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# Sujets de Recherche disponibles à l'UMONS

**Titre du sujet 1 :** Strong coupling methods for unsteady Fluid/Structure Interactions (FSI)

## Informations administratives

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|---|---|
| Personne proposant le sujet[1] /email | Gregory COUSSEMENT<br>gregory.coussement@umons.ac.be |
| Service | Fluides-Machines |
| Faculté | Faculté Polytechnique |
| Institut | Energie |

## Informations relatives au sujet proposé

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|---|---|
| Niveau de recherche | ☒Doctorat ☐Post-Doc |
| 5 mots-clés (français) | Interaction Fluide/Structure, CFD, maillage déformable, instationnaire, multi-physique |
| 5 keywords (English) | |
| Bref descriptif (10-15 lignes) (français) | |
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| Summary (10-15 lines) (English) | |

[1] Membre permanent de l'UMONS (Futur promoteur de la thèse ou futur encadrant du post-doc)

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Virtual prototyping including numerical simulations is playing a major role in industrial designs. Numerous methods and solvers exist for computations involving a single physics. The actual trend to design larger, lighter and more flexible structures, the consideration of Fluid-Structure Interactions (FSI) is more and more a concern for the industry. Accurate, robust, efficient and flexible numerical tools must be developing or improved for their prediction. Among the possible approaches to account the unsteady evolution of the flow, some are working in the time domain and other are based of frequency domain. The aim the PhD research is to provide innovative contribution on these simulation methods for the calculation FSI. These developments should ensure an efficient treatment of the strong coupling between the deformation of the flexible structure due to flow forces acting on its surface and the flow changes due to the deformation of the flexible bodies surface.

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**Titre du sujet 2 :** Strategies and methods for CFD computation for multiple moving and deformable bodies

## Informations administratives

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## Informations relatives au sujet proposé

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|---|---|
| Niveau de recherche | ☒Doctorat ☐Post-Doc |
| 5 mots-clés (français) | Maillage déformable, maillage mobile, maillage chimère, interpolation, CFD |
| 5 keywords (English) | |
| Bref descriptif (10-15 lignes) (français) | |
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| Summary (10-15 lines) (English) | |

[2] Membre permanent de l'UMONS (Futur promoteur de la thèse ou futur encadrant du post-doc)

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Virtual prototyping is more and more broadly used for flow prediction and design. To apply CFD simulation for more complex configuration inducing the relative motion of several bodies (rigid or elastic) or the various possible positions of several bodies (investigation of the flow interaction and energy recovery for various wind turbines placement) interacting with the flow (eg. store separation, booster separation of a space shuttle, valve and piston motions in an engine) and/or having multi-physic interactions (fluid/structure interaction of deformable bodies). Due to the large variation in the boundary displacement linked to these motions (small for little flexible bodies subject to FSI, medium or large for highly flexible bodies, large for the relative motions or the various possible positions of several bodies) the delicate paradigm in term of trade-off in the unsteady CFD methodologies has led to develop different approaches: chimera approach, mesh deformation [and remeshing. The PhD research aims:

- at improving existing the strategies, methods and development for time-dependent CFD computations for multiple moving and deformable bodies on several
- at experiencing these innovative developments and improvements on complex industrial cases in phase with the new problems in simulations on increasingly complex configurations and including multi-physical interactions.

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**Titre du sujet 3 :** Multi-level blood flow simulation strategies accounting effects of red blood cells, White blood cells, clots and platelets and wall interactions.

