The flapping flight of birds

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Propositions belonging to the thesis

The Flapping Flight of Birds

Analysis and Application

by William Thielicke

1. Leading-edge vortices are highly relevant in the slow-speed flapping flight in birds. Their relative importance for the generation of lift scales with the effective angle of attack, the amount of wing camber and to a lesser extent with wing thinness (this thesis).

2. Bird wing morphology is optimized to promote attached flow aerodynamics at the arm wing by having thick and cambered wing sections, and to promote the development of leading-edge vortices at the hand wing by having thin wing sections with low camber (this thesis).

3. Twisted wings can be very disadvantageous in slow speed flight, but advantageous in faster flight (this thesis).

4. The beneficial effect of wing twist may be the increase of the effective angle of attack at the wing base, and not the decrease of the effective angle of attack at the wing tip (this thesis).

5. Flapping flight can be more manoeuvrable than fixed wing or rotary wing flight due to the possibility to generate higher instantaneous peak forces (this thesis).

6. A steady-state blade-element analysis can be used to model the forces of a flapping wing when the force coefficients include the effect of the enhanced lift enabled by leading-edge vortices (this thesis).

7. Artificial flapping wing devices are very well suited for complex missions when they benefit from the high efficiency of attached flow aerodynamics as well as from the increased forces of vortex-enhanced lift (this thesis).

8. Although the accuracy of direct cross correlation and multiple pass direct Fourier transform correlation is very comparable in synthetic images where single parameters are modified, the latter algorithm yields more robust and accurate displacement estimates under challenging conditions and when the dynamic range of velocities is large (this thesis).

9. Approaching a performance limit from below, as well as overshooting it and approaching from above, is advantageous for the progress of one‘s skills - even if it sometimes results in broken equipment or broken bones.

10. Practical tests suggest that the amount of parental sleep scales with 0.6 to the power of the amount of babies.