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THE APPLICATION EXTENDING THE CAPABILITIES OF THE HUMAN-ROBOT INTERACTION OF THE HUMANOID ROBOT NAO

ABSTRACT *In this work of an interdisciplinary character, the potential implementation of the humanoid robot NAO in regards of research on the lateralization phenomenon was presented. Some assumptions regarding the system for therapy on selected laterality disorders in children were presented. The NAO humanoid robot was implemented for the purpose of interaction with child in order to focus its attention and make him willing to make and repeat given exercises. It is particularly important for autistic children. Also the basics of the proposed LES (Lateralization Exercise System) system were presented, which could enable to apply the solution of varying components for the information exchange in human-robot system.*

Keywords: *lateralisation, human-robot interaction, robot NAO*
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1. INTRODUCTION

Lateralisation can be defined as a superiority of one side over the other side of the body. A large number of quite recent investigations have made a hypothesis regarding a correlation between autism, left-handedness and brain laterality, although the results of the particular researches have varied [1, 2]. The domination of one hand over the other, with their simultaneous movement coordination, allows a high degree of performance. Incorrect lateralisation is a phenomenon frequently common among children of school age. Abnormal lateralization is very often accompanied by other disorders, such as an incorrect spatial orientation [1, 3]. It reveals with a confusion between the right and the left side and with manipulation of appropriate sides. It can

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also cause problems with mapping asymmetric shapes. Children with impaired lateralisation and spatial orientation disorders may have difficulties during physical education classes in case they have to imitate the teacher standing in front of them. Trouble in distinguishing right and left side of his body usually appear in children with weakened and delayed process of lateralization, so called – ambidextrous.

Fig. 1. Humanoid robot NAO

One of the main consequences of the cross-domination of in terms of eye and hand can be impaired visual-motor coordination. As well for the right-eye children who are using the left hand, as for the left-eye children using the right hand – the vision control is difficult and often flawed. Disorders of visual-motor coordination can be observed in many daily activities of the child. In particular become they visible In the initial stage of learning to write. In the case, when a child has impaired visual-motor coordination can often be seen a phenomenon called dynamic inversion (reversing the order of the letters in the word, eg. CAT – TAC), static inversion (reversal of the letters), mirror-writing (mirror reflection of normal writing) [4, 5]. Implementation of a NAO humanoid robot (Fig. 1) for the purpose of exercises in order to improve lateralisation in children may be an interesting alternative or complement to traditional therapies. This applies particularly to children who have concentration troubles or suffer from disorders such as autism. Appearing in this case problems with feelings communication, social associations and problems with sensory integration may be an indication for using alternative methods during therapy [5, 6].

NAO robots have been successfully applied in treatment of the autistic children for many years under the program supported by the manufacturer of the company Aldebaran [7, 8]. The authors of this paper have developed a system of LES (Lateralisation Exercise System), which combines various peripheral devices being the source of signals in order to ensure and improve the interaction between human and robot.

The solution proposed in this work is an example of sample methods of classes, where the NAO robot (Fig. 1) could be applied especially in the case of work on lateralisation phenomenon and this could be an interesting addition to the already existing practices. One of the reasons for writing this paper was the observation of the constant growth of autism diagnosis, which is a neuro-developmental disorder, where the factors such as communication, social interaction and behaviours are impaired. Due to that the use of robots in alternative therapies, where the human therapist is being replaced by a humanoid robot, brought some promising results [2].

2. NAO ROBOT

NAO robot is an autonomous humanoid robot, which was developed, designed and constructed by the French company Aldebaran Robotics. NAO has a total of 25 degrees of freedom (DOF), 11 DOF for the lower part, which includes legs and pelvis, and 14 DOF for the upper part including trunk, arms and head [9]. The main advantage of its construction is that it is full programmable and that the producing company provides full documentation and development environment – Choregraphe [10].

