

## A system for behavioral therapy support for autistic children

**Abstract.** The Applied Behavioral Analysis (ABA) is one of the very successful therapies on autistic children. There are no software systems supporting such a complex therapy either in Polish or international ABA rehabilitation centers. This article presents an idea of an integrated system to help managing the vast amount of data collected during behavioral therapy. There are four main modules in the system: a database containing therapy data, system for data analysis based on machine learning techniques, an expert system to support therapist and a semantic based search.

**Streszczenie.** Stosowana analiza behawioralna jest jedną ze skuteczniejszych terapii dla dzieci z autyzmem. Zarówno w Polskich jak i światowych centrach rehabilitacyjnych nie stosuje się systemów oprogramowania, które wspierałyby tą skomplikowaną terapię. Niniejszy artykuł prezentuje ideę zintegrowanego systemu wspomagającego zarządzanie ogromną ilością danych gromadzonych podczas terapii. W systemie zaplanowano cztery moduły: bazę danych zawierającą dane z terapii, system analizy danych wykorzystujący techniki z maszynowego uczenia się, system ekspercki dla terapeutów oraz oparty na semantyce (System wspierający terapię behawioralną dla dzieci z autyzmem).

**Keywords:** autism, ABA, information system for therapy support, artificial intelligence methods.

**Słowa kluczowe:** autyzm, stosowana analiza behawioralna, system informatyczny wspierający terapię, metody sztucznej inteligencji.

### Introduction

Autism Spectrum Disorder (ASD) becomes a public major health problem. It is still difficult to answer the question: „How many people have autism?” There is not any central register of people with autism, which means that any information about the possible number of people with autism in the community must be based on epidemiological surveys (i.e. studies of distinct and identifiable populations) One of such type of studies conducts the CDC: Centers for Disease Control and Prevention [1]. Following the CDC statistics one can learn about an approximate ASDs prevalence. Considering Asia, Europe, and North America 0.6% to 1% of individuals have identified ASD.

So far the most effective method of treating autism is behavioral therapy with applied behavioral analysis (ABA). ABA-based interventions are so effective that they have been endorsed in the USA by leading federal and state agencies<sup>1</sup>. According to [2] ‘ABA is an approach to changing socially useful behaviors that employs scientifically established principles of learning to bring about these changes.’ Applied behavioral analysis has very wide applicability [3] i.e.: substance abuse, HIV prevention, college teaching, poverty, sport and exercise, and geriatrics.

There are plenty of computer programs or software in general supporting ABA in many respects. In Table 1 some commonly used software is shown including analysis from the application point of view.

Table 1. ABA therapy software overview, where ‘+’ a functionality is or ‘-’ is not applied in the software

Software	Application		
	Therapist education	Collecting and visualizing data	Teaching process support
Rethink Autism	+	+	-
Behavior Tracker Pro	-	+	-
Mobile Thinking	-	+	-
Catalyst	-	+	-
TeachTown	-	+	+
TeachingPix	-	+	+
School Rules	-	-	+
Flash Pro	-	-	+

Basing on the review (Table 1), it can be concluded that there are many tools meant as aid of autistic children

<sup>1</sup> Including the American Academy of Pediatrics, the New York State Department of Health, and the United States Surgeon General

therapy in many distinct areas. Most of them help to collect data from interventions and visualize the learning progress on charts. However there is no software for the data analysis. Each chart evaluation has to be done by an experienced person. To gain knowledge and experience teachers and parents undergo continuous training. At the moment, the process of tutoring can be done only by an online contact with the human-expert.

The goal of the presented article is to propose the idea of a complex system (software) aiding persons who work with ABA (behavior analyst, therapist or parent). Authors suggest using many solutions that involve intelligent methods and algorithms. The system functionality is determined based on the behavioral therapy analysis. In the article an idea of the system is presented and each subsystem is described in details. Conclusions outline the pros and cons of the proposed system.

### An overview of data collected during ABA therapy

From the information system point of view ABA therapy requires to store data about children behaviors and to evaluate the effectiveness of intervention procedures. Data are collected during monitoring of some intervention programs [2].

Many published studies have shown that ABA techniques can help individuals with autism learn specific skills, such as how to communicate, develop relationships, play, care for themselves, learn in school, succeed at work, and participate fully and productively in family and community activities. In order to do that, the field of behavior analysis has developed many techniques for increasing useful behaviors and reducing those that may be harmful or that interfere with learning. Registering the whole process of education is the most important aspect of any educational program. It is important to take data about current levels of skills or behavior before beginning any new intervention strategy: a new diet, an ABA home program, occupational therapy, etc. This is called baseline data, and it is used to compare current skill levels with post-intervention data (see Fig 2).

It is also important to record data during an intervention. Data collection helps measuring effects of the intervention. Every change, even a small one can be observed from registered data. It also prevents the continuation of an intervention if it is not beneficial for the student. In other words data collection enables to make future adjustments to the program based on real evidence. Measuring the dynamics in acquiring certain skills etc. the effectiveness of introduced techniques can be compared by.



