Jacek Wołoszyn, Paweł Wołoszyn*

Digital exclusion in the information society and artificial intelligence techniques

K e y w o r d s: information technology, disability, artificial neural networks

S u m m a r y: Along with development of the information society and spreading of computer technology, more and more areas of life of individuals are related to the access to IT services. Execution of daily needs of a modern citizen requires ever increasing use of advanced technical means, such as rich web applications, mobile devices, multimedia services, etc. Many of these activities go along with the need of their individual and autonomous execution, which results from the world of technology entering into highly private areas of life, such as correspondence, social relationships or personal finances. Autonomy of participation in such activities is nowadays more and more dependent on the ability of autonomous operation of computer equipment and the services offered with it.

Due to the civilisation changes that come along with introduction of IT technology in the communities, the term "performance" gains a new meaning and refers not only to the capacity of executing physical activities but also to participation in the information-related area of life. The loss of performance may cut a person off from access to this area, even if the lost capacities are not in themselves necessary for pursuit of similar objectives of the individual. It happens when technology that helps satisfy specific needs does not leave an alternative way of communication of a human being with a machine or does not present the potential of adaptation to specific conditions and limitations to which the user is subjected. Overcoming digital discrimination of the disabled requires application of techniques of artificial intelligence which imitate the redundant and creative human behaviour. In the example of artificial neural networks, analogies between methodological errors made during teaching and assessment of their operation and the problems of barriers of human–computer interfaces accessibility may be noticed.

* Prof. Jacek Wołoszyn, PhD—Independent Department of Computer Science and Quantitative Methods, Małopolska School of Economics in Tarnów; Paweł Wołoszyn, PhD—assistant professor at the Chair of Automatics, AGH University of Science and Technology in Krakow.

1. Introduction

Is seems obvious that every human being should have the conditions to keep his/ her personal, private area of life isolated from outsiders. Respecting independence of a human being as an autonomous individual and protection of individual areas of life and functioning against access of strangers is one of the foundations on which the mature society is based. On the other hand, not every human being has at his/ her disposal the degree of performance necessary to maintain this private area of life. In case of people with diseases or disabled, a carer, therapist or physiotherapist often help in daily activities. Not always, however, is contact with another human being desired, especially if it is a long-term contact. Human being as an integral individuality has a strong need of independence and freedom with which he/ she may be self--sufficient and capable of autonomous deciding about his/ her functioning (1). This applies mostly to simple, daily activities and elementary living functions of the body. The capacity of free breathing, eating, moving or caring about hygiene and aesthetics are the examples of the key activities which determine such terms as freedom, human dignity or quality of life. The more priority a given function has in maintaining health and life, the stronger the need of its individual control.

The present day's trends in the information technology development make us more and more often use the computer as a tool for executing daily, simple activities. Shopping, reviewing the press, talking to friends or listening to music are just a few examples. Many a time these are also activities within the area of private, personal life which remains an individual area of functioning of each human being, isolated against access of other people with the barrier of personal secrecy. This includes private correspondence with the dear ones, managing home finances or seeking medical advice. All these activities may be done with the computer and this form of their execution indeed gains in popularity.

The summary of both problems, that is on the one hand the need to maintain independent control over private areas of daily life, and on the other hand the strengthening dependency of this specific area on the information technology, produces a specific perspective of the situation of people who suffer from less or more apparent limitation in performance: if the computer hardware helps in caring about oneself and one's participation in life, then it is not the general physical or intellectual performance but presence or lack of specialised possibilities of computer operation decide whether the given person is fully able and autonomous. This gives the technological (and not medical) criteria a significant role in determining personal competencies and prospective barriers which exclude him/ her from social life.

2. Machine as support for autonomy

When the body is permanently damaged and its functions are affected, self-sufficiency may be lost. If the person cannot execute the activities which are the basis for healthy functioning, then he/ she starts being dependent on help from the surroundings. This kind of help is no longer a typical therapy or rehabilitation if the dysfunction is irreversible, and the objective of the interaction with the carer is not improvement in the condition but creating ground for further maintaining of life. Search of the demarcation line between freedom and responsibility, between the person of limited performance and his/ her carers is a difficult and controversial task of modern bioethics.

