Quality of Life Support System for People with Intellectual Disability

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ABSTRACT

People with intellectual disabilities (ID) encounter several problems regarding the interaction with their environment in terms of their daily needs, activities and communication. On this concept, an interactive support system with multiple functionalities is proposed, aiming at optimizing the opportunities provided to people with ID in order to cope with particular everyday issues. Specifically, it will provide information as well as entertainment, including creative and educational activities, through specialized learning programs. Additionally, it will automatically recognize health emergency situations, provide appropriate notifications, feature an emergency call button to contact the responsible caregivers, and support interaction using a specialized voice menu of instructions. The final system will be developed within a Greek research project and a pilot implementation will be evaluated by a Greek association of people with ID. The ultimate goal is to provide an affordable and user-friendly solution, tailored to the users' needs.

PETRA '20, June 30-July 3, 2020, Corfu, Greece

ACM ISBN 978-1-4503-7773-7/20/06…$15.00
https://doi.org/10.1145/3389189.3397971

CCS CONCEPTS

• Human-centered computing → Accessibility → Accessibility systems and tools

KEYWORDS

Intellectual Disability (ID), Quality of Life Support System, Infotainment, Creative activities, Sociality enhancement, Emergency detection, Smart mobile devices, Wearable sensors, Speech technologies

ACM Reference format:

Maria Papadogiorgaki, Vasileios Mezaris, Nikos Grammalidis, Kostas Grigoriadis, Ekaterini S. Bei, George Livanos and Michalis E. Zervakis. 2020. Quality of Life Support System for People with Intellectual Disability. In *Proceedings of Pervasive Technologies Related to Assistive Environments conference (PETRA '20). ACM, Corfu, Greece, 6 pages.* https://doi.org/10.1145/3389189.3397971

1 INTRODUCTION

"Intellectual Disability" (ID) constitutes a disorder that appears during the developmental period (from birth to age 18) and includes both intellectual and adaptive functional deficits in conceptual, social and practical domains [1] according to manuals of the classification of diseases (Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), eleventh revision of

the International Classification of Diseases (ICD-11)) [2, 3]. People with ID encounter persistent problems in their daily living with regard to their needs and activities, as well as their communication with other people; generally their interaction within their home and urban environment poses great challenges. Millions of people worldwide suffer from ID issues and the prevalence in the general population is estimated about 3% in developed countries while varies among different countries. In a review survey, the appearance of intellectual disability in the population was in the range of 10.37/1000 [1, 4]. In the DSM-5 classification system, the different levels of ID severity are determined based on the adaptive function rather than the Intelligence Quotient (IQ), since the adaptive function is the one that specifies the required support grade. The ID severity is categorized as mild, moderate, severe and profound. Education, professional training, family support and personal characteristics can help people with intellectual disabilities adapting to the demands of everyday life [2].

A major challenge is to offer to people with ID new opportunities for healthy living, improved quality of life, infotainment, education, specialized training and social reinforcement in order to maintain their morale and psychology at a high level. To this end, technological development can offer new opportunities by providing appropriate interactive systems and services that can stimulate their interest and creativity. Moreover, considering the number and diversity of devices and sensors, as well as the advances in information technology, the clinical and research community have many means (voice assistants, smart applications, intelligent platforms, etc.) available to study, approach, and address the special needs of people with ID. Cihak, et al., examined the use of email by people with intellectual disability across multiple devices or platforms (Windows desktop computer, laptop, iPad tablet device) [5]. Results indicated that people with ID are able to communicate effectively using a variety of technological devices, thus revealing a functional relation [5, 6]. In the same line of thinking, Rocha, et al., studied how people with intellectual disabilities interact with the layout of the well-known entertainment platform *YouTube*. The authors demonstrated that participants with ID had a good experience with the interface, but they could not show autonomy concerning the search option [7]. Wyeth, et al., designed *Stomp*, a tangible user interface (TUI), in order to provide new participatory experiences for people with ID. Considering the bodily interaction and the reality-based interaction, the *Stomp* system was revealed as a source of movement and action, offering physical and social engagement for people with ID [8]. Puspitasari, et al., designed *KIDEA*, an interactive learning media solution based on the Kinect sensor, which enables users to interact with computers through a natural user interface in the form of sound and movement. The *KIDEA* design aims at providing learning media of fundamental life skills for children with ID, thus improving life skills, but also parent and child relation [9]. In a similar way, by utilizing the Kinect sensor, Li and Ip designed *AIMtechKinect*, an interaction-oriented gesture recognition system for students with severe IDs [10]. Also, Rahul Bethi designed a *Kinect Game* for children with ID, a 2.5-dimensional scroller game using a Microsoft Kinect device, which exploits the motivating nature of virtual reality to enhance children's loco-motor skills during their stay at home [11]. In addition, a small number of software platforms have been developed over the last decade in an attempt: i) to meet the special educational needs of people with ID (*application of hot potatoes software* for children with mild to moderate ID, *MAS*, *'prosvasimo'*), ii) to support and enhance the ways of communication, connection and interaction for these persons with other people (*SymbolChat*), and iii) to improve the quality of life of persons with ID (*POWERS*$_{forID}$, *ELPIDA*, *ENABLE*) [12-18].

