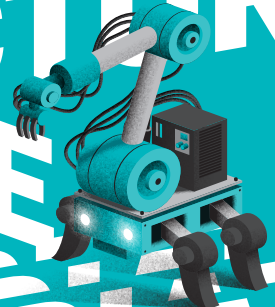


# ARCHITECTURE IN THE AGE OF THE 4TH INDUSTRIAL REVOLUTION



**Edited by**  
**José Pedro Sousa**  
**Gonçalo Castro Henriques**  
**João Pedro Xavier**

**Volume II**  
**The eCAADe and SIGraDi Conference**  
**11-13 sep 2019, Faculty of Architecture**  
**University of Porto, Portugal**

**eCAADe SIGraDi 2019**

***Architecture in the Age of the 4<sup>th</sup> Industrial Revolution***

**Volume 2**

**Editors**

José Pedro Sousa, Faculty of Architecture, University Porto  
Gonçalo Castro Henriques, Rio de Janeiro Federal University  
João Pedro Xavier, Faculty of Architecture, University Porto

**1<sup>st</sup> Edition, September 2019**

Architecture in the Age of the 4th Industrial Revolution – Proceedings of the 37<sup>th</sup> International Conference on Education and Research in Computer Aided Architectural Design in Europe, and of the 23<sup>rd</sup> Conference Iberoamerican Society of Digital Graphics, Porto, Portugal, 11<sup>th</sup>-13<sup>th</sup> September 2019, Volume 2. Edited by José Pedro Sousa, Gonçalo Castro Henriques and João Pedro Xavier. Brussels: Education and Research in Computer Aided Architectural Design in Europe; Rio de Janeiro: Iberoamerican Society of Digital Graphics; Porto: Faculty of Architecture, University of Porto, Portugal.

**ISBN**

9789491207181 (Volume 2)

978-94-91207-18-1

Copyright © 2019

**Legal Deposit**

460231/19

**Publishers**

eCAADe (Education and Research in Computer Aided Architectural Design in Europe)  
SIGraDi (Iberoamerican Society of Digital Graphics)  
FAUP (Faculty of Architecture, University Porto)  
Porto, Portugal

**Cover Design**

Dobra

**Printed by**

Lusoimpress.com

All rights reserved. Nothing from this publication may be produced, stored in computerised system or published in any form or in any manner, including electronic, mechanical, reprographic or photographic, without prior written permission from the publisher. Authors are responsible for all pictures, contents and copyright-related issues in their own paper(s).

# eCAADe SIGraDi 2019

## *Architecture in the Age of the 4<sup>th</sup> Industrial Revolution*

### Volume 2

#### Proceedings

The 37<sup>th</sup> Conference on Education and Research in Computer Aided Architectural Design in Europe

The 23<sup>rd</sup> Conference of the Iberoamerican Society Digital Graphics

#### Conference

11<sup>th</sup>-13<sup>th</sup> September 2019

Porto, Portugal

Faculty of Architecture

University of Porto

#### Edited by

José Pedro Sousa

Gonçalo Castro Henriques

João Pedro Xavier

**ORGANIZATION**



**eCAADe SIGraDi**

**DIAMOND SPONSORS**



**GOLD SPONSORS**



**SUPPORT**



**TECHNICAL SUPPORT**



**eCAADe SPECIAL SUPPORT**

OpenConf (Winchester)  
ProceeDings (Wurzer, Lorenz, Coraglia)  
CuminCAD (Martens, Cerovsek)  
Voting System (Winchester)

**INSTITUTIONAL PARTNERS**

Teatro Municipal do Porto  
Rivoli ● Campo Alegre



# Evolving stages of digital fabrication in Latin America

## *Outlines of a research and extension project*

Rodrigo Scheeren<sup>1</sup>, Pablo C. Herrera<sup>2</sup>, David Sperling<sup>3</sup>

<sup>1,3</sup>University of São Paulo (USP) <sup>2</sup>Universidad Peruana de Ciencias Aplicadas (UPC)

<sup>1</sup>rodrigosscheeren@gmail.com <sup>2</sup>pablo.herrera@upc.edu.pe <sup>3</sup>sperling@sc.usp.br

