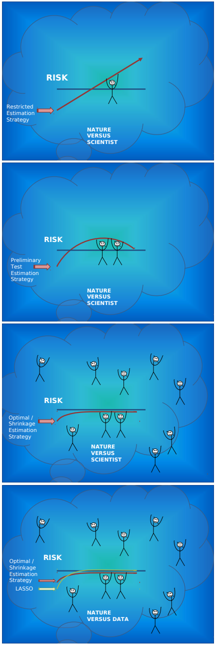
S. Ejaz Ahmed

High Dimensional Data Analysis, Shrinkage Estimation, Asymptotic Theory and applications, Statistical Quality Control, Biostatistics.

My area of expertise includes statistical inference, high dimensional data analysis Shrinkage estimation, statistical quality control, and asymptotic theory and its application. The high dimensional data analysis is a hot topic for the statistical research due to continued rapid advancement of modern technology that is allowing scientists to collect data of increasingly unprecedented size and complexity. Examples include epigenomic data, genomic data, proteomic data, high-resolution image data, high frequency financial data, functional and longitudinal data, and network data, among others. Simultaneous variable selection and estimation is one of the key statistical problems in analyzing such complex data. This joint variable selection and estimation problem is one of the most actively researched topics in the current statistical literature. More recently, regularization, or penalized, methods are becoming increasingly popular and many new developments have been established. The shrinkage estimation strategy is playing in important role in this arena.
Currently, I am working on the following problems including:

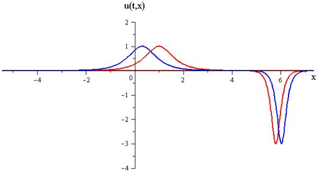
- Shrinkage Estimation for High Dimensional Data Analysis
- Difference Based Shrinkage Analysis in High Dimensional Partially Linear Regression
- Improved Estimation Strategies in Generalized Linear Models
- Shrinkage Estimation and Variable Selection in Multiple Regression Models with Random Coefficient Autoregressive Errors.

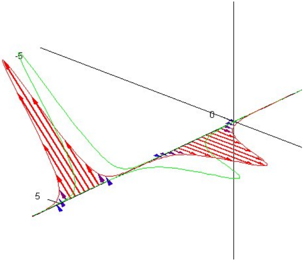


Honey, I Shrunk My Classical Estimators! A CanPak Production ©2009

Stephen Anco

Nonlinear differential equations, integrability and solitons, mathematical physics and analysis.





My research lies in several areas of nonlinear differential equations, integrability and solitons, mathematical physics and analysis. Some problems I am currently working on include:

- new exact solutions of radial nonlinear Schrodinger equations and wave equations in n dimensions
- "hidden" conservation laws of fluid flow equations and related potential systems,
- integrable group-invariant soliton equations and their derivation from curve flows in geometric manifolds,
- symmetry and conservation law structure of wave maps and Schrodinger maps,
- symmetries and conservation laws in curved spacetime for Maxwell's electromagnetic field equations, gravity wave equations, and other fundamental physical field equations,
- exact monopole, plane wave, Witten-ansatz solutions in a nonlinear generalization of Yang-Mills/wave map equations,
- novel nonlinear generalizations (deformations) of Yang-Mills equations for gauge fields, and Einstein's equations for gravitational fields

In addition I am coauthoring two books with G. Bluman in the area of symmetry methods and differential equations, in the Applied Mathematical Sciences series of Springer-Verlag. The first book provides an introduction to symmetry methods for both ordinary and partial differential equations, as well as a comprehensive treatment of first integral methods for ordinary differential equations. The second book will cover conservation laws (local and nonlocal) and potential systems for partial differential equations, and Bluman's nonclassical method of finding exact solutions. I also have an active interest in symbolic computation using Maple and some of my research in symmetry and conservation law analysis makes use of this software and involves development of algorithmic computational methods.

