Haptic virtual assembly testing: what are the requirements for the physics engine?

Dr. Jerome Perret, HAPTION

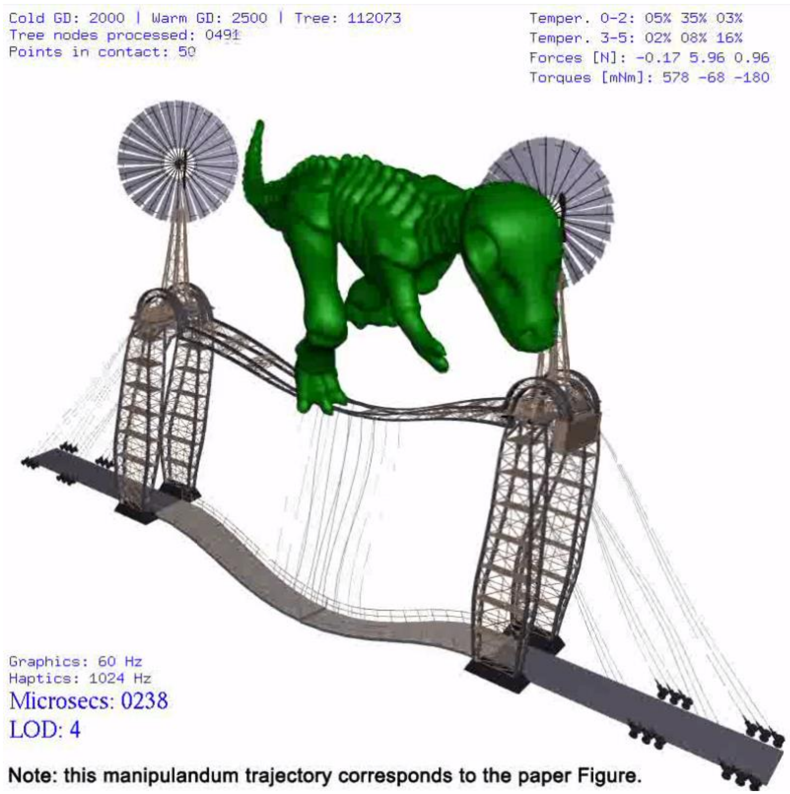
Profile

Dr. Jerome Perret, 49

- Engineering degree in aerospace
- PhD in robotics and artificial intelligence
- Co-founder of Haption SA, CEO (France)
- Founder of Haption GmbH (Germany), CEO
- Executive Committee member of EuroVR (European Association for Virtual Reality and Augmented Reality)
- Executive Committee member of the EuroHaptics Society
- Leader of the "EuroVR Initiative", lobbying action at the European Commission

Examples of complex physics simulation

- J. Barbič & D. James, "Six-DoF Haptic Rendering of Contact between Geometrically Complex Reduced Deformable Models", IEEE Transactions on Haptics, 2008