*The introduction of digital fabrication technologies in Latin America faces diverse, heterogeneous and decentralized conditions. After several years, there was not a comprehensive perspective on the situation in the region. The goal of this paper is to present a project called "Homo Faber: Digital Fabrication in Latin America" and some of its results. The project comprehends the creation of a database that led to researches and exhibitions about digital fabrication in design, architecture and building construction in Latin America. The questions that guide the investigation try to understand which factors contribute and limit the potential of automation in material processes towards 4.0 industry.*

**Keywords:** Computer Aided Architectural Design, Digital Fabrication, Latin America, Mapping

## **INTRODUCTION: AN OUTLOOK OF LATIN AMERICA DIGITAL FABRICATION**

In the fields of design, architecture and building construction, CAAD processes have converged to advances in simulation and in a material approach. If in the first we can consider computational design processes such as performance and optimization and also Building information modeling, in the second we take into account automation processes in the use of novel technologies to prototype and manufacture objects. In the first situation, all come to hand by the use of software and skills on programming, in the second it depends on the acquisition of digital fabrication machines and robotic systems. The implementation, diffusion and development on the use of digital fabrication in the area of Computer-Aided Archi-

itecture Design in Latin America started two decades ago. Throughout this period, different temporalities and specificities in the region's manufacturing processes became noticeable.

In Latin America, the potential of design projects using virtual tools does not match effortlessly with the potential to materialize such complexity by using automation processes of fabrication, leaving us with a gap into the use of this potential to enhance material strategies. Digital fabrication laboratories have been established since the last decade in academic spaces, Fab Labs and Makerspaces, and also design offices, boosting a decentralized routine of activities, focused on a set of internal necessities such as teaching, research and extension and external demands such as design of objects, art installations and

projects for companies. The use of the machines has been seen mainly as a chance to prototype models with precision and reconsider craft as a process to materialize ideas based on a maker philosophy, shaping some kind of hybrid culture. Furthermore, professionals use technologies appropriated from abroad and are accessible in the local market to understand and develop skills in a short time. The globalized influence of projects fosters particular investigations in strategies of applying digital fabrication tools under a certain risk of mimetic proposals. Moreover, there are few strategies to implement the use of digital fabrication technologies with industry to enhance technology transfers, besides increasing attention to local needs and cultural influences on the creative process.

The central question of this investigation is if due to decentralized and multiscalar activities, technological appropriation, hybrid processes and the lack of a strong connection between research and industrial sectors, besides political issues and economic situation, these factors have led us with few initiatives using digital fabrication technologies towards the 4.0 industrial revolution. The investigations and exhibitions mentioned below are part of an ongoing project in order to understand this evolving process, mapping and analyzing the regional context related to digital fabrication laboratories in the areas of design, architecture and building construction, oriented to investigate academic research lines, manufacturing, infrastructure, professionals involved and networking. This article intends to present discuss and analyze a brief history of this project since the first (2015) to the last exhibition carried out last year (2018) by means of: 1) the results of an extensive, long-term and continuous research about digital fabrication in Latin America; 2) overview of the recent context of digital fabrication laboratories in Latin America; 3) assess guidelines on technical and political issues concerning technological appropriation and the applications of new technologies of fabrication.

