RAPORT_IND_TOTAL_Y - Raport indiv. total echiv. A

Anul: 2019

View Results

Download results in : Excel SpreadSheet CSV Text File XML File (1 kb)

View All First 1-1 of 1 Last

	Nume, Prenume	Departament	An	TOTAL_CERCETARE	TOTAL_DIDACTIC	Total
1	Busoniu,Ioan Lucian	Dep. Automatica	2019	85.82614	4.26000	90.08614

RAPORT_IND_TOTAL_Y - Raport indiv. total echiv. A

Anul: 2018

View Results

Download results in : Excel SpreadSheet CSV Text File XML File (1 kb)

View All First 1-1 of 1 Last

	Nume, Prenume	Departament	An	TOTAL_CERCETARE	TOTAL_DIDACTIC	Total
1	Busoniu,Ioan Lucian	Dep. Automatica	2018	55.93336	3.77220	59.70556

RAPORT_IND_TOTAL_Y - Raport indiv. total echiv. A

Anul: 2017

View Results

Download results in : Excel SpreadSheet CSV Text File XML File (1 kb)

View All First 1-1 of 1 Last

	Nume, Prenume	Departament	An	TOTAL_CERCETARE	TOTAL_DIDACTIC	Total
1	Busoniu,Ioan Lucian	Dep. Automatica	2017	27.09800	3.00000	30.09800

LABORATOIRE D'AUTOMATIQUE DE MECANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201

INSTITUT CARNOT ARTS

Invitation letter

To whom it may concern

I, Prof Thierry Marie Guerra, Director of the Laboratory LAMIH UMR CNRS 8201, University of Valenciennes and Hainaut Cambresis, invite Lucian Busoniu, Associate Professor at the Department of Automation at the Technical University of Cluj-Napoca, Romania to the LAMIH UMR CNRS 8201, University of Valenciennes, France, for a research visit over the period 11-19 February 2017.

This visit is to work on the topic of learning control approaches for an assistive wheelchair.

Valenciennes, January 16, 2017

LABORATOIRE D'AUTOMATIQUE DE MÉCANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES UMR CNRS 8201
Université de Valenciennes et du Hainaut-Cambrésis

Prof. Thierry Marie Guerra
Head of the LAMIH UMR CNRS 8201

LABORATOIRE D'AUTOMATIQUE DE MECANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201

INSTITUT CARNOT ARTS

INVITATION LETTER

I, Thierry Marie Guerra, Director of the LAMIH UMR CNRS 8201 at the University of Valenciennes and Hainaut Cambresis, hereby invite Lucian Busoniu from the Automation Department of the Technical University of Cluj-Napoca as an invited Professor, over the period 17-23 june 2018.

Valenciennes, March 15, 2018

LABORATOIRE D'AUTOMATIQUE DE MÉCANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201
Université de Valenciennes et du Hainaut-Cambrésis
cnrs
INSTITUT CARNOT ARTS

Prof. Thierry Marie Guerra
Head of LAMIH UMR CNRS 8201

LABORATOIRE D'AUTOMATIQUE DE MECANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201

INSTITUT CARNOT ARTS

Invitation letter

I, Thierry Marie Guerra, Director of the LAMIH UMR CNRS 8201 at the polytechnic University Hauts-de-France in Valenciennes hereby invite Lucian Busoniu from the Automation Department of the Technical University of Cluj-Napoca as an invited Professor, over the period 1—6 November 2019.

LABORATOIRE D'AUTOMATIQUE DE MÉCANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
UMR CNRS 8201
Université de Valenciennes et du Hainaut-Cambrésis

Valenciennes, September 11, 2019.

Prof. Thierry-Marie GUERRA
Head LAMIH - UMR CNRS 8201

Université Polytechnique HAUTS-DE-FRANCE

Université Polytechnique Hauts-de-France
Campus Le Mont Houy – 59313 Valenciennes Cedex 9
Tél. : 03.27.51.13.50
http://www.univ-valenciennes.fr

cnrs

TO WHOM IT MAY CONCERN

Hereby we declare that Lucian Busoniu, from the Automation Department of the Technical University of Cluj-Napoca, is a plenary invited speaker for ***3rd IFAC Conference on Embedded Systems, Computational Intelligence and Telematics in Control - CESCIT 2018***, that will take place from June 5 to 8, 2018, at University of Algarve, Faro, Portugal.

Faro, March 15th, 2018.

António Ruano
CESCIT 2018 Chairman

ACAI SUMMER SCHOOL ON REINFORCEMENT LEARNING

VUB Home

ACAI Summer School on Reinforcement Learning

Saturday, 7 October, 2017 - 08:00
to
Saturday, 14 October, 2017 - 18:00

Floreal Nieuwpoort
Albert I laan 74, 8620 Nieuwpoort
lmennes@vub.ac.be
https://ai.vub.ac.be/ssrl2017

Summer School

Organising Committee Members
Robert Babuska, TUDelft
Ann Nowe, Vrije Universiteit Brussel
Karl Tuyls, University of Liverpool
Dates
7 October 2017 till 14 October 2017 + optional introduction to Reinforcement Learning on 6th and 7th of October 2017

Theme
In this summer school we want to go beyond the basic introduction to RL and cover the more advanced topics as well, as it is exactly these more innovative subjects which have resulted in the recent successful applications of RL in areas such as robotics and computer games.

