COMBINING LANGUAGE TECHNOLOGY AND WEB TECHNOLOGY TO STREAMLINE AN AUTOMOTIVE HOTLINE SUPPORT SERVICE

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Abstract

With the progress of information-oriented trade and commerce many companies have recognized that the trade on and with the existing and emerging communication technologies is an essential element for the maintenance of the advantage of competition. Significant business reengineering efforts are underway to taming the complexity of both business processes and computer information systems. The information systems that are needed for tomorrows business must be far more robust, intelligent and user-centered than the data processing systems of today. Businesses that will thrive in the next millennium will also have to overcome the existing language and cultural barriers, particularly in applications operating in an international business environment. This paper summarizes our approach to overcome the language barriers of an online multilingual technical information system of the automotive industry. The employed methodology is based on a combination of language technology and Web technology.

1 Introduction

With the progress of information-oriented trade and commerce many companies are aware of the fact that the trade on and with the existing and emerging communication technologies is an essential element for the maintenance of the advantage of competition. Strategies for widening the horizons of information transmission, exchange and reuse from trade to trade through the inclusion of customers and trade partners in a digitized communication infrastructure are the most fundamental aspects nowadays. With the appropriate presentation Web technologies such as Intranets and the Internet, especially its multimedial extension the World Wide Web (WWW or Web) can provide efficient instruments for the determination of new national and international markets as well as new proportions.

Today, most industrial companies tend to use well established solutions for the transmission of information and for the offering of services; therefore they focus more on the complex infrastructure and the strategies of trade communication than on the development of a market-oriented approach for network-based services and trade in a digitized environment. The transition of an enterprise from email or standard electronic data processing to the complete implementation of digitized services and trade requires an entire rethinking and a revision or a total replacement of the existing trading processes and the workflows to achieve reliable, effective and efficient processing of new service and trading capabilities; this with acceptable costs and with a time reduction of the production cycles. As the deployment of Web technologies imposes a replacement of the traditional industrial workflows, it particularly imposes a more global way of thinking on the use of language technology in applications operating in an international business environment (LANs, MANs and WANs) because written and spoken language is the primary medium of human communication and interaction. Currently, we are exactly in this state of industrial and societal transformation.

In this paper we summarize one potential solution for overcoming the language barriers of an online multilingual technical information service of the automotive industry. The basic methodology is to combine language technology and Web technology in an integrated way. The methodology employed in this application also has a direct impact on the general documentation workflow of the involved enterprises, which includes the translation of technical documents into multiple languages. For the field of translation, the vision of the presented solution is that in the future, the translation of a technical document will not be supported by a monolithic machine translation (MT) system or a computer-aided translation (CAT) system owned by the company that needs the translation or owned by a company that is responsible for doing the translation, but by translation engines somewhere on the Intranet/Internet that make use of distributed and local resources. The realization of this vision will provide several spin-offs to be employed in the broad field of documentation.

The remainder of this paper will discuss the deployment of combining language technology and Web technology for an information system in the field of car repair and maintenance. First, we will introduce the field of application and briefly analyze the existing situation. Then we will describe the steps we have taken to extend and enhance the system, and compare the achieved results with the previous results. We will also contrast our approach with other approaches in the field, and we will conclude with ongoing and future work.

2 Automotive Service Information System

2.1 General Scenario

Documentation is an essential element of a technical product. It has to accompany the whole product life-cycle from design and construction to the final consumer and maintenance manuals as well as after-sales services, including the appropriate quality control and quality assurance measures at all stages. Often documentation is seen as being of secondary importance (cf. for example some manuals of electronic consumer appliances or the huge amount of documentation for PC word processors), which is due to the fact that technical documentation, particularly multilingual technical documentation, is faced with several problems ranging from a consistent technical terminology to the translatability of a document including the appropriate cultural embedding of the synthesized text. In the following, we focus on the demands and requirements of the automotive industry for a network-based multilingual information brokering system intended to improve car repair and maintenance operations. The goal is to develop an intelligent system for storing, retrieving, manipulating and distributing service related information (raw data) and knowledge (processed data) primarily over major Intranet/Internet protocols such as TCP/IP, SMTP, HTTP, etc. or other in-house proprietary protocols; we call this system the multilingual information broker (MIB).

