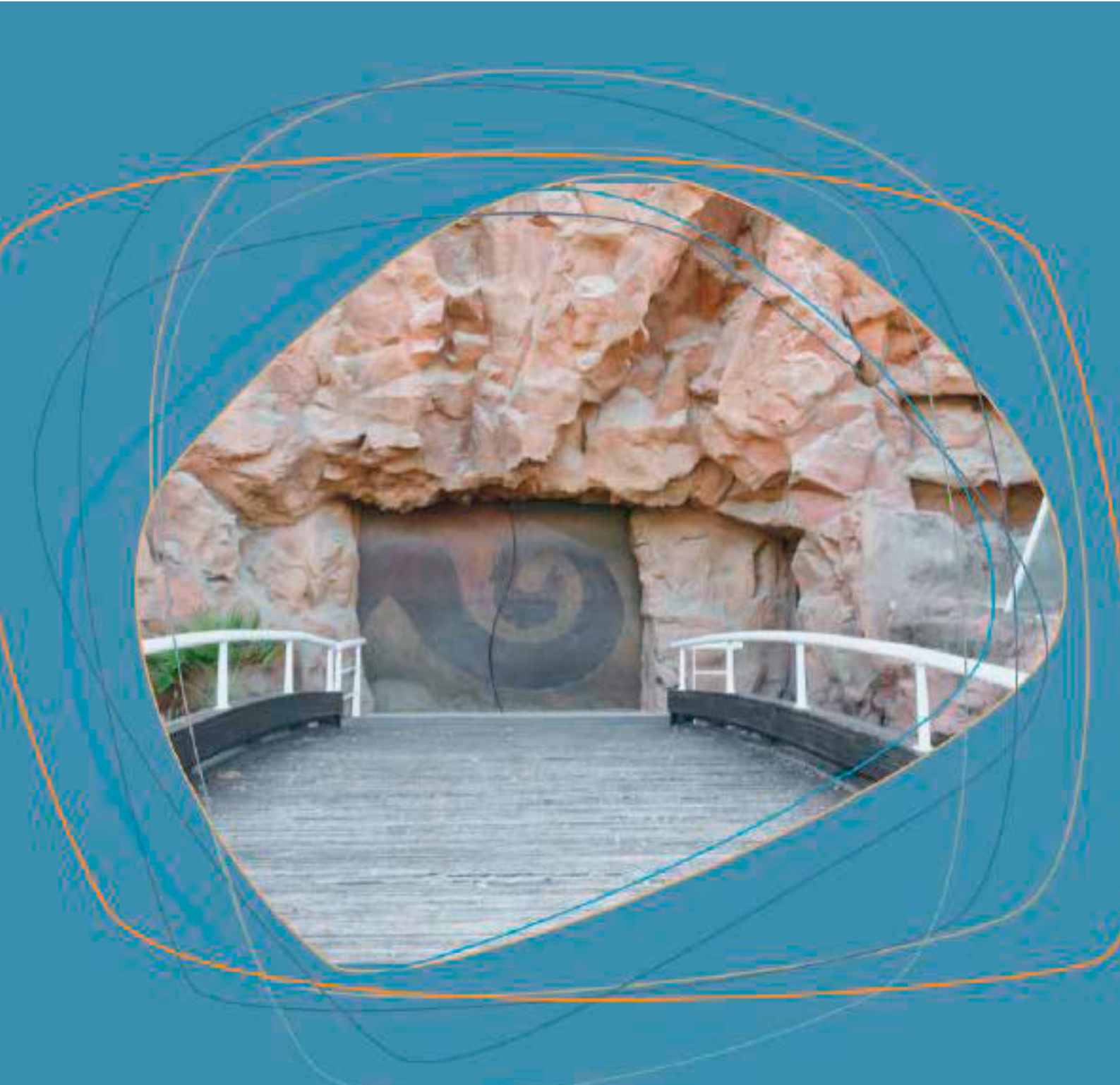

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INSTITUTO DE ESTADÍSTICA Y CARTOGRAFÍA DE ANDALUCÍA

PRESENTACIÓN

El presente boletín de resúmenes tiene una periodicidad trimestral y con él la Biblioteca del Instituto de Estadística y Cartografía de Andalucía pretende dar a conocer a los usuarios de una forma detallada el contenido de las revistas especializadas que entran en su colección. Se trata de un complemento al boletín de novedades de publicaciones seriadas ya que en él se incluyen los resúmenes de cada uno de los artículos que aparecen publicados en los diferentes números de las revistas en el idioma original de las mismas.

