

**PROPOSAL OF TRACKED MOBILE ROBOT WITH FOLDING ARMS**

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**Keywords:** mobile platform, folding arms, 3D model

**Abstract:** This paper deals with mobile robots, specifically on tracked mobile service robots. In this case deal with the design of folding arms. These arms should help the mobile platform in overcoming obstacles. For creating the basic model was used platform Jaguar. For this platform were designed folding arms and parts of the tilting mechanism. Model is represented. Advantages of the service robots are installed systems that help realize operations. It can be a system that helps handling or early by detecting threats or to improve driveability. For better passability tracked mobile robots proposed various improvements such as folding arms. Tracked robots have different versions of the subsystem mobility. This type of tracked robot used in the complicated places, which have many complex obstacles. Great specifications are on construction, sensors, design and communication interface.

**1 Introduction**

Nowadays, modern technology helps us in everyday life at work or at home. In practise, we faced with a situations when in certain places cannot go person. Most of these places are dangerous for human health. It is a place, for example in nuclear plant or hardly accessible terrain. In such situations it is necessary to deploy mobile service robots. These kinds of robots should resist the action of the external environment in which they perform service work [1]. Advantages of the service robots are installed systems that help realize operations. It can be a system that helps handling or early by detecting threats or to improve driveability. For better passability tracked mobile robots proposed various improvements such as folding arms. Tracked robots have different versions of the subsystem mobility. This type of tracked robot used in the complicated places, which have many complex obstacles. Great specifications are on construction, sensors, design and communication interface.

**2 Subsystem mobility of tracked mobile robot**

Mobility system performance may be different. It is a structure that uses as a basis tracked vehicle. In practise we can meet with different versions [2,3]. Utilization different quantity of belts, but also combinations of wheels and belts (Figure 1).



Figure 1 Types of subsystem mobility

Analyse for tracked service robots has demonstrated that these types are used in difficult conditions, for example:

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- army,
- forestry,
- agriculture,
- construction,
- nuclear industry,
- security service (rescue, anti-terrorism).

From the knowledge gained from experience, which is the space in which the robot can move and perform service work may be described as kind:

**• Work environment:**

- horizontal (stairs, inequality, ...),
- vertical (houses, flats, ...).

**• Types of surfaces:**

- urbanized (stairs, path, ...);
- standard natural (grass, surface, soil, ...),
- exacting natural (snow, gravel, ...).

On tracked service robots are placed different demands. Among the most prominent requirements include:

- proportional size (around the robot chassis, width – length – height),
- heavy duty (construction robot should meet high stability even when carrying out service work),
- low weight (this feature should be guaranteed, the lower the contact pressure, respectively landscape, after which the robot should move),
- sizes and types of belts (it should consider the type of belt for specific service activity as well as belt dimension),
- chassis design (the structure itself should be resistant to external environmental influences),
- drives (should be recalculated and then choose the drives that would ensure continuity of operation of the device and would be saving on energy consumption),
- maintenance (maintenance of the entire system should be simple and fast).

### 2.1 Model of tracked robot

Chassis are composed of several assemblies and subassemblies [4]. These parts are shown on (Figure 2).

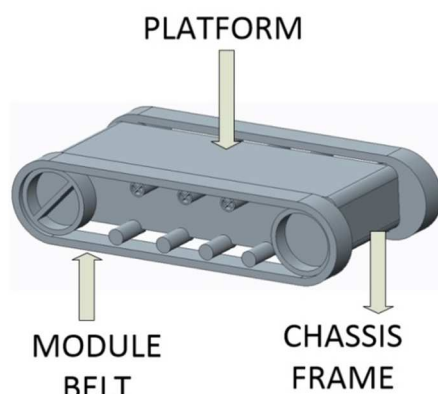


Figure 2 Model of tracked robot

In this article deal with the module belt, which consisting of some general parts that are described in (Figure 3).

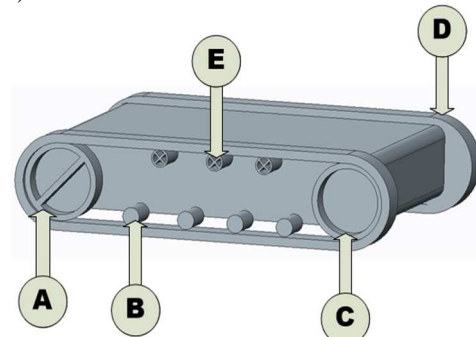


Figure 3 Parts of module belt

Parts of module belt:

**A – Driving wheel** – drive initializes the movement of the drive wheel,

**B – Guiding wheels** – their role is to provide leadership belt also guarantees contact with ground,

**C – Driven wheel** – this type of wheel is not connected to the drive, ensure chassis rigidity,

**D – Belt** – belt realized by the inner side belt transfer power required for the robot and by the outer surface of the belt is realized by ground movement, determines also features traction,

**E – Adjusting wheels** – these types of wheels are guaranteed belt tensioning.

In compiling belt service tracked robots are primarily important elements such as drives and their strength and quantity, types and quantity of belt, type of frame. Secondary elements are important too, for example: quantity of axles and types, types of used wheels, type of belts. Compiled concepts are described by different properties locomotion as well as various parameters of traction. In practise, the use of many types of modules belt, for example:

- standard module,
- starting module,
- folding module,
- double module with folding arm,
- combined module with folding arm,
- special with two folding arm.

