Tampere University

From CAD to physics-based virtual prototypes: Framework for real-time simulation of virtual prototypes

Joao Perreira and Asko Ellman
Tampere University
MODPROD workshop 2020

Topics

- CAD and Virtual Reality
- Virtual Reality and PLM
- Game engine
- Physics engine
- Physics-based virtual prototypes: Framework
- Case Study: Harvester machine
- Conclusions

Introduction

- 3D CAD software is a common engineering tool for studying design ideas.
- Engineering work is mostly done in 3D CAD software throughout the engineering process from **conceptual design** to **manufacturing of final product.**
- **Virtual Reality** has been used for prototype review, co-creation, marketing and training.
- However, **link from CAD to Virtual Reality** has only been weakly supported**.**
- **CAD** model would include essential parameters on mechanical components, such as mass, dimensions, inertia etc…
- Furthermore**, Physics-Based virtual prototypes** would be very valuable addition on CAE, enabling product development simulators, training simulators and digital twin concept in product lift-cycle process.
- A framework was developed, showing how **Physics-Based Virtual Prototypes** can be developed from 3D CAD models with meaningful effort.

Virtual Reality and PLM

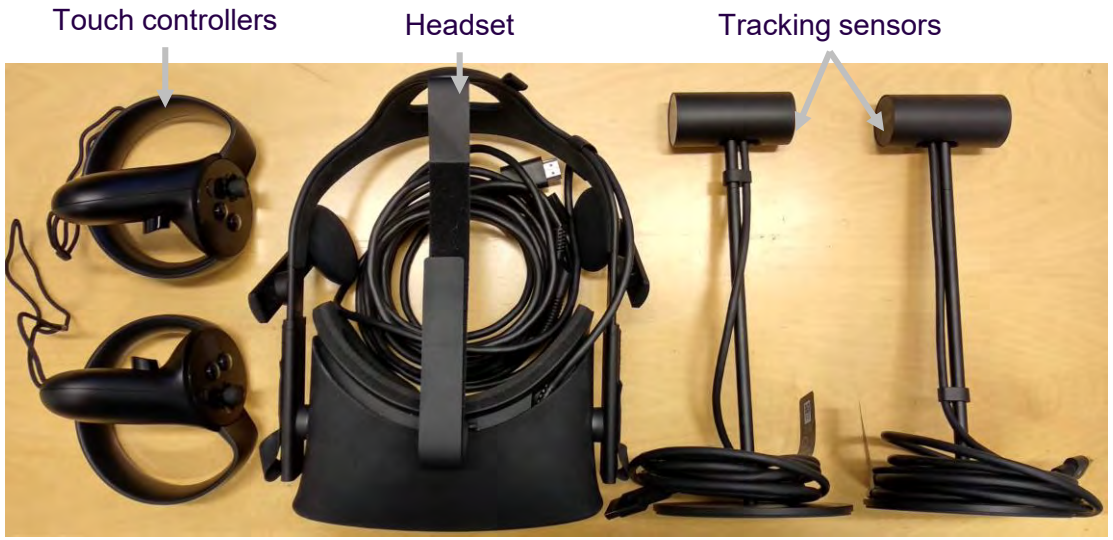
Product Lifecyle Management (PLM)

	VR tasks and advantages related
IDEA	▪Visualization & context
DESIGN	▪Walk-in design ▪Co-creation
PROTOTYPE	▪Real-size virtual prototype ▪Design communication
TESTING	▪Issues in visibility ▪Ergonomics
PRODUCTION PROCESS PLANNING	▪Assembly & maintenance test ▪Job planning & training
MANUFACTURE	▪Data observation
USE	▪Marketing ▪User training ▪Digital Twin

J. Kuusisto, T. Kaapu, A. Ellman and T. Tiainen. Developing VIP2M: A virtual environment for prototyping mobile work machines. Proceedings of International Design Conference Design, 2012.

