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CNRS . INSTITUT PASCAL . SIGMA
& UNIVERSITÉ BLAISE-PASCAL À CLERMONT-FERRAND
ACTIA

UMT
AGROBERGO
DÉVELOPPEMENT DE SOLUTIONS
ROBOTIQUES & ERGONOMIQUES

ADIV & UMT AgRobErgo 19.2

« Mechatronic, Robotic and Ergonomic Solutions For the Food Industrial Sectors »

7th November 2019

Leader of the UMT Partnership :

Matthieu ALRIC
matthieu.alric@adiv.fr

UMT-AGROBERGO-19.2 Leader
Projects Leader in Mechanic and Robotic R&D & Engineering

ADIV viande performances

Pre-Engineering ADIV Team

UMT AgRobErgo (2019-2023)
Partnership

- ***1 Technical Institute for Food-Industrie (TIFI)***
  - ***ADIV*** *– Viande Performances*

- ***1 Engineering School***
  - ***SIGMA Clermont***

- ***1 University***
  - *Université Clermont Auvergne*

- ***1 Research Institute***
  - *Institut Pascal*

- ***1 Association***
  - *Auvergne Rhône-Alpes Gourmand* ***(ARAG)***

Focus Presentation of ADIV

ADIV
viande performances

Supporting meat-based industries in their performances search

Who are we ?

- French leader in **Applied research**, **Audit**, **Consulting**, **Expertise** and **Training services** for meat industries, **from the slaughtering to the consumption** – all species.
- With **more than 40 years experience**

Our mission

- Creating **competencies**, **methods**, **How-know** and **innovating tools** for the **competitiveness of meat and meat products industries**

Our activities

- Partnered and collaborative Research
- R&D collective programs
- **Customized services for industries**

Focus Presentation of ADIV

Label & Accreditation

A quality & professionalism assurance in services delivery

ITAI Accreditation, Food technological institutes, awarded by the French Agriculture Ministry to technological research organizations providing technical support, expertise, training and information for companies

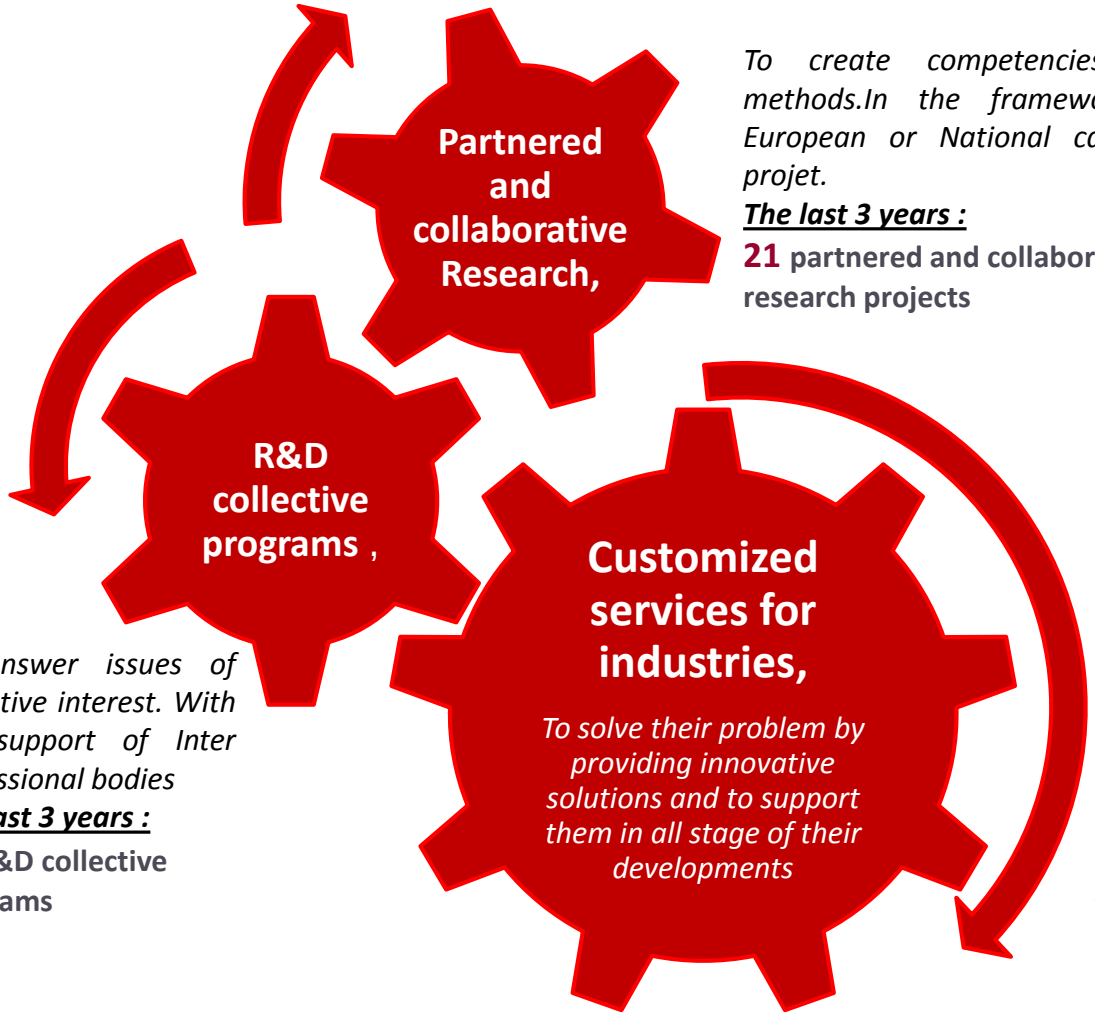
SRC Label, Private Research and Technology Organizations, granted by Bpifrance to private structure which realize R&D services for all size enterprises and provide competencies and adapted solutions improving efficiency, productivity and competitiveness.

History

1975	ADIV creation
1986	Implementation of the trial plateform
Fin 80s	SRC Label
2007	**Moving to new premises**
	ITAI Accréditation

Focus Presentation of ADIV

3 critical missions to develop and innovate with meat and meat products



To create competencies and methods.In the framework of European or National calls for projet.

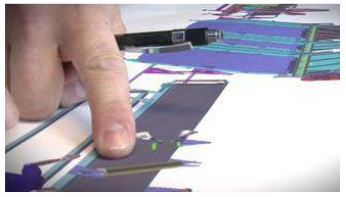
The last 3 years :

21 partnered and collaborative research projects

To answer issues of collective interest. With the support of Inter Professional bodies

The last 3 years :

40 R&D collective programs



The last 3 years :

500 *tailor-made services led for companies*

Focus Presentation of ADIV

Our 5 core business activities offer customized supports including audit, consulting services, expertise and training.

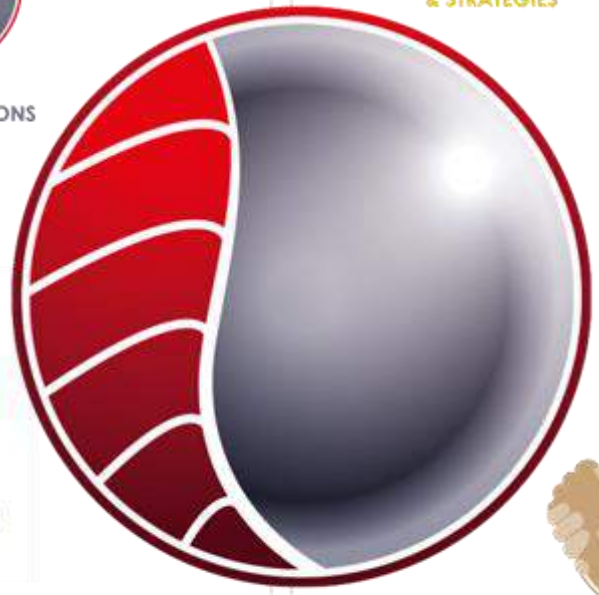
2 main spheres of business relating to the meat industry

Meat processing stages 1 & 2 (slaughtering, cutting)

1ÈRE ET 2ÈME TRANSFORMATIONS

Meat processing stages 3 & 4 (further processed products)

3ÈME ET 4ÈME TRANSFORMATIONS



3 transversal, multi-sector specialist units

ÉCONOMIE & STRATÉGIES

Economic aspects & Strategy consulting

PRÉ-INGÉNIERIE

Project Management *(Assistance with project development, implementation and post-implementation support)*

FORMATION

Training

Focus Presentation of ADIV

Personalized and flexible services

To support, structure and join the companies' projects according to their needs

R&D
AUDIT
CONSULTING SERVICES
EXPERTISE
TRAINING

- Market Positioning
- Business Strategy
- Innovating Research and Development
- Technological Consulting
- Technical, sanitary and economic audit
- Improvement of industrial performances
- Help for the building or rehabilitation of industrial lines or production tools
- Professional Trainings

Focus Presentation of ADIV

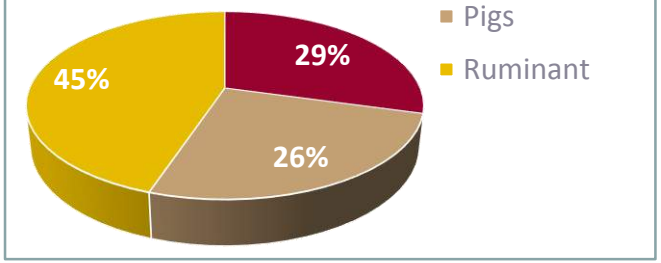
R&D cooperative projects (Partnered and collaborative R&D and collective programs)

3 last years Key figures

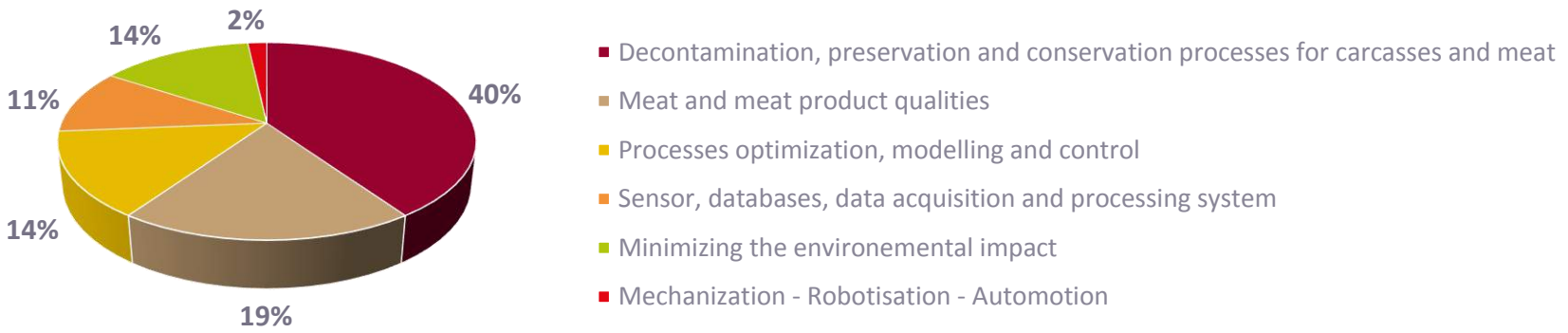
46 R&D programs

- **17** partnered and collaborative research projects
- **2** of them are European Projects
- **29** R&D collective programs
- **23** of them are only supported by inter professional bodies (without any public funding)

Breakdown by species



Breakdown by thematics



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DÉVELOPPEMENT DE SOLUTIONS ROBOTIQUES & ERGONOMIQUES

ADIV viande performances

Focus Presentation of ADIV

Ressources

30 Engineers, Technicians administrative and maintenance staff	Adaptability & versatility			P2+ Laboratory for challenge tests on procedures	Pilot equipments for product transformation
computer-aided design tools	**An Agribusiness platform** of **1.000 m²**	An EC certified for cutting and transformation activities	Cutting edge nutritional analysis laboratory		
		A maturing process area		Microbiology & Biochemistry analysis laboratory	
	Mechanical and boiler making workshop		Robotic unit		

