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ARTIFICIAL INTELLIGENCE CONTROLLED RELAXATION SYSTEM FOR AUTISTIC CHILDREN – IT TECHNOLOGY THAT ADDRESSES SOCIAL ISSUES

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Abstract. *The article presents the development and research of technological tools - a relaxation system for children with autism. The article describes the means and methods of emotional stabilization of children with autism spectrum disorders. The design, operation, and control of the relaxation system controlled by artificial intelligence with image processing and machine learning are described. The relaxation effect on children is carried out with audio-musical signals, by combining them with colored light and mechanical vibration of the back area. The practical research results are described, demonstrating the system's effectiveness for children with autism spectrum disorders. Under normal conditions, if a child takes 3 to 4 hours to calm down, the relaxation system shortens this time to 10 to 15 minutes. Finally, the relaxation system controlled by artificial intelligence-based software, created by scientists from three Lithuanian universities and the students of Vilnius Kolegija, is presented as a technological tool designed to address social issues in society.*
Keywords: *artificial intelligence, autism spectrum disorder, emotion recognition, image processing.*

Introduction

Social integration and emotional well-being become highly relevant issues within specific groups of people, including those with disabilities or special needs.

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Currently, the integration and emotional health of children with autism spectrum disorders have become sensitive topics. Human resources, including psychologists, educators, or other specialists, are no longer sufficient with the increasing number of such individuals. It is essential to incorporate technologies based on modern science and technology to improve the emotional state of such children (Ben-Sasson et al., 2007). It is known from practice that children of this type have emotional instability and can become inactive and unproductive for long periods (e.g., during classes) or even for the entire remaining workday (Dickie, Baranek, Schultz, Watson & McComish, 2009). Typically, a child calms down by changing the environment, such as walking or staying in a quiet place. Calming down in such cases can take up to several hours, leading to the loss of a workday. Extreme cases may involve the child becoming aggressive after an emotional stimulus.

Modern relaxation methods, such as music therapy, soothing visual presentations, and relaxation in a massage chair, help reduce the time needed to calm down. However, each calming method is individual and may not suit all children (Alam, Khan & Farooq, 2018). By leveraging information technologies based on artificial intelligence and machine learning algorithms, it is possible to create individual calming scenarios for specific children and automatically react to the children's reactions (Brondino et al., 2015).

By applying artificial intelligence algorithms like those used for face recognition-based phone unlocking (Face ID) (Shah, Li, Shah, & Ullah, 2018), these same algorithms, when improved, can be applied to emotion recognition (Zhang, Zheng, Cui, Zong & Li, 2018), thereby automatically changing the scenario's impact on the individual. Such AI-controlled comprehensive relaxation systems have been developed by Lithuanian university researchers together with students. This is part of the real project "Adaptation of Specialized Smart Massage Chairs for Relaxation and Integration of Children with Autism Spectrum Disorders in the Educational Environment" (Lithuanian grand No. 01.2.1-MITA-T-851-01-0026), which involved teachers and students from Vilnius College.

The article presents only a small part of the two-year project, during which Vilnius College students gained new competencies and realized their existing skills. The technology developed during the project became one of the tools for solving social problems.

Relevance of the Topic. With the increasing number of children with autism spectrum emotional disorders in Lithuania and worldwide, measures are needed not only for their integration into society but also to improve their emotional well-being.

Problem Statement. The essence of the problem is that autistic children easily lose emotional balance, causing them to be inactive and unproductive during classes. To calm such a child, it often takes several hours or even the entire

remaining day. Therefore, there is a need to create a technological-social tool for rapid relaxation.

Research Objective. To create an automatic relaxation scenarios selecting system combining complex audio, visual, and massage effects aimed at helping autistic children calm down in a short time.

Tasks:

1. To explore the main methods of emotional calming for autistic children.
2. To create a relaxation system combining the researched methods, allowing the child to calm down in the shortest time possible.
3. To examine the effectiveness of the developed system on children and create an automatic method for selecting relaxation scenarios for individual children.

