PhD in MECHANICAL ENGINEERING - 30th cycle

Research Area n. 4 - Methods and tools for Product design

<table>
<thead>
<tr>
<th>Number of scholarship offered</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>Dipartimento di Meccanica</td>
</tr>
</tbody>
</table>

Description of the Research Area

Research in this field is organized in two main research topics:

• PLM-Product Lifecycle Management, which includes process modelling, engineering knowledge management, product innovation methods, systematic innovation principles and methods, topology optimization systems, and data/process interoperability;
• Virtual Prototyping, which includes virtual prototyping for functional and ergonomics product validation, functional mock-up, haptic interfaces and interaction, Reverse Engineering and physics-based modelling and simulation, emotional engineering.

For further information:

A selection of possible PhD thesis in Area 4 is listed here below and described in specific attachments; further research topics are also available.
The assignment of a specific PhD topic to candidates admitted to the Programme will be defined at a later stage by the Faculty Committee, after the beginning of the PhD.

Scholarships allocated in this area may or may not be associated with the PhD topics presented here below:

1. An innovative approach to Design Automation based on Knowledge Engineering and multi-objective optimization

2. Interactive virtual prototyping based on functional mock up

3. Methods and tools for Systematic Innovation

4. Reverse Engineering models for Finite Element Simulations
5. Markerless methods for the recognition of components in the product development process
PhD in MECHANICAL ENGINEERING - 30th cycle

Research Area n. 4 - Methods and tools for Product design

Research Field: AN INNOVATIVE APPROACH TO DESIGN AUTOMATION BASED ON KNOWLEDGE ENGINEERING AND MULTI-OBJECTIVE OPTIMIZATION

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Context of the research activity

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<tr>
<td>The research would evaluate integration of two different methodologies, the so called Knowledge Based Engineering (KBE) and multi-objective optimization, in order to support product design process. KBE has been used to build software application for Design Automation (DA) of some products, especially in aerospace and automotive domain.</td>
</tr>
</tbody>
</table>

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<tr>
<td>A DA application uses knowledge of experts to automate choice, dimensioning and assembling of parts while multi-objective optimization can be used to reach an optimal solution from some points of view (costs, efficiency, stiffness, mass and so on). An innovative approach can be based on KBE methods to configure product architecture and then an optimization procedure focused on technical goals to select the best solution.</td>
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### Job opportunities

National and international academic and non-academic institutions and organizations, engaged in innovation, research and technical development; high-tech SMEs, government departments.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- Tsinghua University (Beijing, China)
- TU Delft
- Electronic Chinese Company
- EPTA SpA

### Composition of the research group

<table>
<thead>
<tr>
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</tr>
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</table>

### Name of the research directors

Bordegoni, Cascini, Colombo, Ferrise, Guidi, Viganò

### Contacts

Supervision of this research topic: Giorgio Colombo
giorgio.colombo@polimi.it

For further information:

For general information:
silvia.barattieri@polimi.it

### Additional support - Financial aid per PhD student per year (gross amount)

<table>
<thead>
<tr>
<th>Type of Housing</th>
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### Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other informations

| Educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student per year: |
| 2nd year: 1.370 euro per student 3rd year: 1.370 euro per student |

**Teaching assistantship:** availability of funding in recognition of supporting teaching activities by the PhD student. 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.

**Computer availability:**
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Research Area n. 4 - Methods and tools for Product design

Research Field: INTERACTIVE VIRTUAL PROTOTYPING BASED ON FUNCTIONAL MOCK UP

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Name of the research directors

Bordegoni, Cascini, Colombo, Ferrise, Guidi, Viganò

Contacts

Supervision of this research topic: Monica Bordegoni
monica.bordegoni@polimi.it

For further information: http://www.mecc.polimi.it/en/research/research-lines/methods-and-tools-for-product-design/

For general information:
silvia.barattieri@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)

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Research Area n. 4 - Methods and tools for Product design

Research Field: MARKERLESS METHODS FOR THE RECOGNITION OF COMPONENTS IN THE PRODUCT DEVELOPMENT PROCESS

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Context of the research activity

Motivation and objectives of the research in this field

Augmented reality technology offers new and effective modalities for users to interact with and learn within an environment. Thus, its use allows new approaches to traditional tasks in industry.

