Application of a Cable Driven Robot for the Construction and Maintenance of Building Facades

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Goal

Time demanding

Costly

Dangerous

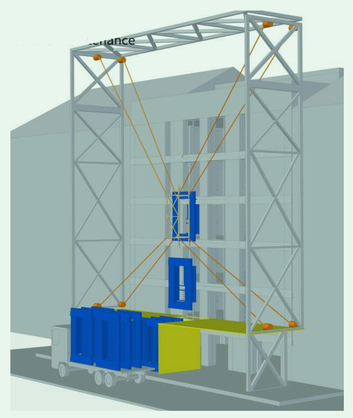
Usual Procedure

Increase the level of automation during works on building facades

Main task:

instalation of curtain wall module

Image by Iturralde, Linner, Bock, Technical University of Munich



Cable Driven Parallel Robot

Load Capacity

Reduced cost

Wide workspace

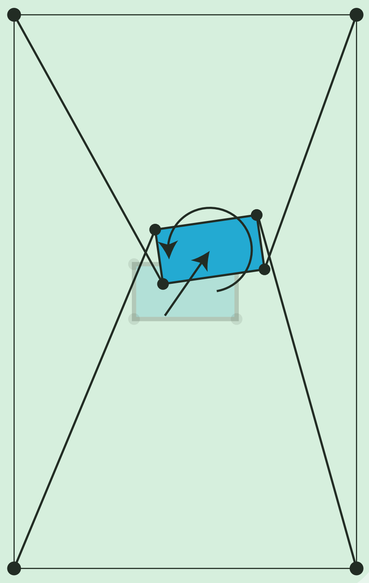
Modelling

Stiffness
static and dynamic

Correlates applied external wrenches to resulting displacements

Influence of unexpected loads

wind



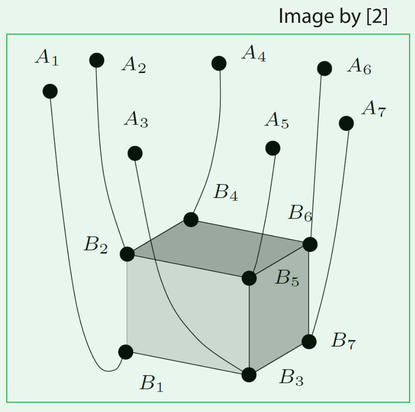
Robot with Large Dimensions

Cable Sagging

Should consider:

- Elasticity
- Distributed mass

Image by [2]



Performance Index

For a given geometry and position

Necessary cable tensions in order attain a given stiffness

$$\min_{\mathbf{t}} \|\mathbf{t}\|_p \quad \text{s.t. } K \geq K_{adm}, \ \mathbf{t} \geq \mathbf{t}_{min}$$

Maximal component of $\mathbf{t}$ argument of the optimization repeated over several positions of the workspace

Geometry Optimization

Find cable anchorage points (base and platform) which optimize the proposed performance index.

Two phases optimization:

- Exhaustive search over the range of geometric parameters
- Gradient based optimization starting from best parameters obtained in phase 1.

Control

Redundancy Resolution

Number of cables > Number of DOF's

Overconstrained robot

$$\mathbf{t} = \mathbf{W}^{+}\mathbf{f} + \mathbf{N}\boldsymbol{\lambda}$$

choice of $\boldsymbol{\lambda}$ seeking an admissible performance

Dual Space Adaptive Control

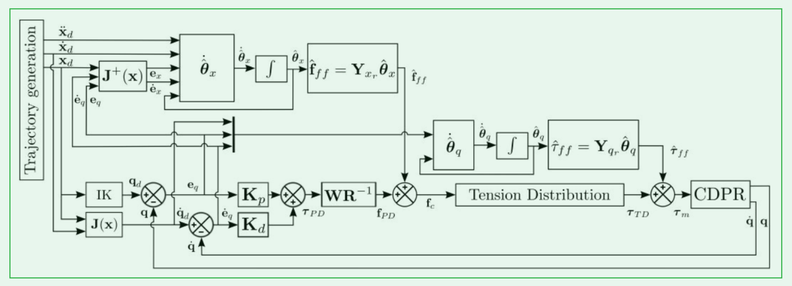


Image by [3]

- Improved tracking peformance
- Adaptive online estimation of parametric uncertainties and variations

References

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[2] Merlet JP. The kinematics of cable-driven parallel robots with sagging cables: Preliminary results. In: Proceedings - IEEE International Conference on Robotics and Automation. Vol 2015-June. IEEE; 2015:1593-1598. doi:10.1109/ICRA.2015.7139401.

[3] Lamaury J, Gouttefarde M, Chemori A, Hervé P-E. Dual-space adaptive control of redundantly actuated cable-driven parallel robots. In: Intelligent Robots and Systems (IROS), 2013 IEEE/RSJ International Conference on. IEEE; 2013:4879-4886.

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