Research, innovation and society, human change, ecological transition

May 2019

Keywords: research and innovation, democracy, human change, ecological transition

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Complex hybrid analysis

Process of co-innovation

Basic and applied research

Research and innovation in a democratic society

- Epistemo-ethical analysis
- Contextual technology and engineering
- Dynamics of (co-)research and (co-)innovation
- Deliberative-participative democracy
- Public debates, citizens juries, governance devices
- Experts-citizens/designers-users dialogue
- Co-production of knowledge and norms

Human change and ecological transition

- Humans / non-humans mediations
- Systems of mediation (ideology, ontology,…)
- Factors and levers of human change
- Human change, ICT, Artificial Intelligence
- Industrial and societal revolutions

Industrial, environmental and societal change

Skills applied

- Philosophy, logic, dialectics
- Experimental / ordinary philosophies
- Complex, contextual and hybrid analysis
- Methodology of research and innovation
- Theory and practice of democracy
- Models and devices of co-production
- Constructive and de/re-constructive dialogue

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Mobile Robotics Packing Demonstrator to pack items on pallets under optimization constraints and Machine Learning

Keywords : Robotics, mobile, ROS, optimization, logistics, packing, constraints programming,

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Collaboration In progress with : IEMN laboratory (*Institutd'électronique de microélectronique et de nanotechnologie*)

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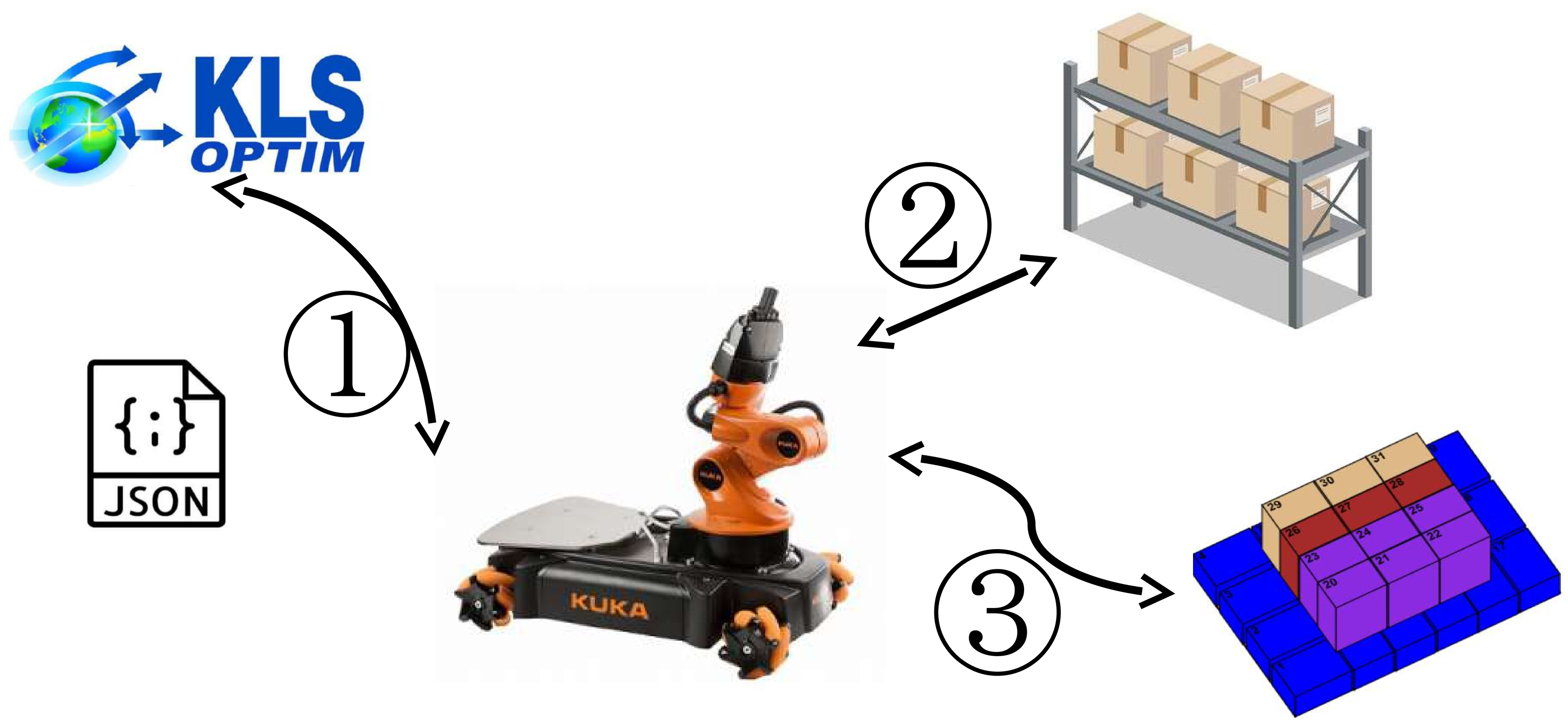
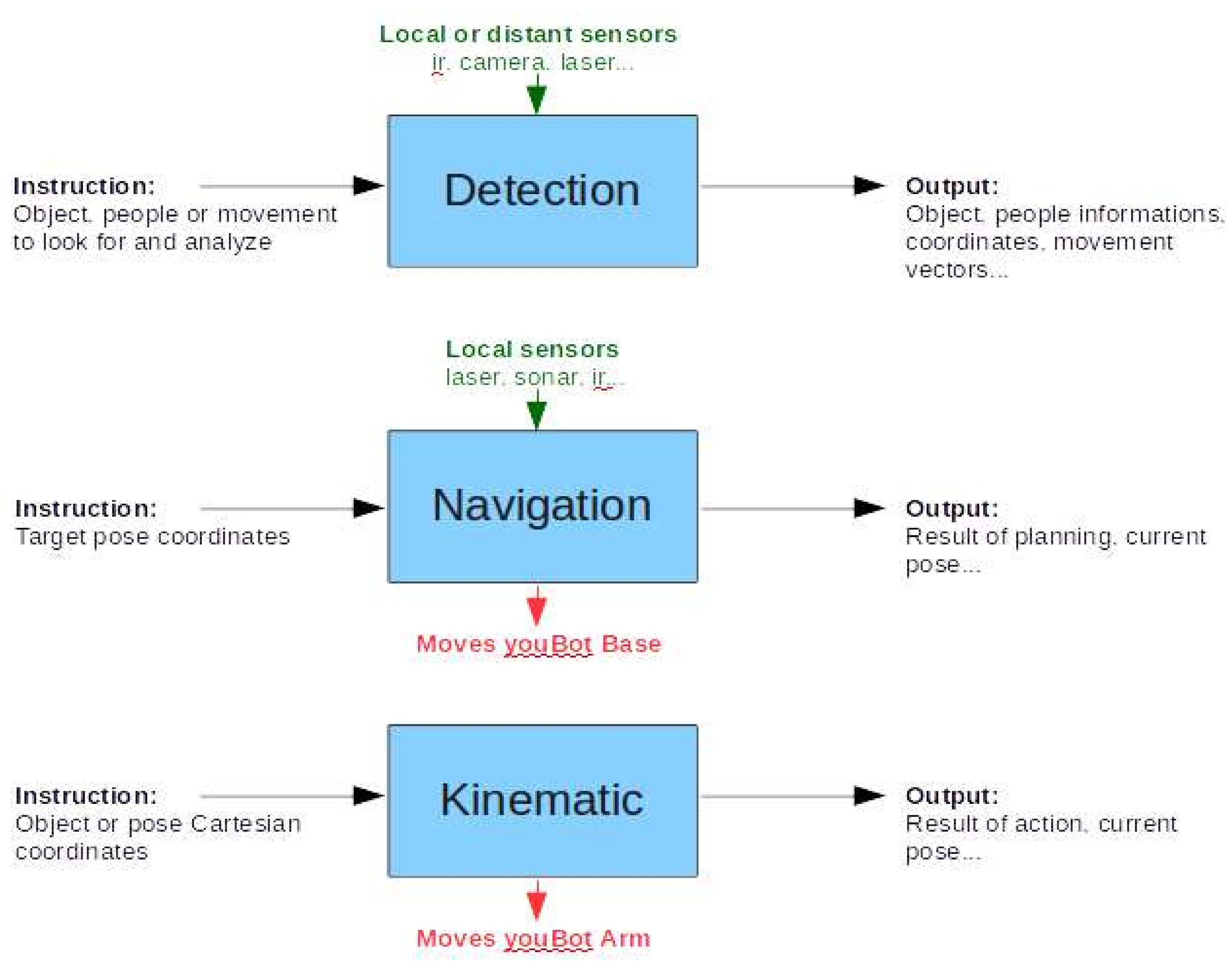


Context

As part of a research project, ICAM has created a demonstrator, to explain the introduction of human factor in commanding an industrial robot KUKA YouBot. This project replicates Autonomous handling system for mobile robots. The second consequential project is to implement this ROS application over different variety of robot



research purpose

- Smart man machine communication.

- Development of an ontology-based system for warehouse logistics and pallet traceability,

- Deploying a knowledge base to organize information about warehouse locations and physical flows into knowledge bases as business rules.

