

# The Sofia Project



Oliver Knill  
Johnny Carlsson  
Andrew Chi  
Mark Lezama



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Funded by the Provosts  
fund for teaching and learning



# The Team:



Johnny

Andrew

Mark

Oliver



**And of course Sofia:**



named after Sofia



**Kovalevskaya (1850-1891)**





# About Kovalevskaya:

An extraordinary woman, Sofia Kovalevskaya was not only a great mathematician, but also a writer and advocate of women's rights in the 19th century. It was her struggle to obtain the best education available which began to open doors at universities to women. In addition, her ground-breaking work in mathematics made her male counterparts reconsider their archaic notions of women's inferiority to men in such scientific arenas.

Becky Wilson, Class of 1997 (Agnes Scott College)

# Oure main goals were:



- teach mathematics to an intelligent agent
- learn about teaching mathematics
- learn about learning mathematics
- add more variety to teaching mathematics
- have fun with IT technology
- learn about artificial intelligence
- build a useful tool for calculus

# Our main tasks were:



- Acquire and setup computer equipment
- Build up a knowledge database
- Learn about existing bot technology
- Interface to computer algebra systems
- Literature about artificial intelligence
- Literature about intelligent agents and education

# Computer equipment



- Dell Power Edge 2650 dual Xeon 3 GHz
- running linux reliably since
- collaboration with CVS



Part of Mathematics Department computing equipment

# Sofia Direct



## Sofia Math Chat Robot

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Project Information:

[Oliver Knill](#)

[Harvard University](#)

[Department of Mathematics](#)

One Oxford Street

Cambridge, MA 02138, USA

Tel: (617) 495 5549

Email: [knill@math.harvard.edu](mailto:knill@math.harvard.edu)

## The Sofia Chat Robot

CONNECT

Hi! My name is Sofia. I'm taught by [a team](#) of Harvard students in a project supported by the [Provost's fund for teaching and learning](#).

Say

Search:

Project funded by [Provost's fund](#) for teaching and learning

# Based on ALICE



## A. L. I. C. E. Artificial Intelligence Foundation

Promoting the development and adoption of **ALICE** and **AIML Free Software**

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### A.L.I.C.E. and AIML Chat Robot News

*March, 2005*

#### Bot Boffins Bespeak Big British Birthday Bash



Statue of Alan Turing unveiled by the Earl of Wessex at University of Surrey, in front of the computing department, on 28th October 2004. The statue was sculpted by John W. Mills. Turing lived in Guildford in his earlier life.

Digital World Research Centre, University of Surrey

COLLOQUIUM ON CONVERSATIONAL SYSTEMS and celebration of **ALICE**'s first ten years online

Guildford, UK, 2-6pm on 25 November 2005

An informal afternoon meeting will be held at which invited speakers will give short

### Subscription Bots

[A.L.I.C.E. Silver Edition](#)  
[DAVE E.S.L. Bot](#)  
[CLAUDIO Personality Test](#)

Ads by Goooooogle

#### [Boe Bot Complete](#)

Boe Bots kits and hundreds of other robot items. Take a look!  
[www.HobbyEngineering.com](http://www.HobbyEngineering.com)

#### [Natural Language Software](#)

Create an Intelligent Chatterbot. Easy to learn, fun to use.  
[www.verbots.com](http://www.verbots.com)

#### [Build Intelligent Robots](#)

IntelliBrain robotics controller, Robo IDE

# Task distribution



Everybody works on content

Each would specialize for a specific topic:



Understanding  
text  
Semantics



Learning  
aspects  
Innovation



Link with  
programs  
Interfaces

# Main Challenges



- Interaction of given bots with computer algebra systems.
- Need wrapper application which can interact with the bots, handle cookies.
- Bots can become unstable under load.
- Need actually use the bots with students.

# Sofia Interface



## Sofia Math Chat Robot

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[Oliver Knill](#)

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You: ""

Do you dream?

