0743-4618/99/1504-0269 $3.00/0; Volume 15, December 1999
AAC Augmentative and Alternative Communication

Access to Lexical Knowledge in Modular Interpersonal Communication Aids

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This paper discusses the role of lexical linguistic information in the framework of modular architectures for interpersonal communication aids and describes the User Vocabulary Definition and Meaning Mapping Module (UVDMM), developed in the context of the TIDE-ACCESS TP1001 project. The UVDMM Module is a multilingual lexical knowledge base that contains linguistic information and lexical translation relations for orthographic languages and symbolic systems. UVDMM has been designed to operate in the framework of component- or module-based communication aid architectures such as the ATIC architecture, which was also developed in the context of the TIDE-ACCESS project.

KEY WORDS: augmentative and alternative communication (AAC), lexical knowledge, lexical translational equivalence, modular architecture, vocabulary

In augmentative and alternative communication (AAC), it is particularly difficult to satisfy the diversity of AAC user requirements because individual user characteristics (e.g., abilities, skills, requirements, and preferences) may vary significantly. In principle, each AAC user may require a communication device specifically tailored to his or her particular needs. Technological advancements have led to the development of a wide variety of communication devices, some of which are configurable by AAC users and/or their facilitators (i.e., persons who assist AAC users to use their devices) and allow some degree of adaptation to individual user requirements. However, at the present time, the majority of available AAC products are designed to provide solutions to specific communication problems of individual AAC users or AAC target groups. This is mainly due to the fact that most interpersonal communication aids do not provide "general purpose" technical solutions that may facilitate user adaptability and flexibility.

One very important adaptation issue in communication aids with respect to AAC user requirements is the provision of effective access to the vocabulary. Before initiating use of a device, an AAC user and/or facilitator usually selects vocabulary that is appropriate for the user's needs, communication skills, and language abilities. Once selected, the vocabulary can be organized in an appropriate layout and subsequently updated or modified as necessary according to specific user requirements and preferences. In addition, if the communication aid includes a language training module, a facilitator may also need to prepare, organize, and update related training materials. Then, when communicating, the user must be able to access vocabulary in order to compose messages. Moreover, vocabulary-related information is often needed for system functions such as rate enhancement and abbreviation expansion.

AAC constitutes a highly multilingual communication environment because an almost infinite number of vocabulary sets from various orthographic languages or symbol systems can be created or adapted. In the context of this paper, we define as "user language" the combination of a linguistic form (orthographic or symbolic) with a vocabulary set. Given the plethora, variety, and often personalized nature of many user languages, translation facilities (at least at a lexical level) are required in order to enhance the communication possibilities of AAC users with other people. The issue of multilinguality is partially addressed today by a variety of tools available in the market. These tools provide lists of words commonly used in AAC, out of which the facilitator can select the vocabulary most suitable for each user. They also include tables of correspondence between particular symbol systems and one or more natural languages. Techniques currently adopted for lexicon selection are based on statistical frequency analysis of conversation corpora, usually collected on the basis of age and context of use. Analysis of such corpora is usually performed before the use of a communication aid (e.g., Fried-Oken & More, 1992; Marvin, Beukelman, Brockhaus, & Kast, 1994; Stuart, Vanderhoof, & Beukelman, 1993).

The existing vocabulary selection and management tools are usually language dependent and do not provide syntactic, semantic, or translational information related to available symbols. As a consequence, they provide little support for structured access and reuse of lexical resources. Although symbol layouts and teaching materials are often structured according to conversational topics or semantic hierarchies, users and/or facilitators must derive their own methods for selecting and meaningfully grouping vocabulary items selected from available vocabulary lists that are usually arranged either alphabetically or in order of the frequency of word use. Such a daunting task fails to take advantage of many aspects of lexical knowledge that can be exploited to adapt communication aids to the requirements of individual users.

Research work concerning lexical knowledge in the AAC field has focused primarily on knowledge-based rate enhancement techniques for natural languages, such as compansion (McCoy & Demasco, 1995) and co-generation (Copestake, 1997). The formal description, processing, and translation of symbol systems (e.g., Blissymbolics) have also been investigated (Guenthner, Kruger-Thielmann, Pasero, & Sabatier, 1993; Vaillant, 1997). Although there are proposals in the literature concerning the exploitation of already existing large-scale lexical resources in AAC (Zickus, McCoy, Demasco, & Pennington, 1995), at the moment such resources are available only for natural languages, and mainly for English.

This paper presents a new approach to lexical knowledge encoding and exploitation in AAC and its use in various AAC-related applications, in particular within the framework of modular- (i.e., component) based communication aid architectures. Specifically, this paper describes a modular architecture for communication aids, Access to Interpersonal Communication (ATIC), and a lexical knowledge base, User Vocabulary Definition and Meaning Mapping Module (UVDMM). Both ATIC and UVDMM were developed in the framework of the European Commission funded TIDE-ACCESS TP1001 Project,[1] which selected AAC as one of its application domains.[2] The paper also discusses a range of possible applications of ATIC and UVDMM.

ATIC MODULAR ARCHITECTURE

ATIC is a novel modular approach to the design and implementation of communication aids. It provides a viable and attractive alternative to existing approaches in this area and is expected to affect future AAC system development by promoting resource sharing and reusability (Kouroupetroglou, 1996). The ATIC approach offers a new development framework consisting of a novel modular software architecture, upon which communication aids can be built; and a set of software tools providing a high degree of flexibility, both during implementation and at run time.

