

survival analysis in python

Survival Analysis in Python: A Comprehensive Guide

Introduction:

Are you a data scientist grappling with time-to-event data? Do you need to understand how long something lasts, whether it's a machine's lifespan, customer retention, or patient survival after a treatment? If so, you've come to the right place. This comprehensive guide dives deep into the world of survival analysis using Python, equipping you with the knowledge and practical skills to analyze this unique type of data effectively. We'll cover everything from fundamental concepts to advanced techniques, providing clear explanations and practical Python code examples. Get ready to unlock the power of survival analysis!

1. Understanding Survival Analysis: The Fundamentals

Survival analysis, also known as time-to-event analysis, deals with data where the outcome of interest is the time until a specific event occurs. This event could be death (hence the name), machine failure, customer churn, or any other event of interest. Unlike traditional regression analysis, survival analysis accounts for censoring, a crucial aspect where the exact event time is unknown for some individuals in the dataset. Censoring occurs when the observation period ends before the event happens. For example, a patient might be enrolled in a study for five years but still be alive at the end of that period. Their survival time is at least five years, but the exact time of death is unknown.

Key concepts in survival analysis include:

Survival function ($S(t)$): The probability that an individual survives beyond time t .

Hazard function ($h(t)$): The instantaneous rate of occurrence of the event at time t , given that the individual has survived up to that time.

Cumulative hazard function ($H(t)$): The cumulative risk of experiencing the event up to time t .

1. Python Libraries for Survival Analysis

Python offers powerful libraries that simplify the process of performing survival analysis. The two most prominent are:

Lifelines: A comprehensive library specifically designed for survival analysis. It provides functions for estimating survival functions, hazard functions, performing Cox proportional hazards regression, and more.

Scikit-survival: A newer library built on scikit-learn, offering a more integrated approach for survival analysis within the familiar scikit-learn ecosystem. It provides similar functionalities to Lifelines but with a different API.

We will primarily focus on Lifelines in this tutorial due to its extensive features and user-friendly documentation.

1. Implementing Survival Analysis with Lifelines

Let's dive into practical examples using Lifelines. We'll use a sample dataset representing patient survival times after a medical treatment.

```
```python
import pandas as pd
from lifelines import KaplanMeierFitter, CoxPHFitter
```

### Sample data (replace with your own data)

```
data = {'duration': [10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 10, 15, 25, 35, 45],
 'event': [1, 1, 0, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1]}
df = pd.DataFrame(data)
```

### Kaplan-Meier estimator

```
kmf = KaplanMeierFitter()
kmf.fit(df['duration'], event_observed=df['event'])
kmf.plot()
```

### Cox Proportional Hazards model

```
cph = CoxPHFitter()
cph.fit(df, 'duration', event_col='event')
cph.print_summary()
```
```

This code demonstrates how to:

1. Import necessary libraries.
2. Create a sample DataFrame with survival times (`duration`) and event indicators (`event` - 1 for event occurred, 0 for censored).
3. Use `KaplanMeierFitter` to estimate the Kaplan-Meier survival curve and plot it.
4. Use `CoxPHFitter` to perform Cox proportional hazards regression, a powerful technique for analyzing the effect of covariates on survival time.

1. Interpreting Results and Choosing the Right Model

Interpreting the results from survival analysis requires careful consideration of the context. The Kaplan-Meier curve visually displays the survival probability over time, highlighting any significant differences between groups. The Cox proportional hazards model provides hazard ratios, indicating the relative risk of an event associated with specific covariates. The assumption of proportional hazards should be checked before drawing conclusions from the Cox model. There are diagnostic tests available within Lifelines to assess this assumption.

1. Advanced Techniques and Considerations

Beyond the basics, survival analysis offers advanced techniques, including:

Accelerated Failure Time (AFT) models: These models are alternatives to Cox models, particularly useful when the proportional hazards assumption is violated.

Competing risks models: These account for situations where multiple events can occur, and the interest lies in the time to a specific event, considering the possibility of other events occurring first.

Frailty models: These incorporate unobserved heterogeneity among individuals, improving model accuracy.

The choice of the appropriate model depends on the specific research question and characteristics of the data.

1. Visualizing Survival Data Effectively

Effective visualization is crucial for understanding survival data. Beyond the Kaplan-Meier curve, other helpful visualizations include:

Hazard rate plots: Illustrate the instantaneous risk of the event over time.

