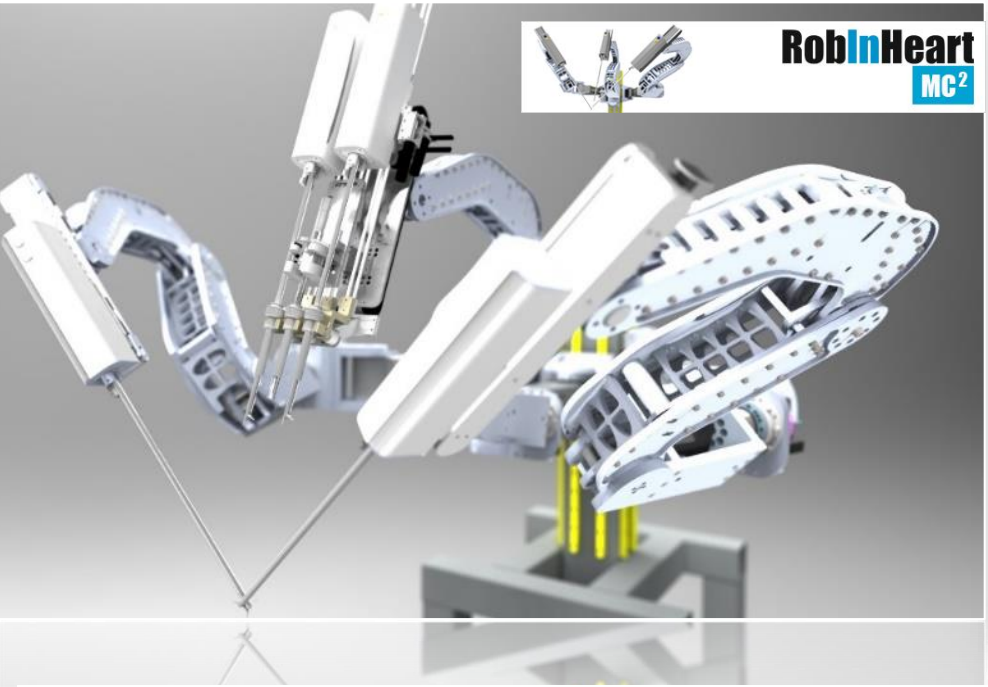

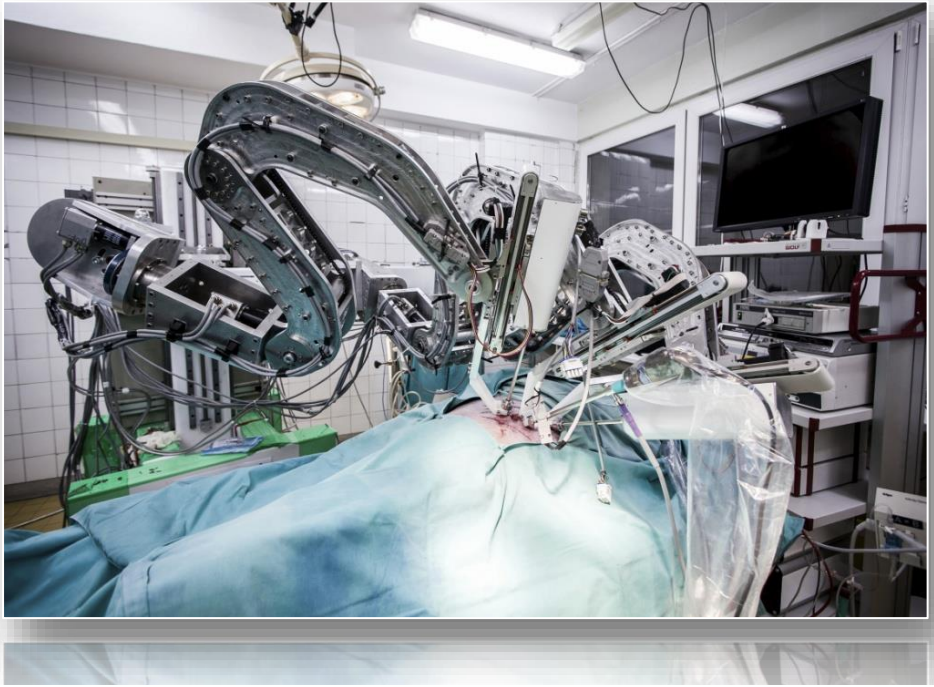

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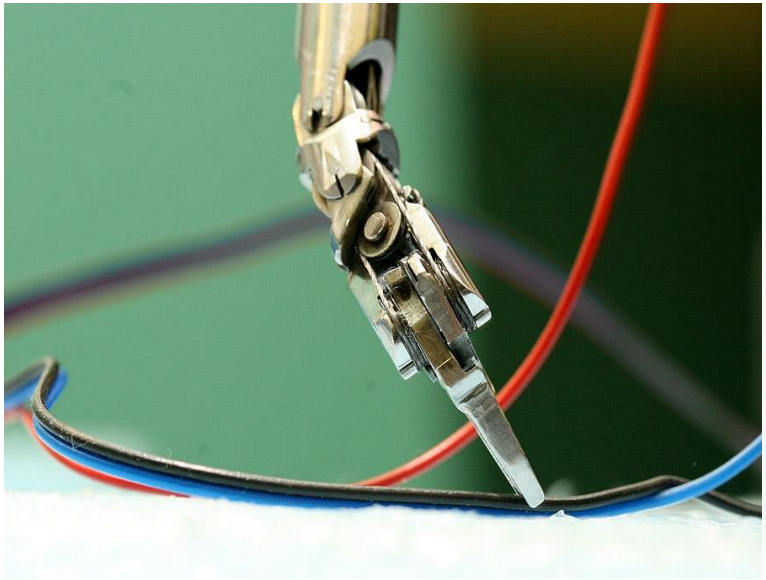
From Heart to Robin Heart



RobinHeart
UniTools
MEDICAL ROBOTS

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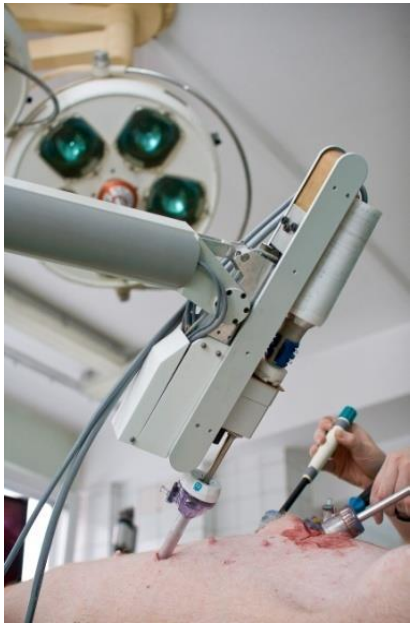
From Heart to Robin Heart



RobinHeart UniTools MEDICAL ROBOTS

Robin Heart Uni System research.
Universal system - tools mounted on the robot arm can be used manually

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Cover the distance

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Need TOUCH

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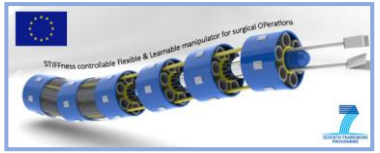
Reach where there is no straight way



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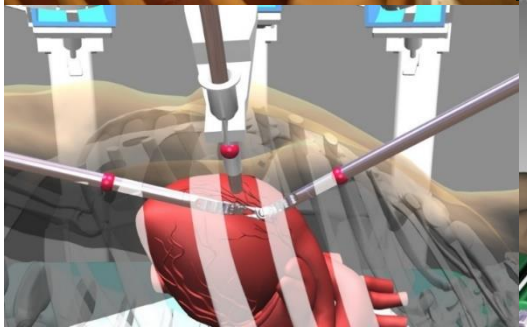
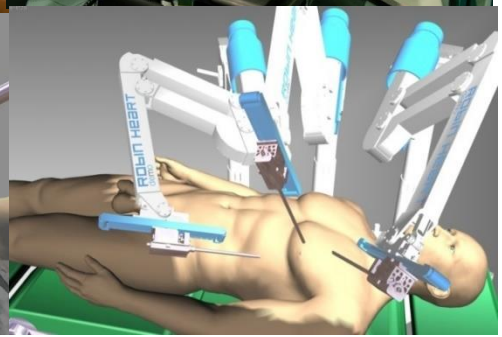
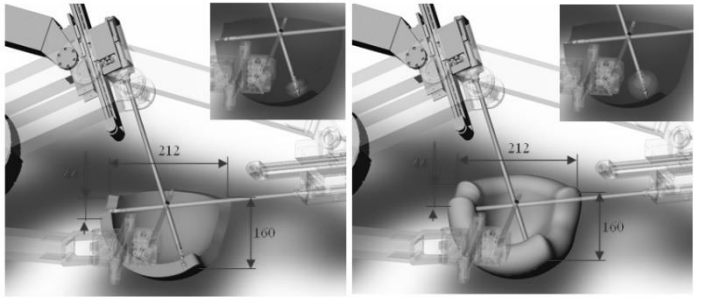
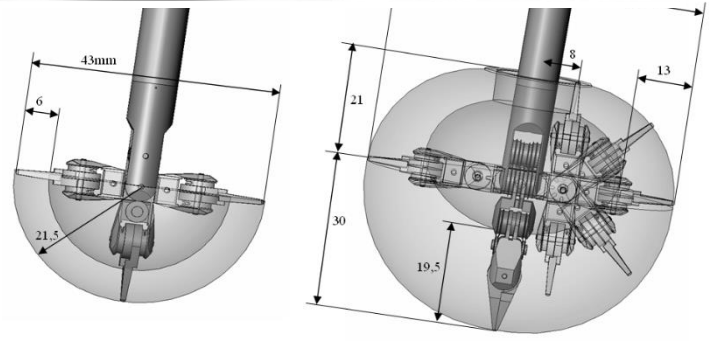
Operation optimization by simulations









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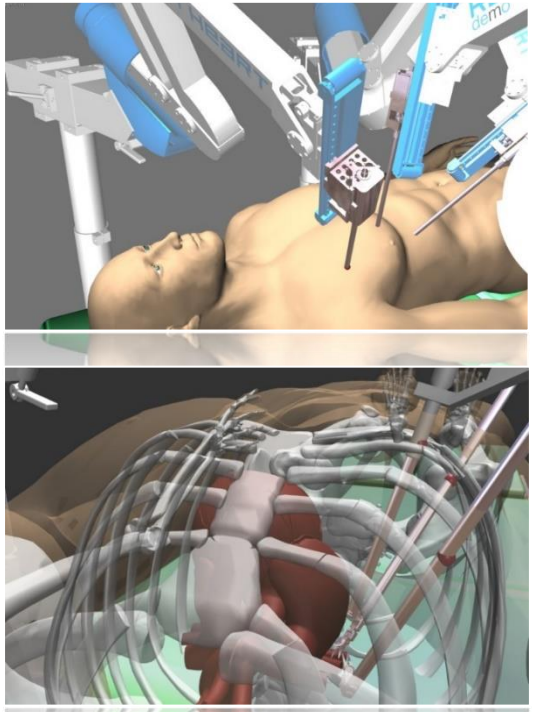
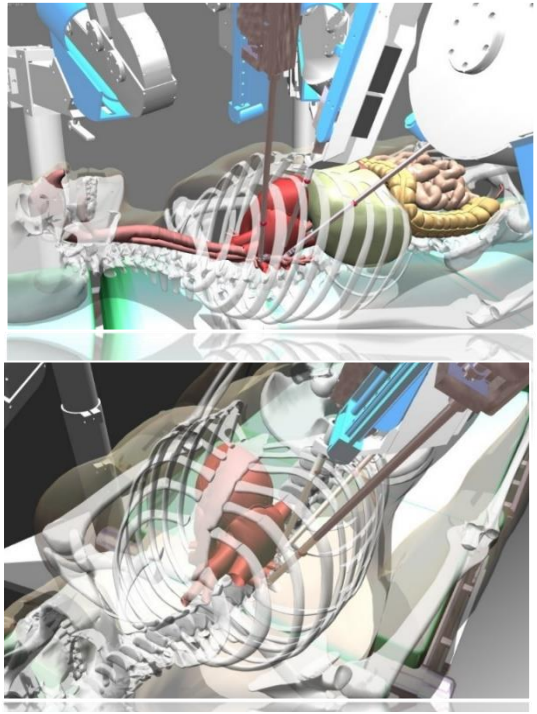
From Heart to Robin Heart

The Professor Zbigniew Religa Foundation of Cardiac Surgery Development

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

Planning of mitral valve repair surgery





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From Heart to Robin Heart

The Polish Program Milestones

- **1985** – The first succesfull heart **transplantation** in Poland, performed in Zabrze by prof. Z. Religa
- **1986** – The first implantation of **mechanical heart assistance** in Poland - the BRNO LVAD, performed in Zabrze by prof. Z.Religa with J.Vasku team of Univ. Brno (Czech)
- **1987** – The first implantaion of **artificial heart** in Poland – the BRNO TAH VII, performed in Zabrze by prof. Z.Religa with J.Vasku team of Univ. Brno (Czech)
- **1987** – The first implantation in Poland of Russian TAH POISK performed in Zabrze, by prof. Z.Religa with W.Szumakow team of Transplantology Inst. Moscow
- 1987 – The first xenotransplantation
- **1993** – The first implantation of **POLVAD**; Zabrze, Z.Religa team
- 1997 – The first implantation of **POLTAH**; Zabrze, Z.Religa team
- 2000 – start of **Robin Heart Project >** 2019 first licence sold