Methodology

Over time, in the field of Autism Spectrum Disorders (ASD), a situation has emerged globally where these disorders are being addressed in a rather isolated manner. Well-known relaxation systems exist worldwide, with their basis being the influence of sound on physical properties (Casanova, 2007). The latest audiovisual technologies (interactive audio and video processes) provide opportunities to integrate many of these relaxation methods into one entity. With their assistance, a child can be affected not only by sound but also by enhancing its impact through sound visualization and utilizing the vibrational properties of particularly low-frequency sound. Working with visual/color material can be "enhanced" by rhythmic pulsation, aiding an anxious child in calming down and focusing. These audiovisual means can be combined with tools that help activate all possible receptors. The system of mini-computers and other control tools, along with creating a microclimate in a relatively closed space, could help customize the impact according to each child's needs. Integrating all these possibilities into one system (in this case, a relaxation system) would create opportunities to achieve results that are not possible by addressing each ASD child's emotional domain separately. The system was designed based on previous studies of children and educational robots (Costa, Steffgen, Lera, Nazarikhorram, & Ziafati, 2017).

Therefore, it is purposeful to create such a relaxation system that would combine the three mentioned means of impacting the child and would be controlled by software capable of individualizing relaxation effects for each child separately.

Considering the available information, it can be stated that until now, there haven't been enough theoretical and practical studies that would enable the creation of algorithms capable of stabilizing the emotional state of children with autism spectrum disorders. The creation of an automatic operating system that

could react to the child's emotions and select a relaxation scenario would be a significant step in the field of science and technology both in Lithuania and globally. Taking all the information into account, a comprehensive relaxation system controlled by artificial intelligence and encompassing sensory, visual, and auditory relaxation functions was developed.

Realization of the Relaxation System

Assessing the data from surveys of autistic children's parents, global practices, and the results of scientific research in this field, as well as personal experience of scientists living with such children, the functions of the relaxation system were concretized:

1. Emotional calming
2. Emotional-visual therapy

Visual relaxation is implemented comprehensively together with audio material, the combination of which is programmatically controlled. The audiovisual environment, its effects, and changes can be perceived by the user outside the system. The audio material is synchronized with colored light sources, whose intensity and color of illumination are automatically controlled according to the selected audiovisual Algorithm (Mousavi & Aghsaghloo, 2018).

3. Emotional-Auditory Therapy

In the relaxation system chair (Figure 1), a 4.1 format acoustic system is installed: two speakers at the back (at head level), two in the front (on armrests), and one low-frequency speaker. Thus, the seated individual directly feels all music or sound vibrations. This achieves a particularly strong psycho-physiological effect of sounding music or sounds (Matson, 2009), (Janzen & Thaut, 2018).

4. Massage Functions

Mechanical massage effects are intended to be realized in the seating area and lower lumbar region through mechanical vibration and air cushions. Vibrations are created according to a predetermined scenario with the possibility of adapting it to the child's specific needs (Huang, Liao & Pang, 2017). Mechanical vibrational tools are programmatically synchronized with auditory effects to create a unified relaxation scenario controlled by an intellectually changing algorithm tailored to each child individually.

5. Child Monitoring in the Relaxation System:

5.1. Observation with Human Presence (Therapist) through the integrated camera in the system.

5.2. Prevention of critical cases by automatically analyzing the video. These may be preventive cases to prevent the child from getting hurt, for example, falling out of the chair.

5.3. Visual information is transmitted to the artificial intelligence method operating the emotion recognition and automatic relaxation scenario control algorithm.

Based on previously defined functions and the purpose of the relaxation system, a prototype design of the system has been developed. The components of the system are illustrated in Figure 1.