Cumulative hazard plots: Show the accumulated risk over time.

Survival curves with confidence intervals: Provide a measure of uncertainty associated with the survival estimates.

Proper visualization helps in communicating findings clearly and concisely.

Book Outline: Mastering Survival Analysis with Python

Introduction: What is survival analysis? Why use Python? Overview of the book's contents.

Chapter 1: Fundamental Concepts: Time-to-event data, censoring, survival function, hazard function, cumulative hazard function.

Chapter 2: Python Libraries for Survival Analysis: Detailed exploration of Lifelines and Scikit-survival, including installation and basic usage.

Chapter 3: Kaplan-Meier Estimation: Detailed explanation and practical examples using Lifelines. Interpretation of results.

Chapter 4: Cox Proportional Hazards Regression: In-depth coverage, model assumptions, interpretation of coefficients and hazard ratios. Model diagnostics.

Chapter 5: Advanced Techniques: Accelerated failure time models, competing risks, frailty models, and other advanced methods.

Chapter 6: Data Visualization: Creating informative and insightful visualizations of survival data using various plotting techniques.

Chapter 7: Case Studies: Real-world applications of survival analysis across various domains (medicine, engineering, business).

Conclusion: Summary of key concepts and future directions in survival analysis.

(Detailed explanation of each chapter would follow, expanding on the points mentioned above. This would be several thousand words and go beyond the scope of this prompt. However, the above outline provides a strong structure for a comprehensive book.)

FAQs:

1. What is censoring in survival analysis? Censoring occurs when the event of interest is not observed within the study period. It's crucial to account for censoring in the analysis.

1. What is the difference between the survival function and the hazard function? The survival function gives the probability of surviving beyond a specific time, while the hazard function gives the instantaneous risk of the event at a given time, given survival up to that time.

1. What is the Kaplan-Meier estimator? It's a non-parametric method used to estimate the survival function from censored data.

1. What is Cox proportional hazards regression? It's a semi-parametric regression model used to analyze the relationship between covariates and survival time.

1. What is the proportional hazards assumption? It's an assumption of the Cox model that the hazard ratio between groups remains constant over time.

1. How can I check the proportional hazards assumption? Lifelines provides

diagnostic tools to assess this assumption.

1. What are some alternatives to Cox models? Accelerated failure time (AFT) models are useful when the proportional hazards assumption is violated.
1. How can I visualize survival data effectively? Kaplan-Meier curves, hazard rate plots, and cumulative hazard plots are useful visualization tools.
1. Where can I find more resources on survival analysis in Python? The Lifelines documentation and various online tutorials are excellent resources.

Related Articles:

1. Introduction to Survival Analysis: A beginner-friendly overview of the fundamental concepts.
2. Kaplan-Meier Estimation in Python: A detailed tutorial on using the Kaplan-Meier estimator with Lifelines.
3. Cox Proportional Hazards Regression Explained: A comprehensive guide to understanding and interpreting Cox models.
4. Handling Censored Data in Survival Analysis: Techniques for correctly managing censored observations.
5. Accelerated Failure Time Models in Python: An introduction to AFT models and their application.
6. Competing Risks Regression using Lifelines: Analysis of situations with multiple possible events.
7. Visualizing Survival Data with Matplotlib and Seaborn: Techniques for creating effective visualizations.
8. Survival Analysis Case Study: Customer Churn Prediction: A real-world application example.
9. Advanced Topics in Survival Analysis: A discussion of more complex methods and techniques.

This detailed guide provides a solid foundation for understanding and applying survival analysis in Python. Remember to adapt the code and techniques to your specific dataset and research question. Remember to always carefully interpret your results and consider the limitations of your chosen model.

survival analysis in python: Survival Analysis with Python Avishek Nag, 2021-12-17 Survival analysis uses statistics to calculate time to failure. Survival Analysis with Python takes a fresh look at this complex subject by explaining how to use the Python programming language to perform this type of analysis. As the subject itself is very mathematical and full of expressions and formulations, the book provides detailed explanations and examines practical implications. The book begins with an overview of the concepts underpinning statistical survival analysis. It then delves into Parametric models with coverage of Concept of maximum likelihood estimate (MLE) of a probability distribution parameter MLE of the survival function Common probability distributions and their analysis Analysis of exponential distribution as a survival function Analysis of Weibull distribution as a survival function Derivation of Gumbel distribution as a survival function from Weibull Non-parametric models including Kaplan-Meier (KM) estimator, a derivation of expression using MLE Fitting KM estimator with an example dataset, Python code and plotting curves Greenwood's formula and its derivation Models with covariates explaining The concept of time shift and the accelerated failure time (AFT) model Weibull-AFT model and derivation of parameters by MLE Proportional Hazard (PH) model Cox-PH model and Breslow's method Significance of covariates Selection of covariates The Python lifelines library is used for coding examples. By mapping theory to practical examples featuring datasets, this book is a hands-on tutorial as well as a handy reference.