- Proposed methodologies for automating the transformation of database information into business rules in order to build knowledge base based on machine learning

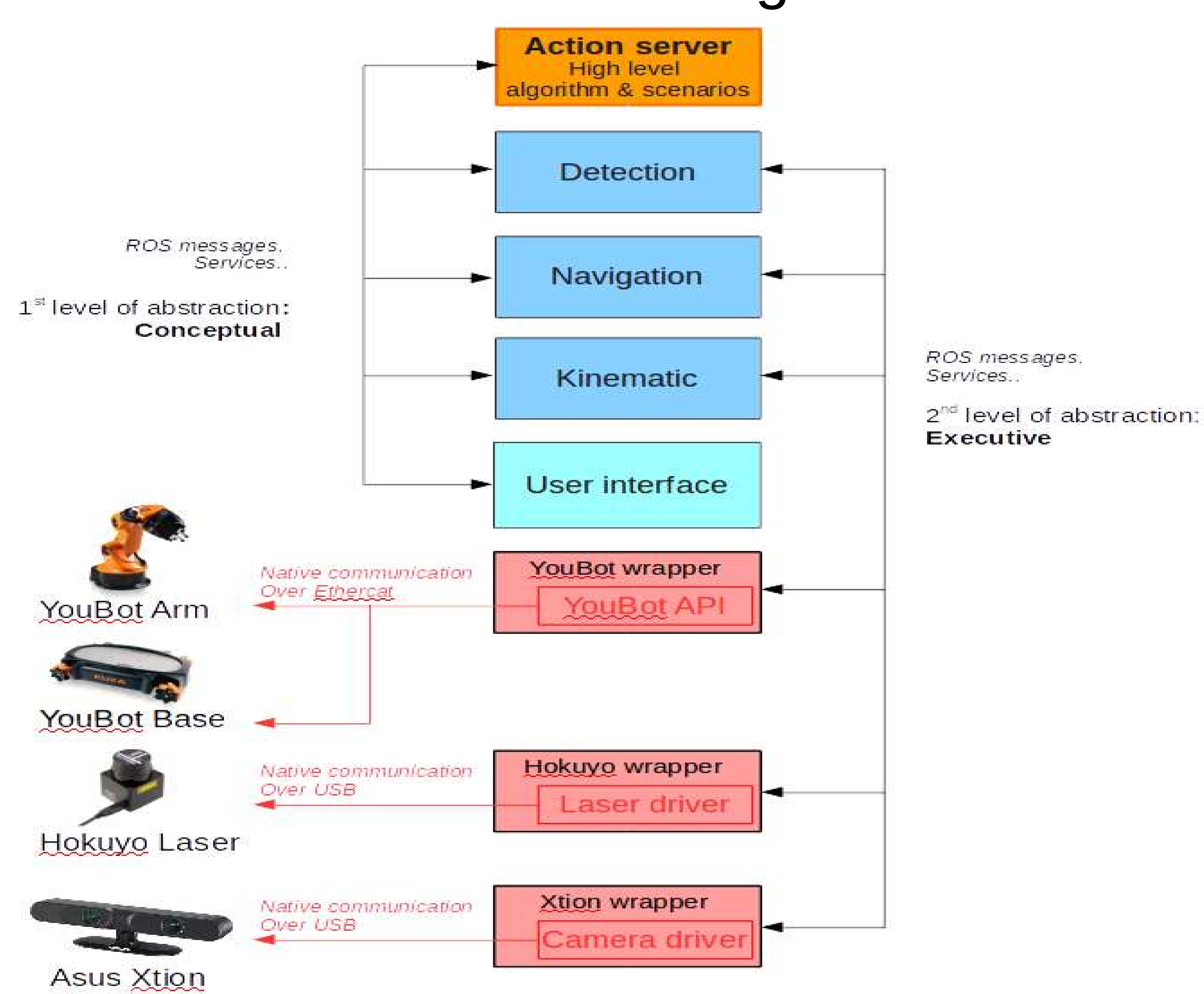
Skills applied

- *Developing smart mobile Robot applications using ROS technologies*

- *Abstract Programming and controlling Robots using ROS2 with J2EE, C++ and , Python*

- *Introduction Machine learning in Robotics and constraints programming using ML API : TensorFlow, Keras, Pandas,... and Choco solver, a CP library*

- *Presenting the finished Prototype to industries and integration of such courses in the ICAM Curriculum*



Study and Analysis of Algorithms

Department of Computer Science : ICAM-Lille

Mobile Robotics Packing Demonstrator to pack items on pallets under optimization constraints

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Robin LACHERE (MSI reasearch : ICAM- *Site de Lille)*
Allal SAADANE *(Teacher-Researcher : ICAM- Site de Lille)*
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Context

As part of the European research project Incase which spotlight the 4.0 industry, ICAM has developed an autonomous robot able to pickup items from a warehouse and place them on a pallet exploiting optimized output solutions of advanced packing modules..

Objectives of the Study

This project has multiple objectives :

1) Introduction of human factor to command an autonomous robot using ROS and also by mounting a camera and a laser sensor allowing search and navigation to a point on a known space.

2) Implementation of the same application developed in ROS; execution of the same application across different architectures, here we have tested in EV3 LEGO Mindstroms.

The project

* KLS OPTIM: packing tools provider

Technologies Used

ROS : *Robot Operating System provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, visualisers, message-passing, package management, etc.*

- ***Navigation Stack*** : *This helps the robot to navigate from point to point on a known space. This also implements obstacle eviction and object grasp with the help of camera.*
- ***Inverse kinematics*** : *Inverse kinematics makes use of the kinematics equations to determine the joint parameters that provide a desired position for each of the robot's end-effectors.*

Object detection: Using Xiton camera and OpenCV algorithms making possible detection of 3D objects and enabling their visualization.

References

- http://www.ros.org/
- https://moveit.ros.org/
- https://github.com/JenniferBuehler
- http://docs.ros.org/kinetic/api/moveit_tutorials/html/
- https://github.com/JenniferBuehler/gazebo-pkgs/wiki/Object-information-and-recognition
- https://github.com/JenniferBuehler/grasp-execution-pkgs/wiki/Object-information-pipeline
- http://www.orocos.org/kdl
- http://wiki.ros.org/navigation
- www.openni.ru - An official documentation webpage.
- structure.io/openni – A brief explanation on what is PrimeSense and its uses.
- wiki.ros.org/face_recognition – A ROS documentation on the package that has been used
- wiki.ros.org/find_object_2d – A ROS documentation on the package with various algorithms and concepts that are used for object detection

Vision sensor technologies in agriculture and industry

Keywords : Image, Video, Lidar, Pattern Recognition, Machine Learning, Multi-Objective Optimization

November 2019

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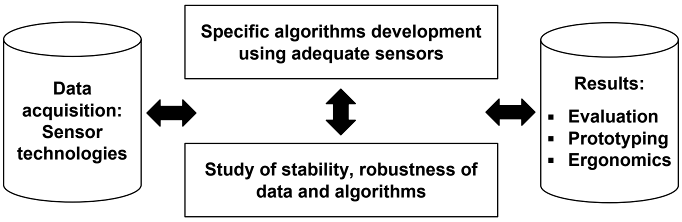
Example of acquisition platforms

Example of acquired images



Adaptive and retroactive research and development approach

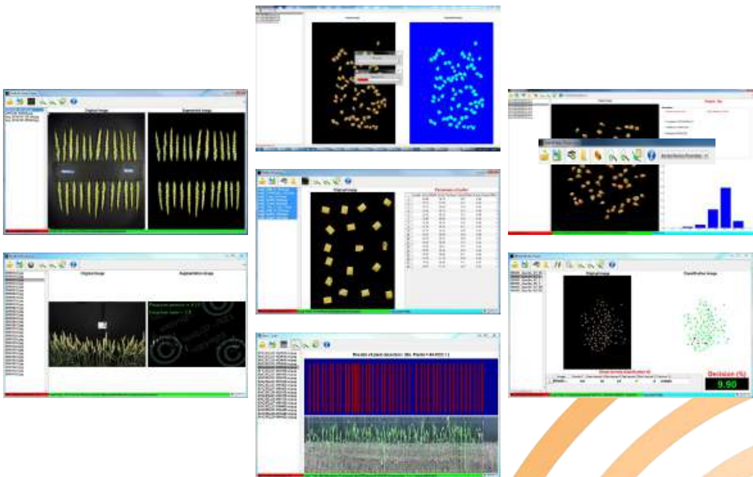
Skills applied

- Image acquisition and processing
- Pattern recognition (colour, shape and texture information's)
- Feature selection (Mutual Information)
- Segmentation/Classification (Deep Learning, SVM, k-NN)
- Multi-objective optimization (Pareto curve, information criteria)
- Quality evaluation

Applied Research

Designing mathematical and algorithmic methodologies to solve problems needed machine learning and computer vision:

- Crop and forest mapping
- Grain, plant characterization, detection, recognition, tracking and counting
- Leaf and spike disease characterization and quantification
- Silo mapping and monitoring
- Robotic tasks guided by 2D-3D vision



Example of software development

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Strategic Management of Corporate Social Responsibility (CSR)

Keywords : CSR, Strategy, Global Performance, Globalization, Social Enterprise, Emerging Countries

