A framework to automatically support autonomous exploration of amusing contents and self-determination in people with profound disabilities

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Abstract

In this paper a framework to support and stimulate the autonomous exploration of leisure activities in people with profound disabilities is described. It is indeed important to help them to gain as much autonomy as possible and, at the same time, reduce caregivers' mediation, especially in children. Starting from the representation of this setting in terms of interacting elements, it is possible to insert tools, enriched with artificial intelligence, that allow people with a reduced autonomy degree to increase it. The framework, indeed, includes the ALA, the artificial leisure assistant that records individual interaction with multisensory materials and proposes materials and activities that share elements or features with previously selected ones. The framework is described in detail.

Keywords: Leisure activities; Games; Intelligent tutoring systems; Profound disabilities.

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1. Introduction

The life of people with severe and profound or multiple disabilities is, in many cases, a big challenge. Satisfying essential needs can be as difficult as climbing a mountain. In the last decades, thanks to technological advancement, many tools and methodologies have been proposed to bring some solutions. For example, Lancioni and colleagues (Lancioni, Sigafoos, O'Reilly, & Singh, 2012) described how different technologies and computer-based systems are opening new opportunities to live independently for people with disabilities, be it motor, sensory or cognitive.

The same authors have underlined that it is important not only to meet basic needs, but also to promote "the pursuit of happiness" (Lancioni, O'Reilly, Campodonico, & Mantini, 2002). Considering the so-called indices of happiness and trying to maximize the positive engagement of people with disabilities can represent a chance to survive, but also to live with an increased quality of life.

Another important aspect that we have to consider is that, in many cases and especially for children, both the satisfaction of basic needs and the recreative activities are governed by caregivers (Lancioni, Singh, O'Reilly, Sigafoos, Oliva, & Cingolani, 2009; Nicolson, Moir, & Millsteed, 2012).

This means that in many cases, people with disabilities cannot explore by themselves even in the perimeter delineated by their own sensor, motor or cognitive impairment and by the assistive technology in use. As a result, their self-determination, an important civil right (Stroman, 2003), correlated with improved quality of life (Nota, Ferrari, Soresi, & Wehmeyer, 2007), is further limited.

In this paper we propose a methodology to improve the capacity of people with severe, profound, and multiple disabilities to interact, with fewer or no mediation, with some assistive technology tools in order to explore materials and activities for leisure: in the next section we introduce the model we rely on with various elements, then we describe the contribution from artificial intelligence.

2. An interactive framework for leisure activity and its translation in digital terms

Let us imagine the following situation, that can be commonly recognized with some variants in different contexts. There is a 4 months-old child crying in his crib while his caregiver tries to calm him down. First, his

favorite dummy is proposed, but the child does not play at all with it; then the rattle is offered, the child holds and shakes it and stops crying.

At this stage, the child can only select between what is proposed by the caregiver, but later he/she will actively look for and reach what he/she likes to have fun. Some limitations on what can be amusing derive from the culture we are immersed in, from habits, from prejudice or from practical reasons, but, at least in principle, with growth, many more chances of exploration become available.

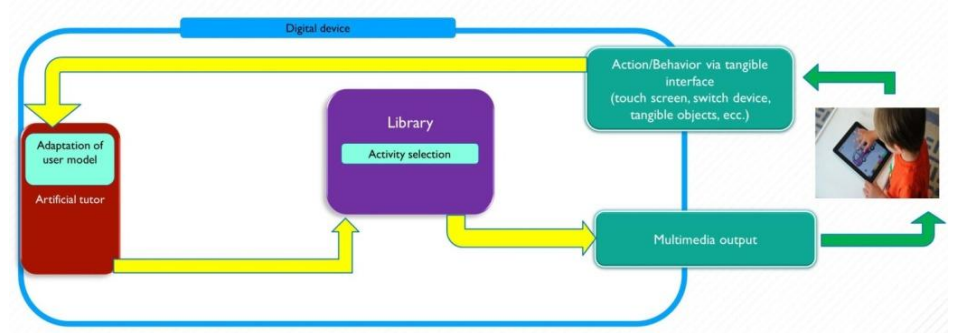
In case of multiple disabilities, or profound disabilities, it is possible that the person is stuck in this stage, where the mediation of someone else that offers stimulation cannot be overcome.

Moreover, in some specific cases, the child or the adult cannot even communicate what is liked and what is not, and it must be inferred by the caregiver.

In more abstract terms, we can identify a first agent to be amused, the second agent that tries to amuse the first one and some leisure material or activity that is proposed by the second agent to the first one.