Thus, even if it may seem contrary to the ideals of altruism and human solidarity, the need to replace a human carer with a machine which performs his/ her role is clearly justified in many cases. A disabled person enjoying help of technical equipment in execution of activities which he/ she cannot do on his/ her own, feels more self-supported and independent than in presence of another person. A neutral and non-personal machine specifically allows maintaining privacy and intimacy at least in some areas of life, which in case of the disabled are the subject of excess exhibition, anyway. Moreover, technological progress makes more and more areas of life enjoy the support of computers. They may not only perform a role of a simple tool, but that of a more advanced system in assistance of the human being (2).

Reading books by the blind may be an example here. The works released in Braille are few, and the range of the titles limited to a fraction of literature legacy. One may ask a carer to read a book aloud, but it means inevitable disclosure of the contents of the text and prevents free moving around the text according to one's own likings. Using for the same purpose a computer, speech synthesis software or an electronic Braille reader allows independent reading of books, but also enables private correspondence or reading official letters.

The machine equivalent of the carer should, however, imitate a living person, replicating his/ her features in the best possible way, such as the capacity for learning, adaptation, expecting or reacting in non-typical situations (3). Only then can the machine be left alone with the disabled person without the necessity of operator's supervision, even if he/ she is hidden and remote. All tools of artificial intelligence come in handy here which provide the machine with less or more advanced equivalents of the features of the human mind (4).

Artificial neural networks constitute one good example of such tools, not only because they can be used in various systems of therapy support, rehabilitation or self-care of the disabled. Some properties of networks allow for finding interesting analogies between the way they function and the functioning of a human being in the context of lost abilities. These analogies do not mean that neural networks are the ideal ground for construction of human assistance systems, but they allow viewing the issue of disability in a slightly non-standard way.

3. Levels of performance and its lack

The complex problem of disability features several levels related to various standards which determine the expected (thus regarded as proper) ability and performance of a human being (5). What is a natural attribute of human functioning should be differentiated from additional roles assigned to the humans during cultural and civilisation development. The lower levels of references may be well grounded with the biological functions of the organism whose lack constitutes some sort of pathology. The higher levels gain stronger features of social convention and evoke pondering whether disability may at all be regarded as an objective phenomenon (Figure 1).

The lowest level in this hierarchy is hindering of the activities which results from damages to the tissue, the organ or the entire system. Loss of the functions of both hands after injury to the upper limbs may be an example here. Some functional disorders result from illness or trauma, other inevitably come with time passing as a result of ageing of the organism. Degenerations accumulating with time may deprive a person the capacity of executing precise hand movements almost to the same degree as amputation. However, disorder in itself does not have to imply disability in its full meaning.

Motor disability is a higher level of this context. If the activity covered with the disorder is crucial for the given aspect of human performance, its lack prevents achieving the objective for which it is used. For example, the lack of a fit hand impairs the writing ability with the standard computer keyboard. However, it is difficult to indicate an obvious example of such an objective which a person could not achieve after excluding the directly related activity. It is a natural consequence of redundancy which is common in biology, including the biology of human being.

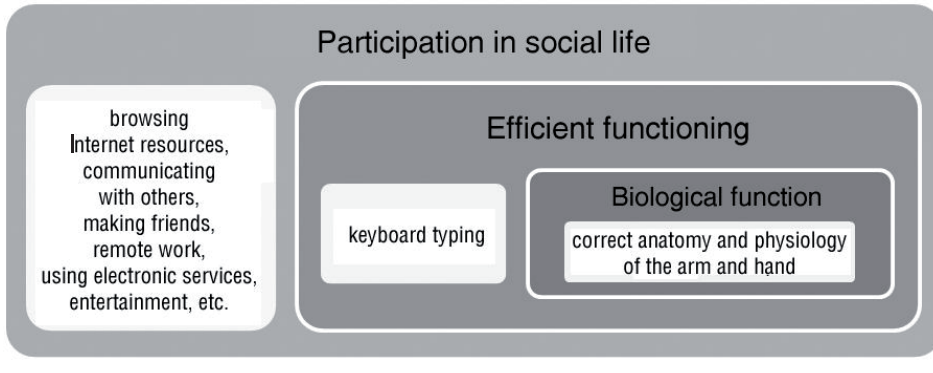

Figure 1. Levels of ability and the corresponding examples of activities

S o u r c e: authors' own study.