Focus Presentation of ADIV

ADIV Film

Focus Presentation of IP (Institut Pascal)

- ***Institut Pascal***
  - Institut Pascal, UMR 6602, is a joint interdisciplinary research and training unit of **370** people, under the threefold supervision of **Université Clermont Auvergne** (UCA), the **CNRS** and **SIGMA** Clermont. The CHU, University Hospital of Clermont-Ferrand, is also a partner of the laboratory.
  - **174** Researcher, **138** PhD student et post-PhD
  - **The unit is organised into five research groups, called Axe:**
    - Process Engineering, Energy and Biosystems (GePEB department)
    - **Image, Perception Systems, Robotics** (ISPR department)

      Image, Artificial perception, Control for robotics)
    - **Mechanics, Mechanical Engineering, Civil Engineering, Industrial Engineering** (M3G department)

      Mechanics, Materials, Structures, Machines, Robotics
    - Photonics, Waves, Nanomaterials (PHOTON department)
    - Image Guided Therapies (TGI department)

Focus Presentation of IP (Institut Pascal)

– **Interdisciplinary research:**

The **transversal program** federates interdisciplinary research of the Institut Pascal

It breaks down into **5 actions**:

- **Intelligent and Innovative Robots and Machines**
- Innovations for the Bioprocesses
- Technologies for Bioreactors – Online Metrologie – Detection of Vfas using Electrochemically Modified Electrodes
- Bioprocesses Intensification with high Frequency Electromagnetic Fields
- Light Scattering properties by Arbitrary Shaped particlules

– **Plateforms:**

- **SIGMA Plateform**

- PAVIN Plateform (Auvergne Platform for INtelligent Vehicles)

Axe ISPR

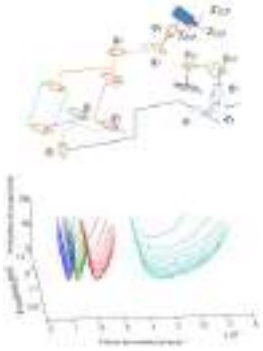
- **Image, systems of perception, robotics**
  - Artificial vision (ComSee)
  - **Modeling, identification and control (MACCS) (Y. Mezouar)**
    - **AV - Autonomous Vehicles**
    - **MLPC - Modeling, Learning and Perception for Control**
      - Robots learning
      - Active Perception
      - Visual Servoing
      - Multi Arms control and Redundancy

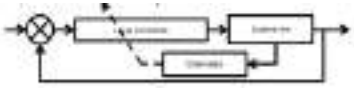
  - **Multi-sensorial perception systems (PerSyst)**
    - multisensor localisation and fusion
    - multisensor localisation and fusion
    - scene mapping, modeling and understanding
  - Hardware and software architectures for perception (DREAM)

Axe M3G

- **Mechanics, Materials and Structures**
  - Materials and structures (MS)
  - Probabilistic mechanics of materials ans structures (MPMS)
  - **Machines, mechanisms and industrial systems (MMSI) (Bouzgarrou C.)**
    - **Synthesis of mechanisms and robots**
      - innovative design and optimization of mechatronic mechanisms and systems
      - develop tools for analysis and structural and geometric synthesis of complex mechanisms

    - **Real-world behavior study of complex systems**
      - Modeling, control and identification of machine behavior
      - Integration of Complex and Redundant Architecture Machines
      - Advanced commands



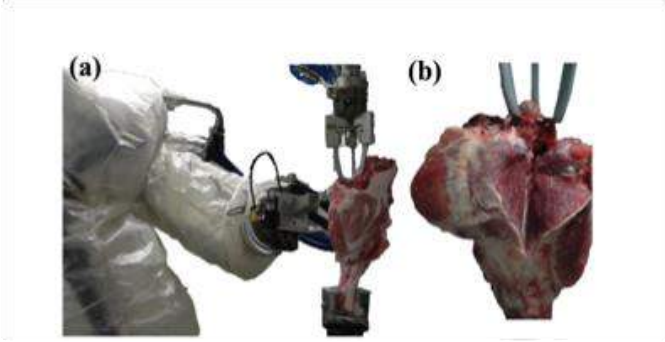


    - **Operational excellence of industrial machines and systems**

Transversal Program

- **Intelligent and Innovative Robots and Machines (Sabourin L., Chapuis R.)**

  - **Redudancy-based optimization approach applied to robotic cell behaviour**
    - **Multi-arm, multi-component manipulation**



Robotized deboning

Machining robotic cell

  - **Collaborative cross and carry mobile robots**
    - **Several co-manipulating : M-bots and P-bots**

SIGMA Clermont

sigma CLERMONT

- **Graduate School of Engineering**

  Industrial Engineering - Chemical Engineering

  Materials – Mechanics - Robotics - Structures

  – **Mechanical department**

    - **MMS – Machines, Mechanisms and Systems**
    - **St2M – Structures and Mechanics of Materials**
    - **SIL – Industrial and Logistic Systems**

  - 977 engineering Students, 60 Teacher/Researcher

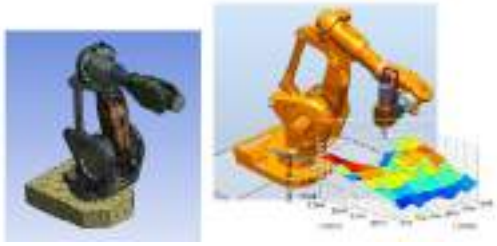
  – **Plateform**

    - **3200 m² of robotic cells, machining machines and metrology**

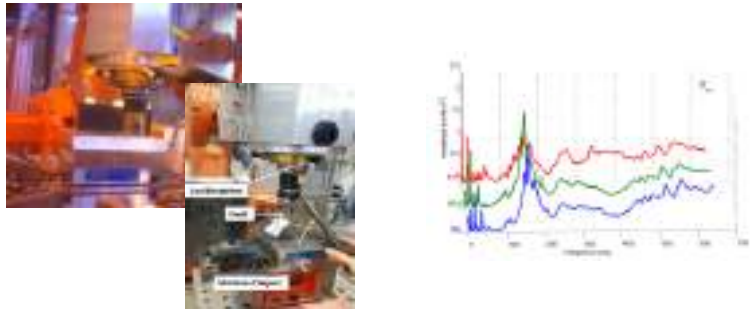
Research Background at Institut Pascal

- **Regional project CAP20-25**
  - **4 multidisciplinary challenges: Agriculture, Industry, Mobility and Natural Hazards**

- **Labex IMoBS3**
  - **Challenge 1: Innovative mobility**
    - Smart vehicles: autonomous vehicles with high mobility
    - **Intelligent machines: agile and reconfigurable manufacturing systems**
      - action ROBDYN: Towards the mastery of the behavior of Robotic systems under heavy DYNAMIC solicitation



(Stiffness Study)



(Operational Modal Identification)

    - Innovative materials for mobility

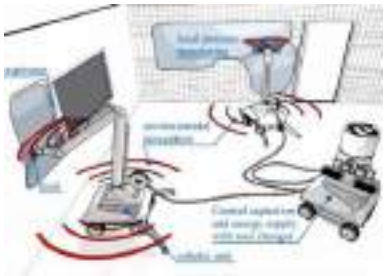
Research Background at Institut Pascal

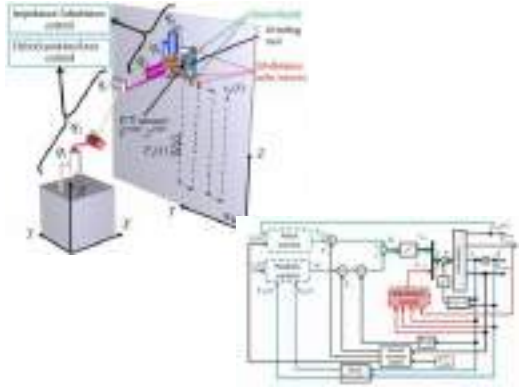
- **AEROSTRIP Project (FUI)**
  - **Robotic stripping of planes:**

(stripping head)

    - Assist force control with a robot manipulator

- **Bots2Rec (H2020 Project)**
  - **Robots for asbestos removal**



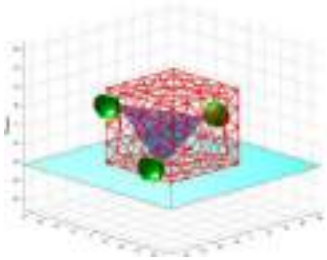


(Hybrid control position/effort)

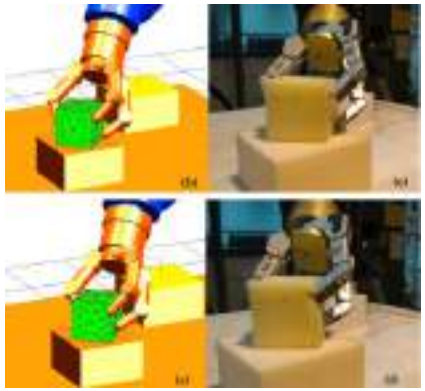
Research Background at Institut Pascal

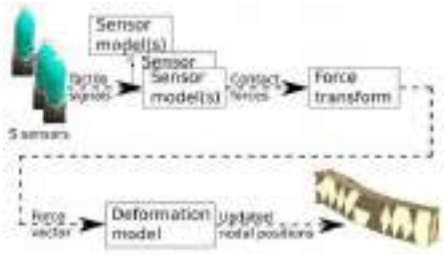
- **Manipulation of deformable objects**

(grasping model)



(strategy of grasping)





- Deformation Model: Vega FEM Library
- Sensor Model

- **Commandia Project**
  - **Robot for shoe assembly**
    - Multi-robot coordination
    - Multi-robot manipulation of deformable objects

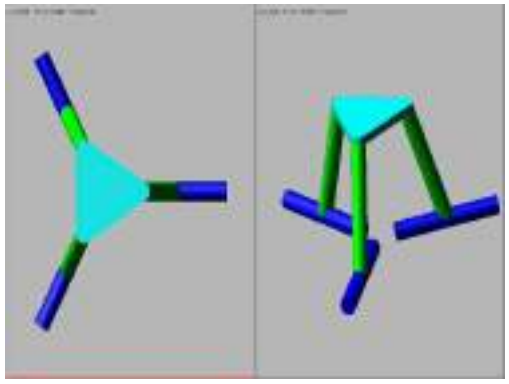
Universidad Zaragoza
Universitat d'Alacant
Universidad de Alicante