Nonlinear Analysis

$$\mathrm{PE} = \Big\{ (p, (y_j)_{j\in J}) \in S \times \prod_{j\in J} \partial Y_j : p \in \bigcap_{j\in J} \Phi_j(p, (y_j)_{j\in J}) \Big\},$$

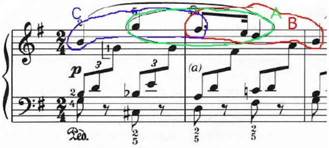
$$\mathrm{APE} = \Big\{ (p, (y_j)_{j\in J}) \in \mathrm{PE}\colon \sum_{j\in J} y_j \in -\sum_{i\in I} e_i + \sum_{i\in I} X_i + \mathbb{R}^L_+ \Big\},$$

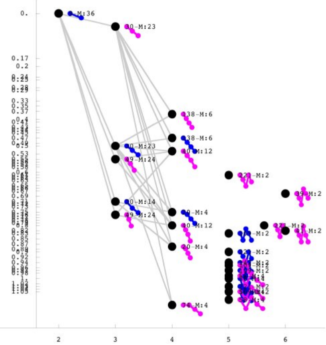
$$\tilde{\alpha} = \sup_X \inf_Y \tilde{g}(x, y) \geq \min_Y \sup_X \tilde{f}(x, y) = \tilde{\beta}.$$

My research interests are in topological methods in nonlinear analysis with focus on set-valued analysis and its applications to fixed point theory, mathematical economics, game theory and optimization. I am particularly interested in the solvability of nonlinear inclusions where classical hypotheses of convexity fail. Methods include a blend of topology, functional analysis, and nonsmooth analysis.

Chantal Buteau

Mathematical music theory. Mathematics education.





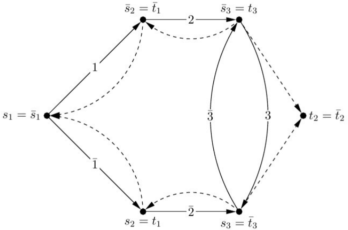
My research field is the Mathematical Music Theory. I am particularly interested in modeling motivic (melodic) structure and analysis of musical compositions through a topological approach. The motivic analysis of a music composition consists of identifying the short melody, called a motif, that unites the composition through its strict repetitions, the so-called imitations, and its variations and transformations which are heard throughout the whole composition. Mainly using group theory, linear algebra and general topology concepts, we construct a (T_0-) topological structure corresponding to the motivic hierarchy of a composition. Our program (JAVA) Melos can analyse music compositions such as Schumanns Dreamery from Kinderszenen My ongoing interdisciplinary research mainly concerns:

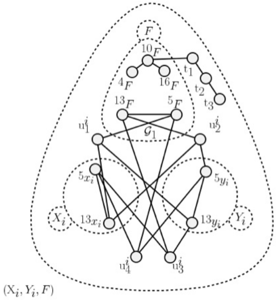
- Concrete applications to a music corpus;
- A categorical extension of our model including e.g. continuous functions between 2 motivic spaces, products of different spaces, natural transformations (gestalt spaces);
- Visualisation of Melos multiple outputs in order to show and hear, and to explore mathematics and music results.

Regarding mathematics education Im interested in developing tools using music for the exploration of mathematics concepts.

Large-scale Networks, Algorithmic Game Theory, Graph Colourings, Probabilistic Method

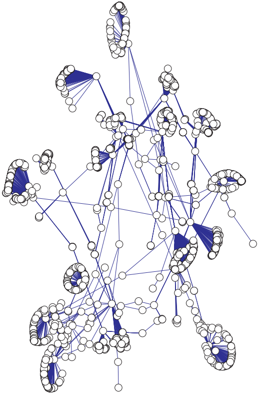
One aspect of my research will focus on the analysis of large-scale networks. This work includes a precise topological analysis and proposing generative mechanisms. Such mechanisms have potential to help us reason, at a general level, about the ways in which real-world networks are organized. A closely related line of research is the study of statistical aspects of graphs and the probabilistic treatment of random graphs - graphs that are generated by some random process. Determining the typical properties of a lift, such as their chromatic number, and how they reflect the properties of the base graph are very important and is another aspect of my research. I also intend to work on some of the classically more important problems in algorithmic graph theory and graph colouring, a traditionally important area of graph theory for computer scientists.





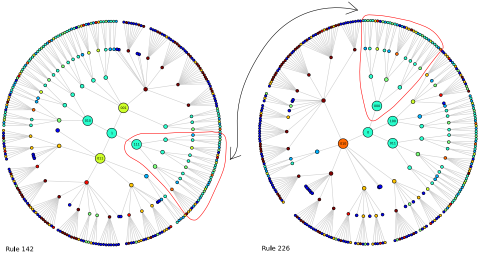
Henryk Fukś

Spatially-extended discrete dynamical systems. Cellular automata. Complex networks.

