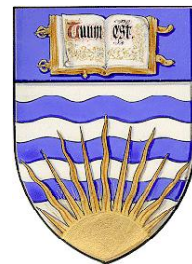




Three Challenges for Deduction

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Honor, Delight and Gratitude

- Thanks to
 - Nominators, Seconders, Award Committee, CADE Inc.
 - Parents, family and teachers (PhD student of Schütte, of Hilbert, of ..., of Leibniz – see Mathematics Genealogy)
 - Students and collaborators – too many to be named individually (18 now professors, 2 artists, and many other professions)



Why me?

- First for ... ? not really
- Initiator of mainstream? not yet at least
- Important papers? my best ones were routinely rejected, also from CADE
- Systems? were mostly programmed by students and collaborators
- In anticipation of future influence?
Then let me take my chance now ...



Extreme Career Difficulties

- Physicist/mathematician turned logician turned intellectician/deductionist
- 1970 one out of two in Germany
- Learning everything the hardest way
- But with a clear vision how to do theorem proving, based on my PhD work in logic (cut elimination in HOL)
- Let me share it with you ...



Systematic Procedure or Connection Method (CM)

- Proving a formula F means eg. finding a proof in a Gentzen-type formal system
- Compression principle: find minimal essentials of a proof, called *skeletons* :
- multiplicity, spanning set of connections, partial ordering, substitution
- Search for skeleton on F in a goal- and connection-oriented, by-need fashion



Why better than resolution ...?

- Search space consisting of
 - small skeletons rather than possibly huge derivations, which speeds up any necessary operations
 - search more driven by given structures
 - each skeleton represents a number of derivations, hence abstracts from irrelevant and redundant features
- ... but the cut is missing ... see below



First Papers in Deduction

- W. Bibel, Ansatz zu einem systematischen Beweisverfahren. GI-Jahrestagung, München, 12.-14.10.1971.
- W. Bibel, Ein mechanisches Beweisverfahren für die Prädikatenlogik. Tagung über mathematische Logik, Oberwolfach, 16.-24.4.1972.
- Mechanische Beweisverfahren für die Prädikatenlogik. Tagung über Automatentheorie und Formale Sprachen, Oberwolfach, 25.11.-1.12.1973.
- A systematic theorem proving procedure. 2nd Annual Computer Science Conference of ACM, Detroit, USA, 12.-14.2.1974.
- An approach to a systematic theorem proving procedure in first-order logic. Computing 12, 43-55 (1974).
- Proof search in a Gentzen-like system of first-order logic. Proceedings of the International Computing Symposium, North-Holland, Amsterdam, 205-212 (1975). (with J. Schreiber)

Reinhold Letz: Boote (boats)



19. August 2006

Herbrand Award

Otten's Theorem Prover for Intuitionistic Logic: ileanCoP

- (1) prove(Mat,PathLim) :-
- (2) append(MatA,[FV:Cla|MatB],Mat), \+ member(-(_):_ ,Cla),
- (3) append(MatA,MatB,Mat1),
- (4) prove([!:[]],[FV:[-(!):(-[])|Cla]|Mat1],[],PathLim,[PreSet,FreeV]),
- (5) check_addco(FreeV), prefix_unify(PreSet).
- (6) prove(Mat,PathLim) :-
- (7) \+ ground(Mat), PathLim1 is PathLim+1, prove(Mat,PathLim1).
- (8) prove([],_,_,_,[[],[[]])).
- (9) prove([Lit:Pre|Cla],Mat,Path,PathLim,[PreSet,FreeV]) :-
- (10) (-NegLit=Lit;-Lit=NegLit) ->
- (11) (member(NegL:PreN,Path), unify_with_occurs_
check(NegL,NegLit),
- (12) \+ \+ prefix_unify([Pre=PreN]), PreSet1=[], FreeV3=[]
- (13) ;
- (14) append(MatA,[Cla1|MatB],Mat), copy_term(Cla1,FV:Cla2),
- (15) append(ClaA,[NegL:PreN|ClaB],Cla2),

