Mechatronic Robot Arm with Active Vibration Absorbers

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ABSTRACT

The serial robots are typically able to cover large workspace, but their mass/stiffness ratio does not allow to combine high accuracy and high dynamic of the end-effector operations. During the last decades there has been an intensive development of serial robots in order to increase their production efficiency, including their non-traditional usage e.g. for drilling [1]. The still open problem is what can be achieved through the accurate measurement of absolute end-effector motion and its subsequent use to compensate for control loop errors between actuators and the end-effector. Anyway each additional absolute position measurement is very difficult to implement especially for large workspaces in complex industrial environment. Consequently the possibilities to improve the dynamic properties of the robot arm using less demanding and more robust additional sensing (e.g. by accelerometers or geophones) are important. The usage of dynamic absorbers with active elements is one of promising methods. The frequency band, where the absorber suppresses the vibrations efficiently, is for clasical passive dynamic absorbers relatively narrow, being centered at the natural frequency of the absorber. The tunable [2] and especially the fully active absorbers can significantly improve the vibration suppression efficiency in a wide frequency band. The necessity of usage of active version of multi degree of freedom (MDOF) absorbers is emphasized by typically strong variability of eigenfrequencies and eigenmodes of serial robots within their workspace. The preliminary study [3] considered active MDOF cubic hexapod absorber mounted on robot arm. Its results are very promising. The submitted paper presents further steps of the research. The absorbing device should be as efficient as possible already in its passive form, without usage of the feedback control of actuators. Such request leads to the primary optimization of stiffness and mass properties and absorber placement. The variants with compact MDOF absorber as well as set of distributed 1DOF absorbers have been optimized. The next range of problems have been the control design including the crucial problem of realistic sensing implementation. Firstly the LQR control with state observer has been designed, concerning sensing by accelerometers on end-effector and accelerometers on absorber/s body. The robot joint positions have been used for the gain scheduling. The second step of control design uses the fixed order H_∞/H_2 controller optimization concerning the same sensors as the observer variant. Finally the interconnected control of the robot drives and absorber actuators have been investigated. Simultaneously with the optimization of mechanical design, sensing strategies and control algorithms, the appropriate demonstrators have been prepared. The voice coils AVM60-25 have been chosen as actuators for testing. The first demonstrator serves for the absorber "leg" evaluation, the second one for the final experiments. The whole concept seems to be functional and very promising.

REFERENCES

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