Zhenning Yu

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Finished on 18th Oct 2016

Summary

My first research project during university was **wheelchair mechanical design**, which was a national innovation experiment program for university students. The projects also needs knowledge about **Industry design and human factors**, which we have to learn by ourself. Therefore, our group members were working hard day by day. Finally, we obtain six patents and I published one paper. After the bachelor project, I realized that I am not only like mechanical design but also good at it. Whats more, I learned how to work in a group, how to write a paper, how to apply patents.

As we known, it is hard to increase research ability without strong mathematical ability. Therefore, I chosen **Nonlinear Control Theory** as major study area during master period. I found there are a lot of systems such as, dynamic vehicle model ,industrial chain, biological loop in cell and economics systems can be described as control system. Based on the foundation of mathematical model, we can control the systems' performance and approach it to objective. What's more, it is a project not only needs individual critical consideration but also group cooperation. My research team was working together and discussing as soon as problem comes. In this kind of effective operating and researching cooperation, we guarantee a lot accomplishments.

In my opinion, it is the ability and passion of studying that the most important skill for a postgraduate student. Therefore, during part time, I was learning relative tech-skills, such as **MATLAB, LaTeX, Embedded C-programming on Micro-controllers**.

I am wondering to study **Artificial Intelligence**, **Adaptive Control** application on **Human Factor Robot** in next step. Based on the control theory I learned during master period, I can build up the robot mathematical system. The robot can learn human behavior based on artificial intelligence algorithm. The controller can change time-varying variables and optimize the system for human's objective.

Professtional Profile

Mechanical Design	Professional
Nonlinear Control Theory	Master Research Program
Linear Optimal Control Theory	Master Research Program
Micro-controllers Embedded System	Bachelor Program
Computational Fluid Dynamic	Bachelor Program

Articles

CCDC - The 28^{th} Chinese Control and Decision Conference — May. 2016
Saturated Backstepping Control for Boat with Disturbance Estimator

ROBIO2016 — Oct. 2016
Road Excitation Predictive Discrete-Time Sliding Mode Control of Vehicle Suspension System

New Technology & New Process — Dec. 2011
Research on Wheelchair Shock Absorption Spring Design based on COSMOS by Analyzing the Finite Element

Journal in process — Oct. 2016 - present
Research of Logistics Composite Practical Course based on Flexsim Simulation

Patents

Patent for Invention — PROPERTY OFFICE OF THE P.R.C
Self-Control Disabled Wheelchairs — *28th August 2013*
Patents Number: ZL 2011 1 0133394.4

Patent for Utility Models — PROPERTY OFFICE OF THE P.R.C

Independent Operation Barrier-Free Wheelchairs — *23th May 2011*
Patents Number: ZL 2011 2 0165109.2

Wheelchair Flexible Climbing Mechanism — *23th May 2011*
Patents Number: ZL 2011 2 0165122.8

Work Experience

Laboratory Assistant — Beijing Normal University Zhuhai

Logistics Center Experiments — *2015-present*

Flexsim Simulation Experiments — *2016*

Teaching Assistant — University of Macau

Applied Mechanics MECH102 — *2011 – 2012*

Theory of Mechanisms MECH408 — *2011 – 2012*

Education

University of Macau — Macau, China

M.Sc Electrimechanical Engineering — *2011 – 2014*

Supervisor: Carlos Silvestre.

My main research direction is Nonlinear Control Theory.

Kunming University of Science and Technology — Kunming, China

B.Eng Packaging Engineering — *2007 – 2011*

Supervisor: Hongbin Liu.

My main study direction is Mechanical Design, Failure Analysis, Computer-Adied Design and Finite Element Analysis.

Skills

Software:

MATLAB,C programming, Linux-Ubuntu, FLUENT, Solidworks, AutoCAD, Pro/E, LaTeX, Photoshop.

Practical Skills:

Programming Microcontroller.

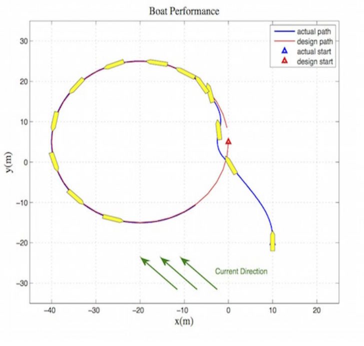
Natural languages:

Mandarin Chinese*(mother tongue)*, English *(Fluent communication)*, Cantonese *(beginner)*.

