inholland composites

Virtual Hybrid Testing – graduation research

Application of VHT principles in assessing strength and stiffness properties of metal and composite structural components using test facilities at Inholland Composites

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Background

Currently, companies like Boeing, Airbus and Fokker(GKN) are using and developing Augmented Reality (AR), Mixed reality (MR) and Virtual Reality (VR) applications in their design, manufacturing and testing environments.

Augmented reality is any sort of computer-based system that overlays data on top of your current view of the world, while continuing to let you see the world around you.

Virtual reality has extended the horizon of what design engineers can create and experiment with, without having to invest in costly and time intrusive prototypes. This also enables quicker management decisions and the ability to adapt to industry innovations. While virtual reality is aiding the design engineering and development of new aircraft, it will never replace the real world in terms of realistic scenario testing or consumer experience. However, it will reduce (a.o.) amount of materials for prototyping and testing, development costs and time-to-market for manufacturing and testing stages.

Mixed reality (hybrid reality) is a form of augmented reality that is somewhere between VR and AR. Mixed reality augments the real world with virtual objects that aim to look as if they are really placed within that world. It locks their position according to real world objects (e.g. placing a virtual cat onto a real world table and having it remain there in augmented reality while the user walks around their house).

Airbus is working on a Virtual Hybrid Testing (VHT) framework, being a kind of Mixed Reality application. Airbus defines VHT as: “Structured mix/coupling of VT and RT to evaluate a product (models/prototypes) against behaviour in a specific (virtual/real) environment.“ See fig. 1 and ref. [1]

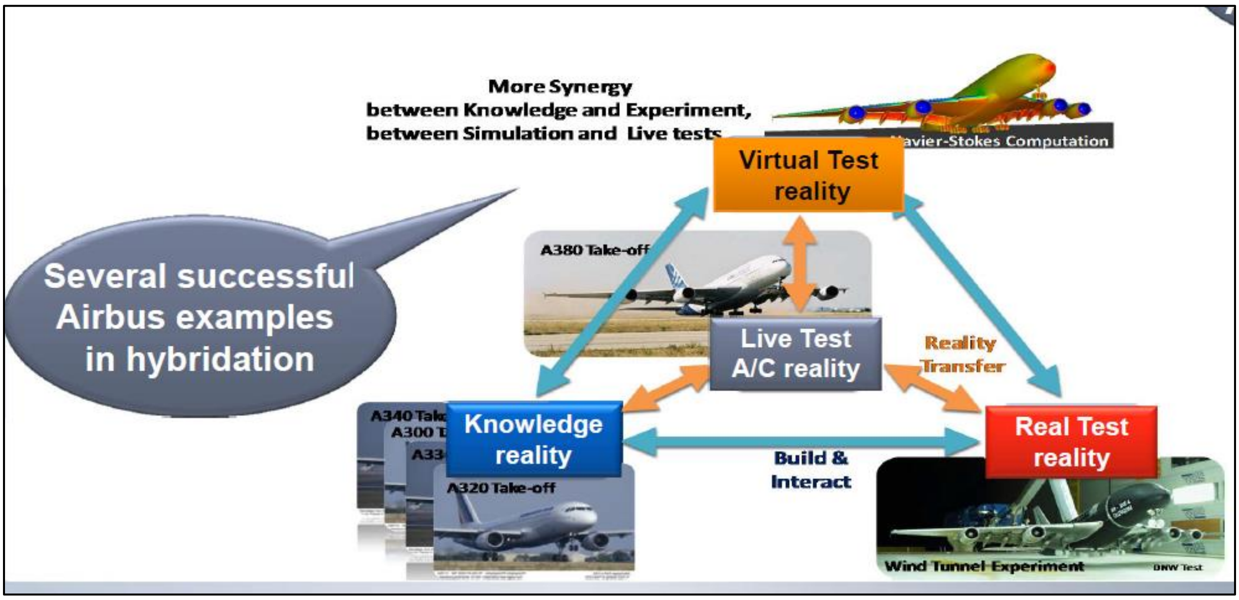

Fig.1 Airbus defined relationships in virtual hybride testing of aircraft structures and systems [1]

Many AR and VR applications use headsets, like a HoloLens or a Head-Up Display headset. Pilot helmets that display data within the pilot's view as they fly are, e.g., AR headsets. Microsoft HoloLens, can be indicated as a "mixed reality" headset: augmented reality, where virtual objects look as if they are part of the real world.

