Portfolio

Hanqi Su

https://github.com/hope-redemption/Portfolio_HS

1. Wearable wheeled "powered super tail" loading system project

Southern University of Science and Technology
Supervised by Dr. Chenglong Fu in Human-Augmented Robotics Lab
Nov 2020 – Jun 2021

Project Description:
Target:

- Aimed to build a wheel-legged robotic limb called Powered Super Tail (PST) to assist human's load carriage in varying terrains and ground conditions.

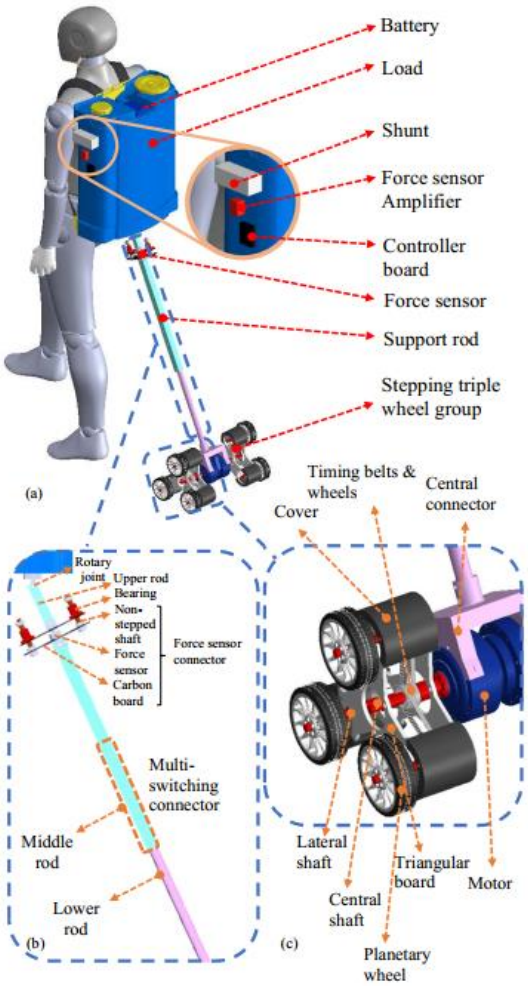
Content:

- The PST system mainly consists of a support rod transferring load to the ground and a pair of stepping triple wheel groups adaptable to different terrain conditions including ground barriers, stairs, and rough roads.
- The PST system was driven by a pair of motors, uplifting support for the load and appropriate force assistance could be effectively provided by the support rod, and thus energy expenditure of the human body could be reduced.
- Independently completed the theoretical analysis, construction of 3D models, and experimental verification of the barrier-stepping capability of the triple wheel group.
- The stepping triple wheel group could successfully traverse barriers of different heights and ascend stairs in the actual test.
- Assisted in collecting and processing data on the system's assistance performance in walking conditions. Experiments demonstrate the following results: during standing, the metabolic power consumption under PST_ON is lowered by 5.42% compared to LOAD and 12.56% compared to PST_OFF; and during walking, the metabolic power consumption is lowered by 20.85% compared to LOAD and 36.58% compared to PST_OFF.
- Wrote the mechanical design of the stepping triple wheel group, theoretical motion analysis and experimental verification in the published paper.

Paper:

Powered Super Tail: A Terrain-Adaptive Wheel-legged Robotic Limb to Assist Human's Load Carriage

Yanzhen Xiang, Xiaoyu Yan[#], Hanqi Su[#], Nuo Chen[#], Shangkun Guo, Jielin Wu, Yuquan Leng[*], *Member, IEEE*, and Chenglong Fu[*], *Member, IEEE*



Chinese Patent

证书号第16633971号

实用新型专利证书

实用新型名称：负重系统

发明人：向沿臻;闫效宇;苏汉祺;陈诺;郭上楚;付成龙;冷雨泉

专利号：ZL 2021 2 2024701.7

专利申请日：2021年08月25日

专利权人：南方科技大学

地址：518000 广东省深圳市南山区西丽学苑大道1088号

授权公告日：2022年05月31日　　授权公告号：CN 216636522 U

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申长雨

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第1页(共2页)

其他事项参见续页

For more details, please refer to the 1_PST project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/1_PST)

2. C++ version software program for parameter identification

Tsinghua University & UBTECH
Supervised by Dr. Mingguo Zhao in Automatic Laboratory
Jun 2021 – Aug 2021

Project Description:
Target:

- Aimed to develop a C++ version based on MATLAB identification software.

Content:

- Read the relevant theoretical literature on parameter identification and calibration and mastered the content of the algorithm.
- Studied and mastered the general process of parameter identification: establishment of the dynamic model, equation linearization, design of incentive trajectory, and data collection.
- Analyzed the functions of the original software and learned C language programming from scratch, the configuration and use of various mathematical libraries, and optimized libraries.
- Wrote the C++ version code of the dynamic parameter optimization and cross-validation part of the software program to make it open source, based on the MATLAB version of the software program.
- Applied a nonlinear optimization library (NLOPT) into the C++ version project to make the optimization algorithm more effective and efficient
- Visualized the dynamic parameter optimization process data, and drew related images for display.
- Finished the project with more than 3000 lines of source code and improved my ability to write code.

