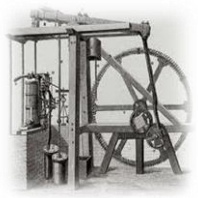


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On the design of adaptive grippers for the grasping of non-rigid materials

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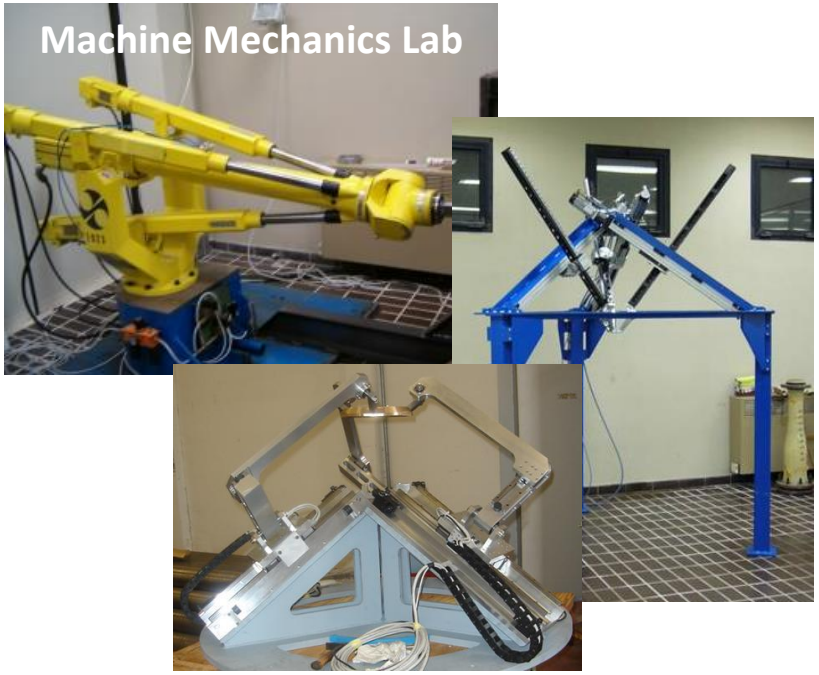

On the design of adaptive grippers for the grasping of non-rigid materials

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Robots 4.0 **Adaptive Grippers**

Introduction

Challenge: Automatic Handling of Non-Rigid Materials (NRMs)

Manufacturing tasks: **picking**, **transferring** and **laying** of limp materials

manually performed → **automation** improves productivity and cost effectiveness

NRMs' features (leather, wallpaper, composites) and **functional requirements**

1. **irregular** and **variable** shape → adaptive gripper systems
   - Literature: **gripping systems** of **small size templates** → small number of grasping points
   - But industrial tasks often require the handling of **large size plies**.

     Ex. In leather industry the leather plies 2,5m x 3m .
2. **deformations** during the handling: produced by the material's own weight and dynamic forces → dense matrix of gripping points is necessary to stabilize large templates.
3. **delicate** surface → damages prevented by sharing the total weight with more gripping points

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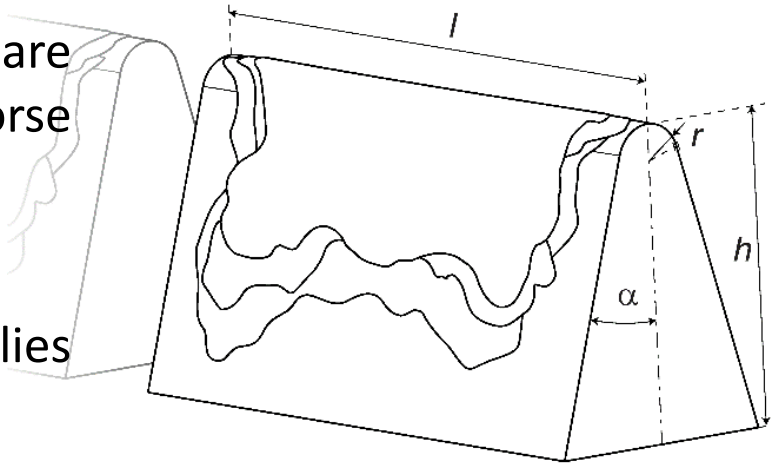
Robots 4.0 **Adaptive Grippers**

Introduction

In the leather manufacturing, leather sheets are stacked on traditional chests with a vaulting horse shape called **beams.**

