TEX in Teaching

Michael Moortgat,
Richard Moot,
Dick Oehrle

Abstract

A well-known slogan in language technology is 'parsing-as-deduction': syntax and meaning analysis of a text takes the form of a mathematical proof. Developers of language technology (and students of computational linguistics) want to visualize these mathematical objects in a variety of formats.

We discuss a language engineering environment for computational grammars. The kernel is a theorem prover, implemented in the logic-programming language Prolog. The kernel produces LaTeX source code for its internal computations. The front-end displays these in a number of user-defined typeset formats. Local interaction with the kernel is via a tcl/tk GUI. Alternatively, one can call the kernel remotely from dynamic PDF documents, using the form features of Sebastian Rahtz' `hyperref` package.

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Dick Oehrle Formerly: Linguistics Dept, U of Arizona. Now: Silicon Valley. Collaborating with MM on a textbook incorporating the materials discussed in this talk. Author of the web scripting components of this project.

2. The project

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- Framework: type-logical grammar $\rightsquigarrow$ 'parsing-as-deduction'
- Two formats:
  - the GRAIL grammar development environment: Prolog kernel + tcl/tk graphical user interface
  - dynamic documents along the lines of the Mathematica notebook concept: exploiting the form features of Rahtz' hyperref package.

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http://grail.let.uu.nl/tour.pdf

http://www.let.uu.nl/~ctl/docenten/moortgat.html

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- type computations/logical derivations.

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    Destroys structural information:

    I had completely forgotten how good beer tastes.

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The system is available under the GNU General Public License agreement from

ftp.let.uu.nl/pub/users/moot

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- Postulate tool: graphical editor to add or modify structural rewrite rules,
- Parsing/debugging: run the theorem prover on sample expressions; interactive mode using proof net technology.

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2.	$\mathsf{surpassed} : (np\backslash s)/np - \mathbf{surpass}$	*Lex*
3.	$\mathsf{himself} : ((np\backslash s)/np)\backslash(np\backslash s) - \lambda z_2.\lambda x_3.((z_2\ x_3)\ x_3)$	*Lex*
4.	$\mathsf{surpassed} \circ \mathsf{himself} : np\backslash s - \lambda x_3.((\mathbf{surpass}\ x_3)\ x_3)$	$\backslash E\ (2,3)$
5.	$\mathsf{knuth} \circ (\mathsf{surpassed} \circ \mathsf{himself}) : s - ((\mathbf{surpass}\ \mathbf{knuth})\ \mathbf{knuth})$	$\backslash E\ (1,4)$

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- an expanded version of `\infer` from proof.sty, taking advantage of
- the `\stepwise` family of commands from Lehmke's texpower.sty package
- the kernel computes the sequencing order from the internal proof object, with bottom-up or top-down options

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Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

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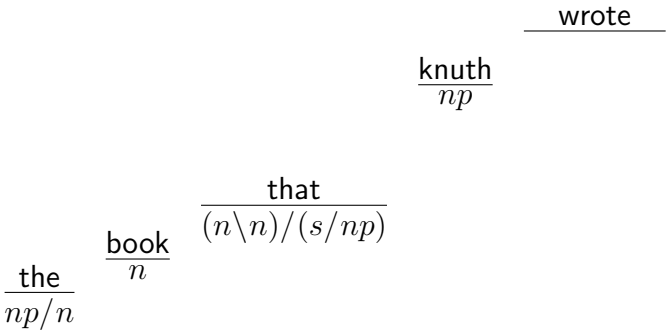

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$$\dfrac{\textsf{the}}{np/n} \quad \dfrac{\textsf{book}}{n} \quad \dfrac{\textsf{that}}{(n\backslash n)/(s/np)}$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

$$\dfrac{\dfrac{\dfrac{\textsf{knuth}}{np} \quad \dfrac{\dfrac{\textsf{wrote}}{(np\backslash s)/np} \quad [\textsf{p}_1 \vdash np]^1}{\textsf{wrote} \circ \textsf{p}_1 \vdash np\backslash s}\,[/E]}{\textsf{knuth} \circ (\textsf{wrote} \circ \textsf{p}_1) \vdash s}\,[\backslash E]}{}\,[P2]$$

$$\dfrac{\textsf{the}}{np/n} \quad \dfrac{\textsf{book}}{n} \quad \dfrac{\textsf{that}}{(n\backslash n)/(s/np)}$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

$$\dfrac{\text{knuth}}{np} \qquad \dfrac{\dfrac{\text{wrote}}{(np\backslash s)/np} \quad [\mathsf{p}_1 \vdash np]^1}{\text{wrote} \circ \mathsf{p}_1 \vdash np\backslash s}[/E]$$