survival analysis in python: Handbook of Regression Modeling in People Analytics Keith McNulty, 2021-07-29 Despite the recent rapid growth in machine learning and predictive analytics, many of the statistical questions that are faced by researchers and practitioners still involve explaining why something is happening. Regression analysis is the best 'swiss army knife' we have for answering these kinds of questions. This book is a learning resource on inferential statistics and regression analysis. It teaches how to do a wide range of statistical analyses in both R and in Python, ranging from simple hypothesis testing to advanced multivariate modelling. Although it is primarily focused on examples related to the analysis of people and talent, the methods easily transfer to any discipline. The book hits a 'sweet spot' where there is just enough mathematical theory to support a strong understanding of the methods, but with a step-by-step guide and easily reproducible examples and code, so that the methods can be put into practice immediately. This makes the book accessible to a wide readership, from public and private sector analysts and practitioners to students and researchers. Key Features: 16 accompanying datasets across a wide range of contexts (e.g. academic, corporate, sports, marketing) Clear step-by-step instructions on executing the analyses Clear guidance on how to interpret results Primary instruction in R but added sections for Python coders Discussion exercises and data exercises for each of the main chapters Final chapter of practice material and datasets ideal for class homework or project work.

survival analysis in python: An Introduction to Statistical Learning Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Jonathan Taylor, 2023-08-01 An Introduction to Statistical Learning provides an accessible overview of the field of statistical learning, an essential toolset for making sense of the vast and complex data sets that have emerged in fields ranging from biology to finance, marketing, and astrophysics in the past twenty years. This book presents some of the most important modeling and prediction techniques, along with relevant applications. Topics include linear regression, classification, resampling methods, shrinkage approaches, tree-based methods, support vector machines, clustering, deep learning, survival analysis, multiple testing, and more. Color graphics and real-world examples are used to illustrate the methods presented. This book is targeted at statisticians and non-statisticians alike, who wish to use cutting-edge statistical learning techniques to analyze their data. Four of the authors co-wrote An Introduction to Statistical

Learning, With Applications in R (ISLR), which has become a mainstay of undergraduate and graduate classrooms worldwide, as well as an important reference book for data scientists. One of the keys to its success was that each chapter contains a tutorial on implementing the analyses and methods presented in the R scientific computing environment. However, in recent years Python has become a popular language for data science, and there has been increasing demand for a Python-based alternative to ISLR. Hence, this book (ISLP) covers the same materials as ISLR but with labs implemented in Python. These labs will be useful both for Python novices, as well as experienced users.

survival analysis in python: Data Science Solutions with Python Tshepo Chris Nokeri, 2021-10-26 Apply supervised and unsupervised learning to solve practical and real-world big data problems. This book teaches you how to engineer features, optimize hyperparameters, train and test models, develop pipelines, and automate the machine learning (ML) process. The book covers an in-memory, distributed cluster computing framework known as PySpark, machine learning framework platforms known as scikit-learn, PySpark MLlib, H2O, and XGBoost, and a deep learning (DL) framework known as Keras. The book starts off presenting supervised and unsupervised ML and DL models, and then it examines big data frameworks along with ML and DL frameworks. Author Tshepo Chris Nokeri considers a parametric model known as the Generalized Linear Model and a survival regression model known as the Cox Proportional Hazards model along with Accelerated Failure Time (AFT). Also presented is a binary classification model (logistic regression) and an ensemble model (Gradient Boosted Trees). The book introduces DL and an artificial neural network known as the Multilayer Perceptron (MLP) classifier. A way of performing cluster analysis using the K-Means model is covered. Dimension reduction techniques such as Principal Components Analysis and Linear Discriminant Analysis are explored. And automated machine learning is unpacked. This book is for intermediate-level data scientists and machine learning engineers who want to learn how to apply key big data frameworks and ML and DL frameworks. You will need prior knowledge of the basics of statistics, Python programming, probability theories, and predictive analytics. What You Will Learn Understand widespread supervised and unsupervised learning, including key dimension reduction techniques Know the big data analytics layers such as data visualization, advanced statistics, predictive analytics, machine learning, and deep learning Integrate big data frameworks with a hybrid of machine learning frameworks and deep learning frameworks Design, build, test, and validate skilled machine models and deep learning models Optimize model performance using data transformation, regularization, outlier remedying, hyperparameter optimization, and data split ratio alteration Who This Book Is For Data scientists and machine learning engineers with basic knowledge and understanding of Python programming, probability theories, and predictive analytics

