Machine Learning and Configurable Systems: A Gentle Introduction

(tutorial at SPLC'19)

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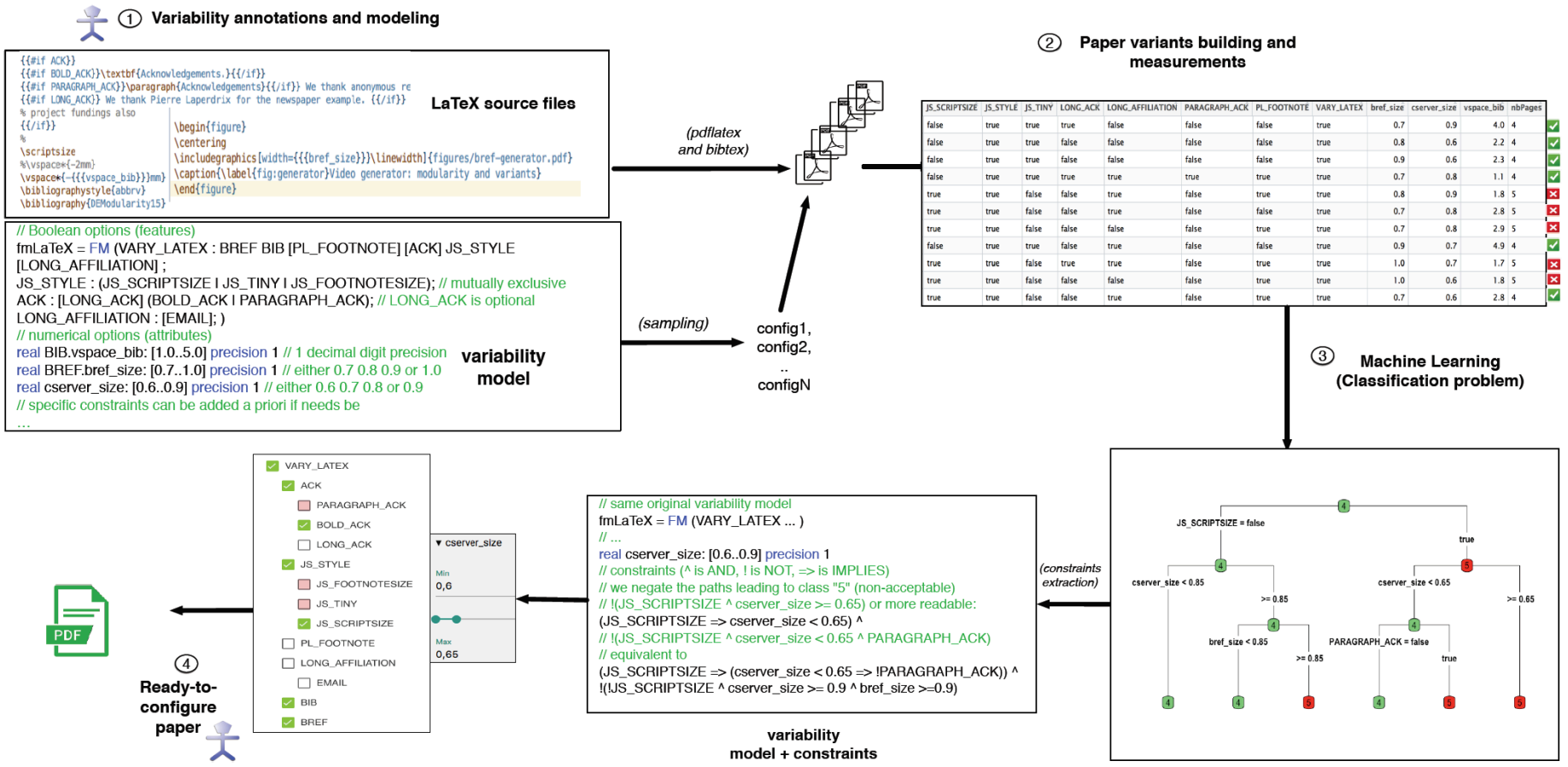
Paul Temple, Mathieu Acher

https://github.com/VaryVary/

VaryLaTeX exercice

- Instructions: https://github.com/VaryVary/ML-configurable-SPLCTutorial
- Execution of the script
- Explanations:
  - Accuracy: metrics, confusion matrix, flexibility vs safety
  - Interpretability: extraction of rules, decision tree algorithm (see also DT.pdf)
- Effect of
  - Training set size
  - Hyperparameters
  - Algorithms (eg random forest)