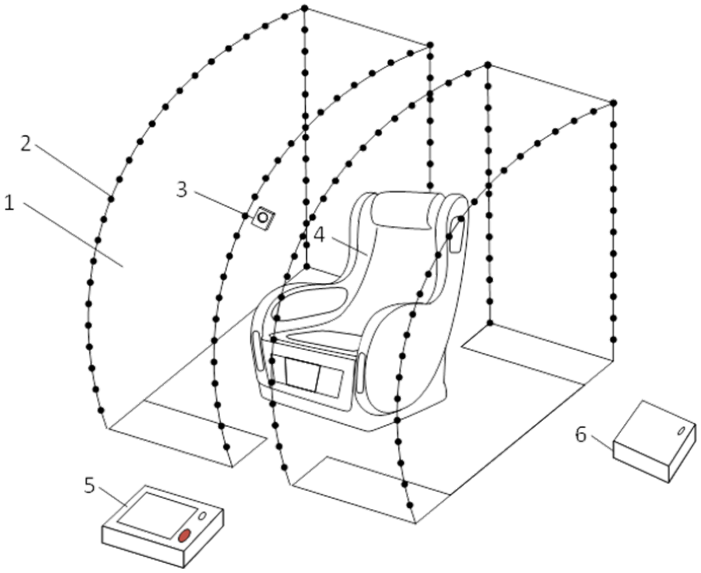

Figure 1 ***Components of the Relaxation System*** *(created by authors)*
1 - Semi-transparent enclosure (left and right parts), 2 - System of colored light sources, 3 - Video camera, 4 - Massage chair with sound system, 5 - Control computer with a touch screen, 6 - External power source.

The system consists of a vibrating chair (4) housing mechanical vibrational and massage functions performed by actuators and an integrated sound system. A semi-transparent enclosure surrounds the chair (1) that slides sideways, housing a system of colored light sources (2) along its edges. One of the enclosure sections contains a stationary video camera (3) designed to monitor the child's face and provide information to an artificial intelligence-driven relaxation scenario selection program. System control is facilitated through a specialized computer (5) featuring a touch screen. Power to the system is supplied via an external power source (6), which is physically distanced from the system at a safe distance, delivering non-hazardous electrical current to ensure the child's safety within the device.

The view of the relaxation system prototype during experiments is presented in Figure 2

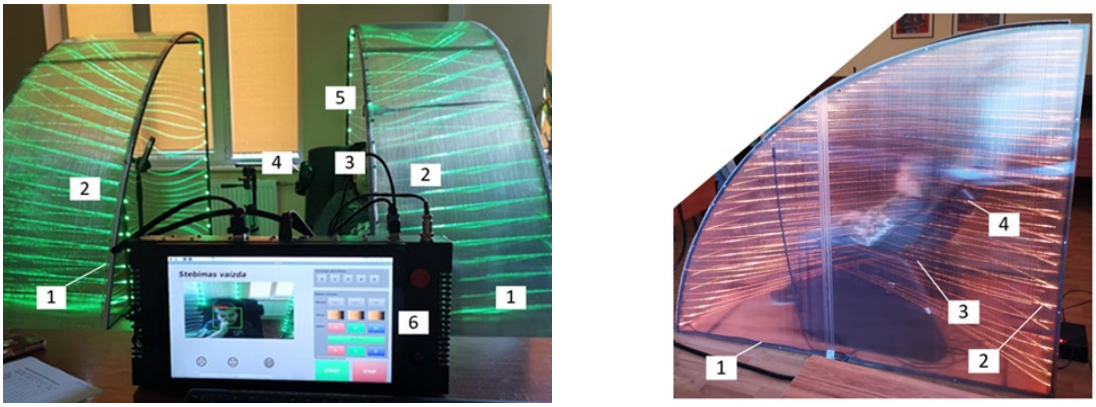

Figure 2 ***Real Prototype Image with the Subject Child*** *(created by authors)*
1 - Semi-transparent enclosure (left and right parts), 2 - System of colored light sources, 3 - Video camera, 4 - Massage chair with sound system, 5 - Control computer with a touch screen, 6 - External power source.