survival analysis in python: Python for Probability, Statistics, and Machine Learning José Unpingco, 2019-06-29 This book, fully updated for Python version 3.6+, covers the key ideas that link probability, statistics, and machine learning illustrated using Python modules in these areas. All the figures and numerical results are reproducible using the Python codes provided. The author develops key intuitions in machine learning by working meaningful examples using multiple analytical methods and Python codes, thereby connecting theoretical concepts to concrete implementations. Detailed proofs for certain important results are also provided. Modern Python modules like Pandas, Sympy, Scikit-learn, Tensorflow, and Keras are applied to simulate and visualize important machine learning concepts like the bias/variance trade-off, cross-validation, and regularization. Many abstract mathematical ideas, such as convergence in probability theory, are developed and illustrated with numerical examples. This updated edition now includes the Fisher Exact Test and the Mann-Whitney-Wilcoxon Test. A new section on survival analysis has been included as well as substantial development of Generalized Linear Models. The new deep learning section for image processing includes an in-depth discussion of gradient descent methods that underpin all deep learning algorithms. As with the prior edition, there are new and updated *Programming Tips* that illustrate effective Python modules and methods for scientific

programming and machine learning. There are 445 run-able code blocks with corresponding outputs that have been tested for accuracy. Over 158 graphical visualizations (almost all generated using Python) illustrate the concepts that are developed both in code and in mathematics. We also discuss and use key Python modules such as Numpy, Scikit-learn, Sympy, Scipy, Lifelines, CvxPy, Theano, Matplotlib, Pandas, Tensorflow, Statsmodels, and Keras. This book is suitable for anyone with an undergraduate-level exposure to probability, statistics, or machine learning and with rudimentary knowledge of Python programming.

survival analysis in python: Survival Analysis David G. Kleinbaum, Mitchel Klein, 2013-04-18 A straightforward and easy-to-follow introduction to the main concepts and techniques of the subject. It is based on numerous courses given by the author to students and researchers in the health sciences and is written with such readers in mind. A user-friendly layout includes numerous illustrations and exercises and the book is written in such a way so as to enable readers learn directly without the assistance of a classroom instructor. Throughout, there is an emphasis on presenting each new topic backed by real examples of a survival analysis investigation, followed up with thorough analyses of real data sets. Each chapter concludes with practice exercises to help readers reinforce their understanding of the concepts covered, before going on to a more comprehensive test. Answers to both are included. Readers will enjoy David Kleinbaums style of presentation, making this an excellent introduction for all those coming to the subject for the first time.

survival analysis in python: Generalized Linear Models P. McCullagh, 2019-01-22 The success of the first edition of Generalized Linear Models led to the updated Second Edition, which continues to provide a definitive unified, treatment of methods for the analysis of diverse types of data. Today, it remains popular for its clarity, richness of content and direct relevance to agricultural, biological, health, engineering, and ot

survival analysis in python: Think Stats Allen B. Downey, 2014-10-16 If you know how to program, you have the skills to turn data into knowledge, using tools of probability and statistics. This concise introduction shows you how to perform statistical analysis computationally, rather than mathematically, with programs written in Python. By working with a single case study throughout this thoroughly revised book, you'll learn the entire process of exploratory data analysis—from collecting data and generating statistics to identifying patterns and testing hypotheses. You'll explore distributions, rules of probability, visualization, and many other tools and concepts. New chapters on regression, time series analysis, survival analysis, and analytic methods will enrich your discoveries. Develop an understanding of probability and statistics by writing and testing code Run experiments to test statistical behavior, such as generating samples from several distributions Use simulations to understand concepts that are hard to grasp mathematically Import data from most sources with Python, rather than rely on data that's cleaned and formatted for statistics tools Use statistical inference to answer questions about real-world data