Projects

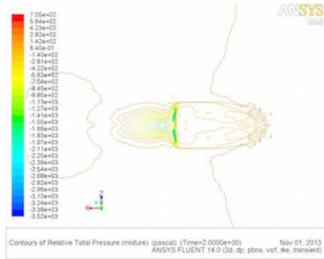
(According to importance)

Nonlinear control for underactuated marine vehicle — *Fed 2012 – June 2014*



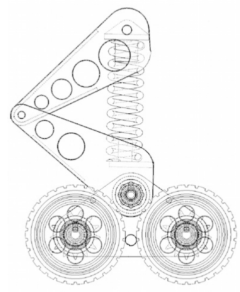
This thesis address problems of driving an underactuated boat following design path against current disturbance. The solution to this problem consists of nonlinear Lyapunov-based tracking control law. For a practical boat, I demonstrate how Lyapunov based techniques and nonlinear hydrodynamic systems yield a control structure that guarantees the error between design and actual path converging to equilibrium with disturbance. I also studied the foundation of boat nonlinear model.

Fluid hydrodynamic estimation — *Sep 2013 – Jan 2014*



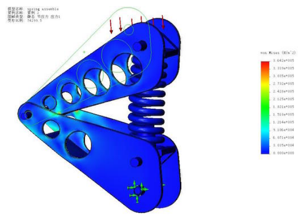
The project performs the estimation of Boat added mass and damping coefficient by CFD software. In the added mass simulation, I assume the boat is moving in insignificant wave with constant surge velocity. In the damping simulation, I simplify ship hull for decreasing the calculation procedure. The hydrodynamic estimated methodology is based on towing tank experiment, a general equipment for testing boat hydrodynamic parameters.

Wheelchair Flexible Climbing Mechanism *Fed 2010 – June 2011*



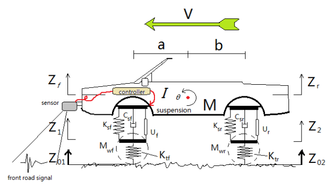
This project is about designing a wheel mechanism drived by chain. During the project, I improved my CAD and mechanical design ability. I think the most important part is designing procedure. It is a complex progress of mechanical design. Each components are related with each other. In some condition, the last part cannot be matched with the first one, even though it is designed in right procedure.

Mechanical components finite element analysis *Sep 2010 – Jan 2011*



During mechanical design process, we used COSMOSWorks software to make the finite element analysis with several components. We simulated the practical effect of damping mechanism in order to test if it conforms to designed technical requirements. Based on computational analysis method, we can estimate the components performance not only faster but also cheaper than realistic experiments.

Automotive suspension control *Fed 2011 – June 2012*



This project is about automotive suspension prediction control. It solves the problems of heavy jolt during moving. There is a camera capturing road data as prediction signal. After comparing with designed vehicle specification, the controller will reduce the vibration. Thus, the objective of vehicle stabilizing is achieved.

Exercise Projects

Headphones Noise Cancellation *Fed 2012 – June 2012*

This case relates to elementary nonlinear controller based on Lyapunov Theory. The control objective is comparing the feedback signal from the exterior microphone, generating an estiamted sound cancellation signal to minimizing the noise heard by customers.