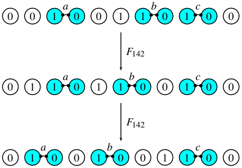


My research interests fall into three main cathegories:

- Theory: "Solving" of cellular automata (CA). Additive invariants in CA. Phase transitions in discrete dynamics. Discrete models of computation. Maximal entropy approximation. Orbits of Bernoulli measures in CA.
- Modeling: Growth of complex networks. Models of granular and traffic flow. Models of language acquisition. Complex graphs as models of vocabulary of human languages. Discrete models of diffusion and spread.
- Software: Agent-based simulations of complex systems. Efficient algorithms for simulation of cellular automata and lattice gases.



Rule 142   Rule 226



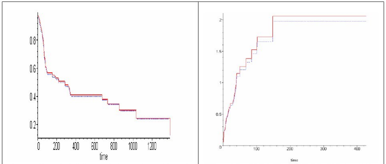
Mei Ling Huang

Statistical inference. Computing and simulation methods in statistics.

My research interests are in exploration of new efficient, optimal methods of statistical inference for distribution function, quantile and regression, and development of computing and simulation methods with applications to survival analysis, network and stochastic models. I am working on the following topics.

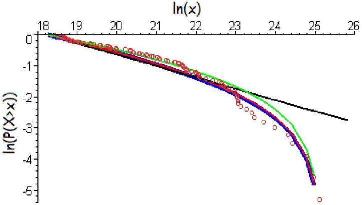
- Nonparametric distribution, quantile and regression estimation and testing are important research directions with many applications. I have been studying several methods in this field. Study weighted empirical distribution function to develop more efficient estimation and testing methods. For example, explore more efficient non-kernel quantile estimation methods. Study properties of these estimators and tests: consistency, rate of convergence, efficiencies. Computational methods and simulation methods also are developing. Develop new prediction methods for stochastic processes. For example, use sample path of martingales and Markov processes. Apply these methods to economics, quality control, queueing networks, insurance and biostatistics.
- Studies of truncated and censored data have important applications in biostatistics, industrial engineering and other fields. The topics are: Search efficient estimation methods for truncated data of types of heavy tail distribution for example, simulating and estimating waiting time of using Internet or other stochastic models by using Pareto distribution. Develop efficient estimation methods in survival analysis and its applications. For example, predicting recovery times of cancer patients, estimating the value at risk of stocks.

Patients with Heart Transplant



Kaplan-Meier (RED) and Weighted Kaplan-Meier (BLUE) Estimators

Nelson-Aalen (BLUE) and Weighted Nelson-Aalen (RED) Estimators.



Algebraic Number Theory, Elliptic Curves, Diophantine Equations. Permutation polynomials over Finite Fields and Galois Theory.

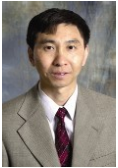
a_1	a_2	a_3	a_4	$F(x)$
0	0	1	0	$x^4-2x^3+5x^2-4x+4$
0	0	1	1	$x^4-2x^3+11x^2+4x+4$
0	1	1	0	$x^4-2x^3+x^2+14$
0	1	1	1	$x^4-2x^3+3x^2+40x+50$
1	0	1	0	$x^4-6x^3+17x^2-24x+16$
1	0	1	1	$x^4-6x^3+23x^2-28x+14$
1	1	1	0	$x^4-6x^3+13x^2-12x+18$
1	1	1	1	$x^4-6x^3+15x^2+24x+16$

My research lies in finite field functions and their applications to coding theory and cryptography; existence of primitive polynomials over finite fields; exponential sums over finite fields.

$$N_p(n+1) \geq \frac{1}{n+1}\sum_{d\,|\,n+1} p^{(n+1)/d} \geq \frac{1}{n+1}(p^{n+1}-p^{(n+1)/2}-\cdots-p)$$
$$= \frac{1}{n+1}\left(p^{n+1}-\frac{p^{(n+1)/2+1}-p}{p-1}\right) > \frac{1}{n+1}(p^{n+1}-p^{(n+3)/2}).$$

$$\Phi^{(1,1)}(m,n) = \sum_{d|n}\mu(d)\left(2^{\lfloor\frac{m}{d}\rfloor}-1\right) = \sum_{d|n}\mu(d)2^{\lfloor\frac{m}{d}\rfloor} = \Phi([1,m],n)$$

$$\Phi_k^{(1,1)}(n) = \sum_{d|n}\mu(d)\binom{\lfloor\frac{m}{d}\rfloor}{k} = \Phi_k([1,m],n).$$