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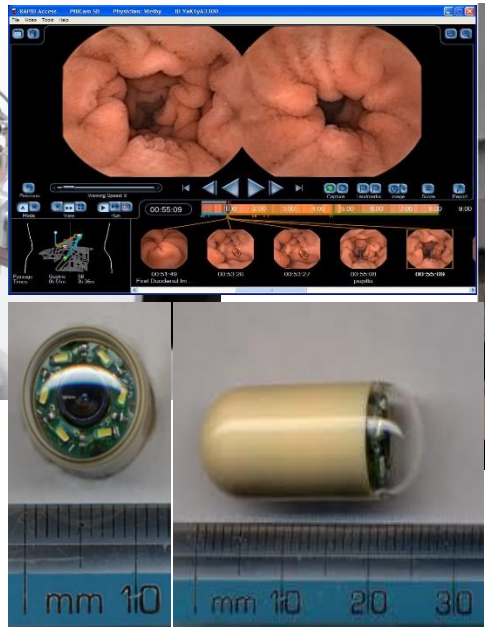
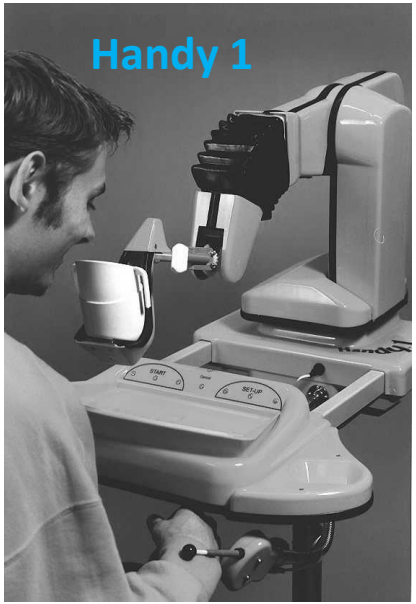
Robots change medicine

Zbigniew Nawrat

Medical robots





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Surgery

Single Port Orifice Robotic Technology

Da Vinci XI

Mako

Cyber Knife

Da Vinci SinglePort

Pharmacy – drug portioning machine (personalized service)

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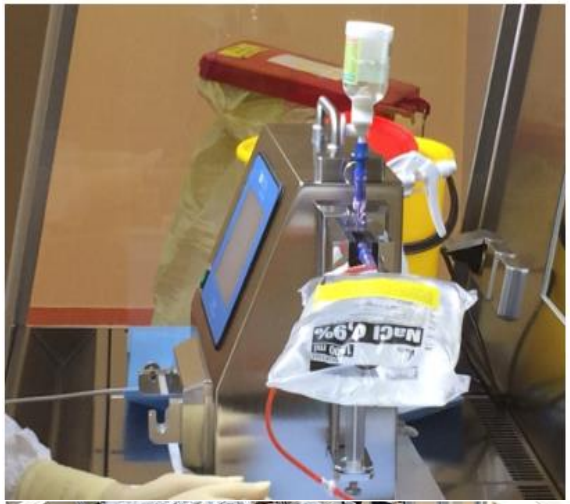
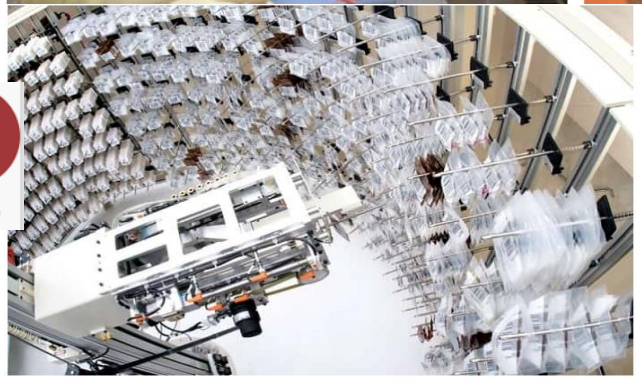
Pharmacy



DIANA

https://www.rmf24.pl/fakty/polska/news-jedyny-w-polsce-robot-do-podawania-lekow,nId,1888979

UNI DOSE



Unit Dose – gotowe dawki leków jednostkowych

Robot pakujący leki do pojemnika poczty pneumatycznej

CoRobots - laboratory

YoMi ABB

https://new.abb.com/news/pl/detail/37397/nowa-koncepcja-mobilnego-robota-laboratoryjnego-dla-szpitala-przyszlosci

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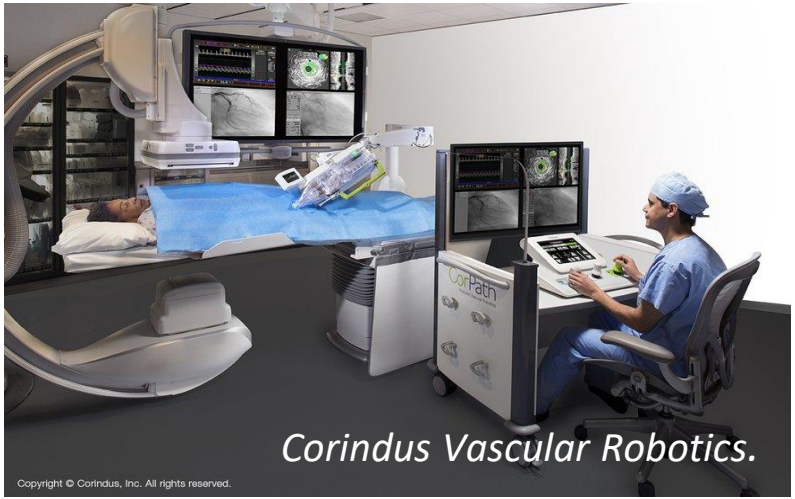
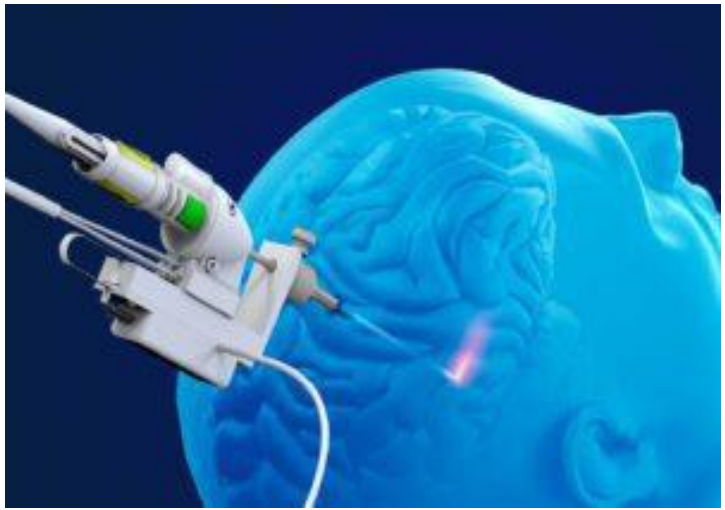
Medical robots





Minnetonka, Minnesota-based Monteris designed its NeuroBlate minimally invasive surgical robot system for controlled laser thermotherapy, known as laser interstitial thermal therapy (LITT).

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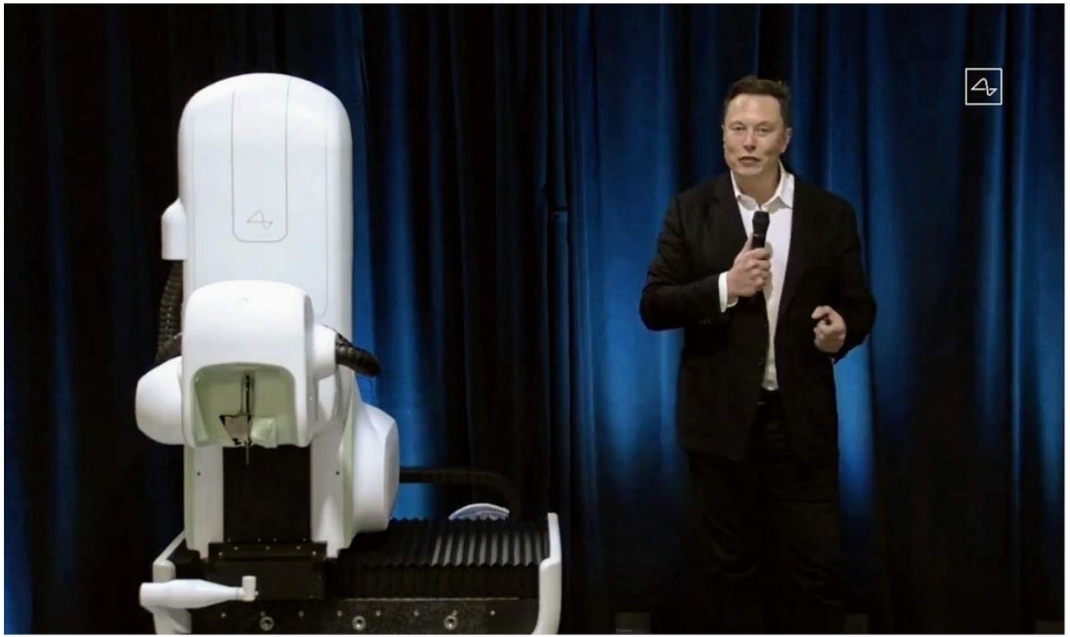
ARTAS

Artas is the only robot in the world that independently extracts thousands of hairs from the scalp, then prepares places for implantation and implants. The transplantation procedure in which it is used can be performed.

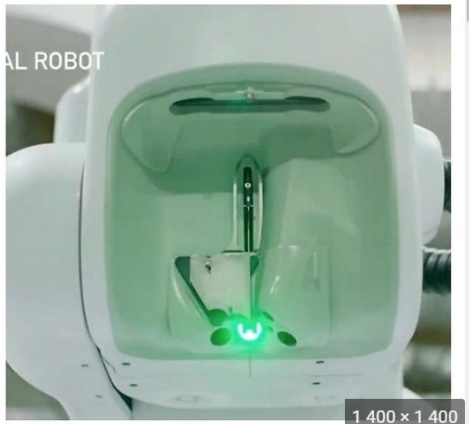
- **Hair-Washing**
- **RoboticBed**


NEURALINK




READ & WRITE ON EVERY CHANNEL
Channels
1,024
Battery life
All day
Recharging time
Overnight
Wireless range
5 - 10 meters
Implant size
23 mm x 8 mm
Look
Not externally visible


SURGICAL ROBOT


AL ROBOT

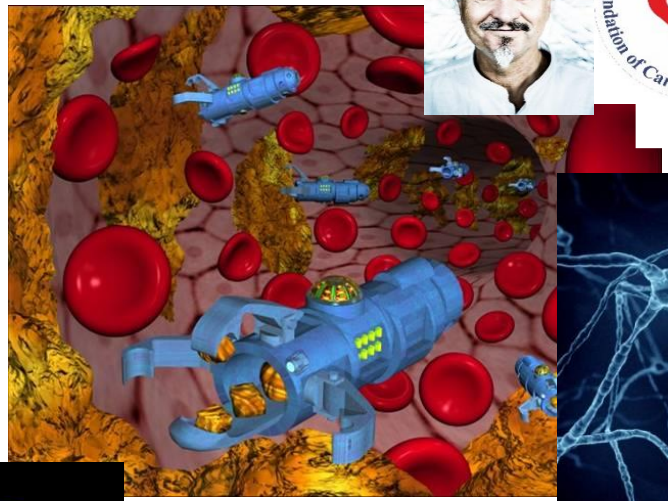
Robot Inoculators Accelerate China's Vaccine Rollout
sixthtone.com

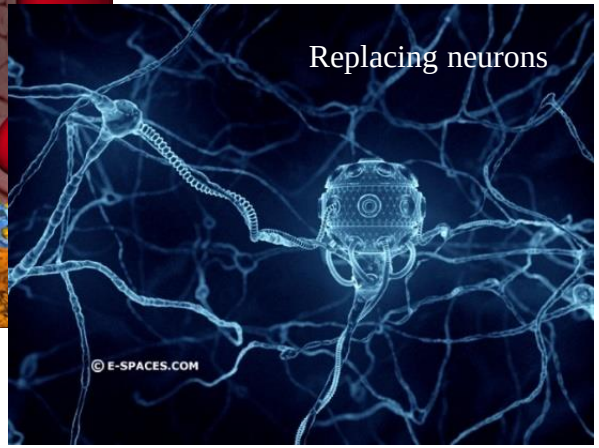
How are robots helping in the coronavirus pa...
weforum.org

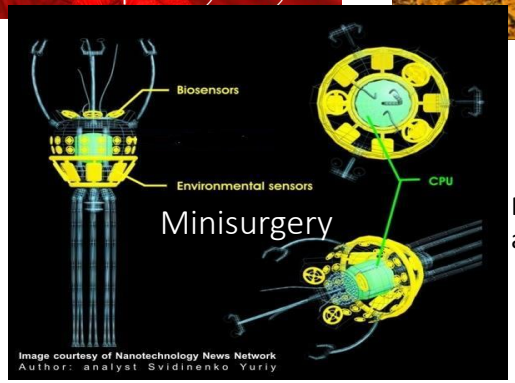
Adult vaccination: can technology help improve acces...
vaccinestoday.eu

In the fight against CoVid - from vaccine production, through diagnosis to vaccination.