ATIC was based on an in-depth analysis of the technical specifications and functionality of currently available communication aids (Kaasinen et al., 1995) and a thorough investigation and understanding of domain-specific user needs and requirements (Abonen et al., 1995). Following the ATIC approach, a communication aid is considered to be a system providing a number of functions and/or services, depending on a particular AAC user's requirements, physical and cognitive abilities, skills, and preferences. Each function may be implemented independently, either as a separate entity or as a set of elementary services. A module or a set of modules is responsible for the implementation of a function or a service in a manner that is transparent to the architecture and the communication aid itself. The communication aid consists of a set of such modules that may be developed separately as individual components and then assembled in order to provide system functionality and to meet specific user requirements. Multiple components, which may be implemented independently by different developers, can cooperate to provide a range of interdependent functions, provided that some basic principles are respected.

The overall ATIC architecture follows a modified "client-server"[3] model (Kouroupetroglou, Viglas,

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[1]The TIDE-ACCESS TP1001 Project has introduced methodologies and tools that have led to the development of general purpose solutions for the design and implementation of highly adaptable communication aids at the levels of (a) the user interface, (b) device functionalities, and (c) user languages (Stephanidis & Kouroupetroglou, 1994). The ACCESS project has focused on the definition and elaboration of methodologies and tools for the development of unified user interfaces, adaptable to individual user abilities, skills, requirements, and preferences (Stephanidis, 1995, 1997; Stephanidis, Savidis, & Akoumianakis, 1995).

[2]Interpersonal Communication Aids was one of the two application domains chosen by the ACCESS Project to demonstrate the technical feasibility and viability of the Unified User Interface Development methodology developed within the Project (Stephanidis, Savidis, & Akoumianakis, 1997). The ACCESS approach to achieving the goal of effective and efficient use of Interpersonal Communication Aids by AAC users was to address user abilities, requirements, and preferences at three levels:

- *Access to the system.* User interfaces in communication aids should meet user motor, sensory, and cognitive abilities so that system functionalities are made accessible to the AAC user, thus minimizing the effort and time required for communication.
- *System functionalities.* The communication aid should provide all of the functionalities necessary for communication in different social environments.
- *Communicative and linguistic resources.* The communication aid should satisfy the individual AAC user's expressive communication needs; therefore, AAC users need to be provided with an appropriate vocabulary belonging to an orthographic language or to a symbol system.

[3]The term client/server was first used in the 1980s in reference to personal computers on a network. The actual client/server model started gaining acceptance in the late 1980s. The client/server software architecture is a versatile, message-based, and modular infrastructure as compared to a centralized, main-

Anagnostopoulos, Stamatis, & Pentaris, 1996). A specific module, the Message Manager, undertakes the task of requesting and providing a service by controlling the communication between the client and the server (no direct communication between modules is allowed). Every module in a communication aid can be regarded at any given time as either a "client" or a "server" and provides its services to the Message Manager. (A more detailed account of the design of the ATIC Architecture is available in Kouroupetroglou et al., 1996.) The ATIC architecture has been implemented under MS-Windows™ (both in 3.x/16-bit and Windows 95/32-bit versions).

The set of modules that may comprise a particular communication aid depends on the specific functionalities that the aid is expected to have. Typical modules of such a system provide functionality for symbol selection, message reception, message composition and editing, rate enhancement, and message transmission. A number of submodules may also be present, such as those related to voice output (digital playback or text to speech), printer, screen, etc. Each module has its own configuration facilities and an appropriate user interface (if required). A variety of modules, such as those for symbol editing, language configuration, training, electronic mail, and environmental control, may be added. Each component can be implemented independent of any particular programming language and can be modified without affecting the performance of other components. New components can be introduced at any time within the life cycle of the system.

The UVDMM lexical knowledge base described in the next section has been designed and implemented so that it can be easily integrated into any modular- or component-based communication aid architecture. It encapsulates all of the functionality and storage/retrieval facilities required for its operation. Moreover, it is totally independent of other external services and can be adapted (by means of a communication interface) for any communication aid architecture that supports the operation of separate, self-reliant modules. In the context of the ACCESS project, UVDMM has been successfully integrated into the ATIC modular architecture for both 16- and 32-bit MS Windows environments. Figure 1 shows the intercommunication between the UVDMM Module and other system components within an ATIC-based communication aid.

As seen in Figure 1, UVDMM functions are first registered into the ATIC Message Manager. The UVDMM Module receives requests and replies through a C++ programmatic interface, which makes its functions available in the ATIC environment. In this way, the

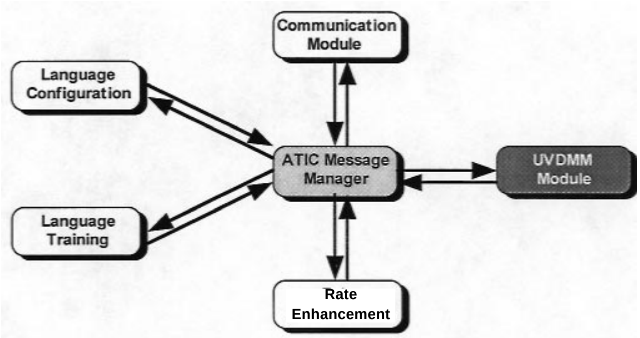

Figure 1. The UVDMM module within the ATIC architecture.