Groups, rings and group rings. Combinatorial number theory.

$$\begin{aligned}
C_1^2 &= 12 + 5C_1 + C_2 + 3C_3,\\
C_1C_2 &= C_1 + C_2 + 3C_3 + 4C_4,\\
C_1C_3 &= 5C_1 + 5C_2 + 3C_3 + 4C_4,\\
C_1C_4 &= 5C_2 + 3C_3 + 4C_4,\\
C_2^2 &= 12 + C_1 + 5C_2 + 3C_3,\\
C_2C_3 &= 5C_1 + 5C_2 + 3C_3 + 4C_4,\\
C_2C_4 &= 5C_1 + 3C_3 + 4C_4,\\
C_3^2 &= 20 + 5C_1 + 5C_2 + 7C_3 + 8C_4,\\
C_3C_4 &= 5C_1 + 5C_2 + 6C_3 + 4C_4,\\
C_4^2 &= 15 + 5C_1 + 5C_2 + 3C_3 + 2C_4.
\end{aligned}$$

My research interest is in the areas of groups, rings, group rings and combinatorial number theory. The group ring of a group G over a commutative ring K is the ring KG of all formal finite sums: $\alpha = \sum a_g g$, and is an attractive object of study. Here group theory, ring theory, commutative algebra and number theory come together in a fruitful way, and moreover the study of group rings has important applications in coding theory. My recent research work has thrown light on structures of group rings and their unit groups. I am also interested in studying homological properties of modules and rings. In addition, I investigate the interplay between rings and their graphs (such as zero-divisor and annihilating ideal graphs). A few years ago, I started a new exciting research initiative and extended my research interest into the additive number theory by investigating a few combinatorial problems (e.g. zero-sum problems) in that filed. Some of my on-going research projects are listed below:

$$u = (1+g+g^2)^{2(p-1)} + \frac{1-3^{2(p-1)}}{4p}\widehat{g}$$

$$(1+g^{2p+1}+g^2)^{2(p-1)} = (1+g+g^2)^{2(p-1)},$$

$$(1+g^{2p+1}+g^2)^{2(p-1)} = (1+g+g^2)^{2(p-1)}g^{2p},$$

- Zassenhaus conjectures and related problems.
- The normalizer problem and Coleman automorphisms.
- Generators of large subgroups of (central) unit groups of group rings.
- Index of a sequence of a finite cyclic group.
- The Erdős-Ginzburg-Ziv Theorem and its improvment.
- Morphic groups and related problems.
- Zero-divisor (annihilating ideal) graphs of (group) rings.
- Morphic and reversible group rings.
- Combinatorial problems in group theory and ring theory.
- Injectivity of modules and related topics.

Mathematical Physics.

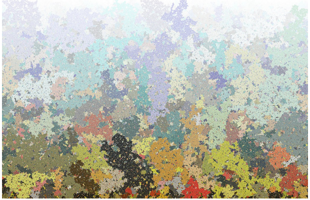
My main research interests are in Mathematical Physics in the sense of Mathematics inspired by ideas that come from Theoretical Physics. More precisely, I am interested in: algebraic and geometric structures which come from quantum field theory, statistical mechanics and the theory of integrable systems.

$$
\begin{aligned}
&\varphi_\alpha(z_{1,1},\ldots,z_{p_h,h},t_1,\ldots,t_h)\\
&= \prod_{\substack{j\neq i,\,1\le j\le h,\\ 1\le\beta\le p_j,\,0\le\delta\le -a_{ji}-1}} \left(\theta(z_{\alpha,i}-z_{\beta,j}-t_i+t_j-((\delta_i,\delta_j)+(\delta_i,\delta_i)+\delta(\delta_j,\delta_j))\tau)\,e^{-\pi i(z_{\alpha,i}-z_{\beta,j}-t_i+t_j)}\right)\\
&\quad\times \prod_{\substack{1\le\beta\le p_i,\\ \beta\neq\alpha}} \frac{e^{2\pi i(z_{\alpha,i}-z_{\beta,i})}}{\theta(z_{\alpha,i}-z_{\beta,i}-(\delta_i,\delta_i)\tau)\,\theta(z_{\alpha,i}-z_{\beta,i})}\,\varphi(z'_{\alpha,i},t'_1,\ldots,t'_h),
\end{aligned}
$$