Based on the literature above, a variety of devices and applications will provide multiple means of learning, playing, acting, communicating, health status monitoring, well-being and safety assessment. These are important components in order to design the proposed comprehensive, modular platform for people with ID in the context of the QuaLiSID project.

To this end, the aim of the proposed system is to develop an appropriate, fully functional and interactive support system for people with ID, which will integrate many different functionalities providing a cost-effective, easy-to-use solution, tailored to the everyday users' needs. The integrated system will provide various stimuli, serve information and entertainment content, and propose creative activities and training through specialized learning programs. In addition, it will allow automatic identification of health emergency situations and send necessary alerts and notifications towards the responsible care givers.

2 CONCEPT AND OBJECTIVES

The proposed system constitutes a flexible, extensible platform that receives signals from computers, smart mobile devices and wearable sensors, such as smart watches or other sensors embedded in smart communication devices (e.g. GPS). The system architecture is illustrated in Figure 1.

The sensors will be used for the detection of health-related emergencies, through the measurement of critical biomedical signals and parameters, such as heart rate, body temperature, etc., but also in cases when the person appears to be disoriented or lost, through the monitoring of location data, such as GPS coordinates. In addition, the smart devices, i.e. mobile phones and tablets, apart from supporting phone communication (voice calls and/or text messages) will also support an "emergency button" functionality to provide automatic alerts to caregivers in case of an emergency. Similarly, to facilitate interaction with the system, a voice menu of instructions will also be incorporated, as well as entertainment functionalities, exploiting voice commands and speech recognition capabilities. Moreover, medication reminders will be automatically sent to the healthcare givers, and/or their relatives through the proposed platform.