survival analysis in python: Explanatory Model Analysis Przemyslaw Biecek, Tomasz Burzykowski, 2021-02-15 Explanatory Model Analysis Explore, Explain and Examine Predictive Models is a set of methods and tools designed to build better predictive models and to monitor their behaviour in a changing environment. Today, the true bottleneck in predictive modelling is neither the lack of data, nor the lack of computational power, nor inadequate algorithms, nor the lack of flexible models. It is the lack of tools for model exploration (extraction of relationships learned by the model), model explanation (understanding the key factors influencing model decisions) and model examination (identification of model weaknesses and evaluation of model's performance). This book presents a collection of model agnostic methods that may be used for any black-box model together with real-world applications to classification and regression problems.

survival analysis in python: Introducing Survival and Event History Analysis Melinda Mills, 2011-01-19 This book is an accessible, practical and comprehensive guide for researchers from multiple disciplines including biomedical, epidemiology, engineering and the social sciences. Written for accessibility, this book will appeal to students and researchers who want to understand the

basics of survival and event history analysis and apply these methods without getting entangled in mathematical and theoretical technicalities. Inside, readers are offered a blueprint for their entire research project from data preparation to model selection and diagnostics. Engaging, easy to read, functional and packed with enlightening examples, 'hands-on' exercises, conversations with key scholars and resources for both students and instructors, this text allows researchers to quickly master advanced statistical techniques. It is written from the perspective of the 'user', making it suitable as both a self-learning tool and graduate-level textbook. Also included are up-to-date innovations in the field, including advancements in the assessment of model fit, unobserved heterogeneity, recurrent events and multilevel event history models. Practical instructions are also included for using the statistical programs of R, STATA and SPSS, enabling readers to replicate the examples described in the text.

survival analysis in python: Pragmatic Machine Learning with Python Avishek Nag, 2020-04-30 An easy-to-understand guide to learn practical Machine Learning techniques with Mathematical foundations KEY FEATURES - A balanced combination of underlying mathematical theories & practical examples with Python code - Coverage of latest topics like multi-label classification, Text Mining, Doc2Vec, Word2Vec, XMeans clustering, unsupervised outlier detection, techniques to deploy ML models in production-grade systems with PMML, etc - Coverage of sufficient & relevant visualization techniques specific to any topic DESCRIPTION - This book will be ideal for working professionals who want to learn Machine Learning from scratch. The first chapter will be an introductory chapter to make readers comfortable with the idea of Machine Learning and the required mathematical theories. There will be a balanced combination of underlying mathematical theories corresponding to any Machine Learning topic and its implementation using Python. Most of the implementations will be based on Scikit-learn, but other Python libraries like Gensim or PyTorch will also be used for some topics like text analytics or deep learning. The book will be divided into chapters based on primary Machine Learning topics like Classification, Regression, Clustering, Deep Learning, Text Mining, etc. The book will also explain different techniques of putting Machine Learning models into production-grade systems using Big Data or Non-Big Data flavors and standards for exporting models. WHAT WILL YOU LEARN - Get familiar with practical concepts of Machine Learning from ground zero - Learn how to deploy Machine Learning models in production - Understand how to do Data Science Storytelling - Explore the latest topics in the current industry about Machine Learning WHO THIS BOOK IS FOR - This book would be ideal for experienced Software Professionals who are trying to get into the field of Machine Learning. Anyone who wishes to Learn Machine Learning concepts and models in the production lifecycle. TABLE OF CONTENTS 1. Introduction to Machine Learning & Mathematical preliminaries 2. Classification 3. Regression 4. Clustering 5. Deep Learning & Neural Networks 6. Miscellaneous Unsupervised Learning 7. Text Mining 8. Machine Learning models in production 9. Case Studies & Data Science Storytelling

survival analysis in python: Regression Analysis with Python Luca Massaron, Alberto Boschetti, 2016-02-29 Learn the art of regression analysis with Python About This Book Become competent at implementing regression analysis in Python Solve some of the complex data science problems related to predicting outcomes Get to grips with various types of regression for effective data analysis Who This Book Is For The book targets Python developers, with a basic understanding of data science, statistics, and math, who want to learn how to do regression analysis on a dataset. It is beneficial if you have some knowledge of statistics and data science. What You Will Learn Format a dataset for regression and evaluate its performance Apply multiple linear regression to real-world problems Learn to classify training points Create an observation matrix, using different techniques of data analysis and cleaning Apply several techniques to decrease (and eventually fix) any overfitting problem Learn to scale linear models to a big dataset and deal with incremental data In Detail Regression is the process of learning relationships between inputs and continuous outputs from example data, which enables predictions for novel inputs. There are many kinds of regression algorithms, and the aim of this book is to explain which is the right one to use for each set of