$$\dfrac{\text{knuth} \circ (\text{wrote} \circ \mathsf{p}_1) \vdash s}{(\text{knuth} \circ \text{wrote}) \circ \mathsf{p}_1 \vdash s}[P2] \quad [\backslash E]$$

$$\dfrac{\text{that}}{(n\backslash n)/(s/np)}$$

$$\dfrac{\text{the}}{np/n} \qquad \dfrac{\text{book}}{n}$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

$$\dfrac{\dfrac{\mathsf{the}}{np/n}\quad\dfrac{\mathsf{book}}{n}}{\dfrac{\mathsf{that}}{(n\backslash n)/(s/np)}\quad\dfrac{\dfrac{\mathsf{knuth}}{np}\quad\dfrac{\dfrac{\dfrac{\dfrac{\mathsf{wrote}}{(np\backslash s)/np}\quad[\mathsf{p}_1\vdash np]^1}{\mathsf{wrote}\circ\mathsf{p}_1\vdash np\backslash s}\,[/E]}{\mathsf{knuth}\circ(\mathsf{wrote}\circ\mathsf{p}_1)\vdash s}\,[\backslash E]}{(\mathsf{knuth}\circ\mathsf{wrote})\circ\mathsf{p}_1\vdash s}\,[P2]}{}\,[/I]^1}$$

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13. Dynamic derivations: bottom up

$$\dfrac{\text{the}}{np/n} \quad \dfrac{\text{book}}{n} \quad \dfrac{\text{that}}{(n\backslash n)/(s/np)} \quad \dfrac{\dfrac{\dfrac{\dfrac{\text{knuth}}{np} \quad \dfrac{\dfrac{\text{wrote}}{(np\backslash s)/np} \quad [\mathsf{p}_1 \vdash np]^1}{\text{wrote} \circ \mathsf{p}_1 \vdash np\backslash s}[/E]}{\text{knuth} \circ (\text{wrote} \circ \mathsf{p}_1) \vdash s}[\backslash E]}{(\text{knuth} \circ \text{wrote}) \circ \mathsf{p}_1 \vdash s}[P2]}{\text{knuth} \circ \text{wrote} \vdash s/np}[/I]^1$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

$$\dfrac{\dfrac{\mathsf{the}}{np/n}\quad\dfrac{\mathsf{book}}{n}\quad\dfrac{\dfrac{\mathsf{that}}{(n\backslash n)/(s/np)}\quad\dfrac{\dfrac{\dfrac{\dfrac{\mathsf{knuth}}{np}\quad\dfrac{\dfrac{\mathsf{wrote}}{(np\backslash s)/np}\quad[\mathsf{p}_1\vdash np]^1}{\mathsf{wrote}\circ\mathsf{p}_1\vdash np\backslash s}\,[/E]}{\mathsf{knuth}\circ(\mathsf{wrote}\circ\mathsf{p}_1)\vdash s}\,[\backslash E]}{(\mathsf{knuth}\circ\mathsf{wrote})\circ\mathsf{p}_1\vdash s}\,[P2]}{\mathsf{knuth}\circ\mathsf{wrote}\vdash s/np}\,[/I]^1}{s/(n\backslash n)}\,[/E]}{s}\,[/E]$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

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$$\dfrac{\dfrac{\textsf{the}}{np/n}\quad\dfrac{\textsf{book}}{n}\quad\dfrac{\dfrac{\textsf{that}}{(n\backslash n)/(s/np)}\quad\dfrac{\dfrac{\dfrac{\textsf{knuth}}{np}\quad\dfrac{\dfrac{\textsf{wrote}}{(np\backslash s)/np}\quad[\mathsf{p}_1 \vdash np]^1}{\textsf{wrote} \circ \mathsf{p}_1 \vdash np\backslash s}\,[/E]}{\textsf{knuth} \circ (\textsf{wrote} \circ \mathsf{p}_1) \vdash s}\,[\backslash E]}{(\textsf{knuth} \circ \textsf{wrote}) \circ \mathsf{p}_1 \vdash s}\,[P2]}{\textsf{knuth} \circ \textsf{wrote} \vdash s/np}\,[/I]^1}{\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote}) \vdash n\backslash n}\,[/E]}$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

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13. Dynamic derivations: bottom up

$$
\dfrac{\mathsf{the}}{np/n}
\qquad
\dfrac{
\dfrac{\mathsf{book}}{n}
\quad
\dfrac{
\dfrac{\mathsf{that}}{(n\backslash n)/(s/np)}
\quad
\dfrac{
\dfrac{
\dfrac{
\dfrac{\mathsf{knuth}}{np}
\quad
\dfrac{\dfrac{\mathsf{wrote}}{(np\backslash s)/np} \quad [\mathsf{p}_1 \vdash np]^1}{\mathsf{wrote} \circ \mathsf{p}_1 \vdash np\backslash s}\,[/E]
}{\mathsf{knuth} \circ (\mathsf{wrote} \circ \mathsf{p}_1) \vdash s}\,[\backslash E]
}{(\mathsf{knuth} \circ \mathsf{wrote}) \circ \mathsf{p}_1 \vdash s}\,[P2]
}{\mathsf{knuth} \circ \mathsf{wrote} \vdash s/np}\,[/I]^1
}{\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}) \vdash n\backslash n}\,[/E]
}{\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote})) \vdash n}\,[\backslash E]
$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

