A Model to Represent Knowledge About Assistive Products

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Abstract. This paper describes a model which has been developed to represent knowledge about assistive products, to feed an artificial-intelligence-based online system offering guidance to identify and select the assistive products that best suit individual needs. In this model, each assistive product is described by a set of "knowledge rules" clustered round 15 chapters: 1) product identification data and overall description; 2) possible configuration variants; 3) optional components; 4) product goals; 5) indicated impairments and 6) contraindicated impairments; 7) indicated and 8) contraindicated environments; 9) other indicated and 10) contraindicated factors; points to consider in 11) selection, 12) fitting, 13) use and 14) maintenance/follow-up; and 15) sources/references. Each "knowledge rule" consists of a sentence – written in English language according to given guidelines – each containing a token of knowledge provided by an expert, based on scientific evidence or field experience; in this way, the knowledge base grows token by token thanks to the collective effort of a worldwide community of experts, each entering their own tokens on a voluntary basis. Today, the knowledge base includes about 2400 knowledge rules, mainly related to products belonging to the WHO APL (Assistive Product Priority List). It feeds an online guidance system called "Assistive Product Explorer" (ASPREX) which is currently under development by the World Health Organization within the GATE initiative (Global Collaboration on Assistive Technology). The model has shown able to represent knowledge about any categories of assistive products, and suitable for being fed by an open community of experts worldwide through the ASPREX system.

Keywords: AT information systems · Artificial intelligence · Guidance to AT choice

1 Background

Several countries have well-established national information systems on assistive products, which provide detailed and impartial information on the products available on the market. A well-known international information system also exists – the Global Assistive Technology Information Network (EASTIN) [1] which aggregates the basic contents of the major databases (currently from Germany [2], Italy [3], Denmark [4], Belgium [5], France [6], the UK [7], Australia [8], Israel [9] and the US [10]) to make it available through a single web interface all over the world in many languages. These information

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systems are a precious resource for people who need to know if any assistive solutions exist that suit their individual need, as well as for AT specialists who have clear ideas on the solutions to be recommended but need to know what brand/models the market is offering in that moment and where [11].

However, product information alone may be not enough; deciding what products are most appropriate to suit an individual need may be a challenging task, requiring guidance and often specialized professionals. In developed countries, these are available in AT assessment centers or specialized rehabilitation facilities; unfortunately, there are countries where these professionals are hardly reachable or do not even exist [12].

To help users self-assess their assistive technology needs and increase their ability to identify and select appropriate products, online guidance systems started appearing. The pioneer and the most well-known is the UK "AskSara" system [13], which mainly concerns daily living equipment and is quite popular in the UK as well in other English-speaking countries. Recently, other systems were launched in other countries making use of artificial intelligence techniques, such as the Israeli "ATvisor" [14] and the Canadian "Evika" [15]. Each of them has a different approach in relation to the range of products considered, the way to build their knowledge base, the actors involved in the contents, the search methods and the way search results are presented; all lead to recommendations on product brand/models contained in their databases.

Recently, within the GATE initiative (Global Collaboration on AT) [16], the World Health Organization also felt the need to develop a machine reasoning system which can help identify the most appropriate products based on a person's goals, circumstances, type of difficulties, level of ability, and life environment. It is expected that - especially in low resources countries – such a system can greatly favor informed and responsible choices of assistive products, by increasing task-shifting of AT provision to the non-specialist workforce at community level; and by increasing awareness about the complexity of the AT assessment and selection process, the risks associated to wrong choices and the competences needed case by case. The development of this artificial-intelligence-based system – now called the Assistive Product Explorer (ASPREX) – started at mid-2020 and is currently ongoing; an experimental version is now available for trial purposes providing guidance on assistive products belonging to the WHO APL (Assistive Technology Priority List) [17]. Within WHO, the term "product" is meant to indicate product categories (such as e.g., "manual wheelchair", "reading glasses", "communication software") with no reference to any brand/models.

2 Method

2.1 The ASPREX Concept

The ASPREX concept (Fig. 1) includes a public section providing information and guidance to find out the products which best meet the individual needs and circumstances; it also includes a knowledge-building system designed in such a way that it can be fed online by assistive technology experts all over the world, whether professionals or users, to continuously expand the knowledge base that drives the reasoning engine which provides guidance to the user.