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Pabellón de Nueva Zelanda
C/Leonardo Da Vinci, n. 21. Isla de La Cartuja
41071 - SEVILLA
E-mail: biblio.ieca@juntadeandalucia.es
Teléfono: 955 033 800
Fax: 955 033 816

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Cartographic journal, The, ISSN 0008-7041
Volume 59, number 1 (february 2022)

Abstract
3D cartographic visualization of a continuous time-dependent phenomenon is not an easy task. The focus of this research is motivated by the struggle to visualize such a phenomenon. Based on the current state of the art, we implemented new visualization methods to visualize continuous time-dependent phenomena. All visualizations are based on the use case of road-traffic-generated noise in outdoor urban areas. These visualizations utilize the third dimension of the map scene. The first two methods focus on the variations of the noise in the vertical dimension (i.e. height). The third method is based on the idea of space–time cube and therefore utilizes the time variable as the third dimension. For demonstration purposes, all methods were implemented in an online application. Furthermore, user testing of those applications was conducted. This paper thus describes design, implementation and user evaluation of newly proposed methods for third dimension visualization.

Abstract
Cartographic generalization is a process similar to text summarization that transforms a map when scale is reduced. Cartographic generalization simplifies the map content while preserving as much as possible the initial characteristics and spatial relations of the map. The automation of this process requires a deep understanding of the context of each map feature, which involves different criteria such as the shape of the feature, the semantic nature of the feature, or the spatial patterns of its neighbouring features. This is why multiple criteria decision techniques can be relevant during the process. This paper proposes two use cases of cartographic generalization sub-tasks where multiple criteria decision techniques improve past techniques: the classification of urban building blocks and the ordering of the buildings to keep in the map as a priority. In both use cases, the proposed methods are experimented on large real cartographic datasets, and evaluated in comparison to alternative techniques.

Abstract
Choropleth maps and graduated symbol maps are often used to visualize quantitative geographic data. However, as the number of classes grows, distinguishing between adjacent classes increasingly becomes challenging. To mitigate this issue, this work introduces choriented maps (maps that use colour and orientation as variables to encode geographic information) and choriented mobile maps (an optimization of choriented maps for mobile devices). The maps were evaluated in a graphical perception study with Sustainable Development Goal data of several European countries. Choriented maps and choriented mobile visualizations resulted in comparable, sometimes better effectiveness and

confidence scores than choropleth and graduated symbol maps. The two visualizations also performed well regarding efficiency and only performed worse than graduated symbol maps. These results suggest that using colour and orientation as visual variables in combination can improve user performance and their selection of map symbols during the exploration of geographic data in some scenarios.

Abstract
Flood maps group different types of cartographies related to flooding and the components and variables of flood risk and its mitigation measures. This paper analyses the most important facts in the development of flood mapping in Spain and assesses the current. While 60/2007 EU Directive has been an important step for mapping risk, future developments must: (i) overcome the concept of return period; (ii) incorporate other aspects of the European Directive, basically vulnerability and susceptibility to flooding from rainwater, also the effect of climate change on flood hazards; (iii) include scenarios for the consequences of climate change; (iv) incorporate risk cartography as a key element of 'green infrastructure', like tool in spatial planning; (v) Reduce the map representation scale; (vi) incorporate new elements within risk maps to improve emergency management; (vii) improve public-private cooperation; (viii) facilitate the legal use of hazard and risk maps in administrative and court processes.

Abstract
This paper emphasizes the role of cartographic modelling of tourist routes in the Carpathians in the context of the development of tourist mapping. It describes the distinguished features of Transcarpathian and Eastern Carpathian tourist routes as the objects of mapping. These routes are extremely popular among tourists due to their remarkable recreational and touristic value. Tourist map series fulfil the needs of tourists and also form a relevant and promising practical area of modern geographical mapping. We systematise the principles and describe the methodological basis of cartographic modelling of tourist routes in the Carpathians. We particularly detail the peculiarities of the decoration of tourist maps. Our research contributes to the development of the integral system of spatial, visual, complementary, and comparative information about the region's location, conditions, and features of natural, historical, cultural and socio-economic tourist resources.

Cartographic journal, The, ISSN 0008-7041
Volume 59, number 2 (may 2022)

Abstract
The geometry of Adriatic Sea basin renderings on 12 portolan charts made from the late thirteenth to the late sixteenth century was compared to a modern map by applying Helmert transformation in order to preserve their initial geometry and by using the same 40 identical points per chart. In the first stage of the research, the geometry of the portolan charts was compared to six selected map projections in order to determine the geometrical 'best fit'. In the second stage, networks of lines plotted on charts were divided regionally and functionally and compared to the 'best fit' map projection to determine their geometric patterns in more detail. The research results showed that Adriatic Sea basin renderings on portolan charts were probably the result of a deliberately applied map projection which was geometrically most similar to the modern conformal cylindrical (Mercator) projection.

