



A Quick Look at the “Reinforcement Learning” course

A. LAZARIC (*SequeL Team @INRIA-Lille*)

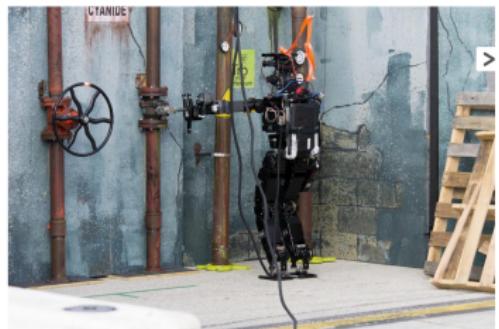
ENS Cachan - Master 2 MVA

Why

Why: Important Problems

Why: Important Problems

- ▶ Autonomous robotics



Why: Important Problems

- ▶ Autonomous robotics



- ▶ *Elder care*

Why: Important Problems

- ▶ Autonomous robotics



- ▶ *Elder care*
- ▶ *Exploration of unknown/dangerous environments*

Why: Important Problems

- ▶ Autonomous robotics



- ▶ *Elder care*
- ▶ *Exploration of unknown/dangerous environments*
- ▶ *Robotics for entertainment*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications



Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications



- ▶ *Trading execution algorithms*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications



- ▶ *Trading execution algorithms*
- ▶ *Portfolio management*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications



- ▶ *Trading execution algorithms*
- ▶ *Portfolio management*
- ▶ *Option pricing*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management



Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management



- ▶ *Energy grid integration*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management



- ▶ *Energy grid integration*
- ▶ *Maintenance scheduling*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management
 - ▶ *Energy grid integration*
 - ▶ *Maintenance scheduling*
 - ▶ *Energy market regulation*



Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management



- ▶ *Energy grid integration*
- ▶ *Maintenance scheduling*
- ▶ *Energy market regulation*
- ▶ *Energy production management*

Why: Important Problems

- ▶ Autonomous robotics
- ▶ Financial applications
- ▶ Energy management
- ▶ Recommender systems

A screenshot of a Google search results page for the query "bird houses". The search bar at the top contains "bird houses". Below it, there are tabs for "Web", "Show options...", and "Search Preferences". The results section shows 10 results out of approximately 22,100,000. The results are divided into "Sponsored Links" and "Organic Results".
Sponsored Links:

- Bird Houses** [www.Scotts.com](#) Scotts attracts colorful birds to your backyard!
- Specialty Bird Houses** [www.birds-out-back.com](#) Roosting Boxes, Purple Martins, Bat Chalets
- Bird Houses at BestNest** [www.bestnest.com](#) Over 225 different houses in stock. Free shipping!
- Learn More About Bird Houses** [www.JustBirdHouses.net](#) Learn more about blue bird houses and birdhouses, along with our blue bird house and purple martin bird houses.
- Bird Houses** [www.birdhouses101.com/](#) Bird Houses and Bird Feeders for north american bird species.
- Bird Feeders, Bird Houses - The Backyard Bird Company** [www.backyardbird.com/](#) Bird Feeders - The Backyard Bird Company has a variety of bird feeders will accent your landscape and attract wildlife.
- Bird Houses - Birdfeeders - Decorative Bird Houses** [www.backyardbird.com/](#) Bird Houses - Birdfeeders - Decorative Bird Houses

Organic Results:

- Bird Houses** [Find All Types Of Bird Feeders And Houses At Lowe's® New Lower Price](#) [www.Lowes.com](#)
- Bird Houses Sale** [Authorized Dealer - New Designs. Low Price Guarantee. Free Shipping](#) [www.OutdoorLivingShowroom.com](#)
- High Quality Bird Houses** [Nesting boxes & decorative houses 5-Star Service. Free Shipping \\$75+](#) [www.backyardbird.com](#)
- Decorative Bird Houses** [Beautify Your Garden With Our Wooden Bird Houses at a Discount](#) [BirdHouseStation.com](#)