### 3 Platform Jaguar LITE

The basic version of tracked chassis consists of platform Jaguar Lite. The tracked robot chassis is designed for external or internal operating environment. The advantage is high manoeuvrability [5]. The chassis is equipped with two primary belts and powered ensure by two independent motors without control elements and electronics. In (Table 1) shows the basic parameters of the tracked platform [6].

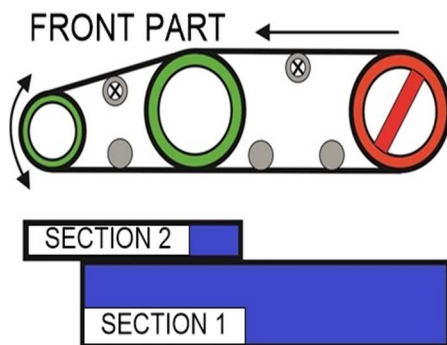
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*Table 1 Parameters of Jaguar LITE*

Parameters	Characteristic
Weight	Max. 10 kg
Dimensions	640 x 538 x 176
Max. speed	5,5 km / h
Climbing	Max. 180 mm of stair step
Terrain	Rock, sand, grass, soil and wet or dry terrain
Possibilities	Camera systems, GPS module, other controllers or sensors, Wi-Fi or Bluetooth module and more other accessories

For this tracked chassis was chosen as the most appropriate module with dual folding arm [7]. It consists of folding arms which are imposed on the primary side of belt. The drive kit is a one-wheel, two banded, double layer, parallel and single row. Use of such a module is no longer for more complex terrain with major obstacles. Schematic views of the mechanism (Figure 4).


*Figure 4 Module with dual folding arm*

Section 1: a main belt contains a front wheel, which is driven by a rear wheel, which functions as the drive. The upper wheels serve to lower the tension and act as guiding wheels.

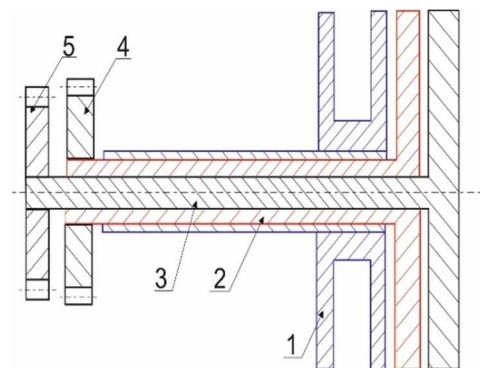
Section 2: rear wheel drive works as a front driven. On the folding arm is fitted with guide wheels.

Using multi-criteria analysis will select the most appropriate variant, which should ensure smooth over obstacles. The analysis should include criteria [8]:

- construct,
- maintenance,
- reliability,
- power of system,
- software and hardware,
- economic factor.

Among the many variants can be chosen as the most suitable alternative with folding unit, located in the basic tracked platform. It is also possible variant including a drive unit in the folding arm, but the execution in terms of the economic factor increased the cost because of more expensive drive unit.

The selected device is made up of a number of shafts. The proposal is structurally complex because the shafts must be securely stored in the bearings and sliding bushes. The whole mechanism is mounted in the platform where there is enough space to store. System of the tilt arms (Figure 5).


*Figure 5 Chosen variant*

1 – driven wheel of the main belt mounted on the first hollow shaft, 2 – hollow shaft with folding arms, 3 – shaft, which transmits torque to the wheel of folding arm, 4 – gear, which transmits torque on folding arm, 5 – gear, which drives the driving wheel of folding arms.

#### 4 Folding arm

Torque from the drive is transmitted through the gears on the shaft. At the end of the shaft is positioned flange. With screws, the shaft is attached to the folding arm.

The whole system of the folding arm consists of several parts. Driven wheel, guiding wheel, adjusting wheel, driving wheel, screws, shafts, bearings and slide bushes. This extended platform of these arms would be through setting different angles of arms, overcome different kinds of obstacles, for example: stairs, curbs and various terrain.

When the design must take into account the technical and economic parameters. Locomotion system consists of two primary belts, which are mounted directly to the base platform. The two secondary belts are arranged on the folding arm. The arms should be making less weight, sketching possibility of using aluminium as a material [9]. The belt carries out the inner side torque transfer the drive and use outside move the terrain.

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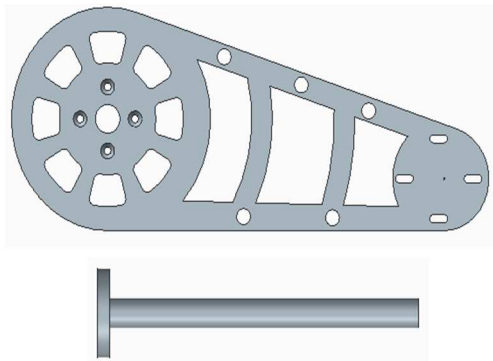


Figure 6 Folding arm

**4.1 Model of tracked robot with folding arms**

The basic structure of the actual mobile robot is a frame that consists of sheet metal. This basic is complemented by two primary belts on the sides. For these belts, the transmitted torque of the two independent motors. Extending the platform has several advantages. The primary drive is stored on the back of base frame. On the other side, plenty of storage sprace for the secondary engine folding arms. For tilting proposed two engines, also independent of each other, which can be tilted 360°. One motor is intended to drive the driving wheels of folding arm.