UVDMM Module functions as a server with respect to other communication aid modules (in particular, to configuration modules) either during the design phase or at run time.

UVDMM DESIGN AND FUNCTIONALITIES

The primary goal of the design of a lexical knowledge base for communication aids was to create a global source of lexical information, exploitable for all vocabulary-related tasks in the AAC application domain. The following general requirements were taken into account in the design of the UVDMM Module: (a) multifunctionality (i.e., the availability of lexical resources to support a variety of AAC tasks, including user access to vocabulary and various natural language processing (NLP) techniques currently adopted for rate enhancement); (b) multilinguality (i.e., the capability of encoding a variety of orthographic languages and symbol systems); and (c) extensibility (i.e., the possibility of extending the content of the knowledge base). The requirements listed previously were considered in order to select (a) the representation formalism for lexical knowledge and (b) the approach to lexical translation.

The requirement of multifunctionality led to the adoption of a hierarchical approach to lexical knowledge representation through a typed feature structure representation formalism, namely, the Attribute Logic Engine (ALE), developed at Carnegie Mellon University in the USA and available for research purposes[4] (Carpenter & Penn, 1994). From the perspective of the AAC application domain, this approach ensures an effective and economic encoding of lexical knowledge through information inheritance and facilitates the capture, retrieval, and exploitation of regularities in the lexicon. In particular, it allows the establish-

frame, time-sharing computing model. A client is defined as a requester of services and a server is defined as the provider of services. A single machine can be both a client and a server depending on the software configuration. For details on client/server software architectures, see Schussel (1996).

[4]The Attribute Logic Engine is an integrated phrase structure parsing and logic programming system based on type feature structures. It provides a complete package including feature structure description and constraints, definite clause logic, and a bottom-up dynamic chart parser. The typed feature structure representation includes variables, types, feature value restriction, equations, inequations, general constraints, and disjunction.

ment and exploitation of semantic and translational relations.[5]

The adopted approach to multilinguality has focused on the establishment of lexical translational relations. Given the multilingual nature of the AAC application domain and the frequent need for extending and modifying AAC user vocabularies, explicit encoding of lexical translational equivalence by means of rules (i.e., transfer; Copestake, 1995) was not considered to be appropriate. This was due to the fact that the transfer approach requires that the total number of transfer modules equals the sum of the translational directions for each language pair (e.g., a system translating between four languages contains 12 transfer modules). Furthermore, the transfer approach requires extensive updating whenever a change occurs in the system's lexical coverage. A language-independent meaning representation for lexical translation and, more specifically, a domain model-based ontology (e.g., Makesh & Nirenburg, 1996) was therefore considered to be better suited to the operational requirements of AAC applications, especially with regard to the need to extend and revise vocabulary on a regular basis. The domain model-based approach to lexical meaning representation allows customization of the knowledge base to be included in run-time communication aids without affecting system functionalities (e.g., translation).

UVDMM Structure and Content

In the current version of UVDMM, knowledge is represented by means of the ALE typed feature structure representation formalism. The knowledge modeled through this formalism includes a hierarchy of types and a set of lexica. Figure 2 shows a simplified representation of the UVDMM internal structure.

The type hierarchy classifies and defines the structure of the knowledge used in lexical descriptions to specify the properties of lexical items. The hierarchy content is comprised of the following:

1. *Classification of user languages.* Languages are classified as either orthographic or symbolic. Additionally, they are classified as universal (e.g., natural languages such as English or symbol systems such as Blissymbolics) or user defined. Universal languages are included in the system as a source of lexical information available in the process of language configuration, and their lexicon is not modifiable by the system user. User-defined languages may be subsets of natural languages, subsets of universal symbol systems,[6] or personalized symbol sets.[7]
2. *Classification of syntactic categories.* The currently encoded classification includes syntactic categories such as noun, verb, adjective, etc.
3. *Semantic classification.* Lexical meaning is represented as a language-independent domain model, which constitutes an ontology (Copestake et al., 1992; Makesh & Nirenburg, 1996; Miller, Beckwith, Fellbaum, Gross, & Miller, 1993; Pustejovsky, 1995) of some of the most common communication topics in AAC. The hierarchy is subdivided into objects, situations, qualities, and relations. Each branch of the hierarchy is further structured into subhierarchies. Entities in the hierarchy (i.e., concepts) are assigned features. Feature values represent semantic information, such as the argument structure of situation concepts, and semantic relations, such as "part of," "location," etc. The domain model is shared between all languages in the UVDMM Module and constitutes the basis for semantic-based retrieval of lexical entries and for lexical translational equivalence relations. The current implementation of the domain model contains the description of about 250 ontologic entities.[8]

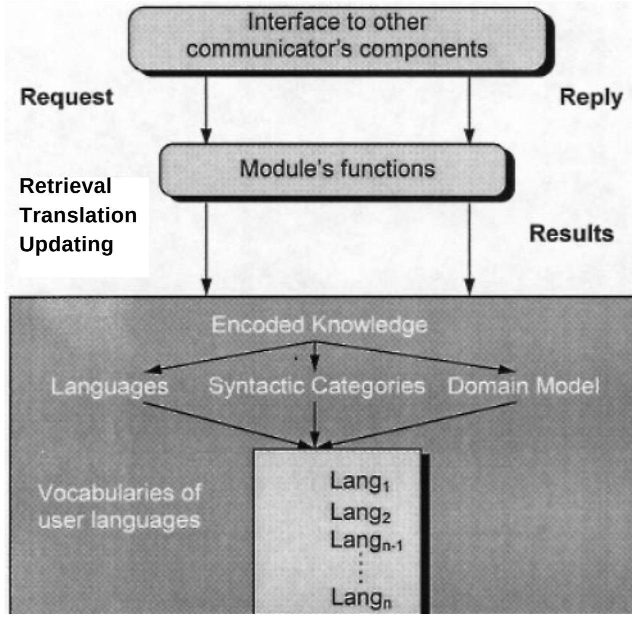

Figure 2. A schematic representation of the UVDMM Module internal architecture.