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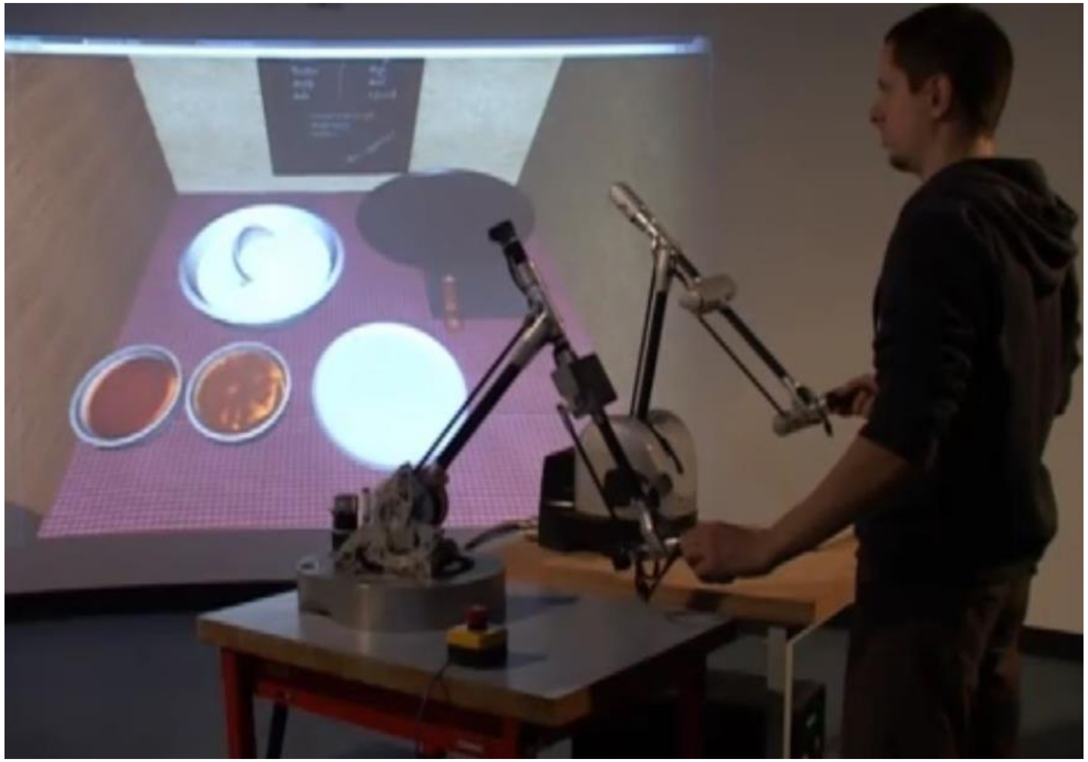
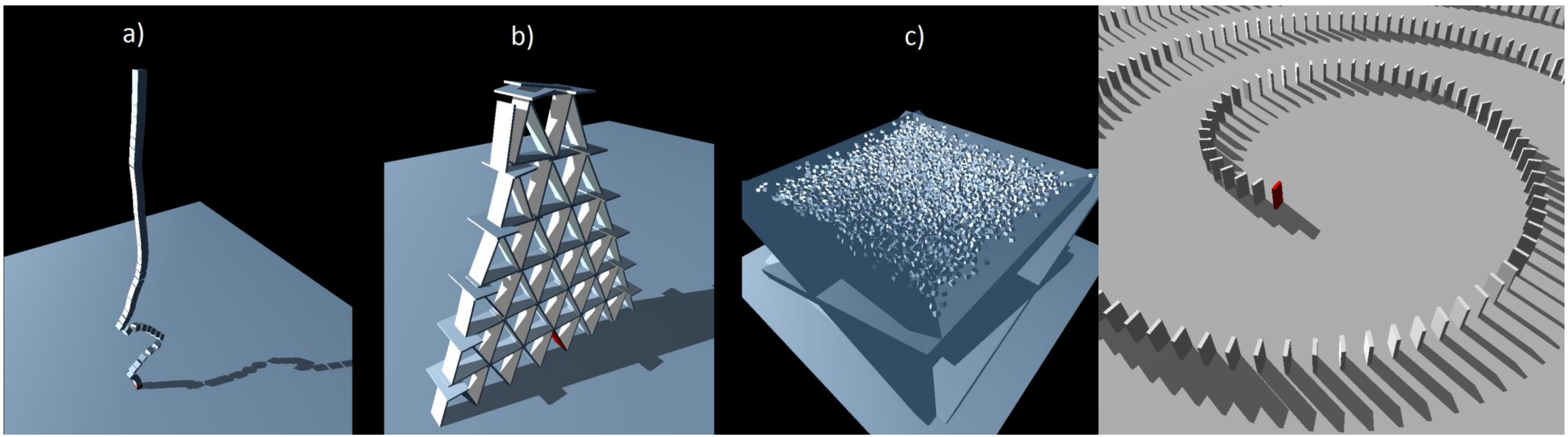
- G. Cirio et al., "The Virtual Crepe Factory: 6DoF Haptic Interaction with Fluids", SIGGRAPH 2010



Comparisons of physic engines

- L. Glondu et al., "Evaluation of physical simulation libraries for haptic rendering of contacts between rigid bodies", WINVR 2010
  - Compared engines: Havok, PhysX, Bullet, Open Tissue
  - Test benches:



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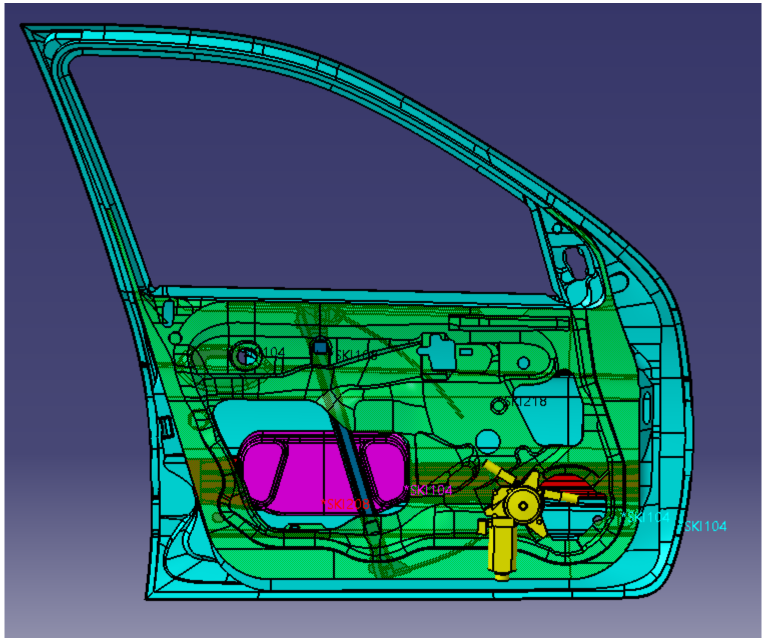

