The Design and Development of a Force-Regulated Hexapod Leg

In this thesis, a Parallel Kinematic Machine called Hexapod with Force Regulatory features has been developed. The purpose is to minimize cost while increasing effectiveness and sustainability of the assembly line. A hardware concept of the robot is being developed to explore novel applications in the production industry.

The manufacturing industry is ever changing, striving towards greater efficiency. Those changes include smarter production methods through automation and the use of robotics. While many improvements and customizations have been made to the production line the use of fixtures has seen limited development. Flexible fixtures are a proposed solution to avoid creating new fixture/tools for each product or assembly variation. However, it has been challenging to find an appropriate approach for this idea. Cognibotics AB has now taken up this challenge through the development of a new robot, a Parallel Kinematic Machine (PKM), called Hexapod.

The Hexapod is a term used to refer to robots with six legs, in this case it was used to name a new version of the Stewart Platform. The Stewart Platform was developed at the end of World War 2 for flight simulations and its strengths are positioning and orientation of object with a very high stability and precision. It is nowadays used in the engineering, medical and scientific industries. It has seen applications in telescope positioning, satellite positioning, surgery, space and sea exploration as well as Lund's very own science lab MAX IV. What differentiates this version of the Stewart Platform from its competitors is its application, which not only requires precise positioning but also force-regulation. The force-regulation allows the robot to sense when excessive pressure or torque has been applied on the product during their assembly and reacts in a such a way that no damage can occur.

The aim of this thesis was to develop a hardware concept of the leg of the Hexapod. The leg of the Hexapod is the only dynamic part of the robot, and it's responsible for the machine's movement. It includes an actuator which translates rotational movement to linear movement, a set of universal joints allowing the legs to smoothly angle and orient themselves, and a driving solution in this case a frameless motor.

Design and development of these parts was done on a conceptual level in co-operation with Cognibotics AB. The aim when designing the actuator and the joints was to minimize their weight, size and eliminating all unnecessary components while meeting the requirements of the project. However, the most interesting and challenging development step was the design of the frameless motor. Designing this drive solution meant taking all the stripped components of a motor: the rotor and stator, encoder, brake, bearings and putting them all together in a housing design of your own. One must determine themselves what parts are needed, figure out how they work together, plan out their positioning to one another and make sure the whole system is possible to service and assembly/disassembly with easy. At the same time, try to minimize its size and weight to create a motor competitive with the commercially available solutions made by experts in the field.

This resulted in a concept of a robot with 6-degrees of freedom, about 1m tall capable of carrying and moving a 300kg object in all sorts of angles and orientations in a 200x200x250mm (x,y,z) space, with an accuracy and repeatability of +/- 0.1mm.

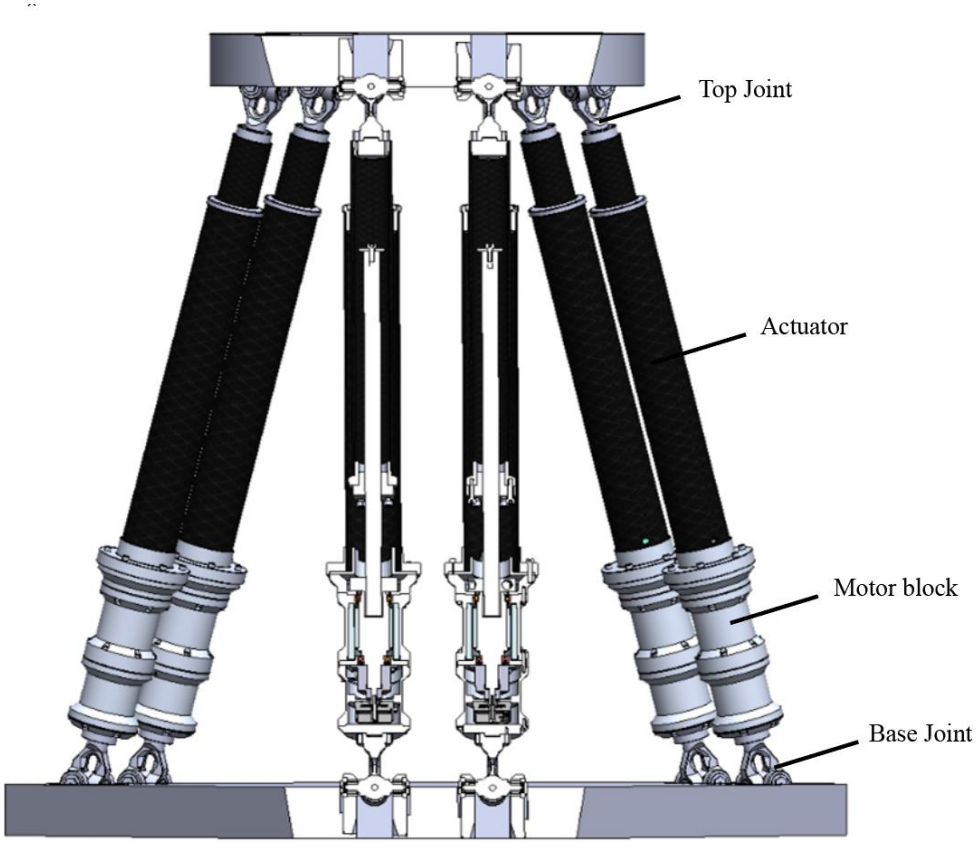

Figure 1: The Hexapod with placeholder plates. The Hexapod leg is made up of the shown parts.