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Robotics — Vocabulary

Robotique — Vocabulaire

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 299, *Robotics*.

This third edition cancels and replaces the second edition (ISO 8373:2012), which has been technically revised.

The main changes to the previous edition are as follows:

— definitions have been reviewed to take into account the state of the art;

— entries have been added, e.g. medical robot, wearable robot and terms related to modularity;

— terms and definitions have been updated for harmonization with existing standards.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

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 ISO/TC 299 documents currently under development.

Robotics — Vocabulary

1 Scope

This document defines terms used in relation to robotics.

2 Normative references

There are no normative references in this document.

3 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 mechanical structure of robots are *manipulator* (4.14), *mobile platform* (4.16) and *wearable robot* (4.17).

3.2
autonomy
ability to perform intended tasks based on current state and sensing, without human intervention

Note 1 to entry: For a particular application, degree of autonomy can be evaluated according to the quality of decision-making and independence from human. For example, metrics for 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
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
mechanism developed with *robotic technology* (3.3), but not fulfilling all characteristics of a *robot* (3.1)

EXAMPLE Teleoperated remote manipulator, haptic device, end-effector, unpowered exoskeleton.

3.6
industrial robot
automatically controlled, reprogrammable multipurpose *manipulator* (4.14), programmable in three or more axes, which can be either fixed in place or fixed to a *mobile platform* (4.16) for use in automation applications in an industrial environment

Note 1 to entry: The industrial robot includes:

— the manipulator, including *robot actuators* (4.1) controlled by the robot controller;

— the robot controller;

— the means by which to teach and/or program the robot, including any communications interface (hardware and software).

Note 2 to entry: Industrial robots include any auxiliary axes that are integrated into the kinematic solution.

Note 3 to entry: Industrial robots include the manipulating portion(s) of mobile robots, where a mobile robot consists of a mobile platform with an integrated manipulator or robot.

3.7
service robot
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 serving of items, transportation, physical 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
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).

3.9
industrial robot system
robot system
machine comprising an *industrial robot* (3.6); *end-effector(s)* (4.12); any end-effector sensors and equipment (e.g. vision systems, adhesive dispensing, weld controller) needed to support the intended task; and a task program

Note 1 to entry: The robot system requirements, including those for controlling hazards, are contained in ISO 10218-2.

3.10
robotics
science and practice of designing, manufacturing, and applying *robots* (3.1)

3.11
operator
person designated to start, monitor and stop the intended operation

3.12
task programmer
person designated to prepare the *task program* (6.1)

3.13
collaboration
operation by purposely designed *robots* (3.1) and person working within the same space

3.14
robot cooperation
information and action exchanges between multiple *robots* (3.1) to ensure that their motions work effectively together to accomplish the task

3.15
human–robot interaction
HRI
information and action exchanges between human and *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.

3.16
validation
confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.13, modified — definition modified and notes to entry removed.]

3.17
verification
confirmation by examination and provision of objective evidence that the requirements have been fulfilled

[SOURCE: ISO 9000:2015, 3.8.12, modified — definition modified and notes to entry removed.]

4 Terms related to mechanical structure

4.1
actuator
robot actuator
power mechanism that converts electrical, hydraulic, pneumatic or any energy to effect motion of the robot

4.2
robotic arm
arm
primary axes
interconnected set of *links* (4.7) and powered joints of the *manipulator* (4.14), between the *base* (4.9) and the *wrist* (4.3)

4.3
robotic wrist
wrist
secondary axes
interconnected set of *links* (4.7) and powered *joints* (4.8) of the *manipulator* (4.14) between the *arm* (4.2) and *end-effector* (4.12) which supports, positions and orients the end-effector

4.4
robotic leg
leg
mechanism of interconnected set of *links* (4.7) and *joints* (4.8) which is actuated to support and propel the *mobile robot* (4.15) by making reciprocating motion and intermittent contact with the *travel surface* (8.7)

4.5
configuration
<kinematics> set of all *joint* (4.8) values that completely determines the shape of the *robot* (3.1) at any time

4.6
configuration
<modularity> arrangement of the *modules* (9.3) to achieve the desired functionality of a *robot* (3.1)

4.7
link
rigid body connected to one or more rigid bodies by *joints* (4.8)

4.8
joint
mechanical part that connects two rigid bodies and enables constrained relative motion between them

Note 1 to entry: A joint is either active/powered or passive/unpowered.