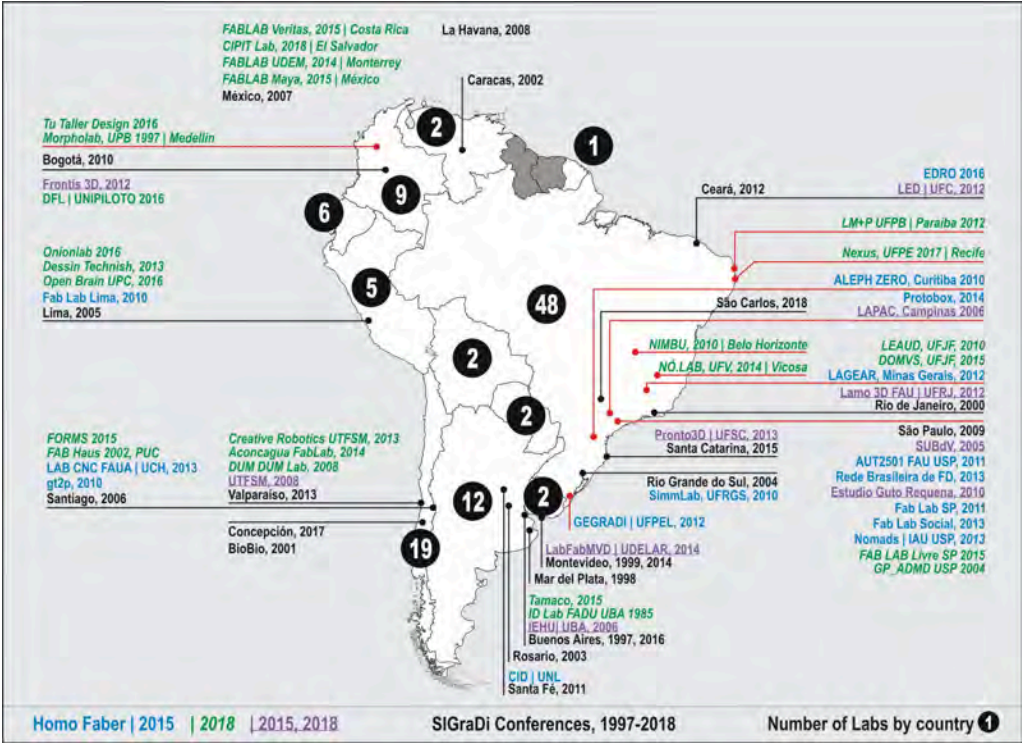
## **METHODS: COLLECTING DATA AND SPREADING INFORMATION**

The project *Homo Faber: Digital Fabrication in Latin America* began in 2014, with the invitation to organize a small exhibition upon the topic of digital fabrication in the Latin America region, in the occasion of the 15th CAAD Futures Conference carried out in 2015. The exhibition resulted from a ground-breaking approach using a survey to collect data from digital fabrication laboratories, structured by four parts: institutional information (city/country, current coordinator, current staff, date of foundation, brief history, institutional associations, email/website), infrastructure (machines and fabrication technologies available in the laboratory), operating and work data (current activities, workshops, courses, uses of digital fabrication and applications of the fabrication processes/fabricated objects). The information compiled was an original opportunity to look at what was going on in the fields of architecture and design to show for the first time a comprehensive mapping of the Latin American scenario.

Since then, the project has been unfolded based on the following strategies: a) setting up of a database about digital fabrication laboratories in Latin America (academic spaces, Fab Labs and design offices); b) systematic review of publications; c) structured surveys to the laboratories (formulary based on Google Forms); d) continuous updating of the database (collecting data from scientific publications and information on the webpages); e) qualitative and quantitative analysis of the collected data; f) elaboration of maps, diagrams and charts from the data; g) organization of exhibitions; h) publication of scientific articles.

A central element of the research and extension project is the organization of triennial exhibitions focusing on the recognition of digital fabrication state of the art in the region and the scientific and technological spreading of their applications. The exhibitions are composed of videos and models, as well as information panels that display the textual and graphic material produced from analysis of the re-

Figure 1  
Location of Labs  
based on the  
research and in  
Homo Faber  
Exhibitions  
between 2015-2018



sulted database, having an itinerant character. In order to amplify the access to the research results, each exhibition occurs with the release of a catalog (printed and digital version) as well as a video repository on the web [2], [3].

### A RECENT STATE OF THE ART OF DIGITAL FABRICATION: HOMO FABER EXHIBITIONS AND CURRENT RESEARCHES

At the beginning of 2014 the research project was started following the settled objectives of the study: “firstly, to draw the cultural, social and economic context of implementation of digital fabrication laboratories in the region; secondly, to synthesize relevant data from correlations between organizational struc-

tures, facilities and technologies, activities, types of prototypes, uses and areas of application; thirdly, to draw a network of people and institutions, recovering connections and the genealogy of these fab labs; and fourthly, to present some fab labs that are intertwined with local questions.” (Sperling, Herrera & Scheeren 2015).

During that year, the number of active MIT Fab Labs in Latin America was composed of 39 laboratories, based on the information available on “fablabs.io” map [1]: Argentina (7), Brazil (14), Chile (4) Colombia (5), Ecuador (2) and Peru (7). In order to expand this background, the investigation was driven to map several other fabrication laboratories that were not participating in this network. For this pur-



pose, the survey was submitted in July 2014 to 48 fabrication laboratories, of which 31 laboratories from 6 countries answered, including three MIT Fab Labs: Argentina (2), Brazil (22), Colombia (1), Chile (4), Peru (1) and Uruguay (1).