Process


① Variability annotations and modeling
LaTeX source files
{{#if ACK}}
{{#if BOLD_ACK}}\textbf{Acknowledgements.}{{/if}}
{{#if PARAGRAPH_ACK}}\paragraph{Acknowledgements}{{/if}} We thank anonymous re
{{#if LONG_ACK}} We thank Pierre Laperdrix for the newspaper example. {{/if}}
% project fundings also
{{/if}}
%
\scriptsize
%\vspace*{-2mm}
\vspace*{-{{{vspace_bib}}}mm}
\bibliographystyle{abbrv}
\bibliography{DEModularity15}
\begin{figure}
\centering
\includegraphics[width={{{bref_size}}}\linewidth]{figures/bref-generator.pdf}
\caption{\label{fig:generator}Video generator: modularity and variants}
\end{figure}
(pdflatex and bibtex)
② Paper variants building and measurements
JS_SCRIPTSIZE | JS_STYLE | JS_TINY | LONG_ACK | LONG_AFFILIATION | PARAGRAPH_ACK | PL_FOOTNOTE | VARY_LATEX | bref_size | cserver_size | vspace_bib | nbPages
false | true | true | true | false | false | false | true | 0.7 | 0.9 | 4.0 | 4
false | true | true | false | false | false | false | true | 0.8 | 0.6 | 2.2 | 4
false | true | true | false | false | false | false | true | 0.9 | 0.6 | 2.3 | 4
false | true | true | true | true | true | true | true | 0.7 | 0.8 | 1.1 | 4
true | true | false | false | true | false | true | true | 0.8 | 0.9 | 1.8 | 5
true | true | false | false | true | false | false | true | 0.7 | 0.8 | 2.8 | 5
true | true | false | false | false | false | true | true | 0.7 | 0.8 | 2.9 | 5
false | true | true | false | true | false | false | true | 0.9 | 0.7 | 4.9 | 4
true | true | false | true | true | false | true | true | 1.0 | 0.7 | 1.7 | 5
true | true | false | false | false | false | true | true | 1.0 | 0.6 | 1.8 | 5
true | true | false | false | true | false | true | true | 0.7 | 0.6 | 2.8 | 4
// Boolean options (features)
fmLaTeX = FM (VARY_LATEX : BREF BIB [PL_FOOTNOTE] [ACK] JS_STYLE [LONG_AFFILIATION] ;
JS_STYLE : (JS_SCRIPTSIZE I JS_TINY I JS_FOOTNOTESIZE); // mutually exclusive
ACK : [LONG_ACK] (BOLD_ACK I PARAGRAPH_ACK); // LONG_ACK is optional
LONG_AFFILIATION : [EMAIL];)
// numerical options (attributes)
real BIB.vspace_bib: [1.0..5.0] precision 1 // 1 decimal digit precision
real BREF.bref_size: [0.7..1.0] precision 1 // either 0.7 0.8 0.9 or 1.0
real cserver_size: [0.6..0.9] precision 1 // either 0.6 0.7 0.8 or 0.9
// specific constraints can be added a priori if needs be
...
variability model
(sampling)
config1,
config2,
..
configN
③ Machine Learning (Classification problem)
JS_SCRIPTSIZE = false
true
cserver_size < 0.85
>= 0.85
cserver_size < 0.65
>= 0.65
bref_size < 0.85
>= 0.85
PARAGRAPH_ACK = false
true
(constraints extraction)
// same original variability model
fmLaTeX = FM (VARY_LATEX ...)
// ...
real cserver_size: [0.6..0.9] precision 1
// constraints (^ is AND, ! is NOT, => is IMPLIES)
// we negate the paths leading to class "5" (non-acceptable)
// !(JS_SCRIPTSIZE ^ cserver_size >= 0.65) or more readable:
(JS_SCRIPTSIZE => cserver_size < 0.65) ^
// !(JS_SCRIPTSIZE ^ cserver_size < 0.65 ^ PARAGRAPH_ACK)
// equivalent to
(JS_SCRIPTSIZE => (cserver_size < 0.65 => !PARAGRAPH_ACK)) ^
!(!JS_SCRIPTSIZE ^ cserver_size >= 0.9 ^ bref_size >=0.9)
variability model + constraints
VARY_LATEX
ACK
PARAGRAPH_ACK
BOLD_ACK
LONG_ACK
JS_STYLE
JS_FOOTNOTESIZE
JS_TINY
JS_SCRIPTSIZE
PL_FOOTNOTE
LONG_AFFILIATION
EMAIL
BIB
BREF
▾ cserver_size
Min
0,6
Max
0,65
PDF
④ Ready-to-configure paper