For the purpose of control NAO robot a specialized Linux-based operating system NAOqi is applied. The NAO V4 generation is equipped with the ATOM Z530 1.6 GHz CPU and the motherboard with 1 GB RAM. The communication process with the robot is enabled with the WiFi 802.11g protocol and through the Ethernet port. Also the communication via infrared sensors is possible [10]. NAO is also equipped with a vision recognition system based on two 960p cameras, which can capture up to 30 images per second [10, 11]. NAO contains a set of algorithms for detecting and recognising objects, such as faces. ALLandMarkDetection is a vision module, in which NAO recognises special landmarks named NAOmarks. It is possible to place those landmarks at different locations and depending on which landmark NAO detects, appropriate information about object which NAO has detected is given [10]. NAO's cameras operating in YUV colour space with separated threshold values per channel. This enable to make a choice between brightness and colour channels, where the threshold value for brightness channels is higher, what significantly improves the invariance of illumination [11].

3. HUMAN-COMPUTER INTERACTION IN REGARDS OF RESEARCH ON LATERALISATION EXERCISE SYSTEM PRINCIPLES

Interaction between human is dependent on various perceptual cues and has always been a challenge in design and development of Human-Machine Interaction (HMI). Making a robot more human-like improves its ability to communicate with humans [12]. The authors of the hereof paper have also developed a system, which was able to support the principle of the therapy of laterality disorders. The program was called LES, which is an acronym for Lateralisation Exercise System. It is a modular program, which enables to develop new peripherals and to adapt the solution to needs of the potential user in terms of exercises for improving disorders resulting from lateralisation.

It combines a wide range of peripherals necessary to obtain signals regarding the state of a task carried out by the child, with the control panel (Fig. 2) controlled by the therapist and the work of the robot control system. This panel allows the therapist to intervene in the process of implementation of the exercise and control of its proper course.

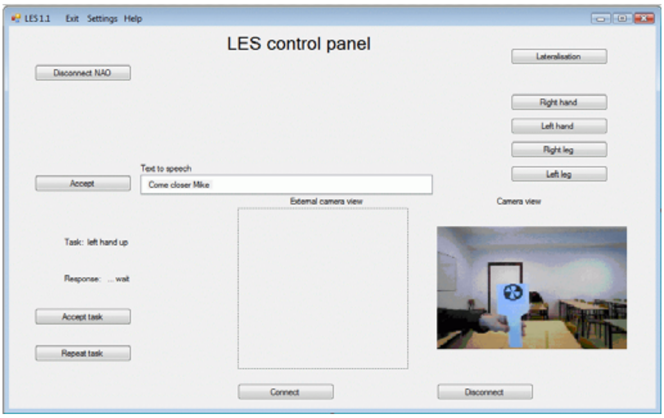

Fig. 2. View of LES control panel

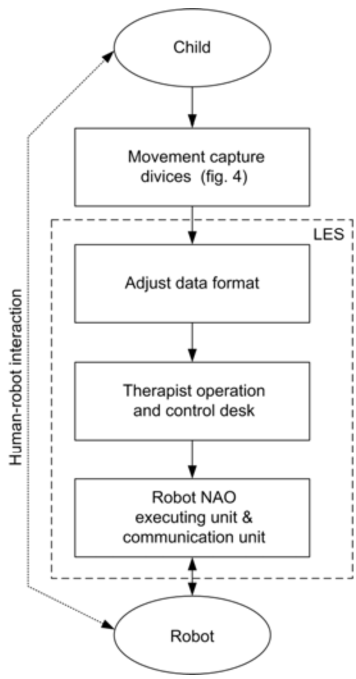

Fig. 3. Block diagram of the LES system strategy in case of left-right site recognition lateralization problem

In Figure 3, the simplified block scheme of the LES system was presented. That figure illustrate the work of the system in the left-right site recognition lateralisation problem. In this case, a capture unit acquires information regarding changes in joints position. Many devices can be used in this purpose (Fig. 4) and a significant problem is the standardisation of the stored data. For example, the system LES uses the BVH (Biovision Hierarchical Data) standard [13]. A typical BVH file consists of two parts – a header section, which describes the hierarchy and initial pose of the skeleton and of – a data section, which contains the motion data. The modular build strategy of the LES system allows the translation from other standard to the BVH.

