Title:
A Web-enabled Configuration System for Interior Design

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Introduction:
Today, contract furniture represents a promising opportunity for SMEs to be competitive in the worldwide market. A previous research work [1] outlined the main characteristics of contract furniture design and the main problems to manage such extensible and temporary cluster of involved companies, different in size, adopted information technologies, developed products, project goals, skill, etc. A technological framework was proposed to face two open issues:

- none Computer Supported Cooperative Work system is dedicated to this complex application area, whose needs regard the simultaneous support of information exchange along the furniture life cycle, the management of multiple and conflicting design constraints and process requirements and finally the creation and sharing of the whole furnishing Bill of Materials [2, 3];
- the management of an high level of furnishing customization is complex as personalization depends on numerous requirements: from the needs of the target market, the standards of the country, the customer profiles, the contract typology, the design style, the target cost to the expected performance, etc. It is much more than a simple variation of the item dimension as it is extended to finishing, functions, aesthetics, etc. In addition it does not regard the single furniture item, but the whole space. As a consequence a CAD-based solution must manage configuration at different levels of abstraction. A browser-based tool could enable users to visualize and interact with complex 3D configuration [4].

To accomplish these objectives an overall platform was developed. It consists of four main user interfaces: one dedicated to the online product configuration and 3D visualization of the custom solution, one to the selection of the personalized items and their integration into a 3D architectural space, one to manufacturing companies to define models and design contractions and one to support the co-design of integral solutions.

The present research work mainly focuses on the description of the web-enabled configuration system that allows both designers and manufacturers to customize 3D CAD models of architectural spaces and items and to share them with the overall contract furniture network. Configuration is based on a set of knowledge-based rules that guarantee the coherence of the designed solutions with manufacturing and installation constraints. The main proposed contribution of this paper is as follows: the developed 3D-web based visualization of integral solutions and single items, the adopted infrastructure to exchange and synchronize data among the different desktop and internet based applications, the structure of the virtual prototype as a compendium of both geometric, functional, technological features to enable each company to contribute with its specific knowledge, the developed graphic rendering algorithms that are homogenous in web and CAD-based tools and finally

the modality to guarantee the coherence of information flowing across the system modules by the sharing of model and data structure.

Main idea:
The paper presents a CAD-Based infrastructure to support the 3D visualization and on-line configuration of furniture items, the creation of a shared relational database of products, integral solutions, design rules and contract furniture applications and finally the configuration of whole architectural spaces by selecting and positioning furniture items according to a set of knowledge-based rules. To accomplish this objective four user interfaces are developed, as follows:

- a web-based virtual marketplace promoting in an appealing way the products offered by different manufacturers. The software allows user identification, authentication and tracking to achieve a complete profile. Once logged, the user can view a rich catalogue of products and assess all predefined variants by an high quality rendering. The catalogue is written in ASP.NET code to produce dynamic Web pages, applications and services and adopts WebGL for rendering interactive 2D and 3D graphics of product models, scene and solutions within any compatible web browser;
- a configuration tool able to support the 3D configuration of both products and architectural space according to a set of knowledge-based rules and best practices. Items are positioned in the environment from the Virtual Catalogue by following manufacturing guidelines, technical constraints and geometrical relationships among objects in space. The system is interfaced and synchronized with the Virtual Catalogue to keep the selected products and solutions ever updated. The Configurator is implemented on the .NET Framework adopting object-oriented computer languages and exploits the programming capabilities of the graphic card through the shading language to realize 2D and 3D photorealistic rendering.
- a management tool to make companies upload products and solutions into the catalogue, preset the product variants (e.g. colors, finishing, functions, features) and add technical documentation suited for the different furniture stakeholders (e.g. contractors, designers, architects and end-users). For each item the company provides the 3D model, indicate existing or customizable characteristics, specify possible accessories or auxiliary functions, define customizable features and allowed range of modification, add installation and configuration constraints and finally attach technical information such as manuals and data sheets. The module is developed by the same implementing technology of the configuration system and is synchronized with the platform-shared database.

A hierarchic structure is introduced to represent the whole environment, product groups (the kitchen), single product instances and the product inner structures (the drawers of a cabinet). A single product is defined as a two-level geometric representation. The first one is a detailed triangulation enriched with material definitions in order to pursuit a realistic rendering. The second one is a hidden B-Rep analytic representation to be used as the basis for geometric functionalities such as mating, part measuring and positioning. Materials and lights are defined with a good level of complexity. The material includes maps for diffuseness, transparency, reflectiveness and bumping. Light description comprises custom illumination diagrams from LTD files and can be associated to products as for lamps. The product exhibits several degrees of configuration. First of all a product comes in variants which basically represent different geometric arrangements. Each product variant may then have several graphic variants, i.e. different materials to be applied on the same geometry. A set of parameters is defined to control each product variant, such as the status of the geometric and/or graphic variant (e.g. active), the position of the part in the assembly, the scaling factors, etc. Rules operate on these parameters to implement configuration logics. The products are stored on a shared repository on the cloud. The repository is filled by the companies which have the rights to view and update only the own product definitions. The repository is accessed by the environment configuration tool and by the virtual catalogue. Information retrieved in the system databases flows across the different platform modules. This is allowed by data sharing and data synchronization once the user logs and connects to Internet.

Conclusions:
A CAD-based configuration system exploiting web-enabling capabilities is presented. Implementation results are described in detail focusing on how the system is able to share and synchronize information among different platform modules in order to keep data coming from different sources updated. The case study for experimentation is the design of a Serviced-Apartment. Testing involved 10 SMEs. Result analysis outlines the usability of the system and the achieved effectiveness in terms of tool flexibility, time to market reduction and capability to manage design conflicts.

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