### Examples to Mathinterface: (Sofia only)

```
Plot  $x \cdot \sin(1/x)$  with  $x$  from  $-2$  to  $2$ 
Integrate  $\sin(x)$  with respect to  $x$ 
 $\sin'(x)$ 
 $123412341234 \cdot 123412341234$ 
FactorInteger[234234234]
What is the derivative of  $\tan(t)$  with respect to  $t$ 
Factor the integer 123123123123123123
Is the integer 1111111 prime
```

# Weekly Activities

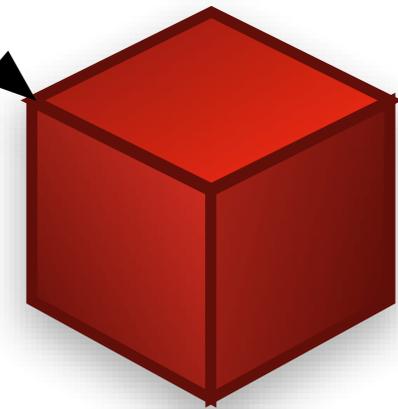
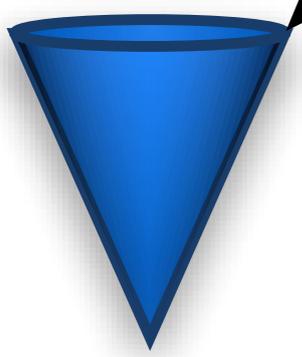
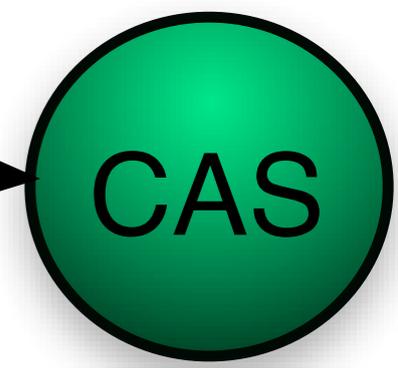
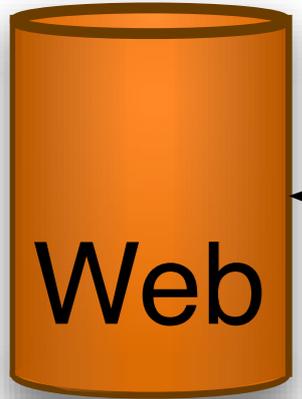
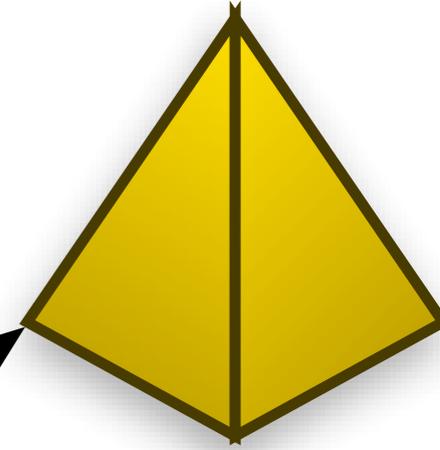
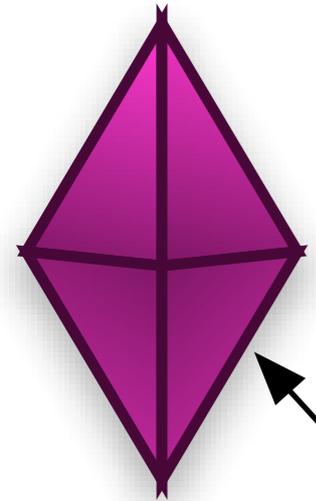


- Learn to collaborate with CVS
- Setting up goals and tasks
- Brainstorming
- Experimenting
- Discussion
- Presenting results
- Lisp workshop