- **Factolab with Michelin**

FACTOLAB

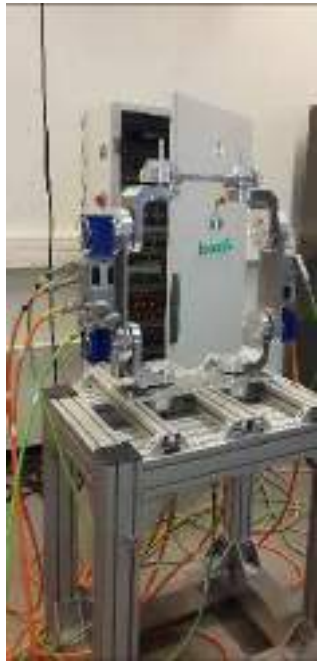
Research Background at Institut Pascal

- **Parallel reconfigurables robots development and integration**



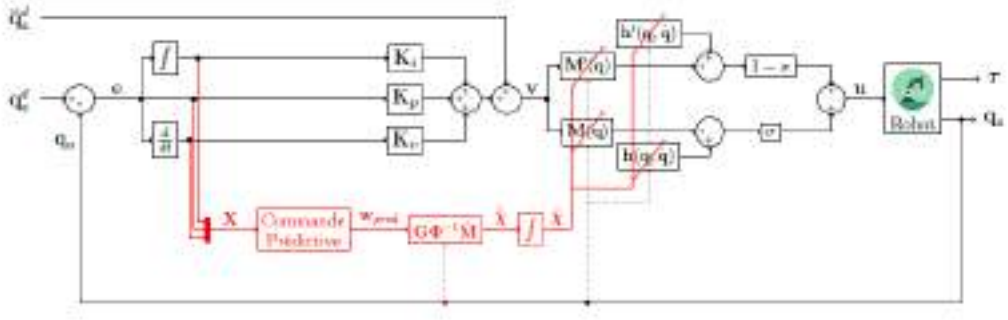
Advanced simulation of 3CRS robot

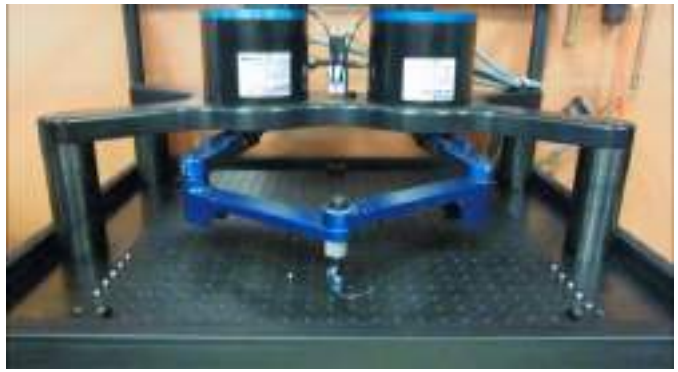
Advanced control of 3RRR robot



Advanced control of 8-bar robot

- **Advanced control law for Type 2 singularity crossing of parallel robots**





Type 2 singularity crossing of 5-bar mechanism

LS2N

ÉTS
Le génie pour l'industrie

Research Background at Institut Pascal

- **STRONGARM project : Individual scrum training**

STRONGARM test with Caroline Thomas (Hooker of the feminine french rugby team and ASM Romagnat rugby club)

STRONGARM test Charles Henri Ducassy (SIGMA rugby team)

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

Mission

- ARAG is a non-profit organization, supporting regional food-sector companies in their development: **performance, innovation, access to market, internationalization** are the 4 main axes for which ARAG provides a support

- ARAG is financially supported by **companies**, **professional organizations and public authorities,** mainly the Regional Council of Auvergne-Rhône-Alpes.

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

Background

ARAG was created in 2014 thanks to the merging of 3 regional organizations

- R3AP, the regional structure to promote Auvergne-Rhône-Alpes food products via the participation to national and international fairs, trade missions, information on foreign markets ... (1986-2014)
- ALLIRA, the regional cluster dedicated to the food sector in Auvergne-Rhône-Alpes that used to be the public-private catalyst of the business and Research-driven initiatives in the fields of innovation. (2011-2014)
- PEACRITT, an organization helping food regional SMEs to develop projects to improve their innovation and performance (2001-2014)

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

- A team of 14 dedicated employees
- 200 members benefiting from ARAG initiatives each year
- More than 50 initiatives each year
- Around 150 companies each year, participating in projects/initiatives (Innovation, Performance..etc)

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

2009, ARAG has launched the regional program:

"Performance and Occupational Health and Safety within agrofood companies"

to improve:

- industrial performance: cost, quality, delay...,

And at the same time

- health and working conditions,

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

"Performance and Occupational Health and Safety within agrofood companies"

Some actions

- Raise awareness, involving different resources in the company
- Make a diagnosis identifying convergent health and performance issues
- Implement ergonomic analyses of selected work situations

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

"Performance and Occupational Health and Safety within agrofood companies"

Some actions

- Implement action plans : on organizational, technical and human sides
- Integrate Health and Performance objectives into industrial management tools and day-to-day management

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

- More than 100 agrofood companies involved in “Health and Performance” program, since 2014

- Each year, around 20 companies, participating in “Health and Performance”initiatives

Focus Presentation of ARAG
Auvergne-Rhône-Alpes Gourmand

Under "AgRobErgo" UMT, ARAG

- Leads the cross-cutting "Ergonomics at Work" axis
- Ensures that the technological innovations developed under the UMT are designed and deployed on an ergonomic basis, to facilitate their acquisition and integration

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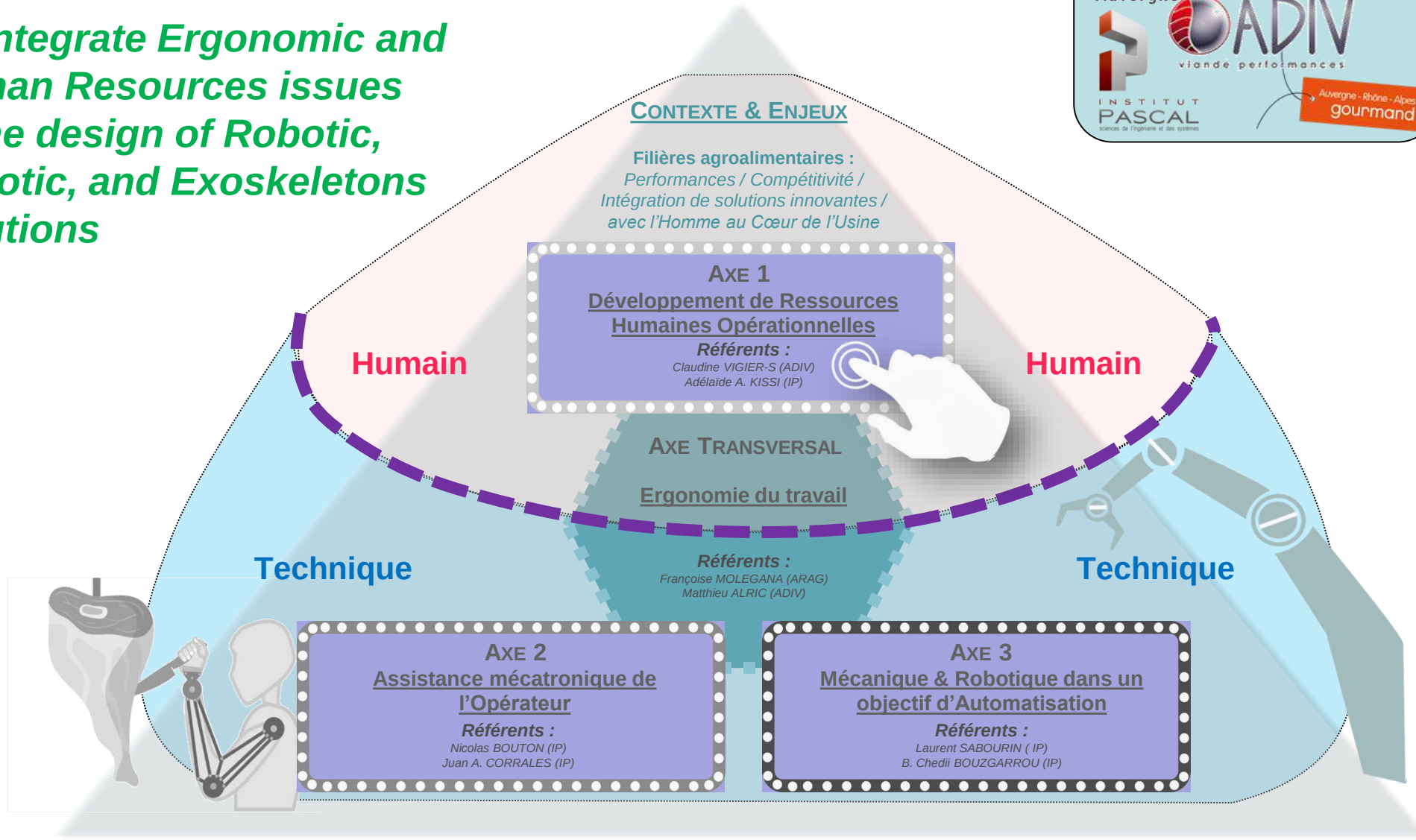
DÉVELOPPEMENT DE SOLUTIONS ROBOTIQUES & ERGONOMIQUES

UMT AgRobErgo (2019-2023)

- ***To integrate Ergonomic and Human Resources issues in the design of Robotic, Cobotic, and Exoskeletons Solutions***



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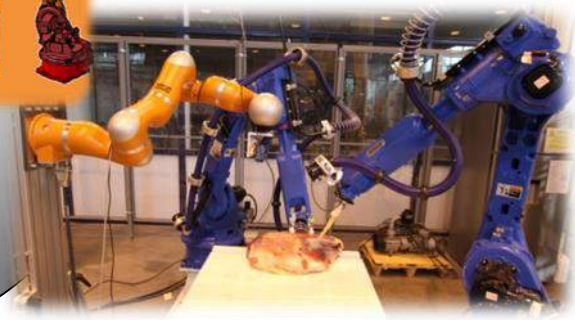
UMT AGROBERGO
DÉVELOPPEMENT DE SOLUTIONS ROBOTIQUES & ERGONOMIQUES

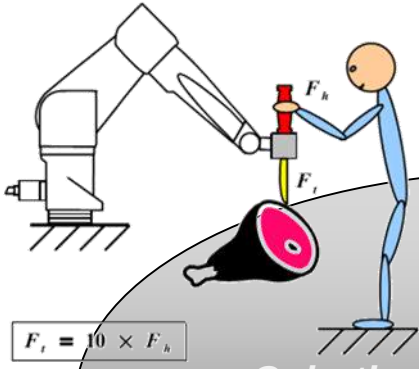
Previous UMT : MÉCARNÉO (2014-2018)

▶ *4 Thematic Axes:*

Axe 1

Complete Automation, Mechanization & Robotization of Unitary Operations or Production Lines



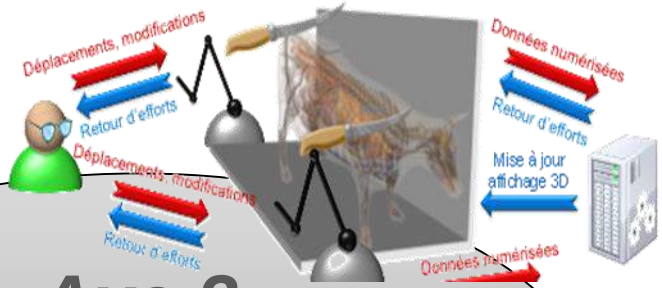


Axe 4

Organizational & Industrial Performances, Systems Management

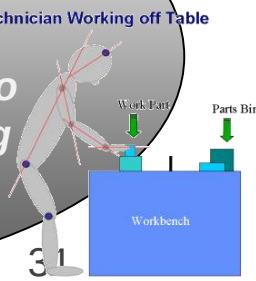
Axe 2

Cobotics & Mechanical Helps (Exoskeletons) to reduce penibility and MSD (TMS)



Axe 3

Virtual & Augmented Reality (3D Real Time Applications) to improve professional training & Ergonomic of stations

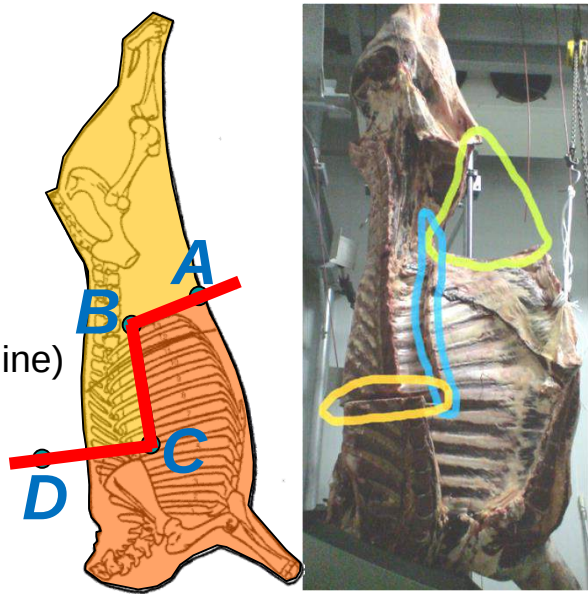


First Robotic Developments

- ***Beef Carcass Separation*** **(SRDViand Project)**
  - ***Operation Characteristics***
    - A « Z » cut from the 5th to the 13th rib