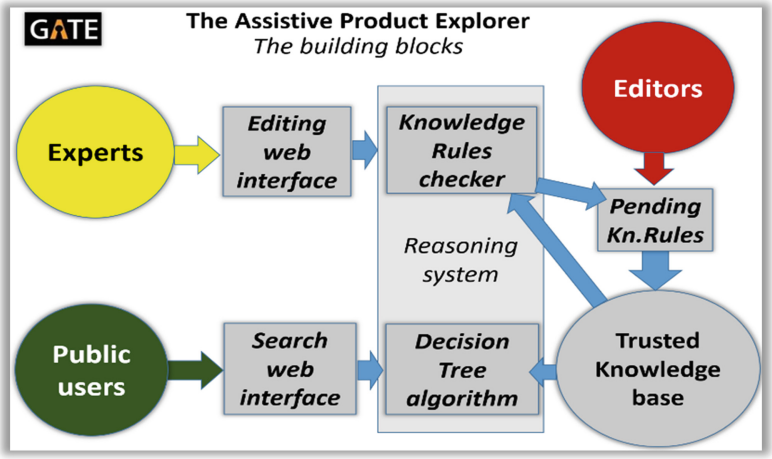

Fig. 1. The building blocks of the ASPREX system

2.2 The Challenge

Any reasoning system, whatever the technology, needs a reliable knowledge base and proper algorithms to extract the knowledge required in response to user requests [18]. Today's best-known artificial intelligence techniques draw knowledge from big data (large information sets reachable through the Web), make use of NLP (natural language processing) and have often some self-learning capability (ability to adapt themselves based on the interaction with the users); they work well when big data are available (millions of documents) and are used daily by massive amounts of users. Other systems, which don't need big data, are based on detailed models of their knowledge domains, often described through ontologies [19].

Excitement about the potential of artificial intelligence (AI) should not make us overlook the fact that either the knowledge or the algorithms are created by humans. AI does not do things that humans cannot do, it just does them faster. AI does not "invent" knowledge, it can only make inferences from available knowledge. Any recommendation generated by a reasoning system will be as reliable as is the knowledge feeding it. Therefore, when designing a reasoning system, the starting point is "what knowledge is available?", "where do we find it?", "who is providing it?".

An additional key question is "how reliable the system must be?" or "how critical would a wrong recommendation be for the user?". There are systems which harm nobody in case of imperfect recommendations (think e.g., a mistake made by an automatic translation system) while others may lead the user to misleading or harmful choices. Our system falls within the latter case, as wrong AT recommendations may be dangerous for the user.

2.3 The Need to Create an Ad-Hoc Knowledge Base

As no big data nor established knowledge models are available in the assistive technology domain, and reliability is of paramount importance, an efficient and sustainable way to

build an ad-hoc knowledge base had to be found. It was decided to create an online system able to collect knowledge from individual experts worldwide, on voluntary basis, each of them entering knowledge rules based on their personal expertise on the assistive products they know best. These people may be expert users as well as professionals or scientists. Their expertise may be based in certain cases on evidence from scientific literature, in other cases on just personal experience in their local practice or in their daily life. In other words, it is a crowdsourcing system of scientific evidence and situated knowledge [20].

Knowledge collected in this way may have not the same level of strength as scientific evidence; some experts may even enter knowledge rules that are in conflict with each other; however, the higher the number of experts providing input and agreeing or disagreeing on rules entered by others, the higher the probability is to get "closer to the truth" and achieve a practice-based evidence that is solid enough to generate reliable decision trees.

To ensure the consistence and the quality of the rules entered in the system, the knowledge base is organized according to a precise structure and includes a rule-checking procedure combining NLP (natural language processing) and human supervision.

3 Results

The structure of the system's knowledge base is based on product records, each including the product identification and an unlimited number of knowledge rules.

Product identification data (chapter 1) include:

- The product name
- The product classification, according to both ISO 9999:2016 and the WHO APL
- Picture (a self-explanatory image with no reference to any specific brand/model)
- The product description (a concise text on what the product is and how it looks like).

Knowledge rules include:

- Rules describing product variations
  - Variants (chapter 2)
  - Accessories (chapter 3)
- Rules driving the "decision tree" of the recommending system
  - Goals (chapter 4)
  - Indicated impairments (chapter 5)
  - Contraindicated impairments (chapter 6)
  - Indicated environments (chapter 7)
  - Contraindicated environments (chapter 8)
  - Other indicated factors (chapter 9)
  - Other contraindicated factors (chapter 10)

- Rules providing guidance in the selection of the product item
  - Points to consider in the product selection (chapter 11)
  - Points to consider in the product fitting (chapter 12)
  - Points to consider in the product use (chapter 13)
  - Points to consider in the product follow-up (chapter 14)
  - Sources/references (chapter 15)