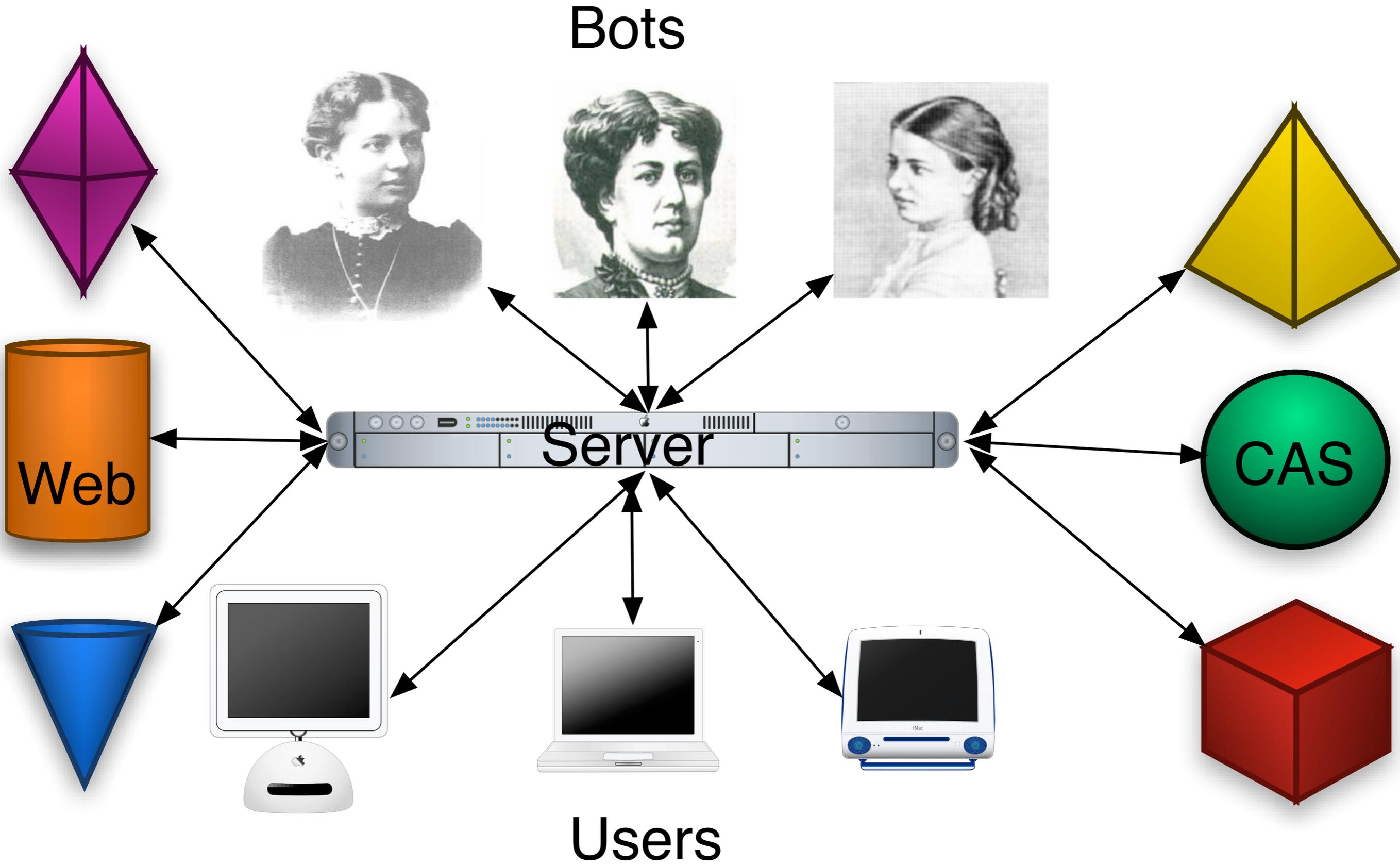
# Sofia Schema



Bots



Users



# Building our own bot



Original question:

"Compute the derivative of  $\text{Sin}[x]$ "

Simplified question:

"Compute derivative  $\text{Sin}[x]$ "