    - Transcription of operator cutting tasks into robotic operations
      3 cutting stapes:
      - **AB cutting trajectory:** along the 13th rib
      - **BC cutting trajectory:** from the 5th to the 13th rib (10 cm far from the spine)
      - **CD cutting trajectory:** spinal column cut

    - Problematic and Constraints:
      - **Important variability**: size (long. : variability > 50cm), shape, concavity, …
      - **Cutting precision** (to cut 8 rib exactly,
        to follow the shape of the 13th rib)
      - **Respect the muscles integrity**
      - Deformation of the carcasses during the cutting operations
        => Need of rigid and precise Holding and Carcasses Positioning System



First Robotic Developments

- ***Beef Carcass Separation*** **(SRDViand Project)**
  - ***Technological Solutions***
    - **Acquisition & 3D Carcass Reconstruction**
      - **Projection of light**
        - » Extraction of 2D profiles
      - **Structured light + Cameras:**
        - » 3D reconstruction

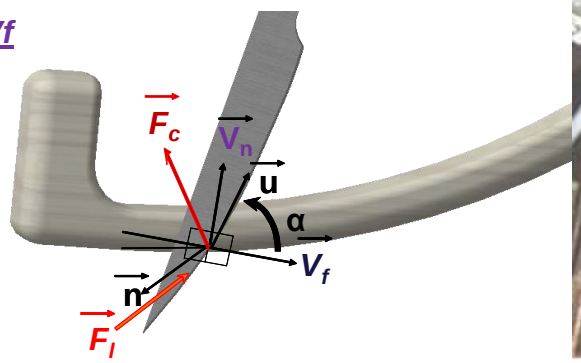
- **Force control**
  - **Adaptation of the theoretical trajectory** according to a real referential, **guided by rigid element**

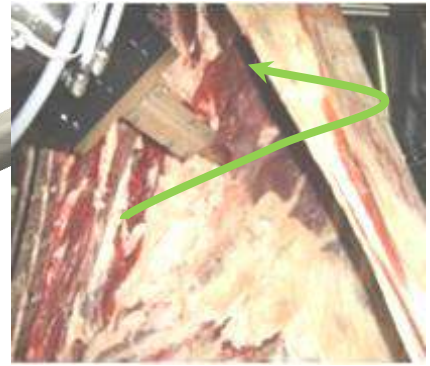
    Ex: using bones as a rigid guide

V_f : Feed rate speed // V_n : Normal speed to Vf

α: Cutting angle // F_c : Cutting effort

F_l : Contact Effort





if α ≈ 30° or $V_n \neq 0$ { => Reduction of Cutting Forces
=> Better cutting quality

- **Other intelligent systems**

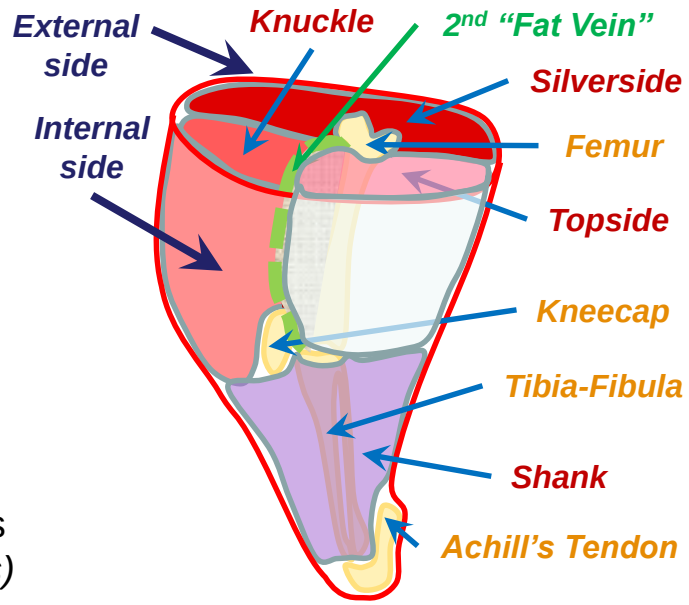
First Robotic Developments

Beef Carcass Separation Film

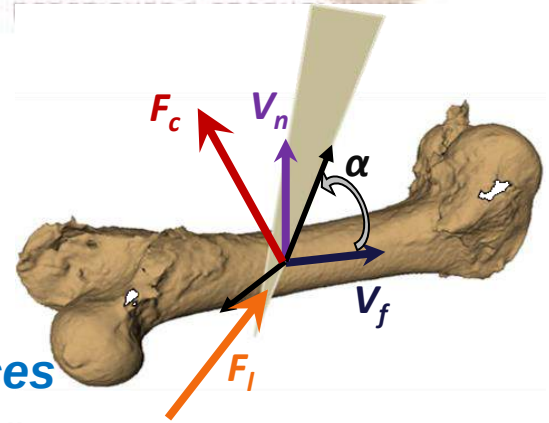
First Robotic Developments

- ***Pork Legs Deboning Process*** **(SRDViand Project)**
  - ***Usual manual deboning Process***
    - **1.** ***Opening the pork leg*** up to the bones *(along Aponevrosis):*
      - ***Cuts*** to mark the separation line *(2nd "Fat Vein"):* *between the **Top side** and the **Knuckle***
      - ***Deep cuts*** to get in contact with the bones:
        1. *Femur (between the **Top side** and the **Knuckle**)*
        2. *Tibia-Fibula (to open the **Shank**)*
    - **2.** ***Bones' extraction*** *(**Tibia-Fibula**, **Femur** and **Kneecap**)*
      - ***Traction*** of the bones and ***Cuts*** around and behind the bones (*Knife guided by the rigid consistence and shape of the bones)*
      - ***Cuts*** around the ***Kneecap*** the separate it from the meat
    - **3.** ***Tendons and tissues cutting***
      - Cuts of the ***Achill's Tendons*** and other small tendons to finish the bones separation

Ex: Right Leg



First Robotic Developments

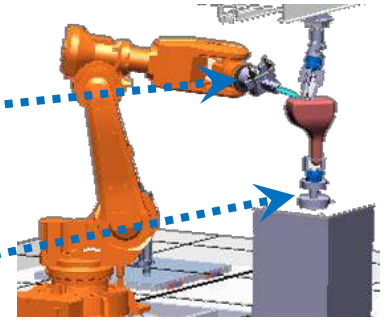


- ***Pork Legs Deboning Process*** **(SRDViand Project)**
  - ***Cutting Parameters*** adjustment ⇔ ***Cutting quality***
    ⇔ ***Reduction of the cutting forces***

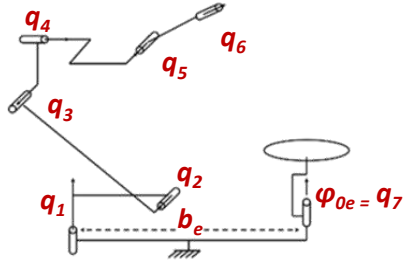
V_f : Feed rate speed // V_n : Normal speed to Vf // α: Cutting angle // F_c : Cutting effort // F_l : Contact Effort

Results: ***2 Solutions:*** ***[α ≈ 30°*** and ***V_n = 0]*** ***or*** ***[α ≠ 30°*** and ***V_n ≠ 0]*** *(combined with* ***V_f****)*

  - ***A 7 D.o.F. Robotic cell***
    - A ***6 axes Robot*** ⇔ holding & manipulation of the *Tools/Knifes*
      => With a ***Force sensor***
    - A ***Controlled External Axis*** ⇔ better accessibility *(incisions around the bones)*



  - ***Geometric model***: ***TCS method*** *[robot + external parameters (φ_{0e}, b_e)]*



  - ***Model and Solving Method***
    - **Kinematic redundancy management** : to ensure the path parcourability
      1 dof of redundancy => 1 more unknown than the number of equations
      => 1 additional criteria in the selection of solutions

First Robotic Developments

- ***Pork Legs Deboning Process*** **(SRDViand Project)**
  - ***Multi-objective optimization***
    - Objective of an Optimization: ***To minimize a criterion***
      => Decomposition of the Optimization Criterion in a sum of sub-criteria

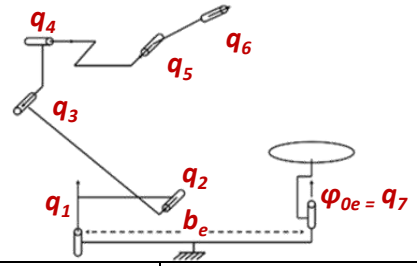
$$\Phi(q) = \sum_{i=1}^{k} w_i\left(\Phi_i(x)\right)\overline{\Phi}_i(q)$$

$\overline{\Phi}_i(q)$: *sub – criterion*

$w_i\left(\Phi_i(x)\right)$: *weight of the sub – criterion*

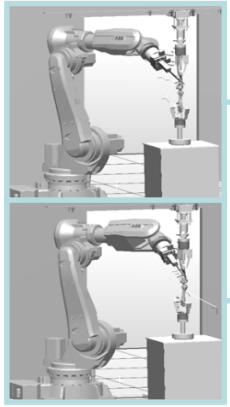
    - ***Adjustment of the criterion's weights (w_i)*** ⇔ Desired robotic behavior

      Ex: More Accuracy => Increase the weight of Φ_r criterion



Criteria	Formulation
joints limit	$\Phi_J = \sum_i^n \left(\frac{q_i - q_{imoy}}{\Delta q_i}\right)^2$
Kinematic	$\Phi_v(q) = u_v^T(J_v J_v^T)^{-1}u_v$
Mechanical advantage	$\Phi_m(q) = u_m^T(J_m J_m^T)u_m$
Accuracy	$\Phi_r(q) = \sum_1^n q_i$ q_i articular value of q_2 and q_3
Cutting pressures	$\Phi_\alpha = \|F_c \wedge u_6\|$

  - ***Global Robotic Force Control Algorithm***



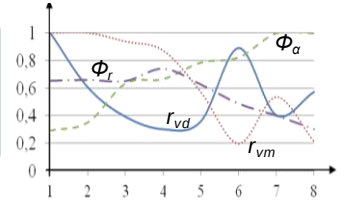
Definition of a ***Theoretical Trajectory***

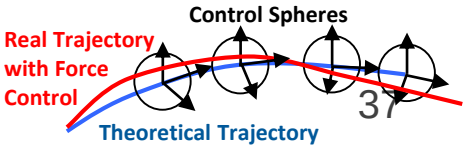
Optimization Loop

Definition of an ***Optimized Theoretical Trajectory***

Use of ***ABB Force Control*** to adapt the ***Real Trajectory*** during the cutting operations

Multi-Criteria Optimization
- Joints limits,
- Kinematic,
- Accuracy, …



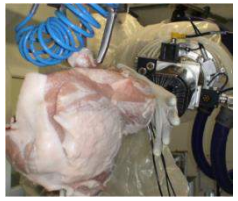


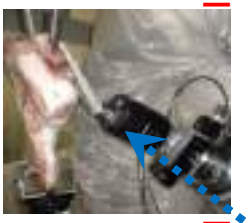
First Robotic Developments

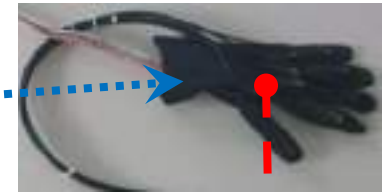
Pork Legs Deboning Process Film

First Robotic Developments

- ***Pork Legs Deboning Operation by Human-Robot Co-Working***
  (ECHORD-DEXDEB European Project)
  - ***Experiments using a Data Glove*** to measure:
    - **Butcher's left hand Forces** applied by the fingertips on the meat
    - **Joints Angular Coordinates of each finger** (proximal interphalangeal – PIP; and metacarpophalangeal – MCP)
      => To define butcher's left hand poses during steps of pork leg deboning