The essence of the system's operation lies in providing relaxation to a child experiencing emotional instability, such as agitation or anxiety, by allowing them to sit in a comfortable chair where they receive vibrational massage relaxation synchronized with soothing music and the calming effects of colored light. The child returns to emotional equilibrium after a short period, much shorter than possible under ordinary circumstances. The operation of individual components of the relaxation system is illustrated in Figure 3.

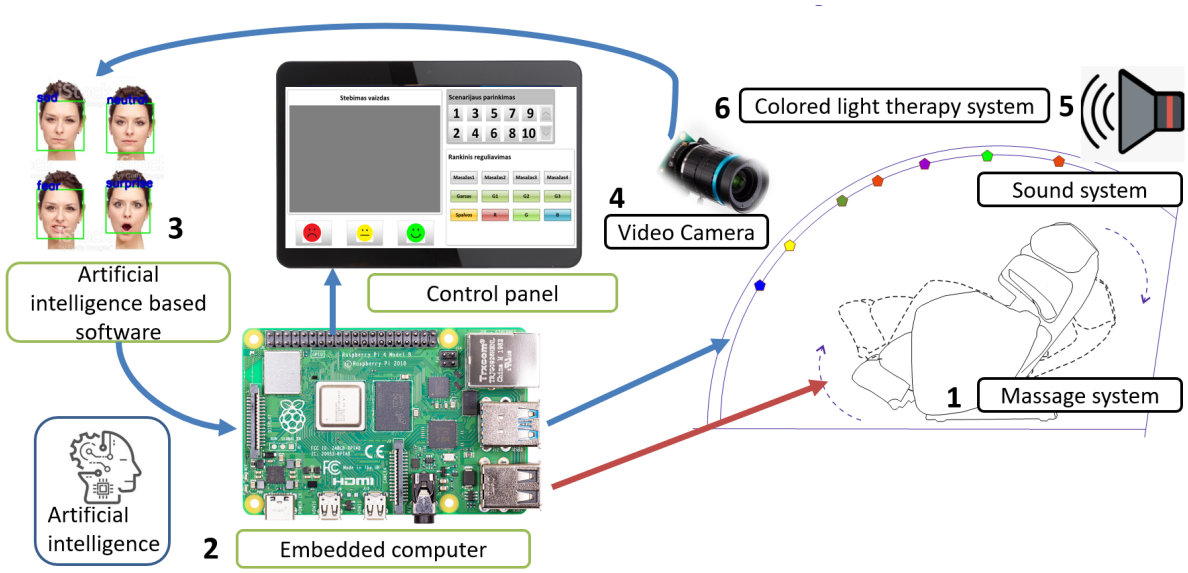

Figure 3 ***Illustration of the Operation of the Relaxation System*** *(created by authors)*
1 - Relaxation chair with massage functions; 2 - Embedded computer for data analysis and control functions implementation; 3 - Software running on the computer with artificial intelligence (AI); 4 - Video camera for monitoring the child's reactions; 5 - Sound system for auditory therapy; 6 - Coloured light system for color therapy.

The control computer (2) running software based on AI controls the system. The intelligent control program is designed to manage the massage chair functions

(1), along with auditory-musical therapy (5) and color therapy (6), creating a relaxation scenario tailored to each child individually. The software on the control computer (2), powered by AI, executes a predefined relaxation program and analyses the child's reactions to stimuli. Thus, Artificial Intelligence learns which light, music, and massage stimuli appeal to a specific child and automatically adapts the relaxation program, enhancing it accordingly (Kahou et al., 2016). The AI program also alerts the caregiver in critical situations where the child overreacts negatively. A provision for halting the relaxation program is included for unforeseen critical situations, e.g., if the child reacts negatively to relaxation techniques, the algorithm presented in Figure 4.