Abstract
The final position of the Norwegian–Swedish border was determined in 1751, after challenging negotiations. This paper focuses on central parts of Scandinavia and investigates the role of cartography in the border positioning process. The examination of a wide variety of historical maps before and after the border treaty provides insight into the differing opinions on the border region's shifting affiliation. Other factors that helped to shape the borderline were a turbulent political situation with shifting sovereignty over the area in question, as well as conflicts over valuable resources. The findings indicate that cartographic evidence had an important role in the position of the Norwegian–Swedish border in central Scandinavia. The paper adds to our understanding of maps as a political tool as well as of the role of resources in border processes, and provides new knowledge on how cartography influenced a national border between two countries fighting for land, resources and hegemony.

Abstract
This research upholds the designer's mediatory role in the representation of places and hand drawing as a privileged tool. Given the current technological capacity for an automatic representation of the territory and landscape, one can question if the hand that draws the map is now anachronistic. The hypothesis of hybridism between the landscape observational drawing and the cartographic code is proposed, supported by the historical analysis of maps from the sixteenth century. The resultant anachronistic techniques are systematized as a design strategy, available for use by other authors,

elsewhere. The techniques were tested by drawing landscapes and producing maps of places. It is concluded that the transference of anachronistic techniques is relevant in contemporary maps intended for touristic, cultural and commercial contexts, when wayfinding skills are not essential. As an open source, other authors may use the same strategy, applying different anachronistic techniques, based on their own subjectivity.

Decoupling Slope and Aspect Vectors to Generalize Relief Shading P. 136-149

Patrick J. Kennelly

Abstract

Relief shading is designed to vary the brightness of terrain elements on a two-dimensional map to create a three-dimensional effect. One concern is how this layer can be generalized for use in multi-scale mapping. We propose a methodology that calculates relief shading from slope and aspect vectors, as these layers allow map users to recognize characteristics of the terrain and show consistent trends in spatial autocorrelation with generalization. We adjust the orientation of surface vectors with a mean filter to preserve the structural terrain elements while eliminating landforms of finer detail. To demonstrate its use, we show two examples of generalizing detailed relief shading and compare results to relief shading of the next coarser scale of DEM data available. The generalized maps remove or smooth out minor landforms while preserving more prominent landforms and eliminate issues of data gaps or interpolated data in lower resolution datasets.

A Review of Maps in PhDs: Is Your Map Worth a Thousand Words? P. 150-164

Serena Coetzee, Sanet Carow & Lourens Snyman

Abstract

Maps are useful for providing location context and for graphically presenting spatial relationships. They are often used in PhD dissertations to show the location of a study area or to present scientific results. These maps have to tell their story without the PhD candidate being present. We searched for maps in 575 PhD dissertations, and reviewed 192 maps in 65 of these: 38% were created by PhD candidates, 48% were inserted and 14% were adapted from other sources. Maps prepared by PhD candidates had more design shortcomings than other maps. Nevertheless, the number of problems with maps from other sources suggests that guidelines for including them in a dissertation could be useful. Our results suggest that PhD candidates use GIS software to design maps, but that there is room for improvement to guide users towards appropriate design choices. The results will help to plan support services for PhD candidates at universities.

Cartographic journal, The, ISSN 0008-7041
Volume 59, number 3 (february 2022)

Abstract
The Coatzacoalcos River is one of the most important rivers in Mexico. The oldest map of this river was drawn by Francisco Gali in 1580. Unlike most maps made in New Spain in the last quarter of the sixteenth century, this map is purely European in style and is somewhat reminiscent of a nautical chart. Analysis of the map suggests that it was made hastily. Both the errors in the distances and the numerous corrections that can still be observed support this conjecture. It seems that Francisco Gali was more interested from his point of view as an explorer and navigator in the most important aspect of the region: the possibility of connecting the North Sea and the South Sea through the Strait of Tehuantepec. In this respect, the map of Coatzacoalcos would have been drawn to show the viability of using the river as an interoceanic passage.

Abstract
Machine learning methods are increasingly used in the automatic generalization of river networks, but previous research lacks a comparative analysis of different methods using the same data set. This innovative study considers eight river network indicators, such as river length, river grade, river spacing, seasonality, connectivity, catchment area, tributaries at the next grade, and total number of tributaries, which can precisely describe the characteristics of the river network. The experiments were carried out and automated selection of river network was established based on back-propagation neural network (BPNN), support vector machine (SVM) and decision tree (DT) methods. We established that BPNN and SVM have high selection accuracy, but the parameters are complex. SVM is more suitable for small samples. In addition, DT has unique advantages due to its visualized tree structure and the characteristic of derivable rules. We hope that this study will provide a reference for the selection of river generalization methods in the future.

