Summary

The habilitation thesis entitled „ *Complex and interdisciplinary applications of computer assisted engineering methods: reverse engineering, virtual reality, 3D modelling and simulation*" synthetically presents the results of the candidate's six-year research on the use of reverse engineering in engineering and other areas.

Chapter one entitled *Academic and professional achievements* presents briefly the research directions and the main achievements of the author after obtaining his PhD title in 2010. There are briefly presented the projects that have been managed as a project manager by the author and the papers published during the implementation of each project.

Chapter two is entitled Reverse Engineering (RE) and it presents the results of application of the RE method done by the author in the automotive industry, medicine and cultural heritage. The author developed and validated a methodology to verify the geometrical and dimensional deviations of free form surfaces with direct application ins the automotive industry. The case studies presented are made on a Formula 1 machine and were carried out in the 3D Measurements and Scanning Laboratory of Design Engineering and Robotics Department. Verification of geometric deviations and symmetry can be done in points in plane or globally, each case having advantages and disadvantages.

3D measurements and scanning is the primary data acquisition tools used in (RE) and they can be used successfully in other areas. Chapter two presents a number of contributions done by the author in regard to the use of RE methods in the medical field. Thus, by scanning a prosthesis obtained by casting the material into the mold, an entire range of prostheses can be modeled and parametrized enabling the manufacturing using more efficient processes such as plastic injection. The measurements have been done on coordinate measuring machines of the worn-out prostheses in order to highlight the location of the wear smear. Measuring prosthesis and highlighting wear areas does not represent an easy task given the precision of these prostheses and the degree of finishing. Using a high tech multisensory measuring machine, the author has obtained results according to those published in the literature. In the field of dentistry, reverse engineering has been used successfully to measure the differences between individual and ideal lingoes resulting from 3D scanning and modeling as well as the creation of detailed 3D models for virtual reality application used in medical training applications.

Mass digitization is a trend in which institutions active in the field of cultural heritage have joined without reservation considering this process to be the most appropriate way to considerably increase the number of people who have access to heritage assets. An important objective of these institutions is the digital preservation of the cultural heritage assets. The use of 3D scanning represents the only method that allows for high-fidelity models that ca be used both in conservation and research. By facilitating access to widely digitized models on a large scale for research, the premise is created to develop virtual workspace where connections between the studied elements are made much faster. Chapter two highlights an original method of restoring ceramic vessels in fragmented state using NUPBS curves (Non-Uniform-Polynomial-B-Spline). Thus, by parameterizing the profile of a vessel, a total number of 32 Dacian ceramic vessels were obtained with parameterized curves that have between 3 to 10 inflection points.

The use of the reverse engineering method for complex geometric artefacts can be aimed not only at preserving and restoring the artefact digitally but also simulating the manufacturing process required to obtain a tangible replica. A study has been carried out on the matrix found at Sarmisegetuza Regia which is probably the most complex antique artefact discovered in the territory of our country. Digitizing this artefact took more than 200 hours and made use of three diverse types of 3D scanners. At the end, after the data interpretation and simulation has been done it was possible to determine the order of drawing of the faces of the mould, the workflow used by the artisan in antiquity and based on the simulations of the casting process a hypothesis regarding the manufacturing of this artefact has been issued.

Another case in the field of cultural heritage was the digital restoration of the wooden support and of the painting layer of imperial gates from 15th-19th century wooden churches. In the case of these patrimonial assets, 3D scanning and modeling was used to fill in the missing parts and to digitally recreate the paint layer. The color layer was restored with current and original colors, the latter being obtained based on the physical-chemical analyzes of the pigments from within the painting layer.

In the third chapter of the habilitation thesis (Advanced Design and 3D Simulation Methods), some results are presented, which were obtained in the field of product design, using reverse engineering and advanced simulation methods. Thus, starting from a 1:20 scale replica of a rotor blade from Los Angeles class atomic submarines, a wind turbine blade was modeled and later manufactured using composite materials, which is much quieter compared to those fitted to household generators up to 4kW.

Advanced design and simulation methods are also used when designing a small electric car intended for the traffic in crowded cities, the 96BG concept will be made entirely of composite materials. This concept care is developed within the "Optimization of fiber-reinforced polymer composite materials and of the manufacturing technology used in the construction of bodywork elements for electric vehicles, PN-III-CERC-CO-BG-2016: 96BG" project.

Hospital beds are important elements in the patient care system, providing comfort to both the patient and the health care staff. The concept of bed developed up to the TRL2 is one that fits into the notion of "smart hospital bed" and allows it to be transformed into an armchair with the patient standing on it, using only a single linear motor and an innovative mechanism. From the innovation standpoint, the bed will be equipped with a retractable dome that will allow the creation of a private space with a connection to a system for purifying and filtering the air and allowing the light intensity to be adjusted inside it.

In chapter three are presented two virtual reality-specific devices, developed using methods such as QFD (Quality Function Deployment), FMEA (Failure Mode & Effects Analysis), or TRIZ (Teoriya Resheniya Izobretatelskikh Zadach).

Chapter 4, entitled "Virtual Reality", presents a training system for operators from critical infrastructures. The nature of these infrastructures often does not allow the staff to be trained in real situations in order not to endanger the lives of the trained operator and the environment. The development of this training platform was carried out using an innovation algorithm based on the TRIZ method, putting the focus on the training of personnel operating marine drilling installations. The design and development of the CAVE (Cave Automatic Virtual Environment) mobile system, which can be transported to various training points has been entirely carried out in CATIA V5 software. The widespread use of augmented reality in industry is imminent, facilitated by the emergence of the "Industry 4.0" and "AR aided manufacturing" concepts. In this context, the development of an augmented reality application allowing the display of quotations and geometric deviations directly on the real workpiece is an appropriate approach. The development state and improving directions for this application and how it works are presented in this chapter.

Chapter five presents development perspectives and topics to be addressed in the short and medium term within the candidate's research activity.