February 2019

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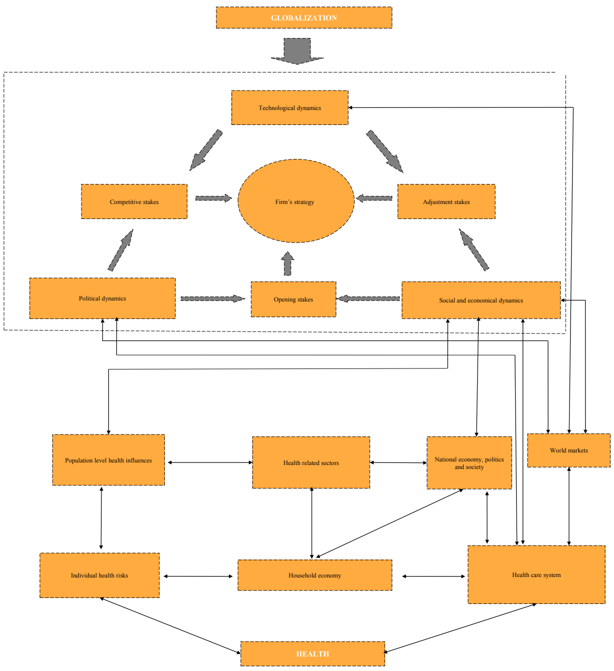


Globalization, public health and big-pharmas' strategy

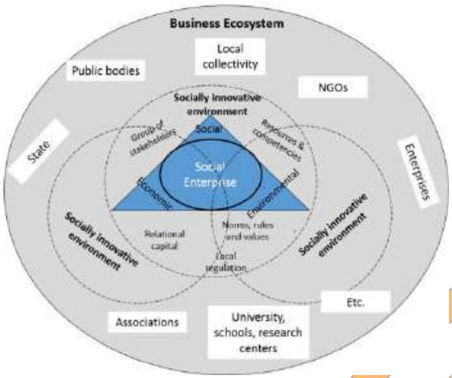
Applied research purpose

Strategic management of CSR:

- Shared-value model (implementation, impacts);
- Strategic CSR in bio-pharmaceutical industry;
- Global performance; link between corporate social performance and financial performance;
- Strategic CSR in an international context: transfer of practice and competencies;
- CSR practices in emerging countries (institutional, cultural, social and economical impacts);

Skills applied

- Mixed methodologies: qualitative/quantitative;
- Statistic treatment: SPSS; XLSTAT;
- Strategic analysis;
- CSR audit and implementation (ISO 26000)



Social entrepreneurship and socially innovative environment

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The meaning of work and its making for the leaders of the digital start-ups and incubators

PhD Student : François HENRY (Chaire Sens & Travail, Icam Lille)
Supervisors : Mathieu DETCHESSAHAR (Université de Nantes)
Laurent FALQUE (Chaire Sens & Travail, Icam Lille)

March 2019

Keywords : work, meaning of work, digital *start-ups*, typology

Research questions:

What is the meaning of the work for the leaders of digital start-ups and incubators ?

- *To which perspective is the meaning of work oriented ?*
- *How is the meaning of work made ?*

Sources : istock (propriété de l'Icam).

Theoretical framework:

The world of work is changing. We observe the emergence of FabLab, Techshop, "uberisation" and, of course, entrepreneurship. The figure of the creator is becoming more attractive (Florida, 2012) while many professions are criticized and challenged (Graeber, 2018). The approach selected in this research is to exhume the founding events, the salient references, as well as any interesting element to understand what, in the individual courses of each leader, shaped their vision of the work and the meaning that they give.

The thesis work is mainly based on two theoretical frameworks:
-the S.O.C model and its three dimensions of work (subjective, objective, collective) (Gomez, 2013);
-the notion of "oeuvre" (in French and in philosophy of work) with Simone Weil (1951, 1999) and Hannah Arendt (1961).

The empirical field : 27 interviews

Incubateur à Lille				Ville	Autres
Euratechnologies	**Blanchemaille**	**La Plaine Image**	**Eurasanté**	**Paris**	
14	1	4	4	2	2

Some results :

Proposal for a typology : four different kinds of meaning

	The idealist	**The pragmatic**	**The adventurer**	**The hedonist**
Number of leaders (1)	7 (9)	6	7 (10)	5 (11)
Meaning of work	Deploy his talents to the service of a cause Finality	Participate in the « Progress » Meritocracy	Live an adventure Take risks	Fulfillment Pleasure « Job-passion »
Age		+		
Relationship to time	Towards a perspective	Anticipation of the event	Race against time	
Strong willingness to learn expressed	Not especially		Strongly expressed	
Trend	Aim		Sensation, feeling	

(1) Le premier nombre indique le nombre de dirigeants qui forment ce groupe, celui entre parenthèses le nombre de dirigeants qui s'en rapprochent et fortifient ce thème.

Sources : bnppre.fr

References:

Arendt, H. (1961). *Condition de l'Homme moderne*, Calmann-Lévy.
Florida, R. (2012). *The rise of the creative class.* New York: Basic Books
Gomez, P.-Y. (2013). *Le Travail invisible.* Paris : François Bourin Editeur. .
Graeber, D. (2018). *Bullshit Jobs : A Theory.* Simon and Schuster.
Weil, S. (1951). *La Condition ouvrière*, Folio, Essai, 2002.
Weil, S. (1999). *Œuvres*, Paris. Gallimard*, coll. « Quarto ».*

Low Power - Embedded Systems
Design, Modeling, Optimizing

Keywords : Low Power, Real-Time OS, Energy-Aware-Scheduling, H/S Co-Design, Agile Method, Model Driven Engineering

March 2019

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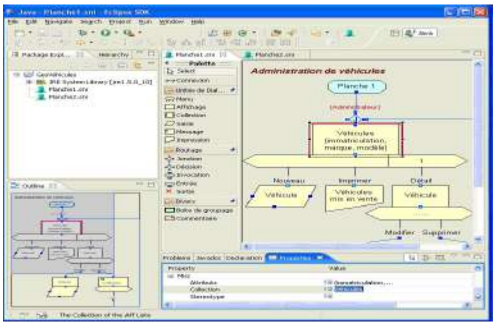
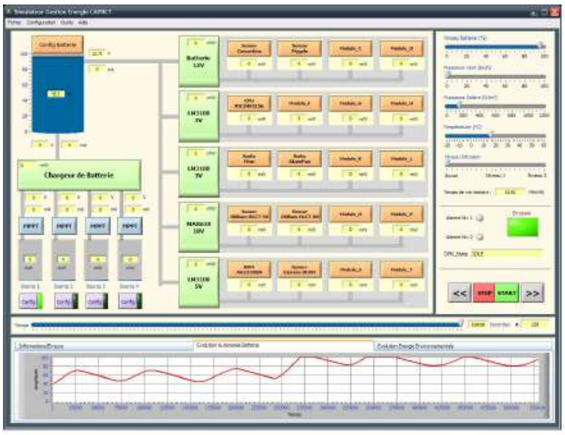


Adaptative HCI Generation – VisualSNI



Power Estimator – Battery autonomy simulator for Embedded Systems

Applied research purpose

- Low Power Design
- Energy-Aware-Scheduling RF Messages
- Embedded Systems – Power Estimator
- Hardware / Software Co-Design
- Fast Electrical Battery Modelling
- Adaptive HCI Generation

Skills applied

- Embedded Systems / IoT Devices
- Real-time OS and Kernel Systems
- Signal Processing (Wavelet transform)
- Solver Engine for coarse-grain modeling
- Model Driven Engineering
- Agile Method - MACAO

A Lora IoT Gateway for Energy-Aware-Scheduling of RF messages

Industry 4.0,
Logistics and transport optimisation

Keywords : Factory of the future, reference model, expert systems, CBR, multi-agent systems, key performance indicators, environmental, social and societal factors,

May 2019

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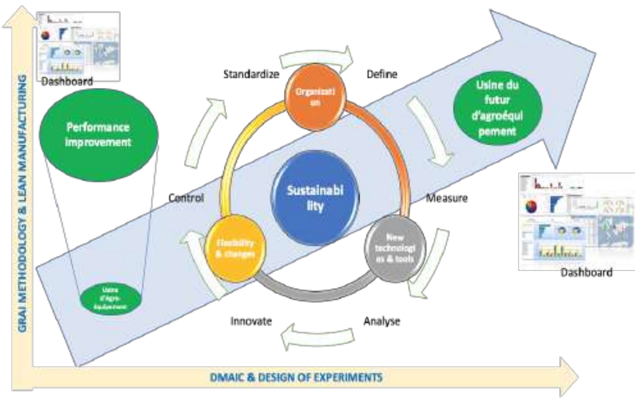
Flow simulation and optimisation (flexsim, anylogic, delmia tools)



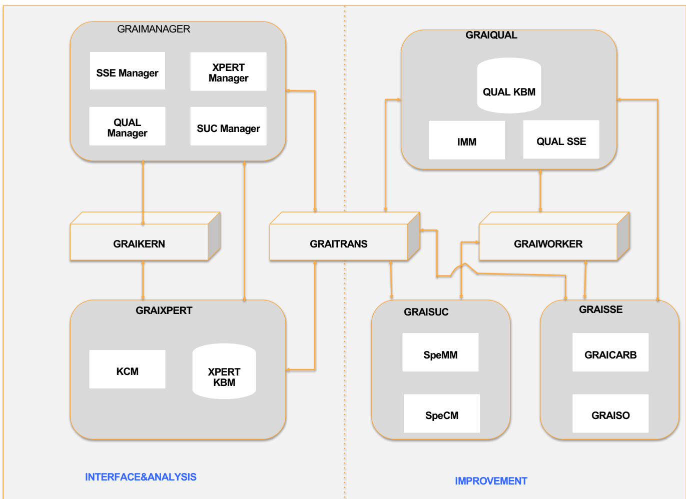
Industry 4.0 framework for agribusiness companies