Nano and Micro Medical robots







Moving in the arteries nanorobot will be "collected" and decomposed accumulation of fat to protect us from atherosclerosis.

PARO theraphy

Transport

Adult vaccination: can technology help improve acces.
vaccinestoday.eu

How are robots helping in the coronavirus pa...
weforum.org

Transport inside

Aethon, founded in 2004 and based in Pittsburgh, is best known for its TUG autonomous mobile delivery robot which is able to carry around a multitude of racks, carts or bins up to 453 kilograms in the form of medications, laboratory specimens or other sensitive materials.

POLSKA

RobotLova

Silesia

RobotLova

Prof. Andrzej Bochenek & Zeus& AESOP Katowice SUM

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

In **2002,** the clinic in Katowice Ochojec rented the **ZEUS** robot from Computer Motion in California for research purposes for a period of approximately 3 months. The initiator of research on the use of a robot in heart surgery was prof. A. Bochenek. 10 heart surgeries were performed..

In **2001,** the first robotic assistant **AESOP** (Automated Endoscopic System for Optimal Positioning) was imported from the United States to this clinic, used to hold an endoscopic camera and support minimally invasive surgeries. It was the first medical robot in Eastern Europe that served as an automatic assistant, among others. in coronary artery bypass surgery (by-pass) for over 300 operations.

Wrocław - prof. W.Witkiewicz – da Vinci

•Gazeta Wrocławska
•Aktualności
•Wrocław: Robot chirurgiczny gotowy do pracy

Wrocław: Robot chirurgiczny gotowy do pracy
SZEJ
9 grudnia 2010, 12:42
Pierwszy w Polsce nowoczesny robot chirurgiczny Da Vinci został dziś zaprezentowany w szpitalu przy ul. Kamieńskiego.

„Pierwszą operację z jego wykorzystaniem prof. Wojciech Witkiewicz przeprowadzi operację w poniedziałek. Zabieg odbędzie się przy udziale specjalistów z zagranicy. Za pomocą robota, którym steruje lekarz, zostanie zoperowany 50-letni pacjent z nowotworem jelita grubego. Urządzenie kosztowało 8 mln zł. NFZ nie refunduje na razie zabiegów przeprowadzanych za jego pomocą. Szpital będzie zdobywał pieniądze na ten cel z fundacji i grantów naukowych.”

Wojewódzki Szpital Specjalistyczny in Wrocław – 406 surgical operations (2010-2021)

POLISH MEDICAL ROBOTS POTENTIAL!!

Let's build **Medical Robot**" by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

World of

Robots

Service robots – top findings

IFR International Federation of Robotics

2020: Still growing strongly

New **professional service robots***

- 131,800 units (+41%)
- Turnover: USD 6.7 billion (+12%)

New **consumer service robots**

- 19 million units (+6%)
- Turnover: USD 4.4 billion (+16%)

*All numbers based on a sample of 235 companies and 3 association reports

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze

Service Robotics – TOP 5 Application trends

IFR International Federation of Robotics

- **AMR and delivery robots**
  flexible solutions
- **Cleaning and disinfection**
  + 50 companies due to Covid-19
- **Medical and rehabilitation**
  individual support
- **Social robots**
  telepresence – particularly during Covid-19
- **Automated restaurant**
  staff support, reduce personal contact due to Covid-19


Image: Effidence


Image: Bluebotics


Image: Cyberdyne


Image: Ava Robotics


Image: Miso Robotics

Press Conference World Robotics 2021 | 28 Oct 2021 33

Service robots – top findings

2020: Still growing strongly

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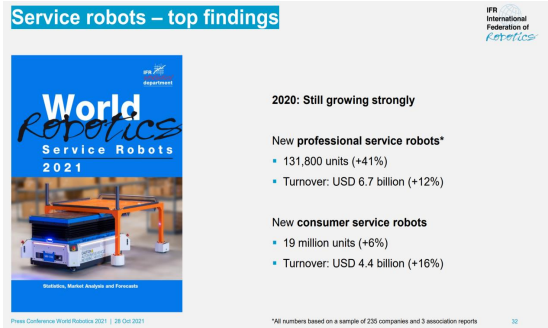
Cleaning and disinfection:
+ 50 companies



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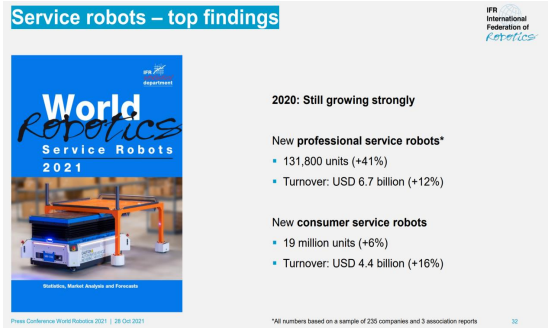
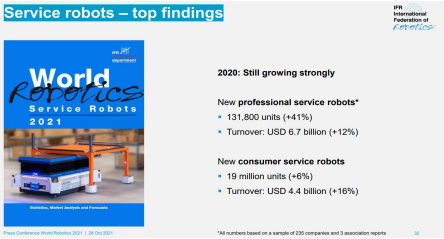
Medical and rehabilitation: individual support



Automated restaurant
staff support, reduce personal contact due to Covid-19



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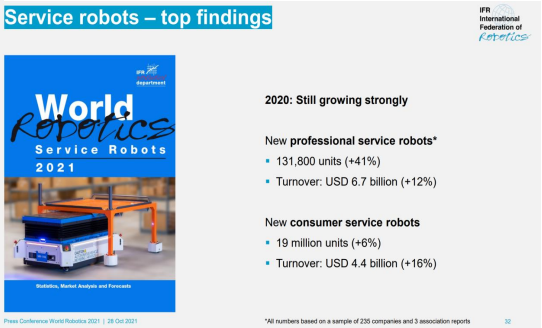
Social robots
telepresence – particularly during Covid-19



Jun 02, 2021 — Leading product design experts recognize ABB's GoFa™ collaborative robot for innovative design to make robots more approachable.

https://ifr.org/


Global Medical Robotics Market
Medical Robotics Market was valued at approximately
USD 23,432 Million by 2025 and is projected to register a
23.21% CAGR over the forecast period
BY PRODUCT
Surgical Robotic Systems
Rehabilitation Robotic Systems
Hospital & Pharmacy Robotic Systems
Noninvasive Radiosurgery Robotic Systems
Others
BY APPLICATION
Laparoscopy
Neurosurgery
Cardiology
Orthopedic Surgery
Pharmacy Applications
Others
BY END USER
Hospitals and Clinics
Specialty Centers
Rehabilitation Centres
Others
BY REGION
North America
Europe
Asia-Pacific
Rest of the World

According to a report published by researchers of **CovidSurg Collaborative, around 28 million surgeries were canceled across the globe during 12 weeks of peak disruption during the COVID-19 pandemic.**

https://www.marketsandmarkets.com/Market-Reports/medical-robotic-systems-market-2916860.html

.. and CoVid

The work presented in this article received funding from the EU's Horizon 2020 research and innovation program under grant 825003 DIH-HERO.

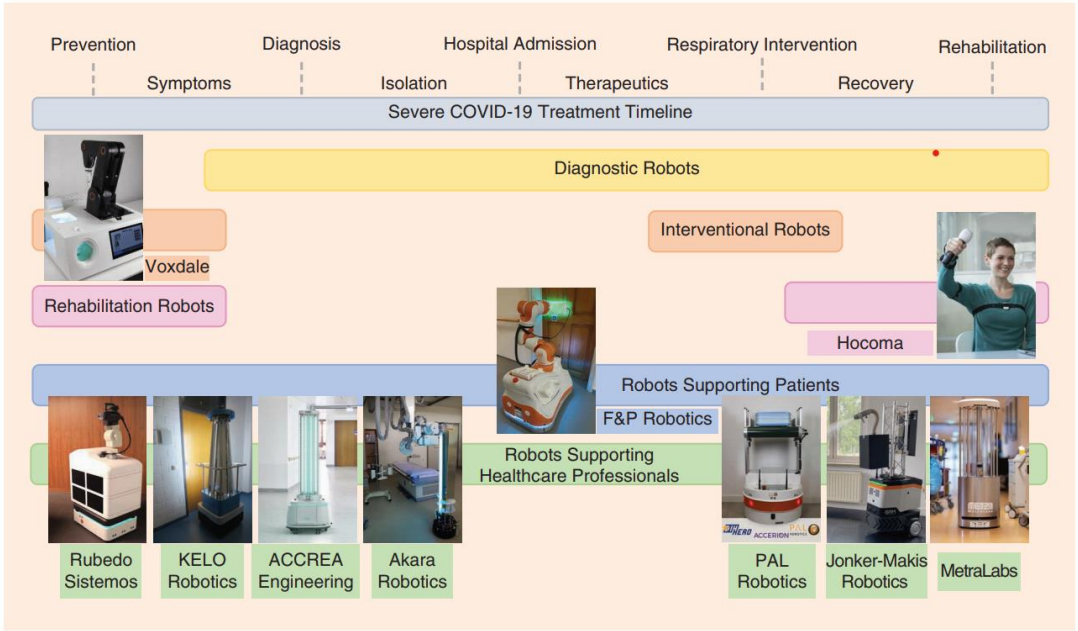


Figure 1. The health-care robotics innovations being developed under the DIH-HERO COVID-19 call within the timeline of the COVID-19 disease.

Table 1. The funded projects of the DIH-HERO COVID-19 call.

Company (Country)	Primary Application Area	Project Title (Acronym)
ACCREA Engineering (Poland)	Robotics supporting health-care professionals	Disinfecting RoboT (DisiRT)
Akara Robotics (United Kingdom)	Robotics supporting health-care professionals	Disinfectant RObots to Protect Against COVID (DROPAC)
F&P Robotics (Switzerland)	Robotics supporting patients	Autonomous sanitizer and assistant (Lio)
Hocoma (Switzerland)	Rehabilitation robotics	Sensor-based arm and hand-functional telerehabilitation with ArmeoSenso (Tele-AX)
Jonker-Makis Robotics (The Netherlands)	Robotics supporting health-care professionals	Autonomous mobile disinfection robot SAM-Air (SAM-Air)
KELO Robotics (Germany)	Robotics supporting health-care professionals	Autonomous robots for disinfection (ARODIS)
MetraLabs (Germany)	Robotics supporting health-care professionals	Portable and agile autonomous disinfection robot (STERY)
PAL Robotics (Spain)	Robotics supporting health-care professionals	Fast deployment of AVs in hospitals (TIAGo delivery)
Rubedo Sistemos (Lithuania)	Robotics supporting health-care professionals	Unmanned disinfection solution (UDS)
Voxdale (Belgium)	Interventional robotics	Robot for intradermal drug delivery (ROB-ID)

By Kosta Jovanovic, Andrea Schwier, Eloise Matheson, Michele Xiloyannis, Esther Rodijk-Rozeboom, Nadine Hochhausen, Brecht Vermeulen, Birgit Graf, Peter Wolf, Zbigniew Nawrat, Jordi Escuder Tisaire, Mare Mechelinck, Birgitte Sørensen, Paola Roberta Boscolo, Michael Obach, Selene Tognarelli, Milica Jankovic, Christophe Leroux, Giancarlo Ferrigno, Françoise J. Siepel, and Stefano Stramigioli Digital Innovation Hubs in Health-Care **Robotics Fighting COVID-19: Novel Support for Patients and Health-Care Workers Across Europe**. January 2021. IEEE Robotics & Automation Magazine PP(99) DOI: 10.1109/MRA.2020.3044965 https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9330556

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.. and CoVid

The work presented in this article received funding from the EU's Horizon 2020 research and innovation program under grant 825003 DIH-HERO.

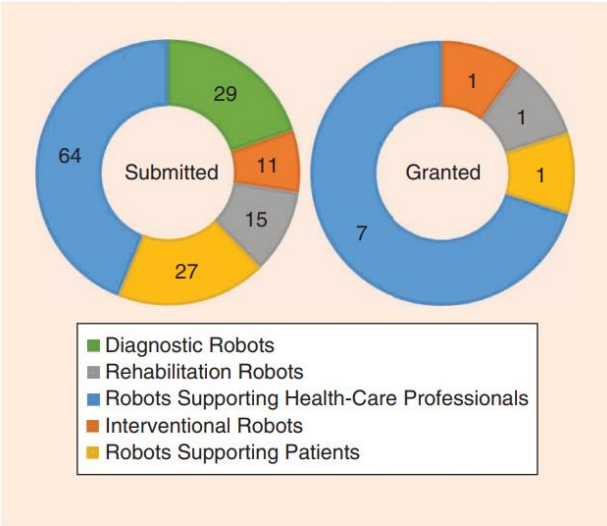


Figure 2. An overview of health-care robotics application areas within the DIH-HERO call for funding in health-care robotics fighting COVID-19.

Table 2. An overview of the main technical features of the DIH-HERO industry projects.

