

#Medical Robots

A medical robot – what is it?

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What is a robot and what is it not. Which of the robots is a medical robot. Let's start with ISO. ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). This document provides a vocabulary of terms and related definitions for use in ISO documents relating to robotics. It supports the development of new documents and the harmonization of existing International Standards. Future amendments might be published in order to harmonize with the ISO/TC 299 documents currently under development. Ponizej fragmenty ed.-2 i ed.-3.

■ 1. ISO

Key definitions (according to ISO 8373:2012 and ISO 10218-1:2011)

2.6 robot

actuated mechanism programmable in two or more **axes** (4.3) with a degree of **autonomy** (2.2), moving within its environment, to perform intended tasks

Note 1 to entry: A robot includes the **control system** (2.7) and interface of the control system.

Note 2 to entry: The classification of robot into **industrial robot** (2.9) or **service robot** (2.10) is done according to its intended application.

2.12 professional service robot

service robot for professional use

service robot (2.10) used for a commercial task, usually operated by a properly trained **operator** (2.17)

EXAMPLE:

Cleaning robot for public places, delivery robot in offices or **hospitals**, fire-fighting robot, and **rehabilitation and surgery robot in hospitals**.

<https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en>

■ TERMS AND DEFINITIONS — GENERAL

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 robot

programmed actuated mechanism with a degree of **autonomy** (3.2) to perform locomotion, manipulation or positioning

Note 1 to entry: A robot includes the **control system** (3.4).

Note 2 to entry: Examples of the mechanical structure of robots are **manipulator** (4.14), **mobile platform** (4.16) and **wearable robot** (4.17).

3.2 autonomy

the ability to perform intended tasks based on the current state and sensing, without human intervention

Note 1 to entry: For a particular application, the degree of autonomy can be evaluated according to the quality of decision-making and independence from human. For example, metrics for the degree of autonomy exists for medical electrical equipment in IEC/TR 60601-4-1.

3.3 robotic technology

practical application knowledge commonly used in the design of robots or their control systems, especially to raise their degree of **autonomy** (3.2)

EXAMPLE:

Perception, reasoning and planning algorithms.

3.4 control system robot controller

a set of hardware and software components implementing logic and power control, and other functions which allow monitoring and controlling of the behaviour of a robot (3.1) and its interaction and communication with other objects and humans in the environment

3.5 robotic device

a mechanism developed with **robotic technology** (3.3), but not fulfilling all characteristics of a robot (3.1)

EXAMPLE:

A teleoperated remote manipulator, haptic device, end-effector, and unpowered exoskeleton.

3.7 service robot

a robot (3.1) in personal use or professional use that performs useful tasks for humans or equipment

Note 1 to entry: Tasks in personal use, include handling or servicing of items, transportation, phys-

ical support, providing guidance or information, grooming, cooking and food handling, and cleaning.

Note 2 to entry: Tasks in professional use, include inspection, surveillance, handling of items, person transportation, providing guidance or information, cooking and food handling, and cleaning.

3.8 medical robot

a robot (3.1) intended to be used as medical electrical equipment or medical electrical systems

Note 1 to entry: A medical robot is not regarded as an industrial robot (3.6) or a service robot (3.7).

3.11 operator

a person designated to start, monitor and stop the intended operation

3.15 human–robot interaction (HRI)

HRI

information and action exchanges between a human and a robot (3.1) to perform a task by means of a user interface (6.18)

EXAMPLE:

Exchanges through vocal, visual and tactile means.

Note 1 to entry: Because of possible confusion, it is advisable not to use the abbreviated term 'HRI' for human–robot interface when describing user interface.

<https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-3:v1:en>

2. IFR

International Federation of Robotics – A non-profit organization since 1987. IFR represents more than 2,000 organizations from 25 countries.

From International Federation of Robotics Press Conference World Robotics 2021 | 28 Oct 2021

- 'Robot' defined by the International Standards Organization ISO (Sic!)
- Non-robots: software ('bots', AI, Robotic Process Automation-RPA) remote-controlled drones, UAV, UGV, UUV voice assisted autonomous cars, ATMs, smart washing machines, etc.