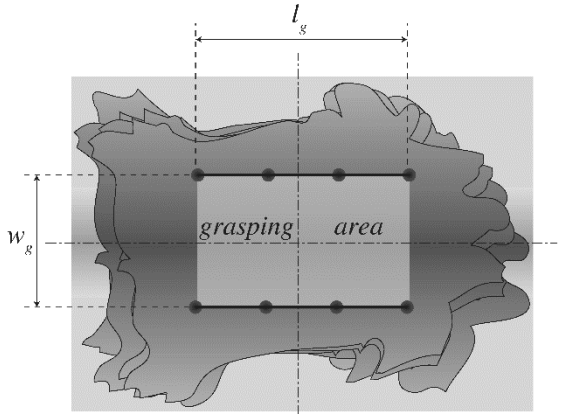
- to minimize their horizontal dimensions
- promote the proper stacking

The **beam surface** affects the stack of the leather plies and consequently the **structure of the device**.



Two different concepts can be followed (a merge of them is also possible) according to the **location of the grasping points**:

1. **FIXED POSITION**
2. **VARIABLE POSITION**



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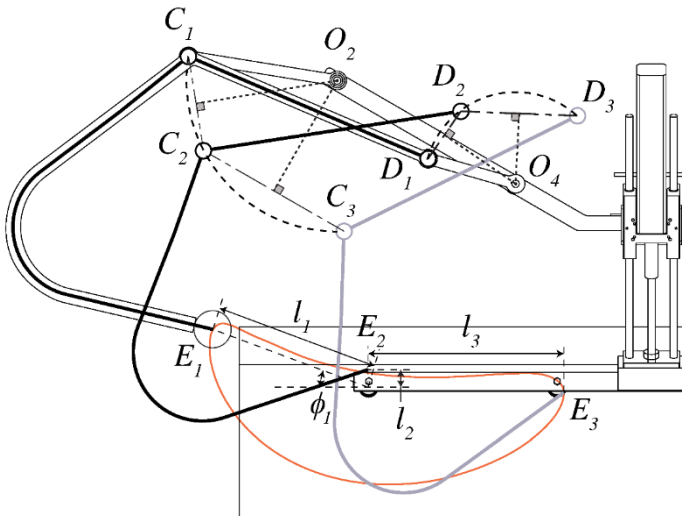
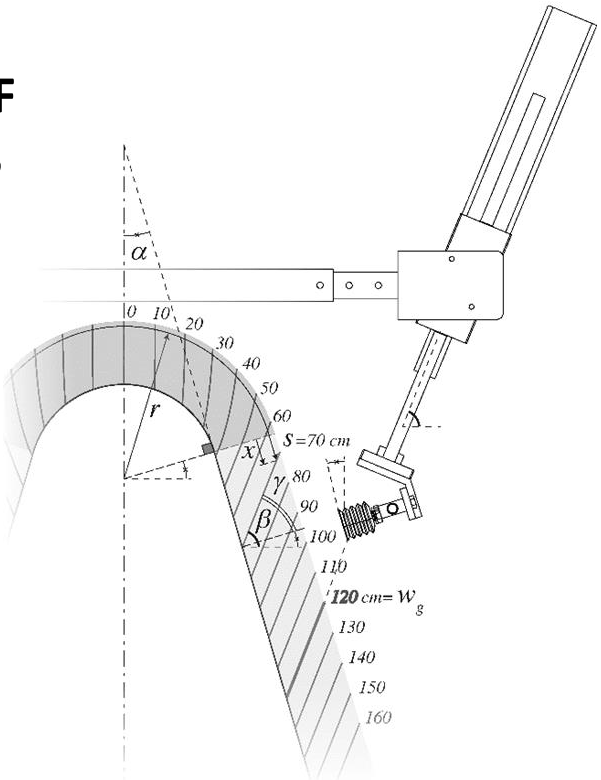
Four-bar linkage to avoid folds, thus damages, during laying