Project Acronym	Project Aim	Distinctive Feature(s)	Results/Impact on COVID-19 and Beyond
DisiRT	Autonomous disinfection of isolation ward areas	Multimodal disinfection	Real-time visual feedback with safety features
DROPAC	Autonomous disinfection of radiology treatment rooms	A 360° computer vision system used to track people in the vicinity of the robot	Disinfection benchmarking against manual techniques (time and effectiveness); an interactive graphical user interface; hospital proof-of-concept validation
Lio	Personal patient assistance; disinfection of nursing homes	Seamless transition between the social and disinfection robots	UVC disinfection of frequently touched surfaces (door handles)
Tele-AX	Home-based rehabilitation	Remote, data-driven therapy program	Telerehabilitation system for upper-extremity training in simulated and real operational environments
SAM-Air	Autonomous disinfection of public environments	Probiotics cleaning sprays	–
ARODIS	Autonomous disinfection of public environments	Human-detection safety feature based on four RGB cameras	UVC dose versus distance characterization
STERY	Autonomous disinfection of public environments	High power-density UV; autonomous charging at the provided docking station	Effectiveness of delivered UVC dose; a mobile app for disinfection configuration
TIAGo delivery	Autonomous transportation of sensible goods	Multisensory system for SLAM and object recognition and precise delivery	Logistic solution adaptable to varied environments
UDS	Autonomous disinfection of public environments	Ionized hydrogen peroxide spray, the VIPER Perception System, and the ORCA smart navigation system named *ORCA*	Spraying disinfection solution validated in the clinical settings and by the virus biomarkers
ROB-ID	Autonomous vaccine delivery	Standardized intradermal vaccine injection	Increased vaccination coverage; solved vaccine shortages (10% of the dose is needed)

SLAM: simultaneous localization and mapping.

The Professor Zbigniew Religa Foundation of Cardiac Surgery Development

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

AI

FIRST STEP FOR AUTONOMOUS MEDICAL ROBOTS

Let’s build **Medical Robot**” by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

*The **CorPath GRX***
robotic surgical device from Corindus Vascular Robotics.

In March 2018, **Corindus** Vascular received 510(k) clearance from the U.S. Food and Drug Administration (**FDA**) for the **first automated robotic movement** designed for its CorPath GRX platform. Called **"Rotate on Retract" (RoR),** the proprietary software feature is the first automated robotic movement in the technIQ Series for the CorPath GRX platform. It allows the operator to quickly navigate to a targeted lesion by automatically rotating the guidewire upon joystick retraction.

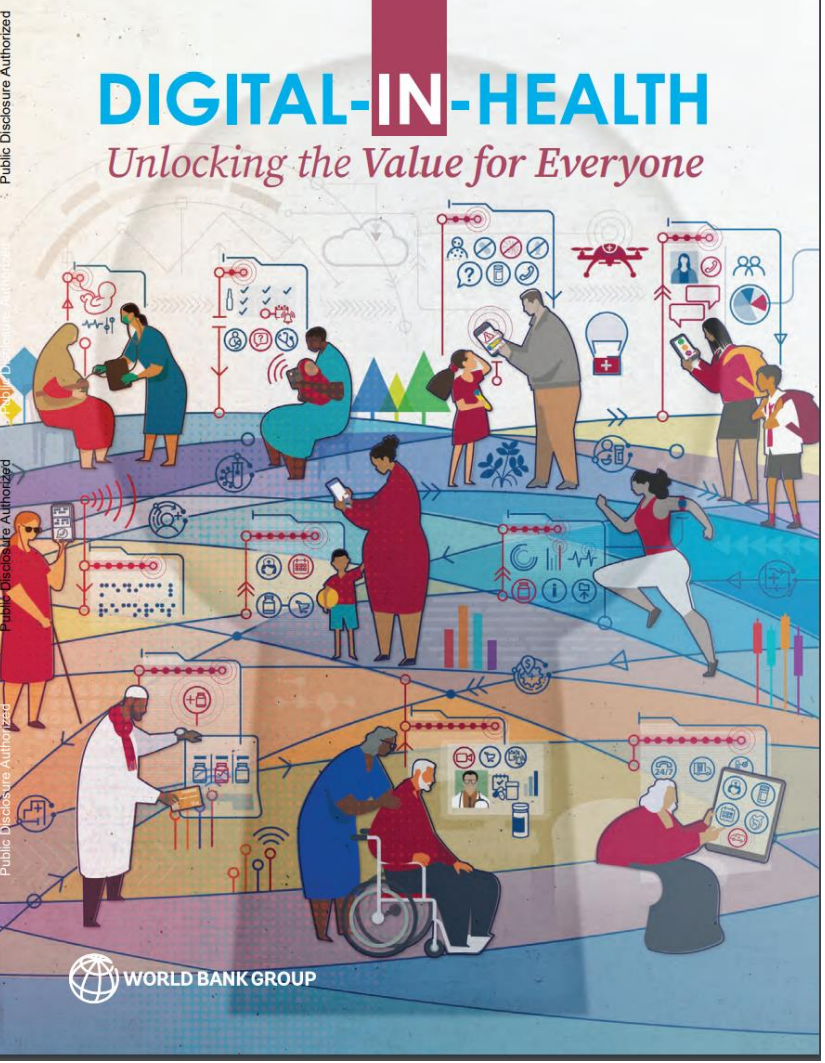
https://www.therobotreport.com/corindus-corpath-grx-clearance-japan/

International Society for Medical Robotics
ul. Wojnicki 345a
41-800 Zabrze
tel.: +48 32 373-56-00
www.medicalrobots.eu

Let's build **Medical Robot**" by Zbigniew Nawrat

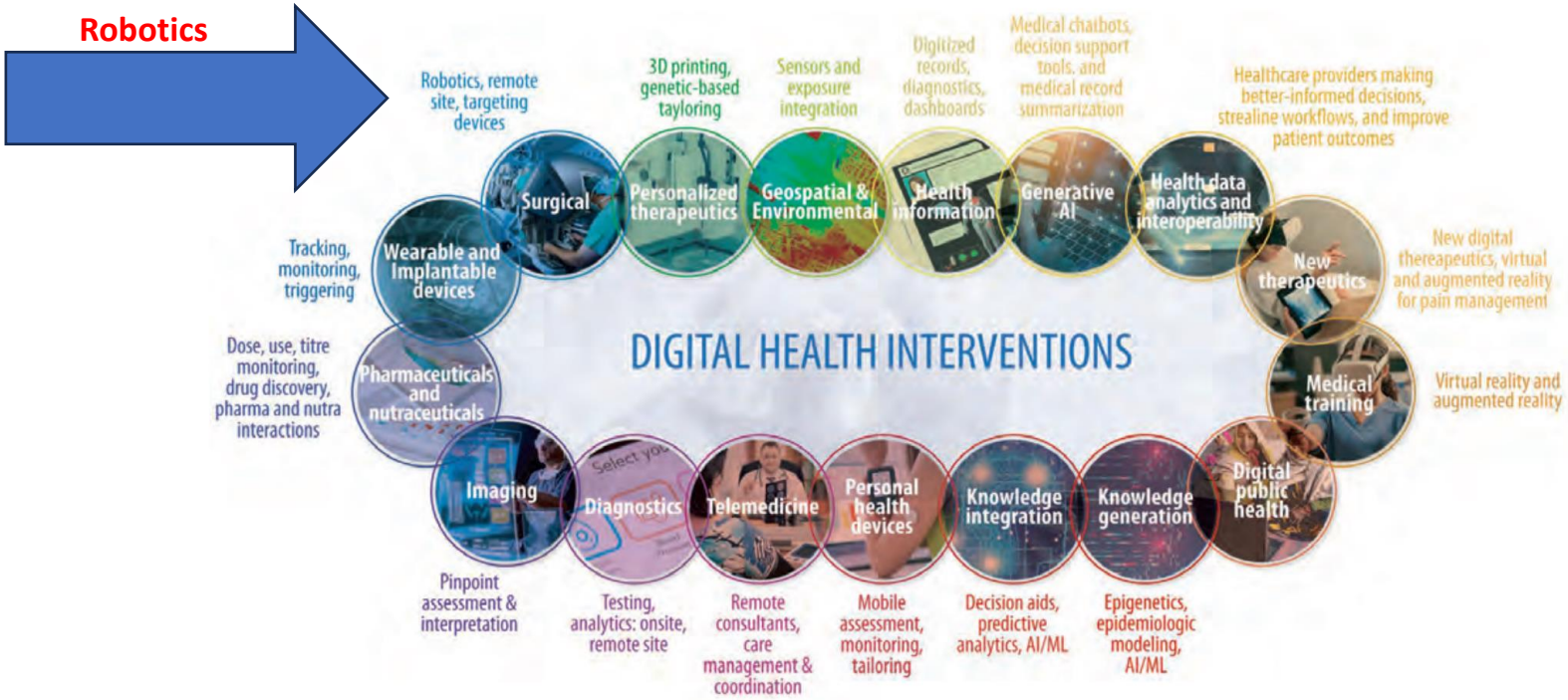
nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

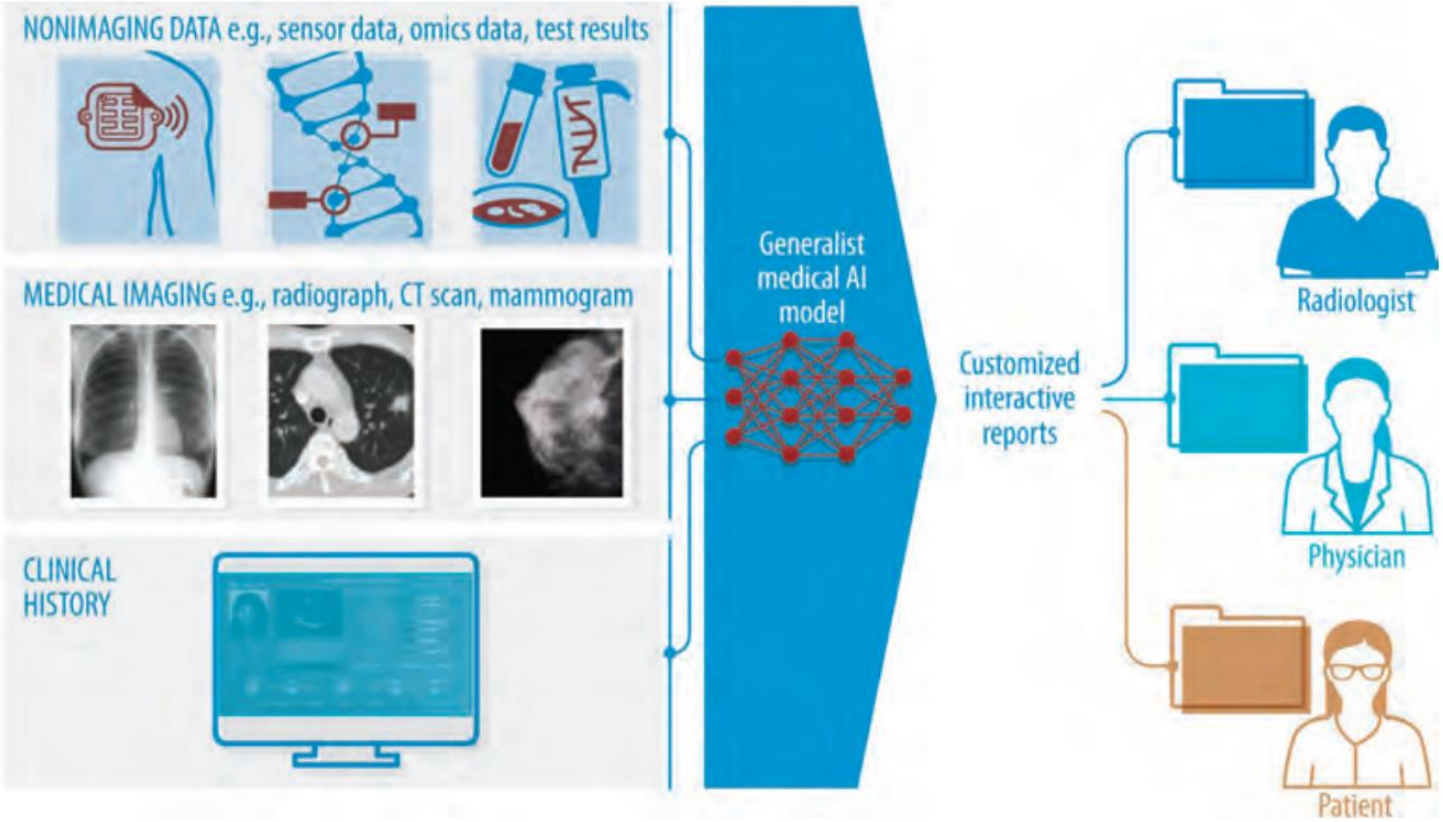
WHY ?
AI



From **Digitalization**
to Digital-in-Health

Figure shows the key areas of expansion already underway, recognizing that these trends represent only a glimpse of the mushrooming field of digital technology in health.