Within this application scenario, the primary aim is to design and implement solutions based on already existing data, information and systems of the automotive industry. The method for this is to find ways of using and combining new technologies, particularly language technology, dynamic data storage technology and Web technology with the already employed technologies. The results will cause a direct effect on the documentation workflow of the automotive industry as well as *on* the actions of car manufacturers to improve car maintenance routines, as well as car design and car construction because of the reusability of the information and knowledge entities (create once, use multiple).

The secondary aim is to find practical ways for interpreting, conveying and presenting service messages in various forms based on the available information and resulting from an ad-hoc request or from an initiative of the information storage. The method for this is to combine appropriate agent-controlled information structures with developments in the telecommunications and data communication area. The result is the ability to communicate potential repair, maintenance and safety features to a wider community irrespective of language and domain.

2.2 Hotline Information System

The R&D work reported in this paper will focus on the "Hotline Unterstützungssystem - HUS" (hotline support system) of BMW; this work represents the more research oriented track of the German MULTILINT project that is concerned with the integration of 'linguistic intelligence' into the document production cycles of BMW[1].

The HUS is an information-based problem solving support system for inquiries of BMW dealers and repair shops about car problems and their effective repair measures. It is the dynamic part of the general "Technisches Informationssystem- TIS" (technical information system) which provides all BMW sales and repair locations with local online technical documentation on a CD (similar to the online manual pages of an operating system). For the maintenance of HUS information the system has an interface to the "Redaktions-System - RS" of BMW, which is the main system for the production and maintenance of technical documents in multiple languages and their publishing on CD, paper and microfiche. The RS/TIS/HUS run on Unix workstations with Motif-based GUIs and they are maintained by the central customer's service department of BMW.

Whereas the static technical documentation can be verified and validated by several linguistics-based utilities before being released (currently being further investigated in the MuLTILINT project), this is not the case with the dynamic HUS information. Therefore, the verification of an inquiry submitted to the HUS as well as the validation of the dynamic HUS content must be integrated into the online processing steps, which must also include multilingual natural language processing (NLP) facilities to make the system applicable in multiple languages. In general, the HUS contains information about

1. Car problems; these are short descriptions of failures, malfunctions, etc. They are mainly derived from customer complaints or are the direct formulation of a customer complaint.

2. Facts or circumstances that caused the problem; this is a kind of problem analysis.

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Beanstandung: *Sitz-Spiegel-Lenksäulen-Memory ohne Funktion.*
ZV nur Türen vorne o.F.
El. Fensterheber nur Türen vorne o.F.
El. Schiebedach o.F.
El. Spiegelverstellung o.F.
Ursache: *P-Bus gestört*
Maßnahme: *Über die Diagnose (DIS) Fehlerspeicher abfragen.*
P-Bus-Leitung auf Durchgang bzw. Kurzschluß überprüfen.
Vorgehensweise in der Prüfanleitung (DIS) beachten.
Die am P-Bus angeschlossenen Steuergeräte der Reihe nach abklemmen und dann die Funktionsprüfungen durchführen.

Figure 1: *Sample HLI (German)*

3. Appropriate repair measures; these are instructions for solving the problem.

This three-sided information is called "Hotline Information (HLI)" (hotline information). A HLI can be of general nature, i.e. it is applicable to a specific series of cars, or it can be specific to an individual car which then can be identified by several attributes such as the chassis number, the car owner's name, etc. The information system is intended for online use by repair shops and official dealers for hotline information entering (complete HLI), retrieval (maintenance or repair request) and update (validating information). In addition, the general HLIs form an integral part of the official technical documentation maintained in TIS.