Problem Definition

One of the simulation tools in virtual testing is Finite element analysis (FEA). FEA has been applied extensively in engineering structural assessment, maintenance and repair, to identify critical components, evaluate structural reliability, investigate causes of failures and determine repair strategies. FEA models can be validated with test results from onsite measurement or inspection and used to assess structural conditions. Current conventional FEA tools rely completely on computergenerated graphics in a desktop virtual environment (VE). This VE does not facilitate validation of finite element (FE) models and interpretation of FEA results. Representation of physical structures in a VE is normally incomplete or unrealistic, e.g., scale, orientation and material. The actual physical context usually cannot be accessed in the VE. It is not intuitive and efficient to examine FE models and interpret FEA results without realistic senses of the physical context. User interfaces of most conventional FEA tools are complex, non-intuitive and require laborious operations for data entry, 3D model development and manipulation. Moreover, users have to repeat standard steps, i.e., pre-processing, solving and post-processing, to investigate modifications on FE models. These cumbersome procedures discourage the use of FEA in different engineering applications.

Augmented reality (AR) has been proven to be effective in data visualization and task assistance. AR visualization of FEA results in the real physical context enhances perception and understanding of datasets. AR can provide intuitive interfaces for interactive simulation and data exploration.

Ref. [2] presents an AR-FEA system that allows users to perform FEA tasks in a real environment to facilitate engineering structural analysis and evaluation; FEA results can be visualized on physical structures and examined through intuitive interfaces. Users can apply virtual loads and make model modifications directly on the physical structures for specific purposes and investigation.

One of the examples presented in ref. [] is a proving ring shown in fig. 2 demonstrates the applicability of AR-FEA to other types of structures. Loads acting on the proving ring are measured using the dial indicator, and interpreted using a micro-processor. After converting the displacement measurements into forces with calibration coefficients, the AR-FEA system simulates the stresses on the proving ring when it is loaded on a testing machine.

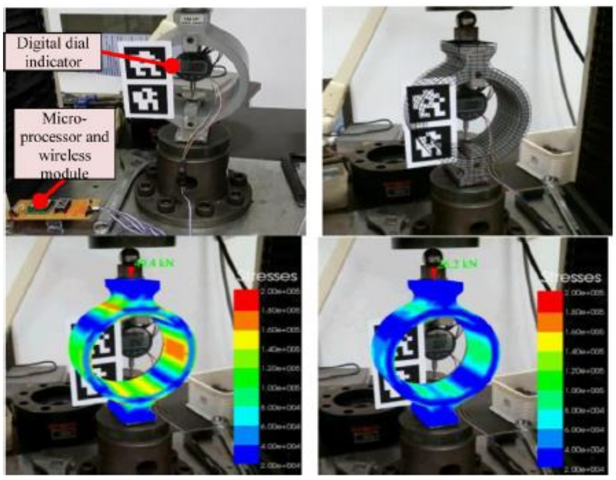

Fig. 9. Real-time simulation of a proving ring. [2]

Inholland Composites is initiating an applied research program with the aim:
1) to become familiar with Virtual Hybrid Testing methods, and
2) to implement technical and economical feasible VHT-principles
in their research work, especially in testing of materials and structures, in combination with the Test Benches available at its facilities in Delft and Alkmaar.

The **focus** in this research program will be the interactive projection of virtual, real-time, simulation results on real test specimens, using appropriate visualisation equipment like e.g. the HoloLens headset (available at Inholland Composites).

As a **first step** in this research program, a start-up project has been defined for this graduation assignment:

- Design, build and test a "VHT-demonstrator" to investigate the technical feasibility of real-time *projection* of both FEA and test results (stresses & displacements) on a test specimen, with the following requirements:
    - the demonstrator shall have at least the level "proof of concept"
    - use analysis tools, software and test equipment available at (or provided by) Inholland Composites lab
    - the test specimen will be a notched metal or composite strip with a centered hole, uni-axial loaded by a tensile load (material and dimensions of the test specimen have to be selected and designed by the researcher)
    - use the HoloLens headset equipment of Inholland Composites for projection of FEA analysis and test results
    - use Patran/Nastran for FEA analysis of test specimen
    - the design shall include a control system design realising the projection of analysis and measurement results (stresses and displacements), see fig. 3