4.8.1
prismatic joint
sliding joint
assembly between two *links* (4.7) which enables one to have a linear motion relative to the other

4.8.2
rotary joint
revolute joint
assembly connecting two *links* (4.7) which enables one to rotate relative to the other about a fixed *axis* (5.3)

4.9
base
structure to which the first *link* (4.7) of the *manipulator* (4.14) is attached

4.10
base mounting surface
connection surface of the first *link* (4.7) of the *manipulator* (4.14) that is connected to the *base* (4.9)

4.11
mechanical interface
mounting surface at the end of the *manipulator* (4.14) to which the *end-effector* (4.12) is attached

Note 1 to entry: See ISO 9409-1 and ISO 9409-2.

4.12
end-effector
device specifically designed for attachment to the *mechanical interface* (4.11) to enable the *robot* (3.1) to perform its task

EXAMPLE *Gripper* (4.13), welding gun, spray gun.

4.13
gripper
end-effector (4.12) designed for seizing and holding

4.14
manipulator
mechanism consisting of an arrangement of segments, jointed or sliding relative to one another

Note 1 to entry: A manipulator includes robot actuators.

Note 2 to entry: A manipulator does not include an *end-effector* (4.12).

Note 3 to entry: A manipulator typically consists of the *arm* (4.2) and the *wrist* (4.3).

4.14.1
rectangular robot
Cartesian robot
manipulator (4.14) which has three *prismatic joints* (4.8.1), whose *axes* (5.3) form a Cartesian coordinate system

EXAMPLE Gantry robot (see Figure A.1)

4.14.2
cylindrical robot
manipulator (4.14) which has at least one *rotary joint* (4.8.2) and at least one *prismatic joint* (4.8.1), whose *axes* (5.3) form a cylindrical coordinate system

Note 1 to entry: See Figure A.2.

4.14.3
polar robot
spherical robot
manipulator (4.14) which has two *rotary joints* (4.8.2) and one *prismatic joint* (4.8.1), whose *axes* (5.3) form a polar coordinate system

Note 1 to entry: See Figure A.3.

4.14.4
pendular robot
manipulator (4.14) whose mechanical structure includes a universal joint pivoting subassembly

Note 1 to entry: See Figure A.4.

4.14.5
articulated robot
manipulator (4.14) which has three or more *rotary joints* (4.8.2)

Note 1 to entry: See Figure A.5.

4.14.6
SCARA robot
manipulator (4.14) which has two parallel *rotary joints* (4.8.2) to provide *compliance* (6.12) in a selected plane

Note 1 to entry: SCARA is derived from selectively compliant arm for robotic assembly.

4.14.7
parallel robot
parallel link robot
manipulator (4.14) whose *arms* (4.2) have *links* (4.7) which form a closed loop structure

EXAMPLE Stewart platform.

4.15
mobile robot
robot (3.1) able to travel under its own control

Note 1 to entry: A mobile robot can be a *mobile platform* (4.16) with or without *manipulators* (4.14).

Note 2 to entry: In addition to autonomous operation, a mobile robot can have means to be remotely controlled.

4.15.1
wheeled robot
mobile robot (4.15) that travels using wheels

Note 1 to entry: See Figure A.6.

4.15.2
legged robot
mobile robot (4.15) that travels using one or more *legs* (4.4)

Note 1 to entry: See Figure A.7.

4.15.3
biped robot
legged robot (4.15.2) that travels using two *legs* (4.4)

Note 1 to entry: See Figure A.8.

4.15.4
crawler robot
tracked robot
mobile robot (4.15) that travels on tracks

Note 1 to entry: See Figure A.9.

4.15.5
humanoid robot
robot (3.1) with body, head and limbs, looking and moving like a human

Note 1 to entry: See Figure A.8.

4.16
mobile platform
assembly of the components which enables locomotion

Note 1 to entry: A mobile platform can include a chassis which can be used to support a *load* (7.2).

Note 2 to entry: A mobile platform can provide the structure by which to affix a *manipulator* (4.14).