If the selected aspect of ability (for example movement, verbal communication or object manipulation) has some margin of redundancy, then the activities covered by this ability may be replaced with their equivalents. The human being may walk on hands, play instruments with feet or operate the keyboard with the mouth. Redundancy in biology, which consists in the lack of strict assignment of specific roles to individual structures and functions of the organism, means possibility of maintaining performance of the system even when some activities are impaired.

The highest level of disability considered in medicine is the barrier of participation in social and cultural life exceeding over the standard of biological life. This barrier arises when there are no alternatives to enable participation in the given activities with the abilities other than those which have sometimes been completely arbitrarily regarded by the humanity as necessary. The lack of capacity to use keyboard and computer mouse practically prevents taking advantage of the Internet resources (apart from a few cases of specially adjusted computer hardware) even if the same person can perfectly speak, move, hear or perceive images.

Further on in the same mood, there are other issues, less obvious and going beyond pure disability: if the given method of participation in the activities of the community is the only way to fulfil high aspirations of the individual, the barriers in this respect may completely deprive him/ her of the possibilities of satisfying the personal needs in education, professional career or interpersonal contacts. In reference to the earlier examples, one may hypothetically assume (although it is not far from reality, considering development of cyber-society) that using online community portals is the only way for making acquaintances, without any other, alternative, redundant way. If this is the case, the lack of access to online services condemns a person to loneliness whether the reason of disability are the limbs or a trifle lack of a computer connected to the network. Basically, it is a form of phenomenon called digital exclusion.

4. Artificial intelligence and creative redundancy

These considerations induce to think about the term "disability", which in the above context becomes very relative. It seems natural that personal performance should be determined by the capacity to achieving the intended objective, and not by the method used (6). Leaving the possibility of free selection of activities and measures to be used is the condition of objectivism of the assessment. Otherwise, anyone who does not fit the highly specialised task where no margin of redundancy is left becomes disabled (7).

With a jump between the contexts, similar observations may be found to refer also to artificial intelligence tools. Various techniques of solving problems with "soft" calculation methods (using, among others, genetic algorithms, neural networks or fuzzy systems, to name just a few examples) are based on a similar assumption: achieving the satisfactory result is important, and not the method that leads to it. The point of

departure for seeking a solution is an undetermined system with adaptation freedom which gives it possibility of adjustment to the problem in a unique way. The way to go is learning process, especially learning without supervision, with clearly exploration nature.

Similarities in some behaviours in people and their biocybernetic models which may be referred to the disability context can be tracked with the example of neural networks regarded as a tool for solving problems. Just as the human body is not a specialised biomachine dedicated to executing specific activities, the artificial neural network does not constitute the data processing unit programmed for the needs of executing a specific task. Just on the contrary, in both cases these are highly complex structures with the potential for solving problems which is difficult to foresee. However, first free and neutral conditions for adaptation to the problem must be secured, free of initial preferences, bias and arbitrary choices, so that this potential could be manifested.

Unsupervised teaching of neural networks may be an example of such independent exploration of the problem area which is to go in the direction of finding the solution without indicating its details. Assessment of the results of teaching (similarly to the above quoted assessment of human performance) is based on checking the results, and not the method of achieving them. It would be difficult even to indicate specific roles and tasks set for particular neurones, because their functions are not determined prior to starting the teaching process, and remain undisclosed after its completion. It again reminds of the situation of a person who, facing the challenge for his/ her performance, will seek a solution with all the available resources of the body. Due to almost unlimited human creativity, one cannot definitely state what is the purpose of hand, foot, mouth, or tongue, as these organs do not have any unanimous role assigned by physiology. For example, categorising a person writing with his/ her mouth as disabled is more and more questionable.