[5]The decision for selecting ALE was based on a review of recent approaches to lexical information structuring in natural language computational lexica and NLP systems (Copestake et al., 1992; Sanfilippo, Briscoe, Copestake, Marti, Taule, & Alonge, 1992).

[6]Subsets include the specific vocabulary required by an individual user.

[7]Personalized symbol sets are collections of specific pictures or photos (usually familiar to the user).

[8]In the context of the ACCESS project, the emphasis was on demonstrating the feasibility of the approach and on ensuring subsequent extensibility, rather than providing a complete domain model. The current domain model content can be easily extended to cover other conversation topics and/or semantic domains (see section entitled "Future Research Issues").

Concepts have been selected in order to cover a consistent subset of Pictograms and Blissymbolics and include people, places, and buildings; food and alimentation in general; house and related equipment; clothing and accessories; means of transportation; weather; common everyday activities; psychological states; and feelings. Figure 3 shows a part of the UVDMM ontology hierarchy.

Information encoded in each entry in the UVDMM lexica includes the language, syntactic category, and corresponding concept in the ontology. This information is specified on the basis of the knowledge declared in the type hierarchy. Vocabularies for three orthographic languages (English, Finnish, and Greek) and two symbol systems (Blissymbolics and Pictograms) are encoded. The knowledge base content can be extended by the facilitator in terms of the lexicon size and the number of user languages included.

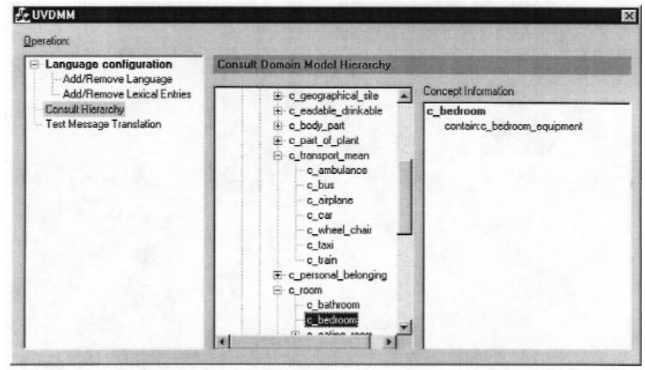

Figure 3. Part of the UVDMM Domain Model Hierarchy, as visualized by the currently implemented interface. The central part of the window shows a section of the hierarchy of physical objects. The concepts belonging to the subhierarchies c_transport_mean and c_room are listed. The concept c_bedroom is highlighted, and the related internal representation is shown in the right-hand side of the window.

UVDMM Implemented Functions

Retrieval, translation, and updating functions in the current version of the UVDMM Module have been implemented in Quintus Prolog and exploit the unification mechanism of ALE typed feature structures. The main functions of the UVDMM Module are:

1. *Retrieval of knowledge concerning language characteristics,* including retrieval of (a) all of the languages declared in the knowledge base, (b) all of the orthographic languages and symbol systems declared in the knowledge base, (c) all of the user-defined languages (i.e., the subset languages and personalized symbol sets created by the facilitator), and (d) all of the subset languages of a given language or symbol system.
2. *Retrieval of lexical knowledge.* Retrieval can be performed using any combination of lexical entry descriptions (i.e., lexical entry features). Entries can be retrieved on the basis of language (e.g., all English entries or all English and Finnish entries), part of speech (e.g., all nouns, verbs, adjectives, etc.), and semantic type or relationship (e.g., all entries related to the concept of food, all situations related to this concept, or all entries belonging to the same type as spoon). Language-based, syntactic, and semantic retrieval can also be combined (e.g., it is possible to retrieve all nouns of a given language that are semantically related to a given entity in the domain). Furthermore, in order to simplify lexicon consulting, retrieval of semantic classes and domains can be performed through predefined options. Three options are currently available: hyponyms of a given concept, coordinated items,[9] and semantic domains. The semantic domain of a concept is built by searching for concepts in the domain knowledge hierarchy that are related to it, or to one of its hypertypes, through the value of some feature (e.g., participants to events, typical locations, typically modified objects). Various other retrieval options can be easily added (e.g., the retrieval of lexical items interrelated through specific semantic relations). Full or partial descriptions of lexical entries (i.e., features) can also be retrieved.
3. *Retrieval of lexical translational equivalence relations.* Lexical translational equivalence for lexical entries of different user languages is established on the basis of domain model referent identity. Word-by-word message translation takes place on unprocessed lists of lexical entries and is performed in two distinct steps: (a) mapping of source language lexical entries onto concepts and (b) mapping of concepts onto target language lexical entries. This option allows the transmission and appropriate translation of messages between communication aids that handle the vocabulary of different languages (e.g., in long-distance communication through a network). Alternative options for dealing with source language ambiguity (i.e., the correspondence of more than one concept to one lexical item in a language) and target language lexical gaps (i.e., the lack of a lexical item in a specific language that corresponds to a concept) in message translation have been allowed. Ambiguity resolution can be either performed automatically or by means of an interactive procedure. Automatic ambiguity resolution is attempted by the system using heuristic rules on a purely semantic basis (since no syntactic parsing is currently implemented) by retrieving lexical items related to the alternative readings of the ambiguous item and comparing them to the current message context. Interactive disambigua-

[9]Coordinated items are hyponyms of the same concept (at the same level) in a hierarchy. For example, all hyponyms of the concept food are coordinated to each other.

tion is performed by asking the user to select the intended reading of each ambiguous entry in the specific context of the composed message. Lexical gaps can be omitted, producing incomplete but usually understandable output; alternatively, the message sender can be advised to modify the message.