Following topics will be covered:
RL & function approximation
RL & speed up through demonstrations, shaping and inverse RL

RL & exploration and exploitation aspects (including some theoretical results on regret bounds)
RL for Multi-agent systems
RL & Deep learning
RL & batch and policy search approaches
Recent applications of RL

Concept
We opt for a location which offers full board, to create a real team spirit. Participants (who don't attent the 2 introdutory days) are expected to arrive on Saturday afternoon, October 7th, in the evening we will organize a social get together. On Sunday morning we plan a poster session by the participants, and in the afternoon an excursion. The actual lectures will start on Monday morning. Lecturers have been asked to include demonstrations and hands on exercises, wherever possible. We also explore the possibility of a friendly contest amongst the participants. The school will be finished by Friday evening, but the accommodation remains available till Saturday morning.

Confirmed lecturers
Lucian Busoniu, Technical University of Cluj-Napoca
Victor Lesser, University of Massachusetts Amherst
Remi Munos INRIA Lille and Google DeepMind
Jan Peters, Max Planck Institute for Intelligent Systems
Doina Precup McGill University
Hado van Hasselt, Google DeepMind

Location
The accommodation provides two bedroom apartments shared by 2 people (i.e. individual rooms). http://www.florealgroup.be/en/page/nieuwpoort-en.html
Individual accomodation is available upon request and subject to availibility.
Nieuwpoort is easy to reach by public transport. The necessary information will be provided the the participants.

Registration fee
The registration fee 670 euro. This registration fee includes full board accomodation form October 7th till October 14th in a 2 bedroom apartement shared by two participants (i.e. individual rooms).
We also provide a very basic introduction for those students with zero background in RL. This will be optional, and organised on Friday 5th and Saturday 6th .The extra cost will be 150 euro to cover the costs of the 2 extra days of full board accommodation.

Applications
Applications should be mailed to Lara Mennes, lmennes@vub.ac.be, and include : short motivation, 1 page cv and recommendation letter of supervisor (in case of students).
Please indicate if you are interested in the two basic RL introductory days.
Cutoff days: June 20th 2017 and August 31st 2017.

First name *

Family name *

Email *

LABORATOIRE D'AUTOMATIQUE DE MECANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201

INSTITUT CARNOT ARTS

INVITATION LETTER

I, Thierry Marie Guerra, Director of the LAMIH UMR CNRS 8201 at the University of Valenciennes and Hainaut Cambresis, hereby invite Lucian Busoniu from the Automation Department of the Technical University of Cluj-Napoca as an invited Professor, over the period 17-23 june 2018.

Valenciennes, March 15, 2018

LABORATOIRE D'AUTOMATIQUE DE MÉCANIQUE ET D'INFORMATIQUE INDUSTRIELLES ET HUMAINES
LAMIH UMR CNRS 8201
Université de Valenciennes et du Hainaut-Cambrésis
cnrs
INSTITUT CARNOT ARTS

Prof. Thierry Marie Guerra
Head of LAMIH UMR CNRS 8201

disc

www.disc.tudelft.nl

Mekelweg 2 = 2628 CD
Delft = The Netherlands

T +31 (0)15 278 55 72
E Secr-DISC-3ME@tudelft.nl

our reference	date	page
disc2019/101/MO	January 15, 2019	1/1

Subject
Letter of invitation

To whom it may concern,

I hereby invite Lucian Busoniu, from the Automation Department of the Technical University of Cluj-Napoca, to give lectures within the DISC winter course on reinforcement learning, to take place in Delft, the Netherlands. The invitation extends to the period 26--31 March, including travel.

With best regards,

Martha Otte
Office manager DISC

dutch institute
of systems
and control

南京大學
NANJING UNIVERSITY
Xianlin Avenue 163, Nanjing 210023, China

Ion-Lucian Busoniu
Technical University of Cluj-Napoca, Romania
Passport Number: 056064692
Citizenship: Romanian
Birthdate: 9 December 1979
Gender: Male

Dear Dr. Busoniu,

On behalf of the organization committee of the 3rd Asian Workshop on Reinforcement Learning (AWRL 2018), it is our pleasure to invite you to attend AWRL 2018, and give a 40 minutes invited speech at the workshop on the topic of reinforcement learning.

AWRL 2018 will be hosted in Beijing Jiaotong University at Nov. 14, 2018, in conjunction with the 10th Asian Conference on Machine Learning (ACML 2018). You are also invited to attend ACML 2018 during Nov. 14 - 16, to have communications with world-wide researchers in machine learning.

We will cover your hotel cost and the registration fee. Other expenses are covered by your end.

More information about AWRL 2018 can be found at http://www.acml-conf.org/2018 . Any questions please feel free to contact me.

Looking forward to meeting you in AWRL 2018!