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- 2005: Start of the RIVAGE project
  - End-users: PSA, Renault, Dassault Aviation

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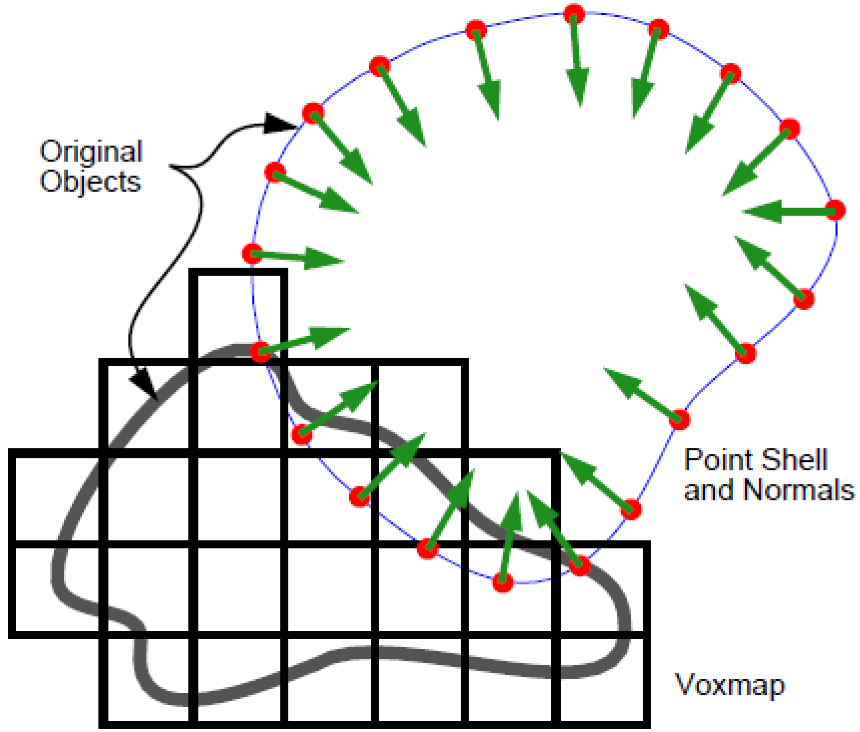

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  - Full-body tracking by ART
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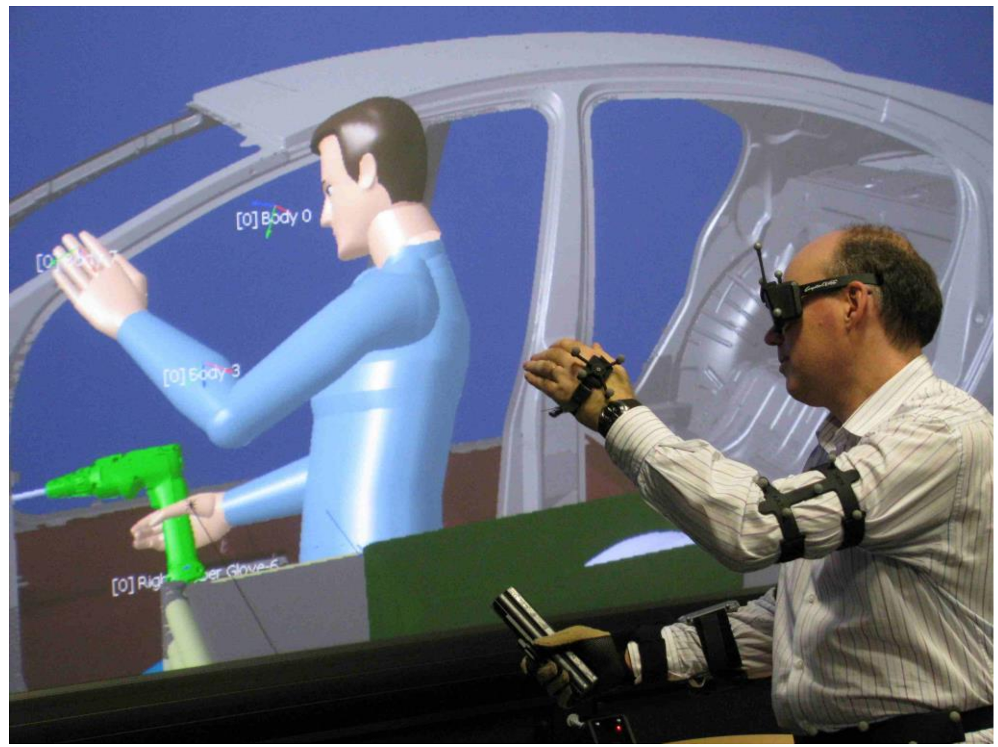

