Offer of a funded master degree position in Mechanical/Aerospace Engineering

Multi-scale Aerodynamic Modelling of Helicopters/UAVs in Urban Environments – MSc 1: AI-accelerated predictions of aerodynamic coefficients of a VTOL rotorcraft

About the project

CAE Inc., a manufacturer of simulation technologies and training services to airlines, aircraft manufacturers, healthcare specialists, and defence customers, Presagis, a provider of commercial off-the-shelf (COTS) modeling, simulation, and embedded display graphics software for the aerospace, defense, and automotive industries, Polytechnique Montréal (PM) and Concordia University (CU) have joined forces in a 3-year project funded by PARTENAR-IA, CRIAQ and NSERC to develop solutions aimed at increasing the capacity of flight simulation environments for urban air mobility through the coupling of rotorcraft models, such as for helicopters or unmanned aerial vehicles (UAVs), and urban city aerodynamic models. The project will investigate novel Machine Learning (ML) and Artificial Intelligence (AI) models specifically tailored for the problem at hand, leading to so-called 'physics-based ML/AI models'. The project involves knowledge of Computational Fluid Dynamics (CFD) algorithms and urban scale modeling (including mesh generation over entire city scales), CPU/GPU high-performance computing and, for all major steps of the digital workflow, ML/AI algorithms.

Along with three professors and several industrial partners, the student will be part of an integrated and diversified team of three PhD students, two MSc students and one post-doctoral fellow whose respective projects will cover various aspects such as improving Vertical Take-Off and Landing (VTOL) aerodynamics and flight simulation models and an urban aerodynamics model, and developing of AI/ML models with acceptable accuracy to provide near-real time predictions of the CFD models.

Specifically, this MSc project will focus on the development of a AI-based surrogate model allowing near-real time predictions of aerodynamic coefficients of a VTOL rotorcraft for all flight conditions. The AI training will be performed using data generated from an existing 2D turbulent flow (RANS) model around a rotor, which will be extended to forward flight conditions, based on a Vortex Lattice - Vortex Particle Method.

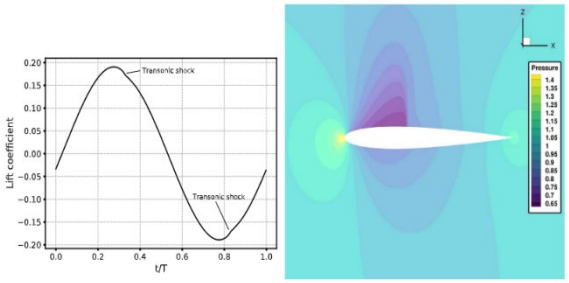

Figure 1: Lift coefficient prediction using the Vortex Lattice method (credit: Parenteau & Laurendeau, 2021)

The project will be carried out at the department of mechanical enginneering of Polytechnique Montreal under the supervision of Prof. David Vidal and the co-supervision of Prof. Eric Laurendeau (PM) and will allow the student to to carry out internships at the industrial

partners mentioned above if warranted. A financial support of 21 000 $CAD/year will be allocated to the MSc student for a 2-year planned MSc.

Skills and training required

The desired candidate should have preferably a Batchelor degree in mechanical/aerospace engineering (or any other relevant science/engineering degree) and thus have expertise in computational fluid mechanics and aerodynamics. Previous experience (e.g. using TensorFlow library) or genuine interest in ML/AI will however be a great asset to carry out this project. The selected candidate should also be autonomous, dynamic and creative, with excellent teamwork and communication skills.

Application

The applicant interested in joining the project should send the following information at david.vidal@polymtl.ca with “AI-CFD project application – MSc 1” as a subject:

1. A letter of motivation;
2. A curriculum vitae;
3. All undergraduate transcripts;
4. An example of technical writing of which she/he is the principal author (e.g. article, report).

With the goal of beginning the project as soon as possible and at the latest for the summer 2023 semester, applications will be evaluated as they are received, and the offer will end as soon as a qualified candidate is identified.