4. *Retrieval of domain model entities.* Subhierarchies can be retrieved in the form of flat lists, structured lists, or semantic domains.
5. *User language addition or removal.* User-defined languages can be added or removed from the knowledge base. New user languages entered in the module by a facilitator (and/or an AAC user) are either subsets of already encoded languages or personalized symbol sets.
6. *Definition or deletion of entries in vocabularies.* Lexical entries can be added or removed from the vocabularies of user-defined languages. In the case of subset languages, lexical entries to be added are selected directly from the vocabulary of the related natural language or symbol system. In new symbol sets, lexical entries are defined by selecting one of the already encoded languages as a source of information (e.g., the user's native language). The semantic features are automatically copied from the source to the target entry when defining the latter. The only information that the user needs to enter is the physical location of the associated symbol and its syntactic category. Given that the semantics of the source entry are automatically copied to the new entry, translational relations are automatically extended to the new entry, without the need to explicitly declare translational equivalence relationships. There is no need for the facilitator to possess specific knowledge about how information is internally encoded and retrieved or how the translation of the defined lexical entries in other languages.

A user interface to the UVDMM lexical knowledge base has been designed and implemented for demonstration and testing purposes. The resulting application implements the functionalities of a configuration tool that facilitates user vocabulary definition, as well as testing of message translation.

UVDMM APPLICATIONS

This section describes some UVDMM applications that have been implemented in the framework of the ATIC architecture and in the context of the ACCESS project. Future applications of the UVDMM in the framework of a modular architecture for communication aids are also discussed.

Figure 4 depicts the possible exploitation of various types of lexical knowledge in AAC tasks. Tasks may be classified according to the phase of use of the communication aid (e.g., preparatory configuration phase versus communication phase) and according to whether they are performed by the user or by system functions (e.g., user access to vocabulary versus rate enhancement techniques). Lexical knowledge can be seen from either a monolingual or translational perspective. Figure 4 shows how lexical knowledge can be applied in different tasks and within different phases of use of a communication aid to facilitate user access to vocabulary and to provide information for system functions.

The UVDMM applications described in this section can be classified as follows, according to the classification shown in Figure 4:

1. *Applications available during communication aid design or at configuration time.* These include vocabulary selection, creation of personalized symbol sets, layout configuration, preparation of training materials, etc.; and
2. *Applications available at communication aid run time.* These include user access to vocabulary (with or without predefined layouts), message translation in face-to-face or e-mail communication, rate enhancement techniques, etc.

User Language Definition and Vocabulary Selection

In the context of language configuration, one of the most important UVDMM features is the possibility of directly connecting vocabulary consulting, in whatever language, with vocabulary selection for a target user language. An AAC user and/or facilitator can obtain information about the user languages contained in the knowledge base of the UVDMM Module, consult vocabularies by means of various retrieval criteria, and then use the retrieved information to create new user languages. In a modular architecture, these functions can be accessed through a configuration module, which also provides access to symbol libraries, audio files, etc. If required, the configuration module can also

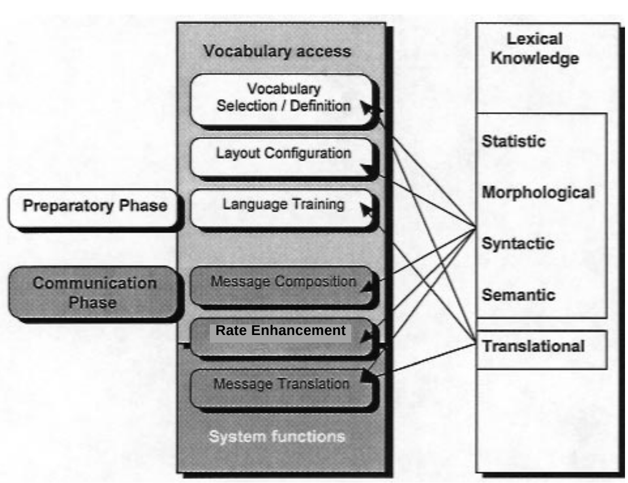

Figure 4. Lexical knowledge in AAC.

store information about created user languages separately from the UVDMM knowledge base.