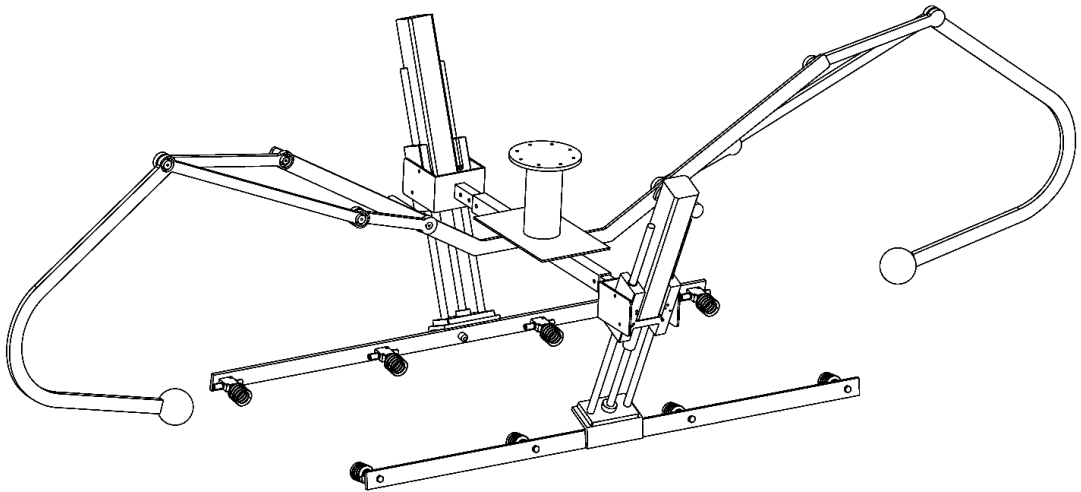
Robots 4.0 **Adaptive Grippers**



CONCEPT 1

FIXED LOCATION OF GRASPING POINTS





Trajectories that prevent the tensioning of leather plies

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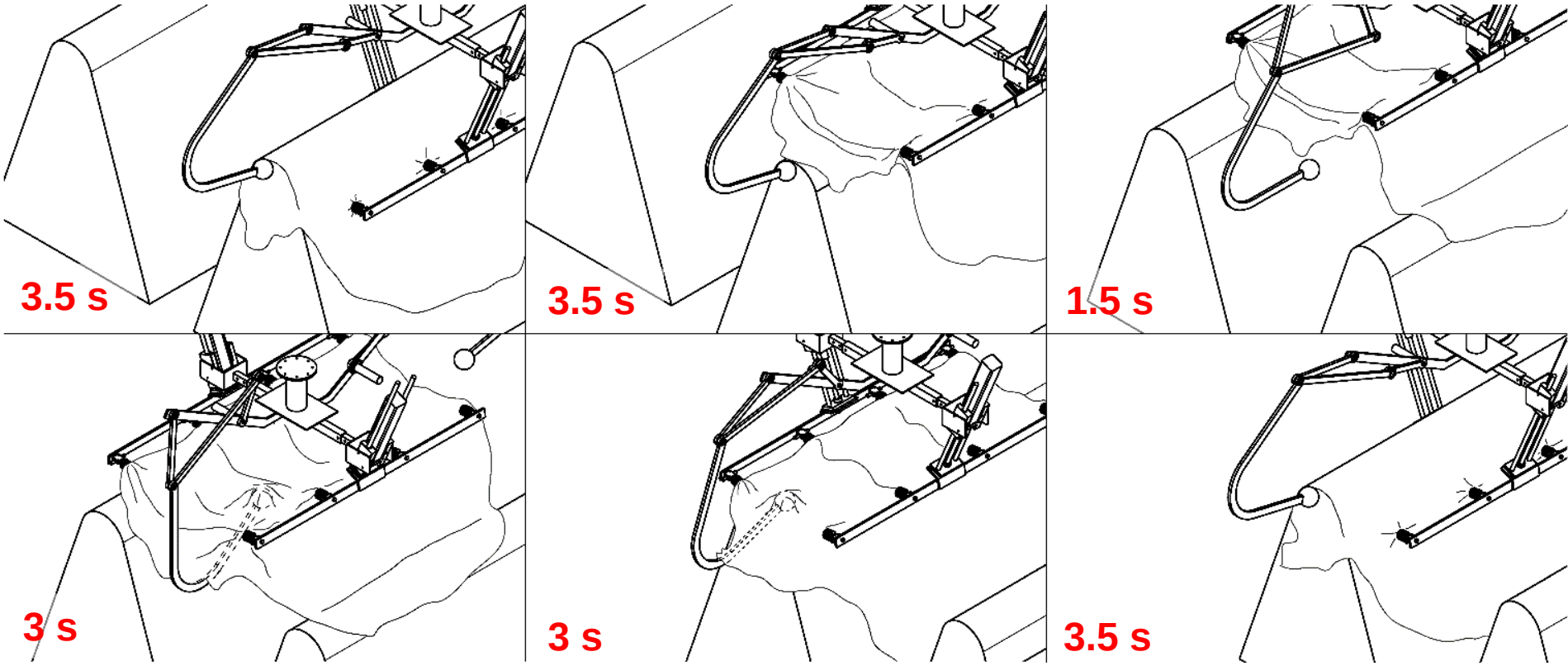
CONCEPT 1

Robots 4.0

Adaptive Grippers



Trapezoidal velocity profile

- **Linear actuators**: **0.2 m/s** target velocity and **1 m/s²** acceleration,
- **Four-bar linkage: 1 rad/s** target angular velocity and **1rad/s²** acceleration.