Erland Körner. "Working with Physically-Based Shading: a Practical Approach". https://bit.ly/2FkpfZs, 2015.

- Game engine.
- Provides tools to design Virtual Environments and user participation through physical devices in real-time.
- Compatible with number of VR devices, such as Oculus Rift.
- Build virtual environments and simulate possible scenarios hypotheses.
- Enables game physics which is not physics based simulation.



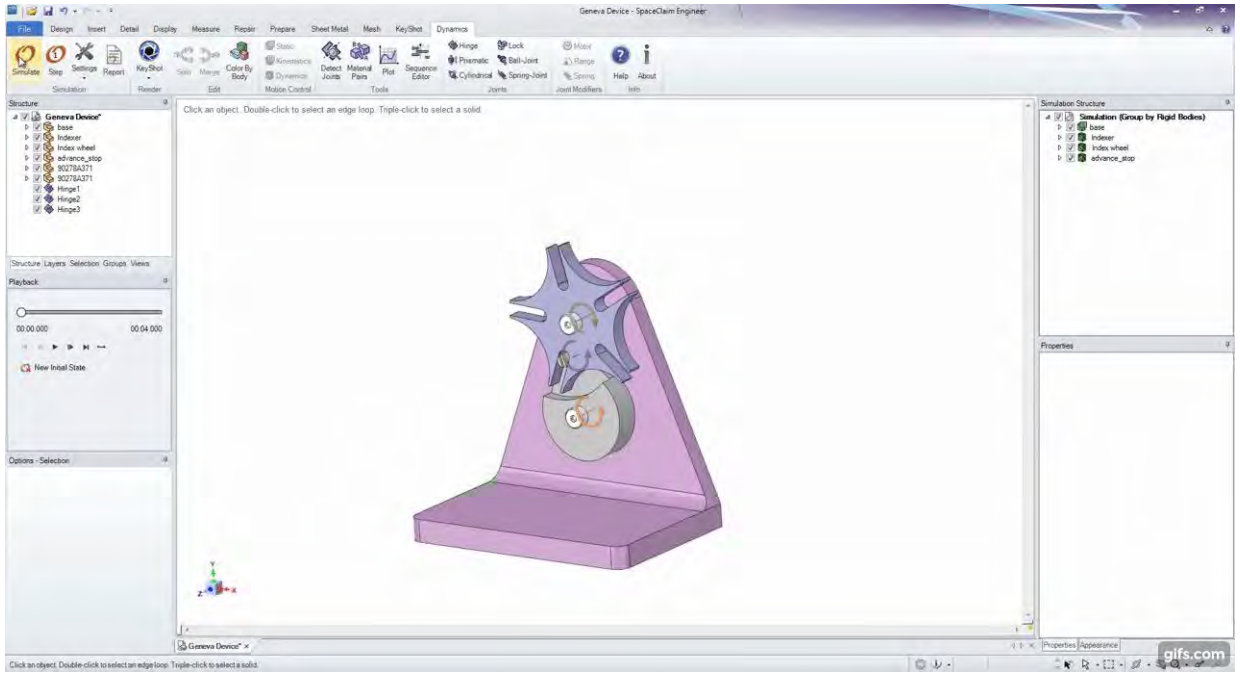
Oculus Rift device.