From the analysis of the survey, 24 consolidated and emerging laboratories that had been established between 2005 and 2014 were invited to participate in the first exhibition called "Homo Faber: Digital Fabrication in Latin America" (2015). The projects selected represented 6 countries in South America: Argentina (2), Brazil (16), Chile (4), Colombia (1), Peru (1) and Uruguay (1). Conceived around the subject *Informing Materials and Materializing Forms* as a tribute to the theoretical work of the Tchek-Brazilian philosopher Villém Flusser, the exhibition was organized in four parts: Informing surfaces, Informing objects, Informing Spaces and Informing social processes (Sperling and Herrera 2015). The most part of the exhibited works came from laboratories situated in Universities, including few Fab Labs and design offices. The exhibition represented, until that date, the main effort to systematize, categorize and present processes and dynamics of digital fabrication in the fields of architecture, design and construction in the region.

Five recurrent categories of uses for the digital fabrication were identified in the set of projects: prototyping of small objects, fabrication of architectural models, architectural components, construction models and fabrication of machines. Seven recurrent applications were also identified from the analysis of processes and results, remarking those from highest to lowest incidence: design prototypes, models of architectural heritage, pedagogical objects, components for the construction industry, objects for impaired people, objects/processes for development of communities, models for art and museology and machine invention.

After an inaugural period in Sao Paulo (Brazil), the traveling exhibition visited other Brazilian cities during 2015. In 2018, a special selection of the project took part of the *Digital Craft in Semi-peripheral Nations* exhibition organized by the Association for

*Computer Aided Design in Architecture* (ACADIA) in Mexico City (Iriarte 2018). The first round of the research unveiled the situation of each laboratory and allowed to understand the way of application of digital technologies as a rich field of investigation. In the first moment, the investigation related to Homo Faber project brought several data to analysis discussed in several publications (Sperling and Herrera 2015; Sperling, Herrera & Scheren 2015; Herrera, Sperling & Scheren 2015; Sperling et al. 2015).

In parallel of that publications, Homo Faber project was unfolded by Ph.D. researches that are in progress since 2016, taking the critical discussion about the Latin American scenario of CAAD and digital fabrication as an opportunity and a requirement to understand the actual context of the region as well as to draw guidelines for future achievements. The first is the study entitled *Digital fabrication laboratories in South America: strategies, processes, and artifacts for architecture and design*, by the Ph.D. candidate Rodrigo Scheeren. The goal of the research is to map and systematize information about the digital fabrication laboratories in South America and take a look at the specificities of their processes and manufacture, bound to the local context, as well as other information related to design, research, education, professionals, technologies and facilities. Up to now, the investigation mapped information about more than 100 laboratories scattered around many cities in the continent under the label of academic research centers, Fab Labs and design offices. Some artifacts and categories, technical, cultural and social activities bound to local contexts and their political issues had already been identified (Scheeren and Sperling 2018).

The second is the study entitled *The levels of computability in the architectural design process: an approach to teaching* by the Ph.D. candidate Tássia Vasconcelos. The goal of the research is to investigate the context of graphic representation technologies and digital design on architectural teaching in Latin America focused on Brazil. This mapping is oriented "to understand an ongoing movement toward Dig-

[illegible]

During this period, Pablo C. Herrera extended the research on programming cultures, digital fabrication and craft in the region. In contrast with the northern hemisphere, where digital fabrication was the starting point for programming during the first decade of the 21st century, in the south, the culture and use of digital fabrication equipment were sparse. Solely in the second decade of the 21st century digital fabrication technologies would be extensively used in academic activities, mostly in Argentina, Brazil and Chile, countries that invested in the education of architects doing their masters and doctorate programs in the US and Europe. The ac-

The fabrication culture at the beginning of the second decade of the 21st century produced academic proposals mainly associated with prototyping of objects, as was evidenced in *Homo Faber 1.0*, which were intensified in more elaborated proposals that shared the stage with the work with craftsmen's communities (Herrera 2016) and even created mobile fabrication laboratories in Brazil, Chile, Peru and Mexico (Herrera 2018). This happened in part because programming culture was not considered for the solution of the scale of the architectural models or prototypes, but only in the design process, and therefore results in fabrication are still not associated to manufacturing, as is the case of the northern hemisphere, as documented by Kolarevic and Klinger (2008) and Gullinq (2018).

