Groupe de réflexion "Automatique et IA" du GDR MACS

Christophe PRIEUR, Gipsa-lab

Congrès SAGIP et Journées Automatique
Novembre 2020

Initiative du GDR Macs

Contacts : Isabelle QUEINNEC et Dimitri PEAUCELLE
avec le GDR MACS

Questions

- Qu'est ce que l'IA ?
- Quelques points importants sur l'IA et Automatique ?
- Pourquoi ces liens sont importants pour l'automatique ? Pour l'IA ?
- Quels sont les succès dans ce domaine ?
- Quelles actions pourrait-on entreprendre ?

Participants au groupe de réflexion

3 animateurs

- Marion Gilson,
- Franck Plestan,
- Christophe Prieur.

Pour 3 groupes

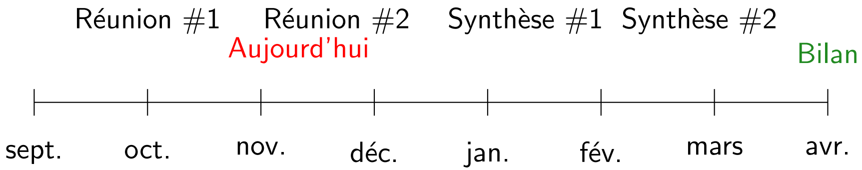
- Thierry Guerra (LAMIH), Jose-Alvaro Perez-Gonzalez (Thales), Franck Plestan (LS2N), Romain Postoyan (CRAN), Sophie Tarbouriech (LAAS),
- Sylvain Durand (ICube), Héléne Evain (CNES), Milan Korda (LAAS), Mihaly Petrecszky (Cristal), Christophe Prieur (Gipsa),
- Vincent Andrieu (Lagep), Martine Ganet-Schoeller (Groupe Ariane), Marion Gilson (CRAN), Antoine Girard (L2S), Guillaume Mercére (LIAS).

Organisation

Fonctionnement

- 2 réunions en sous-groupe
- puis réunion plénière avec synthèses successives
- synthèse avril 2021

Calendrier



Bilan à mi-parcours

Expérience très enrichissante.

Réunions:

- en sous-groupe non-thématique
- échanges informels, courts, *chacun présente à tout le monde*
- courte échéance

Premières réponses sur les liens IA et Automatique

Automatic control issues and solutions

Classical issues in automatic control

1. identification
2. simulation
3. observation
4. control and performance

for dynamical systems, in presence of uncertainties, heterogeneities, constraints...

Proposed solutions

1. reduced-order modeling
2. performance certifications
3. observation and control *could be* done separately
4. cascade, feedback and series are possible

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Opportunities

1. scientific computation
2. big data, sensors are everywhere
3. optimization and efficient algorithms
4. recording of long time-scale signals is possible

Proposed solutions

1. large neural networks
2. efficient applications
3. automatic learning and processing

Already many successes that were not possible 3 years ago.

An example of great success of AI

Matchmaking between AI and sismology

Recent work of Michel Campillo to detect seismic signals [Seydoux et al., *Nature Com.*; 2020]:

- uses [Agen, Mallat; 2014] wavelet on 10^{10} samples on a year for one station
- scattering network to compute clusters
- Human Intelligence is needed but Artificial Intelligence helps
- work in progress in sismology: 800 stations in Alps, on decades.

Matchmaking of Automatic Control and AI?
In both directions?

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Matchmaking of Automatic Control and AI?
In both directions?

In modelling and model reduction

For many physical problems, models are very complex, space-varying

AI techniques + Physical models allow to

- solve complex dynamical systems

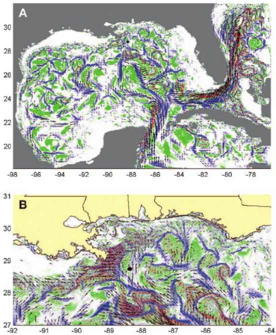
$$\begin{aligned} \dot{x} &= f(x) \\ y &= h(x) \end{aligned}$$

and to get training data

- fix the structure:

$$\begin{aligned} \dot{\hat{x}} &= A\hat{x} \\ y &= C\hat{x} \end{aligned}$$

- find the best A and C, by solving a convex problem



Gulf of Mexico with Kupman operator approach.