problems and how to prepare real-world data for it. With this book you will learn to define a simple regression problem and evaluate its performance. The book will help you understand how to properly parse a dataset, clean it, and create an output matrix optimally built for regression. You will begin with a simple regression algorithm to solve some data science problems and then progress to more complex algorithms. The book will enable you to use regression models to predict outcomes and take critical business decisions. Through the book, you will gain knowledge to use Python for building fast better linear models and to apply the results in Python or in any computer language you prefer. **Style and approach** This is a practical tutorial-based book. You will be given an example problem and then supplied with the relevant code and how to walk through it. The details are provided in a step by step manner, followed by a thorough explanation of the math underlying the solution. This approach will help you leverage your own data using the same techniques.

survival analysis in python: Think Stats Allen B. Downey, 2011-07-01 If you know how to program, you have the skills to turn data into knowledge using the tools of probability and statistics. This concise introduction shows you how to perform statistical analysis computationally, rather than mathematically, with programs written in Python. You'll work with a case study throughout the book to help you learn the entire data analysis process—from collecting data and generating statistics to identifying patterns and testing hypotheses. Along the way, you'll become familiar with distributions, the rules of probability, visualization, and many other tools and concepts. Develop your understanding of probability and statistics by writing and testing code Run experiments to test statistical behavior, such as generating samples from several distributions Use simulations to understand concepts that are hard to grasp mathematically Learn topics not usually covered in an introductory course, such as Bayesian estimation Import data from almost any source using Python, rather than be limited to data that has been cleaned and formatted for statistics tools Use statistical inference to answer questions about real-world data

survival analysis in python: Pandas for Everyone Daniel Y. Chen, 2017-12-15 The Hands-On, Example-Rich Introduction to Pandas Data Analysis in Python Today, analysts must manage data characterized by extraordinary variety, velocity, and volume. Using the open source Pandas library, you can use Python to rapidly automate and perform virtually any data analysis task, no matter how large or complex. Pandas can help you ensure the veracity of your data, visualize it for effective decision-making, and reliably reproduce analyses across multiple datasets. Pandas for Everyone brings together practical knowledge and insight for solving real problems with Pandas, even if you're new to Python data analysis. Daniel Y. Chen introduces key concepts through simple but practical examples, incrementally building on them to solve more difficult, real-world problems. Chen gives you a jumpstart on using Pandas with a realistic dataset and covers combining datasets, handling missing data, and structuring datasets for easier analysis and visualization. He demonstrates powerful data cleaning techniques, from basic string manipulation to applying functions simultaneously across dataframes. Once your data is ready, Chen guides you through fitting models for prediction, clustering, inference, and exploration. He provides tips on performance and scalability, and introduces you to the wider Python data analysis ecosystem. Work with DataFrames and Series, and import or export data Create plots with matplotlib, seaborn, and pandas Combine datasets and handle missing data Reshape, tidy, and clean datasets so they're easier to work with Convert data types and manipulate text strings Apply functions to scale data manipulations Aggregate, transform, and filter large datasets with groupby Leverage Pandas' advanced date and time capabilities Fit linear models using statsmodels and scikit-learn libraries Use generalized linear modeling to fit models with different response variables Compare multiple models to select the "best" Regularize to overcome overfitting and improve performance Use clustering in unsupervised machine learning

survival analysis in python: Think Bayes Allen Downey, 2013-09-12 If you know how to program with Python, and know a little about probability, you're ready to tackle Bayesian statistics. This book shows you how to use Python code instead of math to help you learn Bayesian fundamentals. Once you get the math out of the way, you'll be able to apply these techniques to

real-world problems.

survival analysis in python: Event History Analysis Paul David Allison, 1984-11 Drawing on recent event history analytical methods from biostatistics, engineering, and sociology, this clear and comprehensive monograph explains how longitudinal data can be used to study the causes of deaths, crimes, wars, and many other human events. Allison shows why ordinary multiple regression is not suited to analyze event history data, and demonstrates how innovative regression - like methods can overcome this problem. He then discusses the particular new methods that social scientists should find useful.