Note 3 to entry: Mobile platform following a predetermined *path* (5.5.4) indicated by markers or external guidance commands, typically used for logistic tasks in industrial automation is also referred to as Automated Guided Vehicle (AGV) or Driverless Industrial Truck. Standards for such vehicles are developed by ISO/TC 110.

4.17
wearable robot
robot (3.1) that is attached to and carried by the human during use and provides an assistive force for supplementation or augmentation of personal capabilities

5 Terms related to geometry and kinematics

5.1
forward kinematics
mathematical determination of the relationship between the coordinate systems of two parts of a mechanical linkage, based on the joint values of this linkage

Note 1 to entry: For a *manipulator* (4.14), it is usually the relationship between the *tool coordinate system* (5.11) and the *base coordinate system* (5.8) that is determined.

5.2
inverse kinematics
mathematical determination of the joint values of a mechanical linkage, based on the relationship of the coordinate systems of two parts of this linkage

Note 1 to entry: For a *manipulator* (4.14), it is usually the relationship between the *tool coordinate system* (5.11) and the *base coordinate system* (5.8) that is used to determine the joint values.

5.3
axis
direction used to specify the *robot* (3.1) motion in a linear or rotary mode

Note 1 to entry: "Axis" is also used to mean "robot mechanical joint".

5.4
degree of freedom
DOF
one of the variables (maximum number of six) required to define the motion of a body in space

Note 1 to entry: Because of possible confusion with *axes* (5.3), it is advisable not to use the term degree of freedom to describe the motion of the robot.

5.5
pose
combination of position and orientation in space

Note 1 to entry: Pose for the *manipulator* (4.14) normally refers to the position and orientation of the *end-effector* (4.12) or the *mechanical interface* (4.11).

Note 2 to entry: Pose for a *mobile robot* (4.15) can include the set of poses of the *mobile platform* (4.16) and of any manipulator attached to the mobile platform, with respect to the *mobile platform coordinate system* (5.12).

5.5.1
command pose
programmed pose
pose (5.5) specified by the *task program* (6.1)

5.5.2
attained pose
pose (5.5) achieved by the *robot* (3.1) in response to the *command pose* (5.5.1)

5.5.3
alignment pose
specified *pose* (5.5) used to establish a geometrical reference for the *robot* (3.1)

5.5.4
path
route that connects an ordered set of *poses* (5.5)

5.6
trajectory
path (5.5.4) in time

5.7
world coordinate system
stationary coordinate system referenced to earth, which is independent of the *robot* (3.1) motion

5.8
base coordinate system
coordinate system referenced to the *base mounting surface* (4.10)

5.9
mechanical interface coordinate system
coordinate system referenced to the *mechanical interface* (4.11)

5.10
joint coordinate system
coordinate system referenced to the joint *axes* (5.3), the joint coordinates of which are defined relative to the preceding joint coordinates or to some other coordinate system

5.11
tool coordinate system
TCS
coordinate system referenced to the tool or to the *end-effector* (4.12) attached to the *mechanical interface* (4.11)

5.12
mobile platform coordinate system
coordinate system referenced to one of the components of a *mobile platform* (4.16)

Note 1 to entry: A typical mobile platform coordinate system for the *mobile robot* (4.11) takes positive X as the forward direction and positive Z as the upward direction, and positive Y is decided by right-hand rule.

5.13
maximum space
space which can be swept by the moving parts of the *robot* (3.1), plus the space which can be swept by the *end-effector* (4.12) and the workpiece

Note 1 to entry: Maximum space of the robot system can include the space which can be swept by the *end-effector* (4.12) and the workpiece.

Note 2 to entry: For *mobile platforms* (4.16), this volume can be regarded as the full volume that can theoretically be reached by travelling.

5.14
restricted space
portion of the *maximum space* (5.13) restricted by *limiting devices* (6.21) that establish limits which will not be exceeded

Note 1 to entry: For *mobile platforms* (4.16), this volume can be limited by special markers on floors and walls, or by software limits defined in the internal map.

5.15
operational space
operating space
portion of the *restricted space* (5.14) that is used while performing all motions commanded by the *task program* (6.1)

5.16
working space
space which can be swept by the *wrist reference point* (5.19)

Note 1 to entry: The working space is smaller than the space which can be swept by all the moving parts of the *manipulator* (4.14).