For example, let us consider a facilitator who needs to define a subset of Pictograms for a particular user. As a first step, a name has to be assigned to the new user language (e.g., Pict_1). The lexical entries from the Pictograms vocabulary to be included in Pict_1 are then selected. (The facilitator can consult the Pictograms lexicon in order to perform this task.) Many retrieval options are offered (e.g., retrieve all nouns, retrieve all of nouns and verbs, retrieve all of the hyponyms of a concept). In our example, the facilitator decides to retrieve all types of food. The retrieval is performed by selecting the concept c_food and the option "Hyponyms." The retrieval results are displayed, and the facilitator may then directly select each of the retrieved entries or ask for further information (e.g., the translational equivalents of an entry in other languages, the lexical description of an entry, and/or the corresponding domain concept). The facilitator then adds the selected lexical items to the Pict_1 subset. When all additions of lexical entries have been performed, the facilitator can consult the Pictograms lexicon again, by iterating the procedure described above, until the vocabulary of Pict_1 is complete for the specific AAC user's needs. Then, the vocabulary can be stored and included in the communication aid. As the user's lexical competence increases, the facilitator can reconfigure the vocabulary by gradually adding items related to other conversation topics (e.g., weather, transportation, leisure activities, professional activities, personal care, health care, etc.). The same procedure can be applied for subset vocabulary selection for all languages, including those that are orthographic. Figure 5 illustrates these steps.

An alternative way to create a user language is to design a personalized symbol set. In this case, the UVDMM functionalities can assist the facilitator to select the appropriate vocabulary by using as a source any orthographic language or symbol system already included in the knowledge base. Let us use the example of a Greek-speaking facilitator, who decides to create a personalized set for an AAC user based on photographs or drawings and to name it UserLanguage_1. The facilitator ensures the appropriate vocabulary coverage by consulting Greek vocabulary lists and identifying relevant words related to specific concepts (e.g., family members, professionals, community supporters, etc.). When adding an entry to the UserLanguage_1 vocabulary, the facilitator assigns to it a symbol identifier or a number, and the semantic information related to the source Greek entry is copied automatically into the new entry. As a separate step (which could be performed through a symbol editor or by scanning images), the symbols corresponding to the selected concept are stored into files and linked to symbol identifiers. The UserLanguage_1 vocabulary is now ready for use by the AAC user, and lexical translation to and from UserLanguage_1 can take place because each symbol was automatically mapped into its corresponding concept of the domain model during the concept selection process.

The exploitation of UVDMM retrieval in user vocabulary configuration offers the possibility of enhancing current techniques for AAC vocabulary selection through the automatic extraction of vocabulary sets based on the domain model hierarchy and discourse topics. Decisions about whether to include lexical items in AAC user vocabularies are ultimately made by users and/or their facilitators, who can rapidly access a source vocabulary to extract syntactically or semantically structured subsets as starting points for the selection process. Statistical information about word or symbol occurrence in AAC user's messages can also be encoded in UVDMM vocabularies and combined with syntactic and semantic information for retrieval purposes.

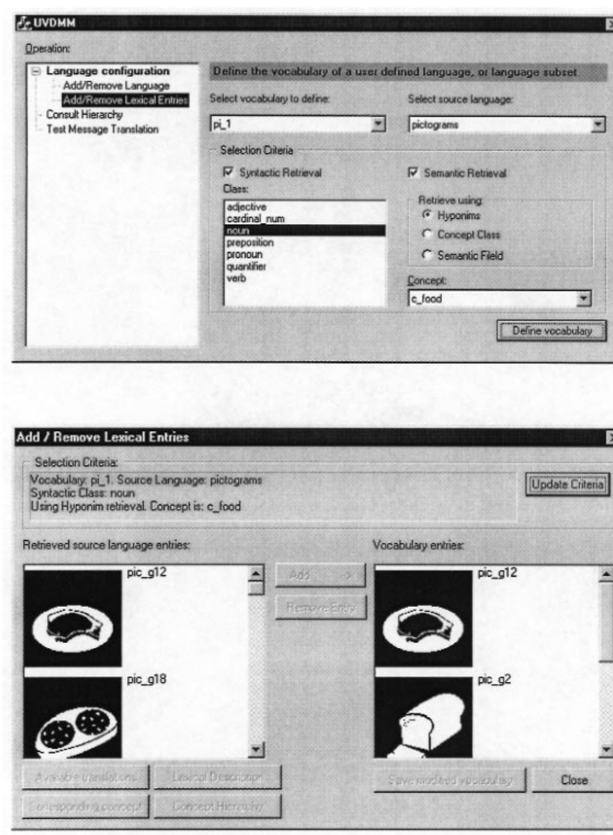

Figure 5. Retrieving food-related Pictograms for defining a Pictograms language subset. In the top window, the setting of retrieval criteria is shown. The Pictograms subset pi_1 is selected as the target vocabulary to be defined. The Pictograms symbol system is selected as a source of information for defining items in pi_1. The selected criteria (syntactic and semantic) for retrieving Pictograms lexical items are combined, and all nouns that are hyponyms of c_food are requested. The bottom window shows the result of the retrieval in the left-hand side. In the right-hand side, the defined items in pi_1 appear. The two buttons in the center of the window are used for adding or removing items from pi_1. To add an item, it is sufficient to select it from the left-hand side and to press the "Add" button.