Currently, the online interactive use of the HITS is in a testing and validation phase with some few BMW locations; information is entered according to a pre-defined entry scheme consisting of three main text areas for *Beanstandung* (complaint), *Ursache* (cause) and *Maßnahme* (action).

Each part of a HLI is formulated in natural language (NL), and thus one may consider that these HLI expressions constitute a kind of technical sublanguage for the description of a car problem, the facts that caused the problem and the repair measures for the problem. However, the sublanguage expressions are often not well-formed, are incomplete, highly abbreviated and sometimes contain colloquial expressions, as well as spelling errors. This is due to the fact that for example complaints are often entered under time constraints and in stress situations. Another reason are non-existing standards across different automotive domains for the technical terminology and for valid abbreviations. A correct HLI example in German is given in Figure 1; Figure 2 represents the equivalent HLI in English. It should be noted that the English HLI is a human translation with obviously no check of the technical terminology; this HLI pair was randomly retrieved from the HUS database as used within the MULTILINT project.

In principle, such HLIs shall form the basis of service communication between car repair shops and the central technical service department in the area of multilingual hotline services (currently only German and English are used in the HUS - in the next release the HUS will support five languages). The HUS information shall be used, on the one hand, for supporting future diagnostics and maintenance operations as well as the selection of appropriate repair measures (single product

Complaint: *Seat/mirror/steering column memory does not work.*
Central looking system does not work for front doors only.
Front electric window lifts do not work.
Electric sun roof does not work.
Electric mirror adjustment does not work.
Cause: *P-Bus damaged.*
Action: *Call-up the fault memory with the DIS.*
Check the P-bus circuit for interruptions and short-circuits.
Follow the DIS diagnostic instructions.
Try disconnecting the control units linked to the P-bus one after the other and carry out a fresh function test.

Figure 2: *Sample HLI (English)*

specific and world-wide accessible via networks and other telecommunication facilities), and on the other hand, the compilation of information which shall be used for product improvements and future design decisions (information linking).

2.3 Problem Areas

The information space in our task domain is open and distributed: new information may be entered, old information may become invalidated, several conflicting pieces of information may coexist. Information is both provided and accessed by a heterogeneous group of users (service engineers, repair staff, technical writers, etc.), with different purposes (information retrieval, update and maintenance, translation, etc.). Users may enter and leave the group at any time.

Information is entered and accessed mainly in text form and in multiple languages. Information entered needs to be validated against the concepts of the domain being maintained in a knowledge base, which itself must be consistent and coherent. The users may require assistance to enter valid input, and to retrieve appropriate information. Non-linguistic modalities are also considered as a method of dealing with information access and management in this multilingual context.

2.3.1 Monolingual Language Barriers

In the HUS the language barriers are multifaceted. On the one hand, this concerns the use of language in terms of spelling correctness and the selection of the right terminology for the description of car problems and the potential causes of a problem, as well as the appropriate and consistent formulation of a repair action. On the other hand, the search for information can be significantly improved by deploying the conceptual dimension, which can be associated with the language expressions. Thus, there are several places for streamlining the HUS by means of language technology based tools and utilities.

To a limited extent the entering of problems and the search for known problems in the HUS is supported by a so-called symptom-tree, which constitutes a taxonomy of the different car parts with associated problem areas and specific technical attributes provided by the technical information system TIS. For example, a *vacuum pump* (Vakuumpumpe) can be (a) *inactive* (ohne Funktion), (b) *noisy* (Geräusche) and (c) *worn* (verschlissen). Since the vacuum pump is part of the *engine* (Motor) which is a part of the *drive* (Antrieb) and if *noisy* applies to an identified problem then there could be a selection of noise attributes such as *droning* (dröhnen), *rubbing* (rubbeln), *buzzing* (brummen), etc. but not *wind noises* (Windgeräusche). The concepts of this taxonomy as well as the associated technical attributes are mainly derived from the technical terminology of the subject field.