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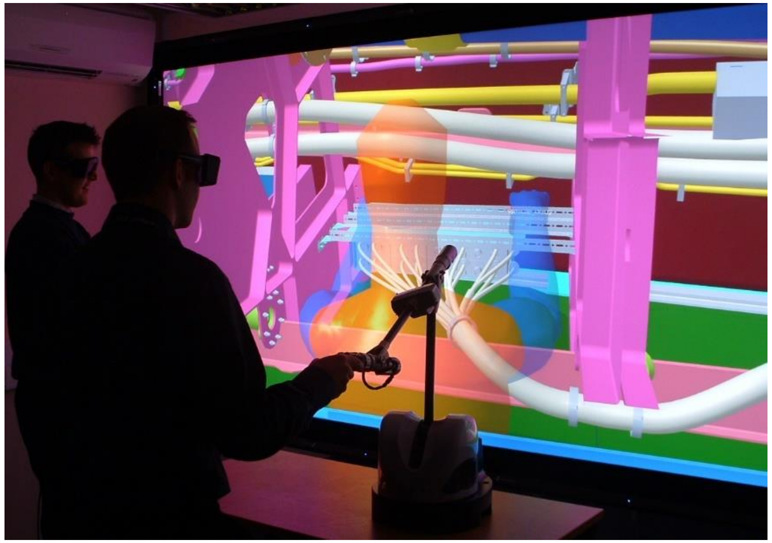

- 2008: Final version of IPSI
  - IPSI: Haption's physics engine (Interactive Physics Simulation Intf)
  - Still using VPS today (2017)

Transition

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  - IPSI is the result of the industry-funded project RIVAGE: between 2005 and 2007, 1 man-year spent by the end-users to write specs, generate validation benches, and perform intensive tests
  - Old wisdom: "if it ain't broke, don't fix it"

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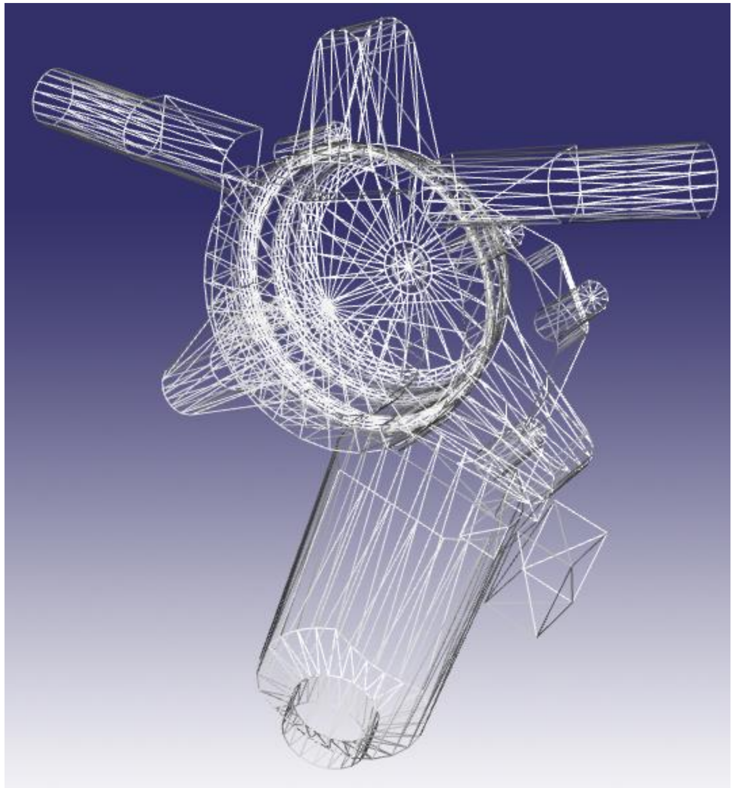