About Polytechnique Montréal

Founded in 1873, Polytechnique Montréal today welcomes close to 10,000 students and relies on the expertise of nearly 1,600 people with diverse skills. Polytechnique promotes excellence and creativity. Located on Mont-Royal, an exceptional site in the heart of Montreal, Polytechnique is a French-speaking internationally renowned engineering university. For students not familiar with the French language, graduate studies can be performed in English while students are encouraged to learn French by enrolling in French classes. Polytechnique Montréal is renowned for its multidisciplinary and multisectoral research, which is at the forefront of the local, national and international scenes, and for the high quality of the training offered at all levels. Polytechnique applies an equal employment opportunity program and particularly encourages women, members of visible and ethnic minorities, Aboriginals and disabled persons to apply.

Offer of a funded doctoral thesis in Mechanical/Aerospace Engineering

Multi-scale Aerodynamic Modelling of Helicopters/UAVs in Urban Environments – PhD1: Aerodynamic and VTOL Modelling Project

About the project

CAE Inc., a manufacturer of simulation technologies and training services to airlines, aircraft manufacturers, healthcare specialists, and defence customers, *Presagis*, a provider of commercial off-the-shelf (COTS) modeling, simulation, and embedded display graphics software for the aerospace, defense, and automotive industries, *Polytechnique Montréal* (PM) and *Concordia University* (CU) have joined forces in a 3-year project funded by PARTENAR-IA, CRIAQ and NSERC to develop solutions aimed at increasing the capacity of flight simulation environments for urban air mobility through the coupling of rotorcraft models, such as for helicopters or unmanned aerial vehicles (UAVs), and urban city aerodynamic models. The project will investigate novel Machine Learning (ML) and Artificial Intelligence (AI) models specifically tailored for the problem at hand, leading to so-called 'physics-based ML/AI models'. The project involves knowledge of Computational Fluid Dynamics (CFD) algorithms and urban scale modeling (including mesh generation over entire city scales), CPU/GPU high-performance computing and, for all major steps of the digital workflow, ML/AI algorithms.

Along with three professors and several industrial partners, the student will be part of an integrated and diversified team of three PhD students, two MSc students and one post-doctoral fellow whose respective projects will cover various aspects such as improving Vertical Take-Off and Landing (VTOL) aerodynamics and flight simulation models and an urban aerodynamics model, and developing of AI/ML models with acceptable accuracy to provide near-real time predictions of the CFD models.

Specifically, this PhD project will focus on the further developments and validations of a Non-Linear Vortex Lattice Method coupled with a Vortex particles Method. Acceleration is via a Fast-Multipole Algorithm. The developments include treatement of fuselages and multi-rotors. The project will generate the following scientific contributions: 1) a better understanding of aircraft aerodynamics interactions in urban conditions, 2) through integration of the aerodynamic model within the citiy model, an better understanding of rotorcraft-vulnerable regions based on coupled analysis.

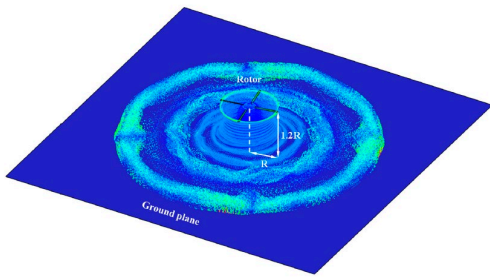

Figure 1: Vectorial circulation colored by the eddy viscosity of wake particles from the S76 rotor rotating (credit: Proulx-Cabana et al. 2022).

The project will be carried out at the department of mechanical enginneering of Polytechnique Montreal under the supervision of Prof. Eric Laurendeau and will allow the student to carry out internships at the industrial partners mentioned above if warranted. A financial support of 25 000 $CAD/year will be allocated to the PhD student for a 3-year planned PhD.

Skills and training required

The desired candidate should have preferably a Master's degree in civil/mechanical/ aerospace/computational engineering or computational science (or any other relevant science/engineering degree) and thus have expertise preferably in computational fluid dynamics. Experience in mesh generation and scientific computing (C/C++, Fortran, Python, Mathematical libraries such as Numpy, MKL, Blass, etc.) can be a great asset to carry out this project. The selected candidate should also be autonomous, dynamic and creative, with excellent teamwork and communication skills.