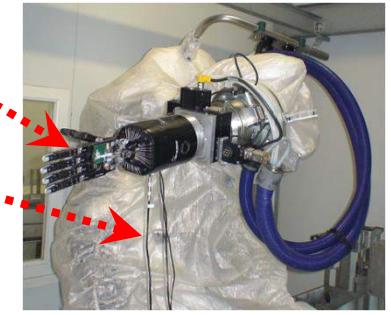






  - ***Movements Formalization of [ABB Robot + Shadow Robotic Hand]***
    - ***A System with 6 dof (Robot) + 24 dof (Hand)***

$$p = \prod \mathrm{T}(\theta_{Ai}, \mu_{Ai}) \prod \mathrm{T}(\theta_{Hj}, \mu_{Hj})$$



  - ***Definition of Initial poses (of ABB Robot + Shadow Robotic Hand)***
    - **To approach and get into contact with the meat**
      with ABB Robot poses inspired from the butcher's arm poses
      & with Shadow Hand poses calculated from Data Glove measurements

  - ***Definition of Manipulation poses*** at each step of the deboning
    - **To grasp the meat** by closing the Shadow Robotic Hand Fingers
    - **To Pull, Push or Twist the meat** to ease the deboning operations of the butcher

First Robotic Developments

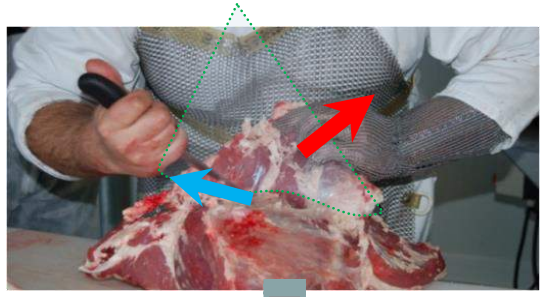
- ***Pork Legs Deboning Operation by Human-Robot Co-Working***
  (ECHORD-DEXDEB European Project)
  - ***Human-Robot co-working experiments for deboning operation***
    - **Teach-by-Show Method to program and test the Robotic System Co-Working Process**
      - **Butcher teach the left hand trajectory/movements to the Robotic System**
      - ⇒ **Then, The Robotic System repeats the left hand trajectory/movements in an Autonomous Mode While The Butcher cuts with his right hand**
        - » **Each movement is validated when the F_{reach} force/resistance is reached**
        - ⇒ **Then it runs the next movement**

First Robotic Developments : ARMS Project

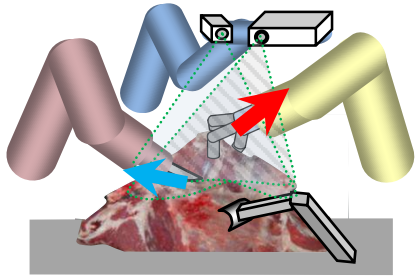
Autonomous multi-Robots system for Muscles Separation

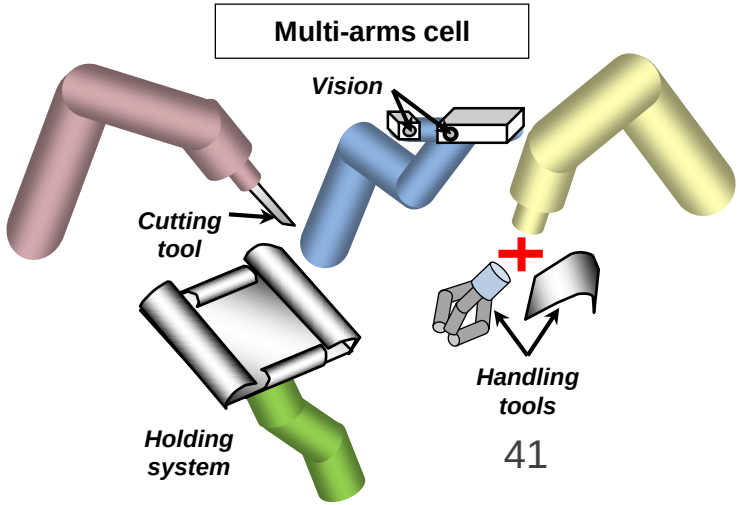
- ***Partnership:***

- ***Objective***
  - Development and control of a multi-arms robotic system for muscles separation of **beef rounds muscles (in suspension or on table)**



- ***Tools and model to develop***
  - Multi-arms Control algorithms,
  - Active perception system,
  - Dexterous manipulation tools and devices,
  - Holding system,
  - …

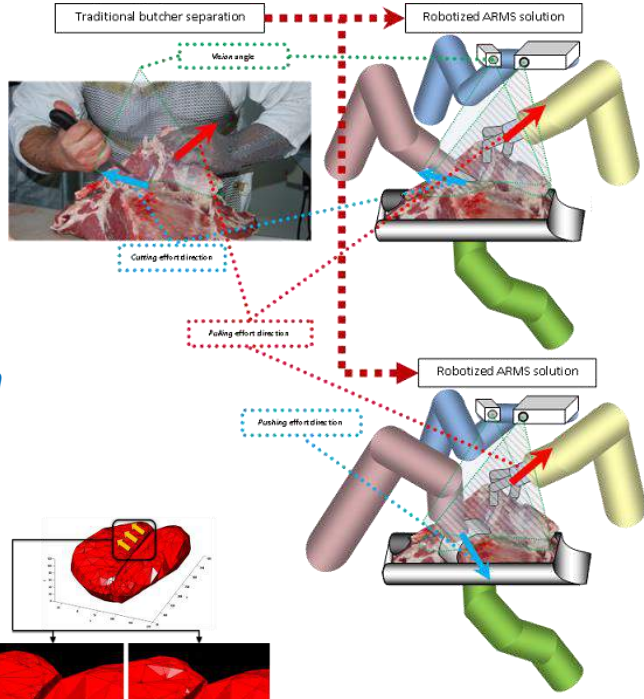




First Robotic Developments : ARMS Project

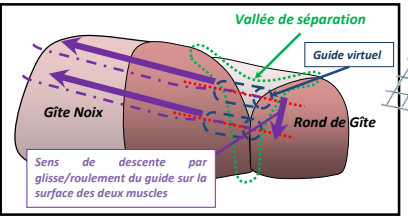
Autonomous multi-Robots system for Muscles Separation

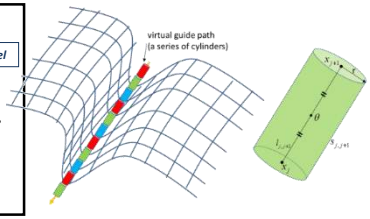
- ***Research challenges:***
  A multi-competences project:

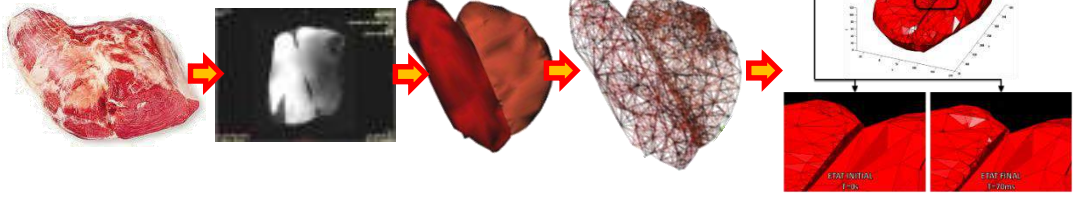


  - *To **define robotized scenarios** from the operator/ buchers gestures*

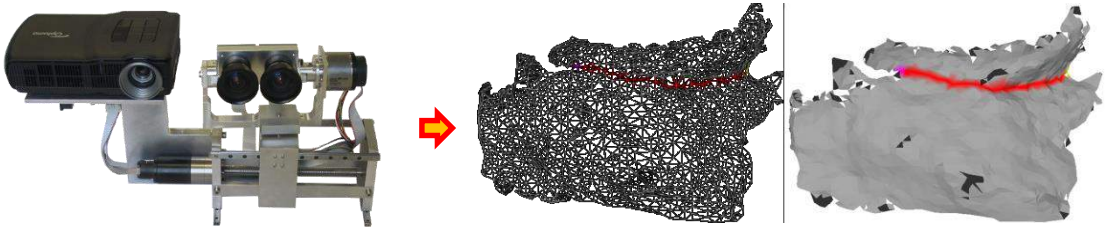
  - *To **define and validate robotic concepts of muscles separation** in between 2 muscles or between muscles and bones by setting up experimentations*







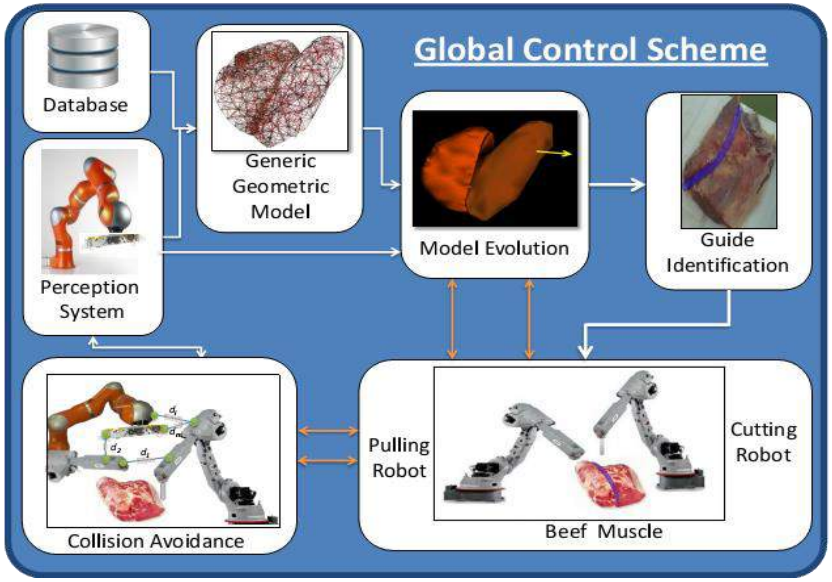
  - *To **design specific equipments**:*
    Active sensors, Handling tools, …

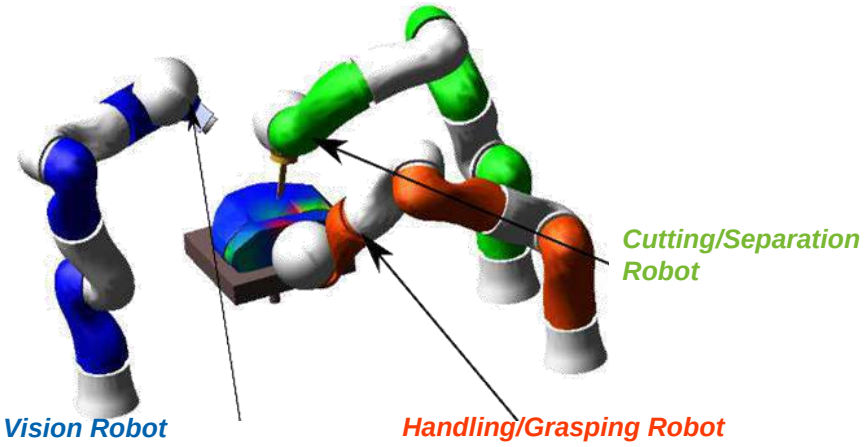


First Robotic Developments : ARMS Project

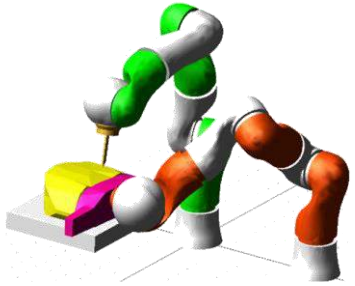
Autonomous multi-Robots system for Muscles Separation

