The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

**DOCTOR OF ENGINEERING SCIENCES**

of **Elias Saerens**

The public defense will take place on **Tuesday, 19th April 2022 at 4:00pm** in the Green room U-Residence (Building U-Residence, Brussels, Humanities, Sciences & Engineering Campus)

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**DESIGN PRINCIPLES AND TOPOLOGY OPTIMIZATION FOR SERIES-PARALLEL ELASTIC CONSTANT TORQUE ACTUATORS**

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Abstract of the PhD research

Throughout the last years, robots and robotic devices in general have taken a more prominent stage in society, since they became less dependent from an external power source. To increase this immersion into our daily lives there is however one major problem left to tackle for these robots, namely their autonomy, which is still not sufficient. To increase the autonomy, an improvement is needed in the actuation technology that is used.

In this thesis a novel actuation concept, namely Series-Parallel Elastic Constant Torque Actuation (SPECTA), is being investigated in order to reduce the energy consumption and hence increase the autonomy. This reduction is achieved by making use of the special characteristics of constant torque mechanisms, which allow to store energy without the need for more and more motor torque to do so, like it is the case for linear springs. Like this, it becomes easier to store energy when possible, and release it when necessary, since a change in (un)winding of the mechanism does not give anymore an influence on the torque that is delivered.

SPECTA is an extension of the earlier developed SPEA and is an actuation scheme that consists of multiple parallel branches that contain motors, gearboxes, clutches and constant torque mechanisms. Due to these clutches the mechanism can be either charged by the input-motor or by the output when there is an excess of energy.

Throughout this manuscript the effect of redundancy on these actuators is investigated by developing scaling laws for each of the actuator's subparts. These scaling laws, in combination with the simulations that have been made by developing a mathematical model of the novel SPECTA concept, also led the way to verify which kind of drive would be recommended for a certain task, namely (quasi)-direct drives or highspeed motors with a high-ratio gearbox.

With these simulations, which are validated with a functional prototype in the end of this dissertation, in combination with the scaling laws a first step is taken to solve the choice of motor question analytically instead of intuitively, which is normally done in robotics nowadays.

From the results found in this thesis it can also be concluded that there is indeed a great potential in SPECTA actuators to reduce the overall energy consumption of robotic devices, which hopefully leads the way to more performant and autonomous robots in the future.