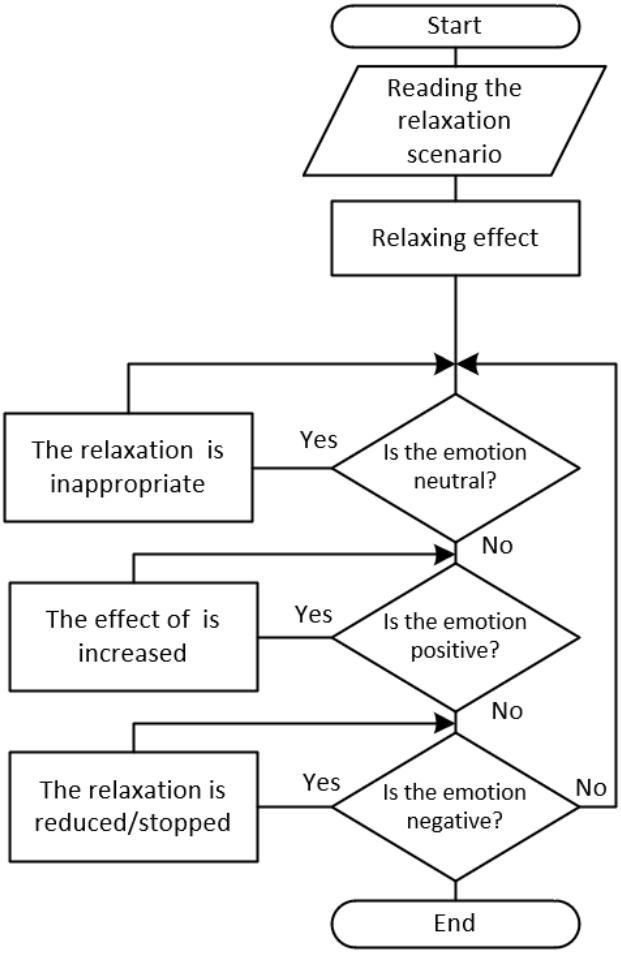

Figure 4 ***Algorithm for Controlling the Relaxation Scenario*** *(created by authors)*

An artificial intelligence algorithm, driven by recognized emotion models, operates by responding to changes in facial expressions (Zhang et al., 2018), (Baltrušaitis, Robinson & Morency, 2012).

Initially, a predefined relaxation scenario created by a human is scanned. After gathering the necessary data, a relaxation effect tailored to the child is generated. If the child's face displays a neutral emotion, meaning the child's

reaction to the stimulus is neutral, the parameters and intensity of the stimulus remain unchanged (He, Zhang, Ren, & Sun, 2016). The cycle continues until an emotional shift occurs. In the case of a positive emotion, the intensity of the stimulus is heightened while leaving other proportional parameters unchanged. Exiting the cycle is only possible when the child's emotional reaction to the relaxation scenario changes. Another logical condition awaits negative emotions, where the relaxation effect is reduced or, in specific cases, halted. Consequently, the system automatically responds to the child's agitation during relaxation. In the absence of emotional change, when negative emotions are absent, the cycle restarts from a neutral emotional state.

During each emotional cycle reassessment, relaxation scenarios can be adjusted by selecting the most optimal and acceptable ones for the specific child. This task is performed by another part of the program based on artificial intelligence algorithms – scenario selection, which is not elaborated upon in detail in this article.

Study of the Relaxation System Prototype

Following the development of the relaxation system prototype, an evaluation of its functions was conducted.

1. The general function evaluation was performed by subjectively assessing the child's reaction to the relaxation environment.
2. Evaluation of massage functions was conducted by subjectively assessing the child's reaction to massage-vibrational effects during specific relaxation scenario executions. The effect was evaluated by analyzing the child's response based on recognized emotions.
3. The study of light and sound synthesis scenarios was conducted similarly by recording changes in the child's emotions using artificial intelligence algorithms and subjectively assessing the observations of the supervising human.

