

Teaching proofs with DEDUCTION

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What is DEVDUCTION?

- an open source graphical proof assistant based on LEAN
a prototype, written in Python and PyQt
- for helping students to learn proofs
experimental but used with real students at SU; viewpoint from which I am developping this app: undergrad math students in a French univ
- aimed primarily at (French?) undergraduate math students
All math students must learn proofs, but not all are willing to learn another computer language

Choose file and exercise — dEDuction

Files Exercises

Exercises

- Exercices
 - Un ensemble contient son intersection avec un autre
 - Inclus dans les deux implique inclus dans l'intersection
 - Transitivité de l'inclusion

Un ensemble contient son intersection avec un autre

Voici un premier exercice !

Let X be a set. Let A, B be two subsets of X .
Prove that $A \cap B \subseteq A$.

Text mode

Quit Start exercise

Preferences Exercise



Context (objects and properties)

- ✓ X : set
- ✓ A : subset of X
- ✓ B : subset of X

Actions (logical rules and statements)

Prove: \forall \exists \Rightarrow \wedge \vee

Use: \forall \exists \Rightarrow \wedge \vee

\neg \Leftrightarrow $=$ \mapsto

Goal! Proof methods...

Statements

- ▾ Définitions
 - Inclusions, égalités
 - Unions, intersections

Target

$$A \cap B \subseteq A$$

✓ Beginning of Proof

Special features: no text output

- students should write down their own proof
so a teacher feedback is required...
- a proof tree provide a global view on the proof

X Y Z f g f injective g injective

Proof of $(g \circ f)$ injective:

Proof of $\forall y \in X, (g \circ f(x) = g \circ f(y) \Rightarrow x = y)$:

x

Proof of $g \circ f(x) = g \circ f(y) \Rightarrow x = y$:

y

Proof of $x = y$:

$g \circ f(x) = g \circ f(y)$

$g \circ f(x) = g \circ f(y)$

g injective

$f(x) = f(y)$

$f(x) = f(y)$

f injective

$x = y$

Goal!

Goal!

Goal!

QED!!

- a tool, not a target

target = write proofs without DEADUCTION

- where is the semantics?

e.g. ask open questions: trying to prove a false statement helps building counter-examples

- mostly set theory and ϵ/δ

content is taken from the classical math course they follow in parallel so that they can put what they learn into practice

- students **do something!**

They still need feedback: app not designed to stand entirely on its own but most of the time students work at their own pace

Super users (teachers)...

- can design exercise sheets in a separate LEAN file
annotated Lean files, with metadata for DEAduction in comments
- can customize the interface (e.g. restrict some functionalities)
e.g. remove negate button
e.g. decide which defs necessitate unfolding

What it is *not*

- not a full LEAN GUI
- not reliable
- not complete
- not easy to install

What it should be

- more fun!
- more ergonomic
- with more learning tools (graphical representation?)

Visual tools? e.g. diagrams for set theory

- with more maths

go beyond naive set theory and elementary analysis

for this, need an interface for computing / entering mathematical objects

- with more developers!

The Lean side is under-developed

DEAduction has benefited a lot from feedback:

if you have any idea of how to improve, please share!

Contributions

- Patrick Massot (help with Lean and first Python-Lean interface)
- First dev team:
 - Marguerite Bin (code sent to Lean),
 - Florian Dupeyron (global architecture and much more),
 - Antoine Leudière (expert PyQt),
 - and later Sébastien Julliot (Pyinstaller package)
- Camille Lichère, Zoé Mesnil (first exercise session)
- Isabelle Dubois (extensive feedback)

- <https://github.com/dEAduction/dEAduction>
- <https://perso.imj-prg.fr/frederic-leroux/telecharger-dEAduction/>
- Bartzia, I., Beffara, E., Meyer, A., Narboux, J.. Proof assistants for undergraduate mathematics education: elements of an a priori analysis. 2023. hal-04087080
- Kerjean, M., Le Roux, F., Massot, P., Mayero, M., Mesnil, Z., Modeste, S., Rousselin, P. (2022, October). Utilisation des assistants de preuves pour l'enseignement en L1: Retours d'expériences. *Gazette de la SMF*, 174.