

*Current Titles and Abstracts from the*

*International Conference on*  
**Statistical  
Inference,  
Combinatorics &  
Related Areas**

**Fourth Conference of the Forum for Interdisciplinary Mathematics**

**Other Sponsors:** University of South Alabama, Mobile, AL, USA  
Council of Scientific and Industrial Research, INDIA  
Banaras Hindu University (BHU), Varanasi, INDIA

**December 18-21, 1997**

**To be held at The Banaras Hindu University, Varanasi, U.P. - 221005, INDIA**

## **Small Robust Response-Surface Designs for Quantitative and Qualitative Factors**

*M. L. Aggarwal\* , B. C. Gupta\*\* and Anita Bansal\**

*\*at University of Delhi, New Delhi, INDIA*

*\*\* at University of Southern Maine, Portland, Maine, USA.*

[bcgupta@maine.maine.edu](mailto:bcgupta@maine.maine.edu)

Draper and John (1988) give some specific response-surface designs for quantitative and qualitative factors. Wu and Ding (1991) give a systematic method for constructing robust response-surface designs for quantitative and qualitative factors using the small response-surface designs given by Draper and Lin (1990). We also apply dual response-surface optimization approach given by Lin and Tu (1995) for finding the optimal setting for a set of design variables involving qualitative and quantitative factors.

## **Transient Busy Period Analysis of $M^b/G/1$ Queues - Lattice Path Approach**

*Manju Agarwal and Kanwar Sen*

*University of Delhi, Delhi - 110007, INDIA*

In this paper we derive the busy period density of a non-Markovian batch-arrival single-server queue  $M^b/G/1$ . Lattice paths (LP) combinatorics analysis is used to obtain the results in explicit computational form. The service time distribution is approximated by 2-phase  $C^2$  Cox distribution that has a Markovian property amenable to LP combinatorics, distributions.  $C^2$  cover a wide class of distributions that have a square coefficient of variation lying in  $[1/2, \infty)$ . Therefore, the results obtained are applicable to a large class of real life situations.

## **Bayesian Estimation Of The Size of A Population Under A Sequential Sampling Design**

*Manzoor Ahamad and Yogendra P. Chaubey*

*Université du Québec à Montréal and Concordia University*

*Montréal, CANADA*

[chaubey@fisher.concordia.ca](mailto:chaubey@fisher.concordia.ca)

Ahmad *et al.* (1993, 1995) and Ahmad and Chaubey (1997) have considered some sequential designs in regard to finite population problems. Here we give a Bayesian extension to the problem of estimating the size of a population under a sequential design with a natural stopping rule. Highlighted among other things is the question of posterior

robustness with respect to variation in priors.

## **On the Configurational Modeling and Analysis of Coke Pushing Systems of Coke-Oven Area of Integrated Steel Plant**

*Indu Anand*

*PT. Ravishankar Shukla University, Raipur (M.P.), INDIA*

This paper deals with the stochastic modeling and analysis of a coke-pushing system of the coke and coal chemicals area of an integrated steel plant. In the integrated steel plant, the coke-oven area comprises several batteries, each of which consists of several coke-ovens. Generally a single battery has 65-67 coke ovens in which raw coal is charged to get rectified coke in return. The coke pushing system plays an important role in pushing the raked coal from the coke-oven. There are two types of maintenance performed in this system, scheduled maintenance and running maintenance. In addition to regular repair, emergent repair is also performed. Failure time distributions are taken to be negative exponential whereas repair and maintenance time distributions are taken to be arbitrary. Using regenerative point technique, several system characteristics that are useful to system managers and designers are evaluated. Graphs are provided which highlight the important results.

### **Selection of the Best Normal Population: A New Exact Solution, Asymptotically Optimal when $k = 2$**

*Makoto Aoshima\**, *Edward J. Dudewicz\*\** and *Hiroto Hyakutake\*\*\**

*\* at Tokyo Gakugei University, Tokyo 184, JAPAN*

*\*\* at Syracuse University, Syracuse, NY 13244, USA*

*\*\*\* at Kyushu University, Fukuoka 810, JAPAN*

[dudewicz@syr.edu](mailto:dudewicz@syr.edu)

*Key words and phrases: Asymptotic efficiency; correct selection; Monte Carlo simulation; two-stage procedure; optimal allocation.*

The problem that we deal with in this paper was first stated in 1954 in Bechhofer's pioneering paper in ranking and selection. Namely, there are  $k$  ( $\geq 2$ ) normal populations with all parameters unknown, and the goal is to select one population that has the largest mean. Despite much interest (and many failed attempts to solve this problem in the literature), the first solution came in a 1975 paper by Dudewicz and Dalal. A slightly

different solution followed in a 1978 paper by Rinott. While there has been other work on the problem, to date these are the only exact solutions (all other “solutions” are either heuristic or asymptotic only. It has been recognized for some time that the available exact solutions do not (asymptotically) allocate sample size in a way that corresponds to what is known to be optimal when the variances are known. In this paper we give a new, third, exact solution to the problem which is asymptotically optimal in the case when there are two populations. In an example on a real data set, we illustrate the procedure and see that it would save 7% of the sample size in that example (and asymptotically saves 6% in that example).

## **Generalized Useful Information Measure and Coding Theorems**

*Ram Avtar*

*National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi,  
110016, INDIA*

This paper presents a generalized useful measure for the incomplete power distribution. This measure is a generalization of the weighted entropy due to Belis and Guansu (1969), Shannon's (1949) entropy and entropy for  $\square$ -power distribution studied by Roy (1976). Appropriate theorems, generalizations and characterizations are presented.

## **Markov Sampling Scheme in the Presence of Linear Trend**

*G.K. Balasubramani*

*Manonmaniam Sundaranar University, Tirunelveli, Tami Nadu, 627012, INDIA*

The Markov sampling scheme is a new class of sampling design with a Markovian behavior that always provides distinct units for a fixed sample size (Chandra et al. (1992)). In this paper we make an elaborate study related to the performance of the Horvitz-Thompson estimator under the Markov sampling scheme using linear trend. The deterministic linear model of the Horvitz-Thompson estimator under a Markov sampling scheme has been compared with the usual expansion estimator based on systematic sampling and simple random sampling. Since the deterministic model is not realistic in practical situations we have considered the super population version of the linear model to assess the performance of the Horvitz-Thompson estimator. Empirical results are presented which reveal that this estimator performs better than the usual expansion estimator.

## **Some Aspects of Bayesian Inference in Discrete Distributions**

*Ashok K. Bansal*

*Department of Statistics, University of Delhi, Delhi, INDIA*

We shall discuss some problems concerning Bayesian prediction, structural change and posterior robustness for some classes of discrete distributions like GNBD, GLSD, and MPSD. There is not much literature in this area and the purpose of this talk would be to introduce the audience with a host of problems.

## **On Asymptotic Distribution for Two-Truncation Parameter Family**

*B.M. Bhatt and S.R. Patel*

*Sardar Patel University, Vallabh Vidya Nagar, 388120, INDIA*

In this paper we present some asymptotic theorems related to the two-truncation parameter family of distributions. Motivated by the problem of finding the variance of the unbiased estimator or MSE of the biased estimator we obtained in the more general case the asymptotic distribution of any differentiable function of the complete sufficient statistic. This result is useful for obtaining asymptotic variance/MSE for various estimators. A performance comparison is conducted of the Maximum Likelihood Estimator (MLE) and UMVU estimator in terms of asymptotic relative efficiency (AARE) and limiting risk.

## **An Early Death Model for Rayleigh Survival Data**

*Samir K Bhattacharya, Rajesh K. Gupta, N.K. Singh and Ram Lal*

In this paper, a Bayesian survival analysis is conducted based on ordered observations from the Rayleigh survival model wherein the first death occurs at a very early stage and is suspected to be an outlier. That is, we have ordered observations  $t_1 < t_2 < t_3 < \dots < t_d$  where the first death comes from a Rayleigh population with scale parameter  $\lambda/\lambda$  and the remaining  $n-d$  terms have a Rayleigh distribution with scale parameter  $\lambda$ . Bayes estimators of the hazard rate, the means survival time (MST) and the survival function are developed using the squared error loss function and suitable prior densities on the underlying parameter space.

## **Optimal Data Augmentation for the Estimation of a Linear Parametric Function in Linear Models**

*Dulal K. Bhaumik and Thomas Mathew*

*University of South Alabama, Mobile, Alabama 36688, USA*

*University of Maryland-Baltimore County, Baltimore, Maryland 21228, USA*

[Bhaumik@mathstat.usouthal.edu](mailto:Bhaumik@mathstat.usouthal.edu)

In the setup of a linear regression model, the problem of augmenting a given set of observations is investigated, when the inference problem is the estimation of a linear parametric function of the mean vector. The optimal selection of a fixed number of additional observations is studied. The optimal design matrix is constructed following the A, D and E-optimality criteria. The results are illustrated with an example.