The study group comprised of 30 children. children were selected from three regions of Lithuania, 10 each, with parents' voluntary consent to participate in the study. The severity level of children's ADS was low to mild and only 2 children had a severe level. Evaluating the uniqueness of the study group, it is essential to note that due to a meticulously prepared procedure (parents and children were briefed in advance about the situation, and detailed information about the relaxation system and the research procedure was provided), most participants responded favorably. They comfortably settled into the chair and remained there for 40 minutes to an hour. While four children needed specific invitations, a few initially felt uncomfortable but later stayed in the chair for the agreed-upon time. No observable signs of aggression or outbursts of anger or aggression were reported by parents during the study. Two children initially felt hesitant or

uncomfortable or resisted the unfamiliar experience, but for the majority, the initial emotional experience was positive. According to the assessment of many parents (26 out of 30), the chair and the relaxation experience were pleasant for the children.

Most parents (26 out of 30) confirmed that the visual stimulation of different colored lights positively affected the children. Three children specifically relaxed in response to the light. The vibration was enjoyable for 24 out of 30 children, and for seven, the effects of vibration helped them relax.

Based on observations and parental feedback, clear emotional reactions to different types of music were observed. Sounds piqued children's interest and prompted activity. Familiar music also improved mood; some children swayed to the rhythm, while tranquil nature sounds helped them relax.

The effectiveness of the relaxation system is illustrated in Figure 5.

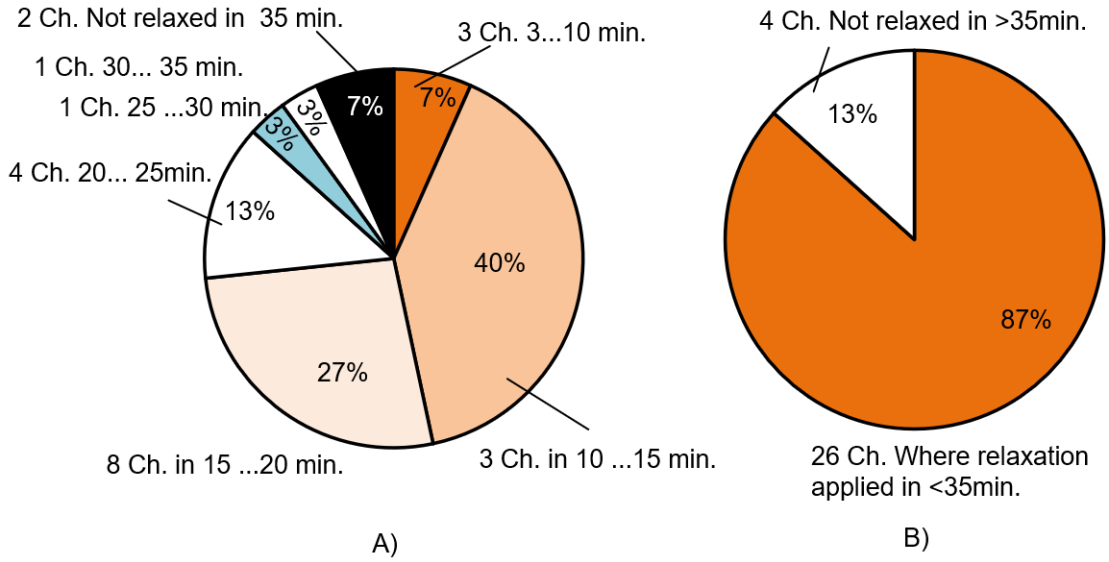

Figure 5 ***The effectivity of the relaxation system***

A) - Number of children who underwent relaxation and relaxation interval in minutes.
B) - Percentage expression of relaxation efficiency

According to the initial study data (illustrated in Fig. 5), the relaxation system shows promise as a tool to meet the self-regulation, relaxation, and concentration needs of children with developmental disorders. Its sensory stimulation affects the nervous system, sometimes manifesting clear signs of nervous system recalibration and transition in children in a relatively short time, such as yawning, drowsiness, and calmness. Considering the challenges of eliciting such reactions in children with serious emotional problems, developmental disorders, and challenges, further research and development are needed to assess the effectiveness of this intervention method.

Conclusions

Modern artificial intelligence methods enable the creation of technologies that facilitate human tasks and address specific social issues. Machine learning algorithms allow IT technology to adapt to specific human behaviors automatically. Technology that can perceive human emotions can be applied to computerized empathy, facilitating seamless human-computer interaction.