The research aims at analyzing and defining markerless methods suitable to permit the recognition of components that are part of a product.

Parts recognition could enable, for example, new modalities for exchanging information during the whole product development process. The study also intends to identify and develop case studies where this method may be successfully used in the product development process.

Methods and techniques that will be developed and used to carry out the research

The research will be based on markerless technologies, which will be implemented and validated through industrial case studies.

Educational objectives

We provide doctoral candidates with high-level scientific training, fostering and refining research and problem solving abilities by focusing on both theoretical and experimental skills. A PhD in Mechanical Engineering will be able to layout, draft and carry on original research, by leading a research group or working in a team.
### Job opportunities

National and international academic and non-academic institutions and organizations, engaged in innovation, research and technical development; high-tech SMEs, government departments.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

EAFIT University (Colombia)

### Composition of the research group

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### Name of the research directors

Bordegoni, Cascini, Colombo, Ferrise, Guidi, Viganò

### Contacts

Supervision of this research topic: Roberto Viganò  
roberto.vigano@polimi.it


For general information: silvia.barattieri@polimi.it

### Additional support - Financial aid per PhD student per year (gross amount)

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Research Area n. 4 - Methods and tools for Product design

Research Field: METHODS AND TOOLS FOR SYSTEMATIC INNOVATION

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Context of the research activity

The research fields concern the development and integration of methodologies providing a systematic support to product and process innovation either at an operational level (inventive design activities, concept development, problem solving), or concerning strategic R&D (technology maturity assessment, IP monitoring, technology forecasting).

Some examples of specific research objectives are:

- Intelligence Amplification through computer-generated creativity stimuli
- Quantitative creativity assessment of innovative products and services
- Technology monitoring and trends extraction through automatic patent mining
- Computer-Aided Bio-Inspired Design

Motivation and objectives of the research in this field

Methods and techniques that will be developed and used to carry out the research

All the methodological developments shall be validated through industrial case studies in different fields of application.
**Educational objectives**

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**Job opportunities**

National and international academic and non-academic institutions and organizations, engaged in innovation, research and technical development; high-tech SMEs, government departments.

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- KU Leuven TUM
- Technische Universität München
- University of Grenoble
- Whirlpool Europe

**Composition of the research group**

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**Contacts**

Supervision of this research topic: Gaetano Cascini
gaetano.cascini@polimi.it

For further information:

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silvia.barattieri@polimi.it
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Research Field: REVERSE ENGINEERING MODELS FOR FINITE ELEMENT SIMULATIONS

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Context of the research activity

Motivation and objectives of the research in this field

A physical simulation based on Finite Elements Analysis (FEA) applied to existing physical objects involves the definition of a CAD model approximating the physical reality, which is then meshed in a suitable way. The simulation is as much significant as the 3D model faithfully follows the real shape. In case of old mechanical structures affected by deformations, the deviation between the approximate 3D model and the real object may hide interesting behaviors. A model obtained by Reverse Engineering could be very helpful in this sense, but such kind of models have topological and granularity characteristics that do not fit with the requirements of FEA packages. The objective of this research is to set up a set of processing steps for adapting acquired 3D models to FEA, allowing also to semantically identify different components in terms of functions and materials, with the purpose of accurately simulating its static and dynamic behavior in assigned conditions.

Methods and techniques that will be developed and used to carry out the research

The research will work on different 3D acquisition and retopology approaches in order to transform high-resolution meshes acquired with both active and passive methods, in light volumetric models suitable for FEA. The testing will be made on certified test object and, as final result, on historical structures.
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List of 5 Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research:

- University of Rochester (NY), USA
- Indiana University (IN), USA
- Pontificia Universidad Católica del Perú, Lima, Perù
- University of Southampton, UK
- FBK, Trento, Italy

### Composition of the research group

- 1 Full Professors
- 5 Associated Professors
- 5 Assistant Professors
- 12 PhD Students

### Name of the research directors

Bordegioni, Cascini, Colombo, Ferrise, Guidi, Viganò

### Contacts

Supervision of this research topic: Gabriele Guidi
gabriele.guidi@polimi.it

For further information: http://www.mecc.polimi.it/en/research/research-lines/methods-and-tools-for-product-design/

For general information:
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