C–Rand: A Package for Generating Nonuniform Random Variates

Ernst Stadlober and Franz Niederl

Institute of Statistics, Technical University Graz, Lessingstraße 27, A-8010 Graz, AUSTRIA, e–mail: stadlober@stat.tu–graz.ac.at

Keywords. Random variate generation, simulation

C–Rand is a system of C–routines and functions intended for use on microcomputers running under MS–DOS. It contains up–to–date generators for more than thirty univariate continuous and discrete distributions:

Continuous distributions

No shape parameter:	Cauchy, exponential, extreme value I, Laplace, logistic, normal, slash, triangular.
One shape parameter:	Burr (II,VII,VIII,X), chi, exponential power, extreme value II, gamma, Student–t, von Mises, Weibull.
Two shape parameters:	beta, Burr (III,IV,V,VI,IX,XII), generalized inverse Gaussian, hyperbolic, Johnson system, lambda, stable.

Discrete distributions

One shape parameter:	geometric, logarithmic, Poisson.
Two shape parameters:	binomial, generalized Poisson, negative binomial, zeta.
Three shape parameters:	hypergeometric.

The generators use a variety of transformation procedures which result in theoretically exact methods: special probabilistic properties, inverse transformation, acceptance rejection, ratio of uniforms, composition, patchwork rejection and acceptance complement. For some classical distributions more than one generation method is implemented. In this case there is a choice between extremely fast but rather complicated methods and somewhat slower but much simpler procedures. Here, our strategy is to provide potential users with the most efficient algorithms available. Uniform random numbers are generated by a multiplicative congruential generator (modulus $m = 2^{32}$, multiplicator $a = 663608941$) with a good lattice structure and period 2^{30}.

A menu driven system of routines allows to study different features of the random variate generators and their underlying distributions. The quality of the output can be checked by means of both numerical quantities and graphical displays. Empirical moments or quantiles can be compared with their related theoretical quantities and the histogram of the generated samples can be visualized together with the true density or histogram function. The execution times, set–up times (both in μsec per sample) and the average number of uniforms needed per variate are delivered as performance measures of the sampling algorithms. Informations on general procedures (e.g. calculation of moments, quantiles, construction of graphics) and inline documentations of the generators are also available. The current version is a modification, improvement and extension of the C–package discussed in [1] and [2]. The graphical surface introduced in [2] has been replaced by a more flexible tool which is easier to handle as its predecessor.

The package may be useful for teaching and research purposes. In lectures one can visualize different shapes of densities by changing shape parameters of the distribution or one can explain 'true randomness' by viewing histograms and moments of random variate sequences starting with different seed values of the basic uniform generator. Researchers may need efficient sampling routines of our collection to perform specific simulation problems. For this they should be prepared to link C–programs to their own software.

C–Rand has been developed with Borland C++3.0 at an IBM PC (CPU: 80486/50MHz; graphics: VGA). It runs under MS–DOS and may be used at any PC with 80x86 processor and an EGA or VGA graphic card. For a detailed description of the software we refer to the manual [3]. The whole package which includes an executable demo program `c_rand.exe`, screen drivers, source codes of program modules and generators occupies approximately 910 Kbyte memory.

References

[1] Kremer, R. (1989): *C–Rand: Generatoren für nicht–gleichverteilte Zufallszahlen*, Diplomarbeit, 152 pp., Techn. Universität Graz, Austria.

[2] Stadlober, E. and Kremer, R. (1992): *Sampling from discrete and continuous distributions with C–Rand*, in *Pflug, G. and Dieter, U. (Eds.), Simulation and Optimization, Springer Lecture Notes Econom. Math. Systems* **371**, *154–162.*

[3] Stadlober, E. and Niederl, F. (1993): *Generation of non–uniform random variates with C–Rand*, Research Report No. 15, 116 pp., Institute of Statistics, Technical University Graz, Austria.