Applied research purpose

- Healthcare logistics 4.0 (collaboration with FEI university (Sao Bernardo – Brazil)
- Application to manufacturing, logistics and transport activities: Company modelling, simulation and performance improvement
- Industry 4.0 for agribusiness and metallurgic companies
- Urban logistics (collaboration with “Grand Paris Sud“ agglomeration & “EPA de Sénart”)

Skills applied

- Industry 4.0 concepts elaboration and implementation
- Enterprise typology, Reference models, Rule base, Case-Based Reasoning
- Sustainable supply chain & transport performance improvement
- Decision aided tool design & development, Expert systems, multi-agent systems



GRAIMOD: an enterprise modelling decision aided tool

City transport flow simulation (PTV-VISSIM tool)

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Design and development of novel system architectures based on robotic technologies

Keywords : System integration, Robotics, Human-Machine Interface, Machine Learning

March 2019

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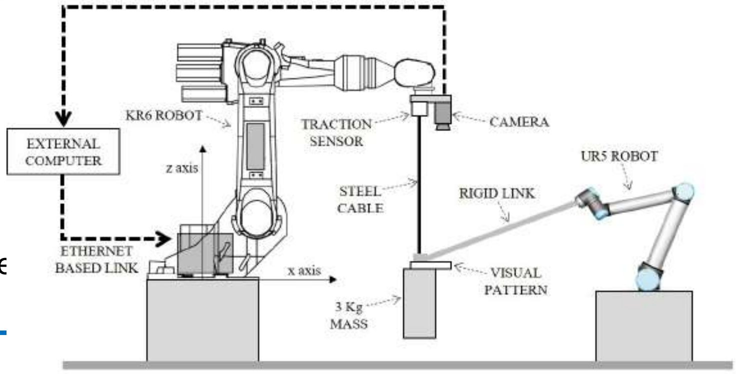

Reduced scale robot based test bench for spatial applications

A novel modular help desk concept

Applied research purpose

Integration of robotic technologies in the design and fabrication of a novel help desk:

- Development of a new concept and architecture of help desk
- Integration of social behaviour
- Integration in woodworking of robotic technologies

Design and development of robotic based test benches for spatial applications:

- Development of reduced and real scale test benches for testing satellite deployment
- Development of a custom sensing system for detecting satellite centre of gravity movements

Skills applied

- Robot and cobot programming
- Sensors and actuators integration: mechatronic and design aspects.
- Sensor system development
- ROS architecture for system control
- Multimodal human-machine interfaces integration
- Machine learning classification algorithms with OpenPose

OpenPose detection of human posture

Decision Support Tools to Deal with Complexity

Keywords : Tools, Digital, Ecological Transition, Artificial Intelligence, Jobs, Human-Machine relationship

February 2019

How to interact and work with a social robot?

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Ethics workshops for companies to think about the impact of AI

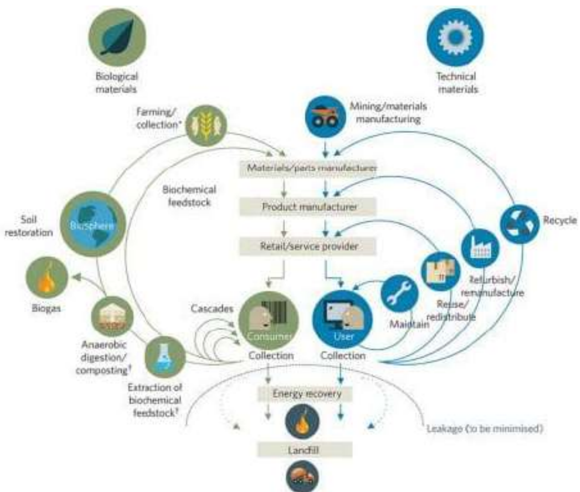
Applied research purpose

Thinking and analysing the uses of digital tools in a changing world:

- Thinking the future of jobs
- Highlighting key skills to work with AI
- Analyzing the impact of AI in companies
- Designing tools to develop the complexity paradigm in urban decision-making
- Helping urban governments build sustainable cities

Skills applied

- Qualitative and quantitative methods
- Monographs
- Participant observation
- Interdisciplinary innovation
- Community planning
- Management Research Project
- Applied Research



The ecological transition requires new thinking patterns, like circular economy, and new tools, like software.

Modelling of plate fin heat sink in forced convection. Application to power electronics systems

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Problem

With the development of more electrical aircraft , there is an increase of embedded systems. The weight of equipment's is a key point of this development. Heat sink is an important part of the converter weight. It is then necessary to design heat sink, to ensure the wanted performance and minimize the weight device. Dedicated tools exists, to size heat sink, but they are not really adapted to optimization routine. In fact theses methods are too complex (CFD simulation) to implement in optimization routine, or very simple but not accurate enough (thermal resistance equivalence) to provide a good design. That's why it is necessary to develop design methods to minimize weight of heat sink and ensure well integrated embedded systems.

Technology chosen and model developed

Configuration chosen

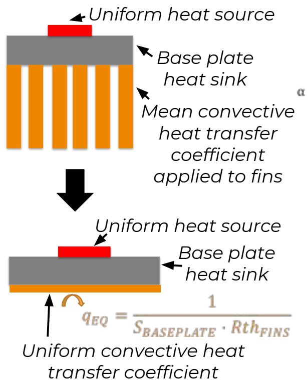
Plate fin heat sink in forced convection

Assembly system : heat pipe and plate fin

Classic configurations used in power converters

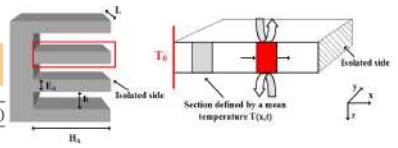
Simplified representation of a plate fin heat sink. Thermal model from junction temperature to ambient temperature

Simplified schema of described configuration



Choice of an analytical modelling

Resistance of a fin



$$\alpha = \sqrt{\frac{h_{AMB} \cdot 2 \cdot (T_{FIN} + L)}{\lambda_{FIN} \cdot S_{FIN}}}$$

$$Rth_{FIN} = \frac{1}{\alpha \cdot \lambda_{FIN} \cdot S_{FIN} \cdot \tanh(\alpha \cdot H_{FIN})} \qquad \frac{1}{Rth_{FINS}} = \frac{N_{FINS}}{R_{TH\,FINS}} + \frac{N_{FINS} - 1}{h_{AMB} \cdot b \cdot L}$$

Thermal model of Heat Sink : From Source to Ambient Air

$$\Delta\overline{T}_{HEATSINK} = \overline{T_{SOURCE}} - T_{AMBIENT} = A_0 + \sum Ai\cos(\alpha) + \sum Aj\cos(\beta) + \sum\sum Aij\cos(\gamma)$$

Solving heat equation in steady state

$$\frac{\partial^2 T(x,y,z)}{\partial x^2} + \frac{\partial^2 T(x,y,z)}{\partial y^2} + \frac{\partial^2 T(x,y,z)}{\partial z^2} = 0$$

Method of separation of variables

Boundary condition on base plate

Lateral side

$$\frac{\partial T(x,y,z)}{\partial y} = 0 \qquad \frac{\partial T(x,y,z)}{\partial x} = 0$$

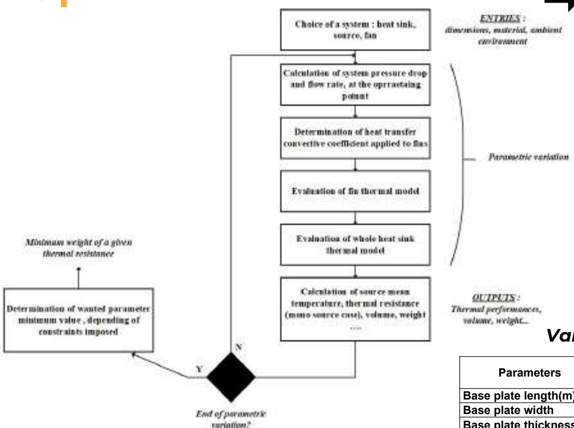
Inferior side

$$\lambda \cdot \frac{\partial T(x,y,z)}{\partial z} = q_{EQ} \cdot (T(x,y,z) - T_{AMBIENT})$$

Superior side

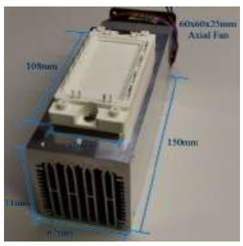
$$\lambda \cdot \frac{\partial T(x,y,z)}{\partial z} = -\varphi_0$$

Optimization results



Optimization routine algorithm

Explored configuration : 690525 points Duration of study : 24 minutes

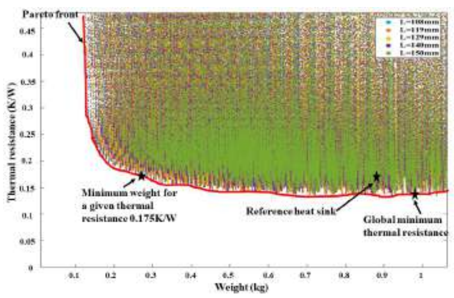


IRT power converter and its heat sink

Values of parameters explored

Parameters	Minimal value	Maximal value	Number of points
Base plate length(m)	0.108	0.150	5
Base plate width	0.047	0.062	5
Base plate thickness(m)	0.003	0.020	9
Fin height(m)	0.01	0.08	9
Number of fins	10	40	31
K= nfin*tfin/W	0.1	0.9	11

Pareto front and optimization results



Values of parameters obtained for minimal weight configuration

Parameters	Value optimized	Relative difference Δx au to reference heat sink (%)
Base plate length(m)	0.1080	-28%
Base plate width(m)	0.0620	0%
Base plate thickness(m)	0.0030	-71.4%
Fin height (m)	0.0450	-29.1%
Number of fins	38	+375%
K= nfin*tfin/W	0.1800	-41.8%
Total weight(kg)	0.2666	-70.2%
Thermal resistance (K/W)	0.174	-0.57%

Relative difference definition: $\Delta x = \frac{x - x_{REF}}{x_{REF}}$

Conclusion

The design of a heat sink is a key point for the integration of power converters. Analytical model offer a possibility to model and optimize the design of plate fin heat sink in forced convection. With the model introduced bellow, the weight of a reference heat sink has been reduced of 70%, for the same thermal resistance. Of course several constraints have also to be considered (mechanical constraints for example), but this analytical model present a real interest in the design process, associated with precise tools and software usually used.