Vocabulary Layout Configuration

During the layout configuration process, a facilitator usually groups and organizes lexical items (e.g., symbols or words) in displays that facilitate user access to the vocabulary. One example of such a symbol display is the virtual keyboard (Kouroupetroglou, Paramythis, Koumpis, Viglas, Anagnostopoulos, & Frangouli, 1995). In layout configuration, facilitators may fill in empty virtual keyboards by retrieving symbols (or their translational equivalents in an orthographic language) according to suitable criteria. The hierarchical domain model and the retrieval function of the UVDMM Module can be exploited by a layout configuration module using, for example, the virtual keyboard display. The facilitator can be assisted in the process of defining the overall structure of the layout and in filling each page with the appropriate lexical items. For example, a facilitator may wish to define a layout for a particular user who communicates using a subset of Blissymbolics (named Bliss_3). A two-level layout organization may be adopted that offers a syntactic and a semantic grouping of lexical entries structured at the interface level into "pages." Lexical entries to be displayed in each page of the layout may be identified by consulting the Blissymbolics vocabulary. The syntactic level may contain one layout page for nouns, one for verbs, one for adjectives, one for cardinal numbers, etc. The content of each page may be identified through the retrieval of Bliss_3 entries by syntactic category. The semantic level of the layout may contain one page for food, one for furniture, etc. Again, the content of each page may be identified by retrieving the respective lexical fields. Dynamic layouts can also be created by using the UVDMM retrieval functions at communication aid run time.

Configuration of Training Materials

The language material contained in training modules of communication aids is usually based on scenarios representing environments or scenes familiar to the AAC user. Pictures in scenarios are then related to corresponding symbols so that the user can learn the meaning of symbols. Exercises whereby AAC users are required to find related symbols or to complete scenarios by adding missing elements may also be designed. Vocabulary retrieval and lexical translation functions of the UVDMM Module can be used in the configuration of training materials to select lexical material for scenarios or exercises and to organize the layout of scenarios. For example, if a facilitator wishes to prepare a scenario based on a restaurant environment, he or she may first select the relevant vocabulary in the user language. This vocabulary might include (a) symbols for tables, chairs, various food and drink items on the menu, waiters, etc. and (b) actions such as ordering, eating, drinking, and paying. Using appropriate retrieval criteria, the selected vocabulary may be structured in appropriate scenes or layouts. Scenarios and exercises created for one user language can be easily translated into another. Personalized symbol sets may also be introduced to the user by creating scenarios and exercises based on sets of already familiar symbols.

User Access to Vocabulary

At run time, user vocabulary access for message composition can be directly supported by UVDMM retrieval functions, especially in the case of expert AAC users using orthographic languages. This eliminates the need for predefined layouts but requires an appropriate interface for the retrieval of lexical entries and the display of dynamically created selection sets, as well as some training. New retrieval options and a simplified representation of the domain model can also be made available to better support vocabulary access directly by AAC users.

Message Translation

In the current implementation of the UVDMM Module, message translation takes place in a word-by-word (or symbol-by-symbol) manner. This approach is useful for applications in which an AAC user wishes to communicate with people outside of the immediate environment and/or to communicate with other AAC users who use different symbol systems. Translation functions may be included in face-to-face or long-distance communication aids, whereas the selection of target language(s) is managed by the system or by the AAC user, according to the functionalities implemented in the communication aid. For example, when an AAC user using Blissymbolics wishes to communicate with someone using Pictograms, the selection of the receiver's name or photograph can be achieved from a menu, and the system can then set the target language to Pictograms accordingly. Alternatively, an AAC user can directly set the translation target to Pictograms. Figure 6 shows an example of translation from Greek to Pictograms.

The UVDMM Module also offers the possibility of changing the translation function with respect to translational problems, such as lexical ambiguity in the source language and lexical gaps in the target language. Lexical ambiguity in the source language can be resolved either by heuristic rules or by the AAC user, who is asked to select the intended reading of the ambiguous lexical entry in the composed message. When the user accesses the vocabulary through a predefined layout or through retrieval functions provided by the UVDMM Module, disambiguation can be performed simply by keeping track of the selection path. For example, the English word "drink" will be interpreted as a verb, if the user has selected it from the layout page of actions; or as a noun, if the user has selected it from the page of objects related to food.

Lexical gaps in the target user language can either be posted to the message composer or simply ignored, producing incomplete but usually understandable translation output. When translation options are appropriately selected, it is not necessary for the AAC user to be aware of the translation process, although communication partners can control this process interactively.

Since translation takes place through the language-independent domain model, long-distance communication can also be readily supported. Each message can be mapped into a list of domain model entities, sent over the network, and remapped into the target language directly by the "receiver" system.

Application of Rate Enhancement Techniques

Lexical information used for the retrieval of lexical items can also be extracted and used by system functions such as rate enhancement. Argument structures and semantic relations are commonly adopted in knowledge-based rate enhancement techniques—in particular, word prediction based on syntactic and semantic rules (Copestake, 1997) and message expansion from abbreviated input (Jones, Demasco, McCoy, & Pennington, 1991), both of which apply techniques very similar to those adopted for natural language generation.

The language-independent approach to semantic knowledge adopted in the UVDMM Module allows the application of knowledge-based rate enhancement techniques to any user language and reduces the required amount of language-specific information to be encoded. Because the ALE environment adopted in the current implementation in the UVDMM Module includes parsing facilities, prediction and expansion techniques can also be implemented directly in the Module. Furthermore, availability of lexical knowledge independent of the specific rate enhancement technique used facilitates the implementation and inclusion of alternative rate enhancement methods in the configuration environment of the communication aid. These can be selected by facilitators with respect to target AAC user requirements.