18 s cycle time of the pick & place operation (-64% manual handling time)

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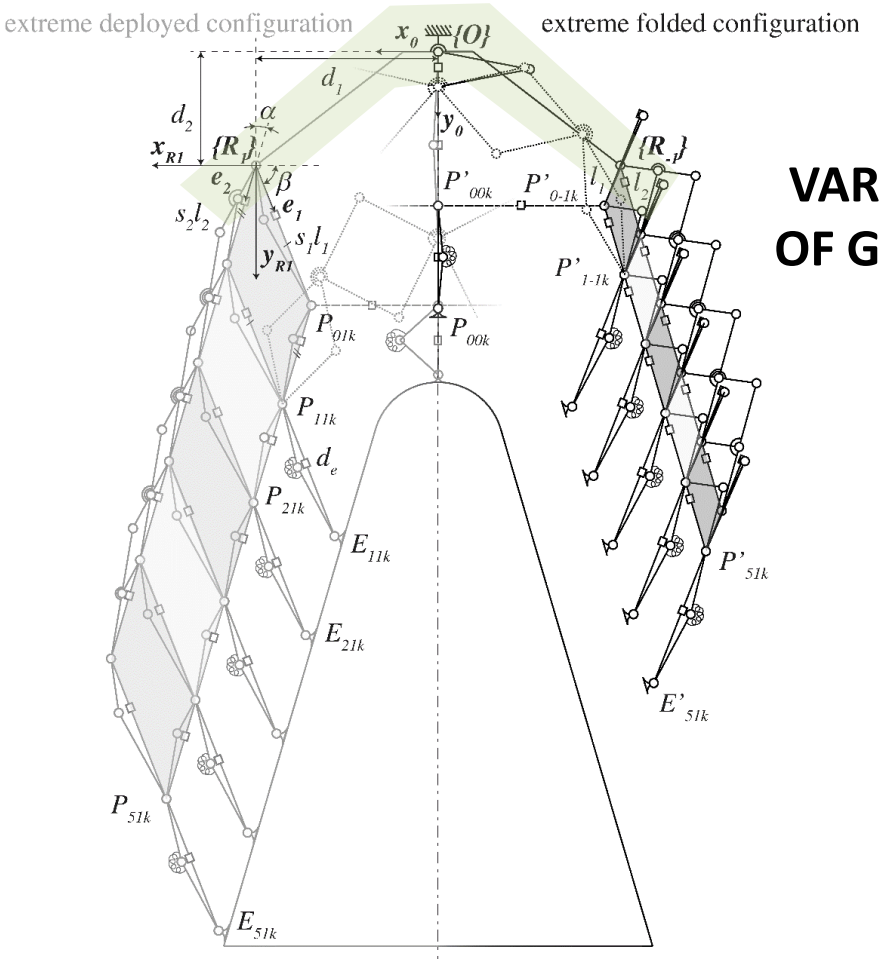
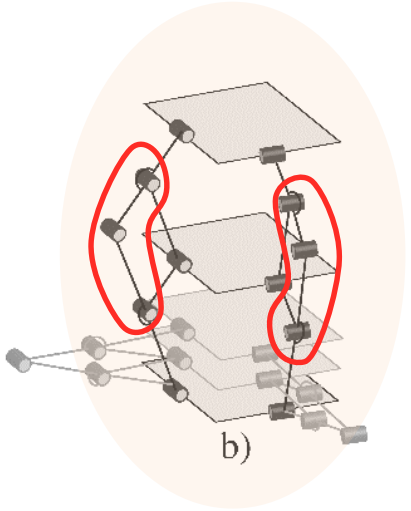
Robots 4.0 **Adaptive Grippers**



CONCEPT 2

VARIABLE LOCATION OF GRASPING POINTS



Parallelepiped Deployable Unit:
Sarrus linkages + Scissor linkages

Anisotropic scaling (3 dof)