In order to translate this situation into a digital setting, it is necessary to define some elements more precisely, as shown in Figure 1.

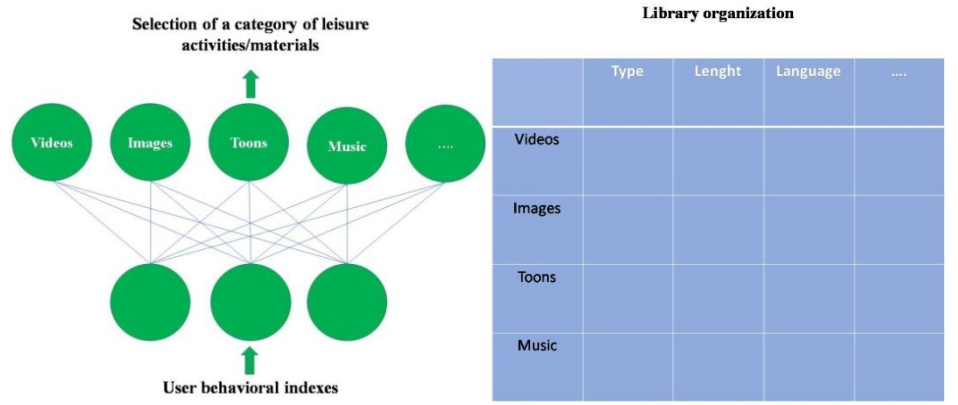
Figure 1 – *Digital setting for exploration of leisure activities*



The digital device, located at the center, includes the library which collects activities to be selected. This function is run by the artificial tutor, that covers the function played by the caregiver in adapting the selection on the user, based on the information about the user. After selection, the user is exposed to the chosen (by the tutor) material and can interact with it with different interfaces, depending on the user preferences or constraints. It can be, for example, a tangible object or a visual content.

This is represented in Figure 2; on the left, we have the activities and materials divided into classes or categories that are selected according to behavioral indexes; on the right, there is the library which groups these materials into categories.

Figure 2 – *The leisure activities materials, organized in a library (on the right) and selected by the tutor (on the left)*



Let us now focus on what the artificial tutor is, how it is implemented and what functions it covers.

3. ALA: the artificial leisure assistant

It is quite clear, from the above description, that the artificial tutor is the core element: we will call it ALA, Artificial Leisure Assistant. It functions as an interface between the user and the activities; in other words, it orchestrates the participant-activities-materials flow.

The Intelligent Tutoring Systems (ITS) are the core of educational science and psychology of education (Ma, Adesope, Nesbit, & Liu, 2014). These computer programs rely on a representation of the learner (the participant), providing him/her with personalized and individualized instructions. Expertise and the richness of pedagogical repertoire of human teachers is translated into automatic algorithms, that are customized to the individual learners (Du Boulay & Luckin, 2001, 2016). A recent contribution has also addressed the role of ITS in disability rehabilitation techniques (Ponticorvo, Rega, & Miglino, 2020a).

Some interesting reviews on this topic show the effectiveness of this approach (Ma *et al.*, 2014) in comparison with other approaches using large-

group instruction by the teacher, non-ITS computer-based instruction, and textbooks or workbooks. Significantly, the effects of ITS on learning is comparable to the outcomes of individualized human tutoring or small-group instruction.

These results lead to a more general consideration: at individual level, what can make a difference is what delineates a learning pathway for a specific learner. Important variables for education at individual level, such as personality (Busato, Prins, Elshout, & Hamaker, 2000; Dumfart & Neubauer, 2016) and motivation to achieve results (Hareli & Weiner, 2002), help to build custom educational materials and solutions.

This becomes even more important if our goal is to look for what people like, what MulSeMediA (Multiple Sensorial Media Advances and Applications) materials they prefer (Ghinea, Timmerer, Lin, & Gulliver, 2014). In this case, any reference to normative elements becomes completely useless: each person has his/her own preferences. Obviously, this kind of approach has an immediate application if – and this is the case – our goal is to find tools, materials or activities that amuse the participant: but it can also have an application in building educational materials that can attract a specific learner. If we propose materials the learner likes, it is more likely that he/she will spend more time playing or exercising with it: this often results into increased learning outcomes (Louw, Muller, & Tredoux, 2008).

What changes is the measure: reproducing the distinction between maximum performance and typical performance test, we do not have to compare an expected result with the actual reply, but we have to maximize some index related to preference, for example the time spent on the task or what can be referred to the indices of happiness introduced above.