Recently, some exhibitions on digital fabrication from Latin America were the center of visibility in the world. Started in *Machinic Processes: Architecture Biennial Beijing* (Del Campo, 2010) held in China, with a section that included projects from Colombia, Peru and Chile. After this first moment, exhibitions took place in Europe such as *New Territories: Laboratories for Design, Craft and Art in Latin America* (Stokes 2014) organized in Madrid and the exhibition *Unsettled Artifacts: Technological Speculations from Latin America* (Gaetano 2017) made in Los Angeles, USA. In 2014, on the occasion of the XVIII Conference of the Iberoamerican Society of Digital Graphics carried out in Uruguay, the exhibition *FAB 01 Uthopia the Unbuild: Digital Manufacturing of architectures not built* was presented (García 2014).

Homo Faber 2.0 started to be planned in November of 2017 following the activities of the XXII Conference of the Iberoamerican Society of Digital Graphics in the Institute of Architecture and Urbanism at the University of São Paulo. The conference revealed as a good opportunity to display information from the researches, planning the second edition of the exhibition, three years after the first one. With this in mind, one of the goals of the Ph.D. research was to amplify the study started in 2014. Along the years of 2016-17, our data bank of digital fabrication laboratories in Latin America grew to 116 entries, recognizing quantitative and qualitative data about 58 academic research centers, 27 Fab Labs and 31 design offices. They are located in Argentina (12), Brazil (48), Bolivia (2), Chile (19), Colombia (9), Ecuador (6), French Guiana (1), Paraguay (2), Peru (5), Uruguay (2) and Venezuela (2).

For Homo Faber 2.0 exhibition, instead of inviting the laboratories after analyzing the answers to the survey as in the first edition, an open call for the exhibition was announced on the internet and directly to the fabrication laboratories contained in the data bank, indicating the theme: *Politics of Digital in Latin America*. The exhibition framework was drawn articulating some theoretical propositions concerning technological artifacts and cultural appropriation

(Winner 1977 and 1980; Montaner and Muxi 2011; Alvarez, Gonzalez & Puentes 2013; Walter-Herrmann 2013; Picon 2014; Alvarez and Gonzalez 2016), with the aim of examine the bounds between politics and society, showing the potential of digital fabrication and its impacts on communities, indicating how some applications of digital fabrication technologies from their disruptive nature may help to implement new policies on manufacturing processes (Scheeren, Herrera, and Sperling 2018, p. 11).

Each laboratory was invited to send one proposal compounded by images, text and technical data of a work done by it. Having received 61 proposals, the organizing committee selected 37 projects that were distributed in three categories: projects related to design collaboration processes for changes in society with activities aimed at citizens in particular and strategies of subversion in the use of digital technologies (12); projects related to processes and prototypes of conceptual research using formal and material experimentation, as well as the technological development of new techniques and products (19); projects related to artisan-digital hybridism / neocraft / cultural identity that promotes the mixed use of artisanal and digital techniques for the creation of the artifact (6).

The selected fabrication laboratories are located in nine countries in South and Central America: Argentina (3), Brazil (16), Chile (5), Colombia (4), Costa Rica (1), El Salvador (1), Mexico (2), Peru (4) and Uruguay (1), and similarly to the 2015 entries, they are mainly located in Universities, with private funding or from the state.

## **THEORETICAL BACKGROUND: FROM TECHNICAL PRODUCTION TO POLITICAL OUTCOMES**

The political view of the impact of digital technologies has been seen in a positive way since the beginning, in the skills experience, the complexity of the project and control of information, also as digital fabrication technologies facilitating a participatory and collaborative approach and accessibility in

their learning and application. Based on the variability of additive, subtractive and robotic technologies, the benefits of imagining, test and prototyping were fostered by desktop printers and the spread of the maker movement in our region. As long as the compromise with novel technologies emerged worldwide, they also raised many inquiries.