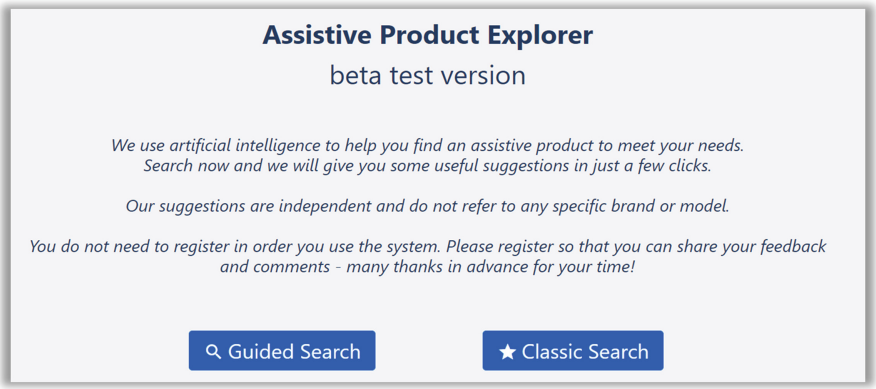

Fig. 2. The public side of the system (beta test for trial purposes)

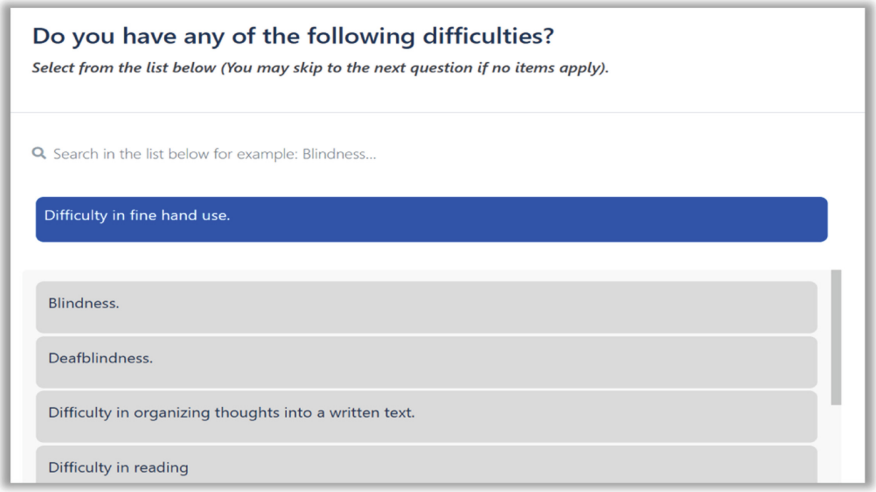

Fig. 3. Example of selection options (step 3)

This structure guides and facilitates the experts to write their knowledge rules in the password-protected side of the system; on the public side, it feeds the reasoning system

which helps the users find products which may suit their needs. When choosing "Guided Search" in the public side of the system (Fig. 2), the reasoning system prompts the user with closed-ended questions and shows a list of choices depending on previous answers (Fig. 3). The maximum number of questions is seven, as shown in Table 1.

Table 1. The seven steps of a guided search ("decision tree")

Step	Question	Selection options
1	What are the goals of the assistive product you are looking for?	*Goals of all products/variants included in the knowledge base*
2	What difficulties should the assistive product address?	*Indicated impairments of products/variants matching the options selected in step 1*
3	Do you have any of the following difficulties?	*Contraindicated impairments of products/variants matching the options selected in step 1–2*
4	Where will you use the assistive product?	*Indicated environments of products/variants matching the options selected in 1–2, and NOT matching the options selected in 3*
5	Will you use the product in any of the following places?	*Contraindicated environments of products/variants matching the options selected in 1-2-4, and NOT matching the options selected in 3*
6	Is there any other factor the assistive product should address?	*Other indicated factors of products/variants matching the options selected in 1-2-4, and NOT matching the options selected in 3–5*
7	Is there any other factor that should be considered?	*Other contraindicated factors of products/variants matching the options selected in 1-2-4-6, and NOT matching the options selected in 3–5*

The knowledge base was initially built by a small team of six experts in various assistive technology domains (mobility, communication, vision, hearing, self-care, orthotics) from various countries (Argentina, Australia, Italy, Pakistan, and the US) and has been revised collegially several times at various stages of software development to improve its consistency and ensure that the search results in the public side would be reliable and understandable.

In January–March 2022 a pilot trial was carried out with other 25 assistive technology experts (users and professionals) from all over the world who volunteered to contribute by adding new knowledge rules (or countering rules entered by others and discussing until achieving consensus).

To date, the knowledge base contains about 2400 rules related to 73 products, 63 or which included in the WHO Assistive Product Priority List [17].

4 Conclusions

The model has shown able to represent knowledge about any categories of assistive products, and suitable to be fed by an open community of experts worldwide through the ASPREX system; the recommending system has shown understandable, straightforward, and fast from the user side, although some software improvements may be needed for better user-friendliness (Fig. 4).

To date, the main limitation lies in the small number of products included in the knowledge base, which currently covers well only the WHO APL products, while it should extend to the whole assistive product world. However, this is just the beginning, as the system is ready to welcome contributions by any expert from wherever in the world to continuously increase its contents.

Fig. 4. Sample fact sheet of a product, showing its knowledge rules

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