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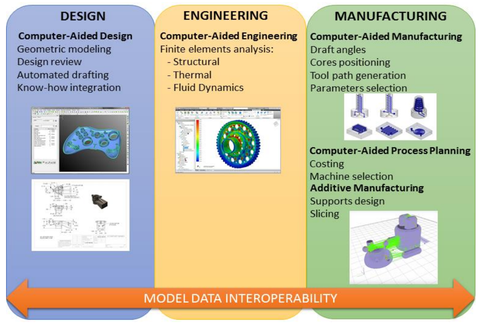
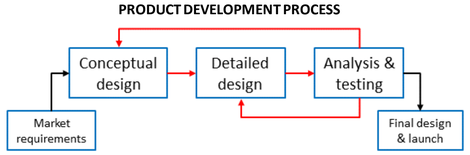
EXPLICIT MODELING TECHNIQUES IN THE CONCEPTUAL DESIGN PHASE

INTRODUCTION



3D CAD models with different levels of detail are widely used for numerous purposes in various industries. These models will be more reliable if users can flexibly control their levels of detail. However, users have to create models with different levels of detail manually, and this is a time-consuming and expensive process. Therefore, it is necessary to develop techniques to simplify 3D CAD models in order to adjust the levels of detail of the model according to its purpose.

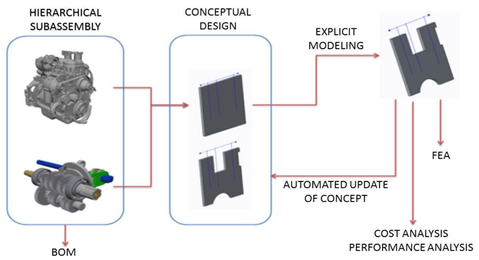
PRODUCT DEVELOPMENT PROCESS



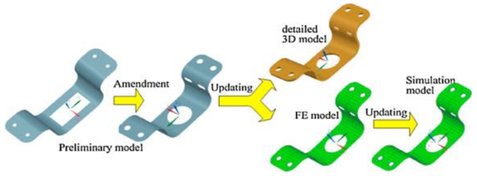
As the product development is a decision-making process based on information, for a better information integration among the different design stages, companies require a shared common model capable of adapting to the different features of every step and collecting different types of information, in order to leverage the company's know-how and to perform a successful Knowledge-Based Engineering (KBE).
The product development process is iterative and time consuming. The more compact are these stages, the more this iterative process is lean and fail-safe.

OBJECTIVES

The main focus of this project is to develop a plug-in for a modeling software for multiformat assemblies. We want to define a Smart Assembly Feature (SAF) which can detect specific relationships between different components. Once this relationship has been recognized and classified, the designer can edit different components simultaneously with direct modeling.



Since SAFs work on a neutral model (STEP, IGES), this process makes reusing 3D design data from older CAD model seamless and/or integrating 3D model from other CAD systems easier.
Direct modeling empowers you to define and capture geometry quickly, without spending time worrying about features, constraints, and original design intent.

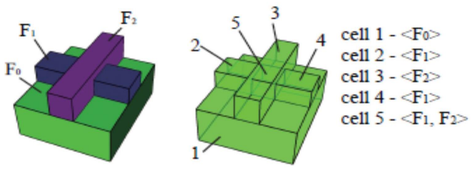


The neutral format model can be edited with direct modeling and thanks to its link with parametric model it can be immediately used in the detailed design phase, where design intent is captured using features and constraints, and this allows users to automate repetitive changes, such as those found in families of product parts. Either way, the new neutral format model can be used for a primarily simulation of the overall behavior.
Moreover, the simulation step can involve also the experience into a virtual and/or augmented environment, such as the assembly and disassembly sequence planning, training, maintenance and product ergonomics. This type of simulations require a simplified model as well, in order to ensure a high framerate for a realistic experience and a great amount of time to prepare the simulation.

