SymPy Tutorial

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All materials for today's tutorial are at
`http://www.sympy.org/scipy-2016-tutorial/`

Outline

SymPy Introduction

- Goal
- Features
- History
- Present
- Future

Tutorial

- Intro to SymPy and Basic features
- Solving real life problems

SymPy Goal

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Provide a symbolic manipulation library in Python.

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Provide a symbolic manipulation library in Python.

"SymPy is an open source Python library for symbolic mathematics. It aims to become a full-featured computer algebra system (CAS) while keeping the code as simple as possible in order to be comprehensible and easily extensible. SymPy is written entirely in Python and does not require any external libraries."

Why SymPy?

- Standalone
- Full featured
- BSD licensed
- Embraces Python
- Usable as a library

Features

- **Core Capabilities**
  - Basic arithmetic: Support for operators such as +, -, *, /, ** (power)
  - Simplification
  - Expansion
  - Functions: trigonometric, hyperbolic, exponential, roots, logarithms, absolute value, spherical harmonics, factorials and gamma functions, zeta functions, polynomials, special functions, ...
  - Substitution
  - Numbers: arbitrary precision integers, rationals, and floats
  - Noncommutative symbols
  - Pattern matching
- **Polynomials**
  - Basic arithmetic: division, gcd, ...
  - Factorization
  - Square-free decomposition
  - Gröbner bases
  - Partial fraction decomposition
  - Resultants
- **Calculus**
  - Limits: $\lim_{x \to 0} x \log(x) = 0$
  - Differentiation
  - Integration: It uses extended Risch-Norman heuristic
  - Taylor (Laurent) series
- **Solving equations**
  - Polynomial equations
  - Algebraic equations
  - Differential equations
  - Difference equations
  - Systems of equations
- **Combinatorics**
  - Permutations
  - Combinations
  - Partitions
  - Subsets
  - Permutation Groups: Polyhedral, Rubik, Symmetric, ...
  - Prufer and Gray Codes

Features

- **Discrete math**
  - Binomial coefficients
  - Summations
  - Products
  - Number theory: generating prime numbers, primality testing, integer factorization, ...
  - Logic expressions
- **Matrices**
  - Basic arithmetic
  - Eigenvalues/eigenvectors
  - Determinants
  - Inversion
  - Solving
  - Abstract expressions
- **Geometric Algebra**
- **Geometry**
  - points, lines, rays, segments, ellipses, circles, polygons, ...
  - Intersection
  - Tangency
  - Similarity
- **Plotting**
  - Coordinate modes
  - Plotting Geometric Entities
  - 2D and 3D
  - Interactive interface
  - Colors
- **Physics**
  - Units
  - Mechanics
  - Quantum
  - Gaussian Optics
  - Pauli Algebra
- **Statistics**
  - Normal distributions
  - Uniform distributions
  - Probability
- **Printing**
  - Pretty printing: ASCII/Unicode pretty printing, LaTeX
  - Code generation: C, Fortran, Python

History

History

- Ondřej Čertík started the project in 2006.
- Development took off in 2007 when SymPy first participated in Google Summer of Code. We have participated in every Google Summer of Code since.
- In 2011, Aaron Meurer (who also joined from Google Summer of Code) took over as lead developer.

Present

Current Status

- Over 450 contributors.
- Current code base has over 400,000 lines of code and documentation.
- We have crossed the point of “sympy a toy” to “sympy a tool”

Future

GSoC (1/2)

These are our current GSoC projects. Expect to see these features by the end of the summer.

- Group Theory, Gaurav Dhingra
- Extending solveset, Kshitij Saraogi
- Completing Solveset, Shekhar Prasad Rajak
- Implementation of Holonomic Functions, Shubham Tibra
- Implementation of Singularity Functions to solve Beam Bending problems, Sampad Kumar Saha

Future

GSoC (2/2)

These are our current GSoC projects. Expect to see these features by the end of the summer.

- Adding to SymEngine's Polynomial functionality and interfacing it with FLINT & Piranha Srajan Garg
- Implementing Finite Fields and Set module in SymEngine Nishant Nikhil

Future

Other Plans

- New assumptions
- Make things faster
- SymEngine (`https://github.com/symengine`)
- Implement more algorithms, so we can compute more things (and also make them faster)
- Replacing `solve` with `solveset`
- Encourage people to use SymPy for many applications
- `https://github.com/sympy/sympy/wiki/gsoc-2016-ideas` for full list of things we want done

Projects Using SymPy

- **Sage**: A CAS, visioned to be a viable free open source alternative to Magma, Maple, Mathematica and MATLAB. Sage includes many open source mathematical libraries, including SymPy.
- **SageMathCloud**: SageMathCloud is a web-based cloud computing and course management platform for computational mathematics.
- **Mathpix**: An iOS App, that detects handwritten math as input, and uses SymPy Gamma to evaluate the math input and generate the relevant steps to solve the problem.
- **PyDy**: Multibody Dynamics with Python.
- **IKFast**: IKFast is a robot kinematics compiler provided by OpenRAVE. It analytically solves robot inverse kinematics equations and generates optimized C++ files. It uses SymPy for its internal symbolic mathematics.

Projects Using SymPy

- **Octave Symbolic**: The Octave-Forge Symbolic package adds symbolic calculation features to GNU Octave. These include common CAS tools such as algebraic operations, calculus, equation solving, Fourier and Laplace transforms, variable precision arithmetic, and other features.
- **galgebra**: Geometric algebra (previously `sympy.galgebra`).
- **SymPy.jl**: Provides a Julia interface to SymPy using PyCall.
- **Mathics**: Mathics is a free, general-purpose online CAS featuring Mathematica compatible syntax and functions. It is backed by highly extensible Python code, relying on SymPy for most mathematical tasks.
- **SfePy**: Simple finite elements in Python.

Projects Using SymPy

- **Quameon**: Quantum Monte Carlo in Python.
- **Lcapy**: Experimental Python package for teaching linear circuit analysis.
- **Quantum Programming in Python**: Quantum 1D Simple Harmonic Oscillator and Quantum Mapping Gate.
- **LaTeX Expression project**: Easy LaTeX typesetting of algebraic expressions in symbolic form with automatic substitution and result computation.
- **Symbolic statistical modeling**: Adding statistical operations to complex physical models.

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Here at SciPy

Talks

- Jason Moore, *Simulating Robot, Vehicle, Spacecraft, and Animal Motion with Python (Advanced)* (Tutorial).
  Monday 1:30 PM - 5:30 PM - Room 103
- Aaron Meurer, Anthony Scopatz *SymPy Code Generation*.
  Thursday 11:30 PM - 12:00 PM - Room 204
- Ondřej Čertík, Isuru Fernando, Thilina Rathnayake, Abhinav Agarwal *SymEngine: A Fast Symbolic Manipulation Library*.
  Friday 3:30 - 4:00 - Room 204

Let's begin!