PPT

Parameter identification software description document

参数辨识软件说明文档

Parameter Identification Software Description Document

软件名称： 机器人参数辨识软件
软件版本： version 2.0
开发人员： 苏汉祺 刘晨澔 黄荔群 任晓雨
开发时间： 2021.06.13-2021.08.14

修改日期：2021 年 08 月 14 日

Software name: robot parameter identification software

Software version: version 2.0

Developer: Hanqi Su, Chenhao Liu, Liqun Huang, Xiaoyu Ren

Development time: 2021.06.13-2021.08.14

For more details, please refer to the 2_PD project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/2_PD)

3. Research on smart car movement and precise positioning control based on continuous gesture perception

Southern University of Science and Technology
Supervised by Dr. Zaiyue Yang in Intelligent System and Decision Making Lab,
Nov 2021 – Sep 2022

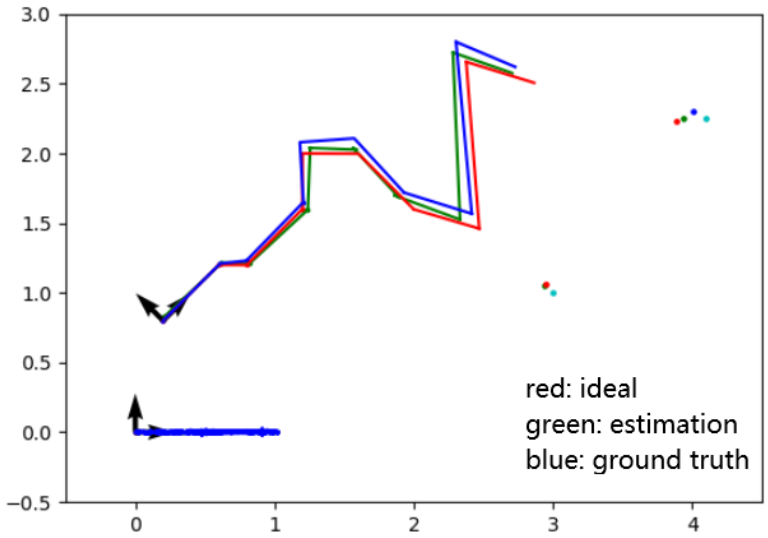
Project Description:
Target:

- Aimed to build a natural human-computer interaction system for the command and scheduling of mobile robots.

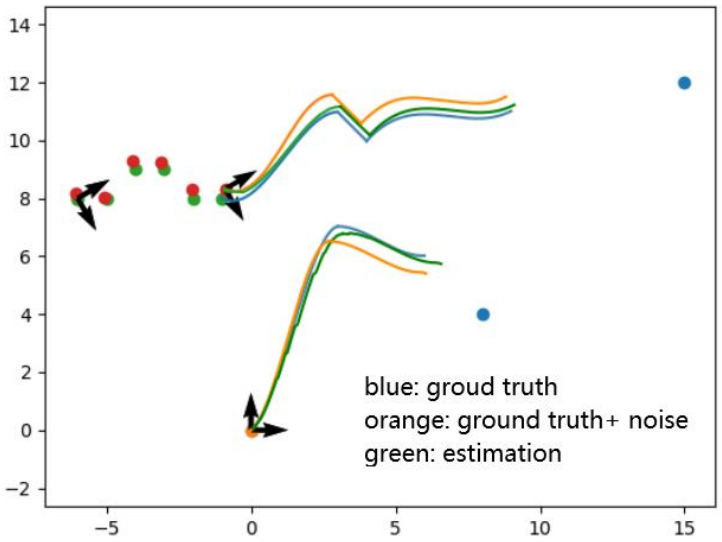
Content:

- Awarded a grant of $2000 as a provincial college students' entrepreneurship project
- Realized intelligent car movement and precise positioning control tasks such as target pointing, target confirmation, and position fine-tuning through the interaction of natural, reasonable, and fluent hand gestures.
- Proposed an adaptive motion control strategy for the mobile robot in unstructured scenarios
- Proposed an EKF optimization algorithm based on angle observation to improve the ability of intelligent car movement and precise positioning
- Proposed a mobile robot command and dispatch interactive system based on hand motion capture. As the commander, the human gives different task-scheduling signals through gestures according to the current state of the car. The signals generated by the hand output the identified information to the intelligent car through the human intention perception module. The car implements different motion control strategies according to the current task and autonomous environment perception and controls the execution of the corresponding movement or specific tasks (such as the initial alignment of the human and the car, Correct vehicle position, correct human position, lock auxiliary markers, determine the target).

Experiment picture:



Simulation Picture:



The experimental code and more videos are not available for the time being as I am working on my research paper.

For more details, please refer to the 3_DC project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/3_DC)

4. Multi-modal learning to facilitate car body design: explore machine learning, 3D modeling, and fluid dynamic simulations

Massachusetts Institute of Technology
Supervised by Dr. Faez Ahmed in DeCoDE lab
Sep 2022 – Present

Project Description:
Target:

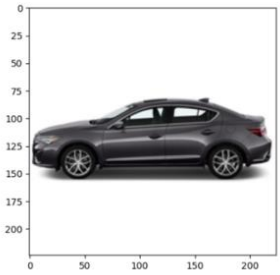
- Aimed to build a multi-modal learning model that can learn car design data in multiple modes effectively to predict car performance.

