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Imputation of missing data in time series by different computation methods in various data set applications

Dhiraj Magare^{1,*}, Sushil Labde², Manoj Gofane³ and Vishwesh Vyawahare⁴

^{1,2,3,4} Ramrao Adik Institute of Technology, D.Y. Patil Group, Nerul, Navi Mumbai-400 706, India

Abstract. In a modern technology generation, big volumes of data are evolved under numerous operations compared to an earlier era. However, collection of data without missing single value, is a great challenge ahead. In practice, there are many solutions suggested to avoid the missing values in time series applications. The existing methods used in imputation and their prediction with time series, varies with applications. The existing methods mostly available for imputation are least squares support vector machine (LSSVM), autoregressive integrated moving average models (ARIMA), Artificial Neural Network (ANN), Artificial Intelligence (AI) techniques, state space models, Kalman filtering and fuzzy model. The extensive experimental application data is used to analyze these methods. In addition, a synthetic set of data can also be used to forecast missing value, which improves performance of imputation methods in time series. In this paper, predominantly used imputation methods have been listed with their fundamental computational information along with their verification on set of data mentioned.

1 INTRODUCTION

A time series observations are the observations that have been taken successfully at an equal time interval. The main objective of time series forecast solely depends on the past recorded data. In case the historical data recorded includes few hours or days or months, of missing data, the parameter prediction increases the complexity. This missing data of various real time applications, influences the deviation in the actual output. Thus, this missing data plays an imperative task in many decision-making applications. The applications are monitoring the industrial activities, financial analysis, business resources, and power plant with grid control.

It would create a loss in prediction in different aspects. There are two different types of methods available for evaluation of missing data in multiple steps. Those are direct method and iterative method. The direct method evaluates the forecasting result in multiple step and reaches towards the final value while, iterative method evaluates the forecasted value iteratively until it matches the required step value. In multi-variable time series, various methods are proposed in the literature.

The various methods are such as linear interpolations, Stineman interpolations, Kalman filtering with structural model and smoothing, weighted moving average are used for estimation of missing values for solar irradiance data [1]. Further, time-series forecasting explained in [2]. In this, author had adopted wavelet model technique. The suggested methods might be infeasible to particular set of application or inefficient to predict missing data in real time. Thus, still there is a scope of improvement to

existing proposed methods, and their verification on various data sets.

As the forecasting of time series data plays a vital role, it is very important to find the accuracy of these different forecasting techniques. Different applications use different parameters for the measurement of the accuracy of these forecasting techniques. Shin-Fu Wu et al. [3] used normalized root mean squared error (NRMSE), performance measurement parameter for defining the accuracy of (LSSVM) forecasting technique of time series data. Root mean square error (RMSE) is used to evaluate the performance of the proposed algorithm for missing data estimation of synthetic multivariate time series data [4, 5, 6].

2 Methodology

In this section, most commonly used and advanced imputation methods are briefly described.

2.1. ARIMA (Autoregressive Integrated Moving Average)

ARIMA is Autoregressive Integrated Moving Average models. With the help of time-series data, statistical modeling technique predicts the future values, so this model is used in the field where short term forecasting is needed. It needs minimum 40 past data points. If the data is reasonably extended and the correlation between the past data points is steady, ARIMA model is more efficient compared to the exponential smoothing. Flowchart of Autoregressive Integrated Moving Average

*Corresponding author: dhiraj.magare@rait.ac.in

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Statistical analysis of randomized trials in tobacco treatment: longitudinal designs with dichotomous outcome

Sharon M. Hall, Kevin L. Delucchi, Wayne F. Velicer, Christopher W. Kahler, James Ranger-Moore, Donald Hedeker, Janice Y. Tsoh, Ray Niaura

This article considers two important issues in the statistical treatment of data from tobacco-treatment clinical trials: (1) data analysis strategies for longitudinal studies and (2) treatment of missing data. With respect to data analysis strategies, methods are classified as "time-naïve" or longitudinal. Time-naïve methods include tests of proportions and logistic regression. Longitudinal methods include Generalized Estimating Equations and Generalized Linear Mixed Models. It is concluded that, despite some advantages accruing to "time-naïve" methods, in most situations, longitudinal methods are preferable. Longitudinal methods allow direct effects of the tests of time and the interaction of treatment with time, and allow model estimates based on all available data. The discussion of missing data strategies examines problems accruing to complete-case analysis, last observation carried forward, mean substitution approaches, and coding participants with missing data as using tobacco. Distinctions between different cases of missing data are reviewed. It is concluded that optimal missing data analysis strategies include a careful description of reasons for data being missing, along with use of either pattern mixture or selection modeling. A standardized method for reporting missing data is proposed. Reference and software programs for both data analysis strategies and handling of missing data are presented.

