**RESEARCH TOPIC FOR APPLYING SMI PHD CONTRACT**

***Field:*** ***Information and Communication Sciences and Technologies***

***Subfield***: Industry 4.0, Virtual Reality (VR), DMU, Geometric modeling.

***Title***: DMU processing for enhancing user experience in VR

***Doctoral college***: Ecole doctorale 432, "Sciences des Métiers de l'Ingénieur (SMI)"

## *Doctoral advisory board*:


| | | | |
|---|---|---|---|
| *Name:* | Prof. Frédéric Mérienne | Prof. Dominique Bechmann | Dr. Ruding Lou |
| *Email:* | frederic.merienne@ensam.eu | bechmann@unistra.fr | ruding.lou@ensam.eu |
| *University:* | Arts et Métiers | University of Strasbourg | Arts et Métiers |
| *Rsearch Lab:* | LiSPEN | ICUBE | LiSPEN |
| *Lab website:* | http://lispen.ensam.eu/ | https://igg.icube.unistra.fr/en/ | http://lispen.ensam.eu/ |


## *Short description of possible research topics for a PhD*:

**Virtual reality** (VR) applications are no longer confined to gaming. Cheaper and better VR hardware has encouraged more and more applications in virtual engineering under the context of **Industry 4.0**. The accessibility to VR highly increased thanks to recent low-cost commercial VR head mounted display (HMD) systems and easy-to-use development toolkits. Many novice VR users have not yet got used to realizing sensorimotor activities in virtual environment and they can feel discomfort during their virtual experience. On one hand users can suffer from cybersickness due to visually induced motion sickness (VIMS) in terms of perception. On the other hand users can feel difficult to interact with **digital mock-up** (DMU) in the virtual environment due to exocentric locomotion interfaces (eg. gamepad). These shortcomings of VR technology remain a major barrier to generalize the VR technology in industry 4.0 and all other engineering domains such as civil engineering.

To tackle this issue, this PhD thesis will investigate an original approach for enhancing the user experience in VR by processing geometrically (deformation, simplification, smoothing, etc.) the 3D DMU in the virtual environment. Pilot studies [4, 6] showed that geometric deformation of the DMU in the virtual environment during navigation in VR can reduce significantly VIMS. In addition the deformation of the DMU in the virtual environment can encourage users to realize more smooth and less jerky navigation trajectories [6]. In compare with the previous work in the literature, this novel approach does not require neither extra device nor physiological stimulus. In addition this approach will not reduce nor immersive degree nor the freedom of navigation for users, which is not always the case for the related work in the literature.

The main scientific objective of this PhD thesis is to devise, implement and experiment the optimal DMU processing methods to enhance user experience in VR according to different situations.

- Notion and criteria of discomfort will be formalized and their measurement methods will be set up. For example:
    - the motion sickness can be evaluated by the human biological factors and optic flow intensity generated by the rendered images in VR.
    - the quality of the navigation in the virtual environment can be evaluated by the trajectory (velocity, acceleration, jerk), the distance and the time duration.

  - the facility of the interaction with the DMU in the virtual environment can be evaluated by the number of trials, the precision of the task, how nature is the body gesture, etc.
  - other criteria will be identified during the PhD thesis.

- Definition and implementation of various processing of DMU and their adaptation to enhancing user experience in VR. Several aspects will be taken into account:
  - Various types of information included in DMU: geometry, texture, lighting, etc.
  - Various geometric representations of DMU: point cloud, CAD, mesh, etc.
  - Deformation of the DMU to reduce the cybersickness dose value (CSDV).
  - Simplification of the DMU to reduce the optic flow.
  - Deformation of the DMU to enhance the navigation quality.
  - DMU processing for enhancing manual interaction in VR.
  - Other DMU processing will be identified during the PhD thesis.
- Smart adaptation/customization of DMU processing according to different application domains and situation.
  - Precision of the tasks according to the industry context will guide and constraint the geometric processing of the DMU.
  - Spatial characteristics of the virtual environment will be taken into account to adapt the DMU processing for enhancing navigation quality.
  - Shape characteristics of DMU will customize the DMU processing for enhancing the manual interaction with virtual objects.
  - Other adaptation methods will be identified during the PhD thesis.
- Application of DMU processing in different use cases.
  - Cybersickness reduction for driving simulation in automotive industry.
  - Reduce cybersickness and enhance virtual navigation quality in civil engineering.
  - Intuitive and natural interaction for manual operation simulation in industrial assembly.
  - Other use cases will be identified.

## *Required background of the student*:

**Master degree** in computer aided design, virtual reality, computer graphics, computer science.

## *References:*


1. J. Gain, **D. Bechmann**, A survey of spatial deformation from a user-centred perspective. ACM TOG Transaction On Graphics, Volume 27, Number 4, pp. 1–21, 2008.
2. A. Kemeny, P. George, **F. Mérienne**, F. Colombet, New VR Navigation Techniques to Reduce Cybersickness, Electronic Imaging 2017, 3, 48—53, 2017.
3. B. Li, F. Segonds, C. Mateev, **R. Lou**, **F. Merienne**, "Design in context of use: An experiment with a multi-view and multi-representation system for collaborative design", Computers in Industry, 103, pp. 28 - 37, 2018.
4. **R. Lou**, Geometry deformation for reducing cybersickness in VR. Journées Françaises d'Informatique Graphique et de Réalité Virtuelle, Marseille, France. pp.229-234, 2019.
5. P. Raimbaud, **R. Lou**, F. Danglade, P. Figueroa, J. T. Hernández, **F. Merienne**, "A Task-Centred Methodology to Evaluate the Design of Virtual Reality User Interactions: A Case Study on Hazard Identification", Buildings, Vol. 11, Iss. 7, 2021.
6. **R. Lou**, R. H. Y. So, **D. Bechmann**, Geometric deformation for reducing optic flow and cybersickness dose value in VR, Eurographics, Reims, France, 2022. (to confirm …).