## **On the Configurational Modeling and Analysis of a Door-Extractor System of Coke-Oven Area of Integrated Steel Plant**

*Rahul Bhave*

*Pt. Ravishankar Shukla University, Raipur (M.P.), INDIA*

This paper deals with the stochastic modeling and analysis of a door-extractor that plays an important role in the coke-oven area of a steel plant. In Integrated steel plant, the coke-oven area comprises several batteries each consisting of several coke-ovens. In each coke-oven raw coal is charged to get rectified coke in return. After charging the coal for about 16 hours the coke is pushed by a coke pusher machine into the door-extractor device. The red-hot coke is then shifted to a quenching car for its cooling process. Two types of maintenance, scheduled and running maintenance, are performed in this system. Failure

time distributions are taken to be negative exponential whereas repair and maintenance time distributions are taken to be arbitrary. Using a regenerative point technique, several system characteristics that are useful to system managers and designers are evaluated.

## **Comparative Study of Two Single-Unit Stochastic Models with Pre-Inspection and On-line Repair by Server on Contract Basis**

*S. Chander and S. Ahlawat*

*Department of Statistics, Maharshi Dayanand University, Rohtak, 124001, INDIA*

This paper studies two single-unit models with three possible modes of the unit - Normal (N), partial failure (P) and complete failure (F). There is a single server on contract basis who is called for on-line repair of the partial failure unit with allowed arrival time. This time will be negligible when a unit fails completely. In both models, the server first inspects the P-mode unit to ascertain whether its on-line repair is possible or not. If it is possible, it is alright, otherwise he repairs it in a down state. In model 1, the server does not take any rest during the on-line repair whereas in model 2, he goes under rest as needed during on-line repair. A comparison, including graphical displays, between these two models is done with respect to MTS and profit by the use of the regenerative point process.

## **A Range Test For The Equality of Means When Variances Are Unequal**

*Shun-Yi Chen and Hubert J. Chen*

*Department of Mathematics, Tamkang University, Tamsui, TAIWAN*

*Department of Statistics, University of Georgia, Athens, GA 30602, USA*

[syichen@stat.tku.edu.tw](mailto:syichen@stat.tku.edu.tw)

The level and the power of the usual F-test in analysis of variances are sensitive to unequal variances. In this paper, we present a range test using a two-stage sampling procedure for testing the hypothesis that the normal means are equal. Both the level and the power associated with the proposed test are controllable at desired values and are completely independent of the unknown variances. Tables needed for implementation are given.

## **FULLERENES AND OTHER BIFACED PLANAR GRAPHS**

*M. Deza*

*CNRS and Ecole Normale Supérieure, Paris, FRANCE*

[Michel.Deza@ens.fr](mailto:Michel.Deza@ens.fr)

We consider regular planar graphs which are bifaced, i.e. any face has either  $a$ , or  $b$  sides for  $7 > b > a$ . Those graphs are important in Chemistry; especially, the case  $a, b = 5, 6$  corresponding to 1 skeletons of fullerenes. We address the problem to identify among them: 1. Face-regular ones, i.e. such that edge-adjacency graph of all  $a$ -faces (or of all  $b$ -faces) is regular; 2. Embeddable ones, i.e. such that the skeleton is an isometric subgraph of a half- $n$ -cube, or (if both,  $a$  and  $b$ , are even) of a  $n$ -cube. An example of obtained results: The classification of all 7 (resp. 12) bifaced polyhedra, such that the graph of all  $a$ -faces (respectively of all  $b$ -faces) is a cycle.

## **Modeling The Economic Family for Social Policy Purposes**

*Marco Doudeijns*

*OECD, Social Policy Division, ELS, 2, rue Andre Pascal, F 75775 Paris Cedex 16, FRANCE*

The role of modeling taxes and benefits on the micro level is becoming increasingly more important in the policy development process in governments throughout the OECD area. One potentially important factor influencing labor market decisions, and ultimately shifting employment patterns, is explained by changes in the tax and benefit system. Marginal effective tax rates over an income continuum have been little studied to date. A new international tax-benefit model compiled by the OECD on a wide range of benefits and their interactions with the tax system enables us to study this issue in more depth, hence is the main purpose of this study.

## **An Almost Unbiased Estimator of Population Mean**

*Vyas Dubey*

*Pt. Ravishankar Shukla University, Raipur, INDIA*

Soivenkataramana (1980) and Bandopadhyay (1980) proposed a dual ratio estimator as an alternative to the usual ratio estimator. In this paper, an estimator is proposed which is almost unbiased and is more efficient than these estimators at smaller sample sizes. The proposed estimator is superior to the Reddy (1979) estimator. Results are supported by numerical illustration.

# **Disturbance Variance Estimation in Misspecified Regression Models using Stein-Rule Estimators**

*M. Dube*

*Department of Statistics, M.D. University, Rohtak, 124001, INDIA*

This article investigates the effect of using Stein-rule estimation instead of least squares on the disturbance variance estimation in misspecified regression models.

# **Robustness of Two Replicated Complete Diallel Cross Plan Against the Unavailability of One Block**

*D. K. Ghosh and Naimesh R. Desai*  
*Saurashtra University, Rajkot- 360 005, Gujrat, INDIA.*

Griffing (1956 a) classified the diallel crosses into four types, depending upon whether the parental inbreds or the reciprocal are included or not. Various methods of construction of complete diallel cross (CDC) plans have been discussed by Kempthorne (1957), Kempthorne and Curnow (1961) Hinkleman and Stren (1961), Curnow (1963), Fyfe and Gilbert (1963), Das and Sivaram (1968), Kaushik et. al. (1987), Agrawal and Das (1990), Ghosh et. Al. (1992m 19970, Divecha and Ghosh (1994)

Here we have considered a situation in which for some reason, let all the crosses in any one block of a two replicated CDC plan are lost when two replicated CDC plan have been obtained by crossing all the distinct treatments in each of the b blocks of a singular group divisible (SGD) design. Next we have developed a method for estimating the general combining ability (gca) effects of two replicated CDC plan of system IV against the unavailability of one block, while specific combining ability (sca) effects has been excluded from the model.

Since the loss of all crosses in a block produces the residual design with a serious loss of efficiency as compared with the original design. Hence the main purpose of this investigation is to evaluate the exact efficiency of residual design obtained by deletion of one block from two replicated CDC plan. Further, it is shown that the two replicated CDC plans are fairly robust against the unavailability of one block. This investigation is supported by an example and the list of robustness of two replicated CDC (obtained through SGD design) against the unavailability of one block along the parameters of singular divisible designs.

# **Semi Regular Group Divisible Design and its Robustness Against the Unavailability of Two Blocks**

*D. K. Ghosh and Dipa Gosai*  
*Saurashtra University, Rajkot-360 005, Gujrat, INDIA.*

Das and Kageyama (1992) discussed the robustness of BIBD using average efficiency against unavailability of (i) some of the treatments lost in a block and (ii) one block is lost. Further they also obtained that the augmented BIBD is fairly robust in terms of efficiency when  $s$  ( $k \geq s \geq 1$ ) observations in any one block of the design are lost. Recently, Mukherjee and Kageyama (1990) obtained the robustness of a group divisible design in terms of efficiency of residual design against the unavailability of a block. Ghosh and Gosai (1996) discussed the robustness of Singular Group Divisible design against the unavailability of two blocks.

The main aim in the present investigation is to obtain the robustness of Semi Regular Group Divisible design in terms of efficiency of residual design against the unavailability of the two blocks. The final investigation shows that 44 SRGD designs satisfy  $e > 0.90$ , 30 SRGD designs satisfy  $e > 0.85$ , and 11 SRGD designs satisfy  $e > 0.80$ . hence these 85 SRGD designs may be fairly robust concerning the loss of any two blocks.

## **Occam's Razor via Information Criterion**

*Arjun K. Gupta*  
*Bowling Green State University, Bowling Green, Ohio, USA*  
[gupta@bgnet.bgsu.edu](mailto:gupta@bgnet.bgsu.edu)

The testing and estimation of multiple covariance change points for a sequence of  $m$ -dimensional ( $m > 1$ ) Gaussian random vectors by using Schwarz information criterion (SIC) have been studied. We will estimate the number of change points as well as their locations. The consistency of the estimator is proved. The unbiased SIC is also obtained. Then asymptotic null distribution of the test statistic is derived. The result is applied to the weekly prices of Exxon and General Dynamics stocks ( $m = 2$ ) from 1990 to 1991, and changes are successfully detected.