In the history of CAAD, Mitchell and McCullough (1995) set up a more positive vision in which technological change brings opportunities and exciting intellectual challenges as well as threats to shape the emergence and development of digital design media and to apply the powerful new computational tools to social and cultural tasks that really matter. Gershenfeld et al. (2018) suggest that “self-sufficient production” or making what one consumes at a personal, family, or local level is expanding through the accelerating advances in digital fabrication, despite this category of job works only in a complementary level. Smith (2013) remarks that using “low-tech” and digital production methodologies, the designer may be more directly involved in the making of an artifact or building component, where the designer operates independently of the fabricator or fabrication

process, sometimes because they have limited skills and access to technologies.

Winner (1980) in his seminal paper addresses that machines, structures and systems of technology can embody forms of power in human associations. According to him, it's important to notice the range of flexibility and how technologies influence the shape of other technologies, how they can reshape or establish a framework in social and production relationships, the arrangements or design of technical systems, decisions that let people with different degrees of power and levels of awareness, effectivity and practical necessity of their use, besides how each technical system influence the quality of public life. Crusiepe (1985) had already pointed out that it is crucial to address the issue of technological appropriation in sectors that are not qualified to produce it, generating a situation of asymmetry and dependency condition between central countries and peripheral countries. Technology becomes a commodity at a time when a structure favorable to innovation is not created within each society since the uncritical transfer of technology can have questionable effects on peripheral economies. Lombardero and

De Canales (2016) reflects about the implications of the different technological levels, the untie of design variables from a unique production system, the relevance of actions from the individual free association and the need to question the current status.

This theoretical background is guiding us in the past and the future of the research towards the third Homo Faber exhibition.

## **RESULTS AND FUTURE WORKS: REFLECTIONS ABOUT A CHANGING ENVIRONMENT**

An overview of the digital fabrication scenario in Latin America in the last years allow us to make some reflections regarding the evolving stages of Digital Fabrication. Although the academia in the region drives some levels of exploration using emerging technologies like 3D printers, CNC milling machines and laser cutters, the progress made in their applications was the result of the policy of each countries that have the most economic resources and research funding to make the process sustainable in universities and architecture studios (Sperling and Herrera 2015).

On the other hand, the cases from academia are different from professional cases. The architecture offices that integrate new technologies were formed by initiatives of architects with education and training skills obtained in foreign regions - especially in the northern hemisphere -, with a self-managed investment in digital fabrication equipment, and that still doesn't have a sustainable model for maintenance and equipment renewal - not so different as in many of the universities. In some cases, the members of the offices explore experimental methods - analog and digital - and proposals with programming and manufacturing techniques, providing workshops in universities in which they also use the academic infrastructure. In contrast to 2015, 8 architecture offices from Brazil, Chile, Colombia and Peru were presented in this exhibition.

Furthermore, the social context was a determining factor over the last years, strengthening the mo-

mentum of researchers who returned to the region after their masters or Ph.D.'s and in many cases shared the knowledge as advisors of local postgraduate students, motivating them in the approach to digital fabrication. Therefore, many of the projects presented in the exhibitions belong to a local generation of professionals that integrates novel technologies into their proposals, trying to establish sustainable policies in the process. Along with the visit of specialists and the participation in international conferences, a favorable ecosystem is still framed for the results that were shown in this exhibition.

From 2015 to 2018, digital fabrication laboratories in Latin America indicate a significant advance not only in the infrastructure but extending the influence of their projects to more countries in our region. Despite the growth of fab labs in the world between 2015 and 2018 was of 134 percent, in South America, it remains at 8 percent (Scheeren, Sperling & Herrera 2018, p. 62). The second edition reflects a maturation of initiatives that enhance an approach to different scales towards the built environment. The investigated processes and resulted artifacts demonstrate an advance in the complexity of the proposals, scale of manufacturing, technical solutions and materialities.

In the second version of the exhibition, we looked for answers to local problems driven by experiences of not only a laboratory but of different contributions that enrich new digital fabrication policies and politics, for their own places, their cities and the world. Among these laboratories, some arise with proposals increasingly associated with local problems, going from experiences referenced to the northern hemisphere to others that seek in their own reality and community: a connection that gives value to their identity.

The process of collecting all information allowed more comprehensive research about the topic of digital fabrication in Latin America and gathered a usual gap between many investigations focused on activities and applications, the locus of each workplace, some theoretical background and an overview of

technical and cultural context. The last effort is to advance in order to understand some economic and political issues as discussed in this paper.