On the arm of the two pulleys are used. Larger wheel is driving, which is connected by a clamping sleeve. Smaller wheel is stored by bearing on the flange. The entire device is secured screw. To arm the coutouts which reduce the total weight. The lower and upper openings are located, for fastening of the guide wheels. On the narrower part of the openings to contain the flange of the driven pulley. Using the flange being stretched folding arm the system. Pulleys have a pitch of 8 mm and the width of the bearing strip is 20 mm. For production of pulley is used steel.

The ensure the smooth running of the mechanism, it is necessary to separate the storage shafts. It is small space, used a plain bushes. The selected bushes are made of a composite of PTFE. These bushes have a layer of teflon and are used for high speed. The advantages of plain bushes:

- high speed,
- low friction,
- maintenance free.

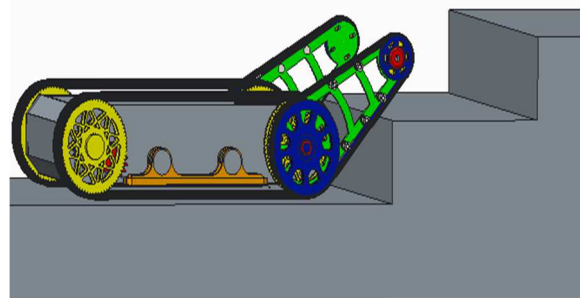
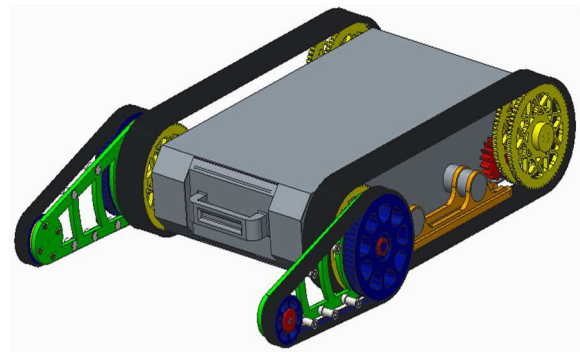


Figure 7 Extended platform

Shows a tracked platform with proposed folding arms, which can be tilted to various positions. Example which makes use of folding arms (Picture 7).

**Conclusion**

The aim was propose folding arms for belt chassis Jaguar LITE. In this case, the proposed arms, which should meet the requirements for more complex overcoming obstacles. The actual tilting arms should be independent to the service robot to avoid various terrain. This modified chassis could be useful for inspection activities in buildings or in vehicles.

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**Review process**

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## CALIBRATION TRENDS IN INDUSTRIAL ROBOTICS

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**Keywords:** calibration, industrial robot, kinematic model, laser

**Abstract:** A survey of calibration techniques was purpose of this article together with kinematic explanation of industrial robot with aim to obtain and implement any of them that are prohibitive for common calibration operations. Each method, if is proven accurately will be a desirable as low-cost solution to real time robot positioning problems. These factors lead us to the fact that better approach of implementing consists in real timing in process calibration. Calibration trends are moving away from older calibration processes, because instruments are more user-friendly and results that previously required long specialized procedures can now be achieved by adopting by right technology.

### 1 Introduction

Calibration trends are moving away from older calibration processes, because instruments are more user-friendly and results that previously required long specialized procedures can now be achieved by adopting by right technology. Motion control of calibration will be implemented on the basis of information obtained from sensors placed directly for drives of industrial robot, as well as the sensor working environment according to the specific requirements for each application [1], [2].

The identified parameters related to robotics calibration are accuracy, repeatability, and resolution. Each of these depends on the various components used (links, motors, encoders, etc.), the construction procedure, the capability of the controller and programming method (online, offline) [3]. Resolution is defined as the smallest incremental move that the robot can physically produce. Repeatability is a measure of the ability of the robot to move back to the same position and orientation. Accuracy is defined as the ability of the robot to precisely move to a desired position in 3-D space [4]. The example of calibration process can be seen at fig. 1.

### 2 Kinematic calibration

A robot kinematics structure is often represented mathematically using a compact representation of the position and orientation of each joint relative to the previous joint. For demonstration purposes, the modified Denavit-Hartenberg (DH) notation as presented in next section will be used.

#### 2.1 Creation of kinematic model

First of all, it is necessary to create a kinematic model of the robot, which is the mathematical expression of the robot geometry and its movements [5], [6]. There are several different ways to build a kinematic model. The most popular method is the method introduced by Denavit and Hartenberg. The principle consists in creation of coordinate systems for each common axis. This method

follows the following specific parameters, D-H parameters, fig. 2.