Why: Important Problems

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- ▶ Energy management
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- ▶ *Web advertising*

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- ▶ *Web advertising*
- ▶ *Product recommendation*

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- ▶ *Web advertising*
- ▶ *Product recommendation*
- ▶ *Date matching*

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- ▶ Social applications



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- ▶ Recommender systems
- ▶ Social applications
- ▶ *Bike sharing optimization*



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- ▶ *Bike sharing optimization*
- ▶ *Election campaign*

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- ▶ *Bike sharing optimization*
- ▶ *Election campaign*
- ▶ *ER service optimization*

Why: Important Problems

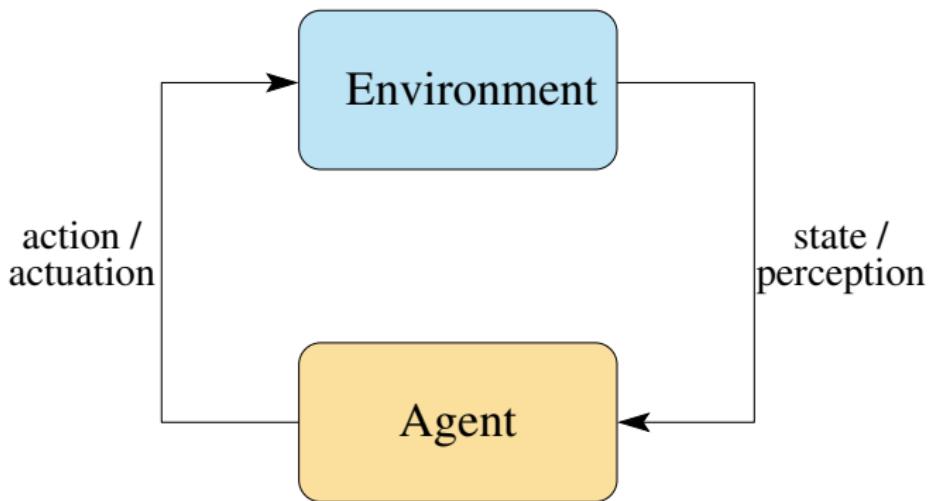
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- ▶ Energy management
- ▶ Recommender systems
- ▶ Social applications



- ▶ *Bike sharing optimization*
- ▶ *Election campaign*
- ▶ *ER service optimization*
- ▶ *Intelligent Tutoring Systems*

What

What: Decision-Making under Uncertainty



How: Reinforcement Learning

Reinforcement learning is learning what to do – how to map situations to actions – so as to **maximize** a numerical **reward** signal in an **unknown uncertain** environment. The learner is not told which actions to take, as in most forms of machine learning, but she must discover which actions yield the most reward by **trying them** (**trial-and-error**). In the most interesting and challenging cases, actions may affect not only the immediate reward but also the **next situation** and, through that, all **subsequent rewards** (**delayed reward**).

*“An introduction to reinforcement learning”,
Sutton and Barto (1998).*

How: the Course

How: the Course



How: the Course



How: the Course



How: the Course



Google search results for "bird houses".

Results 1 - 10 of about 22,100,000 for [bird houses](#) (0.19s)

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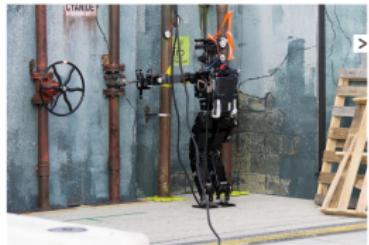
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[Google](#)

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[Learn More About Bird Houses](#)

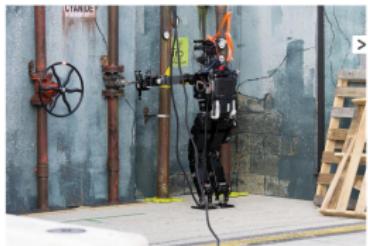
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Bird Feeders, Bird Houses, The Backyard Bird Company The Backyard Bird Company offers a variety of bird feeders will accent your landscape and attract wildlife. [Bird Houses - Birdhouses - Decorative Bird Houses](#) [www.backyardbird.com](#) - Click here - >>>