Cart-pendulum System *Fed 2012 – June 2012*

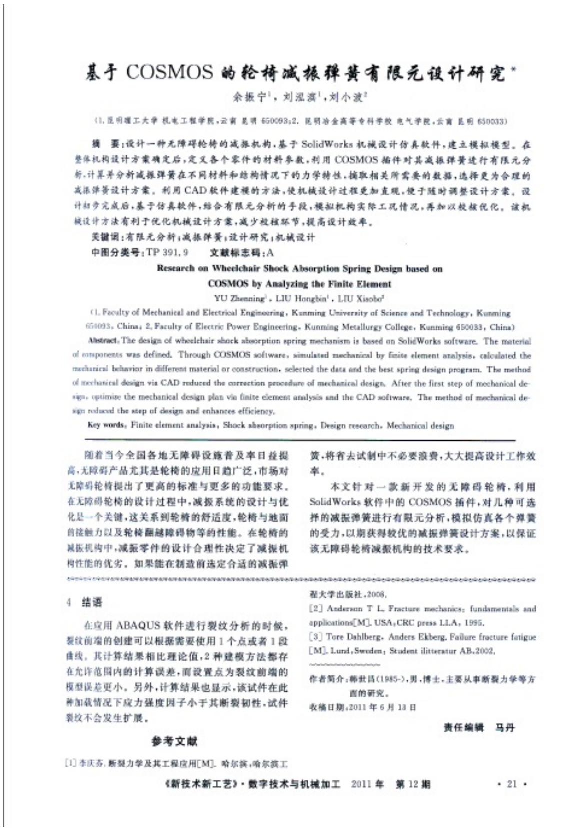
This case is mainly about state-spase feedback controller. The controller objective is maintaining the system stablization based on its feebback signal. Considering there are unpredictable states variables, such as acceleration and velocity. Observer is designed which is a widely used methodology in actual control cases.

Interests

Non-exhaustive and in alphabetical order: Badminton , Chess , Guitar , Microcontroller programing.

Patents Verification

Published Paper Exhibition



基于 COSMOS 的轮椅减振弹簧有限元设计研究*

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(1.昆明理工大学 机电工程学院，云南 昆明 650093；2.昆明冶金高等专科学校 电气学院，云南 昆明 650033)

摘 要：设计一种无障碍轮椅的减振机构，基于 SolidWorks 机械设计仿真软件，建立模拟模型。在整体机构设计方案确定后，定义各个零件的材料参数，利用 COSMOS 插件对其减振弹簧进行有限元分析，计算并分析减振弹簧在不同材料和结构情况下的力学特性，摘取相关所需要的数据，选择更为合理的减振弹簧设计方案。利用 CAD 软件建模的方法，使机械设计过程更加直观，便于随时调整设计方案。设计初步完成后，基于仿真软件，结合有限元分析的手段，模拟机构实际工况情况，再加以校核优化。该机械设计方法有利于优化机械设计方案，减少校核环节，提高设计效率。

关键词：有限元分析；减振弹簧；设计研究；机械设计

中图分类号：TP 391.9 文献标志码：A

Research on Wheelchair Shock Absorption Spring Design based on COSMOS by Analyzing the Finite Element

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Abstract: The design of wheelchair shock absorption spring mechanism is based on SolidWorks software. The material of components was defined. Through COSMOS software, simulated mechanical by finite element analysis, calculated the mechanical behavior in different material or construction, selected the data and the best spring design program. The method of mechanical design via CAD reduced the correction procedure of mechanical design. After the first step of mechanical design, optimize the mechanical design plan via finite element analysis and the CAD software. The method of mechanical design reduced the step of design and enhances efficiency.

Key words: Finite element analysis, Shock absorption spring, Design research, Mechanical design

随着当今全国各地无障碍设施普及率日益提高，无障碍产品尤其是轮椅的应用日趋广泛，市场对无障碍轮椅提出了更高的标准与更多的功能要求。在无障碍轮椅的设计过程中，减振系统的设计与优化是一个关键，这关系到轮椅的舒适度，轮椅与地面的接触力以及轮椅翻越障碍物等的性能。在轮椅的减振机构中，减振零件的设计合理性决定了减振机构性能的优劣。如果能在制造前选定合适的减振弹簧，将省去试制中不必要浪费，大大提高设计工作效率。

本文针对一款新开发的无障碍轮椅，利用 SolidWorks 软件中的 COSMOS 插件，对几种可选择的减振弹簧进行有限元分析，模拟仿真各个弹簧的受力，以期获得较优的减振弹簧设计方案，以保证该无障碍轮椅减振机构的技术要求。

4 结语

在应用 ABAQUS 软件进行裂纹分析的时候，裂纹前端的创建可以根据需要使用1个点或者1段曲线。其计算结果相比理论值，2种建模方法都存在允许范围内的计算误差，而设置点为裂纹前端的模型误差更小。另外，计算结果也显示，该试件在此种加载情况下应力强度因子小于其断裂韧性，试件裂纹不会发生扩展。

参考文献

[1] 李庆芬. 断裂力学及其工程应用[M]. 哈尔滨：哈尔滨工程大学出版社，2008.
[2] Anderson T L. Fracture mechanics: fundamentals and applications[M]. USA: CRC press LLA, 1995.
[3] Tore Dahlberg, Anders Ekberg. Failure fracture fatigue [M]. Lund, Sweden: Student ilitteratur AB, 2002.