5. Teaching as a generalisation process

Setting preliminary expectations for the network in training and adjusting the teaching data according to subjective criteria happen to be an error which deprives the network of the possibility of seeking generalisations and more universal solutions. The example of a similar situation in the context of human performance comes in the form of persuading left-handed children to learn writing with their right hands, that is forcing the solutions developed by one group of people as fitting to the needs of all others. As a rule, it brings about more damage than benefit.

Assessing wrongly trained neural network as incapable of executing the task set forth for it, one should also take into consideration this freedom of problem exploration. It may turn out that the problem in itself is incorrectly defined, and the biased sets of cases hide subjective preferences and hypotheses of the researcher. Another

analogy comes from a pre-school situation of teaching children the names of vegetables and fruit. Colour-blind children may be assessed as incapable of learning because the teacher prepared vegetables which differ only in colour.

Communication between a human being and the external world is a good example of skills acquired in the learning process. Immense plasticity and adjusting capacity of the human brain to very non-typical conditions of communication may be proven with the richness of forms and means used by the disabled to communicate with the surroundings. No activity of the body may be simply indicated which is subject to conscious control and which would not be used for making contact with the world in the situation where there are no other possibilities (8).

This reminds one of another feature considered in the context of neural networks, namely the capacity to generalise the learned models. The correctly trained network should solve the task also in the situations in which it has never been before. The more specialised network, the stronger its fitting with the selected set of cases, the more probable its reliability when circumstances change in which it is to be applied. The same applies to communication solutions, as well as many other areas of civilisation legacy, such as construction, transport or education, which the disabled have to face. Their difference from standard cases constitutes a similar challenge for the used solutions, like an unknown case of the input data for the trained neural network.

6. Final remarks

As regards the earlier described levels of performance or its lack, one may notice that barriers of free transfer between these levels—related to the lack of alternatives which would allow replacing one activity with another—are the consequence of excess fitting of the tools and resources to closely defined methods of their use. It manifests in the place where redundancy characteristic of biological organisms ends and appears specialisation which is typical of products of technology. For example, the problem of the person who lost a hand in an accident does not have to be in the lack of the limb, but in the necessity of using a keyboard fitted perfectly to the shape of the anatomically proper fingers.

It may be assumed that in case of communication of a person with a machine, the overtrained (to use the terminology of neural networks) interface constitutes the basic barrier for the disabled: it is not the human who cannot give instructions to the computer, but the machine itself does not cope with reading them. This presentation of the situation creates motivation to find more universal interfaces, otherwise, due to the information technology spreading in daily life of the people in highly developed countries, the escalating problems may be expected which lead to intensification of digital exclusion phenomenon.

During construction of the human–computer interface for a disabled user, the teaching capacity is in fact used on both sides of this bridge (9). Both the human and

the computer must adapt to ever changing communication conditions and learn new behaviour patterns or methods of expressing intentions. That is why seeking solutions based on neural networks, following some features of the human intellect, is also an activity aimed in a sense at making both sides of the dialogue of the human with the machine similar, because it is his alternative carer. The more tasks related to learning and getting to know its user the computer takes over, the easier will be for that person to make contact with it. In building the interface, one has to remember about maintaining the possibility of generalisation for a broader range of cases and conditions of application. Using the tools and techniques on the side of the computer which give the same possibility brings hope for creating a universal interface which could at the same time serve people with highly varied abilities and competencies.