In general, we observe three stages of experimental applications of digital fabrication technologies: 1) prototyping objects, understanding and development of skills, 2) crafting and full-scale models, short and middle term investigations, 3) long term researches, solve technical and social problems, promote technology transfers. Most part of the digital fabrication laboratories associated with academic institutions still develops projects and activities according to the characteristics of the second stage. The Fab Labs and design offices develop projects and activities according to the characteristics of the first stage.

Digital fabrication laboratories in Latin America run by the desire of automation similar as seen in the automotive industry, at the same time that keeps insisting in an attempt to approach a specific way of maker philosophy. One challenge is to avoid using digital fabrication as a new intellectualism by means of control and automation in confront to the idea of the use of manual labor in the workshops. Although, it is required to advance in a kind of specialization of digital skills and material strategies that go further from an abstract level of understanding and applications towards a more specific, context-based, participatory and integrative level. Another challenge is to deal with material scarcity, appropriation of technologies without a critical perspective and the distance between each laboratory avoiding an easy connection and opportunities to share knowledge by common researches and activities. Even for the design offices, some of them invest in similar strategies to apply the technologies but don't know what each one is working in.

There are technology parks capable of cope with digital fabrication in several Latin American cities; however, the transfer and technological appropriation of digital design processes and digital fabrication technologies by the construction sector are never-ending challenges in the face of superstructural conditions such as: low investment in design innovation;

production chains based on the assembly of serial products; availability of low cost manpower. Future advances in the area of digital fabrication in architecture in Latin America seem to demand the articulation of systemic actions of policies, an incentive to innovation and located actions of technological appropriation that produce new unfoldings of the local cultures.

Overall, it is important to highlight that through this research and exhibitions project, histories and backgrounds of the digital fabrication in Latin America are being traced and registered. The contribution of this research to the history and future of CAAD, digital fabrication and the context towards a Fourth Industrial Revolution in the Latin America architecture began with the first milestone in 2015 and was proposed as a continuous mapping process. In the following three years it will include the organization of the itinerancy of the second exhibition to Latin American cities, the launch of the website with project details, the update of the database based on a new survey, and the organization of the third edition of the exhibition in Lima (Peru), in 2021. The approach to organize and promote the exhibitions have been a powerful strategy to set up networks among agents, allowing them to look at diverse works as outcomes from the same stage sharing concepts and knowledge related to each project. This is an ongoing story that represents the different stages of technological appropriation in our region.

## ACKNOWLEDGMENTS

Coordination for the Improvement of Higher Education Personnel (CAPES) and São Paulo Research Foundation (FAPESP - process 2017/04946-7) for the research scholarship. To the Department of Research of the Universidad Peruana de Ciencias Aplicadas (UPC). To all laboratories and design offices who contributed to the research and the exhibitions.

## REFERENCES

Alvarez, N and Gonzalez, F 2016, *Política y Fabricación Digital. Una discusión en curso*, Vivok Works, Sevilla