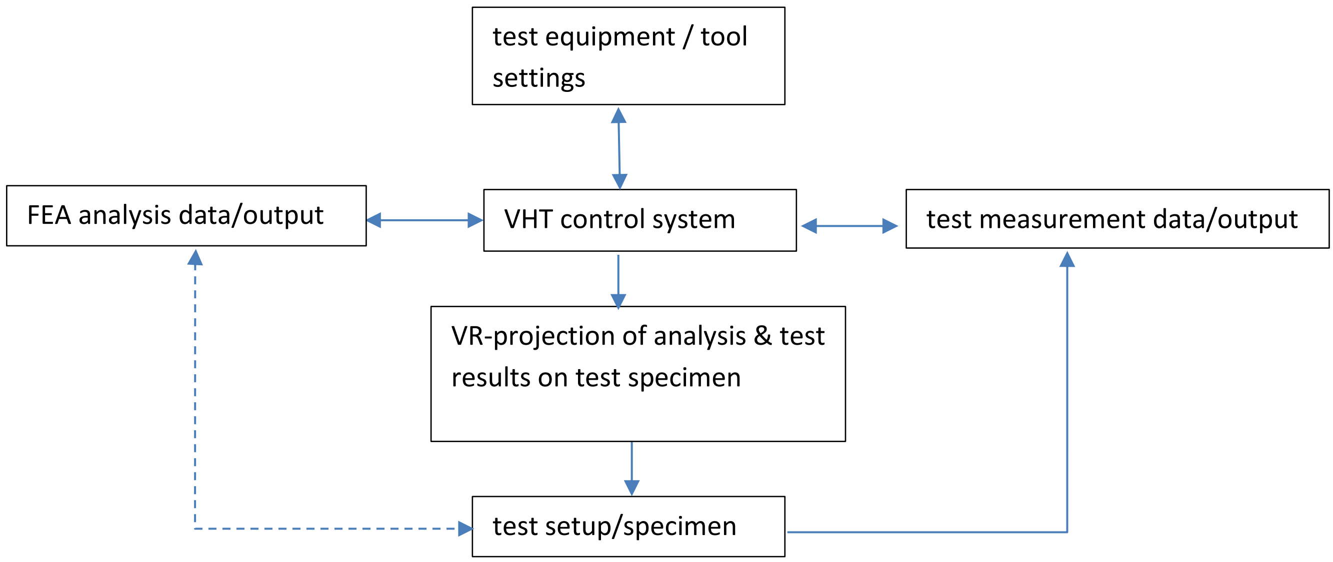

Fig.3: simple representation of required "control system VHT-demonstrator"

Activities
The following activities are expected:

- Research and reporting of existing state of the art of Augmented Reality & Virtual Hybrid Testing
- FEA analysis of test specimen predicting stresses and displacements at different load levels
- Design, build and test a "VHT-demonstrator" (proof of concept) integrating AR/VHT principles

Scope of work
During the research, the graduation researcher will learn about applying tests standards for bending tests using the tests benches at Inholland Composites. To validate the research it is expected to create a physical demonstrator, which can be used as proof of concept. Furthermore, a typical scope of work consists of these elements:

- Project plan, research questions, research method
- Literature study, research on virtual hybrid testing principles
- Functional analysis and concept study
- Concept design / Detailed design
- Demonstrator for verification and validation
- Testing of the system
- Analysis of test results
- Communication and interaction with stakeholders, companies and experts
- Communication through http://inhollandcomposites.nl (status updates to consortium, video's)
- Technical report

Company information
Inholland Composites, located at Inholland in Delft and Alkmaar, is a very well equipped, high-tech laboratory in the field of composite materials and structures. The focus is on fibre reinforced plastics which provide durable and lightweight solutions in a wide range of applications. Inholland Composites needs students from various technical departments and it's our mission to put theory into practice and provide students with up-to-date education, which connects to today's business.

References

1. Dr. Emmanuelle Garcia (2013), AIRBUS Virtual Hybrid Testing Framework: focus on V&V concerns, Airbus Toulouse, EZMM, strategy, process, methods and tools, simulation projects, GdR Mascot-NuM workshop on Model V&V, November 13rd, 2013 (https://www.google.nl/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwif7Me-np_fAhVJKuwKHTaHDQUQFjAAegQIBBAC&url=http%3A%2F%2Fwww.gdr-mascotnum.fr%2Fmedia%2Fvht_garcia.pdf&usg=AOvVaw1EpI2AT6Q6kDceKsa_cXdr)
2. S.K. Ong, J.M. Huang (2017), Structure design and analysis with integrated AR-FEA, *CIRP Annals - Manufacturing Technology 66, page 149–152* (http://dx.doi.org/10.1016/j.cirp.2017.04.035)

Graduation period: February 2019 / July 2019

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