13. Dynamic derivations: bottom up

$$\dfrac{\dfrac{\text{the}}{np/n} \quad \dfrac{\dfrac{\text{book}}{n} \quad \dfrac{\dfrac{\text{that}}{(n\backslash n)/(s/np)} \quad \dfrac{\dfrac{\dfrac{\text{knuth}}{np} \quad \dfrac{\dfrac{\text{wrote}}{(np\backslash s)/np} \quad [\mathsf{p}_1 \vdash np]^1}{\mathsf{wrote} \circ \mathsf{p}_1 \vdash np\backslash s}\,[/E]}{\mathsf{knuth} \circ (\mathsf{wrote} \circ \mathsf{p}_1) \vdash s}\,[\backslash E]}{(\mathsf{knuth} \circ \mathsf{wrote}) \circ \mathsf{p}_1 \vdash s}\,[P2]}{\mathsf{knuth} \circ \mathsf{wrote} \vdash s/np}\,[/I]^1}{\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}) \vdash n\backslash n}\,[/E]}{\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote})) \vdash n}\,[\backslash E]}{}\,[/E]$$

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Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

14. Dynamic derivations: top down

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$\mathsf{the} \circ (\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}))) \vdash np$

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14. Dynamic derivations: top down

$$\frac{}{\mathsf{the} \circ (\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}))) \vdash np}\ [/E]$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

14. Dynamic derivations: top down

$$\frac{np/n}{\mathsf{the} \circ (\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}))) \vdash np}\ [/E]$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

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$$\dfrac{\dfrac{}{np/n}}{\mathsf{the} \circ (\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}))) \vdash np}\,[/E]$$

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$$\dfrac{\dfrac{\mathsf{the}}{np/n} \qquad \mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote})) \vdash n}{\mathsf{the} \circ (\mathsf{book} \circ (\mathsf{that} \circ (\mathsf{knuth} \circ \mathsf{wrote}))) \vdash np}\,[/E]$$

Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

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$$\dfrac{\dfrac{\dfrac{\textsf{the}}{np/n} \qquad \dfrac{}{\textsf{book} \circ (\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote})) \vdash n}\,[\backslash E]}{\textsf{the} \circ (\textsf{book} \circ (\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote}))) \vdash np}\,[/E]$$

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$$\dfrac{\dfrac{\dfrac{\textsf{the}}{np/n} \quad \dfrac{\dfrac{\textsf{book}}{n} \quad \dfrac{\dfrac{\textsf{that}}{(n\backslash n)/(s/np)}}{\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote}) \vdash n\backslash n}\,[/E]}{\textsf{book} \circ (\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote})) \vdash n}\,[\backslash E]}{\textsf{the} \circ (\textsf{book} \circ (\textsf{that} \circ (\textsf{knuth} \circ \textsf{wrote}))) \vdash np}\,[/E]$$

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$$\dfrac{\dfrac{\mathsf{the}}{np/n}\quad\dfrac{\dfrac{\mathsf{book}}{n}\quad\dfrac{\dfrac{\mathsf{that}}{(n\backslash n)/(s/np)}\quad\dfrac{\dfrac{}{(\mathsf{knuth}\circ\mathsf{wrote})\circ\mathsf{p}_1\vdash s}\,[P2]}{\mathsf{knuth}\circ\mathsf{wrote}\vdash s/np}\,[/I]^1}{\mathsf{that}\circ(\mathsf{knuth}\circ\mathsf{wrote})\vdash n\backslash n}\,[/E]}{\mathsf{book}\circ(\mathsf{that}\circ(\mathsf{knuth}\circ\mathsf{wrote}))\vdash n}\,[\backslash E]}{\mathsf{the}\circ(\mathsf{book}\circ(\mathsf{that}\circ(\mathsf{knuth}\circ\mathsf{wrote})))\vdash np}\,[/E]$$

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Meaning. $\iota(\lambda y_3.(\mathbf{write}(\mathbf{knuth}, y_3) \wedge \mathbf{book}(y_3)))$