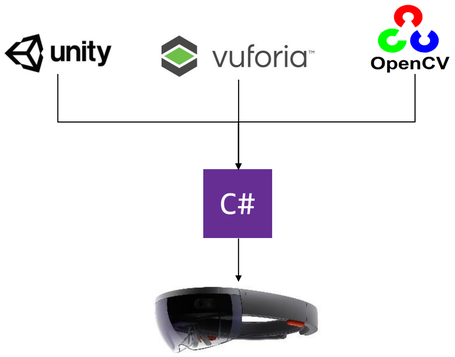
MATERIALS & METHODS

PLUG – IN DEVELOPMENT

C++
CAD software's SDKs and APIs
Open-Source geometric algorithms library (CGAL, OPENCASCADE)
Cellular model on two different STEP models



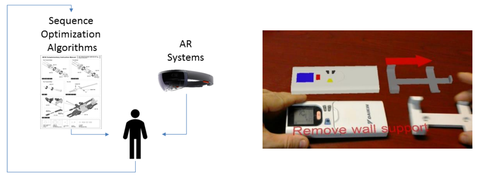
AUGMENTED REALITY ENVIRONMENT



RESULTS

AUGMENTED REALITY ENVIRONMENT

ARDET: Augmented Reality Design Evaluation Tool



27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

"Semi-automatic Design for Disassembly Strategy Planning: An Augmented Reality Approach"
Implementation of AR into a sequence optimization algorithm. The central point of this integration is not the simple use of an AR device with a visualization purpose, but the use of one or multiple devices to capture user's experience and intuitiveness and to embed them in the virtual environment.
In such a way, the AR device become an active sensor not only capable of capturing the physical environment, and to transform this environment in a virtual form, but also of acquiring intangible elements, such as experience, skills and intuitiveness, and converting them into a form that can be handled by a computer (Digital Twin). Filling the gap between virtual environment and real world.

PAPERS IN PROCEEDINGS OF INTERNATIONAL CONFERENCES

- F. Osti, A. Ceruti, A. Liverani, and G. Caligiana, "Semi-automatic Design for Disassembly Strategy Planning: An Augmented Reality Approach," *Procedia Manufacturing*, vol. 11, no. Supplement C, pp. 1481–1488, 2017.

SUBMITTED PAPERS

- F. Osti, G. M. Santi, and A. Liverani, "Real time shadow mapping for Augmented Reality photorealistic rendering," *ABSTRACT: In this paper, we present a solution for the photorealistic ambient light render of holograms into dynamic real scenes, in Augmented Reality applications. Based on Microsoft HoloLens, we achieved this result with an Image Base Lighting approach. The real-time image shot that has been designed is able to automatically locate and place VR lights in the scene, providing holograms with realistic and coherent illumination. Moreover we implemented a negative shadow drawer shader that contributes to the final photorealistic and immersive effect of holograms in real life. The solution is evaluated in various Augmented Reality case studies, where different condition of light occurred.*

CONCLUSIONS

In conclusion, we started the development of a synthetic environment suitable for 3D modeling and AR simulation. The 3D modeling suite adopts a hybrid modeling technique which utilizes both parametric and direct modeling operations in order to minimize the modeling of new geometries. This hybrid modeling enables the reuse of older and/or imported geometries and permits the simultaneous amendment of multiple components directly in the assembly file and the subsequent reorganization of the feature tree of the parametric models. The AR suite, whose development is more advanced, guarantees the automatic object detection and pose estimation. It can be used for the training of workers and/or the validation of design choices, like the assembly and disassembly sequence planning, and it has been tested in a simple case study.

PLANNING OF RESEARCH ACTIVITY

Upcoming objective is the development of the plug - in for the CAD system. The first step will be the selection of the more suitable geometric library. Among the Open – Source library, CGAL seems to be the most powerful and effective. After that, it will follow the development of a proper User Interface, which is crucial for the visual feedback of geometric modeling. Without visual feedback it will be difficult to control the results of the geometric functions application. Last step will be the implementation of cellular model features recognition algorithm on two neutral format component, because at the moment this method is developed only for features recognition on a single component.

