Designing in VR

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The VR technology can be considered the most powerful tool introduced into the design process in order to realise immersive and interactive experience in the virtual world. Since earliest applications, both in the industrial engineering and civil architecture fields, the VR environment has anticipated, for the first time, the interaction of designers with new concepts at the first stages of the design process. The simulated interaction has enabled design team to be timely conscious of design faults and to provide project improvements or to develop innovative learning platform for highly specialised operators. The combination of direct 3D-interaction, 3D-visualization and 3D-devices makes, in prospective, VR an ideal medium for all “designing” tasks, from the conceptual phase to the detailed design phase.

The positive results obtained from the first applications of VR technologies in automotive field have confirmed, to the industrial world, how these tools can be useful, potentially and in practice, to improve the quality of new industrial products and to develop new methodologies and new training procedures. *Design for virtual* styling, usability, ergonomics, maintainability, mechanical assembly/disassembly and crashworthiness, and ‘learning by *virtual* doing’ approach are significant examples.

While in the classical design paradigm the design team explicitly takes into account the object and implicitly the user, in the VR environment the design team can simulate the interaction between the system and real users as a whole. This is a crucial point. The design team has assumed, designing in

VR, an explicit responsibility in planning, doing, checking and consequently acting, in the most realistic way, the simulated interaction between experts or users and design objects. The responsibility concerns both technical aspects and cognitive aspects that influence the human behaviour in learning or evaluating new objects, environments or systems. Therefore, from one hand the design team can realise simulating scenario with a graphical realism—just thinkable two decades ago—on the other hand, the design team needs more and more to grow in competencies, to collect in repeatable way the analysis that are carried on in VR, to synthesise a large amount of data that are collectable during the experimental session and unavailable with old technologies.

To-date main challenges for the “Designing in VR” concern:

- I) simulations, in VR environment, of the users’ behaviour, as in the real world;
- II) planning of the virtual experiments that are repeatable and representative of the real variability, and validation of the collected data;
- III) proposition of tools and methods for civil, industrial and engineering design that take into account the potentiality of these technologies more than in the recent past.

Applying classical design tools and methods in VR could result in a failure. This well known circumstance constitutes the impulse to the development of new researches and it is continuously increasing. New competencies concerning IT, psychology, experimental statistics and design methods are, more and more, required to fully utilise the VR potentiality.

The first aim of the researchers is to design VR *experience*. This means to simulate in VR the behaviours of the users

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as in the real world, and to give an immersive experience involving the users with their senses during the simulated interaction with the virtual concept. Strong research efforts are currently devoted to simplify the human-VR interaction. All those users, managers or technicians that are not skilled in VR technologies will really appreciate the advantages of VR simulations only if researchers will be able to improve the usability of 3D interaction devices and the realism of the simulated human behaviour. Further, a very interesting research field concerns the synergic use of both virtual human and real human in studying user-product-environment interactions.

Second aim of researchers is to demonstrate that data collected in VR are highly correlated to data potentially collectable in real world thanks to real concepts and experiments. Virtual experiments by VR can be viewed as an emerging research field concerning new way to face, understand and control experimental variability; the new approach is at the interface between the classical statistics and the computer experiments. Computer experiment is a quite new research field concerning the statistical design and analysis of virtual experiments under the assumption that no variation is possible between runs that start from the same initial conditions. In the computational environment the variability can be only simulated introducing explicitly random variable in the code and using adequate techniques (e.g. Monte Carlo method). Virtual experiments in VR are deterministic in the simulated environment, but are really useful to evaluate variability, that is naturally introduced by the users or designers who are the principal actors of the simulation experience.

Finally, researchers aim to integrate more and more in the design cycle the VR with other CaX tools. Starting from a deeper understanding of the potentiality that the simulation of human-machine-environment interactions can have in the product or manufacturing or architectural innovation, new design paradigms will be spread in civil and industrial fields. The integration of design methodologies based on VR technologies in product development processes needs a better use of the results of a VR simulation that have to be clearly “visible” and “usable” in the PDM. Many research activities are currently focused to integrate CAD architecture inside a VR-system in order to make possible a real integration CaX-VR and to let the designer to intuitively model component parts, supported by graphical direct-manipulation and real-time feedback. The final goal is to reverse the traditional design practice where the validation of “human factors” is often an “a posteriori” activity. New paradigms of user-centred design or participative design approach are proposed with the aim to listen to the customer “voice”, to collect their evaluation, to capture their explicit and latent needs.

Even if from one hand, “Designing in VR” is a very hard theme to face in its complexity, on the other hand it has been

very attractive to propose a special issue that could focus the attention on *Interactive Land and Urban Planning Design*, *Concept Design in VR* and *Virtual Manufacturing*. The common point of view is the quality improvement that designers or users interacting with the virtual concepts can assure to the project.

For the Interactive Land and Urban Planning Design topic, an innovative approach in the context of future internet is illustrated. The contribution to the scientific community consists in developing an interactive Geo-Visual Analytics platform which allows the operators to access spatial information available from public administration repositories, to perform complex analysis related to the territory and to provide consequent design choice in a fully interactive way.

For the Concept Design in VR topic, a methodological contribution is presented concerning a new design strategy able to integrate the perception and expectation of users since the early stages of design process. An original case study is presented dealing with the quality improvement of train interiors. The design team can develop and evaluate new concepts by combining advanced CAD tools, experimental statistical methods and VR.

For the Virtual Manufacturing topic, a first contribution concerns adaptive manufacturing system design. The problem of the integration among mechanical, electronics and control engineering activities, for the optimisation of the performances of complex systems, is faced through a Virtual Commissioning tool based approach. Virtual Commissioning environments are used to create, model and share the product and process knowledge base, to virtually explore new solution spaces and to evaluate the behaviour of complex mechatronics systems.

A second contribution concerns the development of an innovative assembly process in railway manufacturing. The contribution faces a real industrial problem, proposing an original approach to its solution. Studying the interaction between the real human and the virtual robot for the assembly line of a modular train, and the accuracy requirements through a Computer Aided Tolerancing (CAT) system are, for the first time, proposed in the railway manufacturing field.

A third contribution concerns the interaction between real users and virtual objects and the use of Augmented Reality tools in order to study assembly procedures of virtual parts in a real context. The core of the proposed approach is the implementation of an algorithm able to recognise and interpret the user’s intent about grasping, moving and constraining of the virtual objects in the scene.

The last two contributions concern the development of innovative methodologies for the interactive design and manufacturing of mechanical assemblies through the combined use of Augmented Reality and VR. Both contributions aim to create novel interfaces to manage assembly’s digital data

using innovative visualization systems. The integration of PLO data and CAD functionality in an Augmented Reality and VR context is the main aim of these research works and original methods and applications are shown.

Thanks to all contributors and the Editor in Chief, this special issue gives evidence to promising research trends that constitute little steps toward the dream of *designing in VR*.