Application

The applicant interested in joining the project should send the following information at eric.laurendeau@polymtl.ca with “AI-CFD project application – PhD1” as a subject:

1. A letter of motivation;
2. A curriculum vitae including an eventual list of publications;
3. All undergraduate and graduate transcripts;
4. An example of technical writing of which she/he is the principal author (e.g. article, report or master's thesis).

With the goal of beginning the project as soon as possible and at the latest for the summer 2023 semester, applications will be evaluated as they are received, and the offer will end as soon as a qualified candidate is identified.

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Offer of a funded doctoral thesis in Mechanical/Aerospace Engineering

Multi-scale Aerodynamic Modelling of Helicopters/UAVs in Urban Environments – PhD 3: AI-accelerated Urban Airflow Model Project

About the project

CAE Inc., a manufacturer of simulation technologies and training services to airlines, aircraft manufacturers, healthcare specialists, and defence customers, *Presagis*, a provider of commercial off-the-shelf (COTS) modeling, simulation, and embedded display graphics software for the aerospace, defense, and automotive industries, *Polytechnique Montréal* (PM) and *Concordia University* (CU) have joined forces in a 3-year project funded by PARTENAR-IA, CRIAQ and NSERC to develop solutions aimed at increasing the capacity of flight simulation environments for urban air mobility through the coupling of rotorcraft models, such as for helicopters or unmanned aerial vehicles (UAVs), and urban city aerodynamic models. The project will investigate novel Machine Learning (ML) and Artificial Intelligence (AI) models specifically tailored for the problem at hand, leading to so-called 'physics-based ML/AI models'. The project involves knowledge of Computational Fluid Dynamics (CFD) algorithms and urban scale modeling (including mesh generation over entire city scales), CPU/GPU high-performance computing and, for all major steps of the digital workflow, ML/AI algorithms.

Along with three professors and several industrial partners, the student will be part of an integrated and diversified team of three PhD students, two MSc students and one post-doctoral fellow whose respective projects will cover various aspects such as improving Vertical Take-Off and Landing (VTOL) aerodynamics and flight simulation models and an urban aerodynamics model, and developing of AI/ML models with acceptable accuracy to provide near-real time predictions of the CFD models.

Figure 1: interactive visualization of urban microclimate simulation from the CityFFD engine (credit: Mortezazadeh et al., 2022)

Specifically, this PhD project will focus on the development and validation of AI model trained using an urban airflow solver (CityFFD) that will render near-real time predictions of airflow through any new, un-seen urban environment, thanks to the unprecedented generalization capability of recent ML algorithms such as, e.g., Fourier Neural Operators or Graph Networks. In addition, it will generate the following scientific contributions: 1) a better understanding of aircraft and urban aerodynamics interactions in either one way or two ways, 2) data assimilation techniques for numerically simulated and measured data, 3)

understanding urban aerodynamics and rotorcraft-vulnerable regions based on dimensionless analysis.

The project will be carried out at the department of mechanical enginneering of Polytechnique Montreal under the supervision of Prof. David Vidal and the co-supervision of Prof. Leon Wang (CU) and will allow the student to carry out internships at the industrial partners mentioned above if warranted. A financial support of 25 000 $CAD/year will be allocated to the PhD student for a 3-year planned PhD.

Skills and training required

The desired candidate should have preferably a Master's degree in civil/mechanical/ aerospace/computational engineering or computational science (or any other relevant science/engineering degree) and thus have expertise preferably in ML/AI and/or computational fluid mechanics or urban airflow modelling. A good experience in scientific computing and ML/AI will however be a great asset to carry out this project. The selected candidate should also be autonomous, dynamic and creative, with excellent teamwork and communication skills.

Application

The applicant interested in joining the project should send the following information at david.vidal@polymtl.ca with “AI-CFD project application – PhD3” as a subject:

1. A letter of motivation;
2. A curriculum vitae including an eventual list of publications;
3. All undergraduate and graduate transcripts;
4. An example of technical writing of which she/he is the principal author (e.g. article, report or master's thesis).

With the goal of beginning the project as soon as possible and at the latest for the summer 2023 semester, applications will be evaluated as they are received, and the offer will end as soon as a qualified candidate is identified.

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