Content:

- Learned and mastered deep learning algorithms for different data types to expand deep learning knowledge and skills.
- Learned and mastered the evolution of multi-modal learning (origin, development, challenges, future research directions).
- Explored and implemented the relevant deep learning algorithms for unimodal data (e.g., images, text, sketches, tabular data) with Tensorflow.
- Built a multi-modal learning model based on the image data and Tabular data that can learn car design data in multiple modes effectively to predict car performance.

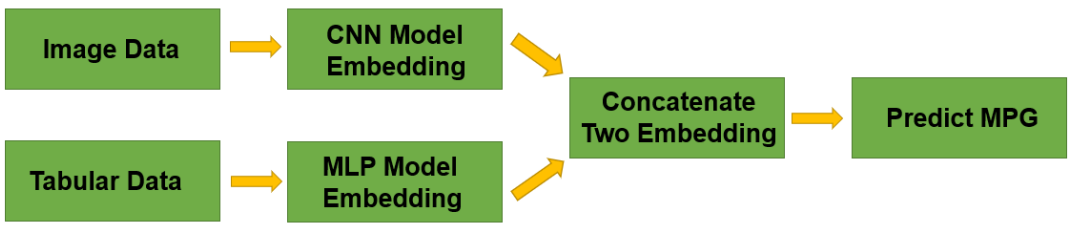
PPT:

Multi-modal learning to facilitate car body design
- explore machine learning, 3D modeling, and fluid dynamic simulations



UROP Student: Hanqi Su
Faculty Supervisor: Faez Ahmed
Direct Supervisor: Binyang Song
Term: 2022 Fall

2022.11.30



Result:

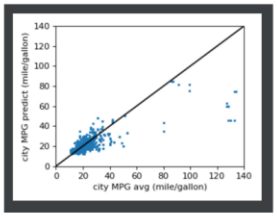
A new way of data split

Cars with the same car model name from different years may have similar configurations, making the model "**see**" the validation data during training. To avoid that, we split the data according to the car model name.

Data Split => Train : Test = 7:3

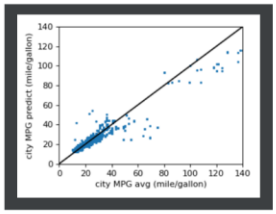
Best Model for Image Data

MSE: 87.3533
MAE: 4.0600
r-squared: 0.6028202033591669 4% ⬇

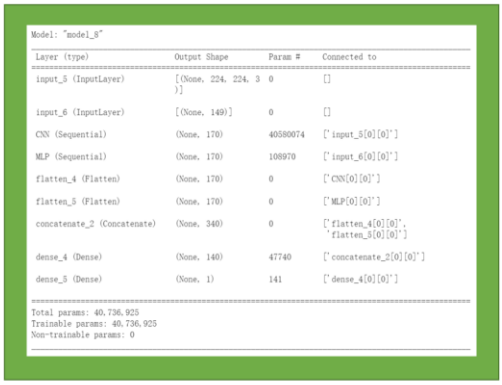


Best Model for Tabular Data

MSE: 10.6091
MAE: 1.5601
r-squared: 0.8940413451574011 2% ⬇



Muti-modal Learning Model



Model: "model_8"

Layer (type)	Output Shape	Param #	Connected to
input_5 (InputLayer)	[(None, 224, 224, 3)]	0	[]
input_6 (InputLayer)	[(None, 149)]	0	[]
CNN (Sequential)	(None, 170)	40580074	['input_5[0][0]']
MLP (Sequential)	(None, 170)	108970	['input_6[0][0]']
flatten_4 (Flatten)	(None, 170)	0	['CNN[0][0]']
flatten_5 (Flatten)	(None, 170)	0	['MLP[0][0]']
concatenate_2 (Concatenate)	(None, 340)	0	['flatten_4[0][0]', 'flatten_5[0][0]']
dense_4 (Dense)	(None, 140)	47740	['concatenate_2[0][0]']
dense_5 (Dense)	(None, 1)	141	['dense_4[0][0]']

Total params: 40,736,925
Trainable params: 40,736,925
Non-trainable params: 0

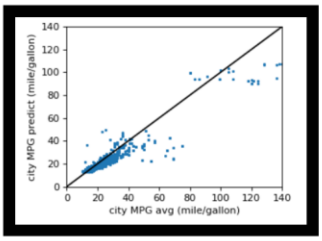


Image model: CNN
pretrain model (VGG16(7*7*512) + first layer=1024 + dropout=0.2)
+ last layer=170

MLP model: MLP
first layer=1024 + last layer=170 + dropout=0.1

Concatenate model:
layers.concatenate([model_CNN.output, model_MLP.output])
first layer=140 + last layer=1

activation = relu
learning rate= scheduler
=> start: 0.00008, after epoch >10, lr = lr* tf.math.exp(-0.05), min lr= 0.0000001
Patience=20