5.17
safeguarded space
space where safeguards are active

Note 1 to entry: This is sometimes described as the space within the perimeter *safeguarding* (6.23).

Note 2 to entry: The safeguarded space can change dynamically.

5.18
tool centre point
TCP
point defined for a given application with regard to the *mechanical interface coordinate system* (5.9)

5.19
wrist reference point
wrist centre point
wrist origin
intersection point of the two innermost *secondary axes* (4.3) [i.e. those closest to the *primary axes* (4.2)] or, if this does not exist, a specified point on the innermost secondary axis

5.20
mobile platform origin
mobile platform reference point
origin point of the *mobile platform coordinate system* (5.12)

5.21
singularity
occurrence whenever the rank of the Jacobian matrix becomes less than full rank

Note 1 to entry: Mathematically, in a singular *configuration* (4.5), the joint velocity in joint space can become infinite to maintain Cartesian velocity. In actual operation, motions defined in Cartesian space that pass near singularities can produce high axis speeds. These high speeds can be unexpected to an *operator* (3.11).

6 Terms related to programming and control

6.1
task program
set of instructions for motion and auxiliary functions that define the specific intended task of the *robot* (3.1) or *robot system* (3.9)

Note 1 to entry: This type of program is generated by the *task programmer* (3.12).

Note 2 to entry: An application is a general area of work; a task is specific within the application.

6.2
control program
inherent set of control instructions which defines the capabilities, actions and responses of a *robot* (3.1) or *robot system* (3.9)

Note 1 to entry: This type of program is usually generated before installation and can only be modified thereafter by the manufacturer.

6.3
task programming
programming
act of providing the *task program* (6.1)

6.4
teach programming
programming of the task performed by a) manually moving the robot to desired positions, i.e. by lead-through; b) using a *teach pendant* (6.16) to move the *robot* (3.1) through the desired positions; c) using a teach pendant to program without causing motion; or d) using algorithm(s) with sensor data

6.5
off-line programming
programming method where the *task program* (6.1) is defined on devices separate from the *robot* (3.1) for later entry into the *robot controller* (3.4)

6.6
pose-to-pose control
PTP control
control procedure whereby the *task programmer* (3.12) can only impose that the *robot* (3.1) pass by the *command poses* (5.5.1) without fixing the *path* (5.5.4) to be followed between the *poses* (5.5)

6.7
continuous path control
CP control
control procedure whereby the programmer can impose on the *robot* (3.1) the *path* (5.5.4) to be followed between *command poses* (5.5.1)

6.8
trajectory control
continuous path control (6.7) with a programmed velocity profile

6.9
leader-follower control
control method where the motion of a primary device (leader) is reproduced on secondary devices (followers)

Note 1 to entry: Leader-follower control is typically used for *teleoperation* (6.17).

6.10
sensory control
control scheme whereby the *robot* (3.1) motion or force is adjusted in accordance with outputs of *exteroceptive sensors* (8.11)

6.11
trajectory planning
process by which the *robot* (3.1) *control program* (6.2) determines how to move the *joints* (4.8) of the mechanical structure between the *command poses* (5.5.1), according to the type of control procedure chosen

6.12
compliance
flexible behaviour of a *robot* (3.1) or any associated tool in response to external forces exerted on it

Note 1 to entry: When the behaviour is independent of sensory feedback, it is passive compliance; if not, it is active compliance.

6.13
operating mode
operational mode
characterization of the way and the extent to which the *operator* (3.11) intervenes in the control equipment

Note 1 to entry: In the context of this document, mode refers to the control state of the *robot* (3.1), e.g. automatic, manual, other.

6.13.1
manual mode
control state that allows for direct control by a human

Note 1 to entry: Sometimes referred to as teach mode where program points and robot attributes are set.

6.13.2
automatic mode
automatic operation
control state in which the *robot* (3.1) *control system* (3.4) operates in accordance with the *task program* (6.1)

6.13.3
semi-autonomous mode
operating mode (6.13) in which motions are determined by combination of the autonomous *task program* (6.1) and manual user inputs given at the same time

Note 1 to entry: In this operating mode, the manual user input can override the autonomous task program (e.g. for steering) or the autonomous task program can override manual user input (e.g. for collision avoidance).