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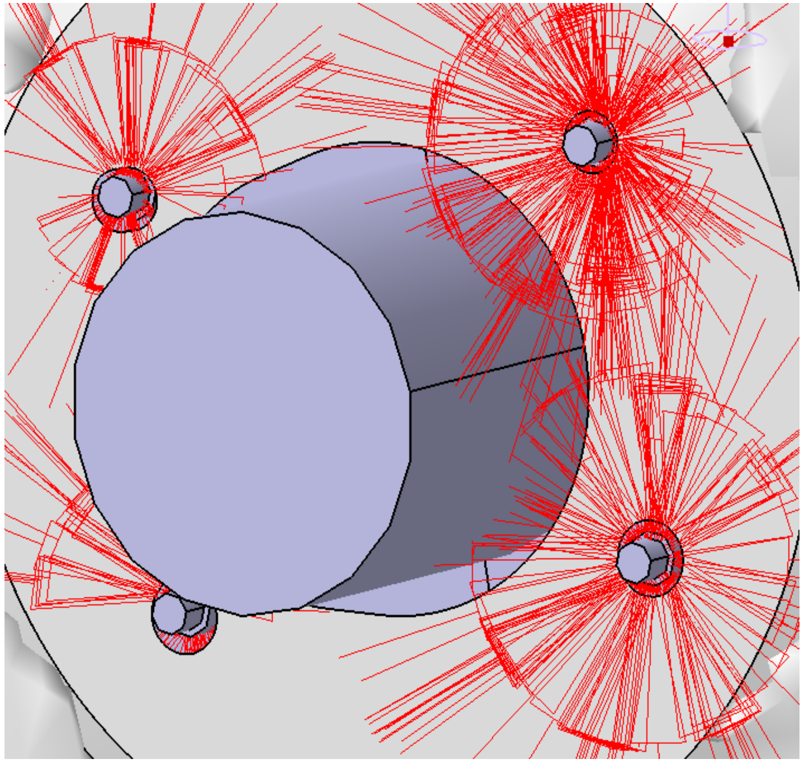
- System
  - Running on Microsoft Windows 64 bits
  - No need for special hardware (aside from a professional GPU)

Application-specific requirements

- Positive clearance
  - Reason 1: no false positives, i.e. assembly succeeds in virtual but fails in reality!
  - Reason 2: absorb tolerances



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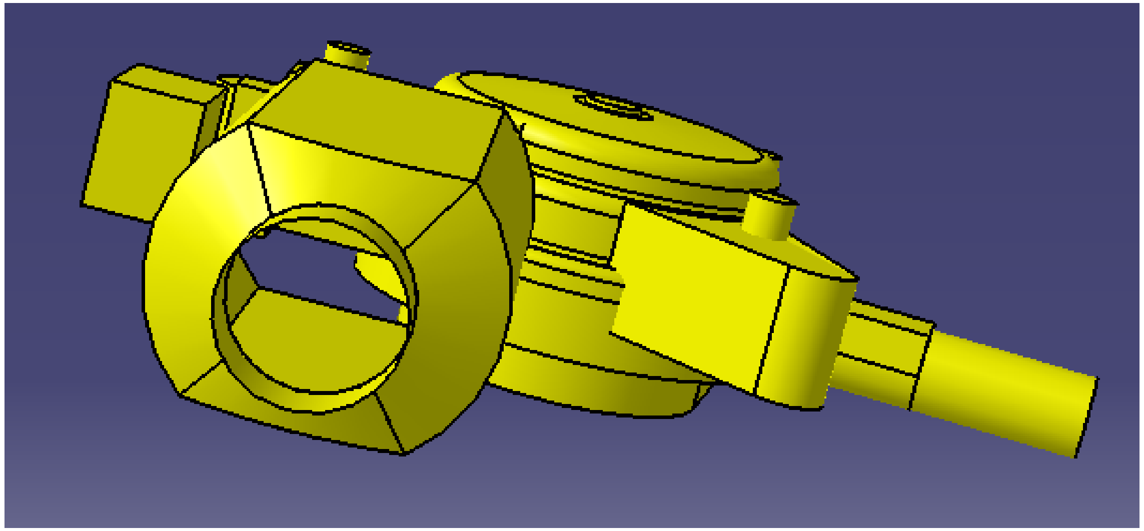

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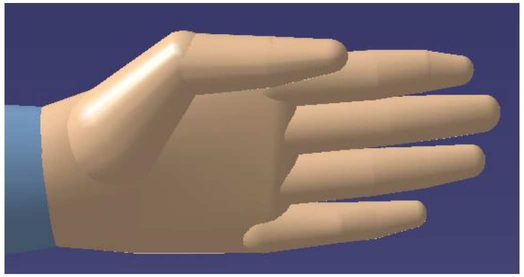
  - Reason 1: most assembly problems are dealing with metal sheets
  - Reason 2: many CAD systems generate objects with holes
- Bilateral constraints (i.e. joints)
  - Reason 1: many assembly problems involve such constraints (e.g. screws, tools, weight-lifting mechanisms)
  - Reason 2: virtual humans are modeled as poly-articulated systems in CAD software