survival analysis in python: Time Series Forecasting in Python Marco Peixeiro, 2022-11-15 Build predictive models from time-based patterns in your data. Master statistical models including new deep learning approaches for time series forecasting. In Time Series Forecasting in Python you will learn how to: Recognize a time series forecasting problem and build a performant predictive model Create univariate forecasting models that account for seasonal effects and external variables Build multivariate forecasting models to predict many time series at once Leverage large datasets by using deep learning for forecasting time series Automate the forecasting process Time Series Forecasting in Python teaches you to build powerful predictive models from time-based data. Every model you create is relevant, useful, and easy to implement with Python. You'll explore interesting real-world datasets like Google's daily stock price and economic data for the USA, quickly progressing from the basics to developing large-scale models that use deep learning tools like TensorFlow. About the technology You can predict the future—with a little help from Python, deep learning, and time series data! Time series forecasting is a technique for modeling time-centric data to identify upcoming events. New Python libraries and powerful deep learning tools make accurate time series forecasts easier than ever before. About the book Time Series Forecasting in Python teaches you how to get immediate, meaningful predictions from time-based data such as logs, customer analytics, and other event streams. In this accessible book, you'll learn statistical and deep learning methods for time series forecasting, fully demonstrated with annotated Python code. Develop your skills with projects like predicting the future volume of drug prescriptions, and you'll soon be ready to build your own accurate, insightful forecasts. What's inside Create models for seasonal effects and external variables Multivariate forecasting models to predict multiple time series Deep learning for large datasets Automate the forecasting process About the reader For data scientists familiar with Python and TensorFlow. About the author Marco Peixeiro is a seasoned data science instructor who has worked as a data scientist for one of Canada's largest banks. Table of Contents PART 1 TIME WAITS FOR NO ONE 1 Understanding time series forecasting 2 A naive prediction of the future 3 Going on a random walk PART 2 FORECASTING WITH STATISTICAL MODELS 4 Modeling a moving average process 5 Modeling an autoregressive process 6 Modeling complex time series 7 Forecasting non-stationary time series 8 Accounting for seasonality 9 Adding external variables to our model 10 Forecasting multiple time series 11 Capstone: Forecasting the number of antidiabetic drug prescriptions in Australia PART 3 LARGE-SCALE FORECASTING WITH DEEP LEARNING 12 Introducing deep learning for time series forecasting 13 Data windowing and creating baselines for deep learning 14 Baby steps with deep learning 15 Remembering the past with LSTM 16 Filtering a time series with CNN 17 Using predictions to make more predictions 18 Capstone: Forecasting the electric power consumption of a household PART 4 AUTOMATING FORECASTING AT SCALE 19 Automating time series forecasting with Prophet 20 Capstone: Forecasting the monthly average retail price of steak in Canada 21 Going above and beyond

survival analysis in python: The Statistical Analysis of Failure Time Data John D. Kalbfleisch, Ross L. Prentice, 2011-01-25 Contains additional discussion and examples on left truncation as well as material on more general censoring and truncation patterns. Introduces the martingale and counting process formulation which will be in a new chapter. Develops multivariate failure time data in a separate chapter and extends the material on Markov and semi Markov formulations. Presents new examples and applications of data analysis.

survival analysis in python: Regression Modeling Strategies Frank E. Harrell, 2013-03-09

Many texts are excellent sources of knowledge about individual statistical tools, but the art of data analysis is about choosing and using multiple tools. Instead of presenting isolated techniques, this text emphasizes problem solving strategies that address the many issues arising when developing multivariable models using real data and not standard textbook examples. It includes imputation methods for dealing with missing data effectively, methods for dealing with nonlinear relationships and for making the estimation of transformations a formal part of the modeling process, methods for dealing with too many variables to analyze and not enough observations, and powerful model validation techniques based on the bootstrap. This text realistically deals with model uncertainty and its effects on inference to achieve safe data mining.

