Mixed Poisson Processes with Panel Flow

Anatoly Zhigljavsky and Vippal Savani *

Abstract— The problem of parameter estimation and statistical inference when fitting an $M/G/\infty$ queuing process to data is considered in the situation where the times of arrival and departure are unknown; instead recurrent events, which occur according to a mixed Poisson process, are observed between the times of arrival and departure.

Keywords: Mixed Poisson process, panel flow, $M/G/\infty$ system

1 Introduction

This paper investigates the modeling of arrival and departure times of individuals in the case where precise arrival and departure times are unknown; instead we observe recurrent events between the times of arrival and departure. In the case where arrival and departure times are known, it is straightforward to fit a standard queueing model of the form $M/G/\infty$ where the arrival process is Markovian, the time spent between arrival and departure follows a general distribution G and there are no queues.

The situation described above occurs in many fields. In the field of market research we observe purchases made by individuals during an observation period. The time when an individual begins or ceases to buy (i.e. time of arrival and departure), however, is unknown. Such an example occurs for purchases of products such as baby food, where individuals "flow" in and out of the panel.

1.1 Panel flow

Consider a panel of individuals consisting of subjects that have recurrent events. Panel flow occurs when individuals move into and out of the panel. We assume that panel flow occurs according to an $M/G/\infty$ process so that: individuals enter the panel according to a Poisson process with intensity ν; individuals stay in the panel for a random period of time σ (independent and identically distributed for each individual) and that there are an infinite number of servers so that an individual will immediately enter into the panel.

When the problem of panel flow exists then recurrent events may no longer be analyzed under the assumption of stationarity. In this case, to model recurrent events, we require knowledge of N_t, the number of individuals in the panel at time t. If we know the intensity of the Poisson arrival process (ν) and the distribution of the time spent in the panel (G) then we can use the properties of $M/G/\infty$ processes to model N_t.

Let us assume that N_t, modeled by an $M/G/\infty$ process, is at a steady stationary state. For all t the random variables N_t have Poisson distribution with mean $\nu E\sigma$ and the covariances $cov(N_t, N_{t+s}) = \nu E[\max(0, \sigma - s)]$ for all $s > 0$ (see e.g. [4]).

The assumption that individuals enter the panel according to a Poisson process with intensity ν is a very natural assumption in practice. If the arrival process is non-stationary, it can be easily deseasonalised (that is, made stationary). The intensity ν of the arrival Poisson is also simple to estimate.

1.2 Recurrent events

In estimating the parameters of the $M/G/\infty$ process we require the arrival and departure times for each individual. In our problem, the arrival and departure times are unknown. We consider the use of recurrent events to estimate these times.

We consider mixed Poisson processes as a model for the recurrent events. We define a mixed Poisson process as a pure Poisson process with random intensity λ.

In the case of panel data analysis, the mixed Poisson process has a natural interpretation in that each individual has events according to a Poisson process; however, the intensity of each process

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Mixed Poisson Processes

Thomas Nowak

Mixed Poisson Processes:

   Mixed Poisson Processes J Grandell,1997-05-01 To date Mixed Poisson processes have been studied by scientists primarily interested in either insurance mathematics or point processes Work in one area has often been carried out without knowledge of the other area Mixed Poisson Processes is the first book to combine and concentrate on these two themes and to distinguish between the notions of distributions and processes The first part of the text gives special emphasis to the estimation of the underlying intensity thinning infinite divisibility and reliability properties The second part is to a greater extent based on Lundberg s thesis **Multivariate Mixed Poisson Processes** Mathias Zocher,2005 **Stochastic Processes in Science, Engineering and Finance** Frank Beichelt,2006-02-22 This book presents a self contained introduction to stochastic processes with emphasis on their applications in science engineering finance computer science and operations research It provides theoretical foundations for modeling time dependent random phenomena in these areas and illustrates their application by analyzing numerous practical examples The treatment assumes few prerequisites requiring only the standard mathematical maturity acquired by undergraduate applied science students It includes an introductory chapter that summarizes the basic probability theory needed as background Numerous exercises reinforce the concepts and techniques discussed and allow readers to assess their grasp of the subject Solutions to most of the exercises are provided in an appendix While focused primarily on practical aspects the presentation includes some important proofs along with more challenging examples and exercises for those more theoretically inclined Mastering the contents of this book prepares readers to apply stochastic modeling in their own fields and enables them to work more creatively with software designed for dealing with the data analysis aspects of stochastic processes *A Martingale Characterization of Mixed Poisson Processes* Dietmar Pfeifer,NORTH CAROLINA UNIV AT CHAPEL HILL CENTER FOR STOCHASTIC PROCESSES.,1985 It is shown that an elementary pure birth process is a mixed Poisson process if the sequence of post jump intensities forms a martingale with respect to the delta fields generated by the jump times of the process In this case the post jump intensities converge a s to the mixing random variable of the process Keyword Applied probability Author *Applied Stochastic Processes* Mario Lefebvre,2007-12-14 Applied Stochastic Processes uses a distinctly applied framework to present the most important topics in the field of stochastic processes Key features Presents carefully chosen topics such as Gaussian and Markovian processes Markov chains Poisson processes Brownian motion and queueing theory Examines in detail special diffusion processes with implications for finance various generalizations of Poisson processes and renewal processes Serves graduate students in a variety of disciplines such as applied mathematics operations research engineering finance and business administration Contains numerous examples and approximately 350 advanced problems reinforcing both concepts and applications Includes entertaining mini biographies of mathematicians giving an enriching historical context Covers basic results in probability Two appendices with statistical tables and solutions to the even numbered problems are included at the end This textbook is

for graduate students in applied mathematics operations research and engineering Pure mathematics students interested in the applications of probability and stochastic processes and students in business administration will also find this book useful

Multivariate Mixed Poisson Processes ,2005 Multivariate mixed Poisson processes are special multivariate counting processes whose coordinates are in general dependent The first part of this thesis is devoted to properties which multivariate counting processes may possess Such properties are for example the Markov property the multinomial property and regularity With regard to regularity we study the properties of transition probabilities and intensities The second part of this thesis restricts the class of all multivariate counting processes by additional assumptions leading to different types of multivariate mixed Poisson processes which however are connected with each other Using a multivariate version of the Bernstein Widder theorem it is shown that multivariate mixed Poisson processes are characterized by the multinomial property Furthermore regularity of multivariate mixed Poisson processes and properties of their moments are studied in detail Throughout this thesis two types of stability of properties of multivariate counting processes are studied It is shown that most properties of a multivariate counting process are stable under certain linear transformations including the selection of single coordinates and summation of all coordinates It is also shown that the different types of multivariate mixed Poisson processes under consideration are in a certain sense stable in time **A Course on Point Processes** R.-D. Reiss,2012-12-06 This graduate level textbook provides a straight forward and mathematically rigorous introduction to the standard theory of point processes The author s aim is to present an account which concentrates on the essentials and which places an emphasis on conveying an intuitive understanding of the subject As a result it provides a clear presentation of how statistical ideas can be viewed from this perspective and particular topics covered include the theory of extreme values and sampling from finite populations Prerequisites are that the reader has a basic grounding in the mathematical theory of probability and statistics but otherwise the book is self contained It arises from courses given by the author over a number of years and includes numerous exercises ranging from simple computations to more challenging explorations of ideas from the text **Fractal-Based Point Processes** Steven Bradley Lowen,Malvin Carl Teich,2005-09-19 An integrated approach to fractals and point processes This publication provides a complete and integrated presentation of the fields of fractals and point processes from definitions and measures to analysis and estimation The authors skillfully demonstrate how fractal based point processes established as the intersection of these two fields are tremendously useful for representing and describing a wide variety of diverse phenomena in the physical and biological sciences Topics range from information packet arrivals on a computer network to action potential occurrences in a neural preparation The authors begin with concrete and key examples of fractals and point processes followed by an introduction to fractals and chaos Point processes are defined and a collection of characterizing measures are presented With the concepts of fractals and point processes thoroughly explored the authors move on to integrate the two fields of study Mathematical formulations for several important fractal