Yours, sincerely

南京大学 计算机科学与技术系

A/Prof. Yang Yu
Department of Computer Science & Technology,
Xianlin Campus, Nanjing University.
Xianlin Avenue 163, Nanjing 210023, China
tel: +86-25-8968-0927
email: yuy@nju.edu.cn

东北大学工业与系统工程研究所
Institute of Industrial & Systems Engineering,
Northeastern University, China
Address: No. 11 Lane 3, Wenhua Road, Heping District, Shenyang, 110819 China

Invitation Letter

To: Professor Lucian Busoniu, male, Romania citizen, born in PETROŞANI, 9 December 1979, passport number 056064692.

Dear Professor Lucian Busoniu,

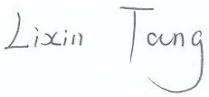
I sincerely invite you to visit the Institute of Industrial & Systems Engineering, Northeastern University, Shenyang, China, during 7 - 15 September 2019. During your visit, you will be staying at NEU International Hotel (No. 80, WenTiXi Road, Heping District, Shenyang, China).

I am honored to invite you to give speeches during your visit. Also, I will organize seminars to discuss our collaborative research.

I will cover all your visiting expenses, including flight, accommodation, etc. Also, allowance will be provided during your visit to China.

Looking forward to seeing you in Shenyang!

Sincerely,



Lixin Tang

==========
Lixin TANG Chair Professor/Vice President/Head /Director
Northeastern University
Operations Analytics and Optimization Center for Smart Industry
Institute of Industrial & Systems Engineering
Shenyang 110819 China
(O): 0086-24-83687772
(F): 0086-24-83687772
Homepage: http://iise.neu.edu.cn/home/TLI/en/
==========

Thèse de doctorat

Présentée en vue d'obtenir le grade de

Docteur de l'Université Polytechnique de Hauts-de-France

En **Automatique**

Présentée et soutenue par Guoxi FENG

Le 04/11/2019, à Valenciennes

Mobility aid for the disabled using unknown input observers and reinforcement learning

JURY:

Président du jury

Rapporteurs

Dugard, Luc. Directeur de Recherche CNRS GIPSA-Lab Grenoble, France.

Nowé, Ann. Professeure, Université Libre de Bruxelles, Belgique.

Examinateurs

Scherrer, Bruno. Professeur, Université de Lorraine, France.

Jean-Philippe Lauffenburger. Professeur, Université de. Haute-Alsace

Directeur de thèse

Guerra, Thierry-Marie. Professeur, Université Polytechnique de Hauts-de-France, France.

Busoniu, Lucian. Professeur, Technical University of Cluj-Napoca, Romania.

Thèse préparée dans le Laboratoire LAMIH (UMR CNRS 8201)

Ecole doctorale : Science Pour l'Ingénieur (SPI 072)

MINISTERUL EDUCAŢIEI NAŢIONALE

UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

Professor Lucian BUSONIU, PhD
Technical University of Cluj-Napoca, Faculty of Automation and Computer Science,
Department of Automation
Str. Memorandumului No. 28, 401114 Cluj-Napoca, Romania
Tel: +40749299890, Fax: +40264599893
Website: http://busoniu.net, E-mail: lucian.busoniu@aut.utcluj.ro

Our ref: 12597/20.05.2019

INVITATION

We have the pleasure to invite Ms. Xinyi Zhao, born on 9 april 1993, PhD student at the School of Electrical and Information Engineering, Tianjin University, to the Robotics and Nonlinear Control Group of the Department of Automation within the Technical University of Cluj-Napoca, Faculty of Automation and Computer Science, Romania, for a period no longer than 90 days during the interval **15 September 2019 – 31 December 2019**. The purpose is a research cooperation on the topic of fault detection and control of unmanned aerial vehicles. The guest's transport, accommodation and living expenses will be supported by a grant from the Tianjin University. The Technical University of Cluj-Napoca does not require tuition fees for this visit. The Technical University of Cluj-Napoca will provide accommodation in our facilities, specifically, at the Swimming Complex, Str. Splaiul Independenţei, between 15-30 September, and in the Mărăşti complex, Str. Fabricii de Zahăr 58, between 1 October and 31 December.

Note for the Embassy of Romania in China:
D-ra Xinyi Zhao, născută în 9 aprilie 1993, este invitată pentru o cooperare de cercetare la Universitatea Tehnică din Cluj-Napoca, pentru o durată totală de maximum 90 de zile în perioada 15 septembrie – 31 decembrie 2019. Transportul, cazarea, şi cheltuielile aferente sunt asigurate dintr-o bursă alocată de către Tianjin University. Universitatea Tehnică din Cluj-Napoca o va caza pe invitată în căminele sale, anume la Complexul de Natație, Str. Splaiul Independenţei între 15-30 septembrie, şi în complexul Mărăşti, Str. Fabricii de Zahăr 58, între 1 octombrie and 31 decembrie. În cazul în care persoana invitată refuză să părăsească teritoriul României, cheltuielile de repatriere vor fi suportate de către prof. univ. dr. Lucian Buşoniu.