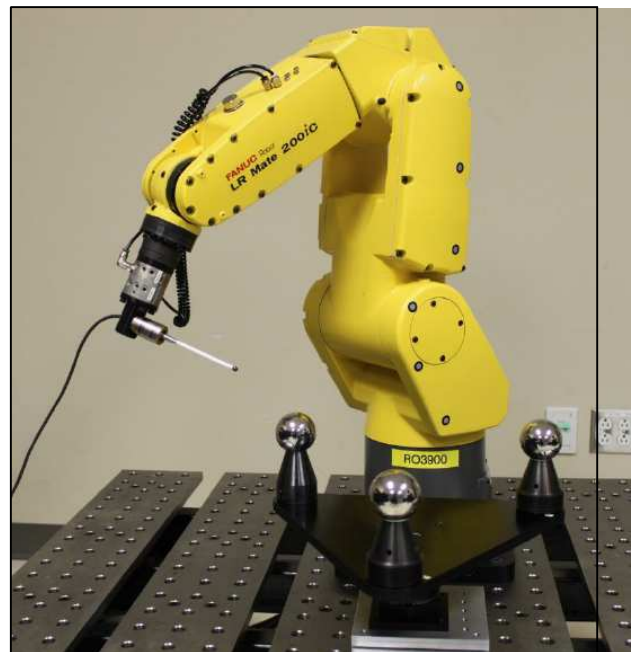


Figure 1 Example of calibration process

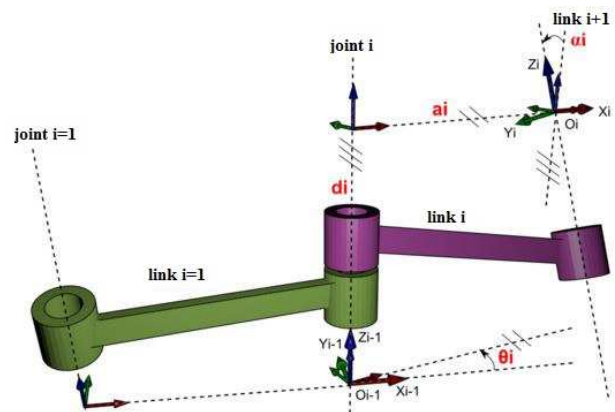


Figure 2 D-H parameters

*Table 1 Description of parameters*

$d_i$	Moving along the previous Z axis after common normal
$\theta_i$	The angle of previous axis X with respect to new axis X
$a_i$	Length of individual links
$\alpha_i$	Angle of previous Z axis with respect to new Z axis

Each coordinate system is interconnected by the D-H parameters, which makes it possible to create a homogeneous transformation matrix [7]. This homogeneous transformation matrix represents the relationship between two consecutive links. These matrices are then multiplied to form a relationship between the robot base coordinate system and the end effector coordinate system. An industrial robot can be used, for example, in control applications to reduce potential human factor failure [8].

## 2.2 Measurement methods

The second step of kinematic calibration is to obtain the end effector coordinates. These coordinates can be determined by measurement them by using different methods.

Manual calibration represents the easiest way to achieve the required robustness of the robot. Most companies engaged in the production of industrial robots and manipulators develop their own manual calibration methods for the robot. These methods are easy to handle and to necessary equipment.

Force control calibration method is designed by ABB and is only usable for industrial robots from this company that are compatible with this method. The system monitors the force exerted on the object by using external sensors (Fig. 3). In other words, the robot feels how much force he applies to the object. The control system is able to detect the position of the used tool automatically.

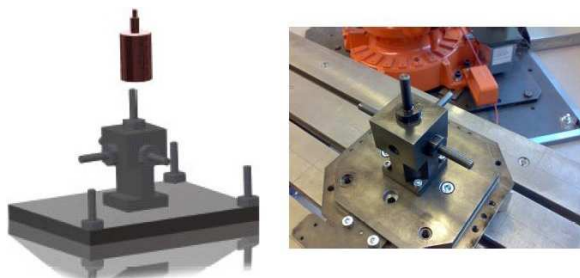


Figure 3 External sensor during the force control method

Navigation calibration method is an automated, very accurate calibration method. The principle lies in the positioning of the spherical object (Fig. 4), which is mounted on the robotic arm. The control system automatically positions with the calibration device in the direction of the individual axes to the fixed spherical object that coordinates we know.

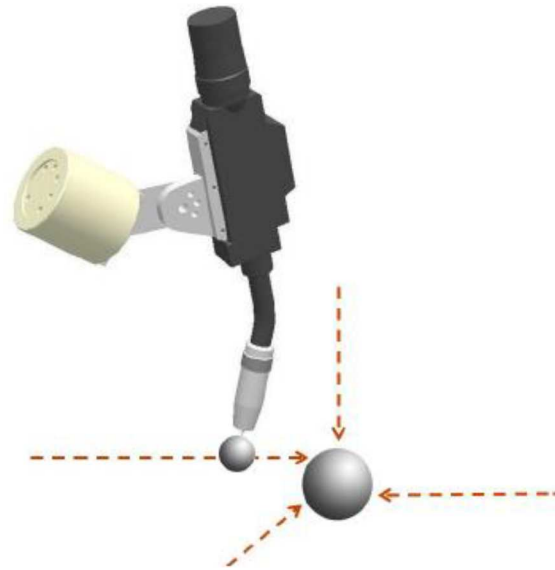


Figure 4 Navigation method of static calibration

## 3 Trends

The LaserLAB calibration system is a measuring system consisting from a five-angled measuring sensor with five laser measuring sensors, measuring gauges and necessary software for robot calibration. Usage is found in all modern robotic production and non-production processes [9]. The LaserLAB calibration system can be used for multiple cells, not for a stationary system.