- ***Research challenges:***
  A multi-competences project:
  - *To **develop** **multi-arms control/cooperative algorithms** adapted to the tasks*





- ***Many Perspectives of Industrial Applications***
  - ***All Cutting/Deboning Unit Operations and Process*** *needing meat products manipulations combining:* ***Handling/ Traction / Compression / Cutting***



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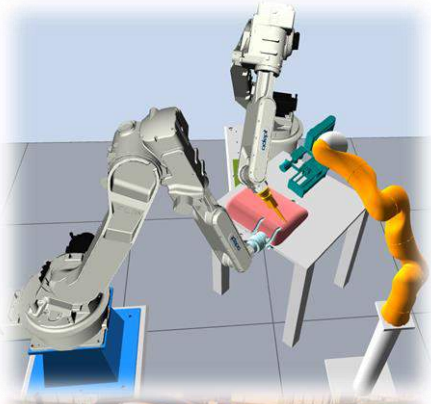
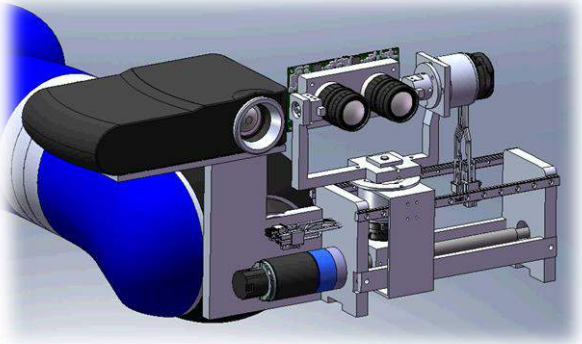
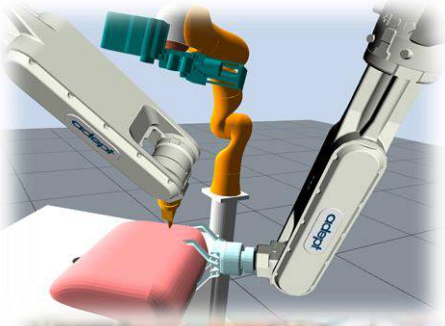
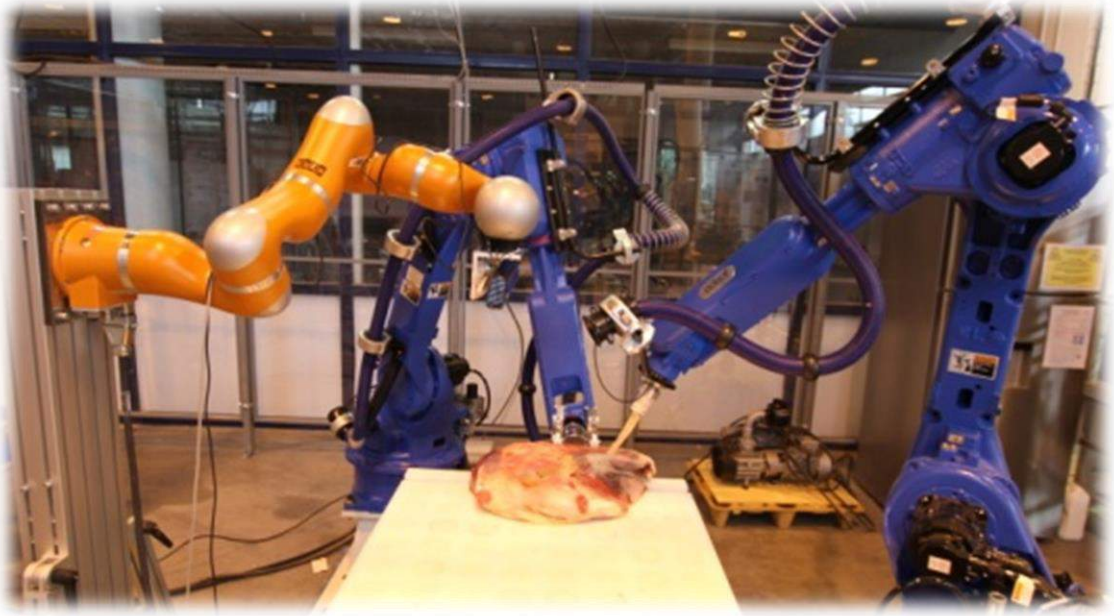
First Robotic Developments : ARMS Project

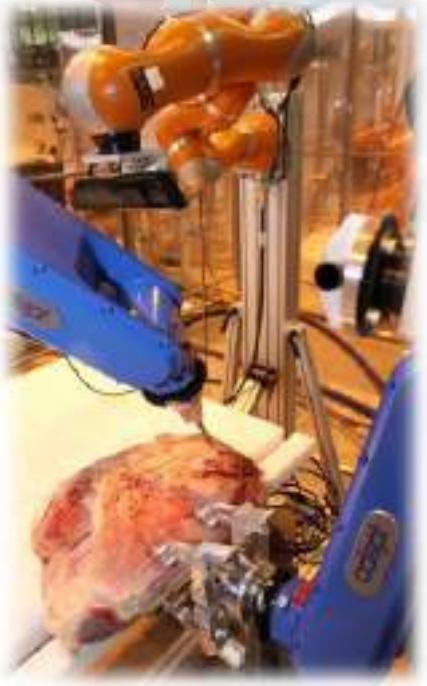
Autonomous multi-Robots system for Muscles Separation











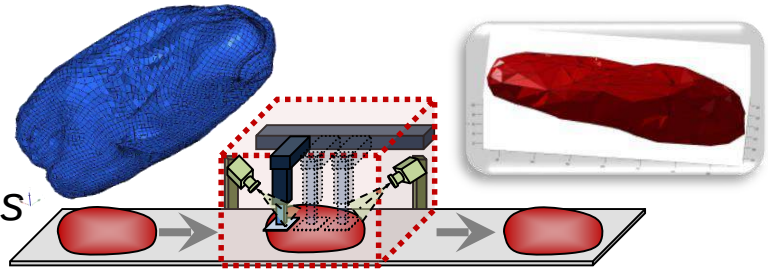
First Robotic Developments : ARMS Project

Autonomous multi-Robots system for Muscles Separation

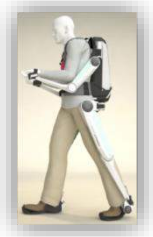
ARMS Film

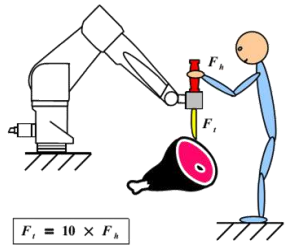
Looking for other technologies to apply to meat process

- ***Meat Muscles modeling***
  (Mechanical Characterization & 3D Vision Tracking)
  ⇒ ***Predictive models***: - *Robotic Control for cutting process*
  - *Meat Tenderness Evaluation*



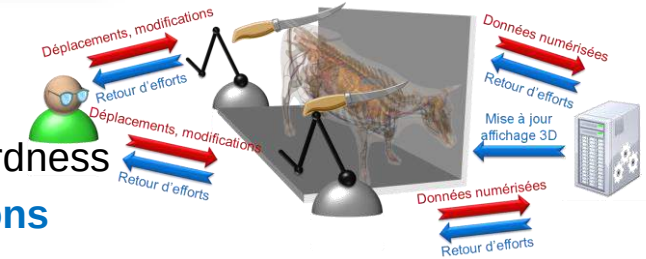
- ***Cobotics*** and
  Mechanical helps – Exoskeletons



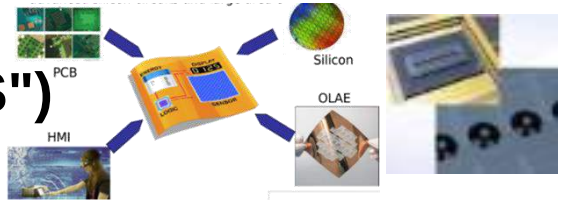


- ***Virtual Reality***

  - To **improve Ergonomy**:
    Design and Optimization of working stations / Reduce Hardness
  - To **propose alternatives Learning and Training Solutions**



- ***Developments of New Sensors***
  (FP7 European Project: "FOODMICROSYSTEMS")



Focus on FOODMICROSYSTEMS - FP7 European Project

- ***Partnership :***

COORDINATOR	PARTNERS
Actia (France)	Estonia (Tartu Biotehnoloogia Park) France (Actia (Actilait, Adiv, Aérial, LNE), CEA, Euroquality) Germany (4M2C, Fraunhofer) Netherlands (DLO, University of Wageningen) Spain (CSIC)

- ***Website for more information :*** www.foodmicrosystems.eu

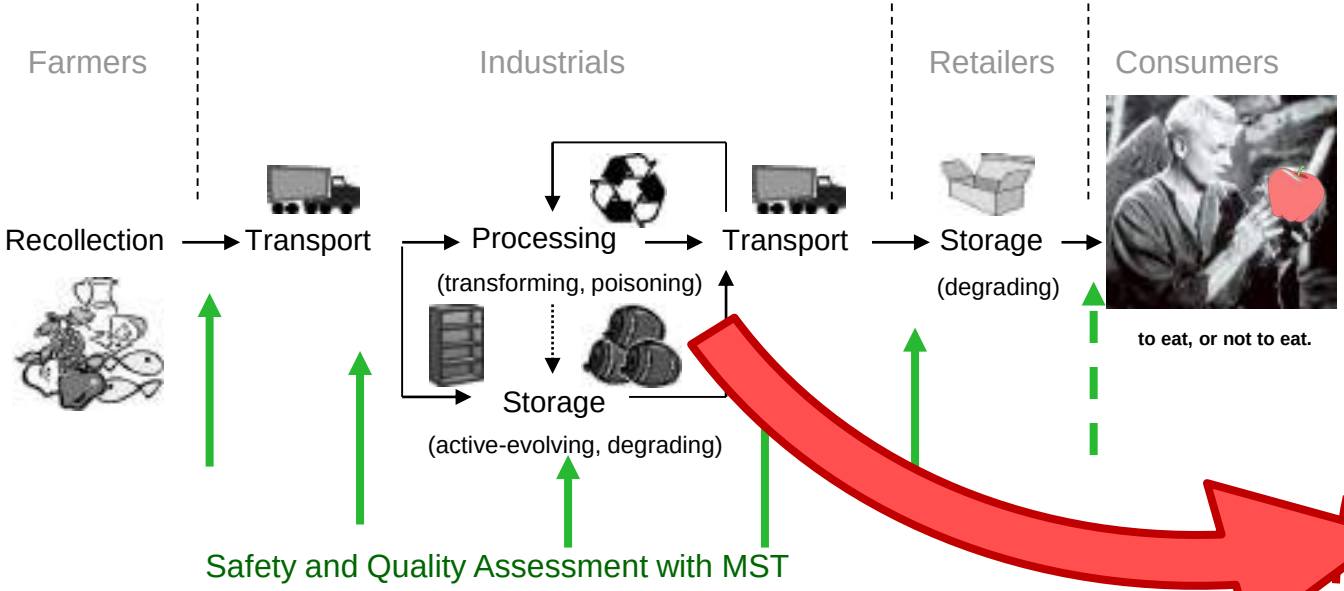
- ***Main objective of the project :***
  - To **Analyze the Food industrial sectors** (Milk, Meat, Fruits, ...) **and their needs**, to **Define Road Maps of Microsystems** Industrial applications