Pentru informaţii suplimentare, vă rugăm să folosiţi următoarele date de contact: prof. univ. dr. Lucian Buşoniu, Departamentul de Automatică, Universitatea Tehnică din Cluj-Napoca, Memorandumului 28, 401114 Cluj-Napoca, România. Telefon: +40749299890, email lucian.busoniu@aut.utcluj.ro.

Prof.univ.dr. Lucian Buşoniu

Semnătura _____

Vizat:
Prorector, Relaţii Internaţionale, Cooperare, Educaţie Continuă
Prof. dr. ing. Silviu Dan Mândru

UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

Université Technique de Cluj-Napoca
28 Rue Memorandumului, 400114, Cluj-Napoca, Romania
Faculté d'Automatique et Génie Informatique

Date 12 mai 2020

N° de référence 11430

À l'attention de Monsieur : NDJE Martial
Étudiant en thèse de doctorat à l'Université de Ngaoundéré
Ville et pays de l'université d'origine : Ngaoundéré, Cameroun
Intitulé du projet de recherche : Commande prédictive dynamique matricielle quadratique d'un système rapide en temps réel par microcontrôleur

Attestation d'accueil

Votre dossier de pré-inscription pour une bourse « Eugen Ionescu » nous est bien parvenu.

Suite à l'analyse de ce dossier, nous avons le plaisir de vous annoncer que vous êtes accepté par notre université, au sein de la Faculté d'Automatique et Génie Informatique sous la direction scientifique de M. Lucian BUŞONIU, professeur des universités pour effectuer un stage de recherche qui se déroulera du 1 octobre 2020 au 28 décembre 2020 pour une durée totale de 3 mois.
Il vous revient à présent de déposer votre dossier complet de candidature auprès de l'Agence universitaire de la Francophonie, en vue de la sélection finale.

Les frais relatifs à votre séjour (matériels et expériences en laboratoire, assurance-maladie, logement, transport, éventuelles taxes pour l'obtention du permis de séjour etc.) ne sont pas pris en charge par l'université.

Autre mentions.-

En vous souhaitant une bonne réussite dans vos projets, nous vous prions d'agréer nos salutations distinguées.

Responsables administratifs

Monsieur Dan MÂNDRU
Fonction : Vice-recteur Relations Internationales
Signature et tampon :.....

Responsable scientifique
Monsieur Lucian BUŞONIU
Grade académique : Professeur
Faculté d'Automatique et Génie Informatique / Département d'Automatique
Signature :

MINISTERUL EDUCAȚIEI ȘI CERCETĂRII

UNIVERSITATEA TEHNICĂ
DIN CLUJ-NAPOCA

Facultatea/Direcția Cercetare CLUJ
Departamentul/Serviciul O R I Z O N T H 2 0 2 0
Nr. **11238** Data:**08.05.2020**

APROBAT
Ordonator Credite
Dan Pitica 12.05.2020
c60000447182
aprobat

REFERAT DE NECESITATE PENTRU ACHIZIȚIONAREA DE PRODUSE, SERVICII, LUCRĂRI

Tip produse, servicii, lucrări : **Tehnica de calcul si echipamente periferice**
Persoana de contact **Lucian Busoniu** Tel.: **0749299890** E-mail: **Lucian.BUSONIU@aut.utcluj.ro**

Scopul: **Cercetare, workstation, din proiect H2020 SeaClear 871295**

Nr Crt	Denumire produse/servicii/lucrări	Cod CPV	U.M.	Cant.	Preț unitar estimat (LEI inclusiv TVA)	Val estimata (LEI cu toate taxele incluse)	Articol bugetar (Nu se completeaza)
1	Workstation: HP Z1 G5 sau echiv, Win10 64 Pro, Intel i9 9900K, 2x32GB, GeForce RTX2080 8GB, 1TB M.2	30213300-8	buc	1.00	18,000.00	18,000.00	581602
TOTAL VALOARE cu toate taxele incluse (TVA, instalare, tranzit, etc) :						18,000.00	

Sursa bugetara: Sursa F

Sursa de finanțare:

ORIZONT H2020	**lista inv**

Decan, Director cercetare	Sef departament	Solicitant, Director Contract
Aprobat, **Ovidiu Nemes**	**Aprobat**, **Gabriela Vica Uglea**	**Depus**, **Lucian Busoniu**
11.05.2020, c60000445986 Da	**11.05.2020**, c60000445200, da, din pr.H2020 SeaClear (Dep.AUT), dir.pr.Busoniu Lucian	**08.05.2020**, c60000445187

Compartimentul de specialitate DGA	Compartimentul de contabilitate	Control financiar preventiv Director economic	Serviciul Contracte si Achiziții	Serviciul Aprovizionare
Aprobat **Cornel Muresan** Data: **12.05.2020** Id: **c60000446415**	**Aprobat** **Laura Rusu** Data: **12.05.2020** Id: **c60000446892**	**Aprobat** **Adriana Ochis** Data: **12.05.2020** Id: **c60000446970**	Data: Id:	Data: Id:
Rezolutia ok	Rezolutia ok, Lista investitii Fonduri speciale	Rezolutia lista inv	Rezolutia	Rezolutia

Acest document se completeaza, se trimite si se aproba exclusiv in format electronic.