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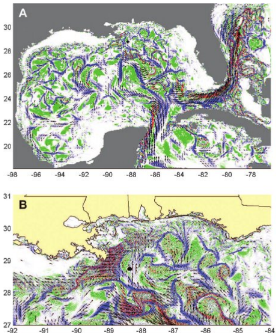

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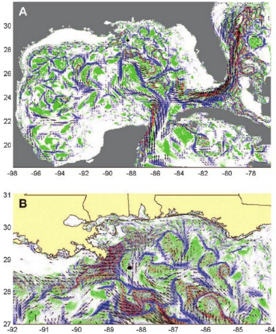
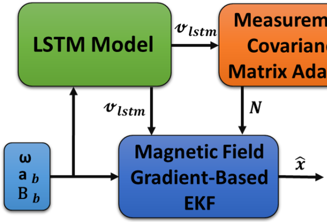


Gulf of Mexico with Kupman operator approach.

Other examples in observation and control

- Machine learning + Kalman filter for observation problem:



(see also some of these presentations)

- Learning + Adaptive Control for control design
  MPC+optimization
  Sensitivity analysis+control design for stability and performance (see Lina Guan's presentation)

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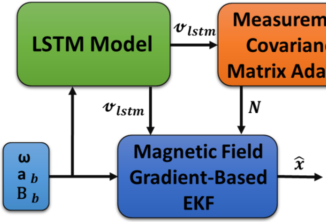

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What can control gain from AI?

A lot:

- Algorithmic
  Reinforcement learning / Iterative learning control / real time optimization
  Automatic differentiation
  Model reduction using AI
  System identification or parameter calibration
  Fictious measures for observation with machine learning
  Links with adaptative control
- Practical solutions to address control problems
- Hardware and architectures
  Tailored hardware and software for AI (e.g., Tensor Processing Units)
  Design control algorithms with such architectures in mind?

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What can control give to AI?

A lot, as well! (But maybe still to be better explained?)

- Some AI problems are control problems
  e.g., robot walking, or human-robot collaborative tasks, or robots catching flying objects
- Some AI problems have an intrinsic dynamical component
  e.g., video processing (Kalman filter, consensus approach)
  System theory for recurrent neural networks, reservoir computing
  Control theory to recurrent neural networks
  Why persistance of excitations in AI could help?
- Some AI tools need verification (safety, stability)
  e.g., Lyapunov techniques, barrier certificates, proofs of AI algorithms.

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Conclusion so far on Automatic Control and AI

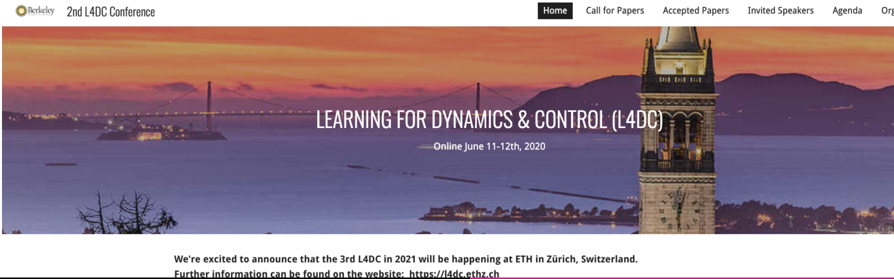
Already many and various successes in the French community. ✓

Not so many multidisciplinary research. ✗

Many opportunities ✓

but only a few participations to the French community to

- industrial transfer ✗
- international projects ✗
- international conferences ✗



Actions? What should we do?

Take-home messages

- Elaborated picture of links between AI and Control
- Actions to be done are under progress

- All comments are welcome to the working group

- Stay tuned until April!

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