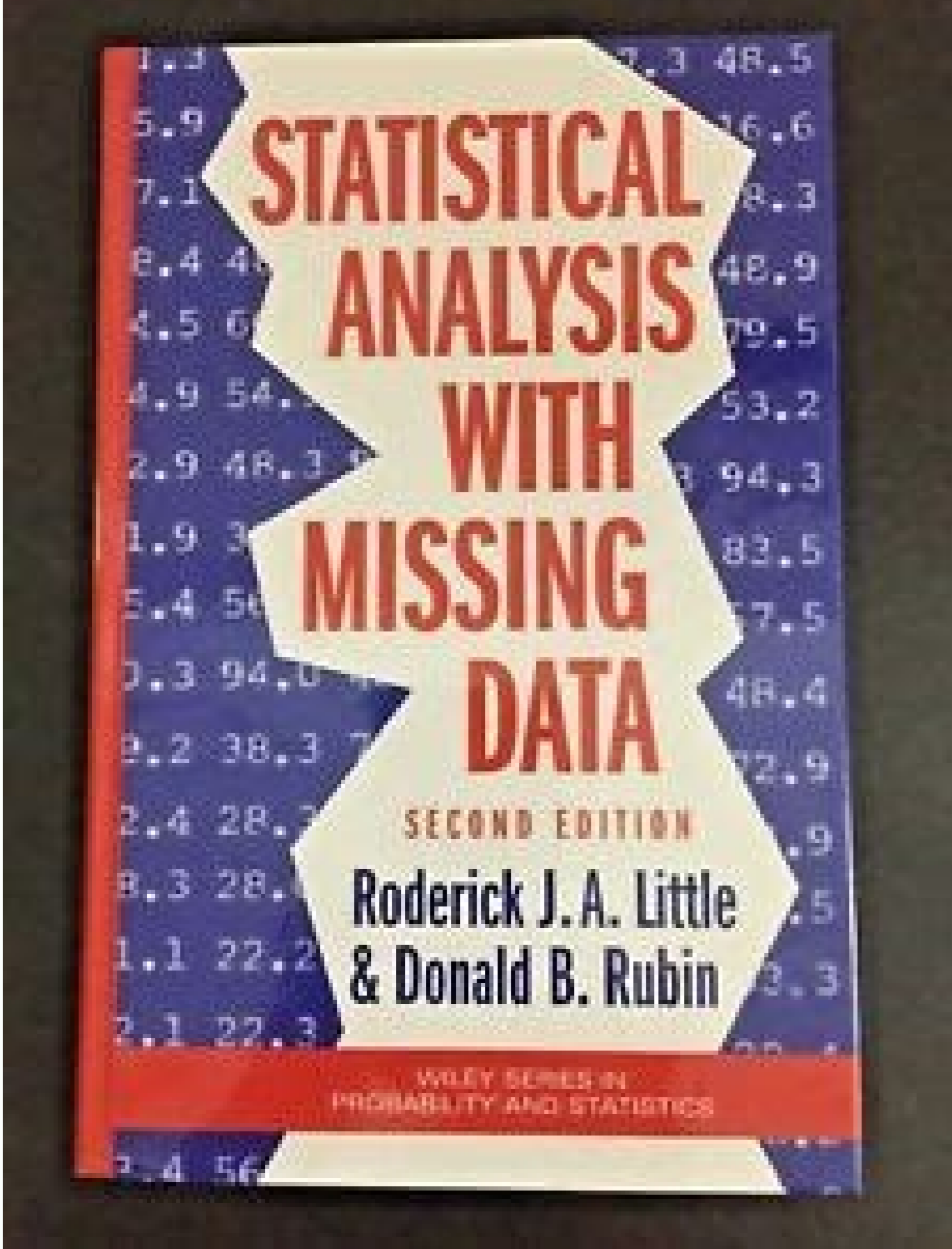
Introduction

This article considers two important issues in the statistical treatment of data from tobacco-treatment clinical trials: (1) data analysis strategies for longitudinal studies and (2) treatment of missing data.

Tobacco treatment outcome studies typically employ a dichotomous dependent measure – abstinence vs. using tobacco products. There have been rapid and voluminous advances in data analytical methods for use with such data. Yet, as far as we could find, papers published in leading research journals generally use a restricted set of "time-naïve" analytical techniques. Logistic regression and Pearson's χ^2 are the most common. There are exceptions to this rule (e.g., Hall et al., 1995). In a few instances, especially when sustained abstinence is the primary variable of interest, these "time-naïve" techniques may be optimal. In most cases, they are not. For example, when abstinence rates at multiple time-points are examined, time-naïve methods lose critical information. Alternative methods that use all the information available and focus on the pattern of change over time have been developed. One purpose of this paper is to present newer alternative data-analysis strategies for longitudinal data.