survival analysis in python: Bayesian Methods for Hackers Cameron Davidson-Pilon, 2015-09-30 Master Bayesian Inference through Practical Examples and Computation-Without Advanced Mathematical Analysis Bayesian methods of inference are deeply natural and extremely powerful. However, most discussions of Bayesian inference rely on intensely complex mathematical analyses and artificial examples, making it inaccessible to anyone without a strong mathematical background. Now, though, Cameron Davidson-Pilon introduces Bayesian inference from a computational perspective, bridging theory to practice-freeing you to get results using computing power. Bayesian Methods for Hackers illuminates Bayesian inference through probabilistic programming with the powerful PyMC language and the closely related Python tools NumPy, SciPy, and Matplotlib. Using this approach, you can reach effective solutions in small increments, without extensive mathematical intervention. Davidson-Pilon begins by introducing the concepts underlying Bayesian inference, comparing it with other techniques and guiding you through building and training your first Bayesian model. Next, he introduces PyMC through a series of detailed examples and intuitive explanations that have been refined after extensive user feedback. You'll learn how to use the Markov Chain Monte Carlo algorithm, choose appropriate sample sizes and priors, work with loss functions, and apply Bayesian inference in domains ranging from finance to marketing. Once you've mastered these techniques, you'll constantly turn to this guide for the working PyMC code you need to jumpstart future projects. Coverage includes • Learning the Bayesian "state of mind" and its practical implications • Understanding how computers perform Bayesian inference • Using the PyMC Python library to program Bayesian analyses • Building and debugging models with PyMC • Testing your model's "goodness of fit" • Opening the "black box" of the Markov Chain Monte Carlo algorithm to see how and why it works • Leveraging the power of the "Law of Large Numbers" • Mastering key concepts, such as clustering, convergence, autocorrelation, and thinning • Using loss functions to measure an estimate's weaknesses based on your goals and desired outcomes • Selecting appropriate priors and understanding how their influence changes with dataset size • Overcoming the "exploration versus exploitation" dilemma: deciding when "pretty good" is good enough • Using Bayesian inference to improve A/B testing • Solving data science problems when only small amounts of data are available Cameron Davidson-Pilon has worked in many areas of applied mathematics, from the evolutionary dynamics of genes and diseases to stochastic modeling of financial prices. His contributions to the open source community include lifelines, an implementation of survival analysis in Python. Educated at the University of Waterloo and at the Independent University of Moscow, he currently works with the online commerce leader Shopify.

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Bogaerts is project manager at I-BioStat, KU Leuven. He received his PhD in science (statistics) at KU Leuven on the analysis of interval-censored data. He has gained expertise in a great variety of statistical topics with a focus on the design and analysis of clinical trials. Arnošt Komárek is associate professor of statistics at Charles University, Prague. His subject area of expertise covers mainly survival analysis with the emphasis on interval-censored data and classification based on longitudinal data. He is past chair of the Statistical Modelling Society and editor of *Statistical Modelling: An International Journal*. Emmanuel Lesaffre is professor of biostatistics at I-BioStat, KU Leuven. His research interests include Bayesian methods, longitudinal data analysis, statistical modelling, analysis of dental data, interval-censored data, misclassification issues, and clinical trials. He is the founding chair of the Statistical Modelling Society, past-president of the International Society for Clinical Biostatistics, and fellow of ISI and ASA.

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individuals. *Frailty Models in Survival Analysis* presents a comprehensive overview of the fundamental approaches in the area of frailty models. The book extensively explores how univariate frailty models can represent unobserved heterogeneity. It also emphasizes correlated frailty models as extensions of univariate and shared frailty models. The author analyzes similarities and differences between frailty and copula models; discusses problems related to frailty models, such as tests for homogeneity; and describes parametric and semiparametric models using both frequentist and Bayesian approaches. He also shows how to apply the models to real data using the statistical packages of R, SAS, and Stata. The appendix provides the technical mathematical results used throughout. Written in nontechnical terms accessible to nonspecialists, this book explains the basic ideas in frailty modeling and statistical techniques, with a focus on real-world data application and interpretation of the results. By applying several models to the same data, it allows for the comparison of their advantages and limitations under varying model assumptions. The book also employs simulations to analyze the finite sample size performance of the models.

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aimed at both statisticians and applied researchers interested in causal inference and general effect estimation for observational and experimental data. Part I is an accessible introduction to super learning and the targeted maximum likelihood estimator, including related concepts necessary to understand and apply these methods. Parts II-IX handle complex data structures and topics applied researchers will immediately recognize from their own research, including time-to-event outcomes, direct and indirect effects, positivity violations, case-control studies, censored data, longitudinal data, and genomic studies.

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