Best Model for MML

MSE: 19.2613
MAE: 2.6628
r-squared: 0.876047664536536

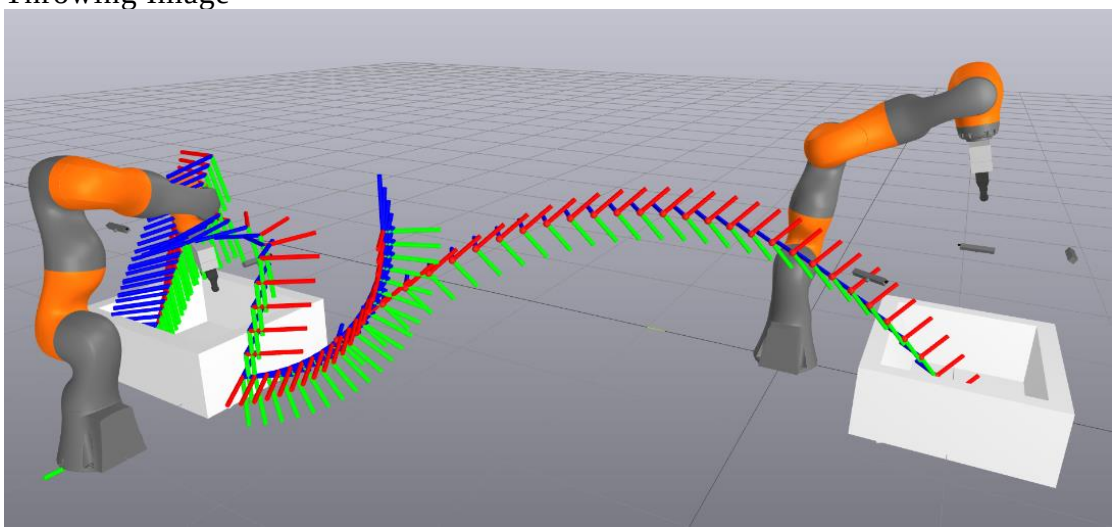
For more details, please refer to the 4_MML project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/4_MML)

5. **Simulation of catching and throwing objects between two separate robots in motion (group project)**

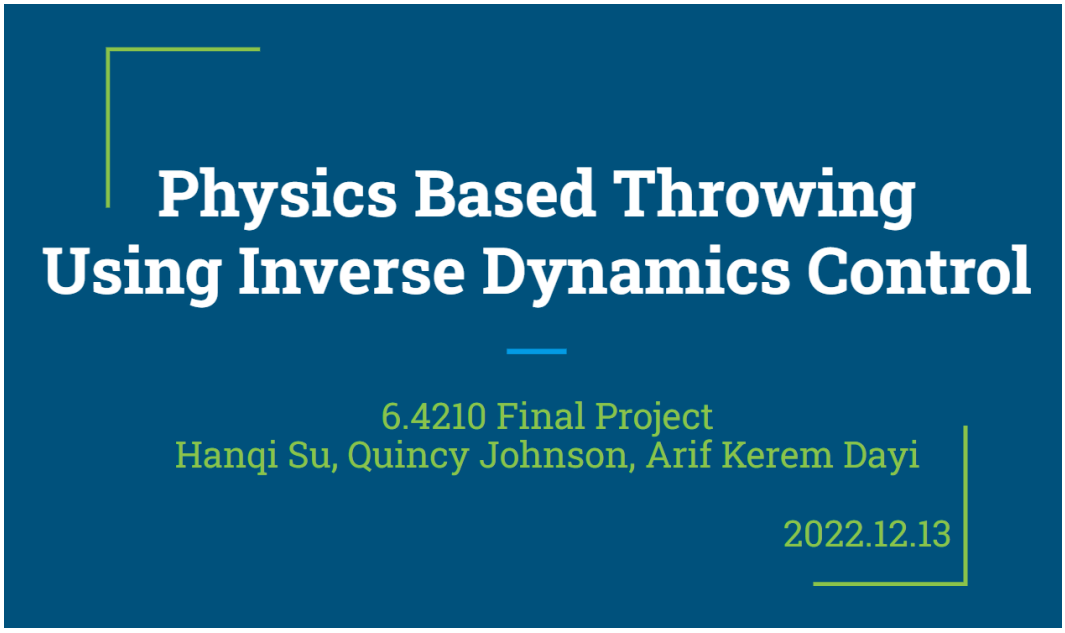
Massachusetts Institute of Technology
Robot Manipulation (Instructor: Russ Tedrake)
Oct 2022 - Dec 2022