AI#1 Logic, satisfiability, constraints, reasoning, solving

① **Variability annotations and modeling**

LaTeX source files

```
{{#if ACK}}
{{#if BOLD_ACK}}\textbf{Acknowledgements.}{{/if}}
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\bibliography{DEModularity15}
```

```
\begin{figure}
\centering
\includegraphics[width={{{bref_size}}}\linewidth]{figures/bref-generator.pdf}
\caption{\label{fig:generator}Video generator: modularity and variants}
\end{figure}
```

variability model

```
// Boolean options (features)
fmLaTeX = FM (VARY_LATEX : BREF BIB [PL_FOOTNOTE] [ACK] JS_STYLE
[LONG_AFFILIATION] ;
JS_STYLE : (JS_SCRIPTSIZE | JS_TINY | JS_FOOTNOTESIZE); // mutually exclusive
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real cserver_size: [0.6..0.9] precision 1 // either 0.6 0.7 0.8 or 0.9
// specific constraints can be added a priori if needs be
…
```

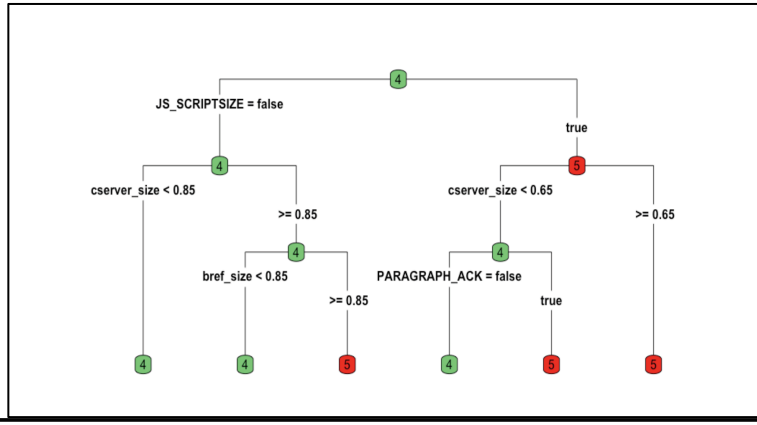
AI#2 Statistical, supervised machine learning (classification problem)

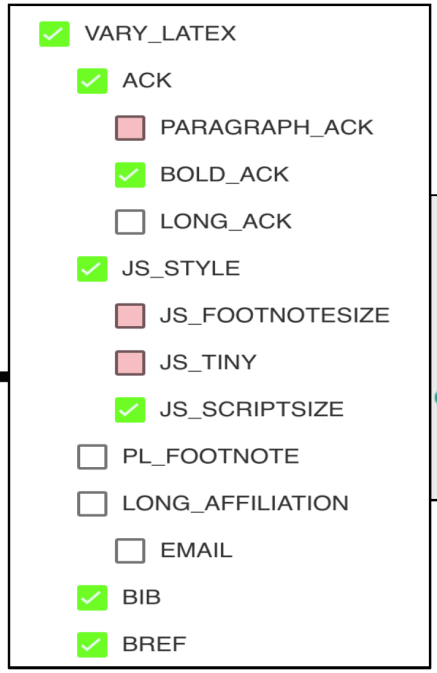
Paper variants building and measurements