Rest of ileanCoP without unification – leanCoP included

```
(16) unify_ with_ occurs_ check(NegL,NegLit),
(17) \+ \+ prefix_ unify([Pre=PreN]),
(18) append(ClaA,ClaB,Cla3),
(19) ( Cla1==FV:Cla2 ->
(20) append(MatB,MatA,Mat1)
(21) ;
(22) length(Path,K), K<PathLim,
(23) append(MatB,[Cla1|MatA],Mat1)
(24) ),
(25) prove(Cla3,Mat1,[Lit:Pre|Path],PathLim,[PreSet1,FreeV1]),
(26) append(FreeV1,FV,FreeV3)
(27) ),
(28) prove(Cla,Mat,Path,PathLim,[PreSet2,FreeV2]),
(29) append([Pre=PreN|PreSet1],PreSet2,PreSet),
(30) append(FreeV2,FreeV3,FreeV).
```

leanCoP Obtained from ileanCoP Simply by Erasing Parameters

- `prove(M,I) :- append(Q,[C|R],M),
\+member(- _,C), append(Q,R,S),
prove([!],[[- ! |C]|S],[],I) .`
- `prove([],_,_,_) .`
- `prove([L |C],M,P,I) :- (-N=L; -L=N) ->
(member(N ,P) ; append(Q,[D|R],M),
copy_term(D, E), append(A,[N |B],E),
append(A,B,F), (D== E -> append(R,Q,S);
length(P,K), K<I, append(R,[D|Q],S)),
prove(F,S,[L |P],I)), prove(C,M,P,I) .`



Facts and First Challenge

- 3 clauses, leanCoP 333 bytes, ileanCoP additional 191 bytes in smallest versions
http://en.wikipedia.org/wiki/Automated_theorem_proving
- ileanCoP world-best prover for IL, leanCoP among the leading provers
- Integrate full power of partial relation (as in Bibel ATP book), =, preprocess F by applying reduction operations, etc.
- Transformation to lower-level program. language, eg. C++, like in Mercury



Second Challenge: Cut

- Cut enables exponential compression
 - well-known result for Gentzen systems
 - pigeonhole formulas can be proved with polynomial proofs in Gentzen system with cut as well as with CM with factoring
 - but they require exponential proofs with resolution
 - hence resolution, although cut-like, does not incorporate the full power of the cut



Second Challenge: Cut

- Cut enables exponential compression
- *Conjecture*: disappears by eliminating common factors in different clauses
 - ie. among the different possibilities of factoring the given formula there is one such that cut elimination does not increase the length of a Gentzen system proof
 - note the search required for finding the right factoring



Second Challenge: Cut

- Cut enables exponential compression
- *Conjecture*: disappears by eliminating common factors in different clauses
- Integrate FACTOR-reduction in leanCoP
- Would overcome the remaining advantage of resolution in comparison with CM
- Evidences: Letz' folding-up in SETHEO; pigeon-hole formulas; derivation props



Third Challenge: Dynamics

- Logic a framework for static reasoning
- Ubiquitous need to cope for changes
- Problems with previous attempts
- Transition calculus in new form
incorporates transitions as first-class
citizens without frame problem
- Integrate in leanCoP
- „Transition Logic Revisited“ submitted

Success of a Relative of the Transition Calculus

- Thielscher's et al. FLUXPLAYER is the current World Champion after having won the 2nd International General Game Playing Competition at AAI-06 in Boston
- derived from his fluent calculus





More Details on Challenges in:

- *Research Perspectives for Logic and Deduction*. In: Reasoning, Action, and Interaction in AI Theories and Systems – Essays in Honor of Luigia Aiello on the Occasion of Her 60th Birthday (Oliviero Stock and Marco Schaerf, eds), LNAI, Vol. 4166, Springer, Berlin, 24–42 (2006).



A Plea for Frege's Innocence

It is a great honor to be now a member of what Alan Robinson calls the Herbrand Award brotherhood. I have the highest respect of all the twelve previous winners which include some of my best professional friends. Martin Davis is one of these dear friends. But he and me have a disagreement in one single, but - as I think - important point which I would like to mention here in public.

In his wonderful book „Engines of Logic“ he puts Gottlob Frege alongside those who actively prepared the grounds for Hitler's indescribable crimes against the Jewish population. In my judgment Frege is the greatest hero in logic from Germany. He was a very decent man throughout his entire life, adopted a son, had great respect for men with scientific achievements independent of their religious beliefs, ie. for jews (like his colleague Dr. Abraham) as well as for christians, never achieved to become full professor, and died in poverty due to the after-war circumstances (inflation etc.).

In his very last and miserable years he, suffering from severe illness, wrote in his personal diary a couple of sentences which unfortunately are open for interpretation. In the context of his life, personality and the circumstances of the early twenties the most likely interpretation of these sentences makes them innocent ones indeed. If you just read the sentences and ignore what we know about Frege's personality, you may give them the bad interpretation of outspoken antisemitism which is what Martin did. After reading Frege's entire diary, Kreiser's excellent biography of Frege, and with the historical facts of the early twenties in mind, I am absolutely sure that Martin does injustice to Frege.

Reinhold Letz: Nonnen (nuns)



19. August 2006

Herbrand Award

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Reinhold Letz: Himmel-1