We can also note: 'Human-robot collaboration is still in its infancy' (bad news for improving technology that medical services need); 'Robots are crucial for cost-efficient production of green technology' (good news as hospitals are a source of high pollution and toxic waste); 'Service Robotics – TOP 5 Application trends' ● AMR and delivery robots offering 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'.

https://ifr.org/downloads/press2018/2021_10_28_WR_PK_Presentation_long_version.pdf

So according to ISO, medical robots are service robots for professional use> **medical service robot for medical professional use**; but according to IEC TR 60601-4-1:

'A medical robot is defined as 'robot intended to be used as medical electrical equipment or a medical electrical system' in IEC TR 60601-4-1. Medical electrical equipment / systems are terms roughly corresponding to 'active medical devices and systems using electric energy.'

In broader terms, this is important because, for example, the best-selling rehabilitation robot in 2020 – the LUNA robot – has only one axis, so according to ISO 8373 ed.-2 it is not a robot.

2. My consideration

The problem with the definition of a robot, i.e. a device for performing work, modeled on a human being, begins with the problem of the definition of work. Let's look at only two dictionaries – British (generally known and recognized) and Polish (because robot is a word of Slavic origin).

Britannica Dictionary definition of WORK

1

a: to have a job

b: to do things as part of your job

c: to do work in, on, or at (an area, event, etc.)

2

a: to do something that involves physical or mental effort

b: to force (someone or something) to do something that involves physical or mental effort

3: to use and control (something)

4: to perform or operate in the correct way

5

a: to have the intended effect or result

b: to have a particular effect or result

6: to cause (something) to happen

7: to move (something) into or out of a particular position slowly or with difficulty

8: to bring (something) into a desired shape or form by cutting it, pressing it, etc.

9: to talk to and try to gain the friendship or support of (the people in a group)

Wg Słownik Języka Polskiego PWN encyklopedia Polskie Wydawnictwo Naukowe – tylko 5 możliwości.

praca

1. «celowa działalność człowieka zmierzająca do wytworzenia określonych dóbr materialnych lub kulturalnych»

2. «wytwór takiej działalności, zwłaszcza w dziedzinie nauki lub kultury»

3. «zajęcie, zatrudnienie jako źródło zarobku; też: instytucja, w której się pracuje zarobkowo»

4. «funkcjonowanie organizmu, narządu lub urządzenia»

5. «wielkość fizyczna określająca ilość energii potrzebnej do przemieszczenia ciała materialnego w przestrzeni, równa iloczynowi wartości siły działającej na to ciało przez wartość przebytej przez nie drogi»

Wg. Encyklopedia PWN – dwie:

praca,

ekon., socjol. proces złożonej aktywności fizyczno-umysłowej, której celem jest przekształcenie szeroko rozumianego środowiska w ten sposób, by zwiększyć szanse przeżycia gatunku ludzkiego.

praca,

fiz. skalarna wielkość będąca miarą energii przekazywanej do układu fizycznego w procesach mechanicznych, elektrycznych i in.;

According to the PWN Dictionary of the Polish Language, the encyclopedia Polish Scientific Publishers – there are only 5 definitions.

job, work

1. 'deliberate human activity aimed at creating specific material or cultural goods'
2. 'a product of such an activity, particularly in the field of science or culture'
3. 'occupation, employment as a source of income; also: institution where you work for profit'
4. 'functioning of the organism, organ or device'
5. 'a physical quantity that determines the amount of energy required to move a material body through space, and is equal to the product of the force acting on this body by the distance traveled through it'

According to PWN encyclopedia – there are two possibilities to define job/work:

– in economics, sociology the process of complex physical and mental activity, the aim of which is to transform the broadly understood environment in such a way as to increase the chances of survival of the human species.

– phys. scalar quantity which is a measure of energy transferred to the physical system in mechanical, electrical and other processes;

So let's use the following algorithm:

If> A robot is an operator-controlled or self-controlled mechanism to perform tasks.

Then> A **medical** robot is an operator-controlled or self-controlled mechanism to perform **medical** tasks.

The robot should contain a decision transmission system from the operator or a decision-making system independently based on the analysis of information obtained from its own sensors or network database, and end effector – a part that works effectively on an external object / environment (there must be an effect of the performed work mechanical / electrical / optical / chemical / biological / ...).

If we extended the activity to the intellectual sphere, creating mathematical solutions (calculations), logical thinking (making an assessment), or creative activity in the field of art (medicine is still art, Sic!), Artificial intelligence would also be part of robotics, especially medical.

In my opinion, the work of a doctor is mainly about making decisions. So expert and advisory programs that undertake medical goals on the basis of an interview with the patient, an analysis of diagnostic data or own research are part of medical robotics.