6.13.4
autonomous mode
operating mode (6.13) in which the *robot* (3.1) function accomplishes its assigned mission without direct human intervention

EXAMPLE A *service robot* (3.7) waiting for an interaction (a command).

6.14
stop-point
command pose (5.5.1) (taught or programmed) attained by the *axes* (5.3) of the *robot* (3.1) with a velocity command equal to zero and no deviation in positioning

6.15
fly-by point
via point
command pose (5.5.1) (taught or programmed) attained by the *axes* (5.3) of the *robot* (3.1) with some deviation, the amount of which depends on the joining profile of the axis velocity to this *pose* (5.5) and a specified criterion of passage (velocity, deviation in pose)

6.16
pendant
teach pendant
hand-held unit linked to the *control system* (3.4) with which a *robot* (3.1) can be programmed or moved

6.17
teleoperation
real-time control of motion of *robot* (3.1) from a remote site by a human

EXAMPLE Robotic operations of bomb disposal, space station assembly, underwater inspection and surgery.

6.18
user interface
means for information and action exchanges between human and *robot* (3.1) during *human–robot interaction* (3.15)

EXAMPLE Microphone, speaker, graphic user interface, joysticks, haptic devices.

6.19
robot language
programming language used for describing the *task program* (6.1)

6.20
simultaneous motion
motion of two or more *robots* (3.1) at the same time under the control of a single control station and which can be coordinated or synchronized with common mathematical correlation

Note 1 to entry: An example of a single control station is a *teach pendant* (6.16).

Note 2 to entry: Coordination can be done as leader-follower.

6.21
limiting device
means that reduces the range of motion of a *robot* (3.1) to a subset of the *maximum space* (5.13) by stopping, or causing to stop, all robot motion

6.22
program verification
execution of a *task program* (6.1) for the purpose of confirming the robot *path* (5.5.4) and process performance

Note 1 to entry: Program verification can include the total *path* (5.5.4) traced by the *tool centre point* (5.18) during the execution of a task program or a segment of the *path* (5.5.4). The instructions can be executed in a single instruction or continuous instruction sequence. Program verification is used in new applications and in fine-tuning or editing of existing ones.

6.23
safeguarding
protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or risks which cannot be sufficiently reduced by inherently safe design measures

6.24
protective stop
type of interruption of operation that allows a cessation of motion for *safeguarding* (6.23) purposes and which retains the program logic to facilitate a restart

6.25
safety-rated
characterized by having a prescribed safety function with a specified safety-related performance

EXAMPLE Safety-rated reduced speed; safety-rated monitored speed; safety-rated output.

6.26
single point of control
ability to operate the *robot* (3.1) such that initiation of robot motion is only possible from one source of control and cannot be overridden from another initiation source

6.27
reduced speed
safety function that limits the speed to be no greater than 250 mm/s

Note 1 to entry: This safety function can also apply to the *robot system* (3.9), robot application, robot cell and other machinery.

7 Terms related to performance

7.1
normal operating conditions
range of environmental conditions and other parameters within which the *robot* (3.1) is expected to perform as specified by the manufacturer

Note 1 to entry: Environmental conditions include temperature and humidity.

Note 2 to entry: Other parameters include electrical supply instability and electromagnetic fields.

7.2
load
force, torque or both at the *mechanical interface* (4.11) or *mobile platform* (4.16) which can be exerted along the various directions of motion under specified conditions of velocity and acceleration

Note 1 to entry: The load is a function of mass, moment of inertia, and static and dynamic forces supported by the *robot* (3.1).

7.2.1
rated load
maximum *load* (7.2) that can be applied to the *mechanical interface* (4.11) or *mobile platform* (4.16) in *normal operating conditions* (7.1) without degradation of any performance specification

Note 1 to entry: The rated load includes the inertial effects of the *end-effector* (4.12), accessories and workpiece, where applicable.