based point process families are provided as well as an explanation of how various operations modify such processes The authors also examine analysis and estimation techniques suitable for these processes Finally computer network traffic an important application used to illustrate the various approaches and models set forth in earlier chapters is discussed Throughout the presentation readers are exposed to a number of important applications that are examined with the aid of a set of point processes drawn from biological signals and computer network traffic Problems are provided at the end of each chapter allowing readers to put their newfound knowledge into practice and all solutions are provided in an appendix An accompanying Web site features links to supplementary materials and tools to assist with data analysis and simulation With its focus on applications and numerous solved problem sets this is an excellent graduate level text for courses in such diverse fields as statistics physics engineering computer science psychology and neuroscience **Point Processes with a Generalized Order Statistic Property** Birgit Debrabant,2008 Mixed Poisson processes are a well known class of point processes derived from stationary Poisson processes In particular they cover cases where the intensity of a Poisson process is unknown but can be assumed to follow a known probability distribution This situation is common e g in insurance mathematics where for instance the number of accident claims in which an individual is involved and which is evolving over some time can in principal be well described by a Poisson process with an individual yet normally unknown intensity corresponding to the individual s accident proneness Modelling this intensity as a random variable naturally leads to a mixed model Usually an insurance company will have a good estimate of the associated mixing distribution due to its large portfolio of policies *Stochastic Processes for Insurance and Finance* Tomasz Rolski,Hanspeter Schmidli,V. Schmidt,Jozef L. Teugels,2009-09-25 Stochastic Processes for Insurance and Finance offers a thorough yet accessible reference for researchers and practitioners of insurance mathematics Building on recent and rapid developments in applied probability the authors describe in general terms models based on Markov processes martingales and various types of point processes Discussing frequently asked insurance questions the authors present a coherent overview of the subject and specifically address The principal concepts from insurance and finance Practical examples with real life data Numerical and algorithmic procedures essential for modern insurance practices Assuming competence in probability calculus this book will provide a fairly rigorous treatment of insurance risk theory recommended for researchers and students interested in applied probability as well as practitioners of actuarial sciences Wiley Series in Probability and Statistics *An Introduction to the Theory of Point Processes* Daryl J. Daley,David Vere-Jones,2013-03-14 Stochastic point processes are sets of randomly located points in time on the plane or in some general space This book provides a general introduction to the theory starting with simple examples and an historical overview and proceeding to the general theory It thoroughly covers recent work in a broad historical perspective in an attempt to provide a wider audience with insights into recent theoretical developments It contains numerous examples and exercises This book aims to bridge the gap between informal treatments concerned with

applications and highly abstract theoretical treatments   <u>Point Processes for Reliability Analysis</u> Ji Hwan Cha,Maxim Finkelstein,2018-01-17 Focusing on the theory and applications of point processes Point Processes for Reliability Analysis naturally combines classical results on the basic and advanced properties of point processes with recent theoretical findings of the authors It also presents numerous examples that illustrate how general results and approaches are applied to stochastic description of repairable systems and systems operating in a random environment modelled by shock processes The real life objects are operating in a changing random environment One of the ways to model an impact of this environment is via the external shocks occurring in accordance with some stochastic point processes The Poisson homogeneous and nonhomogeneous process the renewal process and their generalizations are considered as models for external shocks affecting an operating system At the same time these processes model the consecutive failure repair times of repairable engineering systems Perfect minimal and intermediate imperfect repairs are discussed in this respect Covering material previously available only in the journal literature Point Processes for Reliability Analysis provides a survey of recent developments in this area which will be invaluable to researchers and advanced students in reliability engineering and applied mathematics   **Reinsurance** Hansjörg Albrecher,Jan Beirlant,Jozef L. Teugels,2017-08-21 Reinsurance Actuarial and Statistical Aspects provides a survey of both the academic literature in the field as well as challenges appearing in reinsurance practice and puts the two in perspective The book is written for researchers with an interest in reinsurance problems for graduate students with a basic knowledge of probability and statistics as well as for reinsurance practitioners The focus of the book is on modelling together with the statistical challenges that go along with it The discussed statistical approaches are illustrated alongside six case studies of insurance loss data sets ranging from MTPL over fire to storm and flood loss data Some of the presented material also contains new results that have not yet been published in the research literature An extensive bibliography provides readers with links for further study   *Non-Life Insurance Mathematics* Thomas Mikosch,2006-11-21 Offers a mathematical introduction to non life insurance and at the same time to a multitude of applied stochastic processes It gives detailed discussions of the fundamental models for claim sizes claim arrivals the total claim amount and their probabilistic properties The reader gets to know how the underlying probabilistic structures allow one to determine premiums in a portfolio or in an individual policy Zentralblatt f r Didaktik der Mathematik   *Non-Life Insurance-Linked Securities: Risk and Pricing Analysis* Thomas Nowak,2014-09-25 Unter Insurance Linked Securities ILS versteht man innovative Finanzprodukte welche Versicherungsrisiken aus den eng abgegrenzten M rkten der Erst und R ckversicherungswirtschaft herausl sen und mittels Verbriefung auf Kapitalm rkten handelbar machen Durch ILS erhalten Investoren die M glichkeit f r die Bereitstellung von Deckungskapital in Versicherungsrisiken zu investieren und im Gegenzug eine Versicherungspr mie zu erhalten Hierbei verfolgt das Werk zwei Ziele Zum Einen die Durchf hrung einer genauen Analyse der zugrunde liegenden Zahlungsstr me der beworbenen Eigenschaften und jener Risiken welche mit einer