Abstract
This paper presents the Cameron Aquatic Projection, a novel concept designed to depict the world's surface hydrosphere as it is, a continuous unbroken unit including oceans and rivers. After a review of related past projections, the paper will describe the parameters of the projection, according to the existing layout of surface water on Planet Earth. This description of the design principles is followed by the mathematical realization of the proposal. The article concludes with completed examples of the projection and suggests future applications.

Designing Metaphorical Multivariate Symbols to Optimize Dockless Bike Sharing P. 220-238

Mingguang Wu & Lige Qiao

Abstract

While dockless bike sharing is gaining popularity, oversupplied and poorly maintained bikes introduce chaos and waste (e.g., so-called zombie bikes that unused). Spatiotemporal pattern visualizations can help policy-making and infrastructure improvement (e.g., allocating parking areas). However, multivariate symbolizing (e.g., supply, flow, usage) to optimize dockless bike sharing is challenging. In this paper, we introduce metaphor theory to design multivariate symbols. First, we systemically explore the coupling of three metaphor types (orientational, ontological and structural) with symbols at three levels of iconicity. Then, we construct metaphorical symbols for optimizing dockless bike sharing following a user-centred design process. We also offer an evaluation using eye-tracking and questionnaire techniques. The results indicate that, compared with bin-packing and multiview symbols, metaphorical symbols significantly improved effectiveness and efficiency, and reduced participants' cognitive load. Our evaluation presents preliminary evidence that metaphors can offer new organizational mechanisms for map symbols to represent multivariate naturally and effectively.

Guidelines for Standardizing the Design of Tactile Maps: A Review of Research and Best Practice P. 239-258

Jakub Wabiński, Albina Mościcka & Guillaume Touya

Abstract

Accessibility to tactile maps is limited due to their expensive and time-consuming development. Acceleration of their production requires standardized design guidelines that consider symbol design and production methods. In this paper, based on a review of research and best practice, we summarize knowledge on how to design tactile maps properly and provide a selection of highly legible, recommended symbols for the compilation of tactile maps. We also examine generalization constraints and other design parameters that are necessary for the standardization of tactile mapping. Finally, we explore differences in tactile map design depending upon the selected production method. Over the years, many useful guidelines have been developed although they remain unknown to the wider audience. There is still a long way to go in creating a global standard for the design of tactile maps.

TEST : AN OFFICIAL JOURNAL OF THE SPANISH SOCIETY OF STATISTICS AND OPERATIONS RESEARCH, ISSN 1133-0686
Volume 31, number 4 (december 2022)

Abstract
For a given pair of random lifetimes whose dependence is described by a time-transformed exponential model, we provide analytical expressions for the distribution of their sum. These expressions are obtained by using a representation of the joint distribution in terms of bivariate distortions, which is an alternative approach to the classical copula representation. Since this approach allows one to obtain conditional distributions and their inverses in simple form, then it is also shown how it can be used to predict the value of the sum from the value of one of the variables (or vice versa) by using quantile regression techniques.

Abstract
We analyze reliability systems with components whose lifetimes are identically distributed, and whose joint distribution admits a Samaniego signature representation of the system lifetime distribution. Our main result is the following. We assume that two systems have the same structure and that the lifetimes of the components of the systems share the same dependence copula. If the first system lifetime precedes (succeeds) its single component lifetime in the convex transform order, and if also the component lifetime of the second system precedes the (succeeds) component lifetime of the first system in the convex transform order then the system-component ordering property is preserved by the second system lifetime, i.e., the system lifetime precedes (succeeds) the component lifetime in the second system also. This allows us to conclude various sufficient and necessary conditions on the system signatures under which the monotone failure rate and density properties of the component lifetimes are inherited by the system lifetime under the condition that the component lifetimes are independent.

Abstract
Joint distribution between two or more variables could be influenced by the outcome of a conditioning variable. In this paper, we propose a flexible Wald-type statistic to test for such influence. The test is based on a conditioned multivariate Kendall's tau nonparametric estimator. The asymptotic properties of the test statistic are established under different null hypotheses to be tested for, such as conditional independence or testing for constant conditional dependence. Two simulation studies are presented: The first shows that the estimator proposed and the bandwidth selection procedure perform well. The second presents different bivariate and multivariate models to check the size

and power of the test and runs comparisons with previous proposals when appropriate. The results support the contention that the test is accurate even in complex situations and that its computational cost is low. As an empirical application, we study the dependence between some pillars of European Regional Competitiveness when conditioned on the quality of regional institutions. We find interesting results, such as weaker links between innovation and higher education in regions with lower institutional quality.