ROBOTICS AND NONLINEAR CONTROL

Contact details

Name	**Robotics and Nonlinear Control**
Acronym	**ROCON**
Logo	ROCON ROBOTICS AND NONLINEAR CONTROL
Site	http://rocon.utcluj.ro/
Address	Dorobanţilor str 71-73, Cluj-Napoca, 400609, Romania
Faculty Department	Faculty of Automation and Computer Science Department of Automation
Telephone	+40 264 20 2578
Fax	+40 264 401 585
Director	Prof. Dr. Eng. Lucian Busoniu
E-mail	Lucian.Busoniu@aut.utcluj.ro

Areas of expertise

Our group works on **Ro**botics and Nonlinear **Con**trol (ROCON) at the Department of Automation of the Technical University of Cluj-Napoca. Our research interests range from mobile robotics and robot modeling, to fundamental nonlinear control and estimation using methods from computational and artificial intelligence. These two major directions are connected via applications of nonlinear control to robotics.

Team

Professors: Lucian Busoniu, group lead, Gheorghe Lazea, honorary member
Associate Professors: Zsofia Lendek, Levente Tamas
Assistant Professors: Alexandru Codrean, Cosmin Marcu, Tassos Natsakis
PhD and long-term research students: Ioana Lal, Amalia Matyas, Daniel Mezei, Zoltan Nagy
Technician: Adrian Lucaci

Representative projects (selection of 5 recent projects)

Search, Identification, and Collection of Marine Litter with Autonomous Robots (SeaClear), H2020 Research & Innovation Action, 2020-2023, PI Lucian Busoniu, https://seaclear-project.eu/

Estimation and control of delayed periodic systems: Application to engine optimization (ECOPACE), Young Teams grant, 2018-2020, PI Zsofia Lendek, http://lendek.net/TE11/

A Learning Aerial Guide for the Elderly and Disabled (AIRGUIDE), Young Teams grant, 2018-2020, PI Lucian Busoniu, http://airguide.busoniu.net/

Active perception for flexible manipulation in intelligent manufacturing (TEAMFIT), Bridge Grant, 2016-2018. PI Levente Tamas, http://rocon.utcluj.ro/~levente/?page_id=291

Biomechanically Enabled roboTic controlER for REstoring Human Ability (BETER REHAB), National Postdoctoral Grant, 2018-2020, PI Tassos Natsakis. https://beterrehab.eu/en/

Significant results

Selection of 5 representative publications in the past 5 years

L. Busoniu, J. Ben Rejeb, I. Lal, I.-C. Morarescu, J. Daafouz 2020, *Optimistic minimax search for noncooperative switched control with or without dwell time*. Automatica, vol. 112.

Frohlich R, Tamas L, Kato Z. 2019. *Absolute Pose Estimation of Central Cameras Using Planar Regions*. IEEE Transactions on Pattern Analysis and Machine Intelligence.

Boey H, Verfaillie S, Natsakis T, Sloten J Vander, Jonkers I. 2019. *Augmented Ligament Reconstruction Partially Restores Hindfoot and Midfoot Kinematics After Lateral Ligament Ruptures.* Am J Sports Med.

Feng G, Buşoniu L, Guerra T-M, Mohammad S. 2019. *Data-Efficient Reinforcement Learning for Energy Optimization of Power-Assisted Wheelchairs*. IEEE Transactions on Industrial Electronics. 66:97340–97344

Zs. Lendek, Z. Nagy, J. Lauber, *Local stabilization of discrete-time TS descriptor systems*. Engineering Applications of Artificial Intelligence, vol. 67, pages 409-418, 2018.

Patent: Automatic Obstacle Detection and Breaking System for Cars, nr A10006/16.02.2011: L. Tamas, Gh. Lazea.

What we offer to the economic environment

Research & development	Signal processing Control algorithms Monitoring and estimation Artificial intelligence and machine learning. Mobile robotics and robotic manipulation Advanced system control and monitoring Embedded software design
Consulting	Control system design and development Monitoring system design and development Robotic system design & engineering 2D and 3D mapping and surveys
Applied engineering services	Process and control engineering Robotics related services Process equipment related services
Training	Control and monitoring System identification Optimization and optimal control Computer integrated manufacturing Process equipment Industrial robotics Mobile vehicles

Simulation, Control, and Estimation for an Inverted Pendulum

We consider an inverted pendulum consisting of a weight attached to a disk, which is actuated by a DC motor and rotates in a vertical plane, see Figure 1. The inverted pendulum is interesting due to its nonlinear dynamics, and is a commonly used example in the control field.

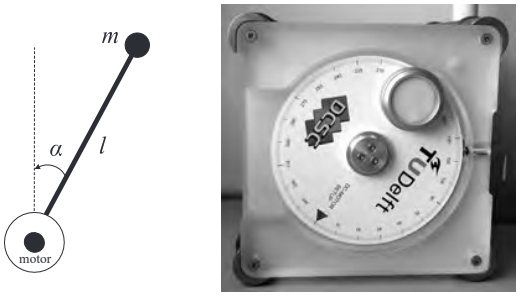


Figure 1: Inverted pendulum schematic (left) and the real system (right).