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Heat transfer enhancement in confined environment

Keywords : Thermal transfer, Hydrodynamics, CFD simulation, Monophasic cooling, Optimization design

March 2019

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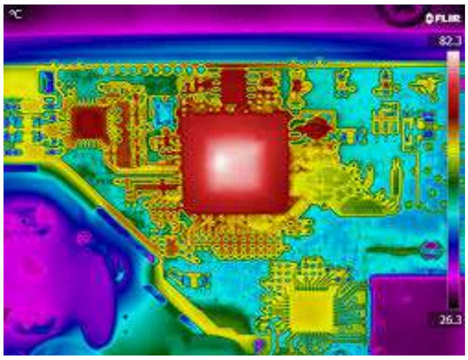
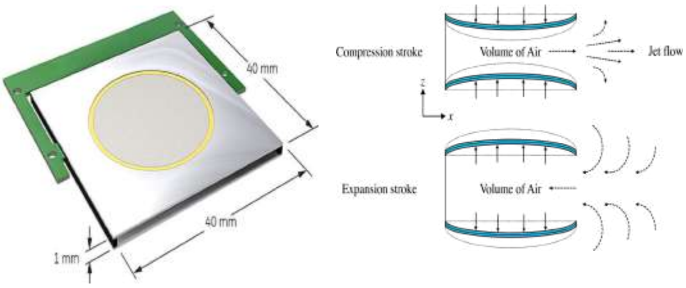
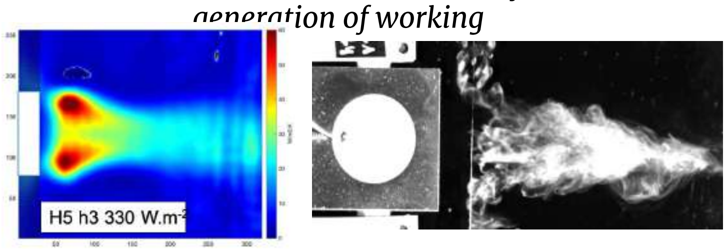


Infrared Image of printed circuit board



Piezoelectric system (DCJ type) dimensions and Mechanisms of air generation of working

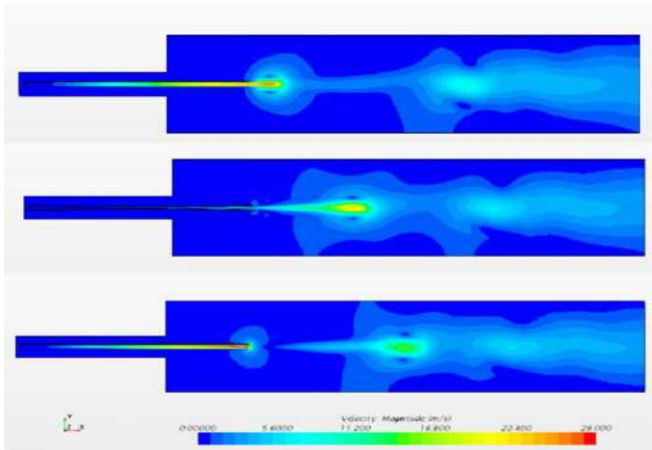


DCJ flow and thermal dissipations measurements

Applied research purpose

Numerical modelling and experimental manipulations for hydrodynamics and thermal transfer coupled characterisation like:

- Heat transfers (conductive, convective and radiation) in electronic casing
- Micro-fluidic systems such as piezoelectric membranes
- Confined and hot environment: embedded applications (aeronautics, automotive…)



Gas velocity field for DCJ behavior (T=0, T=0.25 and T=0.5, on a scale between 0 and 28 m/s)

Skills applied

- CFD simulations by Eulerian approach for dynamic structure coupled to thermal transfer
- Description of unsteady behaviour at high frequency
- Multi-scale simulation: extrapolation models
- Thermal and fluidic experiments : camera IR, hot wire anemometer, PIV…
- Numerical analysis

Energy Flow Modelling, Simulation and Management

Keywords : Energy audit and savings plan, Energy Management, Energy Roadmap, Automation, HMI / SCADA, Control, Regulation

March 2019

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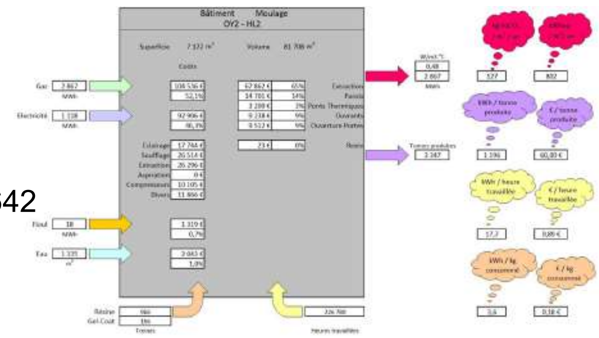
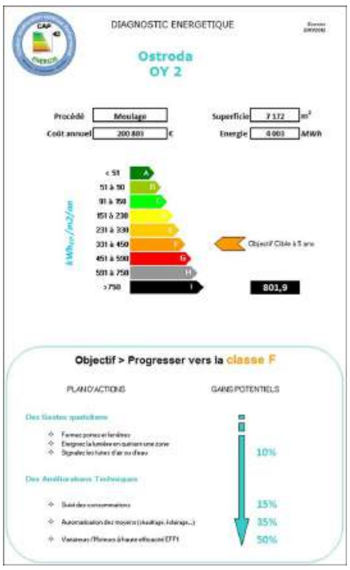


Modeling of energetic systems



Energy Savings Plan

Applied research purpose

Modelling and Management Strategies of multiphysics systems:

- √ Renewable Energy sources : PV, Heat Pumps,…
- √ Storage
- √ Smart buildings and territories

Energy Management Tools, ISO 50001

Automation, Control and Real Time monitoring of industrial processes

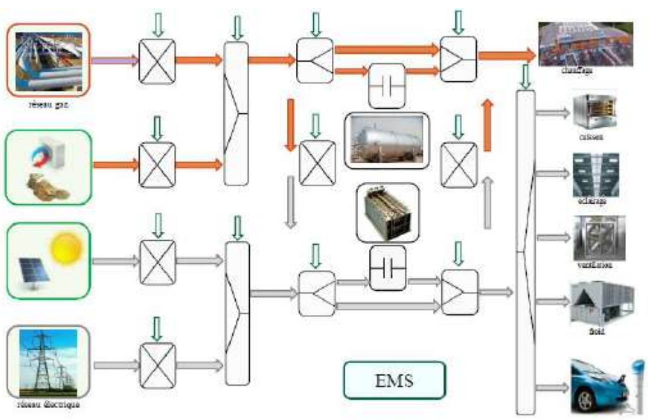
Skills applied

Industrial and territorial Energy Audit

Energetic Building and Process Modelling

Optimization in view of energy efficiency (best available techniques integration)

Electrical Engineering



Multi-flow Grid Modelling

Experimental and numerical assessment of thermal comfort

Keywords : CFD simulation, Experimentation, Heat transfer, Thermal comfort

April 2019

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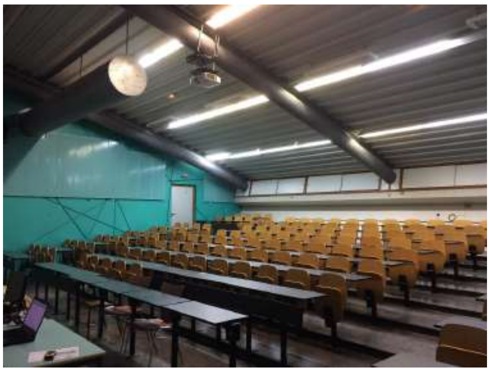
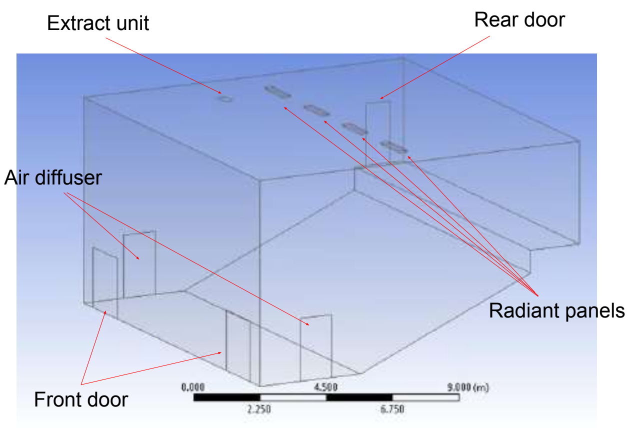