AGX DYNAMICS

Algoryx®
MOMENTUM

AGXUNITY

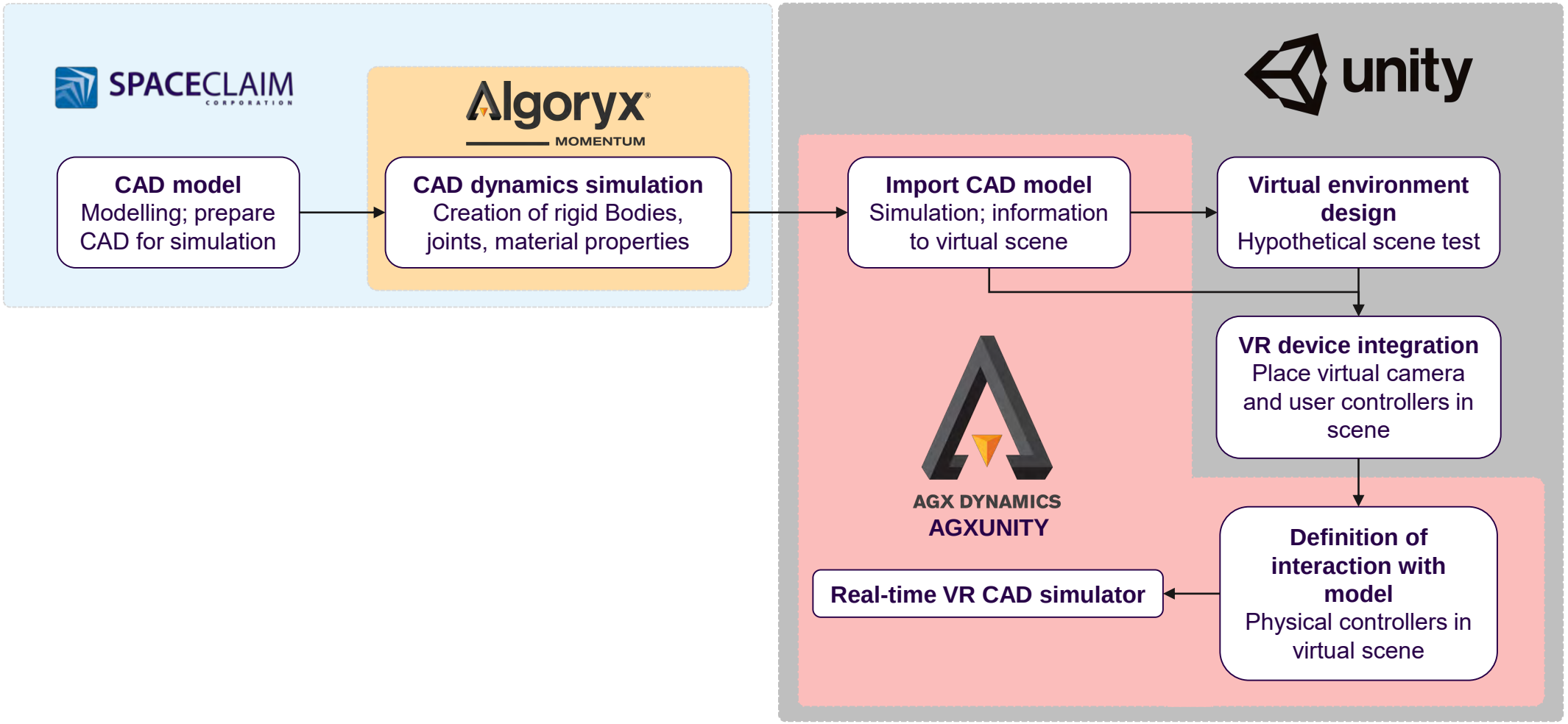
- Software by Algoryx Simulation AB in Umeå.
- Physics engine, which works with a real motion equation.
- Based on dissertation of Dr. Claude LaCoursie.
- Enables real-time simulation of mechanical multi-body systems.
- Allows the definition of rigid bodies and joints between them and the space.
- Integrated GUI in SpaceClaim (AGX Momentum) and in Unity (AGXUnity).