References

Alam, M. M., Khan, A. A., & Farooq, M. (2018). Effect of whole-body vibration on neuromuscular performance: A literature review. *Work*, *59*(4), 571-583. doi:10.3233/WOR-182699

Baltrušaitis, T., Robinson, P., & Morency, L. P. (2012) 3D Constrained Local Model for Rigid and Non-Rigid Facial Tracking. *In 2012 IEEE Conference on Computer Vision and Pattern Recognition,* 2610-2617. doi: 10.1109/CVPR.2012.6247980.

Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-Flusberg, H., Carter, A. S., Kadlec, M. B., & Dunn, W. (2007). Extreme sensory modulation behaviors in toddlers with autism spectrum disorders. *The American Journal of Occupational Therapy*, *61*(5), 584-592. doi: https://doi.org/10.5014/ajot.61.5.584

Brondino, N., Fusar-Poli, L., Rocchetti, M., Provenzani, U., Barale, F., & Politi, P. (2015). Complementary and alternative therapies for autism spectrum disorder. *Evidence-Based Complementary and Alternative Medicine*, *2015*. doi: 10.1155/2015/258589

Casanova, M. F. (2007). The neuropathology of autism. *Brain pathology*, *17*(4), 422-433. doi: https://doi.org/10.1111/j.1750-3639.2007.00100.x

Dickie, V. A., Baranek, G. T., Schultz, B., Watson, L. R., & McComish, C. S. (2009). Parent reports of sensory experiences of preschool children with and without autism: A qualitative study. *The American Journal of Occupational Therapy*, *63*(2), 172-181. doi: https://doi.org/10.5014/ajot.63.2.172

He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep residual learning for image recognition. *In Proceedings of the IEEE conference on computer vision and pattern recognition*. 770-778. Retrvieted from: https://openaccess.thecvf.com/content_cvpr_2016/html/He_Deep_Residual_Learning_CVPR_2016_paper.html

Huang, M., Liao, L. R., & Pang, M. Y. (2017). Effects of whole body vibration on muscle spasticity for people with central nervous system disorders: a systematic review. *Clinical rehabilitation*, *31*(1), 23-33. doi:10.1177/0269215515621117

Shah, S. J., Li, Z., Shah, A. M., & Ullah, R. (2018). Face ID: an innovative biometric approach to control sales personnel production deviance. *International Journal of Information Systems and Change Management*, *10*(3), 227-247. doi: https://doi.org/10.1504/IJISCM.2018.096772

Kahou, S. E., Bouthillier, X., Lamblin, P., Gulcehre, C., Michalski, V., Konda, K., ... & Bengio, Y. (2016). Emonets: Multimodal deep learning approaches for emotion recognition in video. *Journal on Multimodal User Interfaces*, *10*, 99-111.

Matson, J. L. (2009). *Applied Behavior Analysis for Children with Autism Spectrum Disorders*. New York: Springer.

Costa, A. P., Steffgen, G., Lera, F. R., Nazarikhorram, A., & Ziafati, P. (2017). Socially assistive robots for teaching emotional abilities to children with autism spectrum disorder. In *3rd Workshop on Child-Robot Interaction at HRI*.

Mousavi, S. M. H., & Aghsaghloo, N. (2018) Using Visual Evolutionary Art Based On Color Patterns And Depth Assist For Autism Rehabilitation. *Journal of Software Engineering Intelligent Systems, 3*(3) ISSN 2518-8739

Zhang, T., Zheng, W., Cui, Z., Zong, Y., & Li, Y. (2018). Spatial–temporal recurrent neural network for emotion recognition. *IEEE transactions on cybernetics*, *49*(3), 839-847. doi: 10.1109/TCYB.2017.2788081

Janzen, T. B., & Thaut, M. H. (2018). Rethinking the role of music in the neurodevelopment of autism spectrum disorder. *Music & Science*, *1*. doi: https://doi.org/10.1177/20592 04318769639