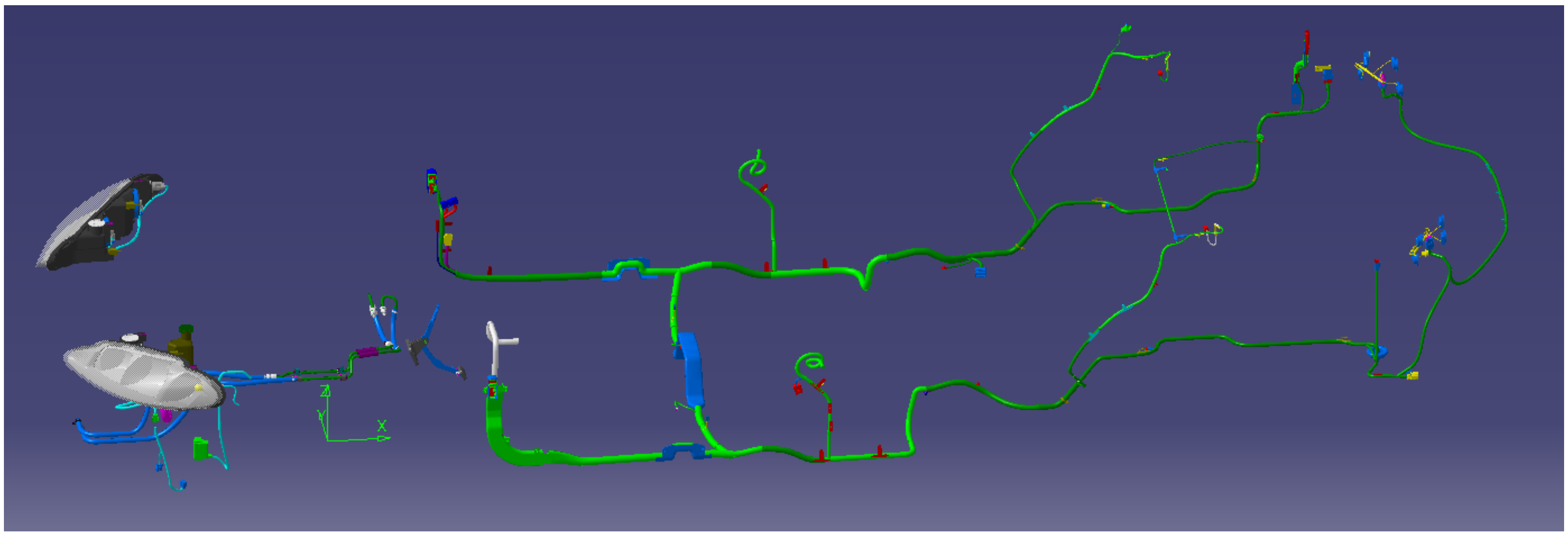


Key requirement for success

- Fool-proof
  - No manual operation needed for data preparation
  - No mandatory parameter settings required
  - Reason: the user is a specialist of product assembly, not an expert in physics simulation!

“Nice to have” requirements

- Support for deformable bodies
  - 1D: cables
  - 1D+: rubber hoses, rubber seals
  - 2D: thin plastic sheets, leather/cloth covers
  - 3D: padding, rubber foam



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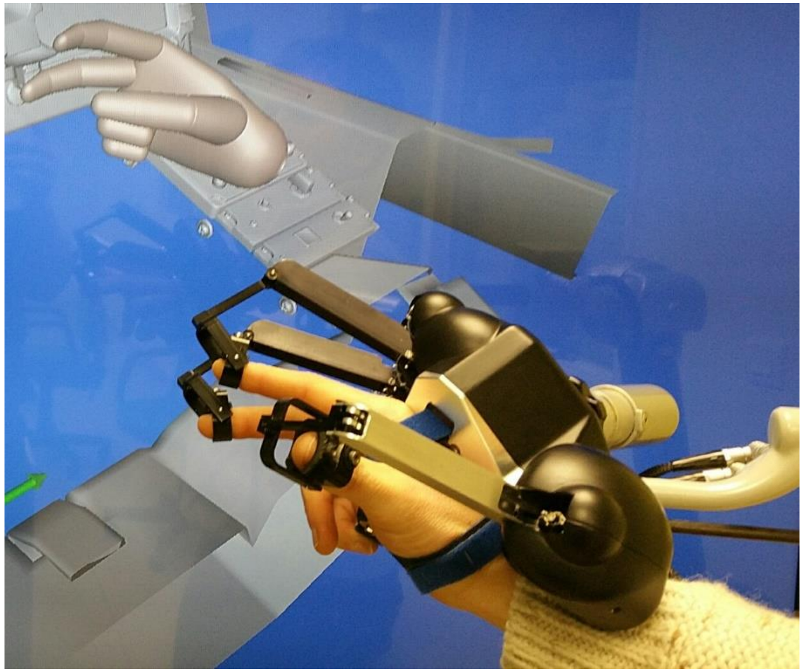
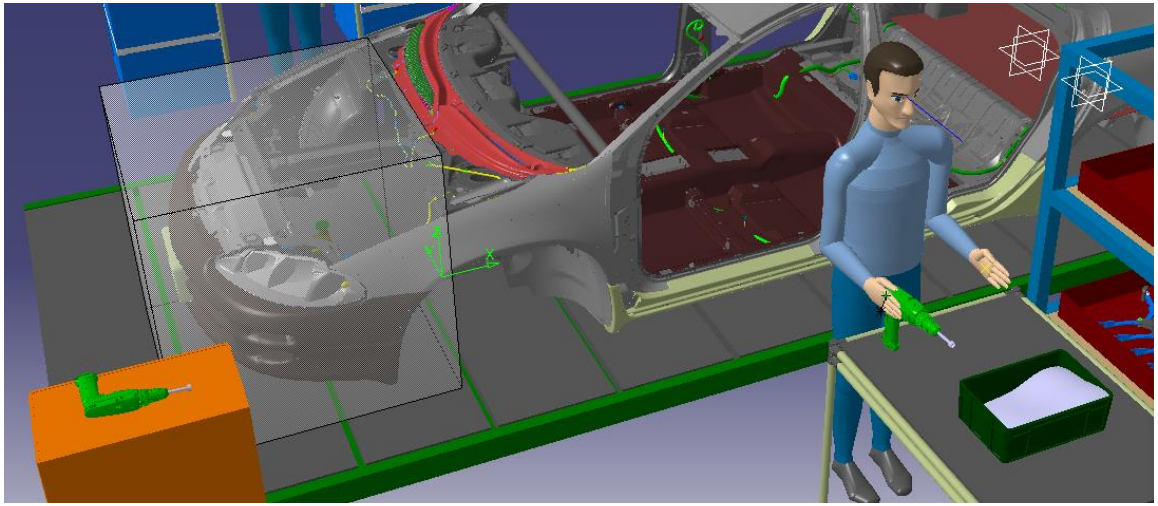
  - 1D: cables
  - 1D+: rubber hoses, rubber seals
  - 2D: thin plastic sheets, leather/cloth covers
  - 3D: padding, rubber foam
- Support for static friction
  - For intuitive manipulation of objects