If the measuring ball is placed by the robot into the measuring system space, system calculates position of the center of ball. It is important to keep in mind that in the close of the robot there is also operator, so security first is necessary [10]. Thanks to direct core center correlation of tool center point (TCP), it is possible to measure robot. Fig. 5 presents LaserLAB calibration method.

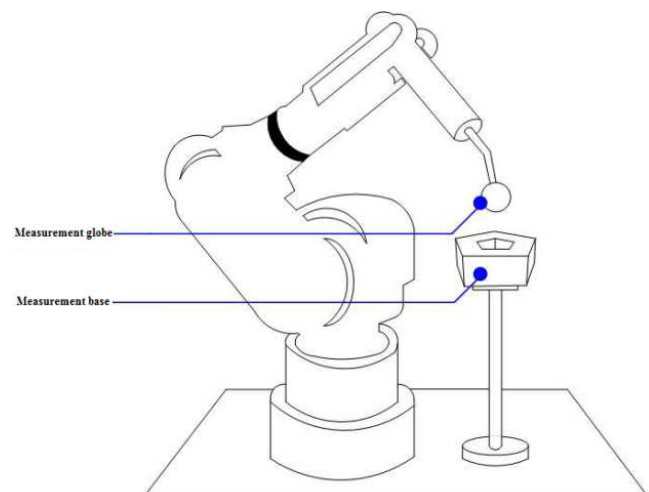


Figure 5 Calibration by LaserLAB system

LaserLAB calibration method consists of two hardware components, namely a pentagonal measuring

sensor and one or more measuring globes. In addition, other measuring tools such as, for example, bars that help measure, for example, electrode holders. Depending on the measurement or calibration tasks, LaserLAB works with various software that allow you to measure the robot tool, the base, the robot itself, the temperature influence of one device based on servomechanisms [11]. LaserLAB allows:

- perform all measurements with one system,
- automated non-contact measurement,
- robot calibration directly inside the production cell,
- simple operations performed by the operator,
- reduce downtime to a minimum,
- compatible with most commonly used robots (ABB, KUKA,...),
- mobile and flexible use.

#### Programs tools contains in LaserLAB system:

*Tool measurement with TOOL-IN:* The aim of the measurement is to determine the center point of the tool. Measurement output is the real geometric dimensions of the tool in 3 as well as in 6 dimensions.

*Measurement of robot by LOOP-IN:* The aim of the measurement is to improve the positioning accuracy. Output is the exact model of the robot axis according to “Closed-Loop Calibration Method“ (calibration method of closed loop).

*Measurement of cooperating industrial robots by KIR-IN method:* The goal is to measure one or several other co-operating robot axes. The output is a common coordinate system in which the kinematics move.

*Measurement of base by BASE-IN method:* The goal is to determine the transformation from the workpiece to the robot coordinate system. The system performs a component holder measurement, or external and stationary tools.

*Measurement of temperature influence by TEMP-IN method:* With LaserLAB a TEMP-IN is possible continuously measure the effect of temperature and immediately compensate it inside the robot - without stopping operation.

Measurement principle by LaserLAB system can be seen at fig. 6.

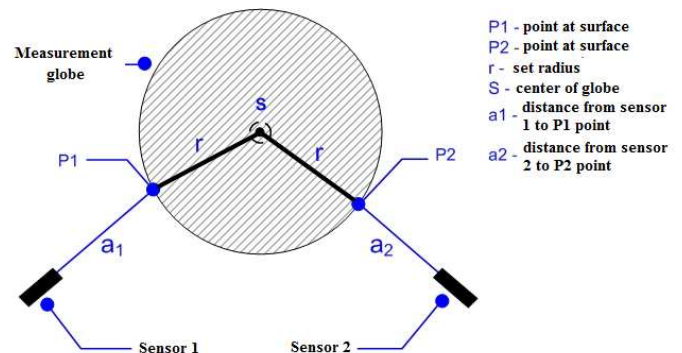


Figure 6 Measuring principle by LaserLAB system

Multiple one-dimensional measurement of distance for measuring globe forms as reliable basis for non-contact measurement of coordinates. Measurement by using five LaserLabs laser sensors is performed so that their rays from different directions meet in a common center [12]. The laser beam directions are determined by the company's calibration.

Surface points on the globe can be determined in three dimensions according to the directions and measured distance from individual sensors. Because of this information, the center of the ball can be calculated. The first approximation for TCP is obtained after four measurements. Further measurements can be obtained by rebalancing spheres within LaserLAB. The rule is that 12 measurements are sufficient to achieve a high enough accuracy [13].

## 4 Conclusion

From the selecting point of view is possible to choose an individual calibration methods, it is advisable to use several methods because they can be applied to most industrial robots. Static calibration is less time consuming for a small number of robots that need to be calibrated, since each robot needs to be calibrated separately, which will significantly affect the overall calibration time.