Precision matrix estimation using penalized Generalized Sylvester matrix equation P. 950-967

Vahe Avagyan

Abstract

Estimating a precision matrix is an important problem in several research fields when dealing with large-scale data. Under high-dimensional settings, one of the most popular approaches is optimizing a Lasso or $\ell 1$ norm penalized objective loss function. This penalization endorses sparsity in the estimated matrix and improves the accuracy under a proper calibration of the penalty parameter. In this paper, we demonstrate that the problem of minimizing Lasso penalized D-trace loss can be seen as solving a penalized Sylvester matrix equation. Motivated by this method, we propose estimating the precision matrix using penalized generalized Sylvester matrix equations. In our method, we develop a particular estimating equation and a new convex loss function constructed through this equation, which we call the generalized D-trace loss. We assess the performance of the proposed method using detailed numerical analysis, including simulated and real data. Extensive results show the advantage of the proposed method compared to other estimation approaches in the literature.

Adaptive bi-level variable selection for multivariate failure time model with a diverging number of covariates P. 968-993

Kaida Cai, Hua Shen, Xuewen Lu

Abstract

In this study we propose an adaptive bi-level variable selection method to analyze multivariate failure time data. In the regression setting, we treat the coefficients corresponding to the same predictor variable as a natural group and then consider variable selection at the group level and individual level simultaneously. By imitating the group variable selection procedure with adaptive bi-level penalty, the proposed variable selection method can select a predictor variable at two different levels allowing different covariate effects for different event types: the group level where the predictor is important to all failure types, and the individual level where the predictor is only important to some failure types. An algorithm based on cycle coordinate descent is developed to carry out the proposed method. Based on the simulation results, our method outperforms the classical penalty methods, especially in removing unimportant variables for different failure types. We obtain the asymptotic oracle properties of the proposed variable selection method in the case of a diverging number of covariates. We construct a generalized cross-validation method for the tuning parameter selection and assess model performance using model errors. We also illustrate the proposed method using a real-life data set.

On the general δ-shock model P. 994-1029

Dheeraj Goyal, Nil Kamal Hazra, Maxim Finkelstein

Abstract

he δ-shock model is one of the basic shock models which has a wide range of applications in reliability, finance and related fields. In existing literature, it is assumed that the recovery time of a system from the damage induced by a shock is constant as well as the shocks magnitude. However, as technical systems gradually deteriorate with time, it takes more time to recover from this damage, whereas the larger magnitude of a shock also results in the same effect. Therefore, in this paper, we introduce a general δ-shock model when the recovery time depends on both the arrival times and the magnitudes of shocks. Moreover, we also consider a more general and flexible shock process, namely,

the Poisson generalized gamma process. It includes the homogeneous Poisson process, the non-homogeneous Poisson process, the Pólya process and the generalized Pólya process as the particular cases. For the defined survival model, we derive the relationships for the survival function and the mean lifetime and study some relevant stochastic properties. As an application, an example of the corresponding optimal replacement policy is discussed.

Interquantile shrinkage in spatial additive autoregressive models P. 1030-1057

Jiawei Hou, Yunquan Song

Abstract

In this paper, we study the commonness of nonparametric component functions at different quantile levels in spatial additive autoregressive models. We propose two fused adaptive group LASSO penalties to shrink the difference of functions between neighbouring quantile levels. Using these methods, we can estimate the nonparametric functions and identify the quantile regions where functions are unvarying simultaneously. Therefore, when there exists a quantity-level region where the functions are unvarying, its performance is expected to be better than the conventional spatial quantile additive autoregressive model. Under some regularity conditions, the proposed penalized estimators can reach the optimal rate of convergence in theory and also recognize the true varying/unvarying regions accurately. At the same time, our proposed method shows good numerical results in simulated and real datasets.

Reducing degradation and age of items in imperfect repair modeling P. 1058-1081

Maxim Finkelstein, Ji Hwan Cha

Abstract

We develop new models for imperfect repair and the corresponding generalized renewal processes for stochastic description of repairable items that fail when their degradation reaches the specified deterministic or random threshold. The discussion is based on the recently suggested notion of a random virtual age and is applied to monotone processes of degradation with independent increments. Imperfect repair reduces degradation of an item on failure to some intermediate level. However, for the nonhomogeneous processes, the corresponding age reduction, which sets back the 'clock' of the process, is also performed. Some relevant stochastic comparisons are obtained. It is shown that the cycles of the corresponding generalized imperfect renewal process are stochastically decreasing/increasing depending on the monotonicity properties of the failure rate that describes the random failure threshold of an item.