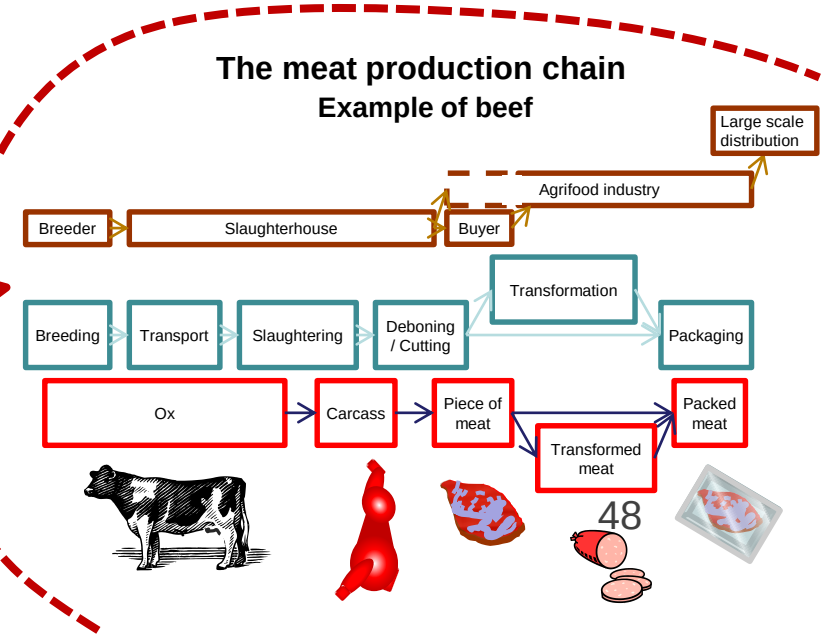
Focus on FOODMICROSYSTEMS - FP7 European Project

- ***First Question :***

Where can MST be used in food industries ?

Foodchain monitoring and traceability: safety and quality assessment stages





MST contribution: closeness to the foodstuff & power of analysis & speed

(multi-sensing, multipoint sensing, continuous monitoring, automation/non-specialist intervention)

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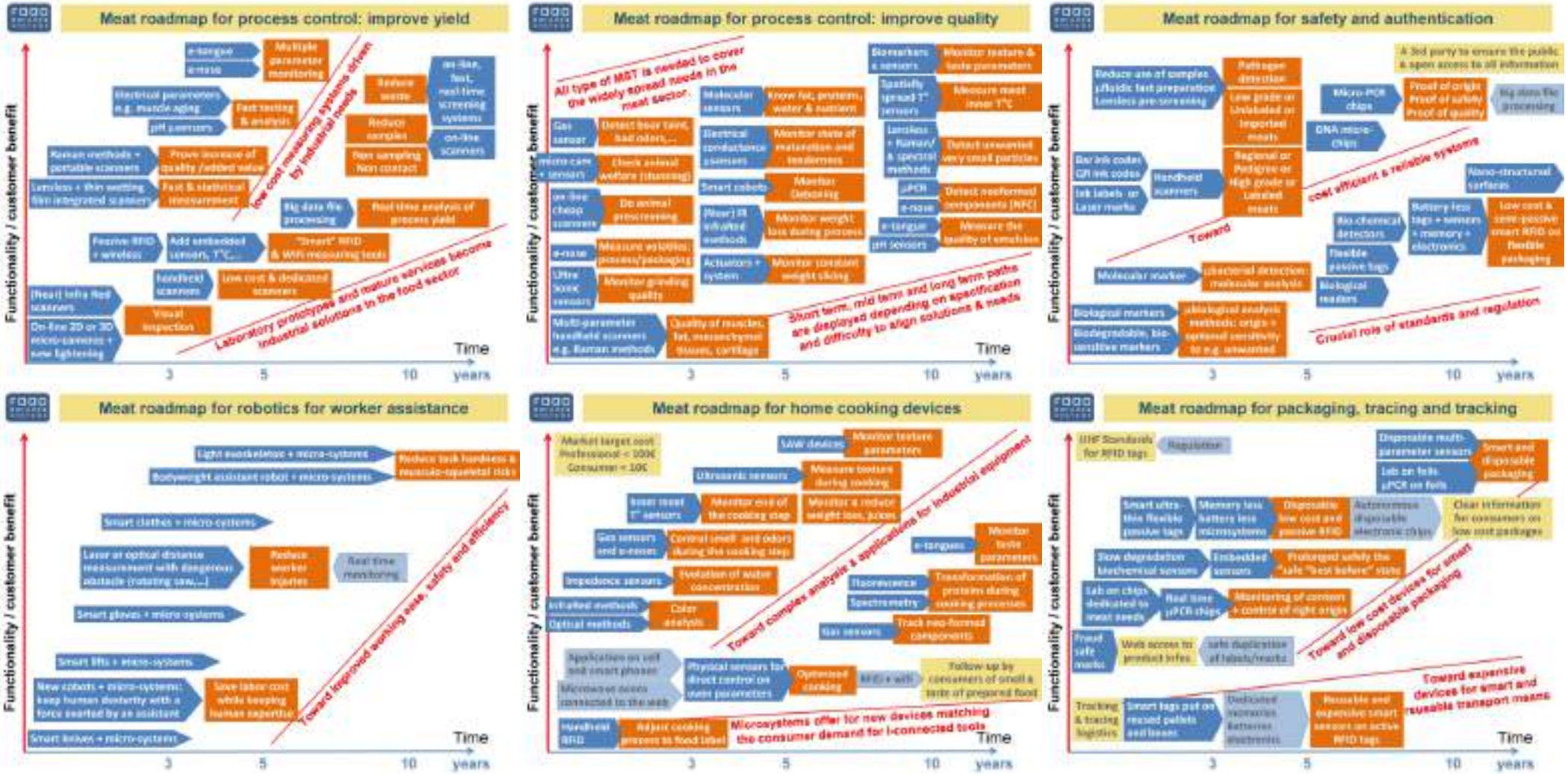
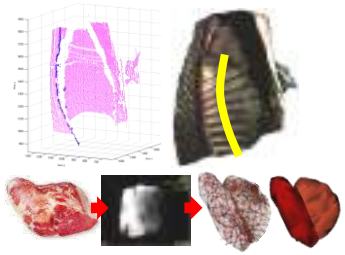
DÉVELOPPEMENT DE SOLUTIONS ROBOTIQUES & ERGONOMIQUES

Focus on FOODMICROSYSTEMS - FP7 European Project

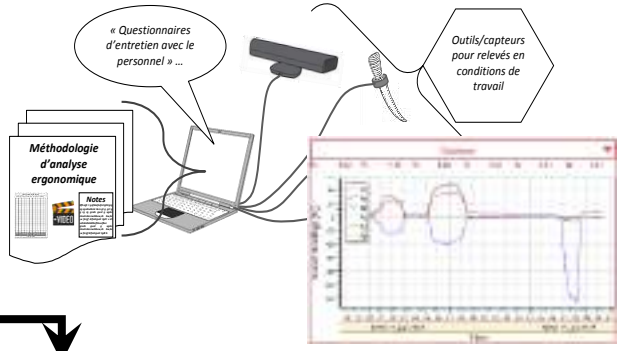
- ***Examples of resulting Road Maps***



Definition of an integrated demarche to modernise the meat sector !



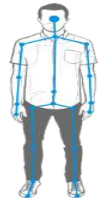
Action 1 : Needs evaluation, Parameters characterisations and evaluation, Specifications definition, Frames and models evaluation

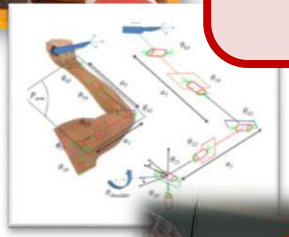


Action 2 : Mechanical design and Cobotic and Exoskeleton Prototypes building

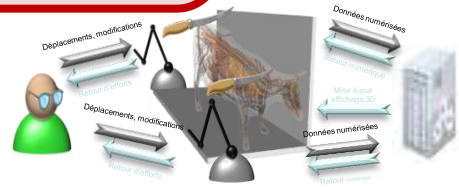
Action 3 : Ergonomic simulation and evaluation (by Virtual Reality and Putting in "Real Situations")

Action 4 : Design of more Didactic/Intuitive/Attractive Training Applications & Simulators





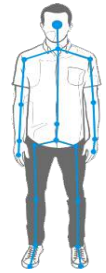
Action 5 : Qualification, Gains & Improvements Evaluation, Prototypes Validation

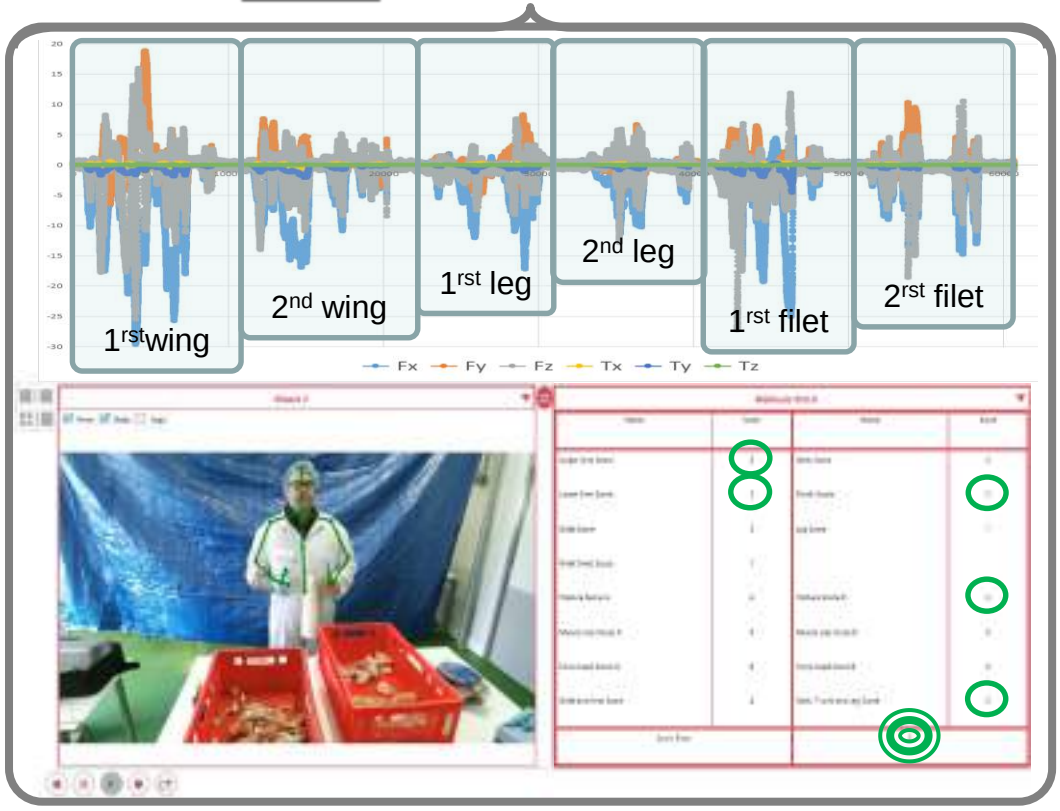


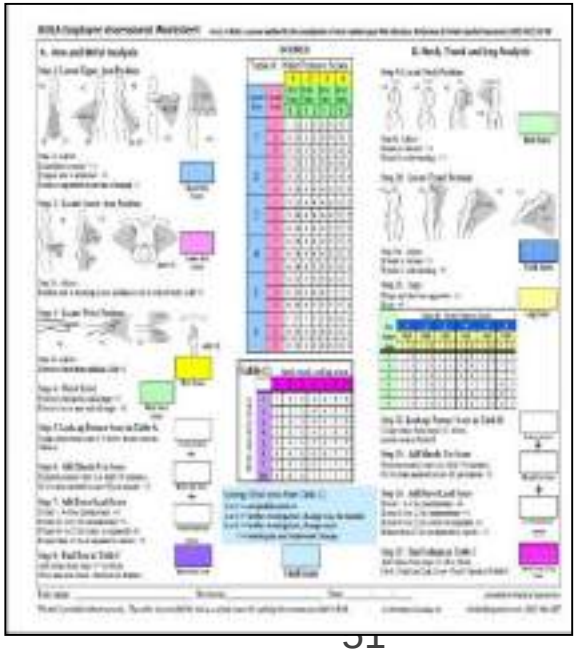
Action 6 : Demonstrations & Diffusion of the technical solutions to the Professionals => New Training Approaches & Methods