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## **TRADITIONAL VERSUS MECHATRONIC TOYS IN CHILDREN WITH AUTISM SPECTRUM DISORDERS**

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**Keywords:** artificial intelligence, cognitive abilities, rehabilitation, toy, autism spectrum disorders

**Abstract:** Functional and developmental outcomes in children (both healthy and with developmental disorders) can be significantly improved thanks to use of appropriate toys. There is need for new generation of toys providing development of motor, cognitive, and social skills. There is also need for more objective assessment of their positive influence functional and cognitive achievements of children because current evidence remains incomplete. Mechatronic tools, such as robots and artificial animals, should receive increased attention of scientists and clinicians due to improved performance of children with autism spectrum disorders. Development of novel toy-related technologies can stimulate new approaches applied in the area of diagnosis, intervention and care. This study aims at assessment how mechatronic toys can be better incorporated into therapy of children with autism spectrum disorders - ASD.

## **1 Introduction**

Developmental outcomes in children can be significantly improved thanks to pre-planned application of appropriate toys. Aforementioned toys can be available, low-cost, fun, and functional, they can provide proper sets of stimulation and promote requested child behavior. Toys are well accepted by infants and children, they cause easier medical examination, moreover toy itself can constitute diagnostic tool. Current milestones in infant and children development allow to assess, plan the therapy, and re-assess e.g. physiological and pathological patterns of movement thanks to subjective observation.

New generations of toys can support objective assessment and development of motor, cognitive, and social skills. True influence of toys to healthy and disturbed development still remains incomplete now. There is need for new theories, devices, concepts of use, and research since current knowledge and experience may constitute weak basement for novel, more efficient intervention strategies. Rehabilitation robots and other therapeutic devices supported by virtual reality (VR) systems are popular way of neurorehabilitation [1], [2].

Toy-oriented changes can include:

- upper limb uses in infants, reflected in hand and joint kinematics,
- arm movements associated with toy using (reaching, grasping),
- cognition skills e.g. ability to insert objects into holes,
- searching behavior e.g. for disappearing object/toy or a button to light a set of distant lights or to retrieve the toy,
- imitation for object manipulation,
- creative thinking,
- transferring the toy between children,
- group toy using,
- task sharing (co-operation) during play.
- replication of target actions to achieve action effects
- conflicts concerning sharing an single attractive toy [1], [2].

Toys in the therapy of children with developmental disorders may play various role:

- support diagnosis and therapy through e.g. increased motivation and stimulation,

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- make easier child-therapist interaction,
- ease exercises performed with child by therapist/parents/caregivers,
- influence positively to responsiveness during toy play (e.g. music toys),
- improve interaction (eye contact, touch, manipulation, and posture) and reduced playfulness (e.g. in autistic children),
- support toy/object exploration in children with Down syndrome.

Age-dependant individual or group toy-related behaviours can include:

1. 5- to 6-month-old infants: searching for a disappearing toy,
2. 7-month-old infants: pushing a button to get a toy,
3. 10- to 12- month-old infants: imitating object manipulation,
4. toddlers (13- to 36-month-old):
  - performing aforementioned activities faster and creatively, with various grasp, variety of objects,
  - simple group behaviour: group toy using, imitating/repeating, passing a toy between children, group cooperation during a play,
5. 19-month-old toddlers: replicating action to achieve established effect,
6. toddlers and older children: increased responsiveness to musical toys,
7. older children: fighting over aa attractive toy.

Eclectic/mixed approach to intervention in children with developmental disorders provides:

- use of toys as monitors and sources of stimulation,
- combined methods, techniques and tools (assistive technology, toys, elements of environment, etc.),
- patient-tailored approach [1], [2].

Autism spectrum disorder (ASD) impacts 1 in 68 children in the U.S., with tremendous individual and societal costs [3]. ASD is a complex neuropsychological disorder characterized mainly by:

- qualitative alterations in social interaction and interpersonal communication,
- decreased object recognition,
- atypical motor behaviors, less mature object manipulation, and reduced grasping activity,
- limited or absent speech [4], [5].

Toys are often used in therapy of children with ASD, e.g. social robots are utilized as therapeutic tools in order to enhance social skills and communication [4], [5].

This study aims at assessment how mechatronic toys can be better incorporated into therapy of children with ASD.

**2 Review**

Six main data bases as well as recent news articles were searched using specified key words. Inclusion criteria consisted of scientific article in electronic or printed media directly studying or reviewing the use of traditional or mechatronic toys in children with ASD. The current literature was critically appraised, and quality of selected articles was assessed and manually filtered for relevance by 2 reviewers.

Intelligent multifunctional toys are the next step toward increased use of toys in the development and therapy of children. Simultaneous monitoring and stimulation of particular skills will optimize achievements accessible for each particular patient, both healthy and with developmental disorder. Moreover, user-friendly supporting devices shaped as toys may be constant element of the environment of dependent children (Table 1, Table 2).