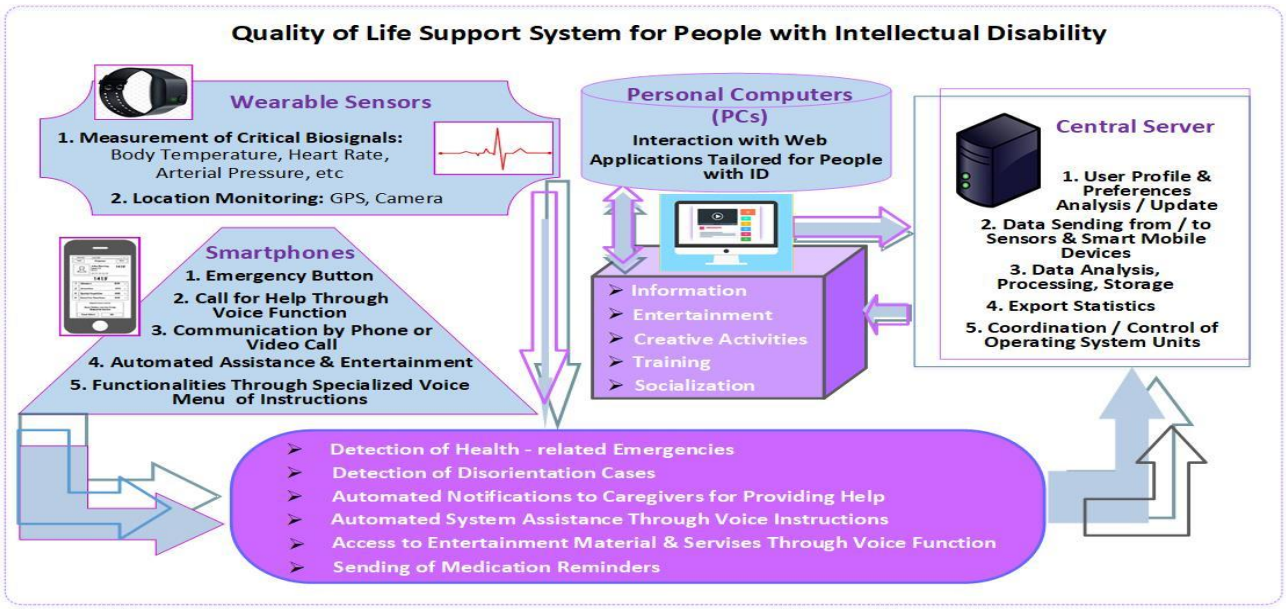

Figure 1: Proposed system architecture.

Furthermore, using a PC web client, people will interact with the internet through a suite of specialized applications tailored for use by people with intellectual disabilities. Via these applications, the system will give its users access to information and entertainment services, such as exploration of natural landscapes, monuments and attractions, as well as creative and training suggestions, such as virtual lessons, according to their preferences, interests and mood. The above parameters will be integrated into the user profile and will be dynamically updated through a specialized estimation / prediction model. The initial construction of the personalized model will be mainly based on the information gathered through questionnaires and interviews and may be further expanded through neurophysiology, i.e. analysis and processing of encephalographic signals. Additionally, another important goal is to strengthen the sociability of people with intellectual disabilities by supporting their communication with people with similar interests through specialized social networks.

Finally, the proposed system includes a central server where the input signals from the sensors, individual smart devices and web clients, will be received, analyzed and processed. Different user profiles will be hosted and updated and the system's functional modules will be coordinated and controlled. The proposed system will exploit the internet by integrating many different types of operations with the expected result of providing an affordable and user-friendly solution, tailored to the users' needs. Regarding the communication between users, as well as the functionalities of data sending and receiving, internet connections will be used (including mobile and wireless internet), as well as other data transmission protocols, such as Bluetooth, if needed.

The final system will be able to both contribute to the active, independent and good quality of life of people with ID and on the other hand to detect and serve potential emergencies. Its implementation includes the following steps:

- Design and development of an integrated platform for recording, sending, storing and exchanging information in a secure way, protecting personal data.
- Design and development of a system that apart from monitoring medical indicators and sending health-related reminders, will cover multiple needs, such as monitoring of the emotional state of people with intellectual disabilities through direct feedback from them (selection of corresponding expressive icons), motivating them for active behavior through enhancing socialization and online creative activities, training, entertainment and interactive digital applications of navigation, exploration and multimedia presentation of selected natural landscapes, sightseeing, etc.
- The adaptation of the system's functionalities in order to be easy to use and provide services to different groups of people according to their ID level, i.e. mild, moderate, severe and profound.
- The control, testing, and evaluation of the multi-functionality system in real-time by several potential users of varying ID levels, that determine their specific needs.
- Market analysis and study of mechanisms for marketing innovative products and solutions for people with ID.
- The production of a prototype product that will be commercially marketed, exploiting the system's capabilities and user evaluation.
- The partnership, collaboration and empowerment of social, business, academic and research foundations for improving the living standards of people with ID.

- The formation and development of social responsibility and ethics within society, research and business community, aiming to provide supportive services and products for people with ID and offer practical solutions to addressing related issues and meeting their everyday needs.

3 IMPLEMENTATION METHODOLOGY

The main objective of the implementation methodology is to integrate multiple technologies into a single, 'smart' platform with customization / extension capabilities and functionality adaptation depending on the user's profile. This modular architecture is adopted to support the following system functionalities:

I. Sensors and mobile devices: wearable sensors for detection and measurement of specific medical biosignals (e.g. heart rate, body temperature, etc.) or location (e.g. GPS) parameters; support for data access from mature health-tracking platforms (Google Fit); and ad-hoc development, deployment and integration of state-of-the-art voice technologies with natural language processing, etc, for smart mobile devices.
II. PC Web client: login to platform and interaction with a suite of web applications; scheduling by the caregiver (e.g. nurse or parent) of medication alerts / reminders.
III. Server: receiving, analyzing, processing and storing signals from sensors and personal smart devices; user interaction with web applications through PCs; inference model and user profiles' updating and storage; exporting and storage of statistics and coordination / control of operating system units.
IV. Communication protocols: standard network communication protocols (i.e. TCP/IP, https, WiFi, 4G, etc.) for sending data to / receiving from users, relatives, nurses, caregivers.
V. Platform architecture: The three-tier Client-Server model [19] will be used (Figure 2).