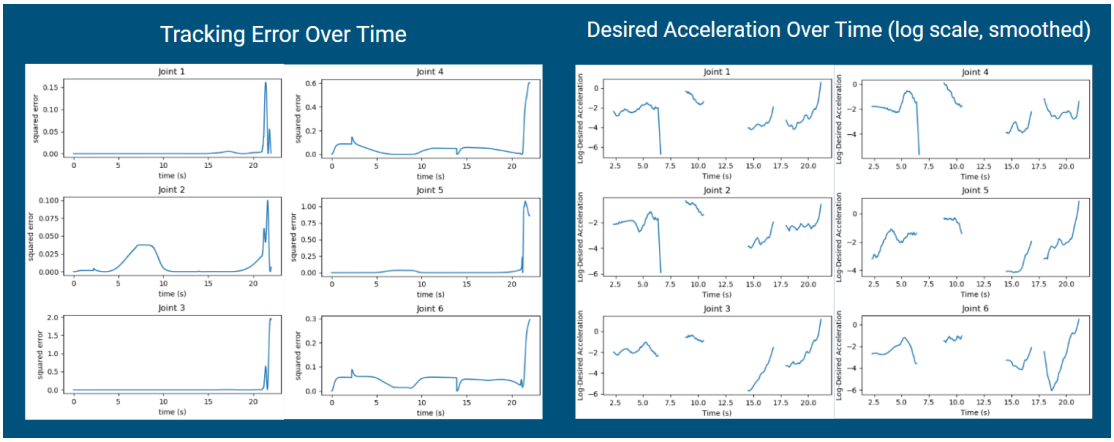
- Aimed to build a physics-based throwing using inverse dynamics control to simulate two robots throwing and catching a simple object back and forth repeatedly
- Implemented the algorithms for throwing trajectory planning and movement strategy of the iiwa robot arm
- Studied the background, implementation, basic principle, and application of throwing and catching problems based on relevant papers

Throwing Image



PPT





Throwing demo link: https://www.youtube.com/watch?v=HvuFJTrRoTU

Presentation video link: https://www.youtube.com/watch?v=7xM149tY0D0

For more details, please refer to the 5_RM project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/5_RM)

6. Ashore (group project)

Massachusetts Institute of Technology
The Product Engineering Processes (Instructor: Josh Wiesman, Ellen Roche)
Sep 2022 - Dec 2022

Project description:
Target

- Our product: **Ashore**, which is designed to be placed around sea turtle nests to rectify the sex ratio imbalance of sea turtles caused by rising global temperatures.

Content:

- The device cools sea turtle nests until they reach 27 ℃ which will produce 100% male hatchlings to help rectify the sex ratio imbalance.
- Our device is designed for marine conservation groups that specialize in sea turtle conservation.
- On the first day, conservationists find new sea turtle nests and will place the eggs inside the housing before reburying it.
- On day 20, the eggs will reach their critical development phase and the user will attach the Ashore pump to the inlet valve above the sand and begins the process of filling the reservoir with up to 4 gallons of 0℃ water.
- From Day 20 to Day 40, volunteers will replenish the ice water in the cooler every 8 days to allow the system to maintain its internal temperature difference.
- On day 40, the conservationists return again. They dig back down to the top of the incubator and remove the lid. This process does not disturb the turtle eggs and allows them to hatch unimpeded.
- After day 60, the sea turtles have hatched and left the nest, and the conservationists return one final time to recover the incubator from the sand.
- In the off-season, our product can be disassembled and stored for later use.

Product Contract

Ashore **Product Contract**

Description
An incubator deployed on the beach that cools sea turtle nests through passive cooling

User Persona
Marine biologists and conservation agencies that monitor new sea turtle nests daily and provide annual reports

Market
40,000 - 84,000 nests along the Florida coast
$14 million in available Sea Turtle Research Grants

Value Proposition
A cooling device that can be inserted around sea turtle nests to rectify the sex ratio imbalance caused by rising global temperatures

User need	Product attribute(s)	Engineering specification(s)
Rectify the sex ratio imbalance	Temperature	Optimal nest temperature of 27°C produces all male turtles
Passive Cooling	Tubing	50' of 0.87" tubing holds 350 cubic inches of ice water to cool sand
Keep nest cooler than surrounding sand	Insulation	2" foam insulation with permeable lining allows sand to stay cool for 3 days
Low interaction frequency	Water capacity	5 gallon cooler holds over 2 times the water of the tubing and only needs to be refilled every 6 days
Encompasses nest (up to 150 eggs)	Dimensions	36" deep in sand, 12" diameter, 10" height
Does not interfere with eggs	Buffer around eggs	3" on either side of nest diameter, 1" on top and bottom
Independently powered	Power source	9V 550mAh rechargeable battery powers water valves and temperature sensors

Pink

Final Product

ASHORE

Product Poster

For more details, please refer to the 6_Ashore project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/5_RM)

Or you can directly learn about our project on the website:
https://2022.2009.mit.edu/teams/pink
I am the presenter in the Technical Review.
https://2022.2009.mit.edu/teams/pink/tech

Here is the final presentation video link: https://www.009move.com/

7. A linkage foot robot (group project)

Southern University of Science and Technology
Fundamentals of Mechanical Design (Instructor: Hongqiang Wang)
Feb 2021 - May 2021

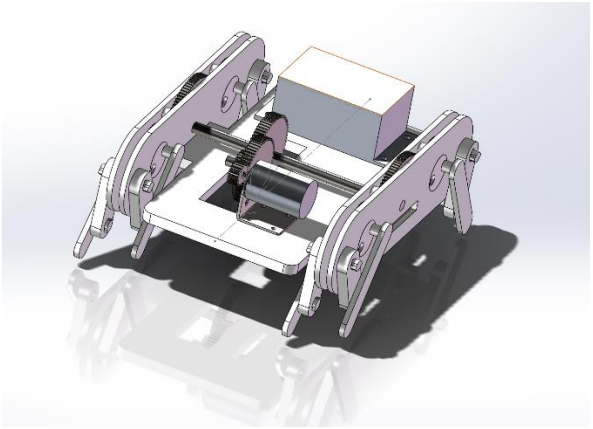
Project Description:
Target:

- Aimed to design and manufacture a linkage foot robot (driven by a single motor) with a reduction gearbox.