$$
z'_{\alpha,i}=z_{\alpha,i}-\frac{1}{\sum\limits_{1\le j\le h} a_{ji}p_j-n_i}\left(\sum_{\substack{1\le j\le h,\\ 1\le\beta\le p_j}} a_{ji}z_{\beta,j}+\sum_{1\le j\le h} a_{ji}p_j(t_i-t_j)\right),
$$

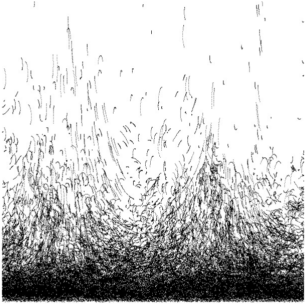
$$
t'_j=t_j-\frac{1}{\sum\limits_{1\le k\le h} a_{kj}p_k-n_j}\left(\sum_{\substack{1\le k\le h,\\ 1\le\beta\le p_k}} a_{kj}z_{\beta,k}+\sum_{1\le k\le h} a_{kj}p_k(t_j-t_k)\right),
$$

Statistics for Metric Spaces, Financial Mathematics, Visualization of Dynamical Systems

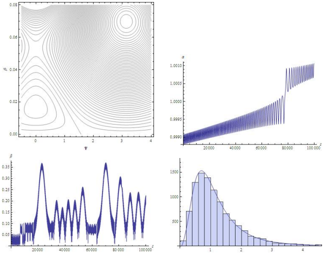


The investigation of many important processes in science and mathematics often yields data in the form of a set of points in a metric space. In order to study such data, I have developed a sequence of scale invariant numbers $\rho_1, \rho_2, \ldots$ called slide statistics that can be computed for any finite set U in a metric space. When U is taken to be a larger and larger sample of a random variable X, the values of $\rho_n(U)$ often approach intriguing limiting values $\rho_n(X)$. For example, ρ_1 appears to converge to the reciprocal of the Hausdorff dimension for many standard fractals. My current work concerns the analysis of financial data using ρ_2 which turns out to be positive for most financial indexes such as the S&P 500 but is negative for most standard distributions.

$$\psi_2(f_D) = -\Big(\sum_{i=1}^{n-1} \big(i\log(i)\log(d_{i+1}/d_i)(2S_1 - n\log(d_i d_{i+1}))\big)$$
$$+\log(n)(2(S_1 - n\log(d_n))^2 - nS_3) + nS_2 - S_1^2\Big)/n^2$$

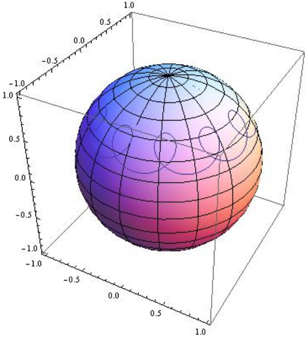


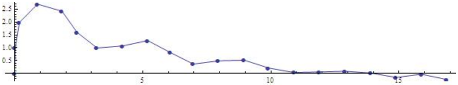
Celestial Mechanics.
Probability and Statistics.



Research interests:

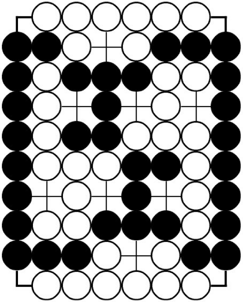
- Approximating sampling distributions of various estimators (MLE in particular) by Edgeworth Series (an extension of the basic Normal approximation) which is capable of achieving high accuracy even with relatively small sample. Currently, this involves:
    - investigating theoretical properties of such series (such as the nature of its asymptotic convergence, applicability to discrete distributions, etc.),
    - constructing accurate confidence regions of distributions parameters (with preference for ML approach),
    - extending the technique to correlated samples (so far restricted to autoregressive models).
- Mote Carlo simulation in Quantum Chemistry (computing properties of small molecules in particular).
- Constructing analytic solution to perturbed Kepler problem, focusing on resonances and the onset of chaos.