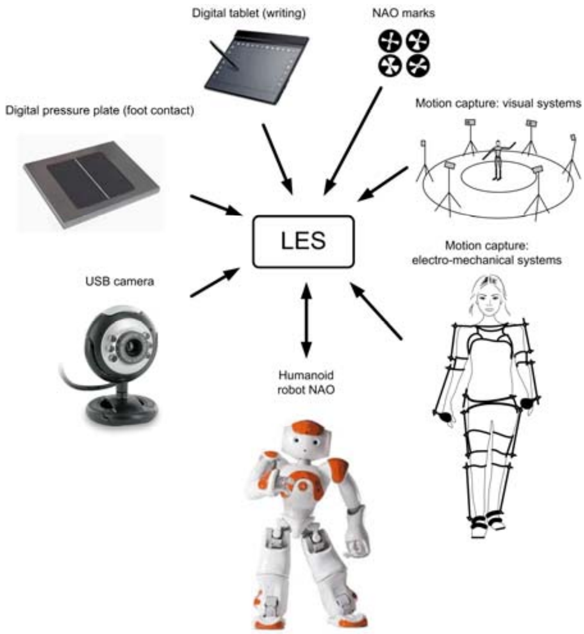

Fig. 4. Devices, signals and peripheral systems cooperating with the proposed LES system

4. SIMPLE EXAMPLE OF LATERALISATION EXERCISE WITH LES SYSTEM AND NAO ROBOT

Issues with abnormal lateralisation are a phenomenon often encountered among children of school age. It is also challenging to make the youngest patient interested or focused on given task, especially in the case they are also affected with other disorders such as Autism [1, 14]. The method proposed by the authors of this paper involves using the interaction between the child, the therapist and the NAO humanoid robot, which seems to be an interesting alternative and complement to the traditional, currently used therapies. In the further part of this work (below) example of exercise with the implementation of a low-cost, easily available on the open market hardware and the intuitive system LES were presented. A very important element of the proposed method is the apparent isolation of the therapist from the therapy subject (e.g. a child).

The examined child patient should have an illusion of an exclusive contact with the humanoid robot NAO only. The LES system makes the task possible as the remote control function is available for the NAO robots.

In various lateralisation disorders with concomitant disorders of spatial orientation it is possible to observe signs of confusion between the right and the left side when handling the sided terms. Therefore the authors of this papers have developed sample exercise in order to improve the condition of the child patient with the use of the NAO humanoid robot (Fig. 5). During the task the child repeats the robot's motion.

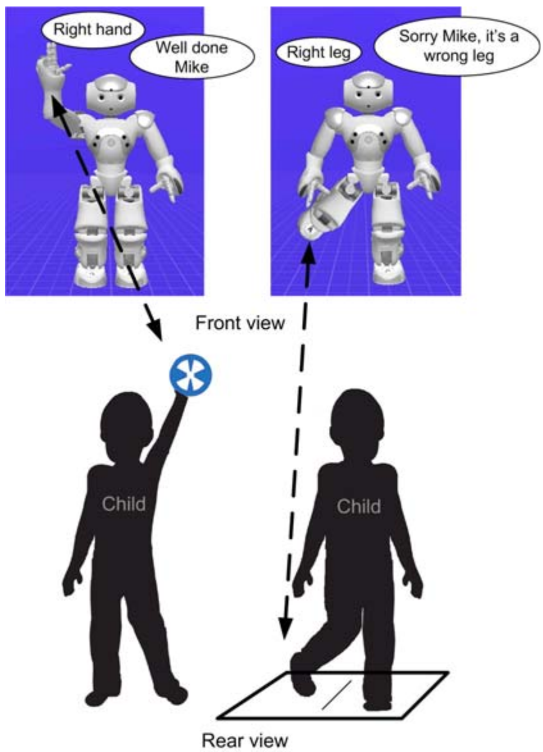

Fig. 5. Sample exercises for left/right site recognition lateralisation issue: the child repeats the robot's motion, the robot either accepts or corrects (verbally) the child's motion (NAOmarks and balance platform)

This exercise enables to train lateralisation of hands as well as feet. Therefore the LES system may be equipped with a set of peripheral devices, which provide the information regarding the position of the child's limbs. Examples of such peripheral devices was presented in Figure 4.