15. Internal proof term representation

```
N: 1 ; Mean: $\iota$(^K.(write(knuth,K) & book(K))) ;
rule(dre([]),(the *[](book *[](that *[](knuth *[]wrote)))),np,B(D(^E.H(E)(G))(C)),
[rule(lex,the,(np /[] n),B,[]),
rule(dle([]),(book *[] (that *[] (knuth *[] wrote))),n,D(^E.H(E)(G))(C),
[rule(lex,book,n,C,[]),
rule(dre([]),(that *[] (knuth *[] wrote)),(n \[] n),D(^E.H(E)(G)),
[rule(lex,that,((n \[] n) /[] (s /[] np)),D,[]),
rule(dri([],1),(knuth *[] wrote),(s /[] np),^E.H(E)(G),
[rule(P2,((knuth *[] wrote) *[] E),s,H(E)(G),
[rule(dle([]),(knuth *[] (wrote *[] E)),s,H(E)(G),
[rule(lex,knuth,np,G,[]),
rule(dre([]),(wrote *[] E),(np \[] s),H(E),
[rule(lex,wrote,((np \[] s) /[] np),H,[]),
rule(hyp(1),E,np,E,[])])])])])])])]),
Con: [],Subst: [$\iota$,book,3-^I.^J.^K.(I(K) & J(K)),knuth,write],  NV 8
```

16. Web interaction with the kernel

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17. Prolog command line interaction

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Consulting a fragment, parsing test sentences, producing LaTeX output `eg.tex` to be processed by a wrapper file `proofs.tex`

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```
SICStus 3.8.5 (sparc-solaris-5.7): Fri Oct 27 10:12:22 MET DST 2000
Licensed to let.uu.nl
| ?- consult('notcl2000.pl'). % the kernel without tcl/tk GUI
{consulting notcl2000.pl...}
yes
| ?- consult('knuth.pl').
{consulting knuth.pl...}
{consulted knuth.pl in module user, 20 msec 6952 bytes}
yes
| ?- tex([knuth,surpassed,himself],s).
===
Lookup: 0, Max # links: 12
===
Telling LaTeX output directory eg.tex
1 solution found. CPU Time used: 0.200 ... ... latex ready
```

18. From shell interaction to web interaction

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Unix $\rightsquigarrow$ shell interaction. The SICStus `save_program` predicate saves a state of the run of the program that can be resumed with the `-r` flag. In addition, arguments can be passed from the unix command line using the `-a` flag.

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```
% sicstus -r wwwgrailstate
-a knuth yes yes yes inactive nd s knuth surpassed himself
{restoring wwwgrailstate...}
{wwwgrailstate restored in 80 msec 513808 bytes}
{consulting knuth.pl...}
```

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Cgi $\rightsquigarrow$ web interaction. The `sicstus -r ... -a ...` call is realized via a cgi program, using the html or pdf form facilities.

19. Using Rahtz' **hyperref** package

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We can use the `\href` command of the hyperref package to call a cgi script:

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```
...
\hyperbaseurl{http://grail.let.uu.nl/cgi-bin/grail/}
\newcommand{\parsescript}[4]
{\href{wwwgrail.cgi?
frag=#1&struct=yes&sem=no&lexsem=yes&unary=inactive&mode=nd&goal=#2&test=#3}{#4}}
...
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...
```

The parameters for `\parsescript` are a fragment name (`#1`), a goal formula (`#2`), and the test expression, in cgi (`#3`) and print (`#4`) format. Sample sentences can now be evaluated/parsed on-line. `wwwgrail.cgi` sends back the typeset derivation, and the source file.

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```
...
\parsescript{whleft}{np}{de+soepschildpad+die+alice+wil+plagen}
{de Soepschildpad die Alice wil plagen} $\vdash  np$
```

20. Fragment libraries

The next step in the direction of the Mathematica ‘notebook’ concept:

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- Dynamic library. Users submit their individual fragments, which the Perl LWP module fetches from a specified URL.

21. hyperref form interaction

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```
\section{Interactive session}
\renewcommand{\LayoutTextField}[2]{\makebox[2in][l]{#1}#2}
\renewcommand{\LayoutChoiceField}[2]{\makebox[1.5in][l]{#1}#2}
\renewcommand{\LayoutCheckField}[2]{#1\makebox[1.5in][l]{#2}}
\renewcommand{\DefaultWidthofCheckBox}{12pt}
\renewcommand{\DefaultHeightofCheckBox}{12pt}

\begin{Form}[action=http://grail.let.uu.nl/cgi-bin/grail/wwwgrail.cgi,
       encoding=html,method=post]

\subsection*{Test example}
\TextField[width=3in,name=test]{Type in an example:}
\TextField[width=3in,name=goal]{Goal formula:}
...
\subsection*{Display options}
\ChoiceMenu[radio,default=yes,name=struct]{Structure labels:}{Yes=yes,No=no}
...
\Submit{\textsf{Submit}}\quad\Reset{\textsf{Reset}}
\end{Form}
```

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  - lets ask him ...

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