## **Regression Analysis of Zero Adjusted Count Data**

*Pushpa L. Gupta*<sup>\*</sup>, *Ramesh C. Gupta*<sup>\*\*</sup> and *Ram C. Tripathi*<sup>@</sup>

*\* and \*\* at University of Maine, Orno, Maine, USA*

*and @ at University of Texas at San Antonio, Texas, USA*

[Tripathi@omkar.math.utsa.edu](mailto:Tripathi@omkar.math.utsa.edu)

In this paper a zero adjusted discrete model is developed. Such a situation arises when the proportion of zeros in the data is higher or lower than that predicted by the original model. The effect of such an adjustment is studied. The failure rates and the survival functions of the adjusted and non-adjusted models are compared. The relative error incurred by ignoring the adjustment is studied and it is shown that the relative error is a decreasing function of the count. An adjusted generalized Poisson distribution is studied and the three parameters of this model are estimated by the maximum likelihood method. Some examples are presented where it is shown that the adjusted generalized Poisson distribution fits the data very well. In many situations involving extra or fewer zeros, the counts are affected by some predictor variables. Score tests for the adjusted model are developed in the regression setting to analyze such data. These tests are helpful in selecting relevant predictors for the model. An example of the regression setting is also presented.

## **Invariant Properties of Some Classical Tests**

*Rameshwar D. Gupta*<sup>\*</sup> and *Donald St. P. Richard*<sup>\*\*</sup>

*\* at University of New Brunswick, Saint John, N.B., CANADA*

*\*\* at University of Virginia, Charlottesville, VA 22903, USA*

[rdg@UnbSJ.CA](mailto:rdg@UnbSJ.CA)

A number of classical statistical procedures are examined under the assumption that the data follow certain Liouville distributions. We show that the large number of these tests have the same distribution if the data follow certain multivariate Liouville distributions. These results highlight the role that the assumption of independence plays in the behavior of the classical test statistics. These results also applied to generalize some characterizations of the normal, exponential, gamma, inverse Gaussian and other distributions.

## **Estimating Fractionally Differenced ARIMA Models**

*Sat N. Gupta*

*University of Southern Maine, Portland, Maine USA*

*Email: [RXM381@USM.MAINE.EDU](mailto:RXM381@USM.MAINE.EDU)*

Fractionally differenced ARIMA models were introduced, independently, by Granger and Joyeux (1980) and Hosking (1981). Since then, many authors have contributed to the development of this topic. These include Geweke and Porter-Hudak (1983), Hosking (1984), Yajima (1985), Fox and Taquq (1986), Boes, davis and Gupta (1989), Vinod (1991), Beran (1994), and Robinson (1995). Statisticians, economists and hydrologists have applied these models to a variety of time series data that exhibit long memory. In this paper we review the early work in this field and present a new regression estimator for these models. A simulation study compares the performance of the proposed estimator with some of the existing estimators

## **Some Non-Additive Generalized Measures of 'Useful' Information and J-Divergence**

*D.S. Hooda*

*Haryana Agricultural University, Hisar-125004, INDIA*

In the present paper an axiomatic characterization of non-additive measures of 'useful' information associated with a pair of probability distributions of a sample space having utility distribution corresponding to the same number of elements in both probability distributions has been studied. The quantity so obtained under additional suitable postulates leads to the generalized measure of 'useful' relative information improvement and J-divergence. Properties of the measures so obtained have also been studied.

## **Visualization of the Classification of Multidimensional Data**

*Moon Yul Huh \*, Kyung Mi Lee\*\*, Kiyeol Kim\*\*, and Kyoung Chul Lim\*\*\**

*\* and \*\* @ Sungkyunkwan University, Seoul, \*\*\*@KEPCO, KOREA*

*[myhuh@yurim.skku.ac.kr](mailto:myhuh@yurim.skku.ac.kr)*

In this talk, we will present a dynamic graphics software we developed that selects an appropriate clustering method through visualization. The clustering methods considered in this work are hierarchical clustering, k-means and fuzzy methods. We consider seven linkage methods and five proximity measures. For the fuzzy clustering, we consider five different methods. For visualization, we consider dendrogram, FEDF scatterplot (Huh, 1995), constellation plot (Wakimoto, 1978) and parallel coordinate plot. Development tool for the software is XLISP-STAT, and the platform is Windows 95/NT.

## **On the Selection of $\alpha$ , the Level of a Test**

*B. K. Kale*

*UGC- Emeritus Fellow, University of Pune, Pune 411 007, Maharashtra, INDIA*

The well known Neyman-Pearson Lemma gives a constructive method of obtaining a most powerful (MP) test for testing a simple  $H_0$  against a simple  $H_1$  at any level  $\alpha \in (0,1)$ , although traditionally small values of  $\alpha$  are chosen in practice. There is no guideline as to how one chooses  $\alpha$ . In the first part of this paper we review the Fisherian approach to tests of significance which led to  $\alpha = 0.05, 0.01, \text{ or } 0.001$  as the standard values. Next, we show that choosing a particular value of  $\alpha$  in a given problem is equivalent to minimizing a weighted average of the two types errors. If these weights are interpreted as prior probabilities of hypotheses then choosing a specific value of  $\alpha$  is equivalent to obtaining a Bayes test. The third part of this paper considers the problems that can arise due to consistency of the MP-test of size  $\alpha$  if  $\alpha$  is chosen independently of  $(n, H_0, H_1)$ .

## **Characterizations of Distributions By Conditional Expectations of Order Statistics**

*A. H. Khan\* and A. M. Abouammoh\*\**

*\* at Aligarh Muslim University, Aligarh, UP, INDIA*

*\*\* at King Saud University, Riyadh, K.S.A.*

General forms of continuous probability distributions are characterized by considering conditional expectations of functions of order statistics when the conditioning is on any order statistics. This result generalizes that of Khan and Abu-Salih (Metron, 47(1989), 171-181), where the conditioning was on the adjacent order statistics.

## **Generalized Estimators for Population Mean in Presence of Nonresponse**

*B. B. Khare\* and S. Srivastava\*\**

*\* at Banaras Hindu University, Varanasi, U.P. 221005, INDIA*

*\*\* at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Satna, MP, INDIA*

Two generalised estimators for population mean in presence of nonresponse have been proposed and their properties have been studied under the fixed population and the superpopulation approach. Under the fixed population approach, specific conditions have been obtained for preferring the use of generalised estimators in comparison to other relevant estimators. Under the superpopulation approach, the proposed estimators have been found to be equally efficient to the corresponding regression estimators.

## **An Application of Multiple Imputation to Adjust for Nonresponse in a National Health Survey**

*Meena Khare*

*National Center for Health Statistics,  
Centers for Disease Control and Prevention*

6525 Belcrest Road, #1000, Hyattsville, MD 20782, U.S.A.

[mxk1@cdc.gov](mailto:mxk1@cdc.gov)

*Keywords: NHANES, complex surveys, missing data*

Missing data due to unit and item nonresponse are a major problem in sample surveys. Historically, weighting adjustment methods are used to adjust for unit nonresponse and single imputation for item nonresponse. Multiple imputation, originally proposed by Rubin (1977), replaces two or more times missing data due to unit and item nonresponse, simultaneously. National Health and Nutrition Examination Surveys (NHANES) are the most important probability based national surveys for collecting nutritional and health-related data on the civilian noninstitutionalized population of the United States. In NHANES, approximately 10% of the sampled persons refuse to be interviewed and 25% refuse to be examined. These high rates of unit nonresponse, when combined with residual item nonresponse, lead to rather high rates of missingness on key survey variables.

This paper presents findings from a project to statistically adjust for nonresponse in NHANES III(1988-1994) using the technique of multiple imputation (Rubin 1987, Schafer 1997). Selected measurements on 12,392 adults from the NHANES III were multiply imputed five times for both, unit and item nonresponse, using techniques of iterative Bayesian simulation via Markov chains. Exploratory analysis of the imputed values suggests that both the marginal distributions of the survey variables, and important relationships between the variables, were accurately reflected. This is the first successful implementation of multiple imputation methodology to a large complex national survey.

# **A New Method for Comparing Experiments and Measuring Information**

*Patty Kitchin*

*VPI and State university, Blacksburg, VA 24061, USA*

[Pkitchin@vt.edu](mailto:Pkitchin@vt.edu)

A new method for comparing experiments and measuring information is introduced. No assumptions are made and no conditions are required in order for this new method to measure the amount of information contained in almost any statistic. Several properties of this new method are discussed and a new characterization of sufficiency based on this new method is presented. The new method is used to evaluate the expected efficiency of a statistic in discriminating between any two values of the parameter as compared to a sufficient statistic. This new method can be self-calibrated to give this expected efficiency a meaningful scale. It is shown that this new method has advantages over existing methods of measuring information. Several card-counting statistics (in Blackjack) are compared by the amount of information each provides in discriminating between different deck compositions as compared to a sufficient statistic. This new method provides new insight about information in card-counting statistics by putting this information on a meaningful scale.