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those interested in learning how probability theory can be applied to the study of phenomena in fields such as engineering computer science management science the physical and social sciences and operations research Ideally this text would be used in a one year course in probability models or a one semester course in introductory probability theory or a course in elementary stochastic processes New to this Edition 65% new chapter material including coverage of finite capacity queues insurance risk models and Markov chains Contains compulsory material for new Exam 3 of the Society of Actuaries containing several sections in the new exams Updated data and a list of commonly used notations and equations a robust ancillary package including a ISM SSM and test bank Includes SPSS PASW Modeler and SAS JMP software packages which are widely used in the field Hallmark features Superior writing style Excellent exercises and examples covering the wide breadth of coverage of probability topics Real world applications in engineering science business and economics **Point Processes and Their Statistical Inference** Alan Karr,2017-09-06 First Published in 2017 Routledge is an imprint of Taylor Francis an Informa company **Stochastic Geometry and Its Applications** Sung Nok Chiu,Dietrich Stoyan,Wilfrid S. Kendall,Joseph Mecke,2013-06-27 An extensive update to a classic text Stochastic geometry and spatial statistics play a fundamental role in many modern branches of physics materials sciences engineering biology and environmental sciences They offer successful models for the description of random two and three dimensional micro and macro structures and statistical methods for their analysis The previous edition of this book has served as the key reference in its field for over 18 years and is regarded as the best treatment of the subject of stochastic geometry both as a subject with vital applications to spatial statistics and as a very interesting field of mathematics in its own right This edition Presents a wealth of models for spatial patterns and related statistical methods Provides a great survey of the modern theory of random tessellations including many new models that became tractable only in the last few years Includes new sections on random networks and random graphs to review the recent ever growing interest in these areas Provides an excellent introduction to theory and modelling of point processes which covers some very latest developments Illustrate the forefront theory of random sets with many applications Adds new results to the discussion of fibre and surface processes Offers an updated collection of useful stereological methods Includes 700 new references Is written in an accessible style enabling non mathematicians to benefit from this book Provides a companion website hosting information on recent developments in the field www wiley com go cskm Stochastic Geometry and its Applications is ideally suited for researchers in physics materials science biology and ecological sciences as well as mathematicians and statisticians It should also serve as a valuable introduction to the subject for students of mathematics and statistics **Mathematical Epidemiology** Fred Brauer,Pauline van den Driessche,J. Wu,2008-04-30 Based on lecture notes of two summer schools with a mixed audience from mathematical sciences epidemiology and public health this volume offers a comprehensive introduction to basic ideas and techniques in modeling infectious diseases for the comparison of strategies to plan for an anticipated epidemic or pandemic and to deal with a

disease outbreak in real time It covers detailed case studies for diseases including pandemic influenza West Nile virus and childhood diseases Models for other diseases including Severe Acute Respiratory Syndrome fox rabies and sexually transmitted infections are included as applications Its chapters are coherent and complementary independent units In order to accustom students to look at the current literature and to experience different perspectives no attempt has been made to achieve united writing style or unified notation Notes on some mathematical background calculus matrix algebra differential equations and probability have been prepared and may be downloaded at the web site of the Centre for Disease Modeling www cdm yorku ca

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