ROBT 402 Robotic/Mechatronic System Design

Mini-Project 3

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**Task 1**

Since the application of a cable pulling system is not specified, I have chosen the winch from available manufacturers and will describe it.

I have chosen portable (mounted on wheels) electrically operated cable pulling winch available at https://www.aacess.com/electric-cable-pulling-winch. Their winches are rugged, sturdy and are able to work in harsh environments. The winch is powered by AC power supply to produce mechanical power that is then used to run a hydro pump, which in turn is used to run a hydro motor.

The main components of the winch include wire rope (to pull the cable), rope holding drum (keeps wire rope wound on it) and hydro motor fixed to the rope drum (to wind and unwind the rope).

The unit is driven throughout double capstan, ensuring steady speed, and is provided with wire rope guiding mechanism. Also, it is equipped with a control panel with HMI and PLC to control speed and load.

Winches with pulling capacity range of 3, 5, 10, 15, 20 and 25 ton; and wire rope length of 100, 500 and 750 meters are available so that the winch with needed parameters can be chosen with respect to its application.

Fig 1. Winch outside

Fig 2. Winch inside

**Task 2**

I have chosen the upper-limb rehabilitation robot CAREX and the lower-limb rehabilitation robot LOPES.

Table I. Characteristics of CAREX and LOPES robots

| | CAREX | LOPES |
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| The overall mechatronic system architecture with the description of the components | It is a 5-DOF robot designed for shoulder, elbow and forearm movements. Its human-robot physical | It is an 8-DOF robot for hip and knee movements. LOPES is a serial exoskeleton with series |

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| | interaction type is parallel exoskeleton, and it uses electric actuator. It is equipped with orientation, rotary and load sensors and utilizes assist-as-needed control strategy. | elastic actuator. It is equipped with 6D force and position sensors, and its control strategy is impedance control. |
| Advantages | It conducted the clinical study with 8 healthy persons and one stroke patient and found that subjects efficiently followed the desired trajectories. It does not cause hinders or incorrect postures to subjects' movements.<br><br>Electric actuators have excellent motion control capabilities, accuracy and repeatability; and they are quieter than other actuators.<br><br>There are no misalignment issues with parallel type exoskeletons.<br><br>For assist-as-needed control strategy, parameters are adjusted based on the level of assistance required by the patient or rehabilitation exercise. | It carried out the clinical study with 10 patients, during which significant improvements in the rehabilitation process were observed.<br><br>Traditional rigid link serial robot modelling and control strategies can be applied to serial type exoskeletons.<br><br>Impedance based control strategy provides stable interaction between a subject and robot and allows adjustment of impedance based on the therapist's experience and patient's disability. Also, real-time adjustments are possible, and the precise knowledge of external parameters is not required. |
| Disadvantages | Patients felt tired after one hour of exercise with it.<br><br>It is not equipped with human-machine interface.<br><br>Electric actuators may overheat.<br><br>Traditional cable-driven parallel mechanism modelling and control strategies are not directly applicable with parallel type exoskeletons. Also, they have a limited workspace. | It is not equipped with human-machine interface.<br><br>Serial type exoskeletons need tuning and readjustment for each patient.<br><br>For impedance based control strategy, performance declined with the decrease in the environment's stiffness. Also, it requires force sensors that are expensive and sensitive to temperature changes. |

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| | For assist-as-needed control strategy, inconsistent and inaccurate estimation of patient's functional movement can be a major limitation and challenge. | |