## **Estimation of Bivariate Mean Residual Life Function**

*Mrs. H. V. Kulkarni and R. N. Rattihalli*

*Shivaji University, Kolhapur, Maharashtra, 416004, INDIA*

An estimator for the bivariate mean residual life function is suggested. It is shown that (i) the bias of the estimator tends to zero exponentially, (ii) the estimator is uniformly strongly consistent over every bounded rectangular subset of the support of the distribution, and (iii) the asymptotic distribution of the estimator evaluated at the finite number of points in the support of the distribution are multivariate normal.

# Unbiased Estimation of Quantile of a Selected Exponential Population

*Somesh Kumar and Aditi Kar*

*Indian Institute of Technology, Kharagpur, West Bengal- 721302, INDIA*

Suppose we have independent random samples from two exponential populations with common location  $\mu$  and scale parameters  $\lambda_1$  and  $\lambda_2$  respectively. We select the population corresponding to the larger sample mean. The problem is to estimate a quantile of the selected population. We show nonexistence of linear unbiased estimators and construct an unbiased estimator using (U-V) method of Robbins. Further, Rao-Blackwellization is used to obtain the uniformly minimum variance unbiased estimator.

## An Algorithm to Bayesian Clustering Rule

*S. Kunte\* and A. Loganathan\*\**

*\* at University of Pune, Pune, Maharashtra 411007, INDIA*

*\*\* at Manonmaniam Sundarnar University, Tirunelveli, Tamil Nadu 627 012, INDIA*

*Keywords: Bayesian decision theory; cluster analysis; similarity matrix; optimal partition*

In recent years, cluster analysis has received much attention among researchers. Binder (1978, 1981) has discussed the cluster analysis problem with Bayesian approach. In his 1981 article, he has given an approximation procedure which is a 'hill-climbing' approach to obtain the optimal partition. In this paper, for the same problem, an algorithm is proposed to obtain the optimal partition for a given similarity matrix, in which the agglomerative and relocation techniques are employed. Numerical studies are carried out applying the proposed algorithm for a given similarity matrix.

## Some Graphs associated with the Seven Point plane

*E. Keith Lloyd*

*University of Southampton, Southampton, SO17 1BJ, UNITED KINGDOM*

[ekl@soton.ac.uk](mailto:ekl@soton.ac.uk)

Let  $F$  denote the Fano (Seven Point) Plane and let  $G$  be a fixed subgroup of the automorphism group of  $F$ . The vertices of  $F$  may be labelled  $0, 1, 2, 3, 4, 5, 6$  in  $5040/|G|$  different ways if two labellings are regarded as equivalent whenever one can be obtained from the other by applying an element of  $G$ . A graph can be constructed the vertices of which correspond to the distinct labellings and an edge joins vertex  $u$  to vertex  $v$  if the labelling corresponding to  $u$  can be obtained from the labelling corresponding to  $v$

by applying a permutation of a fixed type. Certain choices of G and of the permutation type lead to interesting graphs.

## **Maximum Likelihood Estimation for Longitudinal Data with Truncated Observations**

*Kishan G. Mehrotra, P. M. Kulkarni, R.C.Tripathi, and J. E. Michalek*  
*Syracuse University, Syracuse, NY, 13224, USA,*

*University of South Alabama, Mobile, AL 36688, USA*

*University of Texas at San Antonio, San Antonio, TX 78249, USA*

*Epidemiologic Research Division, Armstrong Laboratory, Brooks AFB, TX 78235, USA*

[Kulkarni@mathstat.usouthal.edu](mailto:Kulkarni@mathstat.usouthal.edu)

We obtain maximum likelihood estimates of the parameters when the observations of the response variable in a repeated measures design are truncated above a cut point. The maximum likelihood equations are solved iteratively using an EM-like procedure. It is observed that these estimates have smaller mean squared error than recently proposed iterative weighted least-squares estimates. The results are applied to data arising from a study of dioxin elimination in Air Force veterans.

## **ML and REML Estimation of Matusita's Measure for Two Bivariate Normal Distributions with Missing Observations**

*Mihoko Minami<sup>\*</sup>, Kunio Shimizu<sup>\*</sup> and Satya N. Mishra<sup>\*\*</sup>*

*<sup>\*</sup> at Department of Applied Mathematics, Science University of Tokyo*

*1-3 Kagurazaka, Shinjuku-ku, Tokyo 162, JAPAN*

*e-mail: [mminami@rs.kagu.sut.ac.jp](mailto:mminami@rs.kagu.sut.ac.jp) and [shimizu1@rs.kagu.sut.ac.jp](mailto:shimizu1@rs.kagu.sut.ac.jp)*

*<sup>\*\*</sup> at University of South Alabama, Mobile, AL 36688, U.S.A.*

[shimizu1@rs.kagu.sut.ac.jp](mailto:shimizu1@rs.kagu.sut.ac.jp)

We discuss the problem of estimating Matusita's measure of overlap and similarity when the underlying distributions are bivariate normal. Lu, Smith and Good (1989) studied bias of the maximum likelihood (ML) estimate of the measure by simulation for complete samples. Each sample, however, may include missing observations under some situations.

We assume the data structure that some observations on either of the variables are missing. As for the estimation methods of dispersion parameters, ML and REstricted or REsidual

Maximum Likelihood (REML) estimates are discussed. The restricted likelihood for the observed data is equal to the restricted likelihood when the missing values are filled in

with zeros. We study bias and mean squared error of the ML and REML estimates of Matusita's measure under some kinds of assumption on the variances and correlation coefficients. Simulation results are given to illustrate characteristics of the estimates.

## **Parameter Estimation For Fitting Generalized Beta Distributions**

*Satya N. Mishra and Mark Carpenter*  
*Department of Mathematics and Statistics, University of South Alabama,*  
*Mobile, AL 36688-USA*  
[Dmc@mathstat.usouthal.edu](mailto:Dmc@mathstat.usouthal.edu)

*Keywords: method of moments; generalized gamma; mixtures; MLE.*

Like the generalized lambda distribution, the four-parameter generalized beta distribution (Types I and II) provides an extremely flexible family of distributions that is useful for fitting distributions to data and/or density approximation. The generalized beta distribution has as special cases many common distributions such as the generalized gamma, Weibull and log-normal. Traditional methods typically involve the use of method-of-moments to set up a system of equations involving the sample moments and the unknown parameters. The unknown parameters of the beta distribution are then estimated by numerically solving the system of equations. In this paper, we apply this method, among others, to several five-parameter beta distributions where the fifth parameter represents location. We exploit the fact that a GB2 density can be represented as a scale mixture of generalized gammas where the mixing distribution is an inverse generalized gamma.

## **Compound Beta Distribution in Survival Analysis**

*R.N. Mishra and J.K. Sinha*  
*Patna University, Patna, Bihar, INDIA*

Number of accidents and survival after fatalities have evoked great interest as coverage as exponentially grown from road accidents to the various industrial as well as social shocks and the capability of the system to function normally. Poisson-Poisson and Poisson-binomial models have been suggested to express the relationship between the number of accidents and the number of fatalities and a further suggestion is the application of Poisson-negative binomial models to study the distribution of injury accidents. Sinha and Mishra (1997) suggested the application of generalized Poisson-beta model to study injury accidents over a period of time. The generalized Poisson-beta model converges to the confluent series distributions and the study of survival during an interval becomes troublesome. This paper investigates some characteristics of the generalized Poisson-beta model, basically a compound beta distribution, that concerns survival of the fatalities.



## **On Orthogonality of Latin Squares**

*Ratnakaram Nuv Mohan  
Estrada Dona Castorina, BRASIL*

It was in 1782, Euler invented and studied Latin squares and his famous conjecture states that, "No pair of Orthogonal Latin squares of order  $n$  can exist when  $n \equiv 2 \pmod{4}$ ". This was disproved for larger  $n$  by Bose, Shrikhande and Parker (1959-60). But Tarry (1900) confirmed the conjecture for  $n = 6$  stating that there exists no orthogonal mate for  $n=6$ . Horton (1974) defined, "Almost Orthogonal," and gave the construction of two Almost Orthogonal Latin squares of order 6. But there is one aspect remained untouched so far and I wish to address that invoking a Graph Theoretic approach along with an application in a network system.

## **On the Estimators of Measures of Location of the Lognormal Distribution**

*T. S. K. Moothathu  
University of Kerala, Trivandrum, Kerala 695 581, INDIA*

Here we derive the uniformly minimum variance unbiased (best) estimators of the mean, median (=geometric mean), mode and harmonic mean of the lognormal distribution in the cases when one of the parameters alone is unknown and when both the parameters are known. A novelty here is "the expansion and substitution method" of deriving the best estimators. The variance of the best estimators are also derived. Certain best estimators are in terms of the Bessel function  ${}_0F_1$  and their variances are in terms of the Humbert function  $\Psi_1$ .