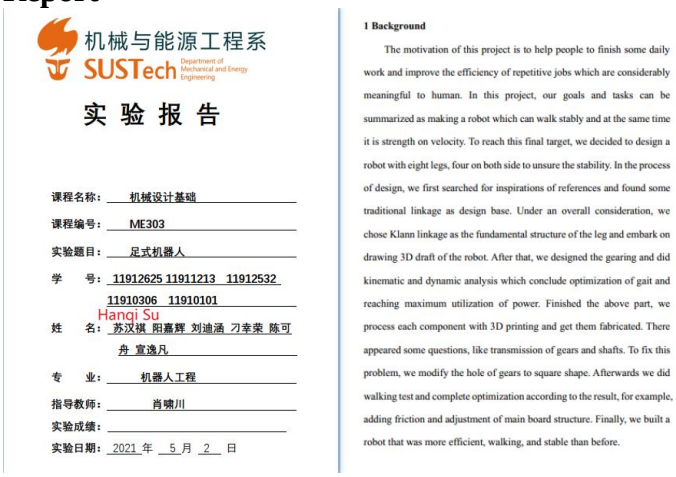
Content:

- led the whole team to successfully design the robot model that gave attention to many details, such as designing the motion scheme, designing and printing individual parts, assembly, and optimization design.
- Individually responsible for the design of the motion scheme, and in the later stage the optimization design of the overall aesthetics and mechanical properties.
- The final team's robot walked the straightest and steadiest

Model



Report



机械与能源工程系
SUSTech Department of Mechanical and Energy Engineering

实 验 报 告

课程名称：机械设计基础
课程编号：ME303
实验题目：足式机器人
学　　号：11912625 11911213 11912532 11910306 11910101
姓　　名：苏汉祺 阳嘉辉 刘迪涵 刁幸荣 陈可舟 宣逸凡
专　　业：机器人工程
指导教师：肖啸川
实验成绩：
实验日期：2021 年 5 月 2 日

Hanqi Su

1 Background

The motivation of this project is to help people to finish some daily work and improve the efficiency of repetitive jobs which are considerably meaningful to human. In this project, our goals and tasks can be summarized as making a robot which can walk stably and at the same time it is strength on velocity. To reach this final target, we decided to design a robot with eight legs, four on both side to unsure the stability. In the process of design, we first searched for inspirations of references and found some traditional linkage as design base. Under an overall consideration, we chose Klann linkage as the fundamental structure of the leg and embark on drawing 3D draft of the robot. After that, we designed the gearing and did kinematic and dynamic analysis which conclude optimization of gait and reaching maximum utilization of power. Finished the above part, we process each component with 3D printing and get them fabricated. There appeared some questions, like transmission of gears and shafts. To fix this problem, we modify the hole of gears to square shape. Afterwards we did walking test and complete optimization according to the result, for example, adding friction and adjustment of main board structure. Finally, we built a robot that was more efficient, walking, and stable than before.

For more details, please refer to the 7_MD project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/7_MD)

8. Hand Gesture Recognition based on LSTM Using Leap Motion (individual project)

Southern University of Science and Technology
Machine Learning for Engineering (Instructor: Kemi Ding)
Feb 2022 - Jun 2022

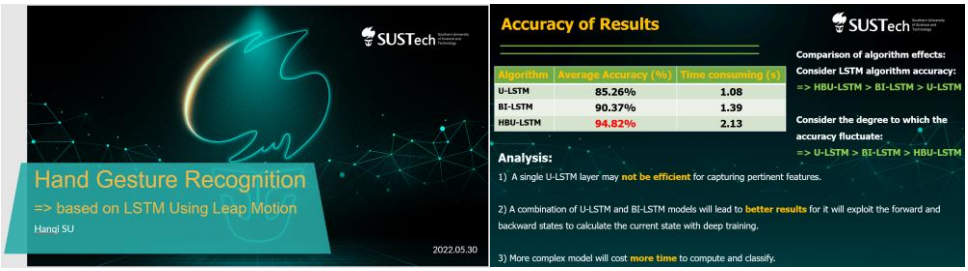
Project Description:
Target:

- Learned the background, development, basic principle, and application of dynamic hand gestures and RNN, LSTM, CNN neural networks
- Implemented LSTM neural network to construct U-LSTM, BI-LSTM, and HBU-LSTM structures to achieve the classification task of dynamic gesture.

Content:

- Independently rebuilt the overall code framework and implemented the algorithms with Python based on the paper by Ameur, S., Ben Khalifa, A. and Bouhlel, M. "A novel hybrid bidirectional unidirectional LSTM network for dynamic hand gesture recognition with Leap Motion," Entertainment Computing, 35, p.100373, 2020.
- Studied the background, implementation, basic principle, and application of dynamic hand gestures and RNN, LSTM, and CNN neural networks based on relevant papers.
- Used the Leap Motion Controller to obtain gesture data, used Python to construct LSTM neural network, and U-LSTM, BI-LSTM, HBU-LSTM structures, trained LSTM Model to achieve the classification task of dynamic hand gesture.
- Achieved a final 94.82% average accuracy in dynamic hand gesture recognition.

