Probability distributions in PARI/GP

Work in progress

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WIMS and PARI/GP

WIMS is free software that runs on a server, and allows teachers to design interactive exercises with automatically generated instances and automatic correction. Created by Gang Xiao, now maintained by several people among which Bernadette Perrin-Riou.

It relies on various computer algebra software as backend, among which PARI/GP. It uses Octave for probabilities and statistics functions, but it would be convenient to **replace Octave by PARI/GP**.

This discussion already took place in 2012 (according to Karim Belabas), and Marie-Line Chabanol wrote a script implementing in GP some of the necessary functionalities.

I got my hands on this script and started working...

Probability distributions over $\mathbb{R}$

All our distributions over $\mathbb{R}$ have a density with respect to the Lebesgue measure or the counting measure.
For a distribution `distr`, we provide:

- `statdistrpdf(params, x)` evaluates the PDF: probability density function at x.
- `statdistrcdf(params, x)` evaluates the CDF: cumulative density function at x.
- `statdistrinvcdf(params, p)` evaluates the inverse of the CDF at the probability $p \in [0, 1]$.
- `statdistrrandom(params)` draws a sample.

Is this reasonable naming? What about cases where a precomputation is useful to generate many samples?

Probability distributions for WIMS

Done:

- normal (continuous, `normal`)
- binomial (discrete, `binom`)
- Poisson (discrete, `poiss`)
- Student (continuous, `student`)
- Chi square (continuous, `chi2`)
- gamma (continuous, `gamma`)
- exponential (continuous, `exp`)

Probability distributions for WIMS

TODO:

- Fisher
- negative binomial
- geometric
- hypergeometric
- beta
- Cauchy
- Laplace
- logistic
- lognormal
- Weibull
- ... do you need another one?

Demo

Watch the demo!

Basic statistics

Done:

- empirical distribution of a sample
- moments, absolute moments, mean, standard deviation
- correlation, rank correlation

TODO:

- median, quantiles in linear time
- Chi square test
- regression?

Question: do we keep the ones that are trivial to implement?

Random generation of various objects

Done:

- discrete gaussian in $\mathbb{Z}$ (`statzgaussxxx(s,c)`)
- random in L^2 ball and sphere (`randominball(d)`, `randominsphere(d)`)
- random HNF with given determinant (`randomhnf(n,d)`)
- random prime ideal with norm up to bound (`nfrandomprime(nf,N)`)
- random permutation (`randomperm`)

TODO:

- discrete gaussian in lattice
- random in L^p ball and sphere
- random in compact Lie groups
- random in ball in noncompact Lie groups
- make your wishlist!

Discrete gaussian over $\mathbb{Z}$

The discrete gaussian over $\mathbb{Z}$ with center $c \in \mathbb{R}$ and width parameter $s > 0$ is the discrete distribution over $\mathbb{Z}$ where

$$\mathbb{P}(n) \sim \exp\left(-\pi\left(\frac{n-c}{s}\right)^2\right)$$

If s is large, it is very close to a continuous gaussian.

Demo

Watch the demo!

Thank you!