7.2.2
limiting load
maximum *load* (7.2) stated by the manufacturer that can be applied to the *mechanical interface* (4.11) or *mobile platform* (4.16) without any damage or failure to the *robot* (3.1) mechanism under restricted operating conditions

7.2.3
additional load
additional mass
load (7.2) that can be carried by the *robot* (3.1), in addition to the *rated load* (7.2.1), yet is not applied at the *mechanical interface* (4.11) but somewhere else on the *manipulator* (4.14), generally on the *arm* (4.2)

7.2.4
maximum force
maximum thrust
force (thrust), excluding any inertial effect, that can be continuously applied to the *mechanical interface* (4.11) or *mobile platform* (4.16) without causing any permanent damage to the *robot* (3.1) mechanism

7.3
individual joint velocity
individual axis velocity
velocity of a specified point resulting from the movement of one individual *joint* (4.8)

7.4
path velocity
change of position per unit time along the *path* (5.5.4)

7.5
pose accuracy
unidirectional pose accuracy
difference between a *command pose* (5.5.1) and the mean of the *attained poses* (5.5.2) when visiting the command pose from the same direction

7.6
pose repeatability
unidirectional pose repeatability
closeness of agreement among the *attained poses* (5.5.2) for the same *command pose* (5.5.1) repeated from the same direction

7.7
multidirectional pose accuracy variation
maximum distance between the mean *attained poses* (5.5.2) achieved when visiting the same *command pose* (5.5.1) multiple times from three perpendicular directions

7.8
distance accuracy
difference between a command distance and the mean of the attained distances

7.9
resolution
smallest increment of movement that can be attained by each *axis* (5.3) or *joint* (4.8) of the *robot* (3.1)

8 Terms related to sensing and navigation

8.1
environment map
environment model
map or model that describes the environment with its distinguishable features

EXAMPLE Grid map, geometrical map, topological map, semantic map.

8.2
localization
recognizing *pose* (5.5) of *mobile robot* (4.15), or identifying it on the *environment map* (8.1)

8.3
landmark
artificial or natural object identifiable on the *environment map* (8.1) used for *localization* (8.2) of the *mobile robot* (4.15)

8.4
obstacle
static or moving object or feature (on ground, wall or ceiling) that obstructs the intended movement

Note 1 to entry: Ground obstacles include steps, holes and uneven terrain.

8.5
mapping
map building
map generation
constructing the *environment map* (8.1) to describe the environment with its geometrical and detectable features, *landmarks* (8.3) and *obstacles* (8.4)

8.6
navigation
process which includes path planning, *localization* (8.2), *mapping* (8.5) and providing the direction of travel

Note 1 to entry: *Navigation* (8.6) can include *path* (5.5.4) planning for pose-to-pose travel and complete area coverage.

8.7
travel surface
terrain on which the *mobile robot* (4.15) travels

8.8
dead reckoning
method of obtaining the *pose* (5.5) of a *mobile robot* (4.15) using only internal measurements from a known initial pose

8.9
task planning
process of solving the task to be carried out by generating a task procedure which includes subtasks and motions

Note 1 to entry: Task planning can include autonomous and user-generated task planning.

8.10
proprioceptive sensor
internal state sensor
robot sensor intended to measure the internal state(s) of a *robot* (3.1)

EXAMPLE Encoder; potentiometer; tachometer generator; inertial sensor such as accelerometer and gyroscope.

8.11
exteroceptive sensor
external state sensor
robot sensor intended to measure the states of a robot's environment or interaction of the *robot* (3.1) with its environment

EXAMPLE GPS; vision sensor; distance sensor; force sensor; tactile sensor; acoustic sensor.

9 Terms related to module and modularity

9.1
component
part of something that is discrete and identifiable with respect to combining with other parts to produce something larger

Note 1 to entry: Component can be either software or hardware. A component that is mainly software or hardware can be referred to as a software or a hardware component, respectively.

Note 2 to entry: Component does not need to have any special properties regarding *modularity* (9.2).

Note 3 to entry: A *module* (9.3) is a component, whereas a component does not need to be a module.

9.2
modularity
set of characteristics which allow systems to be separated into discrete *modules* (9.3) and recombined

9.3
module
component (9.1) or assembly of components with defined interfaces accompanied with property profiles to facilitate system design, integration, interoperability and reuse

Note 1 to entry: A module may have both hardware and software aspects. It may consist of other components (hardware and software) or other modules (hardware and software).

Note 2 to entry: This neither requires nor prevents the use of open source software to implement parts or all of the open module's functionalities.