REFERENCES

[1] Y. Xie, J. Liu, H. Liu, and Y.-S. Ma, "Features and Interoperability of Computer Aided Engineering Systems," in Semantic Modeling and Interoperability in Product and Process Engineering: A Technology for Engineering Informatics, Y. Ma, Ed. London: Springer London, 2013, pp. 143–191.
[2] N. Sajadfar, Y. Xie, H. Liu, and Y.-S. Ma, "Introduction to Engineering Informatics," in Semantic Modeling and Interoperability in Product and Process Engineering: A Technology for Engineering Informatics, Y. Ma, Ed. London: Springer London, 2013, pp. 1–29.
[3] J. Owen and M. S. Bloor, "Neutral formats for product data exchange: The current situation," Computer-Aided Design, vol. 19, no. 8, pp. 436–443, 1987.
[4] F. Bianconi, P. Conti, and L. D. Angelo, "Interoperability among CAD/CAM/CAE Systems: A Review of Current Research Trends," in Geometric Modeling and Imaging–New Trends (GMAI'06), 2006, pp. 82–89.
[5] J. Han, M. Pratt, and W. C. Regli, "Manufacturing feature recognition from solid models: a status report," IEEE Transactions on Robotics and Automation, vol. 16, no. 6, pp. 782–796, Dec. 2000.
[6] S. Gao, W. Zhao, F. Yang, and X. Chen, "Feature suppression based CAD mesh model simplification," in 2008 IEEE International Conference on Shape Modeling and Applications, 2008, pp. 271–272.
[7] M. R. Henderson and D. C. Anderson, "Computer recognition and extraction of form features: A CAD/CAM link," Computers in Industry, vol. 5, no. 4, pp. 329–339, Dec. 1984.
[8] J. H. Vandenbrande and A. A. G. Requicha, "Spatial reasoning for the automatic recognition of machinable features in solid models," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 15, no. 12, pp. 1269–1285, Dec. 1993.
[9] U. Cugini, F. Mandorli, and I. Vicini, "Using Features as Knowledge Formalization for Simultaneous Engineering." pp. [15] K. Rahma337–349, Dec-1992.
[10] J.-Y. Lai et al., "Recognition of virtual loops on 3D CAD models based on the B-rep model," Engineering with Computers, vol. 32, no. 4, pp. 593–606, Oct. 2016.
[11] J.-Y. Lai, M.-H. Wang, Y.-K. Chiu, C.-H. Hsu, Y.-C. Tsai, and C.-Y. Huang, "Recognition of depression and protrusion features on B-rep models based on virtual loops," Computer-Aided Design and Applications, vol. 13, no. 1, pp. 95–107, 2016.
[12] L. Zehtaban, O. Elazhary, and D. Roller, "A framework for similarity recognition of CAD models," Journal of Computational Design and Engineering, vol. 3, no. 3, pp. 274–285, 2016.
[13] R. Jakubowski, "Syntactic Characterization of Machine Parts Shapes," Cybernetics and Systems, vol. 13, no. 1, pp. 1–24, 1982.
[14] V. B. Sunil, R. Agarwal, and S. S. Pande, "An approach to recognize interacting features from B-Rep CAD models of prismatic machined parts using a hybrid (graph and rule-based) technique," Computers in Industry, vol. 61, no. 7, pp. 686–701, 2010.
[15] K. Rahmani and B. Arezoo, "Boundary analysis and geometric completion for recognition of interacting machining features," Computer-Aided Design, vol. 38, no. 8, pp. 845–856, 2006.
[16] V. B. Sunil and S. S. Pande, "Automatic recognition of machining features using artificial neural networks," The International Journal of Advanced Manufacturing Technology, vol. 41, no. 9, pp. 932–947, Apr. 2009.
[17] V. B. Sunil and S. S. Pande, "Automatic recognition of features from freeform surface CAD models," Computer-Aided Design, vol. 40, no. 4, pp. 502–517, 2008.
[18] B. Venu and V. R. Komma, "STEP-based feature recognition from solid models having non-planar surfaces," International Journal of Computer Integrated Manufacturing, vol. 30, no. 10, pp. 1011–1028, 2017.
[19] J. Fu, X. Chen, and S. Gao, "Automatic synchronization of a feature model with direct editing based on cellular model," Computer-Aided Design and Applications, vol. 14, no. 5, pp. 680–692, 2017.

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