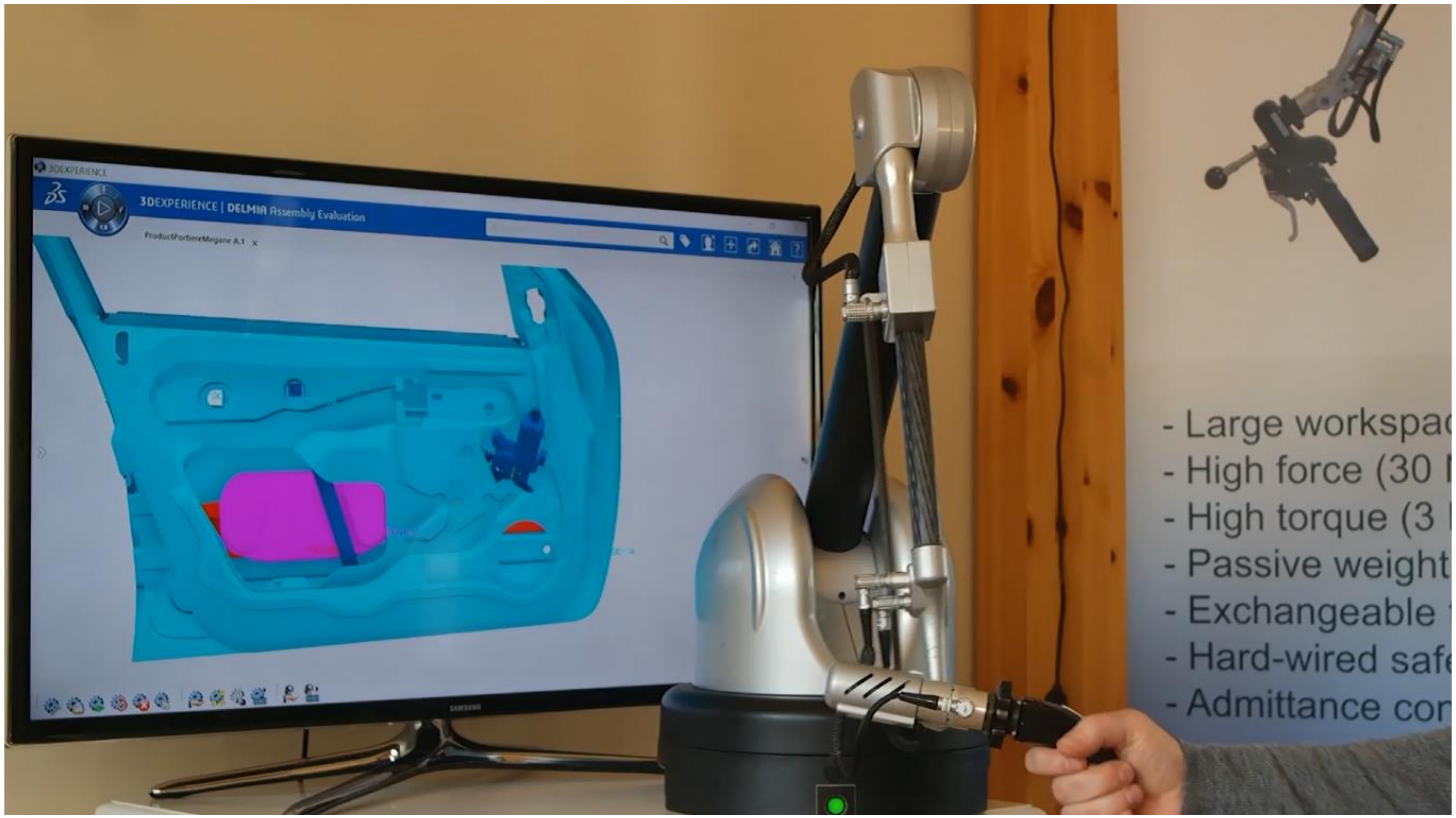
Examples of wrong requirements

- Support for very large 3D models
  - No need to load a complete car/airplane/ship
  - Every assembly is performed in a small volume of space, so the complexity can easily be reduced by setting boundaries
- Support for dynamic-loading of 3D data
  - No need to modify the scene on the fly
  - The people performing assembly simulation work on static datasets, which they are not allowed to modify



Results

- Examples of haptic assembly simulation using IPSI



Conclusion

- The requirements for haptic assembly validation are not physics-related
- Most of the development effort for Haption's IPSI was spent on finding fool-proof parameters and intensive testing
- IPSI is getting old and urgently needs an upgrade, especially
  - Parametric joints (for the human spine)
  - Static friction (for fine manipulation with the force-feedback glove)
- Do you want to help us? You're very welcome!

Haption company profile

- Core business
  Interactive solutions based on 6D haptics/force-feedback
- Founded in 2001
- Located in Laval, France
- Technology developed by CEA LIST (Research Center for Atomic Energy)