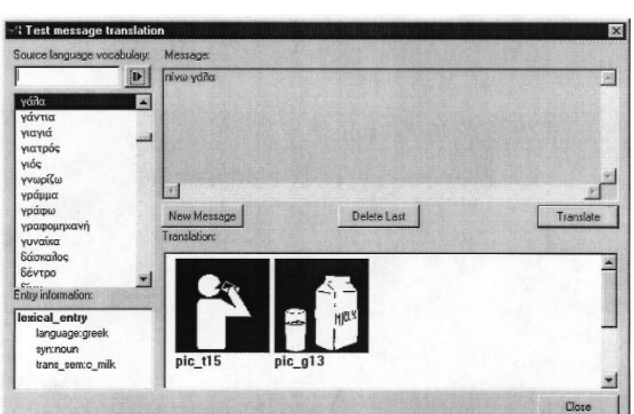

Figure 6. Testing the translation from Greek to Pictograms. The upper right-hand side part of the window shows a message in Greek. The lower part shows its lexical translation in Pictograms. The verb □ίνϖ means to drink. The noun γαγα means milk.

Future Research Issues

Future enhancements of the proposed approach anticipate an extension of the syntactic information and the domain model in the lexical knowledge base in the short-to-medium term. Current plans for extension of the domain model involve (a) the encoding of about 1,000 concepts and (b) the addition of further semantic relations. The inclusion of language-dependent statistical occurrence information in the knowledge base is also being considered.

User evaluation of UVDMM as a configuration tool is currently in progress. Facilitators involved in this evaluation include speech-language pathologists, occupational therapists, pediatricians, and parents of children who use AAC.

Longer-term enhancements foresee the introduction of message parsing and full translation. The current implementation of the UVDMM Module was not meant to provide full message translation (i.e., to produce a syntactically correct translation output); rather, it was intended as a lexical translation "backbone." However, lexical translational equivalence constitutes a concrete step toward the provision of multilingual message translation in AAC because lexical information is expected to play a central role with respect to other types of information (e.g., morphologic and syntactic) in message translation (Vaillant, 1997). In fact, for some symbol systems whose morphologic and syntactic characteristics are much simpler than those of natural languages, lexical information may be the only type of information available for the translation process. Even for orthographic languages, user input may be telegraphic, abbreviated, or ungrammatical and, therefore, provide less morphologic and syntactic information than common text.

A suitable approach to the development of a message translation system that builds on the UVDMM approach to lexical translation could involve the development of an interlingua for the most common conversation domains, following the paradigm of Knowledge Based Machine Translation (Makesh & Nirenburg, 1996). An interesting alternative could be the combination of a lexicalist approach to translation (Whitelock, 1992) within the UVDMM domain model-based ontology. Finally, the development of rate enhancement techniques exploiting the encoded information could also make use of the parsing and generation techniques adopted for translation.

SUMMARY

This paper has discussed the role of lexical knowledge in AAC and has proposed an innovative approach to meeting individual AAC user needs through the provision of a lexical knowledge base that contains syntactic, semantic, and translational information. This knowledge base makes encoded information available during all phases of use of a communication aid through the provision of appropriate functionality. Specifically, this paper has described the UVDMM Module, a multifunctional lexical knowledge base for communication aids that has been designed and implemented as a component of the ATIC architecture, in the framework of the ACCESS project. The UVDMM Module introduces a source of lexical knowledge into component- or module-based communication aid architectures, combines multilinguality with linguistic-based access to lexical resources, and adopts a language-independent and domain model-based approach to lexical semantics.

Potential uses of the UVDMM Module in a component-based communication aid architecture include:

1. Provision of support for language and vocabulary configuration, vocabulary layout configuration, and preparation of training materials by AAC users or their facilitators;
2. Direct and easy access to vocabulary by AAC users;
3. Word-by-word (or symbol-by-symbol) message translation in face-to-face or long-distance communication; and
4. Exploitation of lexical knowledge for the application of rate enhancement techniques.

The exploitation of the UVDMM Module in the context of modular architectures such as ATIC offers the possibility of improving communication aid adaptability in order to better respond to users' communicative and linguistic requirements. In addition, the domain model included in the UVDMM Module allows the establishment of lexical translational equivalence relations between all spoken languages and between AAC users and partners who communicate through unfamiliar languages and symbols. Thus, UVDMM provides the potential to widen the communication options available to AAC users in a variety of environments and situations.

ACKNOWLEDGMENTS

The work reported in this paper has been carried out within the framework of the ACCESS TP1001 project, partially funded by the TIDE programme of the European Commission (DG XIII). Partners in this consortium are CNR and Seleco S.P.A. (Italy); FORTH and the University of Athens (Greece); University of Hertfordshire, RNIB, MA Systems and Control, and Hereward College (U.K.); and STAKES, VTT, and Pikomed (Finland).

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AAC Editor's Awards for 1998

The *AAC* Editor and Associate Editors are pleased to announce the winners of the Editor's Awards for the most significant articles published in the 1998 volume of the journal:

- Teresa Iacono, Mark Carter, and Julie Hook, whose paper "Identification of Intentional Communication in Students with Severe and Multiple Disabilities," (June 1998) was voted the "most significant research article of the year";
- Rajinder Koul and Robyn Harding, whose paper "Identification and Production of Graphic Symbols by Individuals with Aphasia: Efficacy of a Software Application," which was Robyn's master's thesis (March 1998), tied for first place as the "most significant student research article of the year"; and
- Susan Balandin and Teresa Iacono, whose paper "Topics of Meal-Break Conversations," based on Susan's doctoral dissertation (September 1998), was cowinner as the "most significant student research article of the year."

Congratulations to the winners of this annual award, and many thanks to all of you who have submitted your work to the journal!