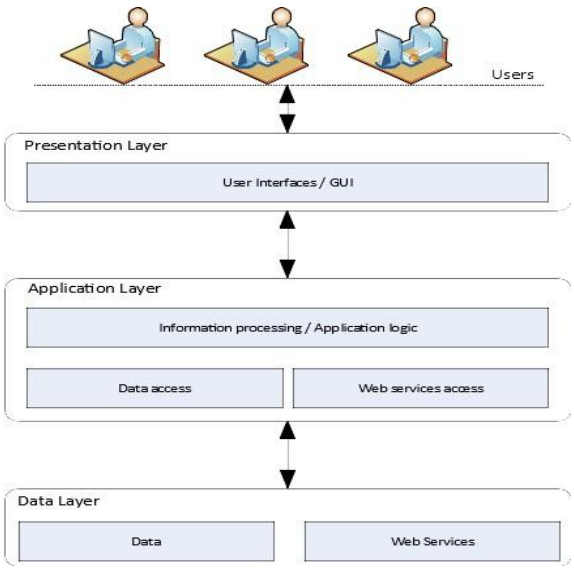

Figure 2: Three-tier Client-Server model.

3.1 Functionality–Usability–Access: Information, Entertainment, Education, Creative Activities and Socialization

The proposed system will enable the interaction with specific web applications, tailored for use by people with ID [20]. In particular, the project platform will provide access to specialized information (e.g. specific news websites) and entertainment services, such as video sites (e.g. YouTube). It will also provide access to photo collections from various locations, navigation and natural landscapes exploration, city attractions, multimedia presentations of art spaces, museums, etc. Furthermore, it will suggest creative activities and training (e.g. virtual lessons), painting, pottery, cooking, exercise, gardening, etc. The resources that will be made available will be carefully selected based on existing knowledge [5], [7-13], [15, 16], or existing organizations' networks, targeting people with ID [17, 18], [21-23]. Personalized suggestions will be provided according to the interests, habits, abilities, skills and current mood of each user.

The individual user preferences will be maintained on the user profile stored in the system. Initially, the profile will be based mainly on the information collected through questionnaires and interviews, but will be expanded by optionally exploiting neurophysiology for detecting key personality dimensions. The user profile will be gradually and dynamically updated through an innovative inference / prediction model reflecting individual user preferences and choices. This model will be constructed based on existing user modeling methodologies and will utilize the most efficient combinations depending on the information types and individual user characteristics. The model development might involve a knowledge base including information related to domains of interest and users, semantic reasoning methods (e.g. rule-based models, inference networks, Boolean models), or statistical inference (e.g. probabilistic models, Bayesian networks and classifiers). Particularly, regarding the content-based information filtering, vector-space models have been widely exploited, while the classification can be based on supervised machine learning algorithms such as SVMs, k-Nearest Neighbor, and a wealth of deep neural network architectures [24]. Specific similarity measures, e.g. cosine similarity, can also be used in order to filter new information by relevance with the user preferences, which, based on the similarity score, can then be displayed in the respective priority order (items ranking) [25].

Another important objective is the enhancement of the socialization of people with ID by supporting communication with people with similar interests through existing specialized social networks, such as the Greek social networking platform for people with ID, DisabledBook [23] or the interaction platform STOMP [8]. Regarding the communication with family members, relatives, friends and colleagues, significant additional functionalities will be provided through voice recognition for calling; and speech recognition, as well as voice synthesis for sending and reading messages from/to the mobile phones. Simple and user-friendly instructions through a dedicated "virtual assistant", also constitutes a design priority of the proposed

system (Figure 3). Along this direction, the user interface will be developed so that it can be used by different groups of people according to their level of disability (mild, moderate, severe, profound) and specific implementation scenarios are expected to meet their functionality capabilities [2].

