Cristian Jesús Vega Cereño

Curriculum Vitae

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General information

Date of birth	**December 6th 1995**
Citizenship	**Chilean**
Affiliation	MaLGa Center, DIMA - Dipartimento di eccellenza 2023-27, Università di Genova, Via Dodecaneso 35, 16146, Genoa, Italy

Education

2021-2024 **PhD programme in Mathematics and Applications**, *Mathematical methods for data analysis, Università degli Studi di Genova* , Genova, Italy.
Final work: "*Implicit Regularization: Insights from Iterative Regularization and Overparameterization*"; Advisors: Silvia Villa and Lorenzo Rosasco

2020 **Master of Science in Applied Mathematics**, *Universidad Técnica Federico Santa María*, Santiago, Chile.
Final work: "*Stochastic primal-dual splitting for composite monotone inclusions*"; Advisors: Luis Briceño-Arias and Julio Deride; Score: 100/100.

2014-2020 **Mathematical Engineering**, *Universidad Técnica Federico Santa María*, Santiago, Chile.
Final work: "*Alternanting and randomized projections on convex optimization*"; Advisors: Luis Briceño-Arias and Julio Deride; Score: 100/100.

Journal publications

L. Briceño-Arias, J. Deride, and C. Vega, "Random activations in primal- dual splittings for monotone inclusions with a priori information", Journal of Optimization Theory and Applications, pp. 1–26, 2021.

C. Vega, C. Molinari, S. Villa, and L. Rosasco, "Fast iterative regularization by reusing data", Journal of Inverse and Ill-posed Problems, 2023.

Articles in preparation

C. Vega, C. Molinari, S. Villa, and L. Rosasco, "Learning from data via overparameterization", In preparation, 2024.

Talks and Seminars

Mathematics for Artificial Intelligence and Machine Learning, "Implicit regularization" Jan. 17-19, 2024, Bocconi University, Milan, Italy.

Seminars of the mathematics department of the Universidad Técnica Federico Santa María, "Regularización iterativa rápida proyectando sobre a priori información" Sep. 12th, 2023, UTFSM, Santiago, Chile.

TraDE-Opt Spring School 2023, "Implicit regularization" March 27-31, 2023, Universität Graz, Graz, Austria.

The International Conference on Optimization and Decision Science (ODS22), OML Optimization for Machine learning, "Regolarizzazione iterativa rapida riutilizzando i dati", Aug. 30th - Sep. 2nd, 2022, Firenze, Italia.

TraDE-OPT Workshop on Algorithmic and Continuous Optimization, "Fast iterative regularization with an extra stepeest gradient descent" July 4-8, 2022, UCLouvain, Belgium.

SIAM Conference on Imaging Science (IS22), MS1 Challenges in Nonsmooth Convex Optimization and Monotone Inclusions Problems, Fast iterative regularization by reusing data.

Malga Optimization Topic-Group, Iterative regularization and the (stochsatic) Chambolle-Pock algorithm", 31st Oct., 2021, Malga-LSCL, Genova, Italy.

Secondments

May 2023-July 2023 **CentraleSupelec - University Paris-Saclay**, *Genova*, Italy, under the supervision of Jean-Christophe Pesquet.

Oct.2022-Jan.2023 **CAMELOT Biomedical Systems Srl**, *Genova*, Italy, under the supervision of Curzio Basso.

Oct.2021-Dic.2021 **Technische Universität Braunschweig**, Germany, under the supervision of Dirk Lorenz.

Experience

Assistant Professor, Universidad Técnica Federico Santa María

2020-2 **Integral Calculus**

2020-1 **Integral Calculus**

Teaching Assistant, Universidad Técnica Federico Santa María

2019-2 **Optimization**

2019-1 **Functional analysis**

2018-1 **Real Analysis**

2017-2 **Integral Calculus**

2017-1 **Integral Calculus**

2016-2 **Differential Calculus**

Community service

- LCSL Biweekly Optimization GM, Organizer, 2023, Malga-LCSL(Genova, Italy).
- Optimization Topic-Group,Organizer, 2023-2024, Malga-LCSL(Genova, Italy).
- Teacher assistant in Topics in Modern Machine Learning school (ModML), 19-23 June 2023, Genoa, Italy.
- Reviewer of: Journal of Mathematical Analysis and Applications (JMAA), Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas (RACSM), and Journal of Machine Learning Research (JMLR)

Grants and awards

- Funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 861137.
- USM scientific/technological master's scholarship
- First Graduate of Mathematical Engineering San Joaquín Campus, Universidad Técnica Federico Santa María, Santiago, Chile.
- Federico Santa María scholarship

Technology skills

Matlab advanced
Latex advanced
Python advanced

Languages

Spanish Native
English B2
Italian B1

Miscellaneous

2020 Math teacher **Preu-Conecta.**

2019 Analysis of audiovisual records of classes of teachers participating in the **ARPA PACE** workshops.

2019 Assistant in **Advanced Research Center in Education**.

Summer-2018 Credit Risk Quant Analyst in **Facturedo**.