Annex A
(informative)

Examples of types of mechanical structure

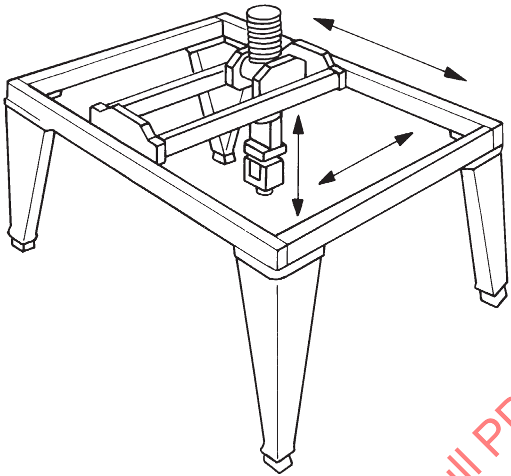

Figure A.1 — Rectangular or Cartesian robot: gantry robot

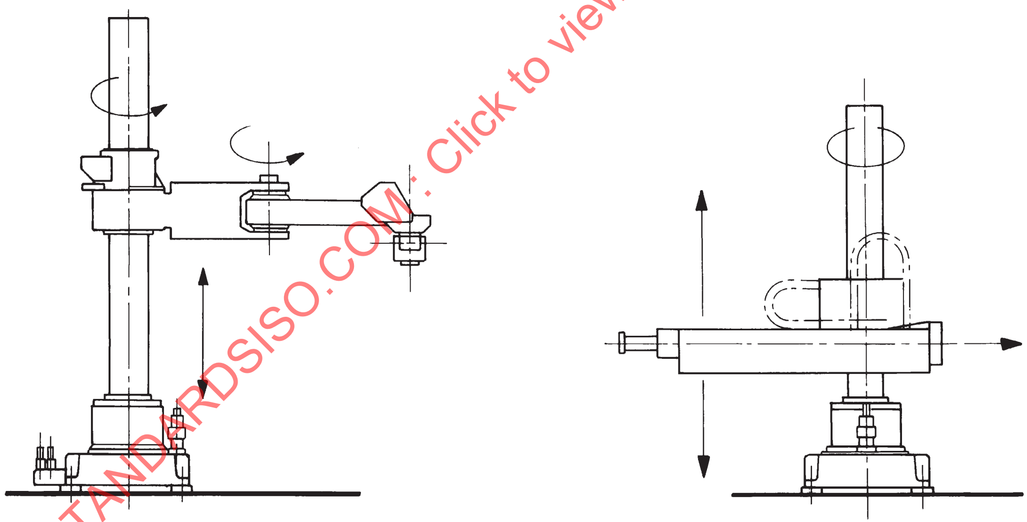

Figure A.2 — Cylindrical robot

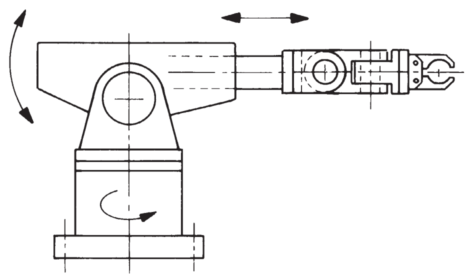

Figure A.3 — Polar robot (spherical robot)