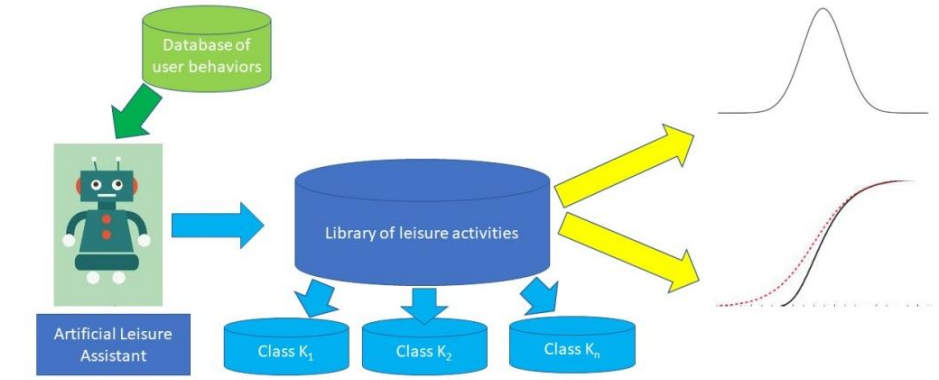
In the next sub-section, we will see how these principles are implemented in the tutoring system, in more details.

3.1. ALA formal definition and implementation

ALA is represented in Figure 3. The starting point is the library which includes the stimuli, divided into groups or classes, called K; each class is associated with a probability of extraction.

This probability is calculated using a formula with a function of the difference between Correct Answer and Emitted Answer. This approach is valid if a Correct Answer exists, as in the case of learning; in the cases of leisure activities, the goal is to maximize the index of happiness.

Figure 3 – *The ALA with the library of activities, the categories and the probability of extraction*



Depending upon how we can direct the learning process, a different function can be used. In the case of normal distribution, the parameters can be modified to have different forms: if we adopt this function, the processes will be addressed according to Vygotsky's zone of proximal development (Chaiklin, 2003), that is to say, the proposed stimuli and activities won't be too difficult or too easy for the player.

Instead, if we select a logistic function, the process will be addressed so as to maximize a certain index and it can be suitable, depending on the task, but also on the present and potential level of the learner. The evaluation can be made, for example, on the basis of pleasantness, or how long a certain stimulus or activity is maintained.

The probability of each class at the beginning is 1 / N, number of categories; then it varies according to the update function. Classes can contain a different number of stimuli, at least 1; this number is taken into account by the tutor to make the extraction.

At time 0 the extraction is completely random and the probability will be equal to 1 / N; within the class we extract at random, unless there is a differentiation in terms of difficulty.

From epoch 1 the tutor comes into play to define the new training set.

In brief:

1. A set of procedural activities (tasks) of an undefined level of difficulty can be organized into N categories or subsets;
2. For sake of simplicity, we impose that categories are disjoint sets;
3. The power (number of tasks) of each category can be different for each of the N categories;

4. Each category is made up of tasks that have the same level of difficulty.

The learner is presented with a certain number of tasks also belonging to different categories for each learning session; the goal is to help the learner to acquire knowledge and skills in a stable way to solve a problem (even simply associative). In practice, he/she has to solve the majority of the tasks of a category, exposing it in his/her learning path to the least possible number of stimuli (this can be an individual variable, just as the optimal sequence to acquire some knowledge can be personal).

It is necessary to expose the learner to a certain number of tasks for each category, and according to a threshold of correct behavior it is estimated that the learner has learned that category. This corresponds to the testing phase, separate from that of learning for economic, educational, organizational reasons.

However, these moments can be combined more fluidly to obtain a fluid process in which the learning estimate takes place and adapts during the learning process (in parallel).

4. Discussion

The framework we have introduced supports the exploration of amusing and leisure contents to improve the self-determination in people with multiple and profound disabilities.

It highlights the importance of leisure activities in itself and not functional to learning, as in the case of game-based learning. In other words, it recovers the benefits of leisure activities in many spheres of everyday life (Narme, 2016).

Moreover, considering and including digital and physical materials can have a boost effect in people's creativity (Ponticorvo, Sica, Rega, & Miglino, 2020b), together with the stimulation of different senses (Ponticorvo, Di Fuccio, Ferrara, Rega, & Miglino, 2019).

On the other side, it underlines the centrality of personalization in determining individual's pathways. If we adopt a psychometric point of view, it goes far from normativity to get close to ideography (Molenaar, 2004): it values the variation between individuals, rather than commonalities, in order to draw tailored pathways to learning and, even more, in leisure. The exploration of materials and activities with the more neutral mediation of technology, rather than the caregiver's, opens new

possibility for freedom and autonomy and may result into a more satisfying everyday life.

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