Source: Rajpurkar and Lungren 2023

A decade retrospective of medical robotics research from 2010 to 2020

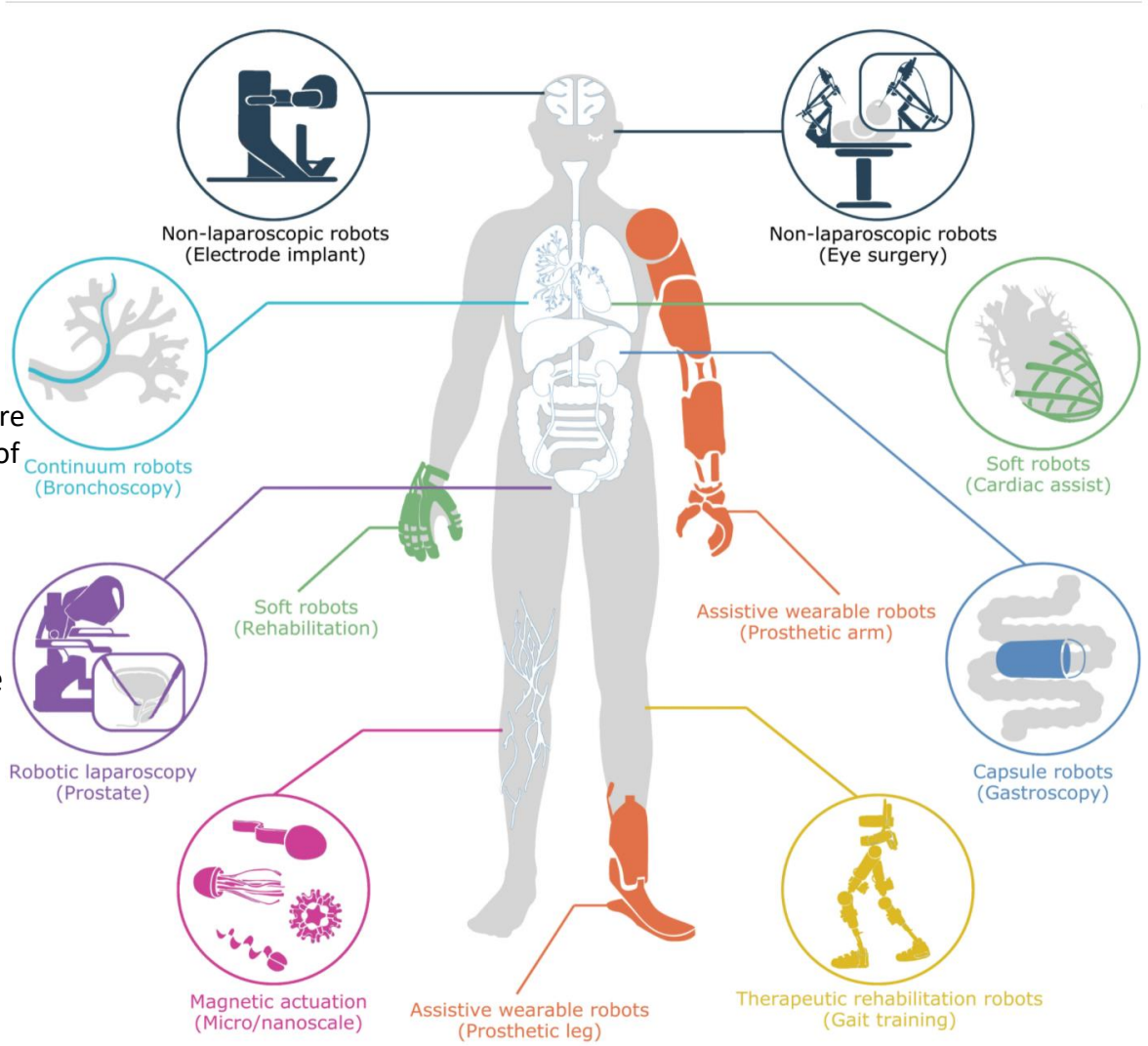
PIERRE E. DUPONT, BRADLEY J. NELSON, MICHAEL GOLDFARB, BLAKE HANNAFORD, ARIANNA MENCIASSI, MARCIA K. O'MALLEY, NABIL SIMAAN, PIETRO VALDASTRI, AND GUANG-ZHONG YANG Authors Info & Affiliations

SCIENCE ROBOTICS • 10 Nov 2021 • Vol 6, Issue 60 • DOI: 10.1126/scirobotics.abi8017

„Just more than three decades ago, the first roboticists began to explore the use of robot manipulators for performing surgical procedures. Two decades ago, the first commercial systems were installed in hospitals. In the past decade, the field of medical robotics has gained momentum, and thousands of robotic surgical systems are now installed in clinics around the world" „ An **evolutionary trend toward progressive automation** will provide time for the necessary technological developments in algorithms and sensors while allowing stakeholders time to progressively construct an appropriate regulatory and legal framework

P. E. DUPONT …

Let's build **Medical Robot**" TRENDS



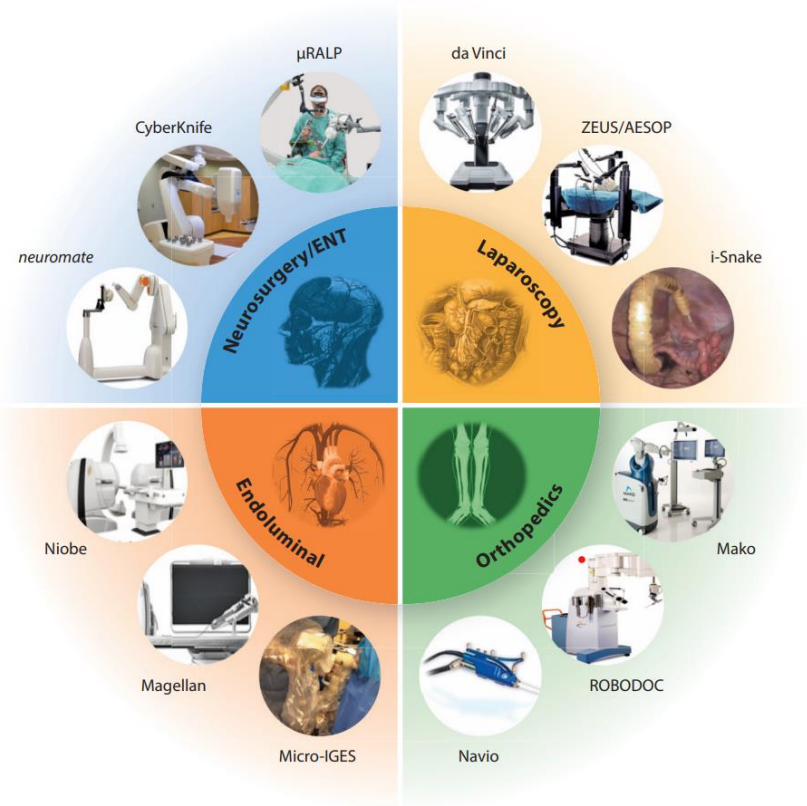


Figure 3

Examples of surgical robot specializations. Abbreviation: ENT, ear, nose, and throat. Images are adapted with permission as follows: *neuromate*, Renishaw, © 2018; CyberKnife, Wikimedia Commons (CC BY 2.0); μRALP Surgical System, Mattos et al. (μRALP Consortium; **https://www.microralp.edu**); da Vinci, Intuitive Surgical Inc., © 2018; ZEUS/AESOP, Reference 20; i-Snake, Reference 26; Mako, Reference 131; ROBODOC, Reference 130; Navio, Reference 131; Micro-IGES, Reference 88; Magellan and Niobe, Reference 24. Figure inspired by Reference 26.

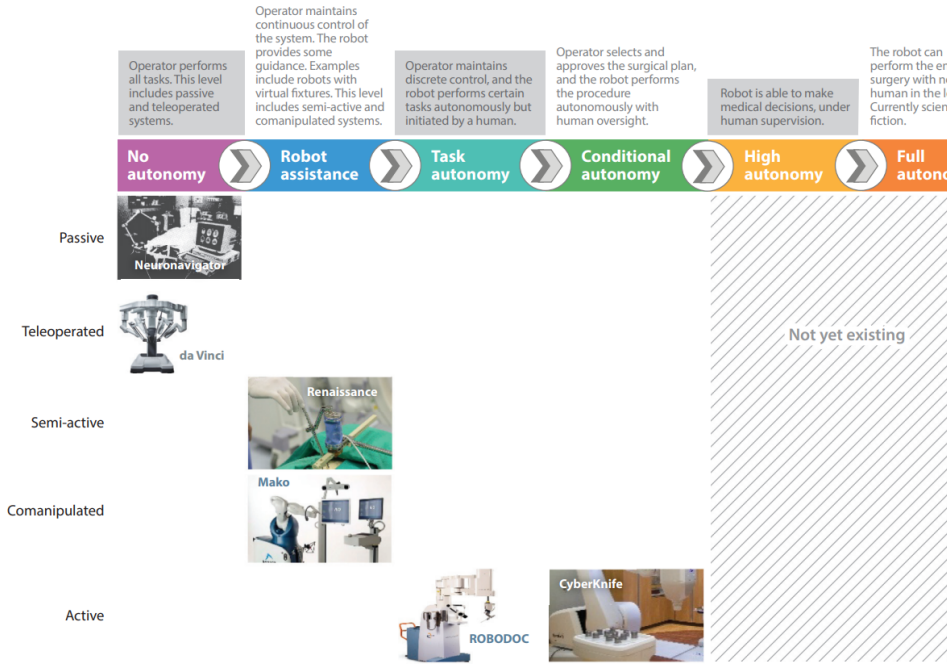


Figure 4

Different levels of human–robot interaction and autonomy mapped to medical robots. Levels of human–robot interactions are described in Reference 132; decision levels are described in Reference 122. Images are adapted with permission as follows: Neuronavigator, Reference 145; da Vinci, Intuitive Surgical Inc., © 2018; Mazor Robotics Renaissance, Mazor Robotics; Mako, Reference 131; ROBODOC, Reference 130; CyberKnife, Wikimedia Commons.

FULL AUTOMATION Level 5
No human operator is needed. This is a "robot expert" that can perform an entire task automatically.

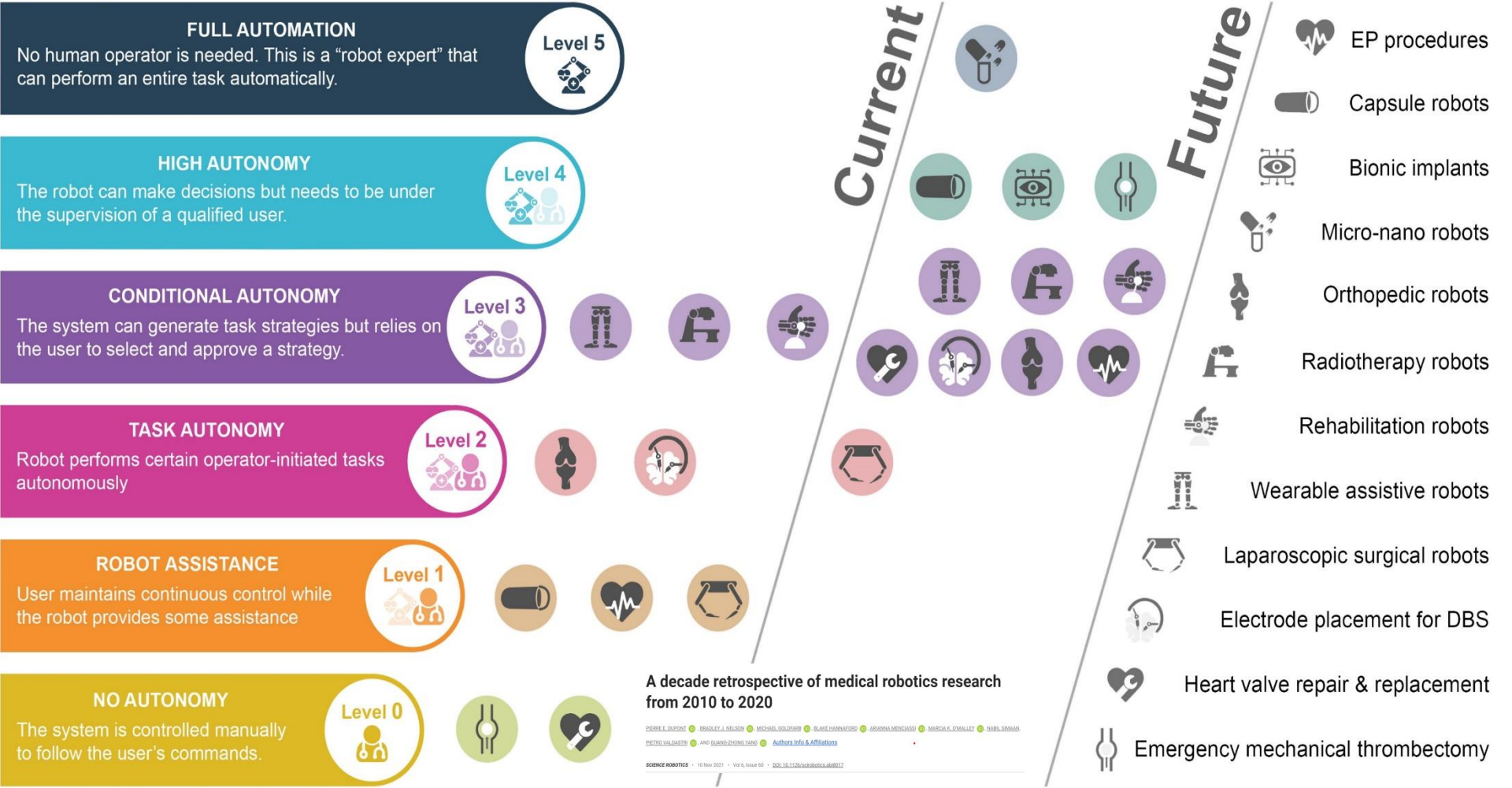
HIGH AUTONOMY Level 4
The robot can make decisions but needs to be under the supervision of a qualified user.

CONDITIONAL AUTONOMY Level 3
The system can generate task strategies but relies on the user to select and approve a strategy.