- Alvarez, N, Gonzalez, F and Puentes, M 2013, 'Contextualizando lo digital. Reflexiones del Taller Politics of Fabrication Laboratory de la Architectural Association y la Universidad Católica de Valparaíso', *Revista 180*, 32, pp. 30-35
- Bonsiepe, G 1985, *El diseño de la periferia*, Editorial Gustavo Gili, Barcelona
- Del Campo, M 2010, 'Latin America', in Leach, N and Weiguo, X (eds) 2010, *Machinic Processes. Architecture Biennial Beijing 2010*, China Architecture & Building Press, Beijing, pp. 194-225
- Gaetano, P 2017, 'Unsettled Artifacts: Technological Speculations from Latin America', *Leonardo*, 50(4), pp. 409-437
- García, F (eds) 2014, *FAB 01 Utopia the Unbuild. Fabricación Digital de arquitecturas no construidas*, Universidad de la República, Montevideo
- Gershenfeld, J, Gershenfeld, A and Gershenfeld, N 2018, 'Digital Fabrication and the Future of Work', *Perspectives on work*, 22, pp. 8-13
- Gulling, D (eds) 2018, *Manufacturing Architecture. An Architects Guide to Custom Processes, Materials, and Applications*, Laurence King Publishing, London
- Herrera, PC 2016 'Digital fabrication and revival craft in Latin America: Alliance between designers and artisans', *Proceedings of 10th ICDHS 2016*, Taipei, pp. 291-295
- Herrera, PC 2018 'Artisans and Digital Craft in Latin America: The contribution of architects to their creativity and production', *Proceedings of 22th SIGraDi 2018*, São Carlos, pp. 1179-1186
- Herrera, PC, Sperling, D and Scheeren, R 2015 'Independent Laboratories of Fabrication in Latin America', *The 11th Fab Lab Conference and Symposium - Making: Impact*, Cambridge, pp. 1-7
- Iriarte, P 2018, 'Digital Craft in Semi-peripheral Nations', in Anzalone, P, Del Signore, M and Wit, J (eds) 2018, *Projects Catalog of the 38th Annual Conference of the ACADIA*, ACADIA, Mexico DF, pp. 50-72
- Kolarevic, B and Klinger, K (eds) 2008, *Manufacturing Material Effects. Rethinking Design and Making in Architecture*, Routledge, New York
- Mitchell, W and McCullough, M (eds) 1995, *Digital Design Media*, Van Nostrand Reinhold, New York
- Montaner, J and Muxi, Z 2011, *Arquitectura y Política. Ensayos para mundos alternativos*, Gustavo Gili, Barcelona
- Picon, A 2014, 'Foreword', in Caneparo, L (eds) 2014, *Digital Fabrication in Architecture, Engineering and Construction*, Springer, New York, pp. v-viii
- Scheeren, R, Herrera, PC and Sperling, D (eds) 2018, *Homo Faber 2.0: Politics of Digital in Latin America*, Instituto de Arquitetura e Urbanismo USP, São Carlos
- Scheeren, R and Sperling, D 2018 'Technological appropriation and socio-technical adequacy in South America: applications of digital fabrication in architecture and design', *Proceedings of 22th SIGraDi 2018*, São Carlos, pp. 1347-1354
- Schwab, K 2015, 'The Fourth Industrial Revolution. What It Means and How to Respond', *Foreign Affairs*, Anthology Series (<https://www.foreignaffairs.com/articles/2015-12-12/fourth-industrial-revolution>), p. December
- Smith, C 2013, 'Labour matters: The politics of materials and making in architecture', *Interstices: Journal of Architecture and Related Arts*, 14, pp. 59-67
- Sperling, D and Herrera, PC (eds) 2015, *Homo Faber. Digital Fabrication in Latin America*, Instituto de Arquitetura e Urbanismo USP, São Carlos
- Sperling, D, Herrera, PC, Celani, G and Scheeren, R 2015 'Fabricação digital na América do Sul: um mapeamento de linhas de ação a partir da arquitetura e urbanismo', *Proceedings of 19th SIGraDi 2015*, Florianópolis, pp. 119-125
- Sperling, D, Herrera, PC and Scheeren, R 2015, 'Migratory Movements of Homo Faber: Mapping Fab Labs in Latin America', in Celani, G, Sperling, D and Franco, J (eds) 2015, *Communications in Computer and Information Science*, Springer, Berlin, pp. 405-421
- Stokes, L 2014, *New Territories. Laboratories for Design, Craft and Art in Latin America*, Museum of Arts and Design, Turner, Madrid
- Vasconcelos, T and Sperling, D 2017, 'From representational to parametric and algorithmic interactions: A panorama of Digital Architectural Design teaching in Latin America', *International Journal of Architectural Computing*, 15, pp. 215-219
- Walter-Herrmann, J 2013, 'FabLabs – A Global Social Movement', in Walter-Herrman, J (eds) 2013, *FabLabs of Machines, Makers and Inventors*, Majuskel Medienproduktion GmbH, Wetzlar, pp. 33-45
- Winner, L 1977, *Autonomous Technology: Technics-out-of-Control as a Theme in Political Thought*, MIT Press, Cambridge
- Winner, L 1980, 'Do Artifacts have Politics', *Daedalus*, 109(1), pp. 121-136

[1] <https://www.fablabs.io/labs/map>

[2] <https://www.youtube.com/channel/UCeyEsC7GCAANrkyqblYENaQ>

[3] <https://www.youtube.com/channel/UCqFJ8miEFLN4552gxXmT1Xg>