2.3.2 Multilingualism

Currently the multilingual capabilities of the HUS are provided by human translation. As soon as a complete HLI is validated, the translation process takes place. This ensures that only technically correct information is available in multiple languages, but there is also a delay of time between information entering and the possibility of multilingual information search. Furthermore, the symptom-tree used for German input is translated into a symptom-tree of the foreign language to ensure the same support for search processes in multiple languages. This of course yields an indexing overhead as well as data redundancy.

In contrast to other application domains where fully automatic machine translation (MT) is more and more replaced by translation memories (TM), e.g. in technical documentation because of the amount of repetitions, the HUS application is well suited for a MT task. However, the resulting reduction of the time delay poses new requirements on the input for its use by a translation engine. Whereas a human translator is able to deal with variations in the use of language such as syntactic variants and changes in terminology and abbreviations, this is not the case with MT systems.

2.3.3 Brokering barriers

Effective information brokering requires several capabilities which, however, are characteristics of most information retrieval tasks and activities; they include: *helping* an agent (human or computer) formulate a request about some class of service in the broker's language; *identifying the* information sources that are relevant; *generating* a plan to fulfill an agent's request; *executing* the plan: this involves the translation of the request into the information source's access language, obtaining the response to the request, and translating the responses into the broker's language; *presenting* the responses to the agent: this involves explaining to an agent how the response relates to the request, defining the terminology used in the response, and suggesting alternative queries that may provide additional relevant information.

In addition, the Intranet/Internet environment imposes particular requirements on the brokering problem, such as dealing with variety; change and autonomy of both agents and information sources; heterogeneous access methods and protocols (SQL, WAIS, HTTP, etc.); different vocabularies (broker, agents, information resources); different information structures (data base relations, natural language documents, email, indexed multi-media, etc.); incomplete responses; and security problems.

These requirements are not satisfied by current information retrieval technology, because the string-based matching techniques employed are too weak and inflexible. Like human brokers, effective computer-based information brokers have to take advantage of specialized domain knowledge such as: (a) the terminology used in the application domain; (b) mappings between different sorts of information in order to support requests that are based on possible relations between information entities; for example, a request asking for a product with a specific functionality would be supported only if a mapping between products and their functions is defined; (c) abstraction (generalization) and specialization will allow for retrieving relevant information; and (d) methods for appropriately combining and summarizing retrieved information.

These sources of knowledge, however, must be combined with Intranet/Internet technology, instead of being monolithic devices. A step further is to enhance information retrieval technology with linguistic intelligence that is beyond the terminological knowledge of a domain.

3 Information Brokering with Linguistic Intelligence

3.1 Basic Requisites

To solve, on the one hand the data, information and knowledge triangle[2], and on the other hand the translation problem, we have adopted a step-wise approach for the streamlining of the HUS:

1. Use the system as it is with some additional checking capabilities based on linguistic intelligence.

2. Use of a controlled language as input language to ensure optimal recall and precision for information retrieval and a better translation throughput.

3. Use of an open and agent-based system architecture.

The central basis for each step is an intensional semantic structure which encodes the implicit rules constraining the structure of a piece of reality of our application domain. This structure is mainly derived from the technical terminology of the subject field and the already used symptom-tree and its associated technical attributes; it is based on previous work in the field of computational terminology (cf. [Schütz, 1994a]). We call this form of conceptualization the ontology of HUS. This ontology will be successively extended to the data, information and knowledge requirements of steps (2) and (3), thus forming a web of ontologies (cf. below).

Initially, the multilingual symptom-trees are used for building the ontologies. There purpose is twofold: on the one hand, they are necessary for the communication and the information exchange of the envisaged Intranet/Internet based information brokering system, and on the other hand the realization of a multi-modal human-computer interface for supporting the efficient use of the system.