作者简介：韩世昌(1985-)，男，博士，主要从事断裂力学等方面的研究。

收稿日期：2011年6月13日

责任编辑 马丹

《新技术新工艺》·数字技术与机械加工 2011年 第12期 ·21·

Saturated Backstepping Control for Boat with Disturbance Estimator

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Abstract: This paper address the problem of driving an underactuated ship to following a desired path under current disturbance. Based on a practical ship, the damping force should be nonlinear which related with velodity. The solution consists of a Lyapunov-based trajectory tracking control law and disturbance estimator. The controller solves the boundedness and convergence of position tracking error, which should be approaching to equilibrium states . The estimator calculates an unknown current under an assumption that the disturbance force is constant. Regarding to a practical boat, we demonstrate how Lyapunov based techniques yield a control structure that *i)* works against unknown current disturbance, *i)* considers the saturation influence on position error and *iii)* computes the nonlinear damping force, torque.

Key Words: nonlinear hydrodynamic model, current disturbance, Lyapunov function, backstepping control.

1 Introduction

The Unmanned Surface Vehicle (USV) is a developing topic as the evolution of mathematics and control theory. Usually, a ship is considered as a underactuated rigid body in marine surface. In the past few years, many kinds of Unmanned Surface Vehicle (USV) have been developed for different tasks, such as seabed investigation , mine searching , ship bottom searching, underwater searching with camera, searching suspicious divers and Target boat. It is a interesting problem about how to control a underactuated ship. One of the solution is trajectory tracking, which is concerned with the design of control laws that drive a vehicle to follow a desired path.

In a industrial control systems, the most widely used controller is PID (proportional-integral-derivative), which calculates an "error" value as the difference between a measured and desired process variable. The controller attempts to minimize the error by adjusting the process control inputs. Because PID is simple and used widely, generally, the controller is consists of PID and some other adaption algorithm, such as two multilayer neural networks which was introduced in [1] and PID heading control of a patrol vessel[2]. In general, single PID controller can gives poor performance when the loop gains must be reduced. They also have difficulties in the presence of non-linearities, and have lag in responding to large disturbances. Therefore, some advanced control methodology were developed instead of PID.

As an important control theory, the linear-quadratic regulator (LQR) is suitable for the a set of linear differential equations of system dynamics and a quadratic function described the cost. With these, the engineers are difficulty finding the right weighting factors limits the application of LQR based controller synthesis. In other words, it is difficult to find the settings of a regulating controller by using a mathematical algorithm which minimizes a cost function with weighting factors. The cost function is often defined as a sum of the deviations of key measurements from their desired values. Actually, in optimizing the controller, LQR algorithm measure the work done by the control systems engineer who still needs to specify the weighting factors and compare the results with the specified design goals. Controller synthesis will still be an iterative process where the engineer judges the produced optimal controllers through simulation and then adjusts the weighting factors to get a controller more in line with the specified design goals. It is difficult to finding the right weighting factors limits the application of LQR based controller synthesis. Generally speaking, the LQR algorithm is a theroy of automatically finding an appropriate state-feedback controller. As a example, there is a paper about feedback controller for helicopter [3]. It is designed to using linear quadratic regulator (LQR) control with full state feedback and LQR with output feed back approaches.

Comparing with other methodology, backstepping is an effective control theory for a specific class of nonlinear dynamic systems. Backstepping is a recursive process which is terminates in the systems built from subsystems that radiate out from an irreducible stabilized subsystem. Because of this recursive structure, the designer can start the design process at the known-stable system and back out new controllers that progressively stabilize each outer subsystem. The process, which is known as backstepping, terminates when the final external control is reached. Recently years, there are several cases using backstepping theorem as control law. In a case of quadrotor [4], it introduces a controller for a quadrotor vehicle following a predefined path under wind distrubance and a timing law in time-variant path function. In another paper [5], it introduced a torpedo MIMO backstepping control technique with acceleration feedback to track a trajectory generated by a way-point guidance system. In order to reach the desired way-points, the surge force controller is designed with an integrator backstepping control that takes the propeller model