TASK AUTONOMY Level 2
Robot performs certain operator-initiated tasks autonomously

ROBOT ASSISTANCE Level 1
User maintains continuous control while the robot provides some assistance

NO AUTONOMY Level 0
The system is controlled manually to follow the user's commands.



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woda, para	elektryczność	komputery	Internet rzeczy
First industrial revolution	**Second industrial revolution**	**Third industrial revolution**	**Fourth industrial revolution**
The first industrial revolution occurred at the end of the 18th century and was driven by mechanization based on steam and water power.	The second industrial revolution started at the beginning of the 20th century. It was driven by electricity and enabled mass production by means of assembly lines and division of labor.	The third industrial revolution started in the 1970s and was driven by computer technology, which was used to further automate machines and production processes.	The fourth industrial revolution, which is ongoing, will prospectively lead to smart factories and a comprehensive digital and interoperable ecosystem of machines and partners.

Fifth revolution? AI – driven industry

without people? for people?

WHY ?

MIS AI

MIS AI

The **robot** is not a machine but an **IT device** that creates a great opportunity for the integration of the entire diagnostic system with the operator. Surgery is a specific type of medical activity that uses direct physical methods of intervention in a body area damaged by illness or injury.

In my opinion, artificial intelligence is a part of robotics. Generally, **artificial intelligence was created for communication between machinery and human intelligence.**

If, however, we assume that we would like to operate in a place where our intervention is necessary by methods that reduce the risk of damage to healthy tissues as much as possible, it means the loss of the ability to freely view and touch the tissue, the inability to directly insert our hands in the place of surgery. This is the current MIS dilemma.

Is this beneficial for the patient? Can a surgeon possibly do this?

This is a challenge for creating new tools and both artificial intelligence and robots are one of them.

The less invasive the surgery,
the less visual and sensory information we have -
the more the role of AI increases.

MIS AI - artificial intelligence application in minimally invasive surgery Zbigniew Nawrat
https://oaepublishstorage.blob.core.windows.net/90c9adc5-df8c-4104-b319-e3543fc1d186/3464.pdf

Let's build **Medical Robot**" by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

Robots change, develop surgeon

Surgical ontologies for automation

22

Level of granularity	Time span	Com-plexity	Example
Operation	~15 min, hours	very high	Laparoscopic cholecystectomy
Task	~1–30 mins	high	Pneumo-peritoneum → Exposing-Calot's triangle → ...
Subtask	~1–5 mins	moderate	Retraction of the gallbladder → Blunt dissection at the Cystic duct → Blunt dissection at the Cystic art.
Surgeme	~1–20 secs	low	Approach the tissue ⇄ Perform dissecting motion
Motion primitive	~1-5 secs	very low	Penetrating connective tissue → Opening the dissector → Removing the dissector

Nagy et al., JMRR, 2018, https://doi.org/10.1142/S2424905X18410052

IROB – http://irob.uni-obuda.hu

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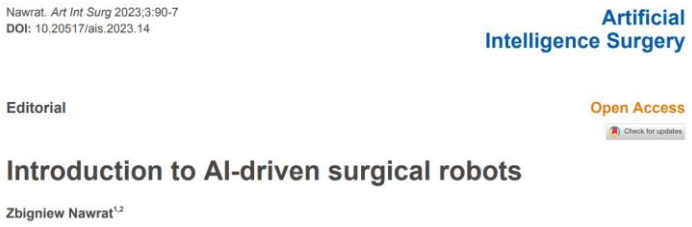


Nawrat. *Art Int Surg* 2023;3:90-7
DOI: 10.20517/ais.2023.14

Artificial Intelligence Surgery

Editorial

Open Access

Check for updates

Introduction to AI-driven surgical robots

Zbigniew Nawrat[1,2]

Why does AI help surgeons? AI can help to improve surgical outcomes by providing surgeons with realtime information and feedback, enhancing surgical planning and decision-making, and reducing the risk of complications during surgery.

Why do robots need AI?

Robots need AI to be able to operate autonomously, make decisions, and perform complex tasks. AI allows robots to learn from experience and adapt to new situations, making them more flexible and versatile in their abilities. Without AI, robots would be limited to performing a predefined set of tasks and would require constant human intervention and programming to adapt to new environments or situations. However, with AI, robots can learn from their interactions with the environment, and use that knowledge to make decisions and perform tasks more efficiently.

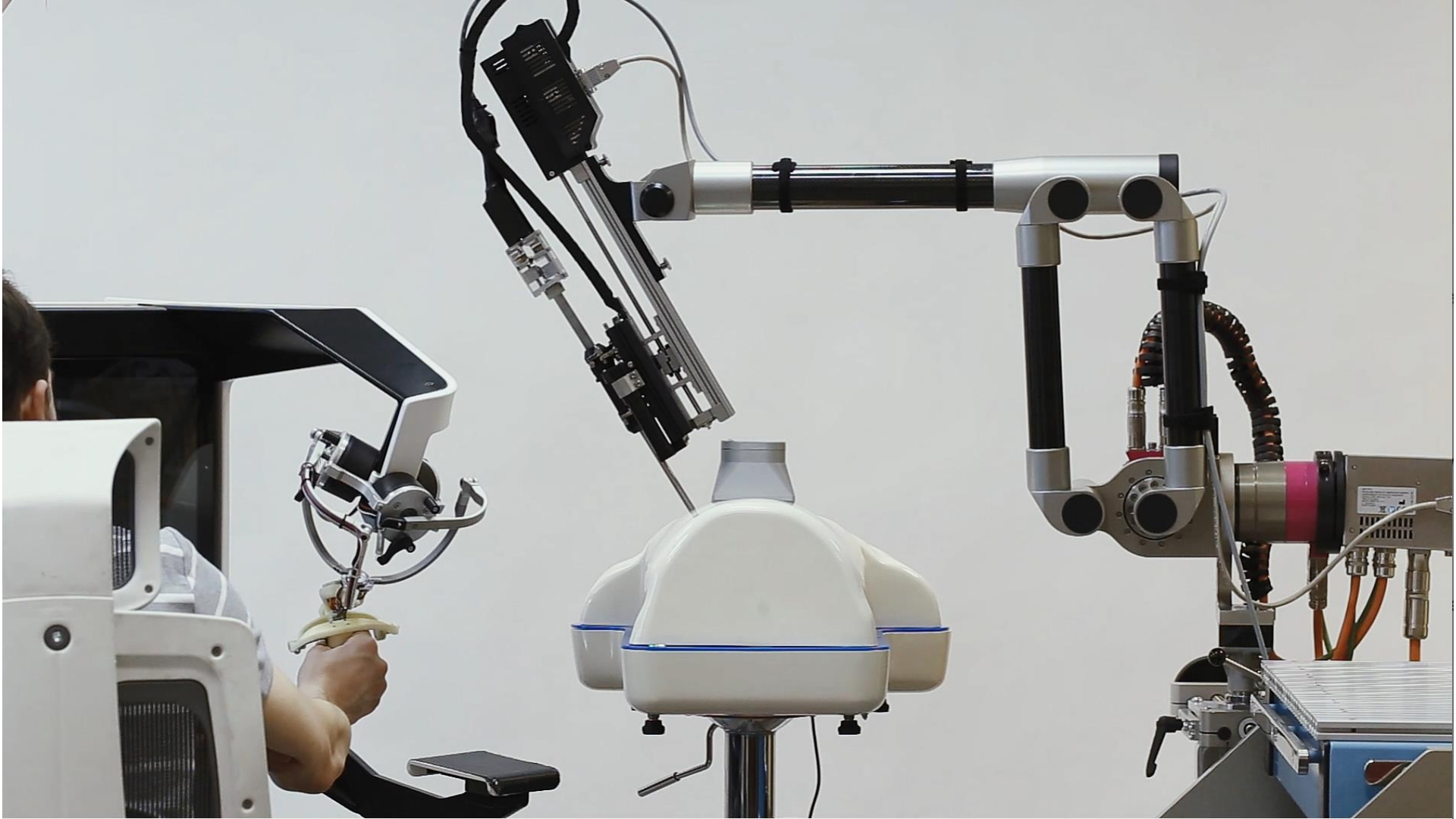
Intelligence means the right reaction to the information received.

https://oaepublishstorage.blob.core.windows.net/cccaccf3-537d-41e9-911f-c56837269138/5701.pdf

Currently, medical robots and AI support medical services in the richest countries in the world. The capitalist system, of course, requires a return on investment and an opportunity for shareholders to enrich themselves. However, **the real breakthrough will occur when medical robots begin to help those who cannot afford "normal healthcare services", when an added group of beneficiaries appears. …** **I have no doubt that without AI, robots will never overcome this barrier - the barrier of interest and business.**

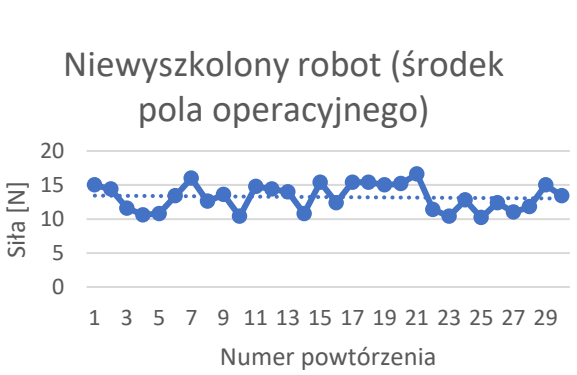
AI is here to communicate with human intelligence,
to free up human hands,
and to enable humans to return to being human.

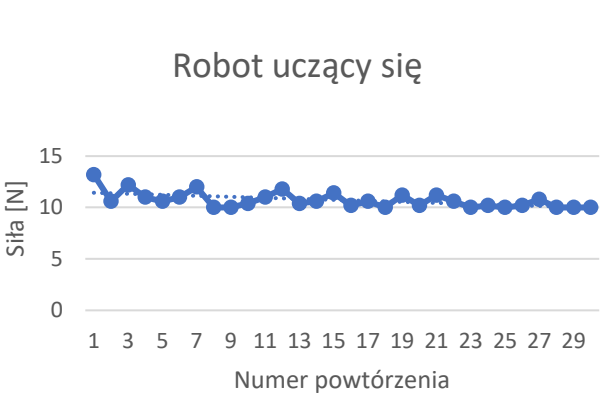
Robin Heart AI

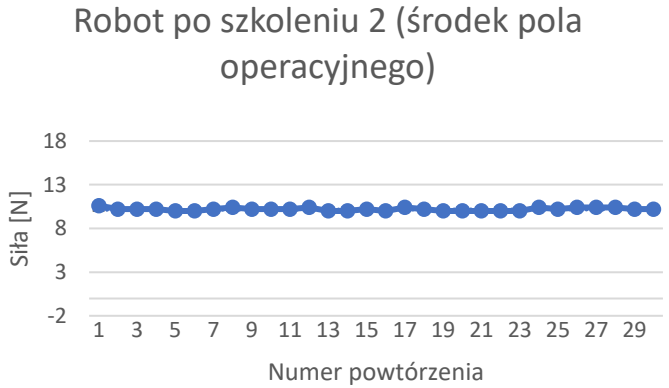



Robin
Stiff Flop
Console
Robin Heart Console

Robin Heart AI: „W trakcie pierwszej próby testowania automatycznej elektrokoagulacji robot ustawiał się w miejscu wykrytego krwawienia, po czym wykonywał ruch w osi z, aż do osiągnięcia zamierzonej siły 10 N. Jednakże na dokładność wykonanego zadania wpływ miała bezwładność oraz prędkość hamowania narzędzia mechatronicznego. Po zakończonym treningu średnia siła wykonywanej elektrokoagulacji wyniosła 10,09 N, co znacznie przewyższa dokładność wykonywanego zabiegu ręcznie przez człowieka”







METODY

DIGITALIZACJA
otworzyła medycynę na AI

Roboty i AI zmieniają medycynę

Zbigniew Nawrat

Robot

Let’s build **Medical Robot**” by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

Robot to też AI

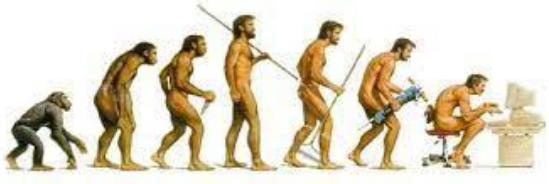
Let’s build **Medical Robot**” by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

„Robot” – wynalazek Karel Capek 1921

Tradycyjna **definicja robota** oznacza **sztucznego człowieka**.
Robot powinien mieć możliwość poruszania się (zdolność do **wykonywania pracy** mechanicznej), **zdolność do podejmowania decyzji** na podstawie informacji dostarczanych przez zmysły (**inteligencja**).

Roboty

Roboty i AI są ewolucyjną konsekwencją rozwoju narzędzi – od sterowanych i uruchamianych przez człowieka narzędzi ręcznych,
przez maszyny, manipulatory do samodzielnych urządzeń wykonawczych.



Medycyna

Róbmy roboty medyczne, stosujmy AI.
Bo inaczej nie damy rady pomóc wszystkim starym, niedołężnym, chorym czy niepełnosprawnym.
Roboty medyczne są niezbędne z powodów humanitarnych.
I z powodu możliwości osiągnięcia najwyższej jakości usług medycznych.

Let's build **Medical Robot**" by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND


SCHWADRON
"Hi, I'll be performing your surgery tomorrow."

