Teaching the Old AI Dog New Symbolic Tricks

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ALMA AI Foundations of AI – Kick Off Meeting
27 April 2021

Next in Line...

Playmates

Today

DISI Andrea Omicini, Enrico Denti, Giovanni Ciatto, Andrea Agiollo, Federico Sabbatini *(Bologna & Cesena)*

DSG Roberta Calegari, Giuseppe Pisano *(with Giovanni Sartor)*

Yesterday

DISI Antonio Natali, Mirko Viroli, Alessandro Ricci, Sara Montagna, Stefano Mariani, ... *(Cesena)*

DISI Ambra Molesini ... *(Bologna)*

Playgrounds I

EXPECTATION

- "Personalized Explainable Artificial Intelligence for decentralized agents with heterogeneous knowledge"
- CHIST-ERA 2019
- April 2021 – March 2024
- http://expectation.apice.unibo.it

Playgrounds II

StairWAI

- "Stairway to AI: Ease the Engagement of Low-Tech users to the AI-on-Demand platform through AI"
- ICT-49-2020 - Artificial Intelligence on demand platform
- H2020-ICT-2020-2
- 2021 – 2023
- http://cordis.europa.eu/project/id/101017142

Playgrounds III

AI4EU

- "A European AI On Demand Platform and Ecosystem"
- ICT-26-2018-2020 - Artificial Intelligence
- H2020-ICT-2018-2
- 2019 – 2021
- http://cordis.europa.eu/project/id/825619

Playgrounds IV

Electrolux Professional

- "Artificial Intelligence Object Detection from Real Time Images in Embedded Environments for Professional Food Service Appliances"
- one PhD student funded

Aim of the Game: Intelligent Systems Engineering (ISE)

Old-fashioned AI

- multi-agent systems (MAS) for *system engineering*
- computational logics (CL) for *intelligence*

Easy AI trends

MAS+ML learning agents

CL+ML hybrid approaches / *symbolic* + *sub-symbolic*

Our special requirements

- usable, up-to-date, maintained *technologies*
- software engineering methods
  - towards full-fledged *methodologies* for ISE

Next in Line...

Good Old LP I

Once upon a time...

- ... in the early logic programming (LP) era, there were unusable Prolog mammoths
- then tuProlog came along
  - `http://tuprolog.unibo.it`
  - *lightweight* and *minimal* [Denti et al., 2001]
  - *interoperable* through multi-paradigm programming [Denti et al., 2005]
- for AI over *small devices*
  - virtually non-existent twenty-five years ago

Good Old LP II

New tricks

- *breaking up the Prolog engine* into small pieces to inject microintelligence into IoT systems [Omicini and Calegari, 2019]
  - towards the Internet of Intelligent Things
- modelling and accessing them as logic-based services [Calegari et al., 2018]
  - Logic Programming as a Service (LPaaS)
    - `http://lpaas.apice.unibo.it`
- expanding the notion of LP *interactive programming* towards effective handling of *streams of data* [Ciatto et al., 2021]
  - based on the brand-new 2P-Kt technological reification of tuProlog (in Kotlin)
    - `https://github.com/tuProlog/2p-kt`

Good Old LP III

Our game now

- providing a uniform LP technological ecosystem for all the many techniques for *automated* (symbolic) *reasoning*
  - abductive, inductive, probabilistic, domain-specific/labelled, ...
- using tuProlog / 2P-Kt as the *reference technology*
  - beyond current state-of-the-art of logic programming technologies

  [Calegari et al., 2020a]
- providing *intelligent systems engineers* with the whole *toolkit* of CL techniques to be injected into components and devices of any sort
  - exploiting any single portion of the 2P-Kt ecosystem as an *independently-usable component*

Good Old MAS I

Once upon a time...

- *agents* and *multi-agent systems* (MAS) were not even considered a legitimate AI topic
- then
  1. their role as the main *sources of abstractions* and mechanisms for intelligent systems engineering (ISE) became common knowledge [Zambonelli and Omicini, 2004]
     - *meta-models* [Omicini et al., 2008] and agent-oriented software engineering (AOSE) *methodologies* [Omicini, 2001, Cernuzzi et al., 2014]
  2. CL for intelligent agents
  3. *agreement technologies* for intelligent agent *societies*
     - logic-based coordination with TuCSoN [Omicini and Zambonelli, 1999] and ReSpecT [Omicini and Denti, 2001]

Good Old MAS II

New tricks

- *nature-inspired coordination* (NIC) for social intelligence in self-organising MAS [Omicini, 2013]
  - cognitive stigmergy mixing *symbolic* and *sub-symbolic* interpretation of environmental traces for the coordination of weak and strong agents [Omicini, 2012]
  - knowledge self-organisation for knowledge-intensive systems [Mariani and Omicini, 2012]
  - *biochemical coordination* and *live semantic annotations* (LSA) for pervasive MAS coordination [Zambonelli et al., 2015]
- *artefact-based argumentation* [Oliva et al., 2008] as a MAS infrastructure

Good Old MAS III

Our game now

- full technological support to the many ways of agent argumentation
  - Arg2P [Pisano et al., 2020]
    - http://arg2p.apice.unibo.it
  - based on 2P-Kt
    - https://pika-lab.gitlab.io/argumentation/arg2p-kt/
- *argumentation* for decision support systems and intelligent system *interpretability* and *explainability*
  - by bridging logic and sub-symbolic techniques, argumentation as technical foundation for ethical AI systems [Calegari et al., 2021]
- explanation *not just for humans*
  - explanation as the *foundation for agent-to-agent communication* [Omicini, 2020]

Good Old ML I

Once upon a time...

