SKI: Symbolic Knowledge Injection

state of the art and our current works

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Definition

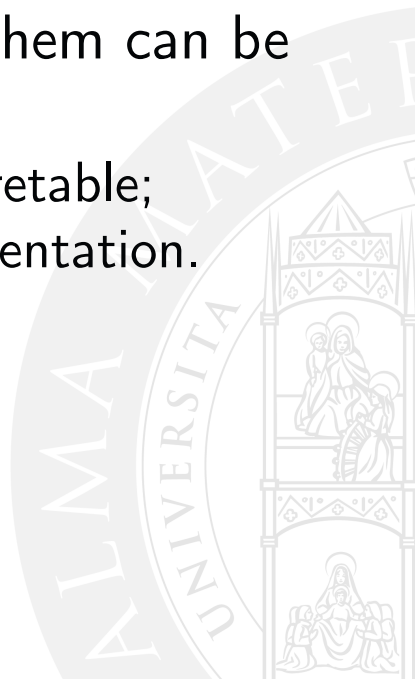
We define symbolic knowledge injection as:

> *any* **algorithmic** *procedure affecting how sub-symbolic predictors draw their inferences in such a way that predictions are either* **computed** *as a function of, or made* **consistent** *with, some* **given** *symbolic knowledge.*

Symbolic Knowledge

A symbolic representation consists of:

1. a set of symbols;
2. a set of grammatical rules governing the combining of symbols;
3. elementary symbols and any admissible combination of them can be assigned with meaning.
   - $\Rightarrow$ Symbolic knowledge is both human and machine interpretable;
   - First order logic (FOL) is an example of symbolic representation.



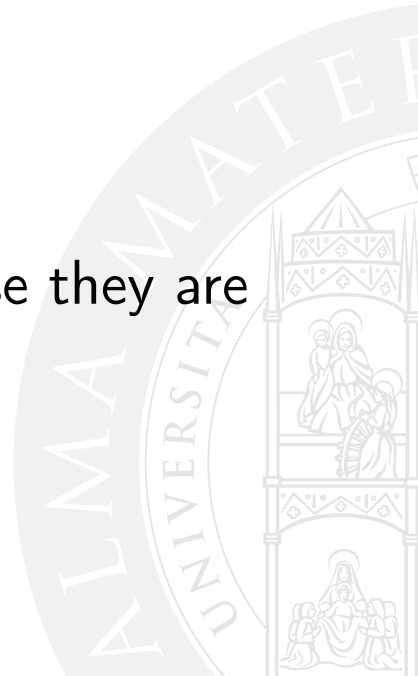
Sub-symbolic data

- ML methods, and sub-symbolic approaches in general, represent data as arrays of real numbers, and knowledge as functions over such data.
- Despite numbers are technically symbols as well, we cannot consider arrays and their functions as symbolic knowledge representation (KR) means.
- Sub-symbolic approaches frequently violate Items 2 and 3.

Sub-symbolic predictors

- deep neural networks (DNN);
  - Convolutional neural networks (CNN);
  - Recurrent neural networks (RNN).
- kernel machines;
- others.

The vast majority of predictors are NN most probably because they are easy to manipulate and they have top performances.



Why SKI

There are several benefits:

- reduce learning time;
- reduce the data size needed for training;
- improve predictor's accuracy;
- build a predictor that behave as a logic engine.

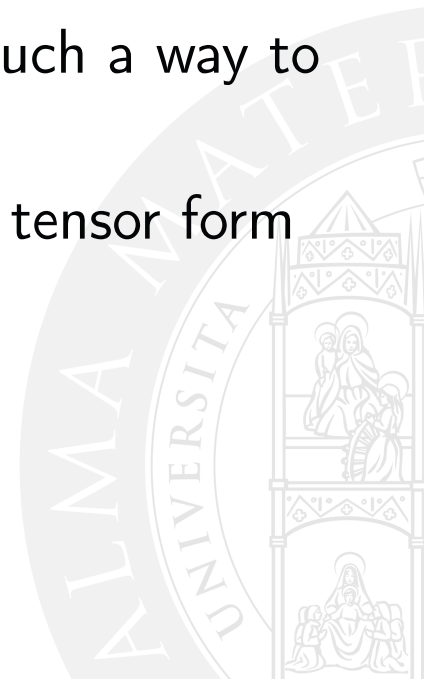
Aim

Predictors

How

There exist three major ways to perform knowledge injection on sub-symbolic predictors:

- constraining, a cost factor proportional to the violation of the knowledge is introduced during learning;
- structuring, the architecture of the predictor is built in such a way to mimic the knowledge;
- embedding, the symbolic knowledge is embedded into a tensor form and it is given in input as training data to the predictor.



Constraining

Structuring

Embedding

Logics

Files I

Style files

The files

- `beamercolorthemebolognafc.sty`
- `beamerthemeAMSBolognaFC.sty`
- `almacesena-background.pdf`

should be placed either in the local folder with the main `.tex` file, or, in your Beamer system directory, e.g.

- `/Users/{username}/Library/texmf/tex/latex/local/beamer/`

Files II

BST files

The files

- `apalike-AMS.bst`

should be placed either in the local folder with the main `.tex` file, or, in your Beamer system directory, e.g.

- `/Users/{username}/Library/texmf/bibtex/bst/local/`

Declaration

\documentclass

Your main Beamer `.tex` file should open with the declaration

```
\documentclass[presentation]{beamer}
    \mode<presentation>{\usetheme{AMSBolognaFC}}
```

so as to use the AMS Bologna FC Beamer style

Bibliography Style

apalike-AMS

Your main Beamer `.tex` file should include the declaration

```
\bibliographystyle{apalike-AMS}
```

so as to use the AMS Bologna FC BibTeX style

Template

AMSBolognaFC-template.tex

This template's sources can be used as a simple example of how yo use this Beamer style

Colours for AMS Bologna FC I

bolognafcblue

HEX #1A2F48

RGB 26,47,72

bolognafcred

HEX #A21C26

RGB 162,28,38

Colours for AMS Bologna FC II

bolognafcwhite

HEX #FFFFFF

RGB 255,255,255

bolognafcsilver

HEX #ECECEC

RGB 236,236,236

Blocks

This is a block environment

```
\begin{block}
...
\end{block}
```

This is an exampleblock environment

```
\begin{exampleblock}
...
\end{exampleblock}
```

This is an alertblock environment

```
\begin{alertblock}
...
\end{alertblock}
```

Citations I

\ccite command—e.g., [?]

```
\ccite{bibtex-patashnik88}
```

- to be used instead of standard \cite command
- prints as [?]
- can be used as a note[?], with no space before

Citations II

\cccite command—e.g., [?]

```
\cccite{bibtex-patashnik88}
```

- a lighter version of the `\ccite` command over non-dark, non-light backgrounds
  - as here above in `examplebox` header
- can be used as a note with no space before, in the same way as `\ccite`

URLs

\uurl command

- to be used instead of standard \url command

e.g. \uurl{http://apice.unibo.it} prints as http://apice.unibo.it

\uuurl command—e.g., http://apice.unibo.it

- to be used instead of standard \url command over dark backgrounds

e.g. see \uuurl{http://apice.unibo.it} above in this block header

Alert

\aalert command—e.g., *alerted text*

- to be used instead of standard \alert command over dark backgrounds

e.g. see \aalert{alerted text} above in this block header

Speaker(s) *vs.* Authors I

\speaker command–e.g., Diego Zorro

- to be used within \author standard BibTeX command to single out the actual speaker among the authors

e.g. as in

```
\author[Garcia \and Zorro]
{Sarg Garcia \and \speaker{Diego Zorro}}
```

- and in the author specification of this template

Speaker(s) *vs.* Authors II

`\sspeaker` command–e.g., *Diego Zorro*

- to be used within `\author` standard BibTeX command to single out the actual speaker among the authors in the short form

e.g. as in

```
\author[Garcia \and \sspeaker{Zorro}]
{Sarg Garcia \and \speaker{Diego Zorro}}
```

- and in the author specification of this template

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References