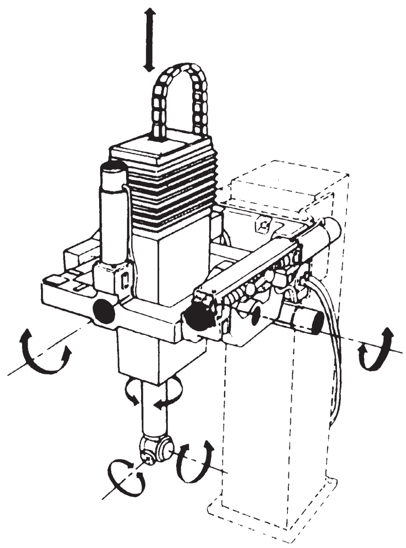

Figure A.4 — Pendular robot

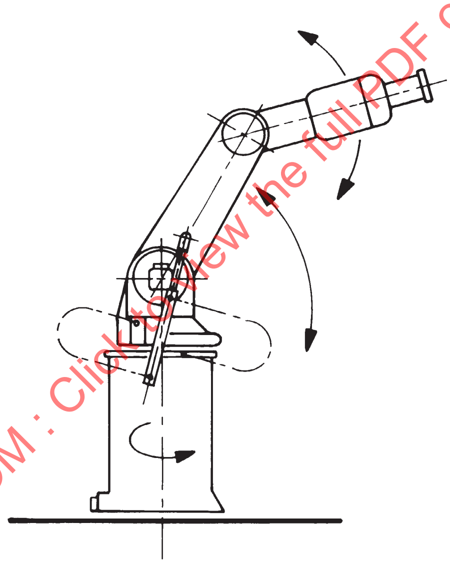

Figure A.5 — Articulated robot

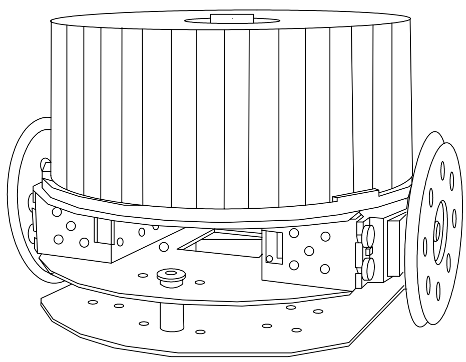

Figure A.6 — Wheeled robot

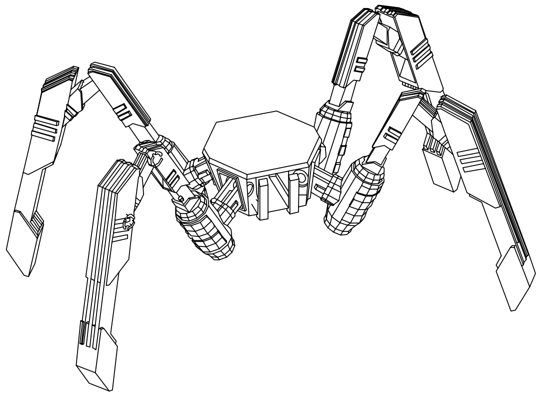

Figure A.7 — Legged robot

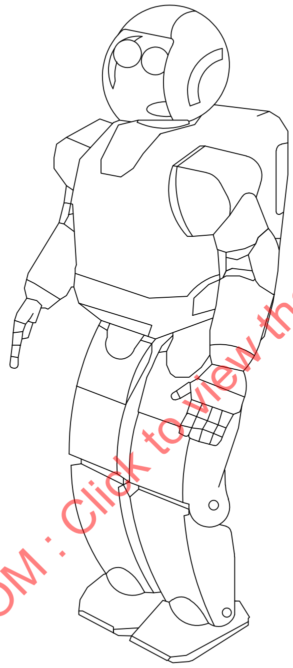

Figure A.8 — Biped robot

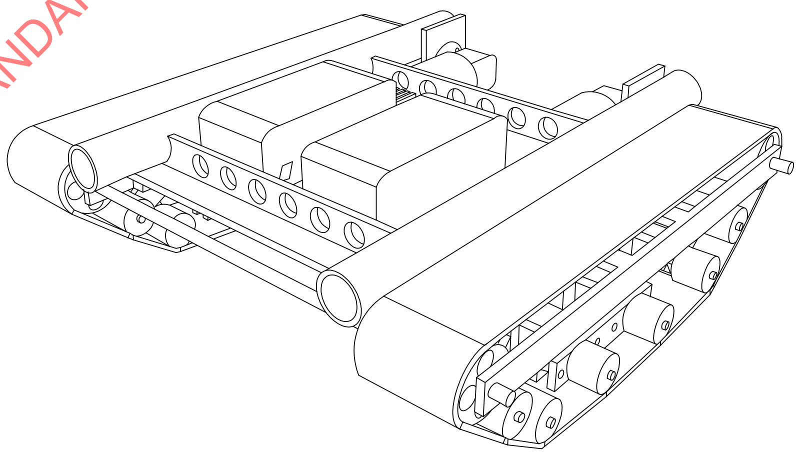

Figure A.9 — Tracked robot (crawler robot)