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An adaptable virtual engineering platform for distributed design based on open source game technology

Paul McIntosh, Aleksandar Subic *, Ka Wai Lee, Patrick Clifton, Pavel Trivailo, Martin Leary

School of Aerospace, Mechanical and Manufacturing Engineering, RMIT University, Melbourne, Australia

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ABSTRACT

This paper presents the *RMIT Adaptable Platform for Interactive Distributed Design, Customisation and Optimisation* (*rapidDCO*), a CAD/CAE research platform which is an extension of distributed component based gaming technology. rapidDCO is designed for use in multidisciplinary, collaborative and distributed engineering environments where conflicting design parameters have to be resolved by remote input from a range of disciplines and techniques. rapidDCO leverages the open source game engine Delta3D, which itself leverages existing open source technologies to provide features such as: cross-platform 3D rendering, physical simulation and networked interaction. Our approach enables the CAD/E platform to seamlessly adopt advances in the technology but leveraging work done through the broader open source community. Through these technologies and the access to the underlying source code rapidDCO is highly adaptable and can be applied to novel problems not readily supported by conventional CAD/CAE environments. Rather than building CAD/CAE capability from a "top down" tool perspective we take a model-centric approach, building capability from the model "up". In rapidDCO individual models are defined as software components which are then shared as libraries that are used by the "component aware" environment. This component based approach means that development can be focused on defining specialised models to address a specific need and not on the infrastructure to realise and interact with those models. We present rapidDCO with a formal design customisation and optimisation example demonstrating the use of rapidDCO's custom interface capability, distributed design and integration with the modeFrontier® design optimisation tool and Microsoft® Excel.

1. Introduction

Novel approaches to computer aided design and engineering, by their nature, necessitate the development of novel computer software to realise and evaluate the application of those approaches. As engineering technology and the associated design and analysis software increase in complexity, so does the complexity in developing the infrastructure to support applied CAD/CAE research. An increasing proportion of the available research effort is expended in developing custom versions of support tools, such as 3D visualisation, file formats and networking capabilities. These support tools are fundamentally necessary, but do not directly contribute to the associated research outcomes. As a consequence, the research effort available for the design project is reduced. Furthermore, the support tools are typically optimised for a specific purpose and the generic functionality is kept to the absolute minimum required, resulting in software that is not easily reusable or extendible to other research areas. This lack of generic functionality results in multiple instances of similar support tools being developed for multiple research projects, each optimised for a specific purpose with little generic capability and with highly limited capacity for integration. The net result is that much effort is lost due to the focus on short term goals.

This research addresses the identified deficiencies by creating a platform that supports novel engineering design, while building a reusable capacity of generic functionality. Our platform is based on the architecture of gaming technology, leveraging a platform which is designed to enable highly customised and reusable content in the context rapidly advancing graphics technology. We have extended this architecture to support distributed design, customisation and optimisation in the context of computer aid design and engineering. The result is *rapidDCO*, the *RMIT Adaptable Platform for Interactive Distributed Design, Customisation and Optimisation*. *rapidDCO* provides a long term solution, while supporting the needs of short term research, reducing the "non-research" effort and increasing the reuse of any effort that is required. The paper presents the rational behind *rapidDCO*, the theoretical and practical basis for its development, and a case study to demonstrate its features and effectiveness. This research effort

* Corresponding author.
E-mail addresses: paul.mcintosh@internetscooter.com (P. McIntosh), aleksandar.subic@rmit.edu.au (A. Subic), kawai.lee@rmit.edu.au (K.W. Lee), patrick.clifton@rmit.edu.au (P. Clifton), pavel.trivailo@rmit.edu.au (P. Trivailo), martin.leary@rmit.edu.au (M. Leary).

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represents 6 months of development by a senior software engineer supported by two PhD students, demonstrating both the reuse of existing RMIT research and the accelerated development provided through open source game technology.

2. Overview

In this section we summarise the need for a virtual engineering platform and the fundamental requirements of computer aided design and applied engineering design research in general. These requirements provide the basis for the capabilities of the *rapidDCO*. Also, this section will reflect on related work in the field that is of relevance to this research.