Usługi medyczne

Jak jest

Usługi medyczne

Jak będzie

Oczywiście ZARZĄDZANIE

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

WYZWANIA

- **DEMOGRAFIA**

- **ROSNĄCE POTRZEBY**

(SPRZĘŻENIE ZWROTNE DODATNIE I UJEMNE POSTĘPU MEDYCYNY)

- **ROSNĄCE KOSZTY**

(OBIEKTYWNE I EKONOMICZNE PODSTAWY BRAKU POWSZECHNEJ DOSTĘPNOŚCI NAJLEPSZYCH TECHNOLOGII I LEKÓW)

ŚLĄSKI UNIWERSYTET MEDYCZNY
W KATOWICACH

Służba zdrowia

Usługi medyczne

Technologia zdrowia

Po postępach

Tele – komunikacji

przesyłaniu informacji
> telemedycyna

Czas na

Tele – działanie

roboty – telemanipulatory

Zbigniew Nawrat

Służba, usługa i technologia zdrowia.

Jesteśmy świadkami kolejnych transformacji i ewolucji opieki zdrowotnej.

Zbigniew Nawrat

Służba

relacja **człowiek<> lekarz**

w obowiązku pomocy człowiekowi w potrzebie

Zbigniew Nawrat

Usługa
relacja **człowiek>pieniądz<lekarz**,

parytet pieniądza, który decyduje i wadze relacji wykonywania usługi

Zbigniew Nawrat

Technologia zdrowia 1.0

relacja **człowiek>technologia<lekarz**

Lekarz jako użytkownik

Zbigniew Nawrat

Technologia zdrowia 2.0
relacja **człowiek>technologia**
Lekarz jako kontroler procesu i decydent

Zbigniew Nawrat

Technologia zdrowia 3.0
relacja **człowiek>technologia**
Pacjent jako kontroler procesu i decydent

Zbigniew Nawrat

Technologia zdrowia 3.0
relacja **człowiek>technologia**
Pacjent jako kontroler procesu i decydent

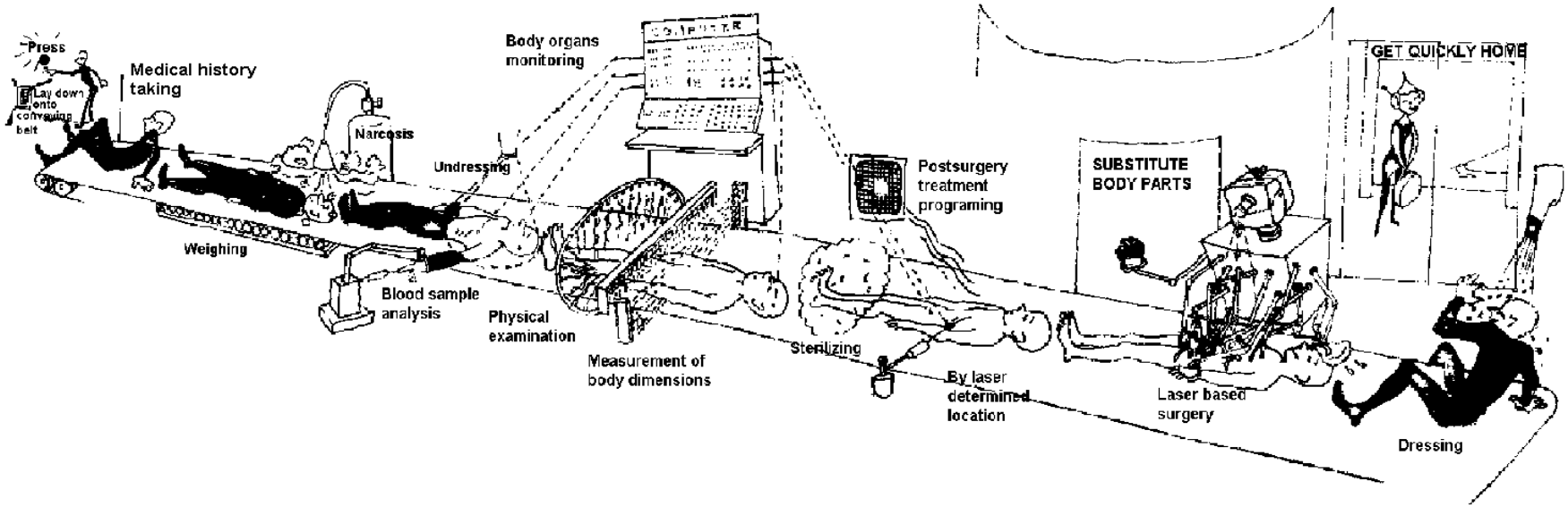
Zbigniew Nawrat

Technologia zdrowia 4.0
relacja **człowiek>*AI* technologia**
AI jako kontroler procesu i decydent

Zbigniew Nawrat

Technologia leczenia,
lekarz jest tylko elementem technologii.
Technologiczne podejście do procesu leczenia ma swoje zalety – **standaryzacje**, ale i wady – człowiek jest tylko obiektem racjonalizowanych działań medycznych.

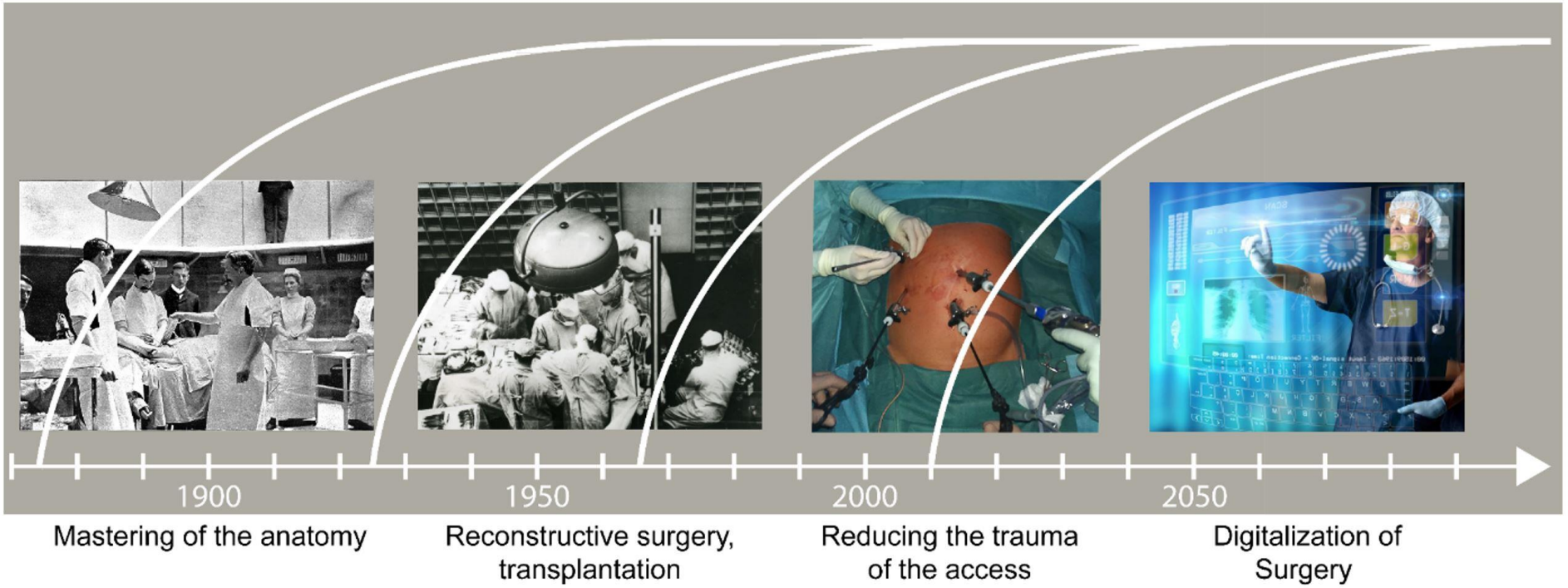
O priorytetach decyduje
WIEDZA i STANDARDY („etyka”)


Press
Lay down onto conveying belt
Medical history taking
Narcosis
Undressing
Weighing
Blood sample analysis
Physical examination
Body organs monitoring
Measurement of body dimensions
Sterilizing
Postsurgery treatment programing
By laser determined location
SUBSTITUTE BODY PARTS
Laser based surgery
GET QUICKLY HOME
Dressing

Surgery 4.0 in the Operating Room

Lukas Bernhard, Jonas Fuchtmann, Lars Wagner, Dirk Wilhelm, Hubertus Feussner

In AI Surgery ed.Gumbs, Karcz, Nawrat



Usługa medyczna to jest proces

Łańcuch od przewidywania > ostrzegania> nadzorowania> diagnozy> terapii> rehabilitacji do spersonalizowanej i ciągłej opieki domowej

Personel medyczny, człowiek jest najcenniejszym elementem tego łańcucha i najbardziej krytycznym,

Personel medyczny,
czuły na różne warunki
zewnętrzne (np.CoVid)
i posiada ograniczenia
w zakresie nadzoru
nad danymi i wyciągania
szybkich i adekwatnych
wniosków oraz działania
bez względu na warunki

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze

Dlatego AI i roboty medyczne znajdują tutaj swoje miejsce szczególne wiążąc, uszczelniając, rozwijając do perfekcji system, proces, usług medycznych

Łańcuch od
przewidywania > AI
ostrzegania> AI
nadzorowania> AI
diagnozy> AI
terapii> AI
rehabilitacji do spersonalizowanej i ciągłej opieki domowej AI

Moja propozycja:

AI jako „ czuły obserwator” w każdym węźle.

5/100/s

Borys Fiodorowicz

Każdy łańcuch jest tak dobry jak jego najsłabsze ogniwo

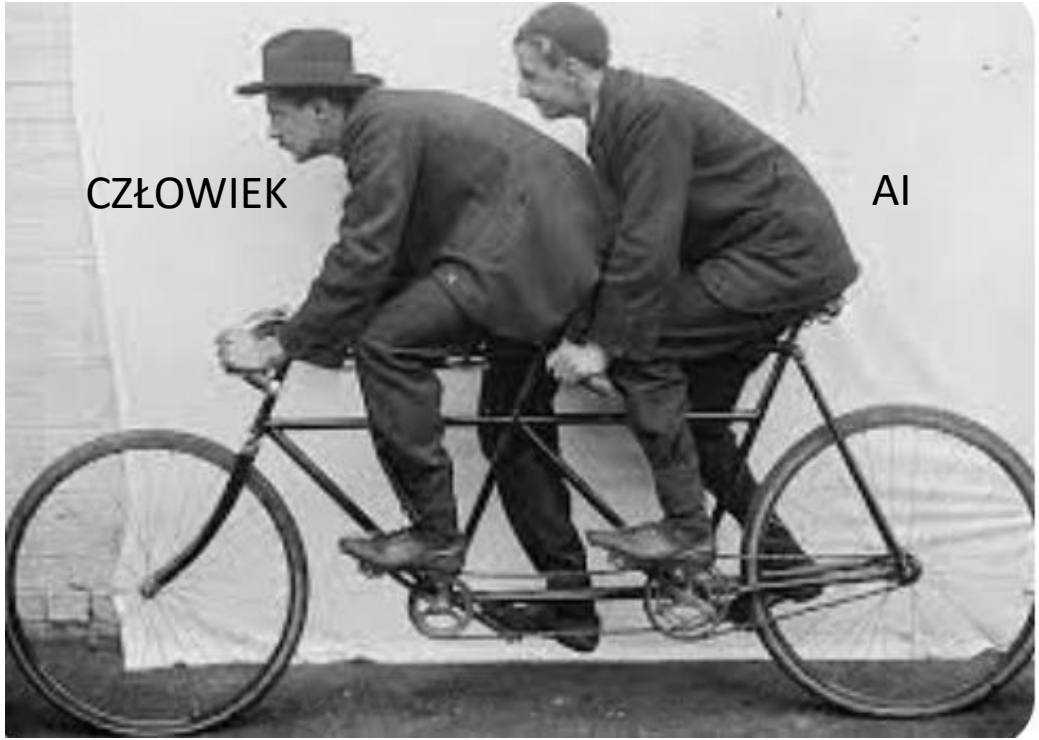
„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze


SHIMANO
SHIMANO

Łańcuch w takim sensie jak tu – czyli z ogniwem AI również napędza system

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze

Potrafisz tylko siedząc przebierać nogami – a tu proszę i wzmocnienie i możliwość osiągnięcia celu niedościgłego dla samych nóg – w dodatku siedząc


CZŁOWIEK
AI

Łańcuch usług medycznych zaczyna się od ZAPOBIEGANIA, PROGNOZY, **UCHWYCENIE ZMIANY I ANALIZA ORAZ PRZESŁANIE INFORMACJI DO CENTRÓW KOMPETENCJI**, DIAGNOSTYKA, TERAPIA, REHABILITACJA, OPIEKA DOMOWA

Człowiek jest jednak .....Analogowy.

Człowiek jest jednak …. Analogowy.

I to cyfrowanie danych o nim otworzyło tą możliwość włączenia człowieka do systemu, który wykorzystuje maszyny i jest nadzorowany przez programy komputerowe.

WYZWANIA

WYZWANIA

- **DEMOGRAFIA**

- **ROSNĄCE POTRZEBY**

(SPRZĘŻENIE ZWROTNE DODATNIE I UJEMNE POSTĘPU MEDYCYNY)

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(OBIEKTYWNE I EKONOMICZNE PODSTAWY BRAKU POWSZECHNEJ DOSTĘPNOŚCI NAJLEPSZYCH TECHNOLOGII I LEKÓW)

Górnośląski Akcelerator Przedsiębiorczości Rynkowej sp. z o.o.

