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# A VR/KM INTEGRATED PLATFORM FOR SUPPORTING INTEROPERABILITY IN CONCEPT DESIGN

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## 1. Introduction

International competition and the rapidly global economy offer to the consumers an enormous choice of goods and services. The result is that companies now require quality, value, time to market and innovation to be successful in order to win the increasing competition. In the automotive sector this is traduced in the need for optimization of the development process, that, in authors' view, can be achieved enhancing the technological support during the creative design phase and through the maximization of re-use of data and internal knowledge of the company.

For this reason the aim of this research is the development of a platform that integrates Virtual Reality and Knowledge Management systems, so far two distinctive research fields, within the early stages of the design process. The main contribution of this article is in the description of a platform that, through the integration of highly information-rich environments such as Virtual Environments, with Knowledge Management systems, will support not only design creativity, enhancing stylers' natural capacities, but will also allow a better understanding of the creative process through its decomposition.

## 2. Related Work

The SIMI-Pro project spans across a number of technologies both related to Media-rich content and to Knowledge Management. Multiple ontologies, together with domain thesauri, set the foundations of SIMI-Pro. Ontologies are "consensual, shared and formal descriptions of the concepts that are important in a given domain" [van Harmelen 2000]. The research community is expressing growing interest towards them in many scientific fields and nowadays they are emerging as crucial ingredients in Semantic Web applications. In particular, in order to effectively automate the combination and coordination of multi-language and cross understanding supports, the system is based upon ontology of the design process. This, in turn, is based upon an existing Knowledge Level theory of design [Bonifacio 2003, Ucelli 2003], which identifies, at a general level, the different kinds of knowledge used and generated in design, the roles they play in the process as a whole, and the relationships between them.

Research efforts in the identification of ontologies, their use and construction, were originally included in the domain of Knowledge Engineering methods. CommonKADS, and various other ontology specification languages were developed with the specific purpose of building domain ontologies. More recently, due to ontologies' increasing role as essential components of the Semantic Web, we have witnessed a convergence of efforts of Web-based specification languages and ontology-based specification languages. This convergence enriches the development of the SIMI-Pro system of important theoretical stimuli and it gives the chance to use the emerging standards and tools in this area. XML and XMLS, RDF and RDFS, together with OIL (Ontology Inference Layer) and DAML (DARPA Agent Markup Language), currently being combined into the DAML+OIL language, have been selected for the implementation of the Semantic system. Furthermore, the tools that have been developed to use these languages, such as OILed, FaCT (Fast Classification of Terminologies), Ontoedit from Ontoprise together with its related products Ontoannotate and Ontobroker, and eventually Protégé-2000 are currently evaluated for use in the implementation phase of the system.

WordNet [WordNet 2004] is a linguistic ontology designed according to psycholinguistic theories of human lexical memory. It contains nouns, verbs, adjectives and adverbs. The most significant feature of WordNet is in organizing lexical information in terms of word meanings rather than word forms, where with *word form* we mean the physical utterance or inscription of a word, versus *word meaning* which instead identifies the concept expresses by the word form.

Software prototypes enabling a distributed approach to knowledge management bring forward a new paradigm for knowledge management systems, called Distributed Knowledge Management (DKM), which considers subjectivity and sociality as intrinsic dimensions of knowledge.

KEEx [Edamok 2004] is one example of this concept, since it is based on a peer-to-peer architecture, on natural language processing techniques and on an automatic algorithm for meaning negotiation which allows the user to arrange its own knowledge structure autonomously.

Key technologies regarding the Media-rich contents are the ISO standards MPEG (Moving Picture Experts Group) versions 4, 7 and 21 which allow delivery and manipulation of multimedia data such as video, audio, images, documents and 3D models. MPEG-4 provides the means to encode multimedia content, MPEG-7 introduces a standard for content description, while MPEG-21 focuses on creating an open framework for multimedia data, which allows standardize interaction and manipulation of multimedia content.

Further, within several ongoing European projects, such as Smartsketches (Smartsketches 2004), WIDE (Wide 2004), and MOKA (Moka 2004) the research community is investigating methodologies and techniques concerning the support of natural designers' creativity in VR, and retrieval of knowledge and re-use of design solutions. The recently started European project AIM@SHAPE (Aim@Shape 2004) aims at establishing a new multi-disciplinary research field, which, to best of the authors' knowledge, for the first time bridges and deeply integrates Computer Graphics and Vision with Knowledge Technologies.

Finally the project is currently implemented in Java™, a programming language that in previous authors' experiences, developing network-based collaborative environments [Ucelli 2002, Conti 2002], has proved to be powerful and offered great flexibility. This choice allows compatibility with Web tools and already available PDM applications, the possibility to use built-in functionalities and libraries related to database management. Finally yet importantly, this choice provides hardware independence, network capabilities and application portability. These represent key factors when various parties have to employ the software from a multitude of different computer configurations through a network system.