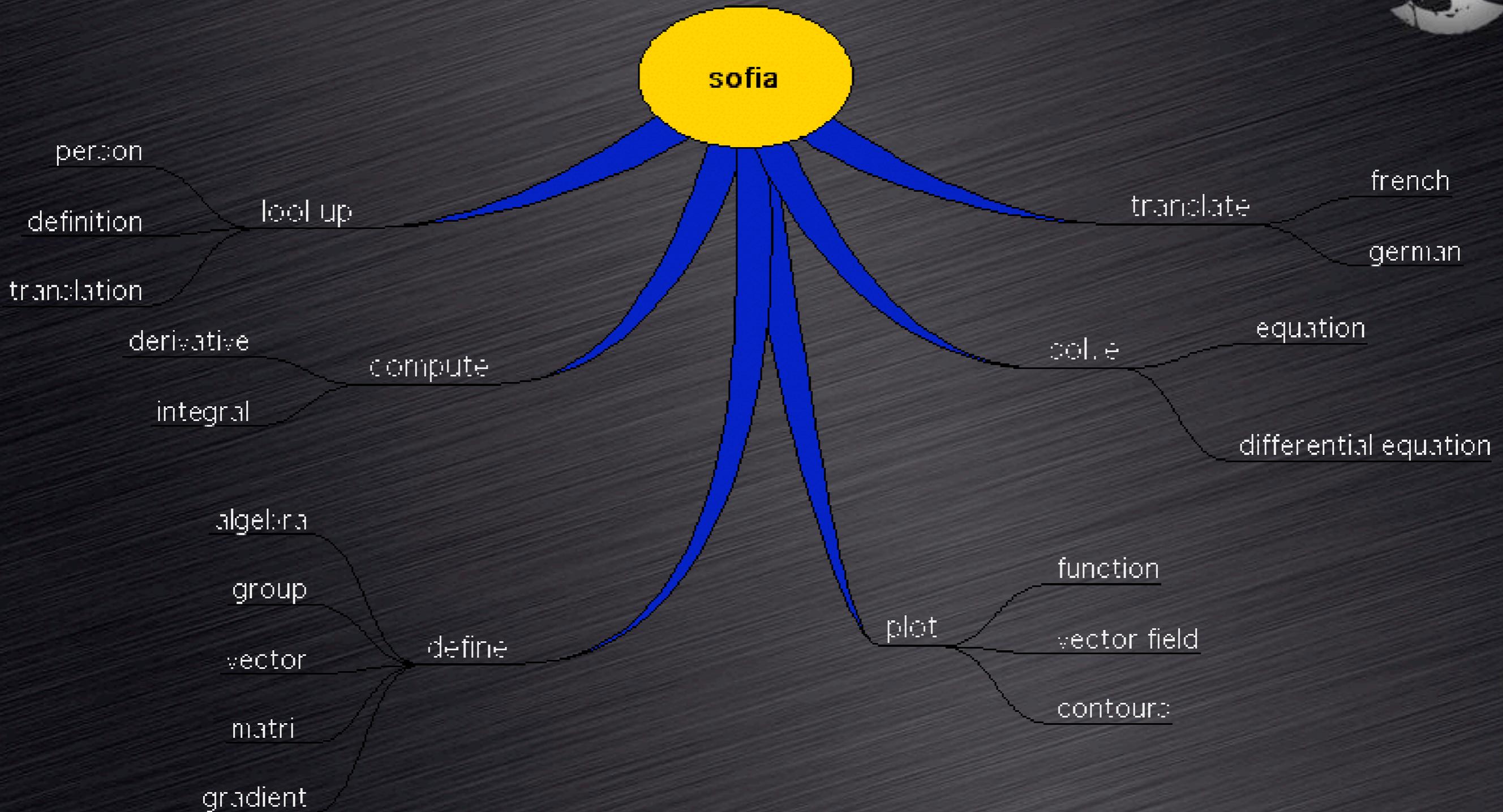
Unix command:

`/compute/derivative/run "Sin[x]"`

Answer:

$\text{Cos}[x]$

# Idea: a program tree



Instead of one monolithic program, the new bot consists of thousands of programs

# Examples 1:



sofia "plot Sin[x] 0 10"

sofia "how are you"

sofia "how are you" "oliver"

sofia "what is your name"

sofia "I love you"

sofia "how to sing"

sofia "nice whether today"

sofia "what is the weather"

sofia "what is the date"

sofia "compute the derivative of  $\sin(10*x)$ "

sofia "compute the eigenvalues of  $\{\{3,2\},\{4,5\}\}$ "

sofia "compute the norm of  $\{\{3,2\},\{5,2\}\}$ "

sofia "compute the eigenvectors of  $\{\{3,2\},\{4,5\}\}$ "

sofia "calculate the integral of  $\log(\tan(x))$ "