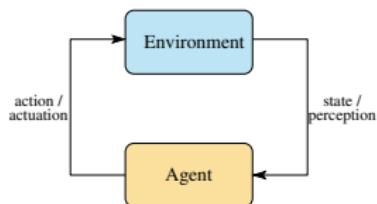


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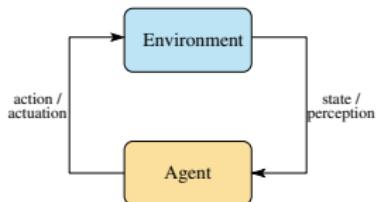


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 - Learn More About Bird Houses
 - Birdhouses 101
 - Bird Feeders, Bird Houses, The Backyard Bird Company
- Organic Search Results:**
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 - Decorative Bird Houses**
Birdhouses101.com - Birdhouses For Wooden Bird Houses at a Discount
BirdHouseStation.com



Formal and *rigorous* approach to
the RL's way to decision-making under uncertainty

What: the Highlights of the Course

How to *model* an RL problem

- ▶ *What*: Markov decision process
- ▶ *Tools*: probability, processes, Markov chain

What: the Highlights of the Course

How to *model* an RL problem

How to solve *exactly* an RL problem

- ▶ *What:* Dynamic programming
- ▶ *Tools:* fixed point, operators

What: the Highlights of the Course

How to *model* an RL problem

How to solve *exactly* an RL problem

How to solve *incrementally* an RL problem

- ▶ *What*: temporal difference, Q-learning
- ▶ *Tools*: stochastic approximation

What: the Highlights of the Course

How to *model* an RL problem

How to solve *exactly* an RL problem

How to solve *incrementally* an RL problem

How to *efficiently* explore in an RL problem

- ▶ *What:* multi-armed bandit problem
- ▶ *Tools:* concentration inequalities

What: the Highlights of the Course

How to *model* an RL problem

How to solve *exactly* an RL problem

How to solve *incrementally* an RL problem

How to *efficiently* explore in an RL problem

How to solve *approximately* an RL problem

- ▶ *What:* approximate dynamic programming
- ▶ *Tools:* statistical learning theory

What: the Highlights of the Course

How to *model* an RL problem

How to solve *exactly* an RL problem

How to solve *incrementally* an RL problem

How to *efficiently* explore in an RL problem

How to solve *approximately* an RL problem

With examples from *resource optimization, trade execution,*
(computer) games, recommendation systems.

When/What/Where

- ▶ 7 lectures
- ▶ 4 practical sessions (and homework) [*1 point each*]
- ▶ 1 final project (report and oral presentation) [*16 points*]

Opportunities for *spring internship* and *Ph.D.* positions.

When/What/Where

researchers.lille.inria.fr/~lazaric/Webpage/Teaching.html

Date	Topic	Classroom
29/09	Intro/MDP	Conference
06/10	Dynamic Programming	Condorcet
13/10	RL Algorithms	Condorcet
20/10	TP on DP and RL	Condorcet
27/10	Multi-arm Bandit (1)	Condorcet
03/11	TP on Bandit	Amphi Curie
10/11	Multi-arm Bandit (2) [projects]	Amphi Curie
17/11	TP on Bandit	Condorcet
24/11	Approximate DP	Condorcet
01/12	TP on ADP	Condorcet
08/12	Sample Complexity of ADP	Condorcet
15/12	Guest lecture	(TBD)
mid-Jan	Evaluation	(TBD)

Lectures are from 11am to 1pm, TP from 11am to 1:15pm.

Reinforcement Learning

Alessandro Lazaric
alessandro.lazaric@inria.fr
sequel.lille.inria.fr

