Giac/Xcas, a swiss knife for mathematics

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Trophées du Libre 2007
Plan

1. Xcas: interface for CAS, dynamic geometry and spreadsheet, audience: scientific students to research
2. Giac: a C++ library, the computation kernel, for C++ programmers and other interfacable languages.
From highschool to university...  

- integer arithmetic: primes, GCD, extended GCD, cryptography...  
- polynomials: GCD, factorization, fractions, finite fields...  
- linear algebra: vectors, matrices, reduction, factorizations  
- calculus: derivatives, integration, limits, series, ...  
- numeric and symbolic solvers (equations, systems)  
- 2-d and 3-d graphs: functions, parametric curves, level curves, ...  
- ...
factor(x^50-1)

(x+1) \cdot (x^4 - x^3 + x^2 - x + 1) \cdot (x^{20} - x^{15} + x^{10} - 5 + 1) \cdot (x^{20} + x^{15} + x^{10} + 1) \cdot (x^4 + 3 \cdot x^3 + x^2 + x)

\int_0^{\text{+ infinity}} \frac{1}{(x^4+1)^4} \, dx = \frac{77 \cdot \pi \cdot \sqrt{2}}{512}

plot(x^2, x=-3..3); plotarea(x^2, x=0..2)

G := GF(2, a^8 + a^6 + a^3 + a^2 + 1, \{'a', 'G'\}, \text{undef}); A := G(a); factor(x^4 + A^4)
French (70 000 lines) and partially in English (13 000 lines)

- tutorial
- commands by themes in the menus or by alphabetic order in index
- command completion
- short help with examples to paste
- more complete help inside the browser
- examples sessions
- manuels, exercices
- Internet ressources
Geometry.

- Make constructions with the mouse or/and by commands
- Interactive figures (pointer mode and parameters)
- In the plane or in the space
- 3-d visualization options inherited from OpenGL
- Analytic proofs of theorems using the CAS
3-d example.
Spreadsheet.

- cells may have a symbolic value
- celles may have a graphic value.
- import/export with other modules
- but few formatting options
Programmation

- interpreted language, not typed
- syntax choice: Xcas, maple, mupad, TI89.
- interactive debugger

```plaintext
bezout(a,b):={
    //renvoie la liste [u,v,d] telle que a*u+b*v=d=pqcd(a,b)
    local 1a,1b,1r,q,1b2
    1a:=[1,0,eval(a)
    1b:=[0,1,eval(b)
    1b2:=eval(b)
    while (1b2 !=0 {
        q:=iquo(1a[2],1b2
        1r:=1a+(-q)*1]
        1a:=1b
        1b:=1r
        1b2:=1b[2]
    }
    return(1a);
};
```
Logo

- programming language for primary school
- to test with childrens

```plaintext
sapins2(n) :
    si n<1 alors crayon jaune; disque 10; crayon vert
    sap(n)
    tourne_gauche 31
    saute 10*n
    tourne_droite 31
    sapins2(n-2)
    tourne_droite 31
    saute 10*n
    tourne_gauche 31
    sap(n)
};
```

```plaintext
efface
[150.0,150.0,0.0,0.0]
pas_de_cote 100
[150.0,250.0,0.0,0.0]
saute -150
[0.0,250.0,0.0,0.8]
sapins2(10)
[519.615242271,250.0,0.0,0.0]
```

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Session

- different kind of levels in a session (commandline, comment, spreadsheet, geometry, program, logo)
- organize your work (move, delete/copy/paste, group)
- save, import/export, print
Native part of the code

- About 110 000 + 30 000 lines of code (giac+xcas)
- Parser using bison/flex
- Generic type gen, anonymous union of several basic types (hardware floats/int or different kinds of pointers), cf. giac.info
- Containers from the standard C++ library (vector, map, ...), for example for polynomials (1-d dense, n-d sparse...)
- Math. algorithms (Cantor-Zassenhaus, Hermite, Yun, mrv, Risch, Gosper, modular, heuristic gcd...)
- Context pointer for multi-threading (not completed)
- Internationalization: gettext + native
Librairies

- GMP: long integers
- MPFR: multiprecision floats
- GSL: numeric algorithms in double precision
- PARI-GP: arithmetic
- NTL: 1-d polynomial factorization
- CoCoA: Groebner basis
- FLTK, FLVW, OpenGL: graphic interface
Performances/tests

- Natives: polynomial arithmetic product (like Trip), GCD (Fermat), ...
- From the libraries: GMP, MPFR, PARI (ifactor\(2^{128}+1\)), NTL (factorization), CoCoA (Groebner)
- Benchmarks Lewis-Wester, Fateman, Zimmermann collection of polynomial to factor, ...
- Small basis of regression tests, including geometry theorems to be proved using the CAS kernel.
Interf aces.

- PC (Linux, Windows) and Mac compatibility
- xcas (graphic), icas (terminal)
- xcas online
- texmacs (via icas)
- emacs (icas+mupad mode)
- PDA: familiar linux, qdcas/StatsNow wince
- \LaTeX and mathml export
- Computing with Giac inside a \LaTeX document
Independant computation kernel as a C++ library:

- C++ programs may use the libgiac
- C++ modules may be loaded at runtime inside a Giac/Xcas session
- PHP/Flash module (Facilimaths)
- probably other languages via SWIG
Abstract

- Maths for education and research
- Compatibility, performances
- Many way to interface

Roadmap
- interfaces (more libraries, e.g. Linbox, Atlas, GetFEM++, integration inside SAGE, linux distributions, browser...)
- more maths algorithms and regression tests, multi-threading