Illustration of one of the investigated room (amphitheater at Polytech Lille)



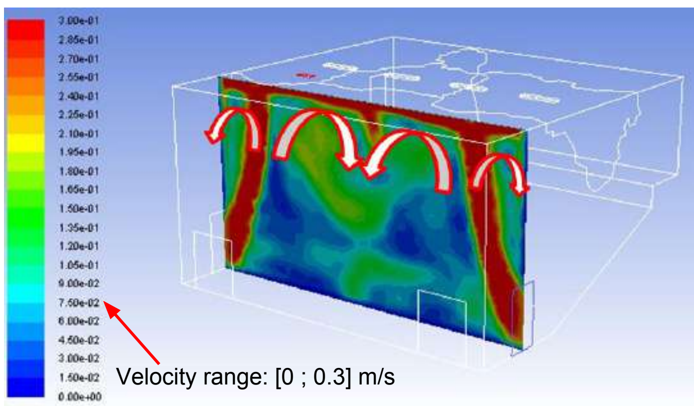
Numerical model of the studied amphitheater

Applied research purpose

- Experimental investigation of the heat transfer allows comparing and validating the use of numerical simulations (CFD)
- Best practice procedures for CFD can be inferred from parametric studies
- CFD allows optimizing the thermal comfort in the enclosure

Skills applied

- Computational fluid dynamics using ANSYS Fluent
- Flow dynamics & heat transfer coupling including conduction, convection and radiation
- Numerical analysis
- Experimental investigation



Flow field and visualization of the convection cells induced by the thermal transfers in the enclosure

Residues to energy valorisation by thermo-chemical processes

Keywords : Gasifier, Pyrolysis, Biomass, waste recovery, Char, Syngas, Biofuel, alternative fuels, tars cracking

April 2019

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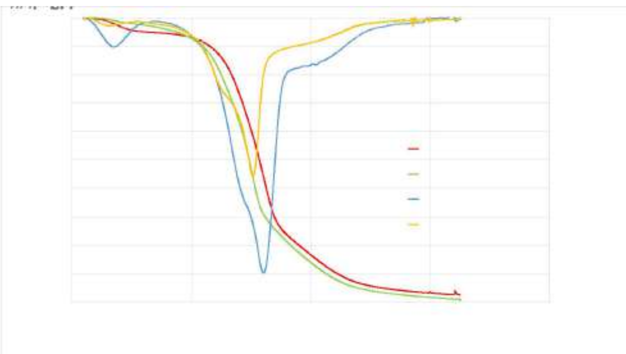
Some Gaseifiers prototypes



TGA of a biomass decomposition

Applied research purpose

Experimental, numerical and analytical modelling of residues valorisation (focus on biomass and oil) by thermal process and tars decomposition :

- Pyrolyse and gasification processes
- Tars producing and tars cracking

Skills applied

- Prototypes development for gasification and tars cracking
- Modelling of chemical reaction (analytical and CFD) for pyrolysis, gasification and tars cracking
- Catalyst development for tars cracking
- Full recycling process development

"Cracker " : Tars-cracking test bench

Thermal Management of electronic systems

Keywords : thermal simulation, power electronics, cooling technologies, compact models, system approach, electro-thermo-fluidic simulation, test benches,

February 2019

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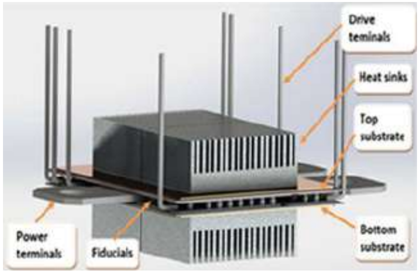
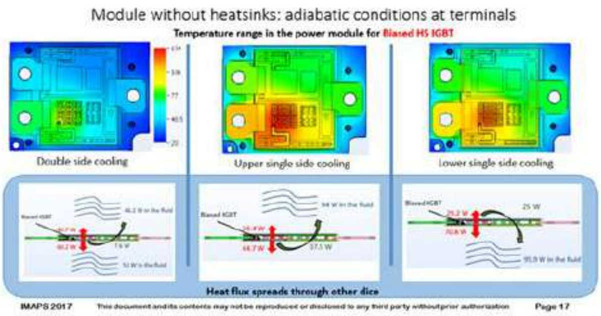


Power module developed by apSI^3D



Temperature of Si chip (APSITHERM project)

Test bench developed for the determination of Rth and Zth of wide gap components

Applied research purpose

Thermal design, modelling, simulation, correlation

- Characterization of electronics systems
- Design of cooling systems for PCB, Racks & power modules
- Simulation and measurement of Rth and Zth for electronic components or power modules (Si, wide gaps)
- Correlation between numerical and experimental results
- Improvement of performance and reliability
- Characterisation of cooling systems

Skills applied

- Thermal: conduction, free and forced convection…
- Modelling methodologies: numerical methods, multi-level methodologies, model reductions, compact models, thermal-multiphysics coupling…
- Cooling technologies: heat-sinks, fans, piezo fans, conductive drains, thermoelectric modules, biphasic technologies, liquid cooling, PCM, …
- Electronic packaging, power electronics, more electric aircraft, automotive electronics…

Test bench for the characterization of new micro-exchanger (SoCool project)

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Latent Heat Thermal Energy Storage for industrial processes

Keywords : Phase Change Material, Heat Transfer Intensification, Latent Heat Storage System

April 2019

Abstract

The objective of this study is to design heat storage systems that improve the energy efficiency of industrial processes operating thermal cycles. The principle is to recover the energy released during the cooling phase in a latent heat storage. The energy stored is then used in the same process during the heating phase.
For processes requiring high heat transfer rate the Phase Change Material (PCM) is associated with graphite in order to enhance its thermal conductivity. The storing materials is then integrated in a heat exchanger. The objective of the research is to design the whole system.

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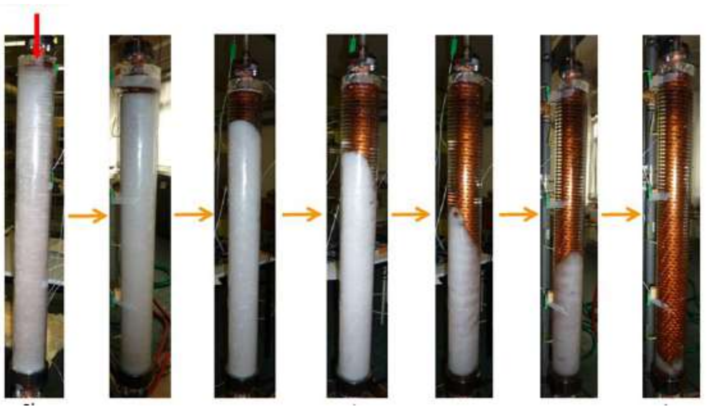
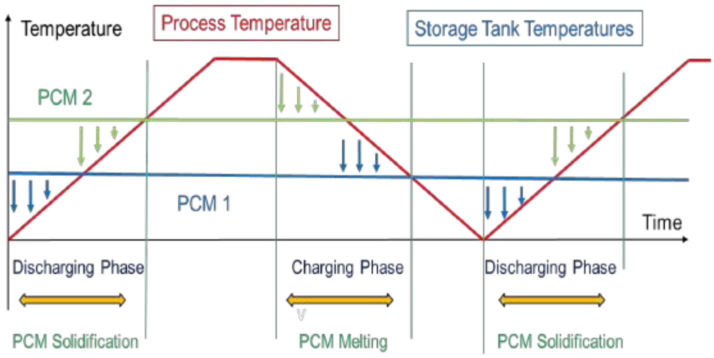


PCM melting phase observed on the laboratory test bench



Principle of energy saving using PCM in cycling thermal process

Applied research purpose

Thermal Energy Storage dedicated to processes

- With short thermal cycles (less than 10 minutes)
- Requiring high heat transfer rate (larger than 2kW/m².K)

Skills applied

- Phase Change Material heat transfer enhancement using conductive media such as graphite: sample manufacturing, and characterization
- Thermo-Fluid numerical simulations including phase change
- Experimental characterization of heat storage performance on a laboratory scale test bench
- Implementation on industrial-scale application: design and experimental tests

6kWh – 150kW PCM storage implemented on STERIFLOW sterilizer

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System Modelling and Controller Design

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UVa

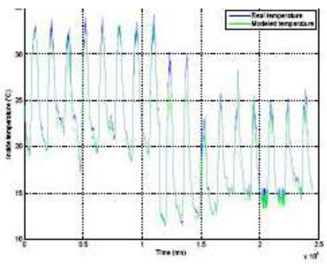
UNIVERSITÉ de Picardie Jules Verne

Keywords: Nonlinear systems, controller design, Stability Analysis,

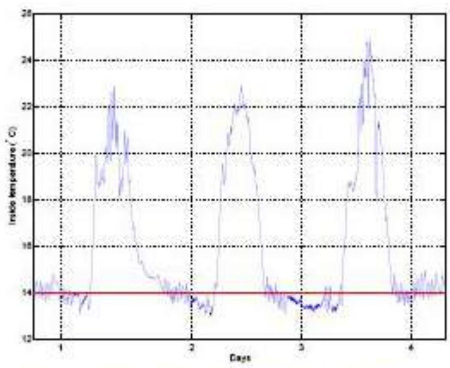
Applied Research Purpose

- ❑ Control of Nocturnal Temperature in Greenhouse using air heating.
- ❑ Robust Output Tracking control of TS fuzzy systems and its application to DC-DC converters
- ❑ Static Output Tracking Control of a Class of Uncertain Nonlinear Discrete-Time Systems

Photograph of the Experimental greenhouse used for testing climate control strategies.