## **Multivariate Control Chart for Variability when the Shift in Variability is Common**

*M. V. Muddapur  
Karnatak University, Dharwad, Karnatak, INDIA.*

Multivariate control chart for process variability is based on either approximate chi-square distribution or the distribution of generalized variance. In this paper a multivariate control chart for the process variability when the shift in the variability is common has been derived. These results are based on exact chi-square distribution. Numerical comparison between the existing multivariate control charts and the suggested one here has been done.

## **Conditional Tests for the Parameters in the Mixture of a Degenerate and a Weibull Distribution**

*K. Muralidharan*

*Bhavnagar University, Bhavnagar, Gujrat, INDIA*

In practice, many times it happens that when we put units in a life testing experiment, then some of the units fail instantaneously and thereafter the life time of units follow a distribution such as Weibull. Similarly, in clinical trials it happens that initially a drug have no response with probability  $q \in (0, 1)$ , but once there is a response, length of response follow an exponential, Weibull or uniform distribution. The distribution function  $F(x)$  of this mixture distribution for mixing proportion  $p$  is given by

$$F(x) = 1 - p \cdot \exp(-x^\alpha/\beta), \quad x \geq 0, \beta > 0, \alpha > 0, p \in (0, 1].$$

Gaver and Lewis (1980), Andel (1988), Jayade and Prasad (1990), Adke and Balkrishna (1992) etc have considered the above distribution for  $\alpha = 1$  in connection with first order exponential auto regressive process. Dahiya and Kleyle (1975) have studied the estimation problems for this distribution. In this paper we propose conditional tests for the shape parameter (when  $p$  is known or unknown) and for the scale parameter.

## **Sequential Estimation in Two-Truncation Parameter Family of Distributions**

*A. Nanthakumar*

*University of Tennessee at Martin, Martin, TN 38238, USA*

[nkumar@utm.edu](mailto:nkumar@utm.edu)

For the two-truncation parameter family of distributions, the density is of the form  $f(x) = q(\theta_1, \theta_2)h(x)$ , where  $\theta_1$  and  $\theta_2$  are the truncation parameters. We propose a sequential method to estimate  $q(\theta_1, \theta_2)$  under the assumption that the functional form of  $q(\cdot, \cdot)$  is known. We discuss an application of the estimate of  $q(\cdot, \cdot)$  in estimating a reliability measure within the stress-strength framework.

## **APPLICATION OF INTERACTIVE OPTIMIZATION METHODOLOGY FOR AIRCRAFT REPAIR TIME ANALYSIS**

*S. Narayanan\*, Nicole L. Schneider\*, Hitesh Nandha\*, Chetan Patel\*\*, Todd M. Carrico\*\*\* and John DiPasquale\*\*\*\**

*\* at Wright State University, Dayton, Ohio, USA*

*\*\* at Internet Computing Group, Hewlett-Packard Corp, Santa Clara, California, USA*

*\*\*\* at Defense Advanced Research Projects Agency, Joint Logistics Technology Suite,  
Arlington, Virginia, USA*

*\*\*\*\* at USAF Armstrong Laboratory, Human Resources Directorate, Logistics  
Research Division, Wright-Patterson AFB, Ohio, USA*

[snarayan@cs.wright.edu](mailto:snarayan@cs.wright.edu)

In the domain of Air Force logistics, models are useful to determine an efficient mix of logistics resources including spare parts, personnel, support equipment, and facilities to achieve a desired sortie rate. Due to the complexity of the domain and qualitative nature of secondary objectives, problems such as aircraft repair time analysis are not amenable to purely prescriptive modeling methods such as math programming. Interactive optimization techniques, which integrate human interaction with evolutionary learning methods are useful analytical methods for generating satisfactory solutions to complex, dynamic design and planning problems in airbase logistics. The focus of this presentation is on the development and application of interactive optimization techniques to aircraft repair time analysis.

First, we describe the aircraft repair time analysis problem and outline the motivations of developing interactive optimization techniques in solving the problem. Second, we describe components of our methodology including a solution explorer and an interactive analyzer. We then discuss a computational architecture implemented using the Java programming language to support our methodology. We conclude with an overview of the results of the application of our architecture to a prototypical problem in repair time analysis.

*\* This research is sponsored by the Air Force Office of Scientific Research, Bolling AFB, D.C.*

## **Type II Censoring with Linex Loss Function under Exponential Distribution**

*B. N. Pandey and C. S. Mishra*

*Banaras Hindu University, Varanasi, UP, 221005, INDIA*

[Bnpandey@banaras.ernet.in](mailto:Bnpandey@banaras.ernet.in)

The estimators for the mean and the variance of an exponential distribution under type II censoring procedure with linex loss function has been obtained. The pooled and preliminary testimators with their properties have been studied. The proposed estimators have certain practical utilities if specified ranges of parameters are under consideration.

## **Generators and Facets for the Polyhedra of Directed Distances**

*Panteleeva E.I.*

The notion of directed distances, quasi-metrics and oriented multi-cuts is the generation of the notion of distances, metrics and cuts, which are well-known and central objects in graph theory, combinatorial optimization and, more generally, discrete mathematics.

Let  $d$  is a mapping  $X \times X$  to  $\mathbb{R}$ , such that for all  $x, y$  and  $z$  from  $X$

- (1)  $d(x, y) \geq 0$ ,
- (2)  $d(x, x) = 0$ ,
- (3)  $d(x, z) + d(z, y) \geq d(x, y)$ .

Such a mapping is called quasisemi-metric. If the inequality (1) is strong for unequal  $x$  and  $y$ ,  $d$  is called quasi-metric. If for every pair  $x$  and  $y$

- (4)  $d(x, y) = d(y, x)$ ,

$d$  is called semi-metric and metric accordingly.

For example, the length of the shortest path in strong graph  $D$  is a metric, and the length of the shortest path in strong directed graph  $D'$  is a quasi-metric. Let  $(S_1, \dots, S_t)$  is a partition of  $X = \{1, \dots, n\}$  and  $d'(S_1, \dots, S_t)$  is the mapping  $X \times X$  to  $\mathbb{R}$ , such that for all  $x, y$  from  $X$

$$d'(x, y) = \begin{cases} 1, & \text{if } x \text{ belong } S_i, y \text{ belong } S_j, i < j, \\ 0, & \text{otherwise.} \end{cases}$$

Such a mapping is called oriented  $t$ -multi-cut or  $t$ -a-cut. 2-a-cut is called a-cut. Obviously,  $d'(S_1, \dots, S_t)$  defines a quasisemi-metric on  $n$  points  $\{1, \dots, n\}$ . Define by  $AMET_n$  the cone of all quasisemi-metrics on  $n$  points.  $AMET_n$  is a full-dimensional cone, generated by  $n(n-1)(n-2)$  inequalities (1) and  $n(n-1)$  inequalities (3). Define by  $AMCUT_n$  the cone of all a-multi-cuts on  $n$  points.  $AMCUT_n$  is a full-dimensional cone, too.

We consider  $AMET_n$  and  $AMCUT_n$  for  $n=3,4,5$  with the use some combinatorial aspects. So, the number of non-zero a-multi-cuts on  $n$  points is  $p(n)-1$ , where  $p(n)$  is the number of all oriented partitions of  $n$ , and  $p(n) = 0,5A_n(2)$ , where  $A_n(x)$  is Euler's polynomial. The number of non-zero a-multi-cuts for  $n=3,4,5,6,7, 8$  is 12,74,540,4682, 41337 accordingly.

## On a Makeham's Survival Function

*I. D. Patel*

*Gujrat University, Ahmedabad, Gujrat, INDIA*

Given a force of mortality function  $u(t) = \lambda + \lambda \exp(-\lambda t)$ , the Makeham's survival function can be given by  $1 - F(t) = \exp[-\lambda t - (\lambda/2)\{\exp(\lambda t) - 1\}]$ ,  $t \geq 0$ . This provides a good fit to observed mortality in the situation where Gompertz survival function fails. Some of the statistical properties of the Makeham's survival function are investigated. The parameters are estimated by ML method on the basis of Cohort life data. A method of grouping with the computer aid is applied to carry out the comparisons.

## **Estimation of Parameters of Mixed Exponential Failure Time Distributions from Progressively Censored Samples and Progressively Grouped Censored Samples with Changing Failure Rates**

*M. N. Patel*

*Gujrat University, Ahmedabad, Gujrat 380 009, INDIA*

*Key Words: Estimation; mixed failure time; progressive censoring, failure rates.*

Mandenhall and Hader (1958) considered the estimation of parameters of mixed exponentially distributed failure time distribution from censored life test data. We have considered the problem by taking progressive censoring with changing failure rate at each stage of censoring using time censored samples. The estimators of the parameters are obtained by the method of maximum likelihood in case of progressively censored samples and progressively grouped censored samples. A numerical example is given to illustrate the estimation procedure.