## 3. Project Aims

Any communication problem among different participants to the design process could be considered a knowledge management issue. The obvious theoretical best solution would be the adoption of a common language across the workplace although the identification upon such language is not always achievable. In fact, industrial designers and product engineers, due to their different education, training, and working practices, tend to develop different working approaches. As a result of having industrial designers and product engineers belonging to different background areas, the two groups are characterised by substantially different points of view on product design. Not surprisingly, this ultimately leads members of the two communities to think and refer to designing of products through different terms.

Effective sharing of knowledge, however, does not necessary require the two parties to speak a common language. In fact, it would be sufficient a mutual understanding of each other's language

while speaking their own: this circumstance would minimize the personal effort since it would not require both groups to adopt a different language.
Starting from this assumption, the concept behind the development of SIMI-Pro is to provide an effective information management and knowledge sharing system specifically targeted for both industrial designers and product engineers. The system will support inter-working by effectively helping the two groups understand other parties' languages and methodologies. It will facilitate the communication among different professional profiles to ultimately deliver a better product result.

## 4. The system architecture

The core of SIMI-Pro is structured in three layers representing different types of information: a content layer, a semantic or meta-layer and the user-interface layer. Each layer has its own purpose and handles different information elements:
The *content layer* deals with the creation of a database and a related query interface. In particular, the primary objective of the database is to store the content of information required by the user. In order to allow access and interaction mechanisms for semantic search engines, it is based on XMLS. Moreover, within this layer, a dedicated interface to the upper levels will be implemented. This layer hides specific data originated by the use of ontologies, such as the origin of information (internet, PDM or local database) and the implicit structure of the information objects. Eventually the content layer takes care of extending the existing meta-data system of the database in order to address semantic aspects for retrieval. Thus, it is closely related to the meta-data system of the next layer.