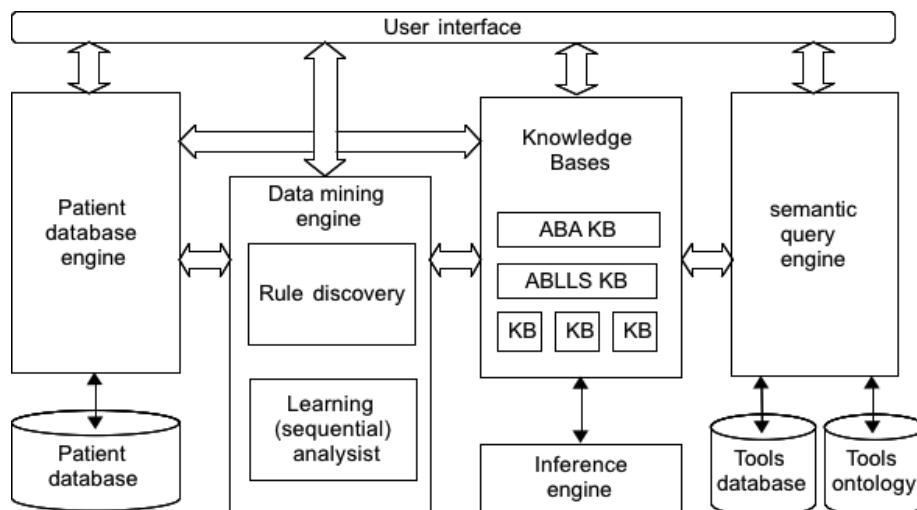


Fig 5. ABA support system architecture

Another category of ABA data makes samples usually statistically independent where the order of data does not matter. That category includes data obtained as a result of interviews with parents (i.e. date of birth, family situation, history of illness etc.)

In both categories we deal with data:

- discrete with all subtypes:

- nominal,
- ordinal,
- whole number,

- and continuous data.

From the information theory point of view the most important are sequential data collected during monitoring of intervention programs. To support the therapy process and to obtain necessary information all data should be collected in a form of the database and analyzed with the data mining methods. It should be stressed that a therapist (expert) has to have the possibility to include knowledge about the therapy. The idea of a general system supporting the behavior therapist work is the main topic of the next section.

### A system for autistic behavioral therapy support

This section demonstrates the software architecture of behavioral therapy support system. An integrated approach for data collection, analysis and management is proposed.

The system allows: (1) collecting patient files including general information and interventions registered during therapy, (2) mining the database to discover knowledge on the patients learning progress, (3) mining the database to discover rules about ADS and involved therapy, (4) computer representation of rules applied to direct the patient therapy and learning, (5) application of automated reasoning suggesting the therapist the appropriate actions and (6) searching for an appropriate therapy tool or literature.

The main components of the architecture are (Fig 5):

1. A user interface which runs within a normal web browser on the user's device/machine as a minimum requirement;
2. A data management subsystem which stores the patient's data and therapy files along with associated metadata and provides facilities for data retrieval and correction;
3. A data mining subsystem which provides a range of data analyzers handling the sequential data and allowing rule extraction for the user or an expert system;

4. An expert system with many knowledge bases (KB) about behavioral therapy and different teaching programs for example Assessment of Basic Language and Learning Skills (ABLLS) that can be used along with the ABA;
5. A context based search subsystem with a data management engine collecting data about state-of-the-art tools and literature on ASD topics allowing finding the appropriate therapy supporting instruments.

In order to analyze large and complex data sets, which are observational samples, appropriate data mining methods could be applied in the data mining component. Some attempts were undertaken with methodological and practical approaches. In [7] authors employed the LERS data mining system (based on rough set theory) to explore the relation between heart rate and problem behavior. In methodological approach [8] mining behavioral data methods are proposed to estimate the effectiveness of a treatment (Hidden Markov Models), predict upcoming changes (Conditional Random Fields) and detect anomalies (fingerprinting algorithms) in the patient's behavior. Developing digital libraries including video recordings of children diagnosed with ASD can be found in [9]. The set was used to predict children's behavior with the help of the ID3 decision tree (using the Weka open source support) and association rules.

A module with an expert system will be used to advice learning process modifications for a new or continued behavioral therapy. Results will be given to a therapist or a parent based on the progress/regress in child's behavior. Facts about the current state can come from the patient database or from the user oneself. A knowledge base which is a centralized repository for storing knowledge (e.g. "IF ... THEN ..." rules) in a logically consistent way could be written in JESS [10]. JESS provides the means to collect, organize, and use knowledge to support automated reasoning. Rules in KB will be automatically extracted from the patient's database or will be given by a human-expert. An "Inference engine" (Fig 5) controls overall execution of rules and performs forward-chaining or backward-chaining, or mixed reasoning. The fuzzy inference system can be used in this module as well by using for example FuzzyCLIPS.

Parents of autistic children often look for help in the Internet. There are some websites that share some knowledge about the therapy itself but usually are very general. Therefore an ABA portal with the semantic query

engine would be very useful. An ABA ontology should be created to semantically search for tools, information, and software.

### Conclusions

The idea of the information system used in the behavioral (ABA) therapy center is proposed. The ABA therapy is commonly used for learning autistic children. The system requirements were described assuming that it will be used in a therapy center for autistic children.

To authors' knowledge there is a gap and there is no software to support all aspects of ABA therapy. In the paper such system is proposed. In ABA a lot of data registered during interventions is collected. Therapists use some tools for visualization, but they cannot compare results, or look for some patterns in learning among many patients. A human therapist/parent is not able to analyze records gathered during long, everyday treatment. Authors propose using a module that will be able to automatically analyze patients' recorded data with data mining methods. There are some major difficulties: (1) storing and categorizing video data, (2) managing time dependent data (time series analyses

Moreover every therapist needs to be trained to react properly to every situation and to plan the next learning step. Today the only way to learn is by exchanging the expert know-how via literature, video classes and personal tutoring. Authors propose to formalize all the knowledge into an expert system for automatic advising in every area of therapy.

The future work will be focused on the each of the proposed system module details.

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