The continuous-time model of the pendulum dynamics is:

$$\ddot{\alpha} = 1/J \cdot [mgl \sin(\alpha) - b\dot{\alpha} - K^2\dot{\alpha}/R + Ku/R] \tag{1}$$

where $J = 1.91 \cdot 10^{-4}\,\mathrm{kgm}^2$, $m = 0.055\,\mathrm{kg}$, $g = 9.81\,\mathrm{m/s}^2$, $l = 0.042\,\mathrm{m}$, $b = 3 \cdot 10^{-6}\,\mathrm{Nms/rad}$, $K = 0.0536\,\mathrm{Nm/A}$, $R = 9.5\,\Omega$. The state vector is $x = [\alpha, v]^T$ where α is the angle and $v = \dot{\alpha}$ is the angular velocity, with the convention that $\alpha = 0$ represents the pointing-up position. The control action u is the voltage, and the motor supports a range of $[-10, 10]\,\mathrm{V}$. The goal is to stabilize the pendulum in the unstable equilibrium $x_{eq} = [0, 0]^T$ (pointing up).

The solution to the assignment consists of the resulting code and Simulink schemes, in a ZIP file; as well as a report in PDF. In your report, briefly describe the problems you solved, any significant choices you made during the implementation, outline your solution, and – most importantly – include the *results* you obtained (e.g., representative graphs of system trajectories) and *discuss* these results. Do not explain your code (or schemes) line by line, as that is not useful. Including literature research, the assignment is intended to take on the order of 20h of work, depending on your experience with Matlab, Simulink, and the methods involved.

Part 1: Modeling and Simulation

First, implement the original, nonlinear and continuous-time model of the pendulum (1) in Simulink. The model should take u as input, and produce the states α and v at the output. It should be possible to easily set (e.g. via Constant blocks) the initial conditions for the angle and angular velocity, and to observe the resulting state trajectories (via Scope, or export to workspace followed by plotting). Simulate trajectories with the model in the following conditions:

- $x(0) = [0.1, 0]^T$, $u(t) = 0$.
- $x(0) = [0, 0]^T$, $u(t)$ a random staircase sequence.
- $x(0) = [\pi, 0]^T$, $u(t)$ a similar random staircase sequence as above.

Think about how the trajectories should behave before running the simulation, and verify if your hypothesis is correct after running it. Debug the model to be sure that it is correct, as it will

form the basis of the other experiments. Hint: to implement the righthand side of (1), use a "user defined function" (Fcn) block.

Second, linearize the model analytically, on paper, around the unstable equilibrium $x_{eq} = [0, 0]^T, u_{eq} = 0$. Hint: to make things easier, linearize the differential equation (1) first, and only then rewrite the dynamics in the state space form. This should result in a continuous-time linear model of the form:

$$\dot{x} = A_c x + B_c u \tag{2}$$

Finally, discretize the linear continuous-time model with a sampling time of $T_s = 0.01\,\text{s}$, and using Euler discretization (and **not** c2d in Matlab, because that method will not preserve the physical meaning of the state variables!). You should end up with a discrete-time linear model of the form:

$$x_{k+1} = A_d x_k + B_d u_k \tag{3}$$

where $k = 0, 1, 2, \ldots$ is the current time step and $x_k = [\alpha_k, v_k]^T$.

Implement in Matlab code, without using Simulink this time, a simulator function for model (3) which takes as input the initial state x_0, an array $\mathbf{u}_N = (u_0, u_1, \ldots, u_{N-1})$ of N consecutive inputs, and produces the resulting state trajectories at the output. Use this function to simulate the linearized model with zero input and $x_0 = [0.1, 0]$. Compare the results with those obtained with the nonlinear system, at the first bullet point above. Do the results match your expectations? Explain.

Part 2: Control

Our goal here will be to control the pendulum so that it is maintained pointed upwards, in a range where the linearization stays valid. Consider the linearized continuous-time system (2), for which a state feedback control law is of the form:

$$u = -Fx \tag{4}$$

where the control gain F is computed such that the closed-loop system

$$\dot{x} = (A_c - B_c F)x \tag{5}$$

will be asymptotically stable. This can be achieved by *pole placement*, i.e., placing all the eigenvalues of the closed-loop system in the left-hand side of the complex plane, see Matlab function `place`.

After choosing suitable values for the closed-loop poles, compute the controller gain. To test that the controller is working correctly, i.e., that it stabilizes the linear system, implement system (2) together with the control law (4) in Simulink. Hint: use the state-space block, and set the output matrix `C` to identity so that the system outputs both states, which can then be seen on a Scope. Simulate the closed-loop system for different initial conditions. Once you have determined that the controller stabilizes the linear system, test the same controller on your Simulink implementation of the nonlinear system for several initial conditions in the range $0, \ldots, \pi$. Comparing to the linearized system, what happens as the initial conditions get further away from the linearization point (e.g., when they get close to π)?