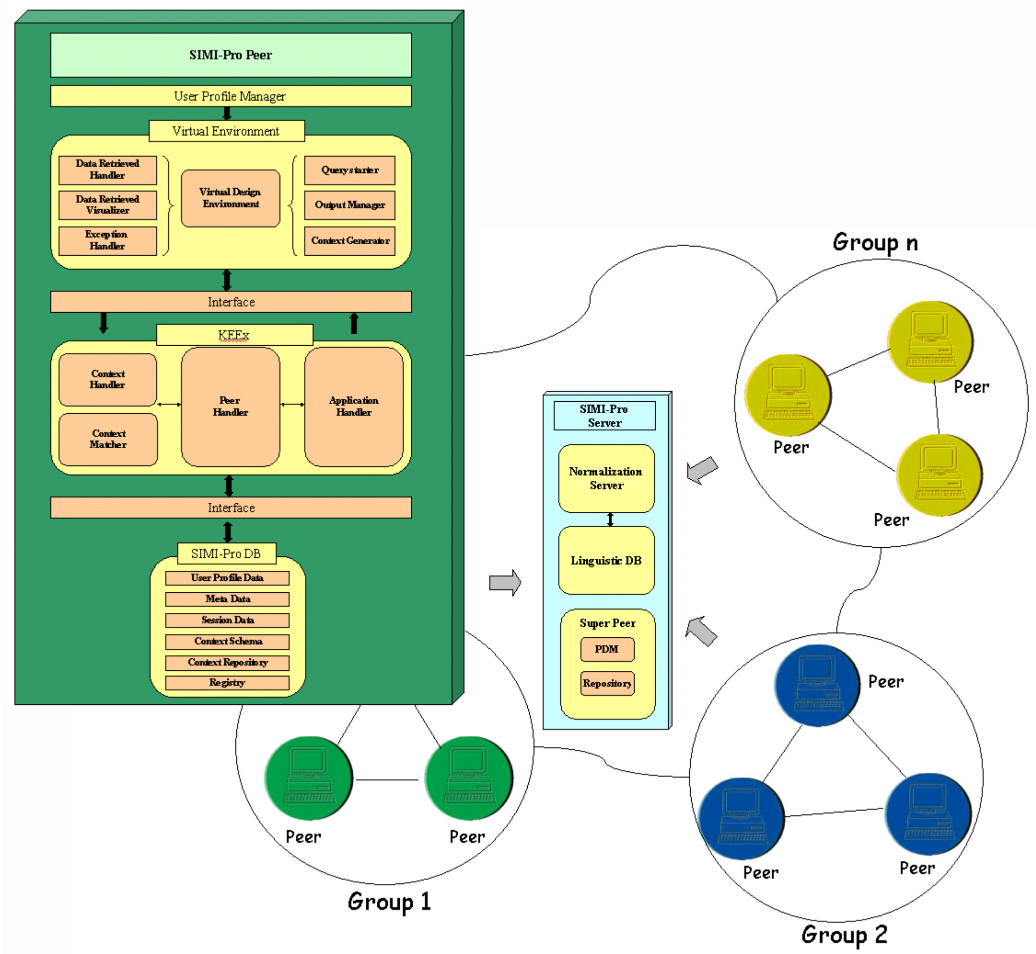


**Figure 1. The system architecture**

The *meta-layer* contains the design process ontology at the base of the system. It coordinates and controls the data flow between the information management and knowledge sharing system. It provides the tools needed to construct, maintain, and access the domain-specific and user-types ontologies. It deals with the meta-data construction and the implementation of access mechanisms. Moreover, within this layer, tools to build and maintain domain and application thesauri will be provided to the user. These are important to transfer and share knowledge among different expert groups, since words interpretations can lead to misunderstanding. By these means, the meta-level adds the semantics to the content layer and it ensures that information from other language domains sources are also considered in the retrieval process.

Finally the *user-interface* layer contains the graphic user interface (GUI) that will be interfaced with a Multimodal Virtual Environment (VE) in order to access information directly from the VE. The information filtering and visualization mechanisms are performed within this layer. Finally, it provides the dynamic interface adaptation mechanisms needed to adapt the system to the type of user, activity context and to the design stage. These functionalities provide the user with a source of information easily customizable and with an information space flexibly adaptable to a specific user.