In our context, we use the term *ontology* in two senses: firstly, it is a synonym of *conceptualization,* which deals with the intensional structure of the technical domain of the HUS, i.e. it is an implicit encoding of rules; and secondly, it is the *logical theory* which gives an explicit partial account of the conceptualization of the domain (axiomatization). This is different from the view adopted by Gruber and his co-workers in the ARPA knowledge sharing initiative (e.g. [Gruber, 1993]), but both views are still compatible, for example, in the sense of the sharing of ontologies.

[2] This triangle can be characterized as follows: Data is the raw material on which information is founded. Data must be compressed, put together and set into relation to gain information. Information is the basic ingredient of knowledge. The more information is available the more knowledge can be inferred. Information becomes knowledge through processing, particularly through validation, classification and already made experiences. The high-end products of the information society will be knowledge products and services based on knowledge.

3.2 Linguistic Intelligence

This step is the main development track of the MULTILINT project, in which the employment of linguistic intelligence in the document production workflow of BMW is investigated.

For the HUS application the input text (complaint, cause and action) is pre-processed to remove typical spelling errors, to expand common abbreviations and to identify unknown expressions (words, multi-word units and abbreviations). The "cleaned text" is then analyzed to yield morphological base forms, parts of speech and functional categories. This surface level analysis is then mapped onto the concepts of the technical part of the ontologies (knowledge base) in two stages:

1. Surface-form-to-terms: the input is validated against a domain-specific terminology dictionary. The dictionary is partitioned into sets of terms appropriate to the different parts of the pre-defined entry scheme (HLI). At this stage, partial term descriptions and colloquial expressions are replaced with the appropriate valid terms. Special attention is given to verbs, which are handled as terminological entities. This permits the specification of a specific technical situation associated with the themes of a verb.

2. Terms-to-concepts: Terms are mapped onto concepts used in the ontology. For this the existing symptom-trees are unified, which also ensures the multilingualism of the system. The adding of further languages may cause ontological alignment because of conceptual mismatches, particularly when adding Asian languages.

In both processes, mapping involves statistical comparison for robust processing. If the match is just below the required best-fit threshold, then the nearest match is used. However, the system informs the user because (a) the match could be wrong, and (b) explicit feedback about the correction can play an important role in teaching the user how to use the system effectively. If there is no match or only very poor matches, then the system can actively assist the user to enter a valid expression (term) appropriate to the pre-defined scheme. For example, the user can be presented with a (high-level) menu of car problem types, which can then be interactively refined to identify a valid term. Again, this can yield significant training effects.

3.3 Controlled Language

To further improve the accuracy of the envisaged HUS application, particularly the improvement of the recall and precision rates, the use of a controlled language is investigated.

In the field of multilingual documentation and document production the role of controlled languages is mainly twofold: firstly, they allow the mono-lingual technical document to be written *in* a readable (according to the intended readership) and unambiguous form; and secondly, they permit the translatability of the document because the input document is "cleaned" wrt. potential translation failures. In addition, the production of multilingual documents can be further supported by the deployment of shared resources (particularly terminological resources) and the use of collaborative authoring environments. In most cases a controlled language consists of:

- restricted vocabularies (particularly the terminology of the domain),
- simplified syntactic constructions (e.g. no passive, short sentences, limited use of pronouns, etc.),

• limited semantic interpretations (e.g. restriction of reading variation according to the domain).

In our context we use a different interpretation of the term *controlled language* (CL). In our approach the CL is not the language of the final technical description (document), i.e. the document language, but the language for *specifying* the content and the structure of the document. The use of this language is not only supported by linguistic means such as checkers (cf. above) but also by multi-modal input utilities such as technical graphics, which certainly improve the learning curve of the user.