## **Comments about Statistical Test of Significance in Management Research**

Dharam S. Rana  
Jackson State University, Jackson, MS 39217  
[dsrana@ccaix.jsums.edu](mailto:dsrana@ccaix.jsums.edu)

Statistical test of significance is widely used in behavioral and social sciences. There has been some controversy regarding validity of the significance test. In spite of controversy, test of significance is used extensively in quantitative management research. Traditional Statisticians defend the significance test and the theoretical mathematicians question the mathematical justification of the test. Some mathematicians claim that many scholars are aware of the fact that the statistical test of significance is based on unscientific research design and invalid mathematical justification. But the management research establishment does not allow a debate on the issue, and thus obstructs a scientific approach to quantitative research. This paper examines a variety of arguments given for and against statistical significance testing.

## **s- and (m,s)-Optimality of Minimal Complete Block Designs and Their Improvements**

*M. B. Rao and Theo O. Ogunyemi*  
*Oakland University, Rochester, MI 48309, USA*  
[ogunyemi@oakland.edu](mailto:ogunyemi@oakland.edu)

We determine s- and (m, s)-optimal block designs in the class of all minimal incomplete block designs under the mixed effects model, using the method of majorization. Furthermore, since these designs do not have degrees of freedom for error, we propose a method of extending them.

## **Ratio of Means or Mean of Ratios or Both?**

*T. J. Rao*

*Indian Statistical Institute, Calcutta-35, INDIA*

Consider a finite population of units ( $U_1, U_2, \dots, U_N$ ). On each unit  $U_i$ , variance of interest  $y$  and  $x$  are defined taking values  $Y_i$  and  $X_i$  respectively,  $i = 1, 2, \dots, N$ . In certain surveys, it is of interest to estimate the population ratio  $R = X/Y$  (or equivalently  $\bar{X}/\bar{Y}$ ), where  $Y$  is the population total corresponding to  $Y$ -variate, and  $X$  is that corresponding to  $X$ -variate., based on a sample of size  $n$  selected according to a sampling design  $p(s)$ . Under simple random sampling scheme, the usual choices for the estimate of  $R$  are, (i)  $R_1$  = ratio of sample means and (ii)  $R_n$  = mean of the  $n$  ratios ( $y_i/x_i$ ). It is well known that  $R_1$  and  $R_n$  are biased for  $R$ . We shall first discuss the role of  $R_1$  and  $R_n$  in the construction of unbiased ratio estimators, using the amount of bias in these estimators. When  $y$  is considered as the study variate and  $x$  is a known auxiliary variate related to  $y$ , the problem of estimation of the population mean  $\bar{Y}$  or the population total  $Y$  follows by the usual estimators.

For the estimation of the population total  $Y$ , we shall next consider a class of Symmetrized Des Raj (SDR) strategies and look for the choice of a model-optimum estimator when design-unbiasedness is not demanded. To improve efficiency, ratio method of estimation is often used along with stratification of the population into homogeneous strata. This leads to a 'separate ratio estimator' and a 'combined ratio estimator' in stratification. However, these are biased. We shall propose a method of combining them to form an unbiased estimator for the population total.

## **A Class of Probability Distributions Characterized Through Paired Comparison Models**

*Dilip Roy*

*Department of Business Administration, Burdwan University, Burdwan, INDIA*

*Keywords and phrases: Life distribution, order statistics, rate of attainment, orderings.*

We examine the paired comparison model and obtain a class of probability distributions for which the ratio of intrinsic worths of two products remains unaltered irrespective of the lower time truncation point applied to items of both products. The class of distributions so obtained has been shown to have many 'nice' properties both from the reliability point of view and paired comparison point of view. We also present a

characterization result using its within class properties.

## Characterization of Mixtures of Pareto Distributions

*S. Sathananthan*

*Tennessee State University, Nashville, TN 37203, USA*

[satha@coe.tnstate.edu](mailto:satha@coe.tnstate.edu)

A Characterization result is presented for Pareto distribution via conditional moments. A necessary and sufficient condition is given to characterize a mixture of several Pareto distributions. To illustrate our obtained results, we use an example from actuarial science.

## Construction of A Family of Regular Partial Difference Sets

*Surinder Sehgal*

*The Ohio State University, Columbus, Ohio 43210, USA*

**Definition:** Let  $G$  be a finite group of order  $v$ . A subset  $D$  of  $G$  of cardinality  $k$  is said to be partial difference set (denoted from now on as P.D.S.) with parameter  $(v, k, \lambda, \mu)$  if the list of differences  $\{d, d^{-1} / d, d \in D\}$  covers each non identity element of  $D$   $\lambda$  times and each identity element of  $G \setminus D$  exactly  $\mu$  times. If identity does not belong to  $D$  then  $D$  is called a regular P.D.S. It is well known that a regular P.D.S. is equivalent to a strongly regular Cayley graph. Alternatively,  $D$  is a regular P.D.S. iff it satisfies the following identity.

$$D * D^{-1} = (k - \lambda) e_G + (\lambda - \mu) (D) + \mu (G)$$

In this talk we will show constructions of new P.D.S. in abelian  $p$  groups of arbitrary rank.

## Some Combinatorial Problems in Parallel Processing

*Ishwar Singh*

*T.I.F.R. Mumbai, INDIA*

Parallel processing interconnections based on hypercubes are used often. Some problems related to fault tolerance in such structures will be discussed. A bound on maximum number of faults allowed so that at least one good partition of subcubes exists will be discussed.

## **Some New Aspects of PPS Sampling**

*T. Srivenkataramna*  
*Banglore University, Banglore, INDIA*

This paper discusses the concept of the extended designs in survey sampling and it examines its utility for resolving some bottle-necks in unequal probability sampling. It also examines the use of qualitative auxiliaries in PPS sampling and discusses from specific schemes based on ranked data.

## **Estimation in the Presence of an Outlier**

*K. Selvavel*  
*Claflin College, Orangeburg, South Carolina 29115, USA*  
[selvavel@claf1.claflin.edu](mailto:selvavel@claf1.claflin.edu)

A variety of outlier models have been the subject of discussion in the literature. In this study we consider an estimation problem in the presence of an outlier. More specifically we derive UMVU estimators of the parameters from truncation parameter families when the outlier has a distribution that is different from the population distribution.

## **On Estimating the Current Intensity of Failure for the Power Law Process**

*Ananda Sen and Ravindra Khattree*  
*Department of Mathematical Sciences, Oakland University, Rochester, MI 48309, USA*  
[khattree@argo.acs.oakland.edu](mailto:khattree@argo.acs.oakland.edu)

We consider the problem of estimating the current failure intensity for the power law (Weibull) process. Closed form optimum estimates under the criteria of minimum risks as well as Pitman-closeness are derived for the failure truncated case. A unique Pitman-closest estimator, which is also invariant of the choice of the loss function within a very wide class of loss functions, is obtained. No admissible estimates under these criteria are available for the time truncated scheme due to the lack of any pivotal quantity. We present a Bayesian approach, which circumvents this problem and

provides a uniform solution. The theoretical findings are supplemented by substantial numerical investigation.

## **A Test for Exponentiality Against Increasing Failure Rate of Age Lag $t_0$ Alternative**

*Kanwar Sen and Preeti Wanti Srivastava*  
*University of Delhi, delhi-110007, INDIA*

It is common in reliability theory to categorize life distributions according to monotonicity properties of the failure rate, the average failure rate and the mean residual life. Among the well known classes of life distributions is increasing failure rate (IFR) class and its dual decreasing failure rate (DFR) class. The IFR (DFR) property is characteristic of devices that consistently deteriorate (improve) with age.

Many physical phenomena do not meet the IFR property for the item's whole life span, even though they still have IFR during subinterval of the life span and probably with different rates of increase in every subinterval. On the other hand, an item's performance might deteriorate at certain age, say  $t_0$  and continue throughout the remainder of the life time. This motivated Al-oosh and Alzaid (1989) to introduce increasing failure rate of age at lag  $t_0$  (IFR- $t_0$ ) class of time distributions. The IFR- $t_0$  class has the property that the failure rate at age  $x + t_0$  is greater than or equal to reduce the that at age  $x$  for  $x \geq 0$  and a fixed  $t_0 > 0$ . This class of life distributions is of importance in maintenance policies which are followed to reduce the incidence of system failure or return a failed system to the operating state.