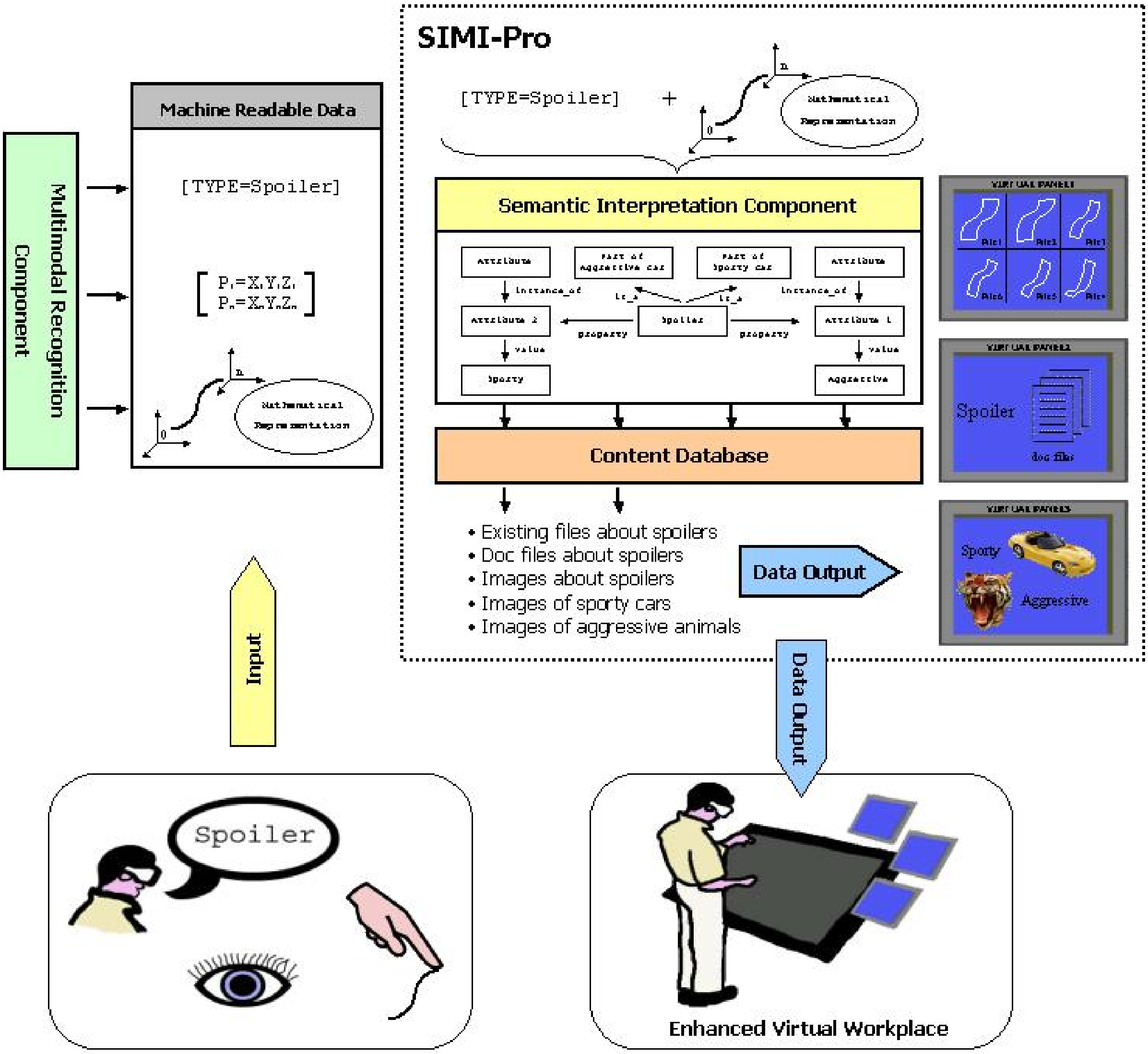


**Figure 2. The interfacing of the system with the Multimodal Virtual Environment**

### 4.1 Semantic Module

The main objective of the semantic module is to allow the semantic description of data that can be easily accessed by computers, and to improve the retrieval of information for people coming from different cultures, i.e. industrial designers and product engineers.

Computer readable semantic descriptions for advanced searching capabilities is one of the goals of the SIMI-Pro system since keyword-based retrieving though search engines of 3D models, multimedia files, visual content, such as images and videos, or audio has been tedious or technically unfeasible. The result was the implementation of information retrieval systems for visual and 3D objects based on pattern recognition or feature recognition where, more than on semantics, the retrieval mechanism was centred on a pattern, texture and feature analysis.

Industrial designers and product engineers need to communicate during the design process but they often refer to very different terminology and especially to meanings of polysemous words, which means terms with various meanings. In particular, designers require a system capable of supporting queries based on natural speech. To allow this the system needs to support, apart from the recognition of lexicon and identification of semantic relations, word morphology, such as inflectional morphology. For instance, the system has to be able to recognize the term “cars” as the plural of “car” in order to process the natural language-based query.

The research work here described has been focused on the quest for a relying approach to address semantic description, interpretation and querying requirements. In order to address the requirements of the SIMI-Pro users, the proposed approach is the adoption and extension of a lexical reference system, named WordNet [WordNet 2004]. This is integrated with some of the functionalities of a general-purpose semantic-based knowledge management software prototype called KEEx, Knowledge Enabling and Exchange system [Bonifacio 2003]. The combination of KEEx and WordNet allows to cover the handling of linguistic resources, the relation between words, hierarchical and parental relations, word sense disambiguation, meaning negotiation and the possibility to search for information taking into account the semantics behind the information.

### 4.2 Handling of multimedia content

Delivery of content for the styling department requires handling data of various formats from still images of old cars to adverts of new car models. The approach proposed for the implementation of the content layer and the meta-layer implies an extensive use of XML based technologies such as XML databases and of MPEG-4/7 ISO standards. In particular the ISO/IEC MPEG-4 standard allows the production, distribution and content access of a broad range of formats for text, images, videos, audios and VRML scenes and it eases the possibility to produce multimedia content wrapping them together into MPEG-4 files. The MPEG-7 standard, formally named “Multimedia Content Description Interface”, eases the creation of metadata for multimedia content since it provides a rich set of standardized description tools, Descriptors and Description Schemes, to create descriptions. The flexible support of different formats provided by the MPEG-4 standard together with the metadata elements, their structure and relationships supported by MPEG-7 can significantly ease a centralized access to data content.

## 5. Results

The main outcome of the present project is the integration, extension and adaptation of existing technologies in the domains of CAD modelling, design, analysis, simulation, networked cooperation, and virtual reality to develop a platform, which provides the basis to take the greatest advantage of the Virtual Prototyping techniques and leads to a wide diffusion of the Virtual Product Development Process (VPDP). The backbone of the desktop environment, the knowledge management platform, can thus enrich existing product information structures, such as PDM systems, with automatic semantic interoperability and capabilities of interpreting shape and product attributes for fast gathering of information and retrieval of design solutions.

## 6. Conclusions and Future Developments

It is acknowledged that the conceptual design phase is characterized by personal creative processes traditionally carried out using freehand sketches and by means of knowledge gained through personal experience. Previous authors' works have delivered Virtual Reality technology-based applications for conceptual design [De Amicis 2001] [Conti 2003] and concurrent research activities have been focusing on technology and methodology for Knowledge Management with the attempt to tackle issues related to the structuring of companies' knowledge [Koch 2001]. The project proposes an integrated approach grounded on both domains, which yields an interactive platform supporting the stages of styling and engineering design within the concept phase of the industrial PDP, wrapped by a knowledge management system.

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