Sharon M. Hall, Kevin L. Delucchi, and Janice Y. Tsoh, Department of Psychiatry, University of California, San Francisco; Wayne F. Velicer, Center for Prevention Research, University of Rhode Island; Christopher W. Kahler, Butler Hospital, Brown University School of Medicine; James Ranger-Moore, Division of Epidemiology and Biostatistics, College of Public Health, University of Arizona; Donald Hedeker, Division of Epidemiology and Biostatistics, Health Research and Policy Center, University of Illinois at Chicago; Ray Niaura, Center for Behavioral and Preventive Medicine, Brown University School of Medicine

*Correspondence to: Sharon M. Hall, Department of Psychiatry, University of California, San Francisco, Box 08042, 401 Parnassus Avenue, 94143-2022, San Francisco, CA 94143, USA. E-mail: smh@ucsf.edu



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Book Google Scholar Download references Open access • Journal Article • DOI: 10.1037/1082-989X.7.2.147 • Missing data: Our view of the state of the art. [..] Joseph L. Schafer, John W. Graham 01 Jun 2002 - Psychological Methods Abstract: Statistical procedures for missing data have vastly improved, yet misconception and unsound practice still abound. The authors frame the missing-data problem, review methods, offer advice, and raise issues that remain unresolved. They clear up common misunderstandings regarding the missing at random (MAR) concept. They summarize the evidence against older procedures and, with few exceptions, discourage their use. They present, in both technical and practical language, 2 general approaches that come highly recommended: maximum likelihood (ML) and Bayesian multiple imputation (MI). Newer developments are discussed, including some for dealing with missing data that are not MAR. Although not yet in the mainstream, these procedures may eventually extend the ML and MI methods that currently represent the state of the art. ...read more Topics: Missing data (57%) Open access • Journal Article • DOI: 10.1086/319501 • Matthew Stephens1, Nicholas M. J. Smith2, Peter Donnelly • Institutions (2) 01 Apr 2001 - American Journal of Human Genetics Abstract: Current routine genotyping methods typically do not provide haplotype information, which is essential for many analyses of fine-scale molecular-genetics data. Haplotypes can be obtained, at considerable cost, experimentally or (partially) through genotyping of additional family members. Alternatively, a statistical method can be used to infer phase and to reconstruct haplotypes. We present a new statistical method, applicable to genotype data at linked loci from a population sample, that improves substantially on current algorithms; often, error rates are reduced by >50%, relative to its nearest competitor. 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In mice, the analysis of imputed data is made completely general, whereas the range of models under which pooling works is substantially extended. mice adds new functionality for imputing multilevel data, automatic predictor selection, data handling, post-processing imputed values, specialized pooling routines, model selection tools, and diagnostic graphs. Imputation of categorical data is improved in order to bypass problems caused by perfect prediction. Special attention is paid to transformations, sum scores, indices and interactions using passive imputation, and to the proper setup of the predictor matrix. mice can be downloaded from the Comprehensive R Archive Network. This article provides a hands-on, stepwise approach to solve applied incomplete data problems. ...read more Topics: Imputation (statistics) (61%), Pooling (53%), Model selection (50%) Journal Article • DOI: 10.1080/01621459.1988.10478722 • Roderick J. A. Little1 • Institutions (1) 01 Jan 1988 - Journal of the American Statistical Association Abstract: A common concern when faced with multivariate data with missing values is whether the missing data are missing completely at random (MCAR); that is, whether missingness depends on the variables in the data set. One way of assessing this is to compare the means of recorded values of each variable between groups defined by whether other variables in the data set are missing or not. Although informative, this procedure yields potentially many correlated statistics for testing MCAR, resulting in multiple-comparison problems. This article proposes a single global test statistic for MCAR that uses all of the available data. The asymptotic null distribution is given, and the small-sample null distribution is derived for multivariate normal data with a monotone pattern of missing data. The test reduces to a standard t test when the data are bivariate with missing data confined to a single variable. A limited simulation study of empirical sizes for the test applied to normal and nonnormal data suggests that. ...read more Topics: Missing data (74%), Imputation (statistics) (68%), Test statistic (57%) ...read more Missing data analysis: making it work in the real world. J. Graham Psychology Annual review of psychology 2009 This review presents a practical summary of the missing data literature, including a sketch of missing data theory and descriptions of normal-model multiple imputation (MI) and maximum likelihood methods, and strategies for reducing attrition bias. View 2 excerpts, cites methods and background Principled missing data methods for researchers Yiran Dong, C. Y. Peng Computer Science Springer Plus 2013 Quality of research will be enhanced if researchers explicitly acknowledge missing data problems and the conditions under which they occurred, principled methods are employed to handle missing data, and the appropriate treatment of missing data is incorporated into review standards of manuscripts submitted for publication. Dual Imputation Strategies for Analyzing Incomplete Data S. Jolani Computer Science 2010 New imputation methods for handling multivariate missing data with a general pattern of missingness are provided and a new methodology that incorporates the concept of double robustness property within the MCMC-based algorithms for imputation of missing values is developed. Interval Estimation for Aggregate Queries on Incomplete Data This paper proposes to directly estimate the aggregate query result on incomplete data, rather than to impute the missing values, and believes that decision support applications could benefit significantly from the estimation, since they can tolerate inexact answers as long as there are clearly defined semantics and guarantees associated with the results. View 16 excerpts, cites methods

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