Arithmetic Mean=21.35 °C	MAE	RMSE	Maximum error
First principle model	0.864	1.176	8.772
T-S model	0.870	1.181	8.773



Experimental results using the PI-PDC controller (December 2007)

Skills:

- ❑ Control therory: stability analysis and stabilzation syntesis in the sense of Lyapunov.
- ❑ Linear matrix inequalities in system and control theory
- ❑ Computational engineering
- ❑ Numerical analysis
- ❑ Simulation

Other Area of interest:

- ❑ Electrical Vehicle Control
- ❑ Energy Efficiency
- ❑ Optimization

Electric Energy Storage and Production Systems

Keywords : Renewable Energy Technologies, Power Electronics, Electrical Machines, Microcontroller based Control

February 2019

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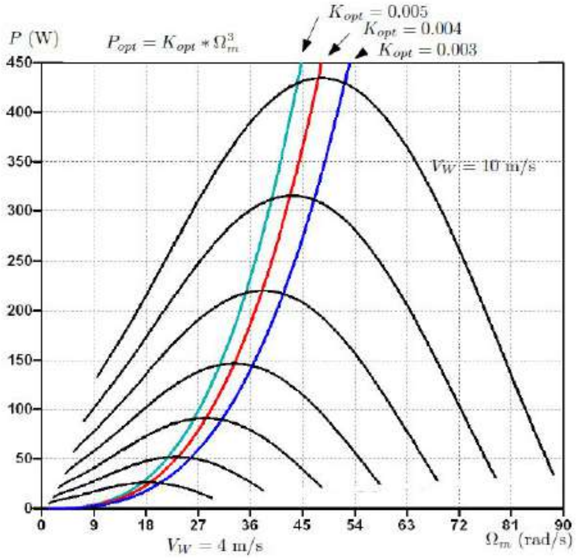
Wind turbine electric chain optimization

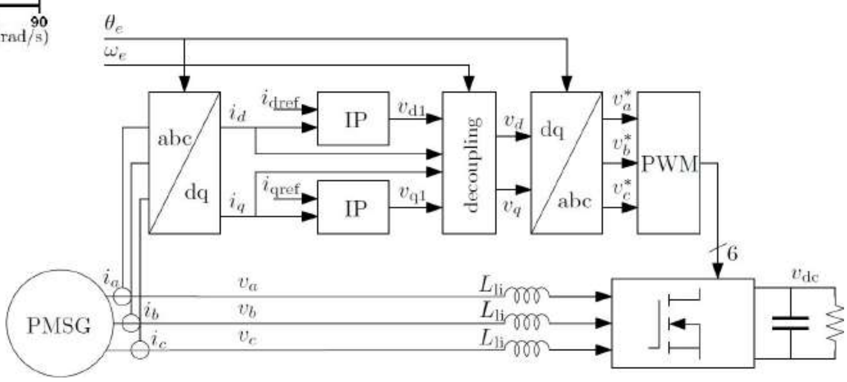


Maximum Power Point Tracking

Applied research purpose

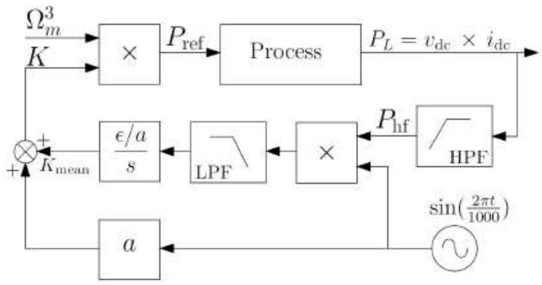
Numerical and analytical modelling of hybrid electric systems like:

- Wind-turbine conversion system
- Wave energy conversion system
- Underwater compressed air energy storage system
- Photovoltaic MPPT



Skills applied

- Sensorless control
- Maximum power point tracking
- Extremum seeking control
- Power electronics
- Microcontrollers
- Spice & HIL simulation



Extremum Seeking Control

Numerical modeling of fluid flows & coupled heat & mass transfer

Keywords : Fluid dynamics, Heat transfer, Numerical analysis

February 2019

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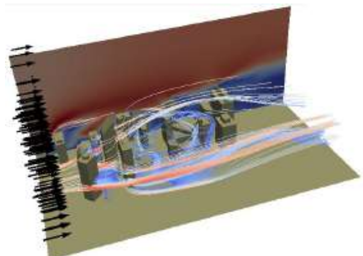
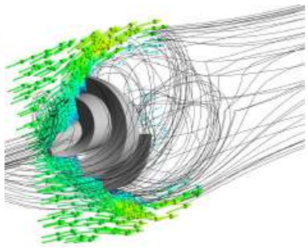
Applied research purpose of Computational Fluid Dynamics (CFD)

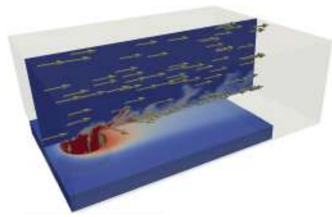
- Examples of complex fluid flow investigations using CFD:
  - Aerodynamic performance for wind turbine applications
  - Wind engineering for windmill potential
  - Thermal and/or mixing process efficiency for industry applications



Numerical analysis of turbulent wind around buildings using RANS method



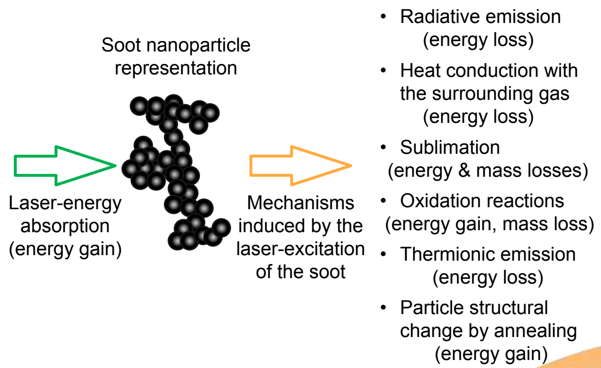
CFD analysis of aerodynamic performance of wind turbines using RANS method



Numerical study of thermal field in a turbulent mixing zone using LES method

Numerical analysis applied to soot properties characterization

- Soot emission is known to have harmful effects on human health and the environment Laser-induced incandescence (LII) is one of the most powerful diagnostic technique in order to quantify soot emission and understand their formation process.
  - LII technique is based on heating the soot particles with a pulsed-laser beam and collecting the emitted radiative signal which is known to be related to the soot volume fraction
  - The emitted radiative signal can moreover be modeled based on heat- and mass-balance equations reproducing the soot laser-energy absorption mechanism and its subsequent cooling processes undergone by the soot after the laser pulse
  - Coupling experimental LII database and numerically modeled signals can be very valuable to infer original information about soot properties



Thermophysical mechanisms undergone by a soot particle during laser-induced incandescence and included in LII modeling (based on Michelsen el al., Prog. Energy Combust. Sci. 51 (2015) 2-48)

Skills applied

- Computational fluid dynamics & coupled heat and mass transfer:

  Ansys Fluent, OpenFOAM
- Numerical analysis applied to industrial applications and lab-scale studies

Stability of time-delay systems

Keywords : automatic control, delay differential equations, robust control, stability analysis

February 2019

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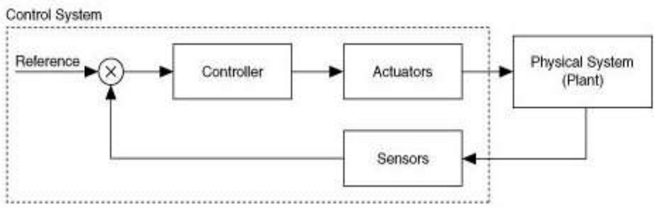
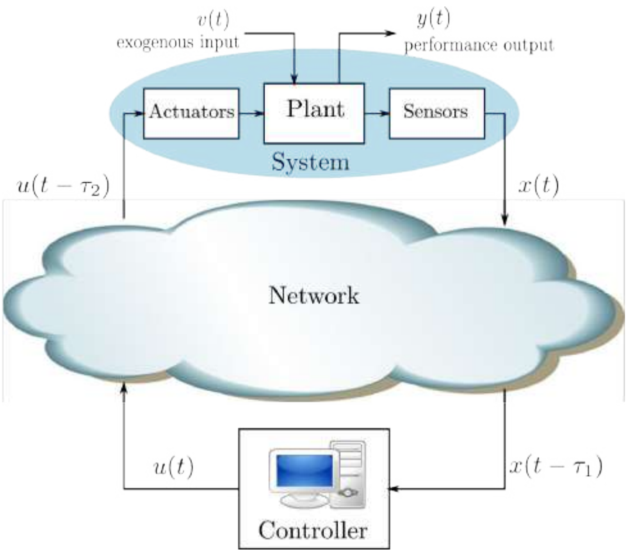


General closed-loop control scheme



Example : networked control system

Applied research purpose

We aim at designing theorems for the stability analysis of linear dynamical systems with delays. Such models (with discrete delays or distributed delays) can be met in several applications:

- biology, chemistry, population dynamic, machine tool vibration problem,
- processing and propagation times in networked control systems,
- traffic flow model, communication network.