Copula-based bivariate finite mixture regression models with an application for insurance claim count data P. 1082-1099

Lluís Bermúdez, Dimitris Karlis

Abstract

Modeling bivariate (or multivariate) count data has received increased interest in recent years. The aim is to model the number of different but correlated counts taking into account covariate information. Bivariate Poisson regression models based on the shock model approach are widely used because of their simple form and interpretation. However, these models do not allow for overdispersion or negative correlation, and thus, other models have been proposed in the literature to avoid these limitations. The present paper proposes copula-based bivariate finite mixture of regression models. These models offer some advantages since they have all the benefits of a finite mixture, allowing for unobserved heterogeneity and clustering effects, while the copula-based derivation can produce more flexible structures, including negative correlations and regressors. In this paper, the new approach is defined, estimation through an EM algorithm is presented, and then different models are applied to a Spanish insurance claim count database.

Inference for dependent error functional data with application to event-related P. 1100-1120

potentials
Kun Huang, Sijie Zheng, Lijian Yang

Abstract
Estimation and testing is studied for functional data with temporally dependent errors, an interesting example of which is the event-related potential (ERP). B-spline estimators are formulated for individual smooth trajectories and their population mean as well. The mean estimator is shown to be oracally efficient in the sense that it is as efficient as the infeasible mean estimator if all trajectories had been fully observed without contamination of errors. The oracle efficiency entails asymptotically correct simultaneous confidence band (SCB) for the mean function, which is useful for making inference on the global shape of the mean. Extensive simulation experiments with various time series errors and functional principal components confirm the theoretical conclusions. For a moderate-sized ERP data set, multiple comparison is made by constructing paired SCBs among four different stimuli, over three components N450, N1, and N2 separately or simultaneously, leading to interesting findings.

Bayes factors for peri-null hypotheses P. 1121-1142
Alexander Ly, Eric-Jan Wagenmakers

Abstract
A perennial objection against Bayes factor point-null hypothesis tests is that the point-null hypothesis is known to be false from the outset. We examine the consequences of approximating the sharp point-null hypothesis by a hazy 'peri-null' hypothesis instantiated as a narrow prior distribution centered on the point of interest. The peri-null Bayes factor then equals the point-null Bayes factor multiplied by a correction term which is itself a Bayes factor. For moderate sample sizes, the correction term is relatively inconsequential; however, for large sample sizes, the correction term becomes influential and causes the peri-null Bayes factor to be inconsistent and approach a limit that depends on the ratio of prior ordinates evaluated at the maximum likelihood estimate. We characterize the asymptotic behavior of the peri-null Bayes factor and briefly discuss suggestions on how to construct peri-null Bayes factor hypothesis tests that are also consistent.

Estimation of poverty and inequality in small areas: review and discussion P. 1143-1166
Isabel Molina, Paul Corral, Minh Nguyen

Abstract
Never better said, a correct diagnosis is crucial for patient recovery. In the eradication of poverty, which is the first of the sustainable development goals (SDGs) established by the United Nations, efforts in the form of social aid and programs will be useless if they are not directed where they are most needed. Nowadays, monitoring the progress on the SDGs is even more urgent after the sanitary crisis, which is reversing the global poverty reduction observed since 1990 and, given that social development funds are always limited, managing them correctly requires disaggregated statistical information on poverty of acceptable quality. But reliable estimates on living conditions are scarce due to sample size limitations of most official surveys. Common small area estimation procedures supplement the survey data with auxiliary data sources to produce more reliable disaggregated estimates than those based solely on the survey data. We describe the traditional as well as recent model-based procedures for obtaining reliable disaggregated estimates of poverty and inequality indicators, discussing their properties from a practical point of view, placing emphasis on real applications and describing software implementations. We discuss results from recent simulation experiments that compare some of the unit-level methods in terms of bias and efficiency, under model- and design-based setups. Finally, we provide some concluding remarks.