Bibliography

1. Kirenko J. 1995. *Niektóre uwarunkowania psychospołecznego funkcjonowania osób z uszkodzeniem rdzenia kręgowego*. Lublin: Wydawnictwo Uniwersytetu Marii Curie-Skłodowskiej. ISBN 83-227-0734-7.
2. Lupton D., Seymour W. 2000. "Technology, selfhood and physical disability". *Social Science and Medicine*, no. 50, pp. 1851–1862. Elsevier Science.
3. Jacko J. A., Sears A. (ed.). 2002. *The human-computer interaction handbook: Fundamentals, evolving technologies, and emerging applications*. New York: Lawrence Erlbaum Associates.
4. Przybyło J., Jabłoński M., Wołoszyn P. 2003. "Wizyjny interfejs człowiek-komputer przeznaczony dla użytkowników niepełnosprawnych". *Automatyka*, vol. 7, no. 3, pp. 385–398. Kraków: Uczelniane Wydawnictwa Naukowo-Dydaktyczne Akademii Górniczo-Hutniczej.
5. World Health Organization. 2002. *Towards a common language for functioning, disability and health*. Geneva.
6. Wołoszyn P., Tadeusiewicz R. 2003. "Analiza ruchów praksyjnych jako nowe narzędzie przydatne w tworzeniu graficznego interfejsu użytkownika". *Informatyka Teoretyczna i Stosowana*, vol. 3, no. 5, pp. 115–138. Częstochowa: Wydawnictwa Politechniki Częstochowskiej.
7. Wołoszyn P. 2009. "Interfejs dla osób niepełnosprawnych". In: *Podstawy inżynierii biomedycznej*. Ed. P. Augustyniak, R. Tadeusiewicz. Kraków: Wydawnictwo Akademii Górniczo-Hutniczej.
8. Wołoszyn P., Przybyło J., Jabłoński M. 2003. "Analiza przydatności metod komunikacji z komputerem w tworzeniu interfejsu dla osób niepełnosprawnych". *Automatyka*, vol. 7, no. 3, pp. 399–408. Kraków: Uczelniane Wydawnictwa Naukowo-Dydaktyczne Akademii Górniczo-Hutniczej.
9. Hartson H. R. 1998. "Human-computer interaction: Interdisciplinary roots and trends". *The Journal of Systems and Software*, no. 43, pp. 103–118. Elsevier Science.

Problem wykluczenia cyfrowego w społeczeństwie informacyjnym a techniki sztucznej inteligencji

Streszczenie: W miarę rozwoju społeczeństwa informacyjnego i upowszechniania się technologii komputerowej coraz szerszy obszar życia jednostki zostaje powiązany z dostępem do

usług informatycznych. Realizacja codziennych potrzeb nowoczesnego obywatela wymaga w rosnącym stopniu wykorzystania zaawansowanych środków technicznych, takich jak bogate aplikacje internetowe, urządzenia mobilne, serwisy multimedialne itp. Wiele z tych aktywności idzie w parze z potrzebą samodzielnego i autonomicznego ich realizowania, co wynika z wkroczenia świata technologii do silnie prywatnych sfer życia, takich jak korespondencja, relacje społeczne czy osobiste finanse. Samodzielność partycypacji w tego rodzaju aktywnościach jest w obecnych czasach coraz silniej warunkowana zdolnością samodzielnej obsługi urządzeń komputerowych oraz oferowanych za ich pośrednictwem serwisów.

Wobec zmian cywilizacyjnych zachodzących wraz z informatyzacją społeczeństw pojęcie sprawności zyskuje nowe znaczenia, odnosząc się nie tylko do zdolności wykonywania czynności fizycznych, ale także do partycypacji w informacyjnej sferze życia. Utrata sprawności może odciąć człowieka od dostępu do owej sfery, nawet jeśli utracone zdolności nie są same w sobie niezbędne do realizacji podobnych celów jednostki. Dzieje się tak wówczas, gdy technologia pośrednicząca w zaspokajaniu określonych potrzeb nie pozostawia alternatywnej drogi komunikacji człowieka z maszyną ani nie wykazuje potencjału adaptacji do specyficznych uwarunkowań i ograniczeń, jakim podlega użytkownik. Pokonywanie cyfrowej dyskryminacji osób niepełnosprawnych wymaga zastosowania technik sztucznej inteligencji naśladujących nadmiarowy i kreatywny sposób postępowania człowieka. Na przykładzie sztucznych sieci neuronowych można dostrzec analogie między błędami metodycznymi popełnianymi przy uczeniu i ocenie ich działania a problemami barier dostępności interfejsów człowiek – komputer.

S ł o w a k l u c z o w e: technologia informacyjna, niepełnosprawność, sieci neuronowe