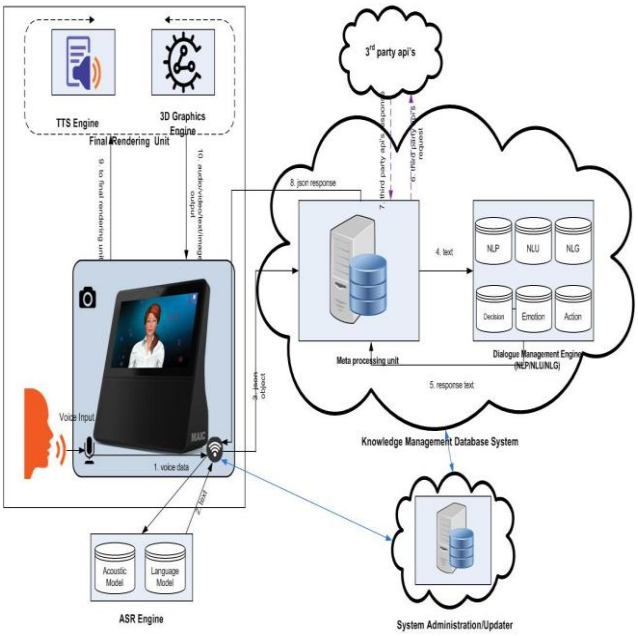

Figure 3: Flowchart of voice function subsystem and interactive models.

3.2 Adaptability and Personalization: Emergency Detection, Assistance

The proposed system will be able to identify health emergency situations and spatial disorientation and issue notifications to caregivers. It will also support emergency button functionality and a specialized menu of voice instructions to facilitate user communication with relatives or caregivers, by phone or video call.

More specifically, wearable sensors will monitor and record critical biosignals, such as heart rate, body temperature and blood pressure. If measurements exceed normal levels, alerts will immediately be sent to caregivers' mobile devices. Similar alerts will be sent if the user location (given by the GPS coordinates of the mobile phone or a wearable) indicates that the person has been disoriented / lost (e.g. current user location deviates significantly from the norm). Automated alerts sent from the user's device will be in the form of voice, text, or push notifications, along with information related to the health status and location (GPS coordinates, optionally including camera photo). Reminders of a person's medication will also be sent through the platform to the person and/or his/her caregivers.

4 EXPECTED RESULTS

The results of the proposed system are expected to have a considerable impact on various sectors. The services offered will be easily accessible and tailored to the needs of people with ID and more specifically to existing groups covering different levels of disability, namely mild, moderate, severe and profound. The entertainment, creative activity and socialization of these people are of particular importance to their psychological condition. At the same time, the reliable and prompt exchange of information with health care providers through the proposed platform will contribute to the improvement of medical services, as well as prevention and response to emergency situations. Hence, the integrated platform will have a significant contribution to upgrading the quality of life, towards, as far as possible, independent living, avoiding isolation and emotional collapse. In addition to the personalized impact, the implementation of the proposed system is expected to have a remarkable effect in the social level, with a focus on exploring and applying practices in order to manage the daily lives of people with ID.

With regard to the design, development and implementation of the end-product, an innovative pilot system supporting multiple functionalities will be evaluated by a user-institution (Greek association for people with ID). Following this evaluation and capitalizing on the obtained knowledge, the product will be ready to be marketed. Multiple application areas of the system and its components exist, with direct applicability, and high social impact. The individual results of the proposed system include:

- Development of a web application for desktop PCs that enables people with intellectual disabilities to access information resources, entertainment programs and to engage in creative activities, social networking, etc.
- Development of a server platform for the storage and processing of data from sensors, mobile devices and the interaction with the Internet in order to dynamically update the user profile and extract statistical data.
- Development of automated services and voice functions on smartphones adapted for use by people with intellectual disabilities.

Moreover, the system will be extendable by design, so various extensions will be feasible, e.g. supporting other languages or studying the activities of people with ID and their daily behavioral patterns.