For example, in order to detect which leg is raised, a digital pressure plate or platform (shown in Figure 6) can be used. The foot pressure and gait analysis recording system (e.g. DIERS pedo-scan) allows the capture of the pressure distribution on the human foot and the analysis while standing or moving. Due to this data it is possible to receive the information which leg is up (was lifted). The LES system also enables the control of the NAO robot's behaviour: acceptance or disgrace – depending on child's behaviour. In order to determine the child's hand movement correctness, while mimicking the robot's commands, multiple devices of various complexity can be applied. A very convenient method is to use the opportunities offered by the robot NAO itself (as a standard), as it is already equipped with a video tags recognition system called NAOmarks (Figure 5). ALLandMarkDetection is a vision module, which returns the number of recognised ID tag, which can be attributed to either left or right hand. A child can hold a NAOmark hand marker, which will enable the interaction with the robot and as a result – acceptance or not of the executed command.

Fig. 6. The balance platform used for inter alia the lateralisation diagnosis

TABLE 1
Efficiency of recognition NAOmark depending on distance

Distance to the robot [m]	Efficiency of recognition [%]
0.4	100
0.8	95
1.2	15
1.5	0

The efficiency of recognition NAOmarks depends on distance to the robot as well as on the brightness of the lights. Time of object recognition usually is less then 1÷2 sec (time to NAO speak communicate). Useful distance between child and robot NAO for this lateralisation exercise is about 0.4÷0.8 m. NAOmark diameter was 55 mm, vertical axis angle of rotation during recognition tests was 0÷30 deg. In every test, 20 repeats were done.

5. CONCLUSION

In this paper, the research area strongly related to the interaction between humans and humanoid robot for the purpose of supporting therapy of various laterality disorders, particularly in autistic children. Also some of the key technical aspects and proposed conditions for the implementation of exercises using the HMI were described. In this work, the humanoid robot NAO (the most popular in autism therapy for children) was applied. NAO is currently the most popular humanoid robot creation used in various research centres around the world [7, 8, 10]. Also wide range of easily available peripherals gives a great ability to adapt NAO to the both – requirements of the proposed system and user capabilities. The developed system is the modular LES program, which allows the communication between the peripherals and adaptation of the system to the needs of the user in terms of exercise in the laterality treatment.

It is also important to mention that the essential part of the control panel allows the therapist the interference in the process of implementation of the exercise and to control it in the aspect of its proper progress. Also the aspect of laterality was investigated, as the research on it was very popular in the 80's and 90's of the previous century. However quite a good research background was done, it is still hard to estimate whether the traditional investigation methods are correct and whether there exist any gaps between particular individuals [14].

In this work, also some key aspects regarding technical conditions for the exercise realisation were discussed. For his purpose the most popular humanoid robot NAO was applied, as the robot is currently widely used in numerous research centres all around the world and also as a tool for therapy of children affected with autism [8].

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APLIKACJA ROZSZERZAJĄCA MOŻLIWOŚCI INTERAKCJI CZŁOWIEK-ROBOT HUMANOIDALNEGO ROBOTA NAO

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ABSTRACT *W artykule o charakterze interdyscyplinarnym zaproponowano użycie humanoidalnego robota NAO do wspomagania terapii lateralizacji. W pracy omówiono założenia dotyczące systemu terapii zaburzeń lateralizacji u dzieci. Zastosowanie w terapii robota humanoidalnego NAO powoduje większe skupienie uwagi dziecka na ćwiczeniach i chęć powtarzania ćwiczeń. Jest to szczególnie ważne w przypadku dzieci autystycznych. Zaprezentowano także podstawy opracowanego systemu LES (System Ćwiczeń Lateralizacji), który umożliwia zastosowanie różnych komponentów do wymiany informacji w systemie człowiek-robot.*

Keywords: *lateralizacja, interakcja człowiek-robot, robot NAO*