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CONCEPT 2

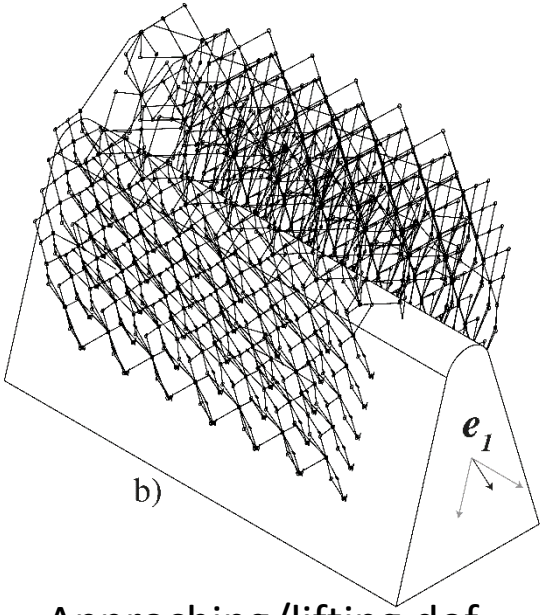
Robots 4.0 **Adaptive Grippers**

Simulations:

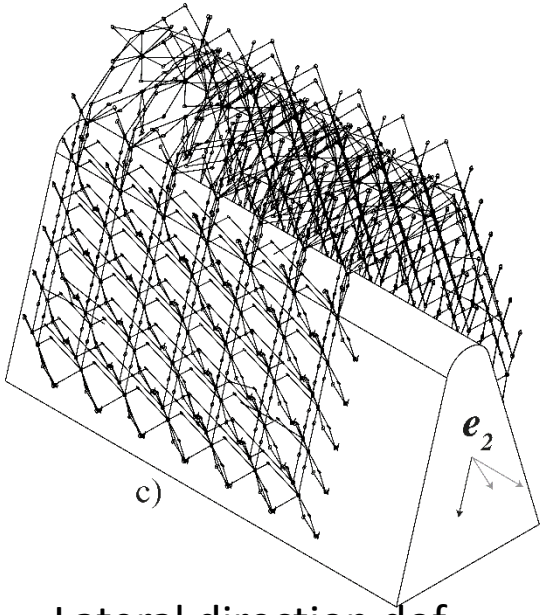
- **Dilations** from the folded configuration to verify the feasibility

  → **anisotropic scaling along each of the three directions**.

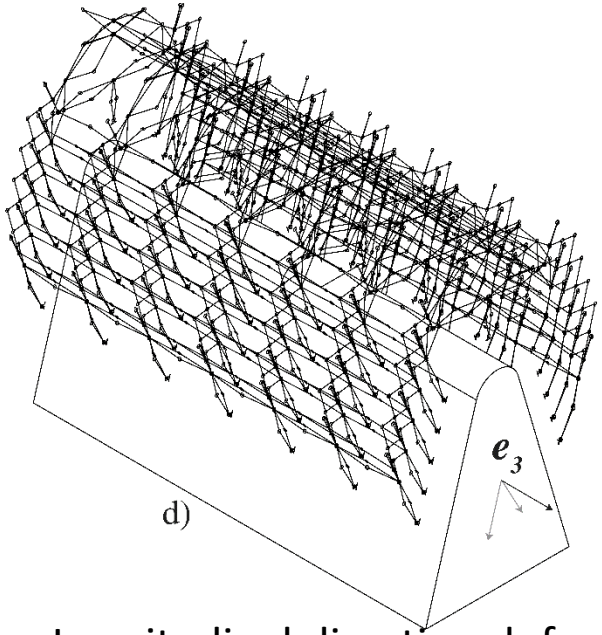
- **Modularity** means **Versatility** (Custom shape of the device to be adaptable to different leather shapes and dimensions)



Approching/lifting dof



Lateral direction dof



Longitudinal direction dof

CONCLUSIONS

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Two concepts of adaptive grippers for the grasping of non-rigid materials are proposed:

Concept 1

- **Simplicity** and **low costs** → fixed configuration of the suction cups along a gripping rectangle inscribed into the **94.7%** of a plies population (statistical analysis).
- **Linear trajectory of the suction cups** for picking up plies in the same rectangle regardless of their position in the stack.

Concept 2

- The **final gripper** is a **deployable mechanism** with three decoupled dof that allows the non-uniform scaling along three non-orthogonal directions lying on a flat piecewise and symmetrical surface, an approximation of the beam surface.
- The **mechanical design** of the structure need to be optimized in order to assess the overall dimensions and solve the intersection of the planes of the linkages.

Design of an adaptive gripper for non-rigid materials by taking advantage of the two concepts by superimposing them in a single device