2.1. Problems in applied CAD/CAE research

The requirements of software for CAD/CAE research may be fundamentally different to the capabilities of conventional CAD/CAE software. For example, CAD/CAE typically aims to assist engineering practitioners to develop representative virtual engineering models. Whereas as CAD/CAE research aims to explore a particular design problem in detail, with an emphasis on demonstrating features outside the standard CAD/CAE feature set.

Applying software to solve three dimensional problems is accepted as difficult and evidence of this can be seen in the expense of commercial CAD/CAE software packages and the limitations of the open source equivalents. For research into novel areas either an existing software package needs to be extended or custom software must be developed. Basing research on existing solutions present a number of problems and creating new software is inherently difficult.

Established commercial software provides an industrial quality platform but introduces limitations through restricted access to the underlying source code and restricted freedom of use through licensing structures. Research is bounded by what can be accomplished within the give feature set of the tool and the provided extensibility. Research is further bounded by licensing conditions preventing, for example, a deployment involving large groups of users in a distributed environment.

Open source software, which aims to provide similar features of commercial software by contrast is less mature and needs careful evaluation before being considered a viable alternative. Also some licensing terms of open source software may conflict with the needs of the research project when considering how the developed extensions can be used and ownership of intellectual property protected.

The above situation has lead to research projects continually re-inventing the wheel or using a ''wheel'' that cannot be reused elsewhere. For example, one research project has used a commercial VRML browser to successfully visualise snowboard design, although the VRML browser accelerated the process it has introduced limitations in what is possible to model. The limitations have removed the ability to freely test the solution on multiple users (due to licensing cost) and to customise the underlying 3D model used for the visualisation.

These issues are not unique to RMIT and occur whenever considering a platform to base research on. Due to these problems RMIT have developed its own platform with a specific focus on CAD/E research. The goals of this platform are outlined in the next section.

2.2. rapidDCO objectives

The overall goal of rapidDCO is to accelerate research in CAD/CAE by building a platform that reduces development effort and increases reuse. In particular RMIT is interested in supporting research projects that have a large long term component of analysing a particular problem domain outside of a CAD/CAE environment. Once the analysis is complete, the projects then generalise the solution through implementation in a CAD/E environment. In this context the key goal of rapidDCO is not to accelerate modelling but to provide an ''anything goes'' platform that can implement key findings from a research project. As an example at RMIT Sports Engineering Technologies (SportzEdge), performance parameters of sports equipment are quantified through user studies and experiments, once these parameters are quantified then CAD/CAE techniques can be customised to meet the needs of the specific product (see Section 5).

To meet the overall goal we approached rapidDCO implementation through the following high level requirements:

2.2.1. ''Model-centric'' approach

Due to the applied research nature of the problem domain rapidDCO does not attempt to provide a platform that initially supports typical CAD features, such as various modelling tools for constructing an object. The platform focuses on models and their features being developed as a C++ library. This library makes use of C++ inheritance where all models are derived from a generic base model. Through inheritance and reuse over a number of research projects the base model will evolve into a fully featured modelling kernel. The evolution path means that a feature such as surface modelling may be introduced as needed through one research project and made generic in the base model so that all derived models gain this feature. Once such generic features exist, the user interface can then be updated to exploit those features (i.e. typical CAD interface tools can be developed).

2.2.2. Open source with permissive licensing

We have a requirement that RMIT have control over the source code RMIT develops for the purposes of commercial in confidence research to be undertaken. This need is served well by licenses such as LGPL (GNU lesser general public license [1]), which enables software to be closed though at the same time, allows access to the underlying libraries that the platform is built on.

2.2.3. Distributed interactive design

We have the requirement that multiple stakeholders can observe and interact with design objects in real-time. The rapidDCO platform must therefore enable real-time distributed communication between instances and have a customisable interface to suit the needs of different users. Further to this, the installation size and licensing terms need to support ease of download, installation and use across the internet.

2.2.4. ''Heterogeneous'' parametric design

We have the requirement for an ''anything goes'' approach, to allow design techniques to be combined in anyway the research sees fit. The rapidDCO platform must therefore provide a number of means of interacting with the model parameters.

2.2.5. Integrate with existing CAD/CAE technology

We have a requirement for a platform that supports the application to novel problems in a research context. The goal is not to imitate existing CAD/CAE environments but to provide a platform to address issues that are not supported by existing CAD/CAE environments. Therefore we have a requirement to allow ease of integration such as supporting a variety of CAD formats and providing interfaces for external tools to utilise.