TOP : AN OFFICIAL JOURNAL OF THE SPANISH SOCIETY OF STATISTICS AND OPERATIONS RESEARCH, ISSN 1134-5764
Volume 30, number 3 (october 2022)

Abstract
In the present work, we tackle the problem of finding the optimal price tariff to be set by a risk-averse electric retailer participating in the pool and whose customers are price sensitive. We assume that the retailer has access to a sufficiently large smart-meter dataset from which it can statistically characterize the relationship between the tariff price and the demand load of its clients. Three different models are analyzed to predict the aggregated load as a function of the electricity prices and other parameters, as humidity or temperature. More specifically, we train linear regression (predictive) models to forecast the resulting demand load as a function of the retail price. Then, we will insert this model in a quadratic optimization problem which evaluates the optimal price to be offered. This optimization problem accounts for different sources of uncertainty including consumer's response, pool prices and renewable source availability, and relies on a stochastic and risk-averse formulation. In particular, one important contribution of this work is to base the scenario generation and reduction procedure on the statistical properties of the resulting predictive model. This allows us to properly quantify (data-driven) not only the expected value but the level of uncertainty associated with the main problem parameters. Moreover, we consider both standard forward-based contracts and the recently introduced power purchase agreement contracts as risk-hedging tools for the retailer. The results are promising as profits are found for the retailer with highly competitive prices and some possible improvements are shown if richer datasets could be available in the future. A realistic case study and multiple sensitivity analyses have been performed to characterize the risk-aversion behavior of the retailer considering price-sensitive consumers. It has been assumed that the energy procurement of the retailer can be satisfied from the pool and different types of contracts. The obtained results reveal that the risk-aversion degree of the retailer strongly influences contracting decisions, whereas the price sensitiveness of consumers has a higher impact on the selling price offered.

Abstract
We address the solution of certain Mathematical Programs with Equilibrium Constraints (MPECs) in power markets using convex optimization. These MPECs constitute a class of complementarity problems relevant to the design and operation of power markets. Specifically, given a non-convex continuous MPEC of the considered type, we iteratively solve a collection of convex optimization problems that approximate the MPEC until a pre-specified tolerance is reached. We use an insightful example to illustrate the proposed solution technique and a case study to analyze its computational performance.

Ambiguities and nonmonotonicities under prosumer power P. 492-532

Afzal S. Siddiqui, Sauleh A. Siddiqui

Abstract

Prosumers adopt distributed energy resources (DER) to cover part of their own consumption and to sell surplus energy. Although individual prosumers are too dispersed to exert operational market power, they may collectively hold a strategic advantage over conventional generation in selecting DER capacity via aggregators. We devise a bilevel model to examine DER capacity sizing by a collective prosumer as a Stackelberg leader in an electricity industry where conventional generation may exert market power in operations. At the upper level, the prosumer chooses DER capacity in anticipation of lower-level operations by conventional generation and DER output. We demonstrate that exertion of market power in operations by conventional generation and the marginal cost of conventional generation affect DER investment by the prosumer in a nonmonotonic manner. Intuitively, in an industry where conventional generation exerts market power in operations similar to a monopoly (MO), the prosumer invests in more DER capacity than under perfectly competitive operations (PC) to take advantage of a high market-clearing price. However, if the marginal cost of conventional generation is high enough, then this intuitive result is reversed as the prosumer adopts more DER capacity under PC than under MO. This is because the high marginal cost of conventional generation prevents the market-clearing price from decreasing, thereby allowing for higher prosumer revenues. Moreover, competition relieves the chokehold on consumption under MO, which further incentivises the prosumer to expand DER capacity to capture market share. We prove the existence of a critical threshold for the marginal cost of conventional generation that leads to this counterintuitive result. Finally, we propose a countervailing regulatory mechanism that yields welfare-enhancing DER investment even in deregulated electricity industries.

Regression markets and application to energy forecasting P. 533-573

Authors

Pierre Pinson, Liyang Han, Jalal Kazempour

Abstract

Energy forecasting has attracted enormous attention over the last few decades, with novel proposals related to the use of heterogeneous data sources, probabilistic forecasting, online learning, etc. A key aspect that emerged is that learning and forecasting may highly benefit from distributed data, though not only in the geographical sense. That is, various agents collect and own data that may be useful to others. In contrast to recent proposals that look into distributed and privacy-preserving learning (incentive-free), we explore here a framework called regression markets. There, agents aiming to improve their forecasts post a regression task, for which other agents may contribute by sharing their data for their features and get monetarily rewarded for it. The market design is for regression models that are linear in their parameters, and possibly separable, with estimation performed based on either batch or online learning. Both in-sample and out-of-sample aspects are considered, with markets for fitting models in-sample, and then for improving genuine forecasts out-of-sample. Such regression markets rely on recent concepts within interpretability of machine learning approaches and cooperative game theory, with Shapley additive explanations. Besides introducing the market design and proving its desirable properties, application results are shown based on simulation studies (to highlight the salient features of the proposal) and with real-world case studies.