In this paper we propose a testing procedure for  $H_0$ : Constant failure rate (i.e., exponentiality) versus  $H_1$ : IFR -  $\{t_0\}$ , but not constant failure rate. The test statistic devised for the purpose is U-statistic and hence asymptotically normally distributed. Pitman's asymptotic relative efficiency comparisons of the test developed have also been made.

## **Bioenvironment and Public Health: Statistical Perspectives**

*Pranab Kumar Sen*  
*University of North Carolina at Chapel Hill, NC 27599-7400, USA*  
[Pksen@bios.unc.edu](mailto:Pksen@bios.unc.edu)

Our bioenvironment constitutes the totality of entities of all socio-economic, cultural-political, clinical and biomedical, ecological and environmental (health and hazard) perspectives that pertain to the existence and propagation of all biosystems on earth, including of course, the human beings. Public awareness of such bioenvironmental impacts on human health and quality of life (QOL) has been an important ingredient in the constitution and development of the public health science and practice discipline. A

challenging task is to protect our bioenvironment and improve our QOL as well. The critical role of (bio-)statistics in this context is appraised, and fundamental methodological aspects are discussed.

## **Testing Using Hypothesis-Dependent Variance Estimates**

*Arvind K. Shah\* and K. Krishnamoorthy\*\**

*\* at University of South Alabama, Mobile, AL 36688 U.S.A.*

*\*\* at University of Southwestern Louisiana, Lafayette, LA 70504 U.S.A.*

[shah@mathstat.usouthal.edu](mailto:shah@mathstat.usouthal.edu)

Some of the commonly used tests on means and proportions are studied where the usual hypothesis-independent variance estimates are replaced with the corresponding hypothesis-dependent variance estimates. It is demonstrated that this approach does not always lead to tests that are equivalent to their corresponding traditional tests.

# **Pitman Closeness Comparison of Least Squares and Stein Rule Estimators in Linear regression Models with Non-normal Disturbances**

*Shalabh*

*University of Jammu, Jammu-180 004, INDIA.*

*Keywords and phrases: Asymptotic approximation, non-normal, Pitman closeness, regression, Stein-rule.*

Employing the large sample asymptotic theory, an asymptotic approximation for the Pitman closeness probability is derived and a comparison of the least squares and Stein-rule estimators is made when the aim is to estimate the coefficients in a linear regression model with not necessarily normal disturbances.

## **Distribution-free Tests for Location-scale Problem**

*I.D. Shetty\* and Parameshwar V. Pandit\*\**

*\* at Karnatak University, Dharwad-580 003, Karnataka, INDIA*

*\*\* at Karnatak College, Dharwad-580 001, Karnataka, INDIA*

The location-scale family in the normal theory setup presents problems regarding inference about the location-scale parameter  $\mu$  as it does not belong to a regular exponential family. In this paper we present two nonparametric procedures for the location-scale parameter  $\mu$  in a general setup. A particular solution for the functional equation arising in this problem is also obtained.

## **On Improved Randomized Response Strategy**

*Housila P. Singh\*, Rajesh Singh\*\* and Sushil Shukla\**

*\*at Vikram University, Ujjain, M.P., INDIA and*

*\*\* at Prestige Institute of Management, Mandsour, M. P., INDIA*

In this paper we have suggested a modification over Mangat (1994) randomized response strategy for estimating human population possessing a sensitive characteristic using inverse sampling. An unbiased estimator is suggested with its variance formula. Several upper bounds of the variance formula have been suggested which are sufficiently accurate. Numerical illustrations have also been given.

## On Inverse Binomial Randomized Response Technique

*Housila P. Singh\*, Rajesh Singh\*\* and Sushil Shukla\**

*\*at Vikram University, Ujjain, M.P., INDIA and*

*\*\* at Prestige Institute of Management, Mandsour, M. P., INDIA*

Examples of non-response in sample surveys are in abundance. To solve this problem, during last three decades a number of efforts with varying degrees of success have been made in the literature. Warner (1965) was first to introduce to a technique called randomized response technique. For estimating  $\pi$ , the proportion population possessing a sensitive attribute, Warner (1965) suggested an unbiased estimator of  $\pi = [(n_1/n) - 1 + p] / (2p - 1)$ , ( $p < 0.5$ ), where  $p$  is the proportion of the sensitive character represented in the randomized response device and  $n_1$  is the number of 'yes' answers obtained from the  $n$  respondents selected by simple random sampling with replacement (SRSWR).

In practice it may happen that the value of  $\pi = [p\pi + (1-p)(1-\pi)]$  is very small. In such situations,  $n_1$  may take 'zero' value for not so-large values of  $n$  and thus the estimate so obtained may depend entirely upon  $p$  which is not desirable. The frequency of the estimate of  $\pi$  taking inadmissible values outside  $[0, 1]$  is also increased in such cases. To overcome such problems, Mangat and Singh (1991) advocated the use of an inverse binomial randomized response (IBRR) procedure and obtained the variance of the estimate of  $\pi$ . They have also obtained two upper bounds for this estimate of the variance with the help of Sathe's (1977) result. In this paper using results of Mikulski and Smith (1976), Prasad and Sahai (1982), Sahai (1983), Ray and Sahai (1984), and Pathak and Sathe (1984), we have suggested a number of upper bounds of the variance of the estimate of  $\pi$  obtained under IBRR procedure and compared with Mangat and Singh's (1991) upper bounds. It also has been shown that some of the proposed upper bounds are sufficiently accurate and serve the purpose even for small  $n_1$ .

## **Sequential Estimation of the Mean of Normal Population with Known Coefficient of Variation**

*Ramkaran Singh*

*Lucknow University, Lucknow, UP, INDIA*

In many situations, the coefficient of variation is known although the mean and variance may not be known. This additional information could be incorporated to improve upon the conventional estimators of the parameters. Given a random sample from the normal distribution  $N(\mu, \sigma^2)$  whose coefficient of variation  $\rho = \sigma/\mu$  is known, the estimator of the mean  $\mu$  could be developed whose risk under the squared error loss function is smaller than that of the sample mean. Utilizing the knowledge of coefficient of variation, the present paper proposes a stopping rule for sequential estimation of the parameter  $\mu$ . The observations are taken one by one and after stopping, the fixed size sample estimator developed with known coefficient of variation is used for estimating  $\mu$ . It has been shown that the proposed sequential procedure terminates with probability one. It has also been shown that the procedure is asymptotically risk efficient. The simulation investigation reveal that the estimated ASN and risk of the procedure are quite close to the corresponding optimal values (that is, the value when  $\rho$  is known) even for the small samples.

## **On Hierarchical Bayesian Analysis**

*Randhir Singh*

*Ewing Christian College, Allahabad, UP, INDIA.*

This paper deals with hierarchical Bayesian approach to reliability estimation for the exponential distribution with an unknown parameter  $\lambda$ . One of the important features of the exponential distribution is that it represents the life time distribution of many electronic components and complex mechanisms. We have assumed as in Epstein and Sobel (1953) that  $n$  units from a population, having exponential distribution are placed on a life test and the experiment is continued till  $r$  failures are observed, for some preassigned  $r$  (also known as Type II Censoring).

Let the life time of a component be a random variable  $X$ . For the specified mission time 't' let  $R(t|\lambda)$  denote the reliability function. In this paper hierarchical Bayes estimator of  $R(t|\lambda)$  have been obtained under the assumption of three types of loss functions. The prior and the hyperprior distributions have been taken from two different families of distributions, unlike Bhattacharya and Tiwari (1992) where the prior and the hyperprior are from the same family. The estimates obtained have been compared with MLE and the Bayesian estimate obtained under the assumption of natural conjugate prior density for  $t$  and various types of loss functions.



## **On the Configurational Modeling and Analysis of a Tippler-Conveyor System of Coke-Oven Area of Integrated Steel Plant**

*S. K. Singh*

*Pt. Ravishankar Shukla University, Raipur, M.P., INDIA*

*Keywords: Mean time to system failure, availability, busy period of the repairman, regeneration point, expected profit earned by the system.*

This paper deals with the stochastic modeling and analysis of a Tippler conveyor system of coke and coal chemicals area of integrated steel plants. In integrated steel plant, coke-oven area comprises of several batteries and these batteries are consisting of several coke-ovens. Generally, a single battery is having 65-67 coke-ovens, in which raw coal is charged to get rectified coke in return. The Tippler-Conveyor system is the starting point of the coke-oven area. Coal is unloaded here with the help of tipplers from wagons. Three tipplers with two conveyor belts each in standby configuration are present in this area. Scheduled maintenance is performed for each of the subsystem. Besides, regular repair, emergent repair is also performed. Failure time distribution of tipplers and conveyor belt is taken to be a negative exponential. Also, repair time distribution of conveyor belt is taken to be an exponentially distributed, whereas scheduled maintenance time distributions are taken to be arbitrary. Using the regenerative point technique, several system characteristics which are useful to the managers and designers are evaluated. Finally, graphical techniques are used to highlight the important results.