Skills applied

- Feedback control system
- Lyapunov theory
- Robust control
- Numerical computing software (MATLAB/Scilab)
- Hardware-in-the-loop and rapid control prototyping experiments

State space model for linear time-delay (discrete) systems:

$$\dot{x}(t) = Ax(t) + A_d x(t-\tau)$$

State space model for linear distributed delay systems:

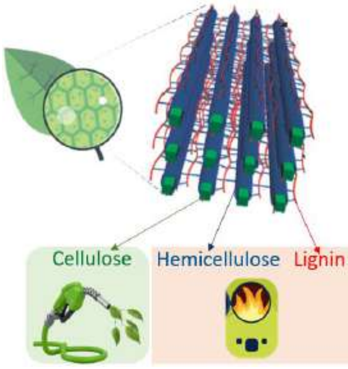
$$\dot{x}(t) = Ax(t) + A_d \int_{-h}^{0} f(\theta)x(t+\theta)\, d\theta$$

New Biobased materials : Catalytic Functionalization of Lignins

Keywords : biomass, lignin, chemistry, catalysis, materials

May 2019

Biomass



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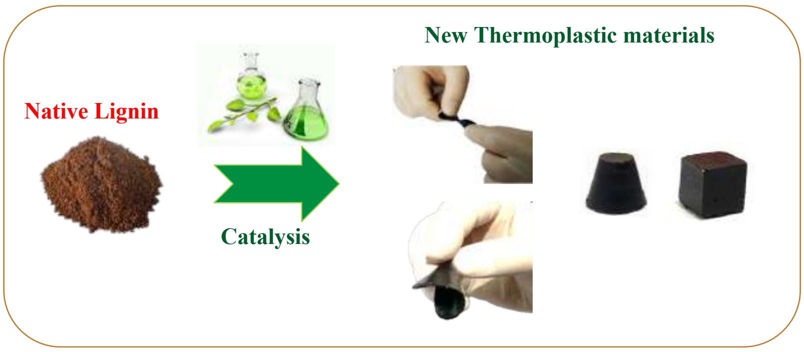
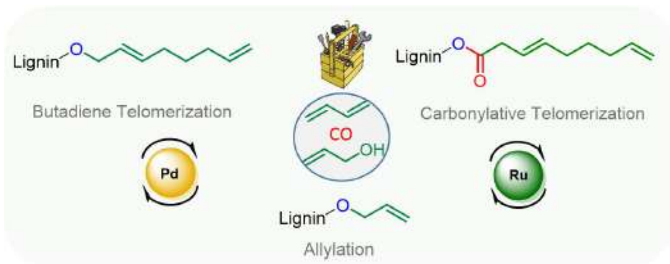
Applied research purpose

Lignin is one of the most abundant biopolymers available on Earth, after cellulose and chitin. The direct use of lignin as component of plastics or hybrid materials is an important valorization pathway. However, the crude material itself does readily decompose upon heating. In this context, chemical functionalization of lignin is required to access materials that can be processed, mixed with other polymeric materials or used as macromonomers. More particularly, the introduction of new polymerisable functions according to green processes would open the way to innovative materials while complying the principles of green chemistry and minimizing the risk with human health.

This research project aims at developing new thermoplastic and curable materials from lignins from catalytic functionalization reactions.



Examples of catalytic reactions



- Analytical study of native and functionnalized lignins
  - ^{1}H NMR / ^{31}P NMR / ^{13}C NMR / 2D NMR on 900 MHz
  - GPC
  - Mass spectrometry MALDI-TOF
  - DSC

Skills applied

- Chemistry / Catalysis
- Polymers
- Biomass and vegetable by-products valorization
- Analytical study of molecules/polymers

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Bolted joints

Keywords : Assembly, Analytical & numerical modelling, Slipping prediction, Aircraft wheels, Satellite structures

March 2019

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Aircraft wheel

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Satellite exposed to dynamic and thermal conditions

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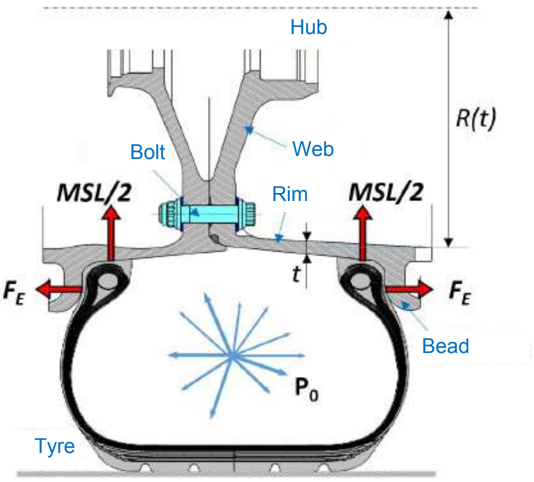

Aircraft wheel structure and loads

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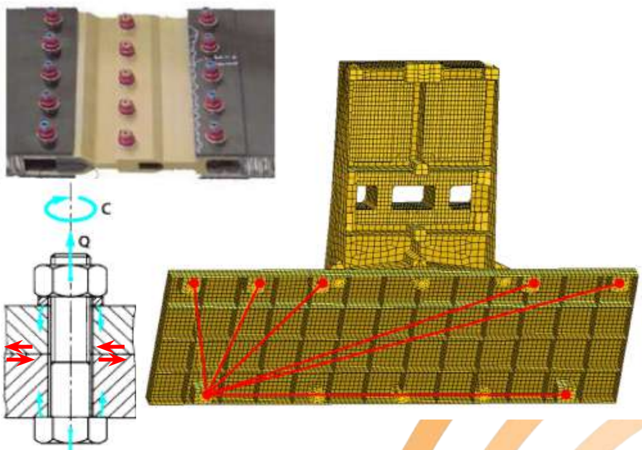
Applied research purpose

- For Safran Landing System designers of aircraft wheels, development of a simple, rapid and flexible pre-design tool for bolted assemblies, via semi-analytical modeling
- For mass reduction of satellites, improvement of bolted assemblies models for slipping prediction:
  - in dynamic conditions
  - in thermal conditions

Skills applied

- Combined Analytical, semi-analytical and Finite Elements models of bolted joints
- Experiments on bolted assemblies
- Characterisation of mechanical behaviour
- Characterisation of interface and contact
- Slipping experiments
- Thermal experiments
- Image correlation techniques



Slipping in a bolted joint

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Structure Accidental Loading

Keywords : Plastic Limit Analysis, Finite elements, Simplified Methods, Analytical formulations, FSI

February 2019

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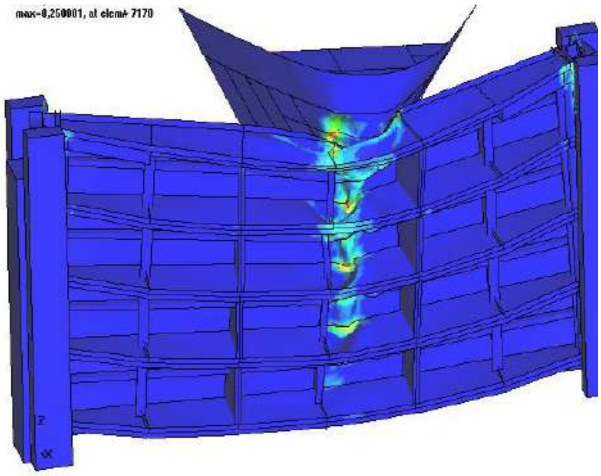
Ship subjected to underwater explosion



Numerical modelling of lock gate impact

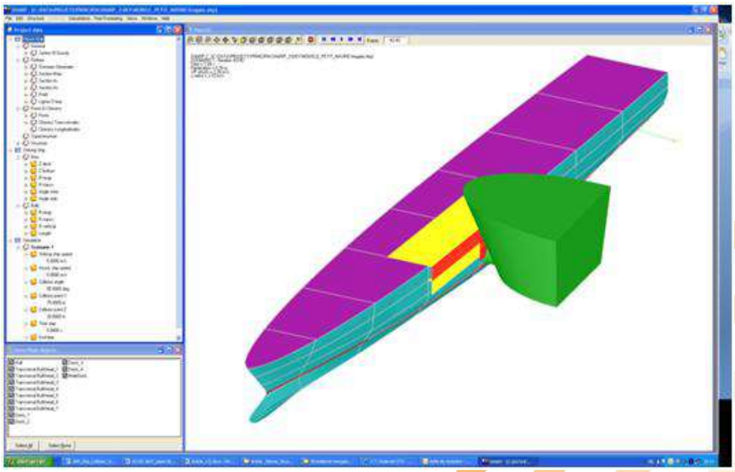
Applied research purpose

Numerical and analytical modelling of dynamic coupled problems like:

- Ship collision and grounding
- Ship response to underwater explosions
- Shock response of immersed composite structures
- Seismic response of lock gates
- Vibrating response of resilient mounts
- Damped response of composite structure including viscoelastic layers

Skills applied

- Non linear FE dynamic simulations including fluid-structure interactions
- Development of analytical formulations based on plastic limit analysis
- Dynamic of materials and impacts
- Shock experiments
- Computational engineering
- Numerical analysis



Analytical tool for ship collision analysis