*Table 1. Selected robot-related studies in ASD children.*

Results	Reference
Difficulties with social interaction: mechanical toy less valuable than communicative or non-communicative person	Verneti 2017 [6]
Alternative, movement-based, rhythm and robotic interventions influence social communication skills	Srinivasan et al. 2016 [7]
Social attention was greater in the rhythm followed by the robot	Srinivasan et al. 2016 [8]
Robots can facilitate increased verbal interaction and responses to faces of robots	Jung et al. 2016 [9]
Robots can potentially be applied to a large scope of objectives for children with ASD	Huijnen et al. 2016 [10]
Minimalistic artificial environment (toy robot) can be considered as the root of neuronal organization and reorganization with the potential to improve brain activity	Giannopulu et al. 2016 [11]
Person recognition may emerge through imitative experience, intercorporeal mapping, and statistical learning	Boucenna et al. 2016 [12]
Rhythm and robot groups showed improved interpersonal synchrony performance	Srinivasan et al. 2015 [13]
Individuals with ASD process motion rather than emotional signals when facing facial expressions (morphed robotic stimuli)	Han et al. 2015 [14]
Children with ASD may feel more comfortable, and may modify their emotional response, if the robots look like deformed humans	Ueyama 2015 [15]

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Robot-mediated Imitation Skill Training Architecture (RISTA) can operate either completely autonomously or in coordination with a human therapist depending on the intervention need.	Zheng et al. 2016 [16]
Children's interaction with a human differed from the interaction with a social robot during a play task	Simut et al. 2016 [17]
Rhythm-based interventions are socially engaging treatment tools to target core impairments in ASD	Srinivasan et al. 2015 [18]
Meter-tall robot (nicknamed ANNIE: Android With Neural Networks, Intellect and Emotions) is useful in the therapy of children with ASD	Frenger 2015 [19]
Interaction between children and Isobot (humanoid robot) improved performance on standardized measures of imitation, planning, and execution of motor behaviors	Laue 2015 [20]
ABI (Penguin for Autism Behavioral Interventions) is a compact humanoid robot taking on an expressive cartoon-like embodiment which can be part of the therapeutic system	Dickstein-Fischer & Fischer 2014 [21]
Novel robotic system capable of dynamic, adaptive, and autonomous interaction during imitation tasks with embedded real-time performance evaluation and feedback	Warren et al. 2015 [22]
Children with ASD are more engaged in the task and they seem to enjoy more the task when interacting with the robot compared with the interaction with the adult	Costescu et al. 2015 [23]
Robot-based intervention resulted in no statistically significant changes in collaborative behaviors of the children with ASD.	Huskens et al. 2015 [24]
As an outcome of robot-based therapy ASD group showed a significant decrease in social anxiety, although neither group showed a significant increase in social skills	Kaboski et al. 2015 [25]
Novel adaptive robot-mediated interaction technology for facilitating early joint attention skills for children with ASD	Zheng et al. 2013 [26]
Mobile toy robot can be used as a mediator of social stimuli during free, spontaneous game play in order to reduce the impairment of ASD children skills related to social information understanding and interaction	Giannopulu & Pradel 2010 [27]

*Table 2. Selected traditional toy-related studies in ASD children.*

Results	Reference
Cooperative play toys focus on captivating the interest of ASD children through e.g. reinforcing the sound and light effects to improve the attractiveness of the toys	Tseng et al. 2016 [28]
Importance and utility of examining sex differences in toy use in children with ASD	Harrop et al. 2017 [29]
Toy-based functional communication training	Leon et al. 2013 [30]
Atypical methods of play with toys from the personal collections of children with ASD	McLaren et al. 2013 [31]
Development of visual attention may impact later cognitive outcomes of children with ASD	Sacrey et al. 2013 [32]
Children with AS who exhibited noncompliance when asked to relinquish a preferred toy were exposed sequentially to interventions that included a reduction in response effort, differential reinforcement, and guided compliance – there is need to individualize treatments for compliance	Fischetti et al. 2012 [33]
Experience-dependent learning of feature-based object categories in children with ASD	Fields 2012 [34]
Even 5½-month-old infants demonstrate preferences for 3-dimensional objects (toys) on the basis of affective information depicted in videotaped events	Vaillant-Molina & Bahrck 2012 [35]
Infants later diagnosed with ASD tended to continue looking at a toy during the distress condition despite the salience of social information	Hutman et al. 2012 [36]
A training program designed to teach gaze following used the activation of remote controlled mechanical toys as both prompts and consequences	Klein et al. 2009 [37]
Three different typologies of instruments were designed to assess infants behavior in different perceptual and motor domains	Campolo et al. 2008 [38]



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Pairing a vocal sound with a preferred stimulus (e.g., toy) to condition automatic reinforcement	Carroll & Klatt 2008 [39]
Worse executive functioning performance of children with ASD with chronological- and verbal-matched controls in a spatial-reversal task	Coldren & Halloran 2003 [40]
Children with ASD learned to ask questions about hidden objects (closed box with a toy inside)	Williams et al. 2000 [41]
Imitation generalized from reinforced training models to nonreinforced probe models within a response type, but it did not generalize across response types	Young et al. 1994 [42]

### 3 Discussion

Toy-related play may involve forms from early involving the exploration of objects, early manipulative and relational play, through development of meaningful perceptual representations, to the most advanced development of functional and symbolic play. No doubt early detection and diagnosis of developmental disorders is critical: it enables the implementation of preventive measures and therapy of pathological elements at a very early stage. We should be aware that every day can make a significant difference in further therapy. Effectiveness of the therapy is closely connected with the early and proper diagnosis, patient/parents-therapist relationship (for 24/7 therapy and care purposes), as well as with patient - tailored, advanced methods, techniques and tools applied in a particular case.

