POLITECNICO DI MILANO

PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 38th cycle

INTERDISCIPLINARY Research Field: ADVANCED MODELS AND METHODS FOR THE DESIGN AND THE OPTIMIZATION OF SOILLESS GROWING MEDIA

Monthly net income of PhDscholarship (max 36 months)
€ 1325.0 In case of a change of the welfare rates or of changes of the scholarship minimum amount from the Ministry of University and Reasearch, during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "**INFORMATION TECHNOLOGY**". See https://www.dottorato.polimi.it/?id=422&L=1 for further information. Over the last decade a significant shift in global agricultural practice has taken place. The main motivation in such a direction is represented by the rapid increase of human population. FAO has estimated that a 70% increase of agricultural production is needed by 2050, to meet the demand of the world¿s expected 9 billion inhabitants. This request has prompted new technologies to improve crop production in a sustainable and scalable way. At the European level, the EU commission has launched mission "A Soil Deal for Europe: 100 living labs and lighthouses to lead the transition towards healthy soils", aiming a transition towards a healthful soil and its preservation. This research is focused on soilless cultivations (classified into aeroponics, aquaponics, hydroponics systems), i.e., the method of growing plants in the absence of soil, with the aim of preserving soil consumption at the EU level. Compared to traditional farming techniques, soilless cultivations guarantee a reduction in terms of land usage, water consumption,

	fertilizer supply, while ensuring an increased yield per unit area. In soilless cultivation, plants are grown on artificial substrates which provide the necessary physical support, and act as reservoirs of nutrients and oxygen, for roots to grow. This project aims at proposing new design procedures for soilless growing media, to overcome the principal limits of common artificial soils and to optimize soilless growth systems, with a focus on hydroponics systems.
Methods and techniques that will be developed and used to carry out the research	Growing media typically consist of inert organic (coconut, peat) or inorganic (polyurethane foam, sand, clay) substrates supporting the roots. The substrate is determinant for plant survival and growth, in terms of i) mechanical (for attachment, growth, support), ii) chemical (to ensure a specific range to the pH), iii) biological (to prevent pathogen infections) properties, as well as of iv) microscopic structure (to guarantee nutrient/water availability, aeration). This project resorts to additive manufacturing (AM) technologies in order to replicate most of these characteristics with 3D printed artificial soils. Advanced mathematical techniques have been recently proposed by the one of this research directors for the design of innovative cellular materials for 3D printing, to match user-selected properties at the macro-scale. So far, this technology has been developed in a thermo-mechanical setting. The candidate will be expected to extend such a methodology to a more general multi-physics context, to incorporate the mechanical, chemical, biological requirements in i)-iii). This will turn into a considerable effort from a modeling and a methodological viewpoint, with the setting of advanced optimization tools to make the whole design procedure affordable, and also from a control and monitoring perspective since hydroponic cultures need constant supervision to result in high yielding and low resource consumption.
Educational objectives	This research project provides the candidate the possibility to explore the whole pipeline, from theory to practice. She/He will familiarize with advanced mathematical methodologies (such as homogenization, mesh adaptation, multi-objective optimization, etc.) used

	for the setting of cutting-edge techniques for the design of completely new materials; the new materials will be realized in practice, by resorting to 3D printing procedures, based on suitable materials; finally, the effectiveness of such new 3D printed soilless media will be verified by devising specific sensors to monitor the agronomic efficacy.
Job opportunities	The interdisciplinarity of this research project will help the candidate to acquire a problem-solving capacity, between theoretical rigour and practical experience. We are currently establishing contacts with spin-offs working in the design of soilless media, to complete the candidate's training with the forma mentis typical of an industrial environment.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Simona Perotto and Andrea Bonarini

Contacts
simona.perotto@polimi.it *andrea.bonarini@polimi.it*

Additional support - Financial aid per PhD student per year (gross amount)			
Housing - Foreign Students	**1st year**	**2nd year**	**3rd year**
	1500.0 € per student	0.0 € per student	0.0 € per student
	max number of financial aid available: 3, given in order of merit ..		
Housing - Out-of-town residents (more than 80Km out of Milano)	--		

Scholarship Increase for a period abroad	
Amount monthly	662.5 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year

1st year: max 1.800,47 euros
2nd year: max 1.800,47 euros
3rd year: max 1.800,47 euros

The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations.1 individual PC per student + several shared PC.
Access to one cluster with 32 processors and 384 GB RAM, and to several multi-processor servers and 1 individual desk per student are granted.