## Informations administratives

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| Service | Fluides-Machines |
| Faculté | Faculté Polytechnique |
| Institut | Energie |

## Informations relatives au sujet proposé

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| Niveau de recherche | ☒Doctorat ☐Post-Doc |
| 5 mots-clés (français) | Multi-échelle, CFD, écoulement sanguin, pulsatile, particules, frontière immergée, lattice Boltzmann |
| 5 keywords (English) | Multi-level, CFD, blood flow, pulsatile, particles, immersed boundary, lattice Boltzmann |
| Bref descriptif (10-15 lignes) (français) | |
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| Summary (10-15 lines) (English) | |
| Due to the strong impact of blood flow behavior and pattern in the occurrence or the cure of cardiovascular diseases, the prediction of circulatory pathologies and the development of new drugs and treatments against these pathologies is requiring tools enabling to produce pulsatile flow conditions found in reality, ideally patient specific, to assess their effect. In order to avoid difficult in vivo investigations, virtual prototyping base on CFD models are tools more and more efficient and widely used. Due to the complexity of the flow behavior and interaction, at small scale of the blood formed element (red blood cells, with blood cells, platelets), the drugs or the treatments using devices such stent and filters, efficient simulation tools are required to capture the multiple scale of the physical phenomena in the flow. The PhD research aims at developing multiscale simulation methodologies to capture, efficiently a low CPU cost, both the large scale flow patterns driven by the non-Newtonian continuous fluid dynamics law (Navier-Stokes conservation equations) and the small scale motion of particles in the plasma using particles models (lattice Boltzmann, immersed boundary…). | |

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**Titre du sujet 4 :** Detail experimental optical flow measurements and flow pattern description in vessel phantoms in a controlled test bench mimicking in vivo pulsatile flow conditions.

## Informations administratives

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| Faculté | Faculté Polytechnique |
| Institut | Energie |

## Informations relatives au sujet proposé

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|---|---|
| Niveau de recherche | ☒Doctorat ☐Post-Doc |
| 5 mots-clés (français) | Chambre in vitro, flux pulsatile sanguin, PIV, multivariable control, IRM flux 4D, fantômes de vaisseau |
| 5 keywords (English) | Pulsatile test bench, pulsatile blood flow, PIV, multivariable control, 4D flow MRI, vessel phantoms |
| Bref descriptif (10-15 lignes) (français) | |
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| Summary (10-15 lines) (English) | |

[4] Membre permanent de l'UMONS (Futur promoteur de la thèse ou futur encadrant du post-doc)

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| Due to the strong impact of blood flow behavior and pattern in the occurrence or the cure of cardiovascular diseases, the development of new drugs and treatments against these pathologies is requiring tools enabling to produce pulsatile flow conditions found in reality, ideally patient specific, to predict their effect. In order to avoid difficult in vivo investigations or virtual prototyping base on unperfect CFD model, in vitro testes are undeniably an efficient complementary method providing valuable experimental data and information. The PhD research aims at developing:<br>• A new generation of test bench technology and multi-variable controls enabling to mimic accurately a wide range of real patient specific in vivo pulsatile flow conditions for arteries phantoms having several bifurcations,<br>• And experimental methodology and post-processing technics to ensure unsteady time resolved non-intrusive measurement such as PIV and 4D flow MRI. |

**Titre du sujet 5 :** Artificial intelligence and fast multi-objective optimisation methodology for robust aerodynamic design under uncertainties including fuzzy logic.

## Informations administratives

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| Institut | Energie |

## Informations relatives au sujet proposé

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|---|---|
| Niveau de recherche | ☒Doctorat ☐Post-Doc |
| 5 mots-clés (français) | Optimisation multi-objectif, intelligence artificielle, logique floue, conception CFD |
| 5 keywords (English) | Multi-objective optimisation, artificial intelligence, fuzzy logic, CFD design |
| Bref descriptif (10-15 lignes) (français) | |
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Summary (10-15 lines) (English)

Virtual prototyping based on robust design methods are nowadays a key issue to account the operating and geometrical uncertainties existing in reality for aerodynamical CFD conception and multi-objective design optimization. To enable the innovative design optimizing the flow performances, the methods should account a large number of design parameters and be driven intelligently to explore a large range of possible design and fast optimization methodology to reduce the overall computational cost. In response these requirements fulfilling the needs of aeronautics industries and CFD software editors, the PhD research aims at providing engineering-oriented research and development of innovative methods integrating artificial intelligence for fast and robust aerodynamic optimization. For robustness the research also aims at developing more innovative methods related to broader concepts of possibility or imprecise probability (p-box), to the fuzzy that may exist on the uncertain variability of input parameters.