Random activations in stochastic primal-dual methods for constrained monotone inclusions.

Abstract. In this thesis, we propose a numerical approach for solving constrained primal-dual monotone inclusions, in which the constraint models a priori information on the solution. This a priori information constraint is represented by the intersection of fixed points of a finite number operators. In particular the problem models convex optimization problems with a priori information, which is an intersection of convex sets when the operators projections onto them. We propose two methods for solving this problem.

The first method combines classical primal-dual schemes with random activations of the operators that define the a priori information constraint. In the context of convex optimization with linear inequality constraints, any combination of the constraints can define the a priori information set. This formulation leads to an algorithm which randomly projects onto the selected constraints, which improves its efficiency. The advantages of including these projections are illustrated via numerical implementations on the stochastic arc capacity expansion problem in a transport network.

The second algorithm is an extension of the first method, in which one of the operators of the inclusion allows for stochastic errors in its computation. In the particular case of convex optimization problems, the method incorporates stochastic approximations of gradients. We guarantee almost sure convergence by imposing classic conditions on the bias of the approximation and upper bounds on its variance.

We prove that both methods generates stochastic Quasi-Fejér sequences and the almost sure convergence follows from their martingale property. The proposed algorithms generalize several stochastic and deterministic primal-dual methods in the literature and classical algorithms for solving convex feasibility problems, as cyclic projections and Randomized Kaczmarz methods.

Keywords. Arc capacity expansion in transport networks · Averaged nonexpansive operators · Monotone inclusions Theory · Stochastic Quasi-Fejér sequences · Stochastic Primal-dual splitting algorithm · Randomized Kaczmarz algorithm.

AMS Mathematics Subject Classification (2020): 47H05, 49M29, 90B15, 65K10, 65K05

Implicit Regularization: Insights from Iterative Regularization and Overparameterization.

Abstract. The goal of many data-driven problems is to achieve a good prediction by estimating a quantity of interest based on a finite set of (possibly noisy) measurements, exploiting training data, and some property of the model that may be known or not a-priori. The most common methods to reach the last objective are explicit and implicit regularization. The first technique consists of minimizing the sum of a loss function plus a regularizer, which is explicitly added to the objective function and entails some a priori knowledge or some desired property of the solutions that we want to select. The second technique, implicit regularization, which is the main focus of this thesis, consists of minimizing a regularizer subject to the constraints established by the loss function minimizers. Typically, to address this problem, a regularizer and a loss function are fixed. Subsequently, a suitable algorithm that leverages the properties of both the loss and the regularizer is designed to efficiently find an implicit bias. In this thesis, we propose two different approaches to solving the implicit problem.

In the first part of the thesis, following a more traditional approach, we propose and study two new iterative regularization methods, based on a primal-dual algorithm, to regularize inverse problems efficiently. Our analysis, in the noise-free case, provides convergence rates for the Lagrangian and the feasibility gap. In the noisy case, it provides stability bounds and early stopping rules with theoretical guarantees. The main novelty of our work is the exploitation of some a priori knowledge about the solution set: we show that the linear equations determined by the data can be used more than once along the iterations. We discuss various approaches to reusing linear equations that are at the same time consistent with our assumptions and flexible in their implementation. Finally, we illustrate our theoretical findings with numerical simulations for robust sparse recovery and image reconstruction. We confirm the efficiency of the proposed regularization approaches by comparing the results with state-of-the-art methods.

In the second part of this thesis, we flip this perspective by fixing the loss and the algorithm (gradient flow) and reparameterizing the linear model. Then, we aim to find the implicit bias introduced by the chosen optimization method and reparameterization. But there is still an open question of how to find systematically what the inductive bias is hidden behind. The goal of this thesis is to take a step in this direction by studying a unified framework observed in various reparametrizations presented in the state of the art, called time-warped mirror flow. However, a theoretical analysis of the existence and convergence of the trajectory is missing in the state of the art. Here, we fill this gap by providing a comprehensive study. First, we prove the existence and uniqueness of the solution. Next, we establish the convergence of both the trajectory and the corresponding values of the loss function. Finally, for any convex loss function, we prove that the trajectory converges towards a minimizer of the loss function, and we provide an implicit bias. For a specific case of loss functions, including least squares, the implicit bias can be made explicit. Furthermore, we explore the flexibility of our formulation by applying the previous results to different examples related to weight normalization. Finally, we give a criterion to determine, for a given function that depends only on the norm, a suitable weight normalization parameterization.

Keywords. Primal-dual splitting algorithms, Iterative regularization, Early stopping, Landweber method, Stability and convergence analysis, Overparameterization, Implicit Regularization, Mirror Flow, Time-warping, Existence and uniqueness, Fully connected normalized linear networks, Weight normalization.

AMS Mathematics Subject Classification (2020): 34A55, 90C25, 65K10, 49M29.