# Examples II



sofia "determine a factorization of 23425"

sofia "compute the heck the derivative of  $\log(x)$ "

sofia "can you find the determinant of  
 $\{\{1,3,4\},\{23,2,4\},\{12,123,1\}\}$ "

sofia "find the critical points of  $-2x^3+3x^2y+3y^3-3y$ "

sofia "find gcd 26,39"

sofia "find the lcm of 26,39"

sofia "find the critical points under constraint of  $13-4*x+x^2$   
 $-6*y+y^2+z^2$  and  $z^2-x^2-2*y^2$ "

sofia "find lagrange solution  $x^2+y^2+y$  and  $4x-5x^2-y^2-3*y$   
 $-3$ "

sofia "what is a determinant"

sofia "compute  $2341234+234234$  with pari"

sofia "add 234 234 2 2 43 243 234"

# Examples III



sofia "find the largest eigenvalue of  $\{\{2,3\},\{3,4\}\}$ "

sofia "find the row reduction of  $\{\{2,3\},\{3,4\}\}$ "

sofia "find the row reduced echelon form of  $\{\{3,2\},\{1,4\}\}$ "

sofia "find the continued fraction of  $\pi$ "

sofia "find the base form of 1234134,2"

sofia "compute 234123 in the base 2"

sofia "compute a billion in the base 17"

sofia "find 234234234 in the base 16"

sofia "calculate 11111123124112341234 in the base 28"

sofia "compute the prime factorization of one billion"

sofia "find the inverse of  $\{\{2,3,4,2\},\{2,1,2,3\},\{1,2,3,4\},\{1,2,3,12\}\}$ "

sofia "compute the transpose of  
 $\{\{2,3,4,2\},\{2,1,2,3\},\{1,2,3,4\},\{1,2,3,12\}\}$ "

# Examples IV



sofia "calculate 11111123124112341234 in the base 28"

sofia "compute the prime factorization of one billion"

sofia "find the inverse of  $\{\{2,3,4,2\},\{2,1,2,3\},\{1,2,3,4\},\{1,2,3,12\}\}$ "

sofia "compute the transpose of

$\{\{2,3,4,2\},\{2,1,2,3\},\{1,2,3,4\},\{1,2,3,12\}\}$ "

sofia "compute the surface area of  $\{\{u,v,u+v\},\{u,0,1\},\{v,0,1\}\}$ "

sofia "figure out the surface area of  $\{(2+v*\text{Cos}[u/2])* \text{Cos}[u],(2+v*\text{Cos}[u/2])* \text{Sin}[u],v*\text{Sin}[u/2]\},\{u,0,2\text{Pi}\},\{v,-1,1\}\}$ "

sofia "compute the surface area of

$\{\{\text{Sin}[u],\text{Cos}[u],v\},\{u,0,2\text{Pi}\},\{v,0,h\}\}$ "

sofia "compute the length of the curve  $\{\{t,0,t^2\},\{t,0,1\}\}$ "

sofia "dictionary glue"

sofia "spell the word glue"

sofia "could you spell me the word chinese"

sofia "can you remind me what is a gradient"

# How do people learn?



Know definitions

“What?”

What is the definition of a gradient?

Master algorithms:

“How?”

Extremize  $\sin(x y)$

accessible to AI

Understand concepts

“Why”

The gradient is large if level curves are close.

Be innovative:

“Why not?”

Are there examples, where the Lagrange method works and substitution not?

not yet accessible to AI

# Still to be done:



- More information into brain
- Implement context (have only prototypes)
- Implement automatic learning (have only prototypes)
- Publish code
- Study dynamics of interacting bots
- Build classroom of bots to study learning
- Test the tool in courses
- Data collection

# Achievements:



- Great collaboration, working technology
- We have a decent knowledge database.
- Made ALICE technology work with CAS's
- Built a new Chat bot from scratch
- Build CGI wrapper to transfer context
- Learned about AI and teaching
- Explored new learning interface
- Authored paper