Algoryx, “Setting up a simple model”, https://www.youtube.com/watch?v=qNznEDZzBzE

Framework from CAD to real-time simulation

Overview



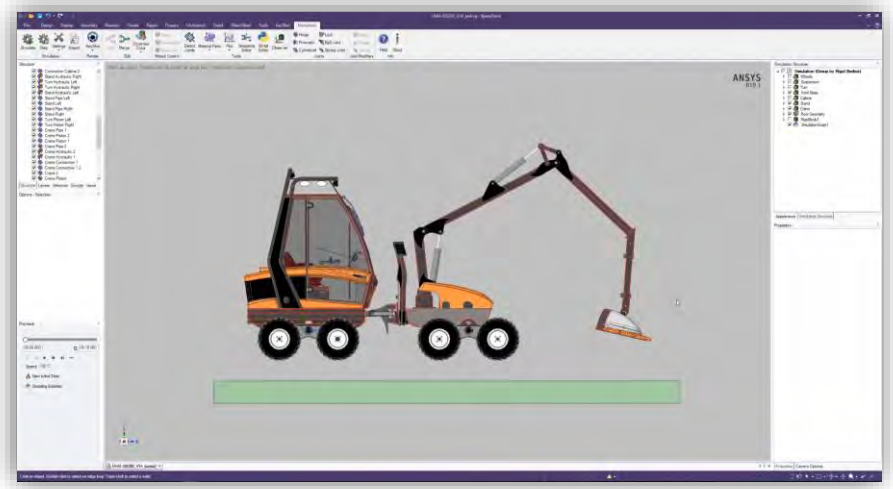
Example case: Harvester machine

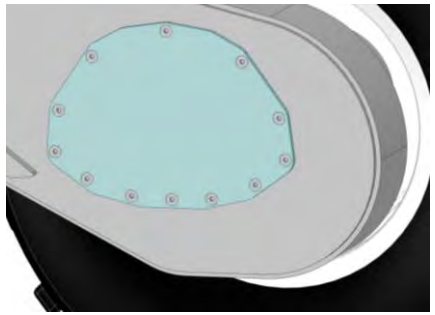
- Model designed on SolidWorks.
- Formed by 3298 solids.