Part 3: State Estimation

The real system only has a sensor for the angle (an encoder), and the angular velocity is not measurable. So, for example, the state feedback control above would not be directly implementable. Therefore, we will design and use an observer (state estimator) to recover this velocity from the angle measurements. In this part we will only use the linearized dynamics.

Consider the linear discrete-time model you obtained above together with the measurement

$$y_k = C_d x_k \tag{6}$$

Since only the angle is measured, $y_k = \alpha_k$ and so $C_d = [1,\ 0]$. The velocity needs to be estimated based on the system dynamics and this measurement. The dynamics of the observer are of the form

$$\begin{aligned} \hat{x}_{k+1} &= A_d\hat{x}_k + B_d u_k + L(y_k - \hat{y}_k) \\ \hat{y}_k &= C_d\hat{x}_k \end{aligned} \tag{7}$$

where the observer gain L is computed such that the estimation error dynamics

$$e_{k+1} = x_{k+1} - \hat{x}_{k+1} = (A_d - LC_d)e_k \tag{8}$$

is asymptotically stable. This is called a Luenberger observer.

Similarly to controller design, the gain L can be designed by suitably placing the poles of the error system. Comparing (8) to (5), one can observe that in both cases a matrix has to be computed, but the place of the matrix in the two equations is different. However, if one considers $(A_d - LC_d)' = A_d' - L'C_d'$ then this has the same form as (5). Therefore, for the transposed equation, one can use the same pole placement technique as for controller design, and the observer gain will be the transpose of the resulting matrix. Remember that this is a discrete-time system, and thus for stability the poles should be inside the unit circle!

After choosing suitable values for the poles, compute the observer gain. First test that the observer correctly estimate the states of the linearized discrete-time system for *zero input* and different initial conditions. Note that the "true" and estimated initial conditions should be different, since e.g. there is no practical way to know the initial angular velocity. Run the estimator also for the *controlled* system, where the inputs are computed with the controller found above: $u_k = Fx_k$ (even though this controller was designed with the continuous-time system in mind, it should work since the sampling time is small, which means that the discretized system approximates well the continuous-time one).

Reinforcement learning and nonlinear optimal control

Open Invited Track at IFAC World Congress 2020

Lucian Buşoniu [*] **Robert Babuška** [**]

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Reinforcement learning (RL) offers a principled way to control nonlinear stochastic systems with partly or even fully unknown dynamics, modeled as Markov decision processes. The primary objective is to optimize a cumulative performance index. Over the last decade, the integration of deep neural networks and deep learning techniques into RL has led to the highly successful field of deep RL, with impressive applications in robotics, artificial intelligence and game playing, automotive systems, etc. Alongside deep RL, more classical approaches to solve Markov decision processes keep advancing, such as those from optimal control, adaptive dynamic programming (ADP), policy search, etc. This open track provides a forum of interaction and an outlet for all areas of RL for control, from deep RL to more classical optimal control techniques. We welcome both algorithmic and analytical contributions, as well as applications in engineering, artificial intelligence, operations research, economics, medicine, and other relevant fields. We moreover invite surveys by established researchers in the field.

We are especially interested in the promising interactions between artificial-intelligence and control-theoretic approaches to RL, with the open issues they entail, including stability and robustness of RL techniques. Synergy between artificial intelligence and control theory in RL can lead to major breakthroughs such as computationally efficient algorithms with strong, simultaneous performance and stability guarantees.

Topics of interest include, but are not limited to:

- RL and nonlinear optimal control methods
- Deep RL
- Adaptive dynamic programming
- Performance and complexity analysis of RL and nonlinear optimal control
- Stability analysis of RL and nonlinear optimal control
- Multiagent and distributed RL
- Model-based and model-learning techniques
- Hybrid RL and ADP
- Policy search methods
- Partially observable Markov decision processes
- Exploration techniques
- Applications of RL and ADP
- Other novel perspectives, e.g. neuroscience-inspired methods

For additional information and updates, see the website of the open track at `http://busoniu.net/rltrack2020`.

Technical Committee: **TC3.2 - Computational Intelligence in Control**.

Subject: Jury Invitation: Ph.D. defense of Edouard Leurent (Inria Lille)
From: Odalric Maillard <odalric.maillard@inria.fr>
Date: 29-Jun-20 11:57 AM
To: lucian@busoniu.net
CC: Efimov Denis <Denis.Efimov@inria.fr>

Hello Lucian,

It's been a while since we met at SequeL. I hope this recent confinement time was not too complicated for you and that it leads to fruitful thoughts.

I would like to invite you to be part of the Jury for the Ph.D. defense of Edouard Leurent, who is coadvised by Denis Effimov from the Valse team (control theory, interval predictors) and myself from SequeL (soon becoming SCOoL) on the reinforcement learning and statistical part, both at Inria Lille. Edouard did his Ph.D. also with the car-company Renault, as his topic is on autonomous vehicles.
Unlike people trying to do some end-to-end deep learning approach based on visual inputs and computer vision, here the approach is more high-level, considering the agent is given a scene description (road information + objects positions,speeds,types), and the goal is to provide a safe control policy in the context where one has to interact with other vehicles and anticipate their move/reactions. Ideally, this would be applied on real vehicles as well (but later).

