Sparse estimation: applications in atrial fibrillation

Citation for published version (APA):

Zeemering, S. (2015). *Sparse estimation: applications in atrial fibrillation*. Datawyse / Universitaire Pers Maastricht. https://doi.org/10.26481/dis.20151126sz

Document status and date:
Published: 01/01/2015

DOI:
10.26481/dis.20151126sz

Document Version:
Publisher's PDF, also known as Version of record

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:

www.umlib.nl/taverne-license

Take down policy
If you believe that this document breaches copyright please contact us at:

repository@maastrichtuniversity.nl

providing details and we will investigate your claim.

Download date: 23 Sep. 2021

Valorization

Introduction

The notion of sparsity, as discussed in this thesis, is nowadays ubiquitous in science, for instance in feature selection in high-dimensional datasets (big data), or complex interaction network identification. The growing number of potential features that can be related to a certain trait or outcome is often not matched by the number of observations that can be recorded. This makes it more difficult to quantify the role of each feature in a unique and unambiguous way. Assuming sparsity in the relationship between all the candidate features or interactions and the observed behavior can overcome this limitation to some extent.

Sparse estimation

Sparse estimation of parameters in a linear regression problem (Chapter 3), given a limited set of available measurements, greatly improves the chances of correctly estimating the data generating parameter values, if the data generating parameter vector is indeed sparse. This is a technique that is applicable in many fields of research, in principle in every research question where the parameter estimation problem is underdetermined, i.e. when the number of parameters (greatly) exceeds the number of available measurements, or when one aims to determine the dominant regressors in a regression model. The application in this thesis of sparse (logistic) regression to determine the dominant predictors of successful pharmacological cardioversion, given a large set of candidate predictors, illustrates this application directly.

When considering state-space models (Chapter 4) there is an inherent model equivalence present (in the fully parameterized setting) that can be exploited to search for a maximally sparse solution within the set of models that exhibit equivalent input-output behaviour. In models where the interactions between states represent physical connections, finding a sparse solution can help to lower model complexity and reduce for instance the number of connections to be manufactured in a digital chip or the number of interactions between a large number of genes to take into account.

The case of sparse network interaction models (as a subclass of state-space models) has been studied in more detail in this thesis. In the case of a limited amount of available measurements, sparse estimation of network model parameters can also aid in identifying the correct data generating parameters, using an adapted form of sparse linear regression (in discrete time) or an iterative version of the sparsity maximization algorithm (in continuous time). An application of sparse estimation of network interaction models in discrete time is presented in this thesis in Chapter 7. One limiting factor in this approach to sparse network interaction estimation, in discrete, but most notably in continuous time, is that appropriate sampling of the network inputs and outputs is critical to finding a meaningful solution. This issue needs to be investigated further, to determine necessary and sufficient conditions under which sparse estimation of network interactions is a viable approach.

Applications in atrial fibrillation

The developed software package to automatically process and annotate atrial electrograms (Chapter 6) is now used within our Physiology department, enabling fast and reproducible analysis of longer recordings of high-density contact mapping. This has substantially changed the way mapping data is being collected in our recent studies, moving from manually analyzing 4-second segments, which could take days, to analyzing several minutes of electrogram data recorded simultaneously at several atrial sites, in only a few minutes.

The algorithm developed for identification of recurring wave front propagation patterns (Chapter 7) has a potential application during (surgical) ablation of atrial fibrillation to identify regions with highly recurrent propagation patterns that are associated with the maintenance of AF. The readout of the algorithm is a directed graph of the mapping area that shows the dominant interactions between atrial locations, also indicating the strength of the interaction. This information will show a cardiologist an immediate impression of the prevailing conduction pattern in that area, which may be instrumental in guiding the ablation process.

The demonstrated predictive value of noninvasive AF complexity parameters (Chapter 8), when it comes to predicting successful pharmacological cardioversion of paroxysmal AF, has a clear potential to guide AF treatment. Using the software package that has been developed to extract the atrial signal from body surface ECGs and to compute complexity parameters in a standardized way, an initial noninvasive assessment of AF complexity can be made when a patient visits the clinic. Properly trained and validated prediction models can be developed and integrated in a knowledge support system that assists a physician in making an informed decision on patient treatment. This will eventually lead to a more patient-specific treatment, improving quality of care and reducing costs by abandoning likely unsuccessful treatment options.