Action 1 - CAPFOR Project

- **CAPFOR Project (supported by BPi FRANCE – RCS Projects Call)**
  - **Tools/Software synchronising Force Sensors & Kinect v2**
    - Acquisition Example (Chicken cutting)



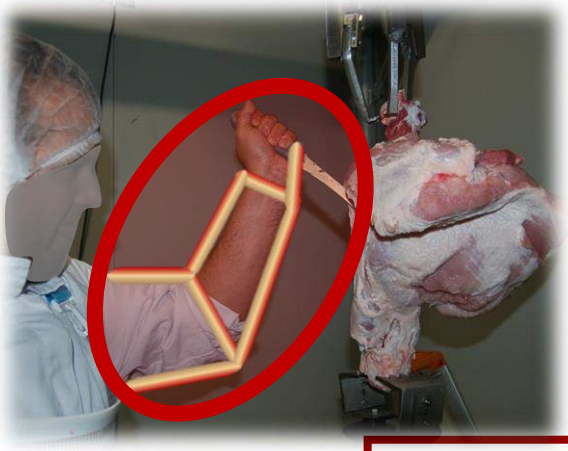


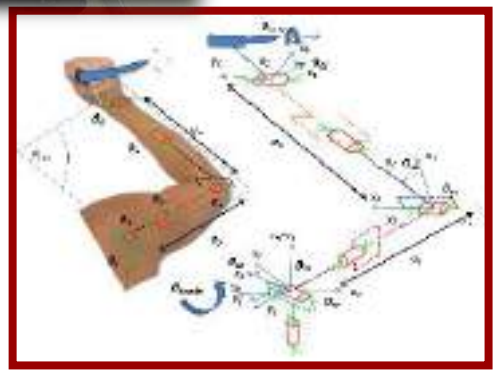


Action 2 - EXOSCARNE Project

- **EXOSCARNE Project (Supported by FranceAgriMer – "P3A" Program)**
  - **Design of Cobotic and Exoskeleton Prototypes to reduce operator wrist and arm forces, needed for meat deboning and cutting operations**

    "P3A" Program – "ICF2A" Projects Call - 2I2A Competitive Branch





Partnership

Leader

ADIV Développement SA,
(Clermont-Ferrand - 63)

Scientific Partner

Institut Pascal,
(Clermont-Ferrand - 63)

Industrial integrator Partner

Société CIP Automation
(Lamballe - 22)

Labelling

CIMES (ex-ViaMéca)
Competiveness Cluster

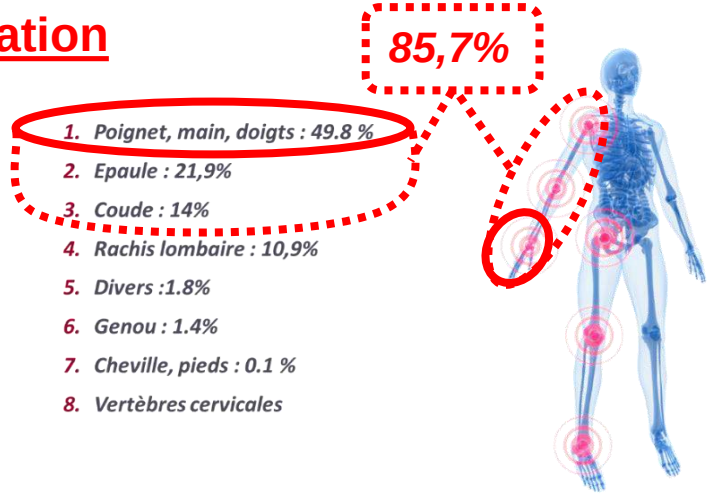
Action 2 - EXOSCARNE Project

State of Arts

- **No company** are proposing Exoskeletons **dedicated to meat operations**
- **No Exoskeleton Patent** on specific meat cutting solutions for wrist forces reduction
- **Most of the patents** deal with :
  - Either **Vertical Force (Gravity) compensation**
  - Either **Unidirectional compensation** (example: lift, pulling/pushing actions) or **Shoulder and Upper Arm part assistance**

Needs & Specifications of Meat Sector

- **MSD Location**



- **Objectives**
  - **3D curved Trajectories** achievement, adapting each successive **positions** and **orientations**
  - Generate **Forces & Torks** in **every space direction**
  - **Focus on wrist assistance**

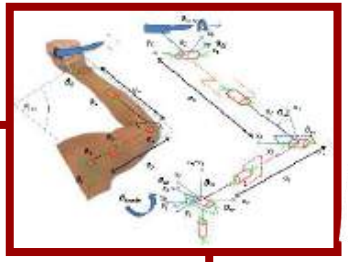
ADIV . AUVERGNE-RHÔNE-ALPES GOURMAND
CNRS . INSTITUT PASCAL . SIGMA
& UNIVERSITÉ BLAISE-PASCAL À CLERMONT-FERRAND
ACTIA

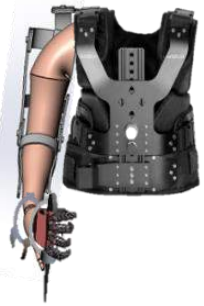
UMT AGROBERGO
DÉVELOPPEMENT DE SOLUTIONS ROBOTIQUES & ERGONOMIQUES

Action 2 - EXOSCARNE Project Structuration

LOT 1 :
MEAT DEBONING & CUTTING OPERATIONS CHARACTERISATION, NEEDS & SPECIFICATIONS DEFINITION

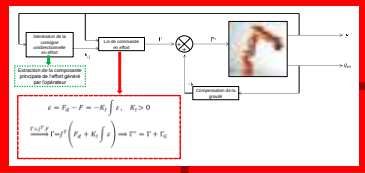
Deboning & Cutting analyse, Selection of sequences and operational cases, Needs & Specifications





LOT 2:
DEVELOPPEMENT OF A MULTIDIRECTIONNAL FORCES & TORCS COMPENSATION CONTROLER & TESTS ON COBOTIC AND EXOSKELETON ARMS PROTOTYPES

Design of the Forces & Torks Compensation Control Model



LOT 3:
DESIGN OF 3D MOCK-UPS WITH CAD SOFTWARES & COBOTIC AND EXOSKELETON PROTOTYPES MACHINING AND BUILDING

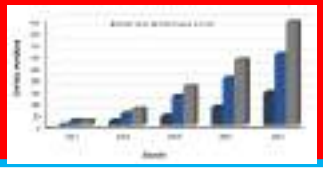
Exoskeleton & Cobotic Prototypes Achievement

Control Cabinet of the solutions

Exoskeleton/Cobotic Arms (parts, actuators)

LOT 4:
SOCIO-ECONOMIC IMPACTS OF THE TECHNOLOGICAL SOLUTIONS (EXOSKELETON AND COBOT) ON DEBONING AND CUTTING WORK

Demonstrations & Gains/Improvements Evaluation, Selling Prices & Market



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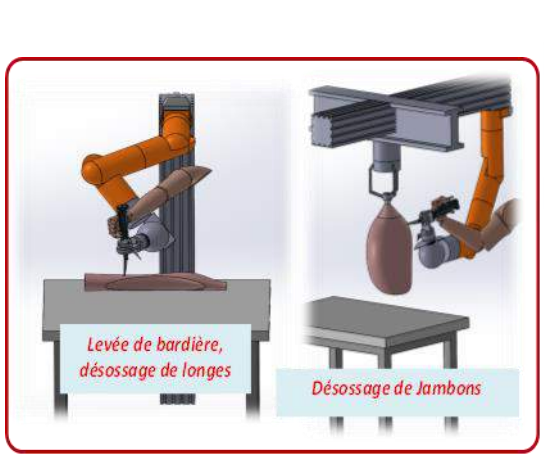
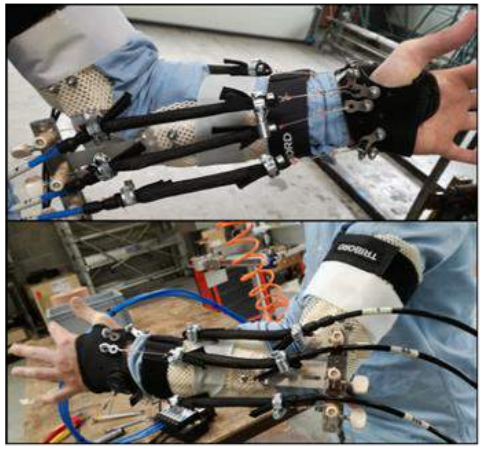
Works in progress & First Results

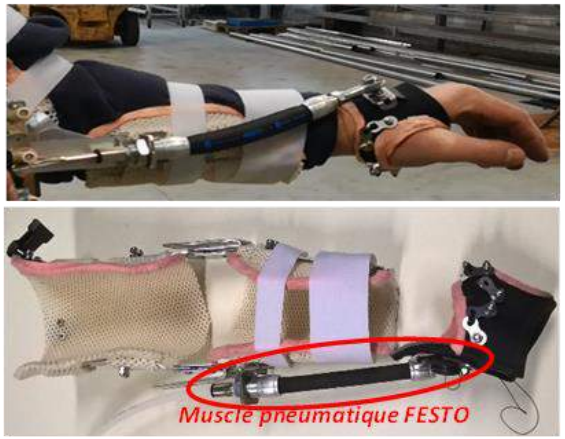
- **Most Deliverables**
  - **Needs & Specifications**
  - **3D Numerical Mock-ups** of Prototypes
  - Actuating solutions, Controller and Command Algorithms
  - **Different versions of Prototypes**
  - **Socio-Economic impacts and Potential Market** Evaluation
  - **Intellectual Property** **(Patent deposing)**

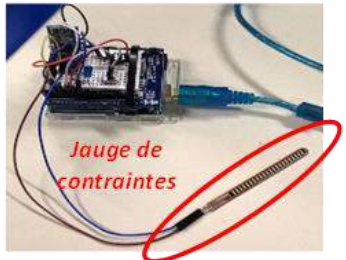


Attelle Exosquelette avec muscles pneumatiques "artisanaux"



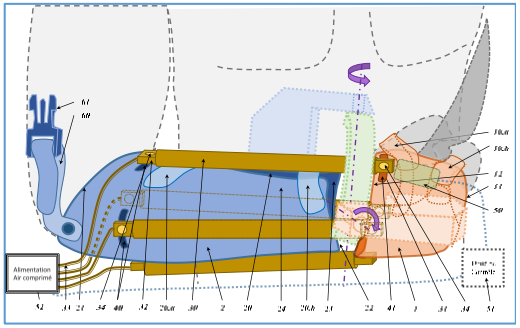
Attelle Exosquelette avec muscle pneumatique FESTO





Works in progress & First Results

- **2 Prototypes**
  - **1 Exoskeleton actuated Prototype** ⇒ ***Patented*** inpi INSTITUT NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE



  - **1 Cobotic Prototype**

Action 2 - EXOSCARNE Project

ExosCarne Films

Matthieu ALRIC

matthieu.alric@adiv.fr

Tel: 04 73 98 53 80

UMT AGROBERGO Leader
Projects Manager/Leader
in Mechanical & Robotics Engineering

ADIV Engineering

Thank you for your attention !