**RECODO**: Elbow Rehabilitation Device  
Sponsor: Tecnalia Research & Innovation (Donostia-San Sebastián, Spain)

**Abstract:**  
Rehabilitation of the elbow following recovering from surgery or other traumatic injury is currently a very labor-intensive manual process which involves a therapist applying loads in precise directions in order to increase joint mobility. This project aims to provide a therapeutic robot to provide the precise application of forces and torques to replicate the movements typically performed by therapist.

**Project Overview:**  
**RECODO** is a hybrid FES-EXO system for elbow contracture rehabilitation after elbow fractures that addresses underlying causes, not just symptoms including a neurophysiological approach. The system allows pain management, muscle relaxation and strengthening, synergetic movements, including advanced exercises. The actuation method provides therapist-like movements and support through electromechanical actuation and neuromuscular stimulation using an array of advanced FES exercises acting both on sensory and motor nerves. The stimulation facilitates physiological recovery of muscular weakness and analgesic stimuli for pain reduction. The electromechanical actuation aims at reversing and, in the follow-up, preventing the contracture.

The primary challenge to be addressed in this project is the development of the wearable attachments to the arm, and the wearable design and placement of the actuation system. The lower arm attachments should stabilizing the hand/wrist orientation, and support the upper and lower arm during actuated movements of the forearm with respect to the upper arm and distal end of the humerus. The upper arm (and torso) attachments should allow adjustable positioning of the shoulder and provide secure support of the upper arm with respect to the elbow.

**Existing technology:**  
The initial prototype was constructed with two motors operating in parallel to control two linear lead screws. Rotation of the lead screws in the same direction produces translation, whereas rotation in opposite directions produces rotation.
Initial hardware prototype (left) using dual parallel lead screws and gear (right) for linear and rotational movement.

**Positive features:**
- Both degrees of freedom, traction and rotation, can be independently controlled and performed individually or in unison. This allows many different scenarios
  - Traction followed by rotation (as in 1),
  - Rotation without traction,
  - Traction, followed by rotation with additional traction,
  - Traction with arbitrarily chosen elbow angle, etc
- There is a large workspace as opposed to a single trajectory
- Maximal flexion and extension angles are limited only by the patient’s physiology
- Traction displacement can be programmatically changed
- Easily reversible (left arm/right arm)

**Limitations and drawbacks:**
- Having two motors increases system complexity, hazard and potential for failures
- Control of two independent DoF is more complex
- Needs additional mechanisms to limit workspace to the segment which is safe for the patient

**Ideas for the (Idaho) project:**
Decouple the parallel mechanism so that one motor drives the linear motion (elbow traction) and a second motor (in series, downstream from the first module) provides rotational movement (elbow flexion-extension).

**Project Objectives:**
1. Design and develop (or select) a set of fixation/support orthoses in order to position the shoulder with an appropriate upper-arm orientation.
2. Design and develop (or select) an appropriate orthosis system to support the forearm and allow safe and comfortable application of linear and torsional loads to the forearm.
3. Design a transmission system to transmit appropriate linear and torsional loads from powered actuators to the elbow joint and forearm via the forearm orthosis.

**Budget:** $5,000

**Deliverables:**
- shoulder fixation orthosis setup (adjustable)
- upper arm orthosis (adjustable or variable sizes)
- lower arm orthosis (adjustable or variable sizes)
- structural framework with force/torque transmission system
- Team Portfolio, CAD files, project logbooks