The Professor Zbigniew Religa Foundation of Cardiac Surgery Development

Już obecnie na świecie potrzebujemy

100mln lekarzy,
300 mln opiekunów domowych,
pielęgniarek, inżynierów medycznych …..

Roboty i AI wprowadzamy
w przemyśle i usługach,
bo potrzebujemy coraz więcej ludzi
dla … ludzi

Roboty i AI potrzebne są byśmy mogli świadczyć lepiej usługi medyczne …

Pośrednio - by nas było na to stać i by coraz więcej z nas mogło służyć innym ludziom w potrzebie

Bezpośrednio – by podnosić jakość usług i rozszerzać dostęp do spersonalizowanej medycyny adekwatnie do potrzeb, we właściwym czasie i miejscu



W medycynie nie chodzi o to by żyć najdłużej tylko by każdy miał szansę je przeżyć – wbrew chorobom, wypadkom czy innym losowym zagrożeniom, które czyhają na każdego z nas.

Lekarz lecząc pacjenta naprawia kawałek świata

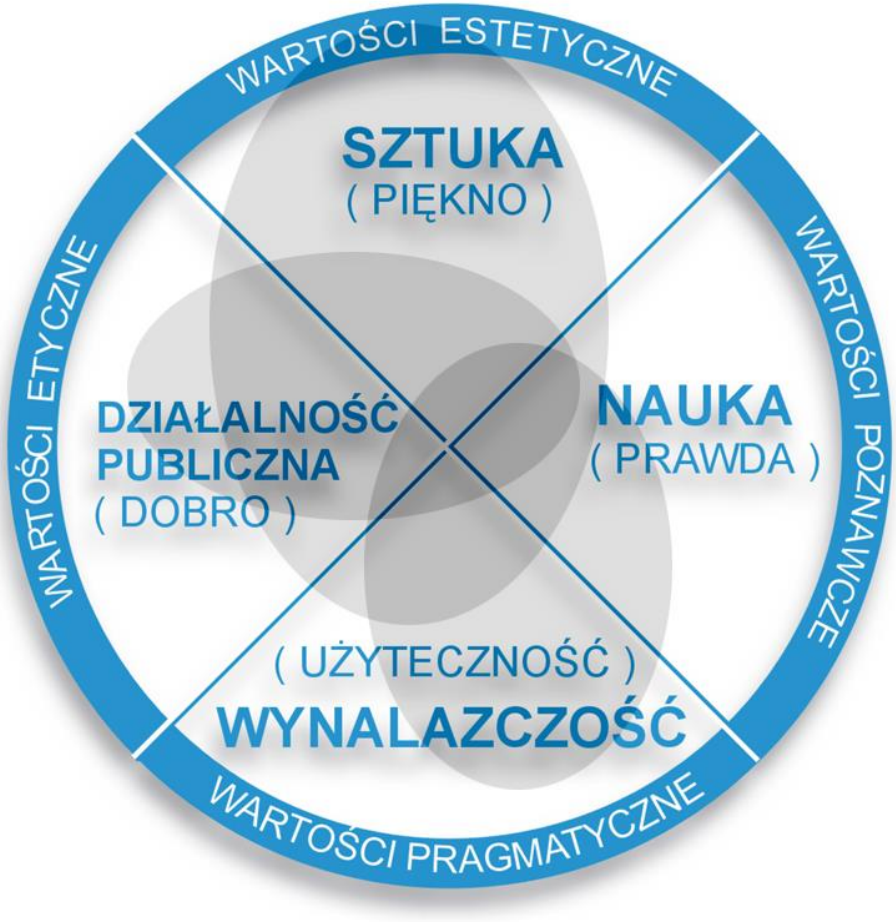
Let's build **Medical Robot**" by Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze, POLAND

To technologia zmienia świat

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze

To technologia zmienia świat i nasze wybory Co z nią zrobimy?

„ O robotach …” Zbigniew Nawrat nawrat@frk.pl … SUM,FRK, ISMR, Zabrze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(PRAWDA)
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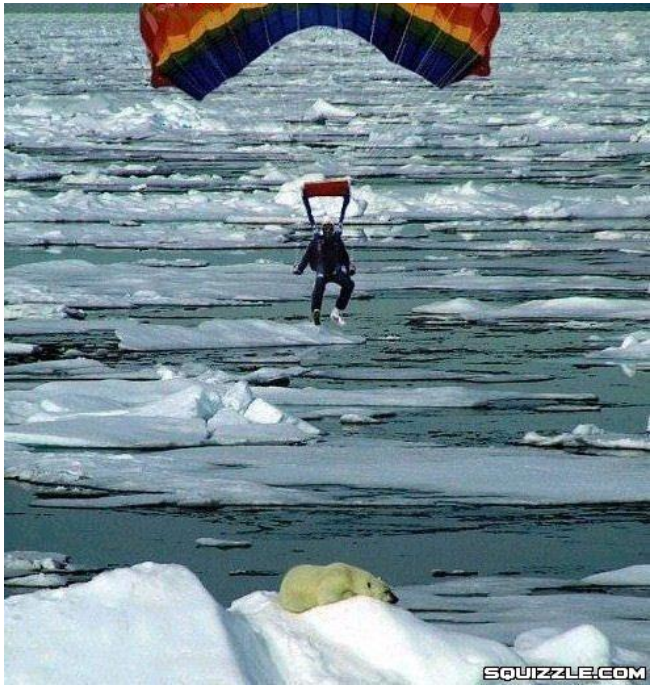
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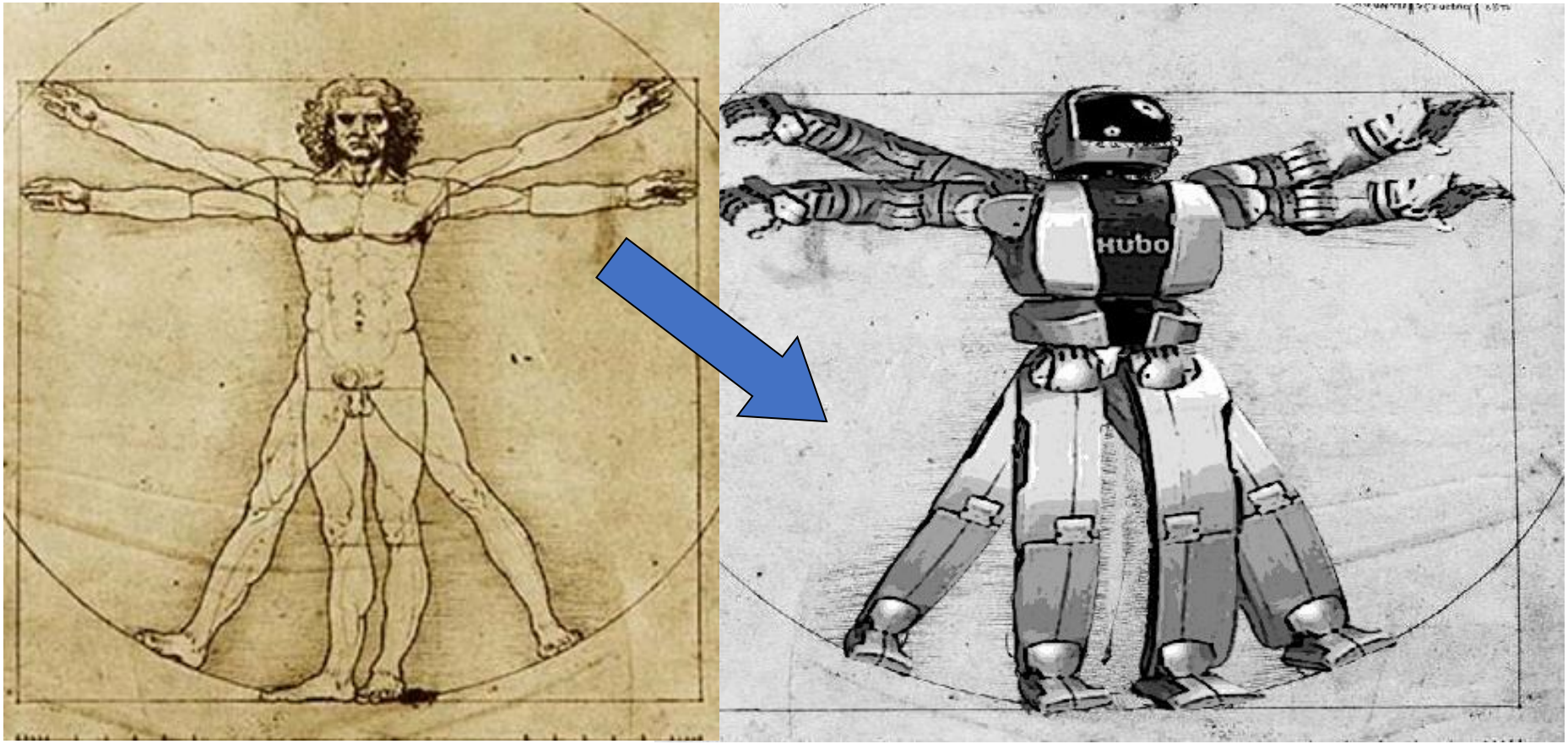
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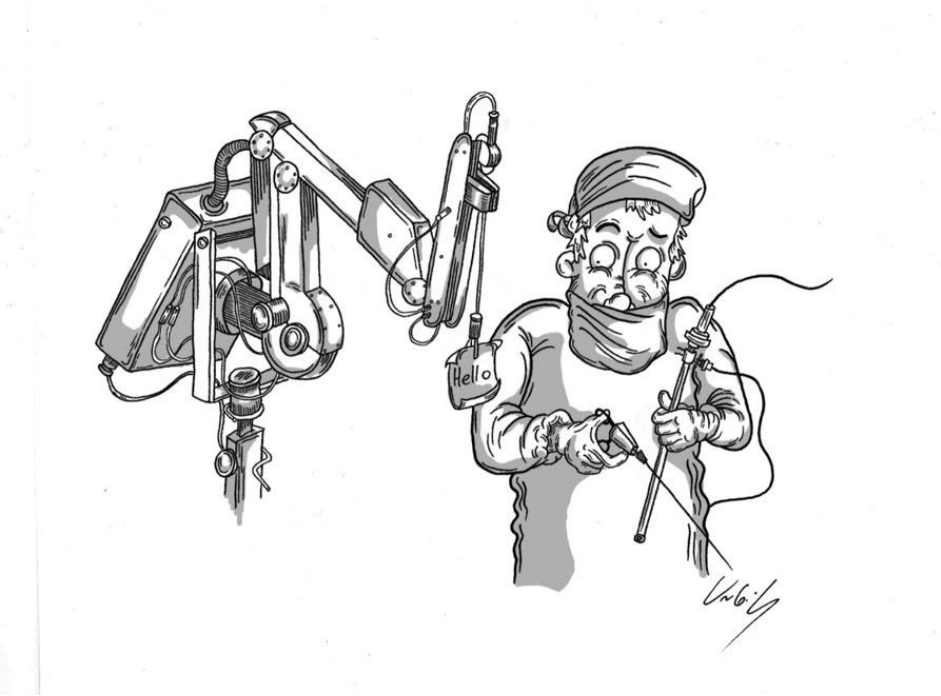
- PIERWSZY W DZIEJACH PROEKT ROBOTA ROK OK. 1495

2023

Mężczyźni są z Marsa,
Kobiety z Wenus



Mężczyźni są z Marsa
Kobiety z Wenus
Roboty i ta Inteligencja AI
są z Ziemi

Więc zróbmy je na miarę naszych
marzeń i potrzeb

International Society for Medical Robotics
ul. Wolności 345a
41-800 Zabrze
tel.: +48 32 373-56-00
www.medicalrobots.eu

International Society for Medical Robotics

The Professor Zbigniew Religa Foundation of Cardiac Surgery Development

ŚLĄSKI UNIWERSYTET MEDYCZNY W KATOWICACH

Zbigniew Nawrat
nawrat@frk.pl; sekretariat@frk.pl
+48 32 3735664

Fundacja Rozwoju Kardiochirurgii
Ul.Wolności 345a
41-800 ZABRZE

Polska

Let’s make robots

…. bo rzeczy naprawdę **wielkie**

robimy z ciekawości

rzeczy naprawdę **ważne**

z potrzeby pomocy drugiemu człowiekowi

Dziękuję wszystkim współpracownikom z FRK, SUM, przyjaciołom z wielu ośrodków akademickich, sponsorom, grantodawcom, i pacjentom – za ich wiarę, że zdążymy..

Dziękuję za zaproszenie…

nawrat@frk.pl

Dziękuję za fotografie Mariuszowi Jakubowskiemu z FRK i za niezwykłe portrety znakomitemu **Rafałowi Maslow**.

This is us

Prof. Zbigniew Religa Foundation of Cardiac Surergery Development (FRK) is established in 1991. **FRK**, is known for its achievements, research and implementation, promotion and education related to technologies saving cardiac surgery patients. The Polish system of mechanical heart support has been clinically implemented since 1993. The license for the Robin Heart PortVisionAble - one of the representatives of a large family of medical robots and mechatronic tools developed here - was sold in 2019. FRK is therefore a pioneer of healthcare robotics in the field of artificial organs and surgical robots, has well-equipped research laboratories and experience in technical, biological and clinical experiments.

Robin Heart –
20years R&D for cost ½ da Vinci

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