Discrepancy between scientific research, current knowledge, and clinical practice within the toy-based therapy can be observed since current research do not cover full spectrum of possible interventions. Robotic system is assessed as well-tolerated by children with ASD, and even may create greater attention than the parent or therapist. Social robots can encourage children with ASD to interact with the robotic tools, stimulate emotional responses, and take the initiative [15]. Also imitation performance can be superior during the robotic interaction [22]. Contexts, both movement-based and socially-based are regarded valuable in promoting motor performance, imitation, and interpersonal synchrony. Mechatronic toys are regarded supplementary way of the therapy thus therapists shouldn't be replaced by robots. Moreover, robots need for so called supervised autonomy [43]. A systematic literature review of the studies on social robotics as a promising method for ASD. Especially children with ASD:

- have a lot of social behaviors toward robots,
- often performed better with a robot-partner rather than a human-partner,
- have, toward robots, behaviors that typically developing children have toward human agents,
- showed reduced repetitive and stereotyped behaviors in the interaction with robots,
- improve spontaneous language [44].

There is still huge number of ethical, social and therapeutic concerns to solve, including children's and parent's expectations about this kind of therapy. Acceptability of this technology is associated with more

general human-robot interaction for everyday purposes [43]. Fundamental is regarded ability for robots to convey emotion [45].

Limitation is a lack of detailed schemes describing use of toy (including intelligent toy or robot) in the therapy of infants with developmental disorders. There is many unknown or uncharted applications of toys and associated responses, e.g. robots and artificial animals can cause social interaction requiring interpretation of associated (indirect) social information. From the other hand robot-toys level of control huge, stimuli can follow various pre-planned scenarios, amount and time-span of stimulation can be more precise and individually shaped. Animal robots ("artificial friends") can be as close to the original as possible, but they can meet requirements fulfilled by medical devices.

Another limitation is a few research (especially randomized controlled trials and compartmental studies) concerning application of virtual reality (VR) technologies, computer games, and biofeedback-based devices in pediatric neurorehabilitation. Despite many commercial devices pretend to play role of rehabilitation tools, they need for additional research in clinical pediatric environment. We should check whether age, sex, intelligence quotient of participants affects the outcome of robot-supported therapy [44]. We need more evidences concerning both short-term and long-term results including children in pre-school age and school age. Only better understanding of normal growth and development in healthy and delayed infants and children can provide appropriate stimulation enhancing motor and cognitive skills. Aforementioned knowledge should be also a part of normal preparation of parents and caregivers.

Consciousness concerning ingestions and toy-related injuries is only the basement for safe clinical toy application methodology, including also safe mobility, seating, transfers, etc. in both healthy children and children with developmental disabilities. We should be aware that children with more complicated or severe disorders will require patient-tailored methods, more advanced techniques or tools, carefully re-assessed and modified [1], [2].

From methodological point of view even the most advanced mechatronic toys may be useful for monitoring and measuring behaviours of children with ASD, but cannot be taken as the only determinant. It may play rather role of screening test or supplementary tool. No doubt more advanced clinical tests are needed, e.g. videotaping may be

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useful for measurement and analysis of certain behaviours. Diagnosis is individual, despite we know, that weak reactions to stimulus, asymmetrical performance, poor coordination, poor mobility of the upper limbs, varied motor skills and problems in adaptation of posture to the various movements may suppose developing disorders [1], [2].

From the ethical point of view medical knowledge and clinical experience are not enough to assure recovery and respect the children free will and choice. Early identification of developmental problems, proper diagnosis, and communication with paediatric patients with ASD and their parents can be extremely difficult. It may require not only extraordinary abilities of the whole interdisciplinary therapeutic team, but also novel sophisticated tools such as intelligent toys cooperating with the therapist. Despite current concept of child-therapist communication is based on knowledge, experience, and mutual trust, it can be limited by many factors observed in both healthy children and children with developmental disabilities: hunger, thirst, boredom, drowsiness, fear, or even pain, etc. Thus objective and relatively quick assessment of functional achievements can constitute real challenge. New generation of interactive toys can facilitate an easier diagnosis, and further faster development of motor, cognitive, and social skills in young patients with ASD. However, the use of such toys as relatively simple peacemakers is not always proper and enough. Risk are also dehumanization of the health care and a lack of an individual approach to each particular paediatric patient and his/her parents. / caregivers.

Technical limitations concerning imitation of living animals can play significant role. Compartmental study of living dog and a robotic dog in the therapy of children with ASD made by Silva et al. showed, that live dog still has a bigger calming effect on the children with ASD [46]

Therapeutic success is measured by the patients' capacity to return to kindergarten/school, participation in everyday life of their family and community, and finally by the general patient satisfaction. Therapeutic success may be achieved even despite the impossibility of complete recovery.

#### 4 Conclusions

Mechatronic tools, such as robots and artificial animals, should receive increased attention of scientists and clinicians due to improved performance of children with ASD. Development of novel toy-related technologies can stimulate new approaches applied in the area of diagnosis, intervention and care.

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**Review process**

Single-blind peer reviewed process by two reviewers.