POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

## PNRR 118 PA Research Field: STATISTICAL MODELING OF LUNGS' INSUFFLATION-EXSUFFLATION MECHANICAL DYNAMICS FOR INTRAOPERATIVE SURGICAL NAVIGATION

| Monthly net income of PhDscholarship (max 36 months) |
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| **€ 1400.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | The increasing need for personalized medicine requires the development of novel tools for supporting surgical procedure. **This is especially true for public administration institutions, like public hospitals, where the availability of new digital tools is required to strongly empower user-oriented strategies.**<br>In particular, about thoracic surgery, a minimally invasive approach to remove lungs nodules can be used if their spot can be accurately predicted. Since CT or CAT are usually performed while the patient's lungs are normally inflated, while surgery occurs while his or her lung is completely exsufflated, nodule position changes from what seen in medical imagery and may be difficult to locate. This increases procedure time, which raises the risks related to infections and sedatation.<br>Accurate prediction about nodules spot during live surgery can support ablative procedure, positively addressing these challenges. The goal of this research is to develop a specific simulation algorithm of the lungs' insufflation-exsufflation mechanical dynamics, able to provide an accurate deformation of the 3D virtual model of a patient's lungs. This 3D model, obtained from the standard pre-operative medical imagery, portraits the lungs in their normal activity shape.<br>The research intends to evaluate if by a FSI (Fluid Structure Interaction) simulation, the 3D model will assume the completely exsufflated shape, alike to what |

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| | happens during procedure. This will give the surgeon an accurate prediction of the nodule(s) final spot during in-vivo surgeries.<br>We also intend to evaluate AI techniques for estimating of that completely exsufflated shape Augmented Reality applications will leverage on the devised simulation algorithm to provide support during procedures by registering the 3D model over the images of the endoscope used to frame the intraoperative field, so that nodule location can be showed contextually to the surgeon's normal vision. **This will improve the capabilities of the public hospital to address complex clinical challenges with new digital techniques, that reduce time procedure costs.**<br>As a additional goal of this research, the vast amount of lungs pre-operative images and their 3D virtual models that will be collected to develop the simulative algorithm will be analyzed to create a statistical lungs model to be used when a more general approach is required. This includes situations outside the field of minimally invasive surgery, such as, e.g., Human Modelling, Medical Training, Educational... |
| **Methods and techniques that will be developed and used to carry out the research** | To obtain a simulation algorithm of the lungs' insufflation-exsufflation mechanical dynamics, different techniques must be combined together, **with a multi-disciplinary approach.**<br>After extensive data collection, which will be possible thanks to the pneumology unit of the P.A. contributing to this proposal, different simulation approaches concerning fluid dynamics and fluid and structure interaction, as well as specific neural networks models, will be used to forecast the lungs' insufflation-exsufflation mechanics. Computer Vision techniques will also be used in order to improve input images quality. To develop AR/VR tools for surgery support, Machine Learning and Computer Vision-based technique for the registration of the 3D model of lungs over the endoscope intraoperative image will be also investigated. |
| **Educational objectives** | **The PhD candidate will develop advanced university-level skills** concerning statistics and programming skills, |

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| | with a focus on Machine Learning methodologies, Computer Vision in biomedical sector and CFD/FSI. Skills in the application of novel technologies in the biomedical sector will also be greatly increased as well as an in-depth understanding of the human body tissues mechanical dynamic. **The candidate will also have the possibility to learn in qualified research institutions, both from the medical sector, both from the academics, and disseminate the achieved results by means of publications and seminars.** |
| **Job opportunities** | The educational objectives of this doctorate will train the candidate with a number of professional skills of high impact in several biomedical companies. **The "Servizio Sanitario Nazionale" (SSN) will be the foremost institution to benefit from this research, by improving the innovative and technical quality of the services provided.** Other international institution interested to a professional figure with the skills acquired in this research project are the Centre Hospetalier Régional Universitaire de Nancy, France, and the Guy's and St. Thomas NHS Foundation Trust, London, GB. |
| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>3 Assistant Professors<br>3 PhD Students |
| **Name of the research directors** | Prof. Giorgio Colombo |

| **Contacts** |
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| *Phone:* +39 349 459 36 49 *Email:* giorgio.colombo@polimi.it<br><br>For questions about scholarship/support, please contact phd-dmec@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** | |
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| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents (more than 80Km out of Milano)** | -- |

| **Scholarship Increase for a period abroad** | |
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| **Amount monthly** | 700.0 € |
| **By number of months** | 6 |

| National Operational Program for Research and Innovation | |
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| **Company where the candidate will attend the stage (name and brief description)** | A.O.U. Città della Salute e della Scienza di Torino |
| **By number of months at the company** | 6 |
| **Institution or company where the candidate will spend the period abroad (name and brief description)** | to be defined |
| **By number of months abroad** | 6 |

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707, 13.

Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.