PPT



Report

Hand Gesture Recognition based on LSTM Using Leap Motion

1st Hanqi SU
Department of Mechanical and Energy Engineering
Southern University of Science and Technology
Shenzhen, China
11912625@mail.sustech.edu.cn

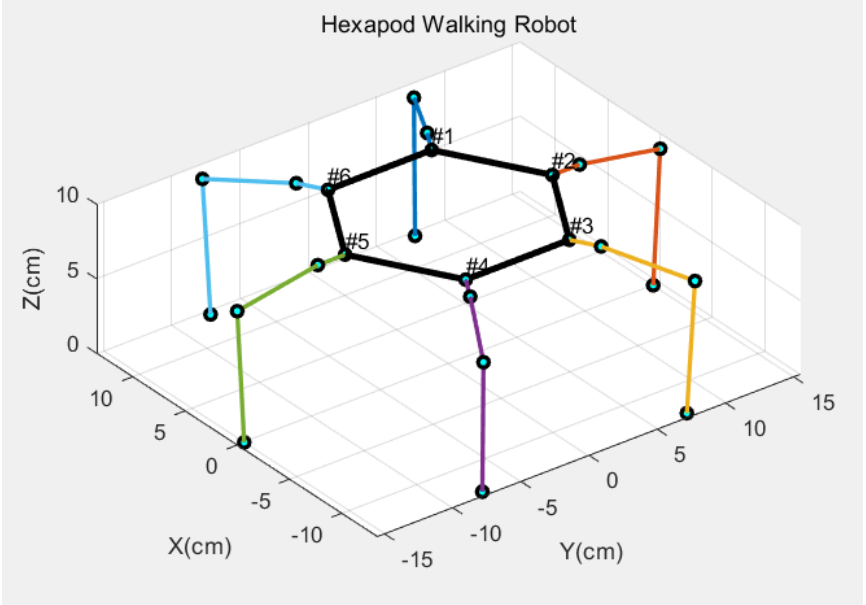
For more details, please refer to the 8_ML project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/8_ML)

9. Motion simulation of the hexapod robot (group project)

Southern University of Science and Technology
Robot Modeling and Control (Instructor: Chenglong Fu)
Nov 2021 – Dec 2021

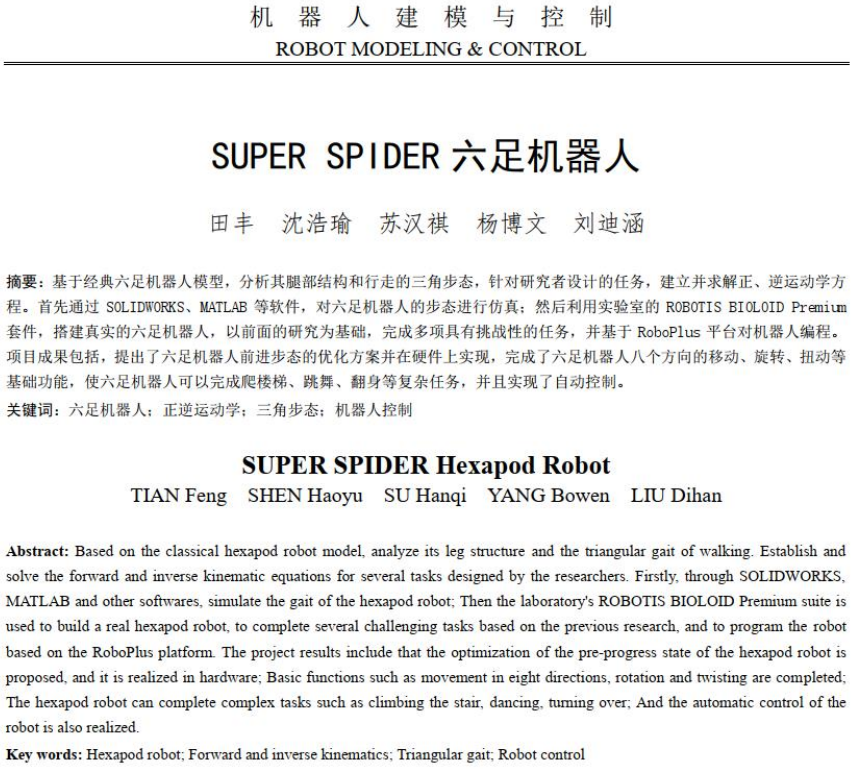
- Studied papers related to kinematic analysis and model construction of hexapod robots, such as Shahriari, M., & GHAEMI, O. K. (2012). Kinematic and Gait Analysis Implementation of an Experimental Radially Symmetric Six-Legged Walking Robot.
- Studied design strategy and implementation from an open-source project on Github (https://github.com/dallyria/Mobile-Robotics)
- Implemented the simulation of a stick model of four kinds of motion postures independently based on the model structure of the open-source project, including (i) a new straightforward walking gait, (ii) panning to the right, (iii) rotating dancing, (iv) climbing the stairs

PPT



Report

In the report, the parts from 1.3 to 3.1 are the work content I completed.