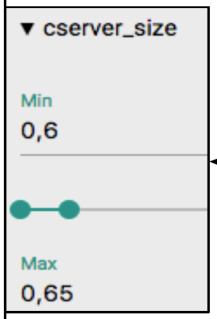
ONG_ACK	LONG_AFFILIATION	PARAGRAPH_ACK	PL_FOOTNOTE	VARY_LATEX	bref_size	cserver_size	vspace_bib	nbPages	
rue	false	false	false	true	0.7	0.9	4.0	4	✅
alse	false	false	false	true	0.8	0.6	2.2	4	✅
alse	false	false	false	true	0.9	0.6	2.3	4	✅
rue	true	true	true	true	0.7	0.8	1.1	4	✅
alse	true	false	true	true	0.8	0.9	1.8	5	❌
alse	true	false	false	true	0.7	0.8	2.8	5	❌
alse	false	false	true	true	0.7	0.8	2.9	5	❌
alse	true	false	false	true	0.9	0.7	4.9	4	✅
rue	true	false	true	true	1.0	0.7	1.7	5	❌
alse	false	false	true	true	1.0	0.6	1.8	5	❌
alse	true	false	true	true	0.7	0.6	2.8	4	✅

#AI1 + #AI2

Specialization of the variability model








```
// same original variability model
fmLaTeX = FM (VARY_LATEX ... )
// ...
real cserver_size: [0.6..0.9] precision 1
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// equivalent to
(JS_SCRIPTSIZE => (cserver_size < 0.65 => !PARAGRAPH_ACK)) ^
!(!JS_SCRIPTSIZE ^ cserver_size >= 0.9 ^ bref_size >=0.9)
```

variability

https://github.com/FAMILIAR-project/varylatex/

```
{{#if ACK}}
{{#if BOLD_ACK}}\textbf{Acknowledgements.}{{/if}}
{{#if PARAGRAPH_ACK}}\paragraph{Acknowledgements}{{/if}} We thank anonymous re
{{#if LONG_ACK}} We thank Pierre Laperdrix for the newspaper example. {{/if}}
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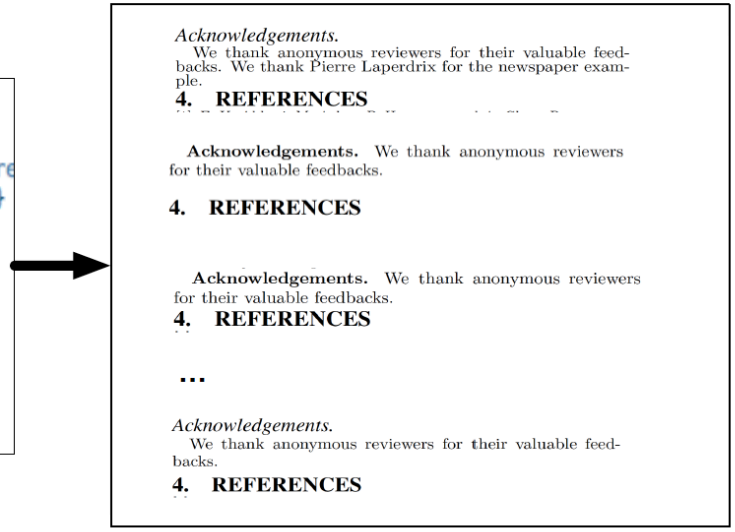

Variability and LaTeX source files

Paper variants (PDF)

(a) Variability annotations and excerpt of some possible paper variants

```
\lstdefinelanguage{JavaScript}{
  keywords={typeof, new, true, false, catch, function, return, null, catch, switch, var, if, in, while, do, else, case, break},
  keywordstyle=\color{blue}\bfseries,
  basicstyle=\ttfamily{{#if JS_SCRIPTSIZE}}\scriptsize{{/if}}{{#if JS_TINY}}\tiny{{/if}}{{#if JS_FOOTNOTESIZE}}\footnotesize{{/if}},
```

```
{{#if PL_FOOTNOTE}}\footnote{We are considering "product lines" in a broad sense,
```

```
\begin{figure}
\centering
\includegraphics[width={{{bref_size}}}\linewidth]{figures/bref-generator.pdf}
\caption{\label{fig:generator}Video generator: modularity and variants}
\end{figure}
```

(b) Users can vary the font size of a code snippet, activate a footnote, vary the font size of a figure, *etc.*

Classification tree