指导教师对硕士学位论文的评语

论文题目	基于进化算法的蝙蝠机器人控制参 数优化	姓 名	安武
		学 号	2022280136
		学科/类别	机械工程

对论文的总体评价：

论文通过理论分析、结构设计和样机实验研究了薄膜扑翼飞行机器人的结构参数优化算法和测试平台，提出了协方差矩阵自适应（CMA）进化算法。利用台架实验测试了仿蝙蝠机器人的性能参数。通过进化迭代算法逐步优化了蝙蝠机器人的飞行控制参数。结合 CMA 进化策略，实现了蝙蝠机器人的飞行动力学优化，特别是在参数调整方面，达到了机器人与自然蝙蝠在力学性能方面的趋同一致。蝙蝠机器人的飞行性能参数优化到了自然界中观察值。这一工作不仅验证了进化算法在扑翼机器人设计中的有效性，还增强了我们对飞行哺乳动物生物力学的理解，为未来的仿生机器人系统设计提供了一定的理论、设计和实验基础。论文完成的主要工作包括：

1. 通过结构参数和运动参数分析，设计了扑翼飞行机器人的测试平台及测试算法。
2. 提出了协方差矩阵自适应（CMA）进化算法。
3. 研究了运动参数的反馈控制策略并开发了相关算法及程序。
4. 通过机器学习实现了自适应的进化算法，给出了运动参数的动态调控方案。
5. 优化了薄膜翼机器人的结构设计参数和运动调控参数，其运动性能和力学性能已非常接近蝙蝠的飞行。

Through theoretical analysis, structural design and prototype experiment, this thesis studies the optimization algorithm of structure parameters and test platform of thin-film-flapping-wing flying robot, and proposes the covariance matrix adaptive (CMA) evolutionary algorithm. The performance parameters of the bat-like robot are tested by bench experiments. The flight control parameters of Batbot are optimized by evolutionary iterative algorithm. Combined with the CMA evolution strategy, the flight dynamics optimization of the bat robot is realized, especially in terms of parameter adjustment, and the mechanical properties of the robot and the natural bat are convergent. The flight performance parameters of the Batbot are optimized to the observed values in nature. This work not only validates the effectiveness of evolutionary algorithms in the design of flapping-wing robots, but also enhances our understanding of the biomechanics of flying mammals, and provides a certain theoretical, design and experimental basis for the future design of biomimetic robot systems. The main work completed in this thesis includes:

1. Through the analysis of structural parameters and motion parameters, the test platform and test algorithm of flapping-wing flying robot are designed.
2. The covariance matrix adaptive (CMA) evolutionary algorithm is proposed.
3. The feedback control strategy of motion parameters is studied and related algorithms and programs are developed.
4. The adaptive evolutionary algorithm is realized through machine learning, and the dynamic control scheme of motion parameters is given.
5. The structural design parameters and motion control parameters of the thin-film wing robot are optimized, and its motion and mechanical properties are very close to the flight of bats.

对该硕士生政治表现、基础理论、专门知识、科学研究或实践创新能力、学术作风的综合评语，对申请硕士学位创新成果简介一栏的审定意见，是否同意组织硕士学位论文答辩。

安武同学在学期间，努力学习、刻苦钻研、反复实验，在基于进化算法的蝙蝠机器人控制参数优化研究中取得了一系列新的进展。论文工作反映了该同学已掌握了坚实宽广的基础理论和系统深入的专门知识，初步具备了独立从事科学研究的基本能力。论文已达到工学硕士学位水平，同意该生按时参加学位论文答辩。

Pursuing academic excellence and achieving future achievements during his study, Mr. Anuar Santoyo studied hard and experimented repeatedly, and made a series of new progress in the research of bat robot control parameter optimization based on evolutionary algorithm. The thesis work reflects that the student has mastered a solid and broad basic theory and systematic in-depth specialized knowledge, and has initially possessed the basic ability to engage in scientific research independently. The thesis has reached the level of master of engineering degree, and the student is allowed to participate in the dissertation defense on time.

（接附页）

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