## **On Some Properties of the Modified Generalized Gamma Distribution**

*Shobh Nath Singh*

*University of Transkei, Umtata, SOUTH AFRICA*

[SINGH@getafix.utr.ac.za](mailto:SINGH@getafix.utr.ac.za)

Statistical distributions like the Gamma, Weibull, exponential have many applications in reliability and diffraction theory. These distributions are reasonable models for the life distribution of a device. Agarwal and Kalla (1996) considered a new generalization of the Gamma distribution which generates family of Gamma distributions. Properties such as skewness, kurtosis and general moments of this model are studied in this paper.

## **Some Combinatorial Problems in Parallel Processing.**

*N. Singhi*

*Tata Institute of Fundamental Research, Mumbai, INDIA*

[SINGHI@tifrvax.tifr.res.in](mailto:SINGHI@tifrvax.tifr.res.in)

Parallel processing interconnections based on hypercubes are used often. Some problems related to fault tolerance in such structure will be discussed. A bound on maximum number of faults allowed so that at least one good partition of subcubes exists will be discussed.

## **A New Pooling Procedure for Exponential Life Model**

*Rakesh Srivastava and Zoola S. Kapasi*  
*Saurashtra University, Rajkot, Gujrat, INDIA*

Having two censored samples, it is advantageous to pool the two samples for estimating the scale parameter (mean life). In practice when there are two samples available and it is uncertain whether these two samples come from the same distribution the question to pool these two samples is usually determined via a preliminary test. The present paper proposes a conditional guess testimator of the scale parameter (mean life) when it is suspected that  $\theta_1 \geq \theta_2$  and an additional information about  $\theta_1$  is available in the form of a point guess value  $\theta_1^0$ . Expressions for bias, mean square error and relative efficiency of the proposed testimator fairs better than the 'neverpool' estimator in certain range of life ratio and shrinkage factor. Recommendations regarding its use have been suggested.

## **Efficiency of Constrained Estimator**

*R. Tiwari*  
*University of Jammu, Jammu, INDIA.*

For the estimation of coefficients of an identified structural equation of a complete system in the presence of linear constraints, Nagar and Kawani (1965) derived the estimators based on two stage least squares (2SLS) method by employing the mixed and constrained estimation techniques. Specifying full information model, Theil (1979, pp. 515-524) obtained similar estimators in the context of three stage least squares (3SLS) method. This article compares the variance-covariance matrices of constrained and mixed estimators and examines the consequences of introducing variability in the constraints.

## **Two-Sample Test Procedures With Censored Data**

*Ram C. Tiwari*  
*University of North Carolina at Charlotte, USA*  
[fma00rct@unccvm.uncc.edu](mailto:fma00rct@unccvm.uncc.edu)

In this paper a control percentile test, a chi-squared test, and a Kolmogorov type test are

proposed for comparing two distributions from incomplete survival data. The test procedures are derived under very general conditions which hold for the well known random censorship and random truncation models and have applications in diverse field such as signal detection theory, psychology, epidemiology, and medicine. The performances of the proposed tests are studied using Monte Carlo simulation. The methods are applied to analyze the Mayo ovarian carcinoma data.

# Efficiency Properties of Weighted Mixed Regression Estimation Procedure

*H. Toutenburg\* and V. K. Srivastava\*\**

*\* at Institut für Statistik, University Munchen, Munchen, GERMANY*

*\*\* at Lucknow University, Lucknow, UP, INDIA*

This paper considers the estimation of coefficient vector in a linear regression model subject to a set of stochastic linear restrictions binding the regression coefficients and presents the method of weighted mixed regression estimation which permits to assign possibly unequal weightage to prior information in relation to sample information. Efficiency properties of this estimation procedure are analyzed when disturbances are not necessarily normally distributed.

## Procedure for the Selection of CSP-M One-Level Skip-Lot Sampling Inspection Plans with Single Sampling Plan as the Reference Plan with Acceptance Number Zero

*R. Vijayaraghavan*

*Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, INDIA*

Carr ( JQT, Volume 14, pp. 105-116, 1982) has proposed a new type of skip-lot designated as CSP-MSkSP which is similar to the multi-level continuous sampling plan CSP-M. The operating procedure of this plan

Is as follows:

1. Start with normal inspection using the reference plan.
2. When  $i$  consecutive lots are accepted on normal inspection, switch to skipping inspection (i.e., inspect only a fraction,  $f$  of the lot). When a lot is rejected, proceed as in Step 3.
3. Inspect next four lots only. If all the four lots are accepted proceed as in Step 4. If one or more lots are rejected, go to Step 1.
4. Inspect only a fraction,  $f$  of the lots at random. If a lot is rejected, go to Step 1. If ( $i-4$ ) Lots are accepted, go to Step 2.

This paper is concerned with the design of CSP-MSkSP plans with single sampling plan as the reference plan having the acceptance number 0 which is advantageous for situation involving costly or destructive testing. A search procedure has been developed for the determination of plan parameters when two points on the Operating Characteristic curve are specified, the two points being  $(p_1, \square)$  and  $(p_2, \square)$  where  $p_1$  is the producer's

quality level,  $\alpha$  is the producer's risk,  $p_2$  is the consumer's quality and  $\beta$  is the consumer's risk.

## **Exact Confidence Intervals in the Analysis of Saturated and Supersaturated Factorial Designs**

*Dan Voss, Weizhen Wang, and Kimberly Kinateder*  
*Wright State University, Dayton, Ohio 45435, U.S.A.*  
[dvoss@desire.wright.edu](mailto:dvoss@desire.wright.edu)

Given  $m$  independent, normally distributed, unbiased estimators of treatment contrasts and an independent chi-squared estimator of the variance, best simultaneous confidence intervals for the treatment contrasts are based on the Studentized maximum modulus distribution. We discuss analogous methods for the analysis of saturated and supersaturated designs, under the assumption of effect sparsity. Lacking an independent estimator of the variance, a quasi mean squared error is constructed for each treatment contrast from the other treatment contrast estimates or sums of squares. Given an orthogonal saturated design, individual and simultaneous exact confidence intervals can be established for the independently estimated treatment contrasts via a stochastic ordering lemma and a conditional probability argument, respectively. The same stochastic ordering lemma can be used to establish exact individual confidence intervals for treatment contrasts in supersaturated designs, even though such designs are necessarily not orthogonal. The methodology involves projections to orthogonality of estimates. The best known result still requires an undesirable arbitrariness with respect to how the projections are taken. The latest results will be presented, and open problems will be posed.

## **Geometry of Classical Groups over Finite Fields and Its Applications**

*Zhe-xian Wan*  
*Chinese Academy of Sciences, Geijing, CHINA*  
*and*  
*Lund University, Lund, SWEDEN*

This is a survey talk on the geometry of classical groups over finite fields and its applications, old and new. The contents of the paper are as follows: 1. The germ of our study, 2. The problems we are interested in, 3. The history of problems, 4. Recent results, 5. Application to association schemes and designs, 6. Application to

authentication codes, 7. Application to projective codes, 8. Application to lattices generated by orbits of subspaces, 9. Application to representations of forms by forms, 10, concluding remarks.

## **Abstract Alphabet Source Coding Theorem Revisited**

*En-hui Yang<sup>\*</sup> and Zhen Zhang<sup>\*\*</sup>*

*\* University of Waterloo, Ontario CANADA, e-mail: [ehyang@bbcr.uwaterloo.ca](mailto:ehyang@bbcr.uwaterloo.ca)*

*\*\*University of Southern California, Los Angeles, CA 90089, USA,*

[zzhang@milly.usc.edu](mailto:zzhang@milly.usc.edu)

The abstract alphabet source coding theorem is revisited. For coding at a fixed rate level, it is shown that for any fixed rate  $R > 0$  and any memoryless abstract alphabet source  $P$  satisfying some mild conditions, there exists a sequence  $\{C_n\}$  of block codes at the rate  $R$  such that the distortion redundancy of  $C_n$  (defined as the difference between the performance of  $C_n$  and the distortion rate function  $d(P, R)$  of  $P$ ) is upper bounded. For coding at the fixed distortion level, it is demonstrated that for every  $d > 0$  and any memoryless abstract alphabet source  $P$  satisfying some mild conditions, there exists a sequence  $\{C_n\}$  of block codes at the fixed distortion  $d$  such that the rate redundancy  $C_n$  (defined as the difference between the performance of  $C_n$  and the rate distortion function  $R(P, d)$  of  $P$ ) is upper bounded. These results strengthen the traditional Berger's abstract alphabet source coding theorem, and extend the positive redundancy results of Zhang, Yang and Wei on lossy source coding with finite alphabets and the redundancy result of Wyner on block coding memoryless Gaussian sources.