The final integrated platform will be able to be accessed by research groups focusing on the study of the flexibility and skills of people with ID and their interaction with online environments. It is noted that it will not be possible to trace the user's identity in this platform. In addition, the application related to automated services and voice functions on smartphones adapted for people with ID is planned to be commercially available to individual users. However, the free use of the end-application / system by particular cases of non-profit organizations, associations of people with disabilities, etc. will be considered in the final exploitation

plan. In any case, a specific framework of commercial exploitation and communication with the potential customers, investors, or markets will be formed during the project. Additionally, during the pilot application, the cost-benefit ratio of the provided subsystems will be assessed.

5 CONCLUSIONS AND FUTURE WORK

In this paper, an interactive ICT support system was proposed, offering new functionalities and opportunities to people with Intellectual Disabilities (IDs) and allowing them to cope with specific everyday issues. The integrated system will initially support only the Greek language and will be evaluated by a Greek association of people with ID. However, it will be designed so that it can be easily extended to support other languages in the future (with respect to its user interface, the available content, and the voice recognition and voice synthesis functionalities). In addition, contacts with relevant institutions from other countries will be established, so that members of the developing team and Greek users of the system will be able to interact with their colleagues outside Greece, to exchange information on education, care and support issues for people with ID.

ACKNOWLEDGMENTS

This work was prepared in the framework of the QuaLiSID – "Quality of Life Support System for People with Intellectual Disability" project, which is co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH–CREATE–INNOVATE (project code: T2EDK-00306).

REFERENCES

[1] Efi Parpa, NG Katsantonis, Eleni Tsilika, Antonis Galanos, Irene Papazoglou, and Kyriaki Mystakidou. 2017. Validity and Reliability of the Greek Version of the ZBI in Informal Carers of Adults with Intellectual Disabilities. *International. Journal. of Mental. Health. & Psychiatry*. 3, 3 (July 2017), 1-7. https://doi.scitechnol.com/10.4172/2471-4372.1000145

[2] American Psychiatric Association. 2013. *Diagnostic and statistical manual of mental disorders (5th ed)*. American Psychiatric Association, Washington, DC, USA. https://doi.org/10.1176/appi.books.9780890425596

[3] World Health Organization. 2014. *International Classification of Diseases (ICD-11)*. https://icd.who.int/en

[4] World Health Organization. *World report on disability 2011*. https://www.who.int/disabilities/world_report/2011/report.pdf

[5] David F. Cihak, Don Douglas Mcmahon, Cate Smith, Rachel Wright, and Melinda Gibbons. 2015. Teaching individuals with intellectual disability to email across multiple device platforms. *Research. in Developmental. Disabilities*. 36, (January 2015), 645–656. https://doi.org/10.1016/j.ridd.2014.10.044

[6] Sue Caton and Melanie Chapman. 2016. The use of social media and people with intellectual disability: A systematic review and thematic analysis. *Journal. of Intellectual. & Developmental. Disability*. 41, 2 (March 2016), 125-139. https://doi.org/10.3109/13668250.2016.1153052

[7] Tânia Rocha, José Martins, Ramiro Gonçalves, and Frederico Branco. 2016. Usability evaluation of an entertainment platform by people with intellectual disabilities. In *Proceedings of the 11th Iberian Conference on Information Systems and Technologies (CISTI 2016)*. Las Palmas, Spain, 1-5. https://ieeexplore.ieee.org/10.1109/CISTI.2016.7521507

[8] Peta Wyeth, Jenny Summerville, and Barbara A. Adkins. 2011. Stomp: an interactive platform for people with intellectual disabilities. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology (ACE 2011)*. Lisbon, Portugal, 1-8. https://dl.acm.org/doi/10.1145/2071423.2071487

[9] Warih Puspitasari, Kholifatul Ummah, and Ainu Faisal Pambudy. 2013. KIDEA: An innovative computer technology to improve skills in children with intelectual disability using Kinect sensor. In *Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2013)*. Bangkok, Thailand, 1097-1101. https://www.aconf.org/10.1109/IEEM.2013.6962580

[10] Chen Li and Horace Ho-Shing Ip. 2013. AIMtechKinect: A Kinect Based Interaction-Oriented Gesture Recognition System Designed for Students with Severe Intellectual Disabilities. In *Proceedings of the International Conference on Computer-Aided Design and Computer Graphics (CAD/Graphics 2013*). Guangzhou, China, 322-329. https://www.computer.org/10.1109/CADGraphics.2013.49

[11] Rahul Bethi. 2017. *Kinect Game for Children with Intellectual Disability*. Master's Thesis. Department of Computing Sciences, Texas A&M University-Corpus Christi, Texas, USA.