- *no contribution at all* from ours
  - yet the field somehow managed to survive and even thrive
- *(we don't know how, thanks for asking anyway)*

New tricks

- possibly not so new
  - still using agents as the rightful place for ML (ISE-wise)
  - still mixing up symbolic and sub-symbolic [Calegari et al., 2020b]
  - still using CL/LP as our reference scientific and technical framework for symbolic techniques

Good Old ML II

Our game now

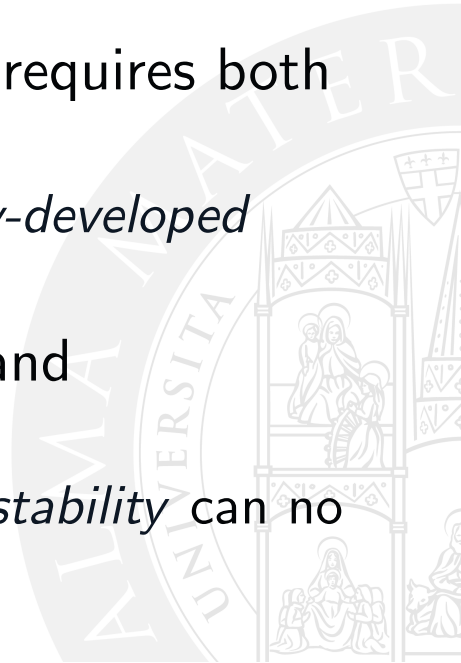
- harnessing deep learning (DL) complexity (size, computation) for small devices
  - Shallow2Deep [Agiollo et al., 2021]
    - https://github.com/AndAgio/Shallow2Deep
  - neural architecture search (NAS) soon in Electrolux Professional devices
- knowledge extraction as a means for drawing explanations
  - from sub-symbolic regressors to if-then-else rules
  - GridEx [Sabbatini et al., 2021]
    - https://github.com/sabbatinif/GridEx
- ML classifiers as *logic relations*
  - sub-symbolic classifiers as technological reification of Prolog predicates

Next in Line...

Still Mixing & Blending

- most of our work still leverages on computational logic and multi-agent systems at both the theoretical and the technological level
  - along with the many possible blends of symbolic and sub-symbolic techniques of any sort

  e.g. solutions can emerge from sub-symbolic approaches, then be mapped upon symbolic systems & used as such
- yet within a conceptual and technical framework that requires both *theoretical* and *methodological integrity*
  - looking towards the long-term establishment of a *fully-developed discipline* for intelligent systems engineering
- also accounting for non-trivial scenarios such as IoIT and *socio-technical systems* (STS)
  - where issues such as, say, *system engineering* and *trustability* can no way be addressed separately



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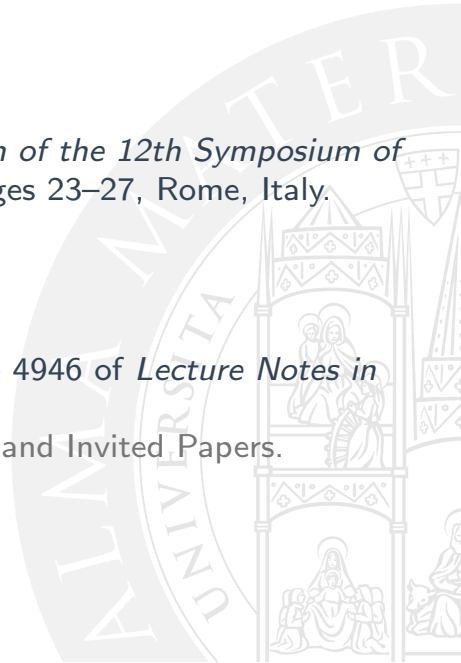

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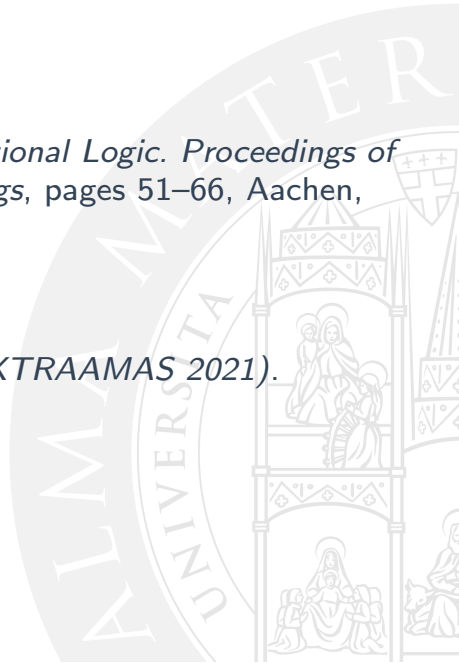

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