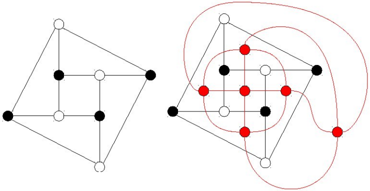


Thomas Wolf

Differential equations, Computer algebra, General Relativity, Computer Go.

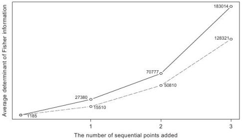


My research interests include differential equations and integrability, computer algebra and classical General Relativity.
Work in computer algebra concerns algorithms to simplify and solve overdetermined systems of equations (linear/non-linear), (algebraic, ODEs, PDEs). These algorithms and implementations are applied in higher level programs for the determination of symmetries, conservation laws or other properties of differential equations. Applications include the classification of integrable systems of various types.
Attempts to increase the efficiency of related programs lead to a study of the parallelization of my algorithms and programs.
For the last 10 years I was the Brock site leader of the SHARCNET consortium and serve currently on the board of BISC, the Brock Institute of Scientific Computing.
A hobby of mine concerns the mathematical analysis and computerization of the Asian game of Go. Recent work includes the static analysis of positions interpreted as discrete dynamical systems and the mathematics of semeai and seki positions.



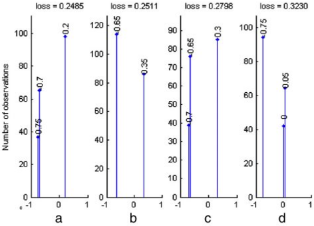
Xiaojian Xu

Statistical Models and Inference; Optimal Regression Designs; Robust Methods; Multivariate Analysis; Accelerated Life testing



My research lies in several areas of experimental designs, robust inferences, and survey sampling. Some problems that I am currently working on include:

- Constructing exact designs that provide optimal solutions for a variety of inferences.
- Analysis for robustness of experimental designs against different model violations.
- Optimal planning for accelerated life testing experiments.
- Optimal designs for mixed models.
- Robust designs for nonlinear models.
- Optimal methods for statistical inferences in indirect sampling.

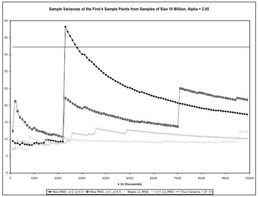


Wai Kong (John) Yuen

Convergence rate and efficiency optimization of Markov chain Monte Carlo algorithms in high dimensions with the aid of extensive and computationally intensive simulation studies

My research interests are in bounding the convergence rate and optimizing the efficiency of various Markov chain Monte Carlo (MCMC) algorithms in high dimensions with the aid of extensive and computationally intensive simulation studies. Over the last 15 years, MCMC algorithms are widely used, largely due to their general applicability to Bayesian inference problems. Therefore, monitoring the convergence of these algorithms has become an important topic. One important class of algorithms called local MCMC algorithms refers to one with the property that the transition of the underlying Markov chain is local, e.g. random walk Metropolis algorithms. My research focuses on local MCMC algorithms, typically on unbounded Euclidean state spaces, motivated by distributions such as those encountered in Bayesian analysis. Currently, I am working on the following problems:

- Bound the convergence rate of these algorithms quantitatively, using techniques developed on discrete state space.
- Optimize the convergence rates by proper scaling of the underlying Markov chain, with significant implications to algorithms in high dimension.
- Apply MCMC algorithms to a Bayesian model for baseball predictions.



$$
\begin{aligned}
\int \chi_A(x) P_1^t(x, A^c)\pi(dx) &= \int_A \int_{A^c} p_1^t(x,y)dy\frac{1}{d}dx \\
&= \sum_{i=1}^{l}\sum_{j=1}^{l}\int_{a_i}^{b_i}\int_{b_j}^{a_{j+1}} p_1^t(x,y)dy\frac{1}{d}dx. \\
&= \sum_{i=1}^{l}\sum_{j=1}^{l}\int_{a_i}^{b_i}\int_{b_j}^{a_{j+1}} \sum_{m=-\infty}^{\infty}(2\pi\sigma^2 t)^{-\frac{1}{2}} \\
&\qquad \times \exp\left\{-\frac{(md+y-x)^2}{2\sigma^2 t}\right\} dy\frac{1}{d}dx.
\end{aligned}
$$