An Analysis and Optimization of Double Parallelogram Lifting Mechanism

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Double Parallelogram Lifting Mechanism (DPLM) is a compact and stable lifting mechanism with a large extension range widely adopted in robot designs. Rubber bands and springs are often installed on the DPLM to lighten the motors' load and maintain its height, yet the installation positions are often obtained through trial and error. This project aims at finding the optimal rubber band installation positions for DPLM using modeling and optimization techniques. A mathematical model which describes the forces and moments acting on all the linkages of DPLM was derived based on the conditions for the static equilibrium and verified with a 3D simulation software. A genetic algorithm (GA) was implemented to optimize rubber band installation positions, which managed to find solutions with the overall root-mean-square-error (RMSE) of the net moment less than 2 for 2 to 6 rubber bands. A further statistical analysis of 50000 random rubber band samples showed that installing rubber bands in triangles is the best solution with the overall lowest RMSE. A test was conducted with a prototype of the DPLM and the results were consistent with our model and optimization. This project derived and verified a mathematical model for the DPLM, and found the optimal way and positions to install rubber bands. The results of this project provide a theoretical basis for controlling DPLM with rubber bands, allowing it to be further adopted in industrial robots that require repetitive lifting and lowering such as inspection robots and aerial work platforms.