[12] George P. Papanastasiou. 2009. *Software for children with mild-to-moderate intelectual disability (Application of Hot Potatoes software using Makaton images)*. In 1st Educational Conference on Integrating and Using ICT in the Educational Process. Retrieved March 27, 2020 from https://www.specialeducation.gr/frontend/article.php?aid=237&cid=71

[13] Fernando Paniagua Martín, Ricardo Colomo-Palacios, Angel Garcia Crespo, and Belén Ruíz-Mezcua. 2010. MAS: building an educational platform for people with intellectual disabilities and cerebral paralysis. *International. Journal. of Knowledge. and Learning*. 6, 2/3 (Aug. 2010), 175 – 184. https://www.inderscience.com/10.1504/IJKL.2010.034752

[14] Design and Development of Accessible Educational & Instructional Material for Students with Disabilities. http://prosvasimo.iep.edu.gr/el/

[15] Tuuli Keskinen, Tomi Heimonen, Markku Turunen, Juha-Pekka Rajaniemi, and Sami Kauppinen. 2012. SymbolChat: Picture-Based Communication Platform for Users with Intellectual Disabilities. In *Proceedings of the ICCHP Conference (ICCHP 2012*). Linz, Austria. In: Miesenberger K., Karshmer A., Penaz P., Zagler W. (eds) Computers Helping People with Special Needs. Lecture Notes in Computer Science. Vol. 7383. Springer-Verlag, Berlin, Heidelberg, Germany. 279-286 pages. https://doi.org/10.1007/978-3-642-31534-3_43

[16] William H. Neumeier, Nichole Guerra, Mohanraj Thirumalai, Betty Geer, David Ervin, and James H. Rimmer. 2017. POWERS forID: Personalized Online Weight and Exercise Response System for Individuals with Intellectual Disability: study protocol for a randomized controlled trial. *Trials*. 18, 1, (Oct. 2017), 487. https://doi.org/10.1186/s13063-017-2239-2

[17] ELPIDA project. *E-Learning Platform for Intellectual Disability Awareness*. http://elpida-project.eu/index.php/en/

[18] ENABLE project. *From Culture of Caring to Culture of Enabling: Co-produce Services for People with Intellectual Disability*. https://arfie.info/2017/12/08/enable-project/

[19] Wayne W. Eckerson. 1995. Three tier client/server architecture: Achieving scalability, performance and efficiency in client server applications. *Open. Information. Systems*. 10, 1, 46-50.

[20] Dany Lussier-Desrochers, Claude L. Normand, Alejandro Romero-Torres, Yves Lachapelle, Valérie Godin-Tremblay, Marie-Ève Dupont, Jeannie Roux, Laurence Pépin-Beauchesne, and Pascale Bilodeau. 2017. Bridging the digital divide for people with intellectual disability. *Cyberpsychology: Journal. of Psychosocial. Research. on Cyberspace*. 11, 1, Article 1, 20 pages. https://doi.org/10.5817/CP2017-1-1

[21] Inclusion international. *The international network of people with intellectual disabilities and their families*. https://inclusion-international.org/

[22] Social Platform. https://www.socialplatform.org/

[23] Greek Social Network AMEA. https://webcare.gr/GREEK-SOCIAL-NETWORK-AMEA/

[24] Duyu Tang, Bing Qin, Ting Liu, and Yuekui Yang. 2015. User Modeling with Neural Network for Review Rating Prediction. In *Proceedings of the 24th International Joint Conference on Artificial Intelligence (IJCAI 2015)*. Buenos Aires, Argentina, 1340-1346. https://dl.acm.org/doi/10.5555/2832415.2832436

[25] Maria Papadogiorgaki, Vasileios Papastathis, Evangelia Nidelkou, Simon Waddington, Ben Bratu, Myriam Ribiere, and Ioannis Kompatsiaris. 2008. Two-level Automatic Adaptation of a Distributed User Profile for Personalized News Content Delivery. *International. Journal. of Digital. Multimedia. Broadcasting*, Special Issue on Personalization of Mobile Multimedia Broadcasting. 2008 (Aug. 2008), 1-21, Hindawi. https://doi.org/10.1155/2008/863613