You will find more information on his webpage: http://edouardleurent.com, especially regarding publications, and the highway environment he introduced https://github.com/eleurent/highway-env. He also introduced some exciting novel ideas (under submission at Neurips) about planning, revisiting optimistic planning and MCTS from a graph-based perspective (introducing e.g. Monte Carlo Graph Search).

Due to your long expertise in the related fields of reinforcement learning, planning and control, it would be great if you could accept to be one of the two official reviewers for his Ph.D. (As you may remember in France, the reports written by the reviewers are quite important, as they follow the candidate during all his/her research career).

We woud like to plan the defense somewhere in October. Of course, depending on your availability at that time and circumstances due to the virus, this can be held remotely.

Best,
Looking forward to getting your positive answer,
Odalric-Ambrym

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Subject: Re: invitation for PhD committee of Jia Xu
From: Bart De Schutter <b.deschutter@tudelft.nl>
Date: 3/8/2018 12:50 PM
To: Lucian Busoniu <lucian@busoniu.net>
CC: Ton van den Boom <a.j.j.vandenBoom@tudelft.nl>, Bart De Schutter <b.deschutter@tudelft.nl>
X-Account-Key: account2
X-UIDL: 0000a71f4e92acf5
X-Mozilla-Status: 0011
X-Mozilla-Status2: 00000000
Return-path: <b.deschutter@tudelft.nl>
Envelope-to: lucian@busoniu.net
Delivery-date: Fri, 03 Aug 2018 11:50:16 +0200
Received: from mailservice.tudelft.nl ([130.161.131.5]) by ikdirectadmin10.ikoula.com with esmtps (TLSv1.2:ECDHE-RSA-AES256-GCM-SHA384:256) (Exim 4.90) (envelope-from <b.deschutter@tudelft.nl>) id 1flWiu-0005aD-Dr for lucian@busoniu.net; Fri, 03 Aug 2018 11:50:16 +0200
Received: from localhost (localhost [127.0.0.1]) by amavis (Postfix) with ESMTP id A03F4240076 for <lucian@busoniu.net>; Fri, 3 Aug 2018 11:50:15 +0200 (CEST)
X-Virus-Scanned: amavisd-new at tudelft.nl
X-Spam-Flag: NO
X-Spam-Score: -20.99
X-Spam-Status: No, score=-20.99 tagged_above=-99 required=5 tests=[ALL_TRUSTED=-1, BASW_FROM=0.01, TUD_REL01=-20] autolearn=ham
Received: from mailservice.tudelft.nl ([130.161.131.71]) by localhost (tudelft.nl [127.0.0.1]) (amavisd-new, port 10026) with ESMTP id aJryOBejCAEs; Fri, 3 Aug 2018 11:50:14 +0200 (CEST)
Received: from smtp-a.tudelft.nl (smtp-a.tudelft.nl [131.180.190.158]) by mx4.tudelft.nl (Postfix) with ESMTP id ECD7724005D; Fri, 3 Aug 2018 11:50:14 +0200 (CEST)
Received: from [192.168.0.241] (94-226-71-23.access.telenet.be [94.226.71.23]) (using TLSv1.2 with cipher ECDHE-RSA-AES128-GCM-SHA256 (128/128 bits)) (No client certificate requested) by smtp-a.tudelft.nl (Postfix) with ESMTPSA id BDB1021E72; Fri, 3 Aug 2018 11:50:14 +0200 (CEST)
References: <b913c544-3985-6f12-ec1c-fd0341150199@tudelft.nl> <58A6C285.6000206@busoniu.net>
Message-ID: <733a2fab-d39c-86f4-ed13-5fdff3468a51@tudelft.nl>
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:52.0) Gecko/20100101 Thunderbird/52.9.1
MIME-Version: 1.0
In-Reply-To: <58A6C285.6000206@busoniu.net>
Content-Type: text/plain; charset=windows-1252; format=flowed
Content-Language: en-US
Content-Transfer-Encoding: 7bit
X-Antivirus-Scanner: Seems clean. You should still use an Antivirus Scanner

Dear Lucian,

after some period of inactivity Jia has now almost completed
the draft of the PhD thesis.

Hereby we would like to invite you once more to participate in
the PhD committee of Jia Xu, who is doing her PhD research on
"Optimization and Model-Based Control for Max-Plus Linear and
Continuous Piecewise Affine Systems", where in particular
optimistic optimization is considered.

The new planning goes as follows
* the draft of the PhD thesis will be sent to the committee by the
  beginning of September
* we then expect to receive the feedback of the committee by the
  beginning of October
* the PhD defense will then take place in December or January
  with the date being planned in consultation with all the
  committee members.

We hope that you will be willing to accept this invitation. Please
feel free to contact us in case you require additional information
before being able to reply to this invitation.

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