We can define a robot as an electrically, pneumatically or hydraulically powered mechanism, a controllable device that performs mechanical work, and remotely controlled or autonomous in making decisions. Or – simply – as a programmable device to get the job done. For medicine – it is a device that performs work for healthcare: from cleaning, and sterilization to surgery. It can be defined regardless of the number of axes or the number of sensors.

The medical robot is an intelligent combination of sensor technology with healthcare work and decision-making skills.

The robot is one of the few words of Slavic origin, which entered the global language of modern science and technology. Robotics is a technical discipline devoted in principle to mechanisms, with robots performing selected human activities. The robot, unlike automaton, is a smart combination of perception (sensors) with action (mechanical work). The robot consists of a mechanical manipulator, a control and programming system. A fully autonomous robot acquires and processes information and takes specific physical action.

Medical robotics, as the technical discipline, deals with the synthesis of certain functions of the doctor or nurse by means of using some mechanisms, sensors, actuators and computers. It includes the manipulators and robots dedicated to support surgery, therapy, prosthetics and rehabilitation. Medical robots improve quality and create an opportunity to introduce new standards.

To shorten the discussion: a robot is a Slavic word meaning a person who performs work (in Polish, work being done = job = robota). So let's assume that a medical robot is a device that performs or supports the work performed within the framework of medical services by medical personnel. In this sense, a surgical robot is a tool to assist or replace the surgeon. The intervention or diagnostic robot – similar.

Since the doctor performs mechanical work (treatment specialties) and / or decision-making (collects and analyzes information, determines which drugs or procedures are best for a given patient), then he or she extends the definition of a robot from meas-

uring devices (e.g. a holter for automatic ECG measurements, collection, selection of infections) to advisory programs and other applications of decision algorithms in medical equipment: from cleaning, disinfection and transport to surgical operations and micro-devices supervising the body or automatically dosing (sensory analysis) drugs. From educating doctors to automatic pharmacies or evaluating medical images (radiologists), because that's what people do (did).

Important – as in medicine – is the target function. Even typical activity such as walking or eating a meal can be, after all, a form of medical activities. Similarly, devices become medical when they are used in a medical process, i.e. they have an impact on preventing disease or eliminating the effects of disease, pathology or injuries.

Let us add that since an artificial man is a robot, artificial organs also belong to this group. And there are artificial organs that use cells or biological tissues.

We come to conclusions. Let us use a slightly broader definition of a technical device. The dictionary definition of the term technical devices says that they are objects that enable the performance of specific activities. Technical devices consist of interconnected elements that constitute a coherent, functional whole characterized by a specific type of construction depending on the operating parameters and intended use.

To sum up. A medical robot is any technical or biological-technical device that performs a medical service; diagnostic, therapeutic, rehabilitative, rescue or is a necessary element of the decision-making or executive process of such a service; if it has intelligence, i.e. the possibility of appropriate reaction, action, movement modification or the result of data analysis (decision making) based on information (e.g. sensory or control).

A robot is not a software or a mathematical formula, just like a robot is not a technical documentation of a robot's execution. A computer or smartphone with an appropriate user interface, communication with sensors, or signal or image data – yes.

You can also use the indirect method. Any activity performed by a doctor, nurse, physiotherapist or other medical personnel in the process of medical services, if it is replaced by a device – it is a medical device, but if this device has elements of independence in the performance of work (access to sensory data or information databases) and makes decisions or enhances human skills in the process (telemanipulators), it can be called a medical robot.

Finally, I propose a view from the management perspective. The strategy of managing health care units requires the use of improvement methods (not only for business but also for ethical reasons) and there should be proof of the application of standards for all processes affecting the quality of services (i.e. measurements, verification, validation in accordance with the relevant ISO). The medical enterprise pursues medical, economic and social goals. One of the main goals of a medical enterprise is to obtain a high-quality service. Quality means 'customer satisfaction', the complexity of a hospital service consisting of, inter alia, from the processes of prevention, diagnosis, treatment, rehabilitation, evidence-based, EBM – Evidence Based Medicine, guidelines, and state-of-the-art knowledge in each field. The quality depends on the hospital equipment and the qualifications of the medical staff. The operation of the hospital is also subject to legal and ethical evaluation. In this sense, EVERY ROBOT used in medical and health services is a medical robot.

So we have the simplest answer to a simple question: What is a medical robot? Any robot used in medicine.