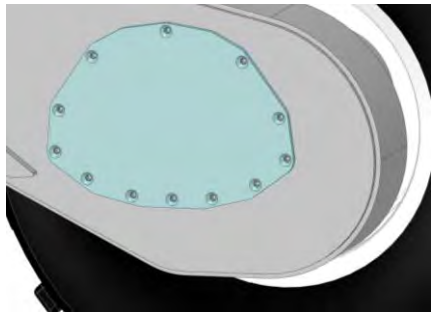
Example case: Harvester machine

SPACECLAIM CORPORATION

Import model



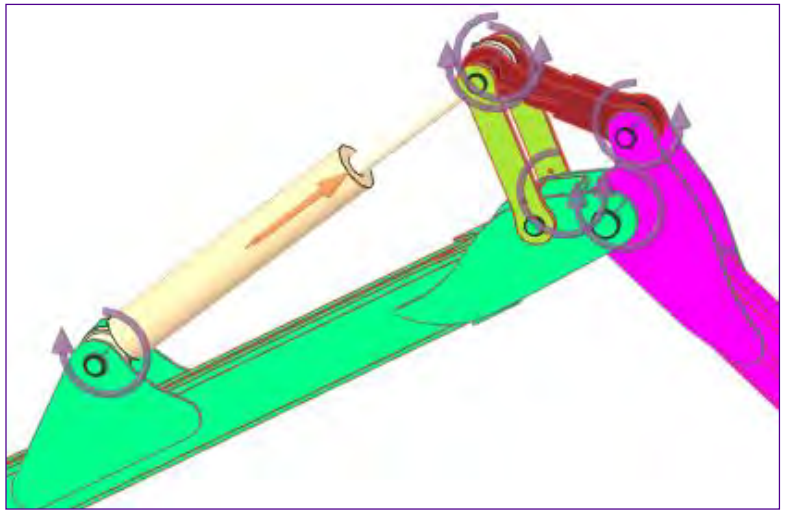


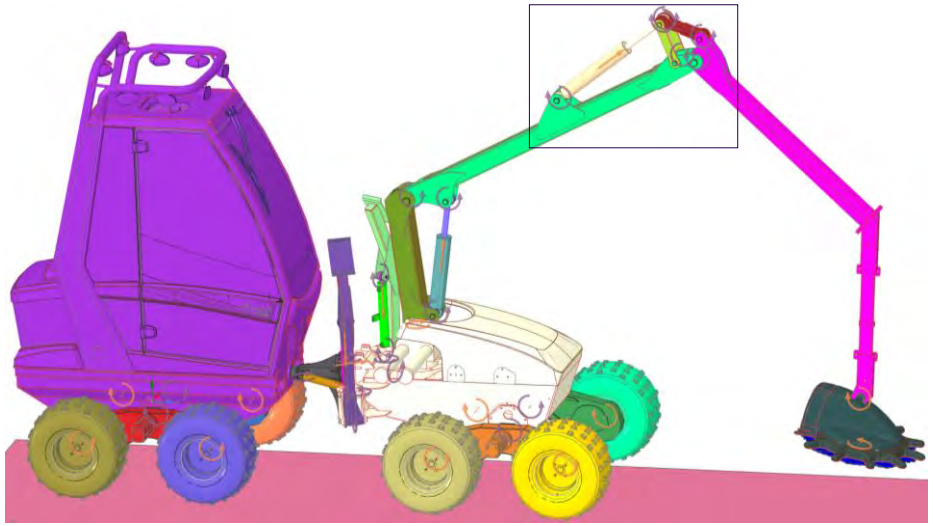


Small solids disregarded

Algoryx MOMENTUM

Creation of rigid Bodies, joints, material properties

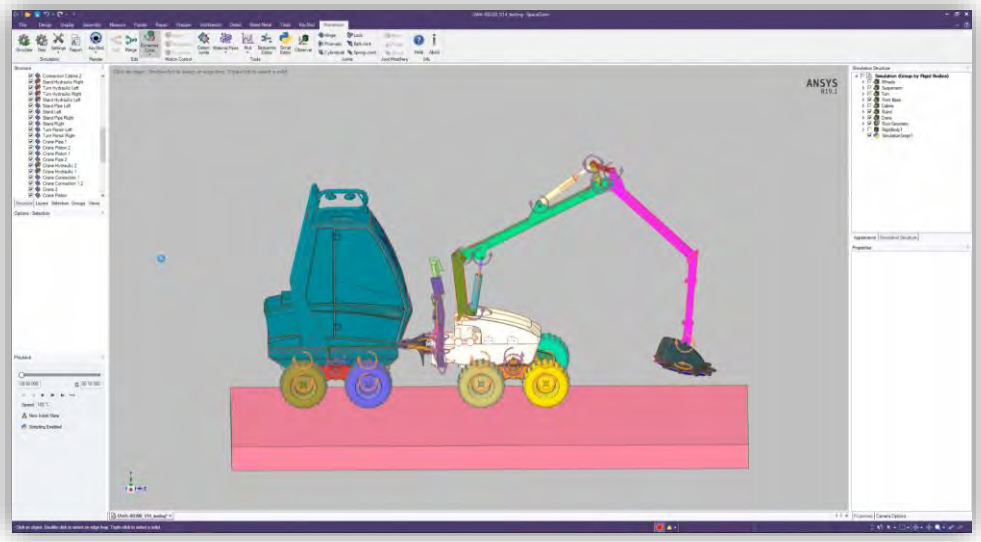




Example case: Harvester machine

Algoryx MOMENTUM

CAD dynamic simulation



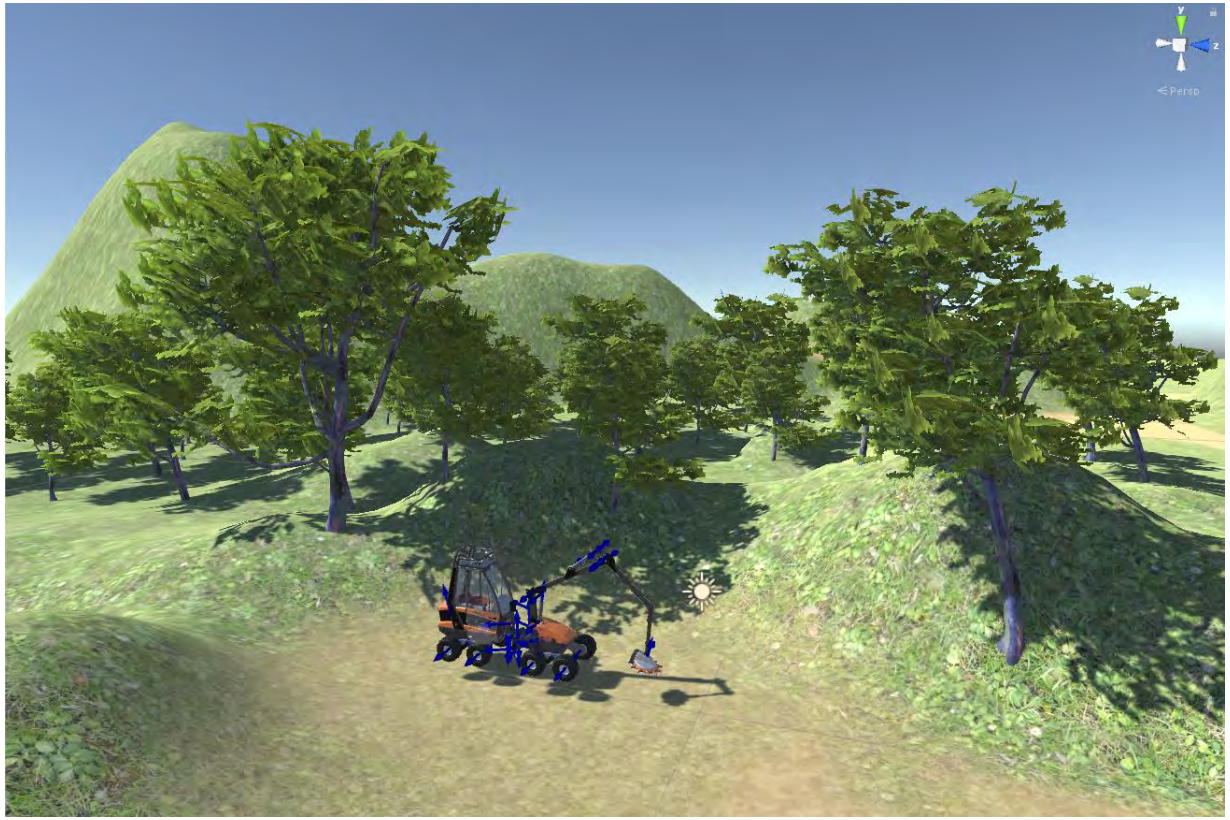
unity

AGX DYNAMICS
AGXUNITY

Virtual Environment design-forest

Import harvester model

Oculus Rift integration



Example case: Harvester machine

unity

AGX DYNAMICS
AGXUNITY

Real-time VR CAD simulator

Results

The **user** is able to:

- Be fully immersed in the VE.
- Visualize the CAD model in real size.
- Interact with the CAD model.
- Dynamically control the CAD model in real-time.
- Get realistic and precise feedback.

Implementation

- Small components were disregarded.
- Simple and fast CAD model conversion to the virtual forest.
- modeling information held.
- Time spent for simulator construction: ~16 hours (for expert user).

Real-time simulator achieved

	Solids in the model	Rigid bodies	Rigid bodies with contact enabled	Joints	Triangles mesh	Simulation frequency	Total time each solving step
Harvester CAD model	527	36	11	40	545 143	50 Hz	~18 ms

Conclusions

This **framework** allows to:

- Obtain physics-based virtual prototypes from CAD models.
- Simulate the dynamics of the prototype in a virtual environment in real-time.
- Interact with the virtual prototype in real-time.