Within our project we have started to develop a specific rule set for German (HUS-CL-DE)[3]; this rule set constitutes language-specific specializations of the general rule set HUS-CL, which is concerned with language-independent text structure related controlling facilities (a kind of generic document type definition – DTD). As an information source this rule set forms another part of the web of ontologies, which constitutes the entire knowledge infrastructure of the streamlined HUS. The language-dependent part of HUS-CL contains links to the appropriate mono-lingual resources (grammar and lexis) that are needed, on the one hand, for the CL interpretation (analysis), and on the other hand, for the generation of parts of a HLI in multiple languages.

The HUS-CL specifications are mapped onto ontological descriptions which are then the input of the document generator. In order to allow for the exchangeability of these specifications parts of them can be mapped onto the Knowledge Interchange Format (KIF); here particularly terminological and ontological descriptions for maintenance and exchange purposes. When used as an information request language, the HUS-CL specifications can be mapped directly onto knowledge base queries (e.g. SQL statements). This flexibility then allows for the integration of the streamlined HUS in different network-based applications.

3.4 Agent-based Architecture

The third step then deals with the network embedding of the HUS. For this the HUS information space is realized in a distributed, real-time, interactive system. The key feature of this system is that it is agent-based: an agent being an autonomous program, or software component, operating on behalf of a human user or another program. The core architecture of our solution consists of:

Domain Model constituting the theory of the system's expertise. It comprises: (a) the vocabulary of objects, relations, functions and service classes, (b) models of typical tasks, (c) mappings between the entities of the vocabulary, and (d) heuristics and inference models for identifying relevant information.

Resource Models constituting the system's competence.

Support Agents for request assistance, retrieval planning, retrieval execution and information presentation.

In this scenario the NLP agent is one of the main application agents; it exhibits the following functionalities: (a) Communication with the local information base agents and the transformation of the local restricted natural language information into a local knowledge base entity; (b) maintenance of the local knowledge base and announcement of possible services; (c) performance of possible legal checks to guarantee the consistent use of the current part of the web of ontologies. This is done by

[3] Additional languages will follow if the approach has proven to be successful.

communication with the local ontology agent and the local knowledge base agents; and (d) serving of requests coming from the network through the facilitator, cf. below).

At the highest level this system is organized as a number of resident agents communicating through a network infrastructure. The network infrastructure is provided by a set of lower level agents, one per site to provide different functionalities such as anonymous interaction, dynamic interaction via the facilitator, maintenance of distributed ontologies, etc.

In proof-of-concept implementations we are experimenting with the concurrent constraint object-oriented language Oz as well as with Sicstus Prolog Objects and pure Java implementations. For the user interfaces on top of existing network browsers, such as Netscape, we use the Java programming language and Java Applets based on previous Tcl/Tk implementations.

4 Conclusions and Prospects

The presented approach to step-by-step streamlining an existing online service support system ensures a consistent representation of different data, information and knowledge entities, which can serve different natural language related processes including translation, as well as information storage, maintenance and retrieval. In addition, the conceptual representation of domain, product and production knowledge in a knowledge base can act as a multi-purpose basis for other network-based applications. In our application the use of ontologies is threefold: (1) it constitutes the information and knowledge repository of the domain, (2) it ensures the effective message passing (communication) of several agents of the network infrastructure, and (3) it facilitates the deployment of machine translation.

The knowledge structure used for navigating through the information base could be enhanced by a *data-mining* agent which identifies non-explicit correlations between concepts. This would contribute to summarizing regularities needed for product improvement, future diagnostics, etc.

Since multilinguality is a major advantage of future network-based information services for citizens of the information society, language technology shall be further integrated with other multimedia technologies, in particular with virtual reality (VR). This then allows better information visualization, information communication and the maintenance of shared worlds, where individuals, objects and processes interact without regard to their location, but by preserving personality, privacy and cultural heritage.

Lust but not least, network-based information services, as presented in this paper, constitute a new challenging application field for machine translation that is getting more and more important within the next years, although today it can be seen as a niche application only.

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