- Dassault Systemes CAAV5 partner since 2004
- Siemens PLM Partner since 2013
- Resellers in
  - France, Germany, Russia
  - USA, Canada, Brazil
  - China, Japan, South Korea
  - Australia, Singapore
- Office in Germany (Aachen)

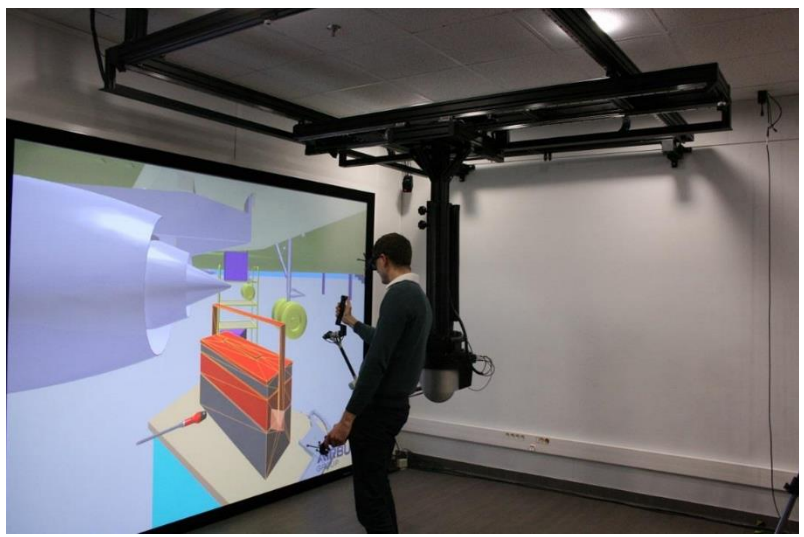
Haption products

Virtuose 6D Desktop

Virtuose 6D

Virtuose 6D TAO

Able 7D



Scale 1

Inca 6D

Commercial references

- Industry
  - France: Airbus , Areva, Dassault Aviation, PSA Peugeot Citroën, Renault
  - Europe: Airbus, BMW, Volkswagen, Daimler (Germany), Airbus (UK), Alstom Transport (Spain), Thales Alenia Space (Italy)
  - USA: Boeing, Lockheed Martin, NASA Marshall, Sikorsky, Tesla Motors, United Space Alliance
  - Asia: Mitsubishi Motors, Toyota, Daihatsu (Japan), AVIC 132/601/611 (China), ADD (South Korea), ADA (India)
- Academic
  - France: CEA LIST, CNRS/LIMSI, ENISE, ENIT, INP Grenoble, IRISA, ISIR
  - Europe: Univ Hannover, Univ Karlsruhe (Germany), IIT, Politecnico di Milano (Italy), DIFFER (Netherlands)
  - USA: Iowa State University, Univ Arkansas, Univ Connecticut
  - Asia: Univ Beihang, Univ Shangaï (China), Univ Deakin (Australia), DMI (South Korea)

Conclusion

Thank you for your attention!

www.haption.com