The impact of convexity on expansion planning in low-carbon electricity markets P. 574–593

S. Wogrin, D. Tejada-Arango, A. Botterud

Abstract

Expansion planning models are tools frequently employed to analyze the transition to a carbon-neutral power system. Such models provide estimates for an optimal technology mix and optimal operating decisions, but they are also often used to obtain prices and subsequently calculate profits. This paper analyzes the impact of modeling assumptions on convexity for power system outcomes and, in particular, on investment cost recovery. Through a case study, we find that although there is a long-term equilibrium for producers under convex models, introducing realistic constraints, such as non-convexities/lumpiness of investments, inelastic demand or unit commitment constraints, leads to

profitability challenges. We furthermore demonstrate that considering only short-term marginal costs in market-clearing may potentially create a significant missing-money problem caused by a missing-market problem and dual degeneracy in a 100 percent renewable system.

Integrating unimodality into distributionally robust optimal power flow P. 594–617

Bowen Li, Ruiwei Jiang, Johanna L. Mathieu

Abstract

To manage renewable generation and load consumption uncertainty, chance-constrained optimal power flow (OPF) formulations have been proposed. However, conventional solution approaches often rely on accurate estimates of uncertainty distributions, which are rarely available in reality. When the distributions are not known but can be limited to a set of plausible candidates, termed an ambiguity set, distributionally robust (DR) optimization can reduce out-of-sample violation of chance constraints. Nevertheless, a DR model may yield conservative solutions if the ambiguity set is too large. In view that most practical uncertainty distributions for renewable generation are unimodal, in this paper, we integrate unimodality into a moment-based ambiguity set to reduce the conservatism of a DR-OPF model. We review exact reformulations, approximations, and an online algorithm for solving this model. We extend these results to derive a new, offline solution algorithm. Specifically, this algorithm uses a parameter selection approach that searches for an optimal approximation of the DR-OPF model before solving it. This significantly improves the computational efficiency and solution quality. We evaluate the performance of the offline algorithm against existing solution approaches for DR-OPF using modified IEEE 118-bus and 300-bus systems with high penetrations of renewable generation. Results show that including unimodality reduces solution conservatism and cost without degrading reliability significantly.

Recent contributions to the optimal design of pipeline networks in the energy industry using mathematical programming P. 618-648

Diego C. Cafaro, Demian J. Presser, Ignacio E. Grossmann

Abstract

The optimal design of pipeline networks has inspired process systems engineers and operations research practitioners since the earliest times of mathematical programming. The nonlinear equations governing pressure drops, energy consumption and capital investments have motivated nonlinear programming (NLP) approaches and solution techniques, as well as mixed-integer nonlinear programming (MINLP) formulations and decomposition strategies. In this overview paper, we present a systematic description of the mathematical models proposed in recent years for the optimal design of pipeline networks in the energy industry. We provide a general framework to address these problems based on both the topology of the network to build, and the physical properties of the fluids to transport. We illustrate the computational challenges through several examples from industry collaboration projects, published in recent papers from our research group.

Data-driven tuning for chance constrained optimization: analysis and extensions P. 649-682

Ashley M. Hou, Line A. Roald

Abstract

Many optimization problems involve uncertain parameters which, if not appropriately accounted for, can cause solution infeasiblity. In this work, we consider joint chance-constrained optimization problems, which require all constraints to hold with a given probability, and a two-step solution method based on iterative tuning. Previous work established an a priori feasibility guarantee for this tuning approach, which relies on an assumption that must be verified on a case-by-case basis. In this paper, we propose an empirical methodology using statistical hypothesis testing to assess the validity of this assumption, thus providing further insight into the validity of the a priori guarantee. In addition, we provide sample complexity results to assess the requisite amount of data for the tuning method. We find that for large scale optimization problems, the tuning approach may require significantly less samples than the scenario approach.

We numerically assess these results via application to the optimal power flow problem as well as further assess the scalability of the method and the optimality and feasibility of solutions obtained from tuning.

Day-ahead market bidding taking the balancing power market into account p. 683-703
Authors (first, second and last of 4)
Gro Klæboe, Jørgen Braathen, Stein-Erik Fleten

Abstract
Generation companies with controllable units put considerable analysis into the process of bidding into the day-ahead markets for electricity. This article investigates the gain of coordinating price-taking bids to the day-ahead electricity market (DA) and sequentially cleared energy-only markets, such as the Nordic balancing market (BM). A technically detailed case study from the Nordic market is presented. We find that coordinated bidding is hardly worthwhile under current market conditions, but that only a modest increase in the demand for balancing energy will make coordination profitable. If the supply curve for balancing energy is convex, so that the cost of balancing energy is asymmetric, the gains will be even higher. Finally, we find that day-ahead market bid curves that result from coordinated instances provide extra supply at low prices, and lower supply at high prices, compared to sequential bids. This is rational given the anticipated opportunities that the balancing market offers; however, it makes day-ahead bidding appear to exploit market power.