机 器 人 建 模 与 控 制

ROBOT MODELING & CONTROL

SUPER SPIDER 六足机器人

田丰 沈浩瑜 苏汉祺 杨博文 刘迪涵

摘要：基于经典六足机器人模型，分析其腿部结构和行走的三角步态，针对研究者设计的任务，建立并求解正、逆运动学方程。首先通过 SOLIDWORKS、MATLAB 等软件，对六足机器人的步态进行仿真；然后利用实验室的 ROBOTIS BIOLOID Premium 套件，搭建真实的六足机器人，以前面的研究为基础，完成多项具有挑战性的任务，并基于 RoboPlus 平台对机器人编程。项目成果包括，提出了六足机器人前进步态的优化方案并在硬件上实现，完成了六足机器人八个方向的移动、旋转、扭动等基础功能，使六足机器人可以完成爬楼梯、跳舞、翻身等复杂任务，并且实现了自动控制。

关键词：六足机器人；正逆运动学；三角步态；机器人控制

SUPER SPIDER Hexapod Robot

TIAN Feng SHEN Haoyu SU Hanqi YANG Bowen LIU Dihan

Abstract: Based on the classical hexapod robot model, analyze its leg structure and the triangular gait of walking. Establish and solve the forward and inverse kinematic equations for several tasks designed by the researchers. Firstly, through SOLIDWORKS, MATLAB and other softwares, simulate the gait of the hexapod robot; Then the laboratory's ROBOTIS BIOLOID Premium suite is used to build a real hexapod robot, to complete several challenging tasks based on the previous research, and to program the robot based on the RoboPlus platform. The project results include that the optimization of the pre-progress state of the hexapod robot is proposed, and it is realized in hardware; Basic functions such as movement in eight directions, rotation and twisting are completed; The hexapod robot can complete complex tasks such as climbing the stair, dancing, turning over; And the automatic control of the robot is also realized.

Key words: Hexapod robot; Forward and inverse kinematics; Triangular gait; Robot control

For more details, please refer to the 9_RMC project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/9_RMC)

10. Artificial Intelligence B

Southern University of Science and Technology,
Instructor: Jianguo Zhang

Project 1: Composite Image Generation & Binary Image Classification (group project)
Oct 2021 – Nov 2021

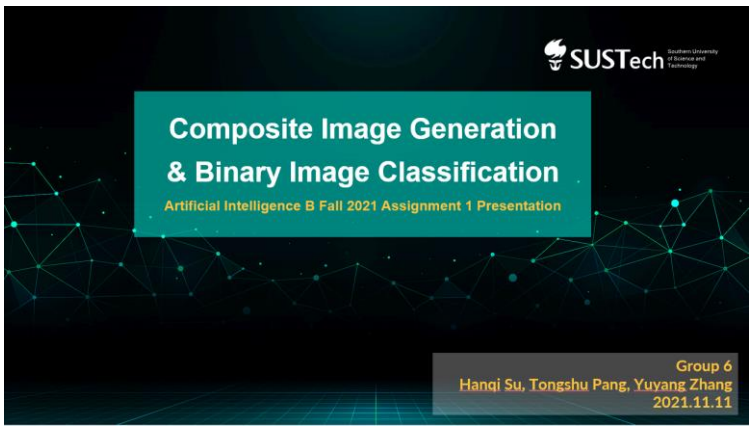
Project Description:
Target:

- To develop, evaluate and report image processing software to automatically create various types of composite images, using automatically selected images as specific categories of the scene.

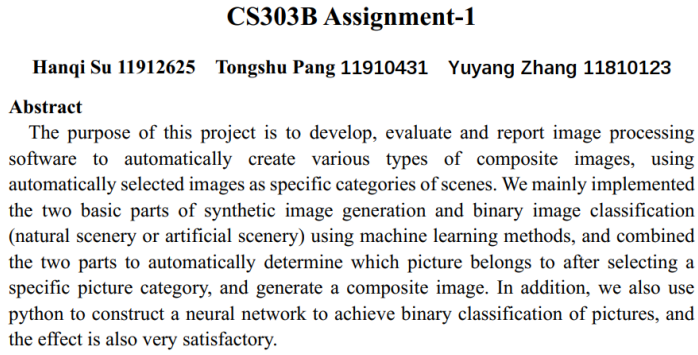
Content:

- Implemented the two basic parts of synthetic image generation and binary image classification (natural scenery or artificial scenery) using machine learning methods
- Combined the above two parts to automatically determine which picture belongs after selecting a specific picture category, and generate a composite image.
- Used python to construct a neural network to achieve the binary classification of pictures, and the accuracy became 85% during the tests.

PPT



Report



CS303B Assignment-1

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Abstract

The purpose of this project is to develop, evaluate and report image processing software to automatically create various types of composite images, using automatically selected images as specific categories of scenes. We mainly implemented the two basic parts of synthetic image generation and binary image classification (natural scenery or artificial scenery) using machine learning methods, and combined the two parts to automatically determine which picture belongs to after selecting a specific picture category, and generate a composite image. In addition, we also use python to construct a neural network to achieve binary classification of pictures, and the effect is also very satisfactory.

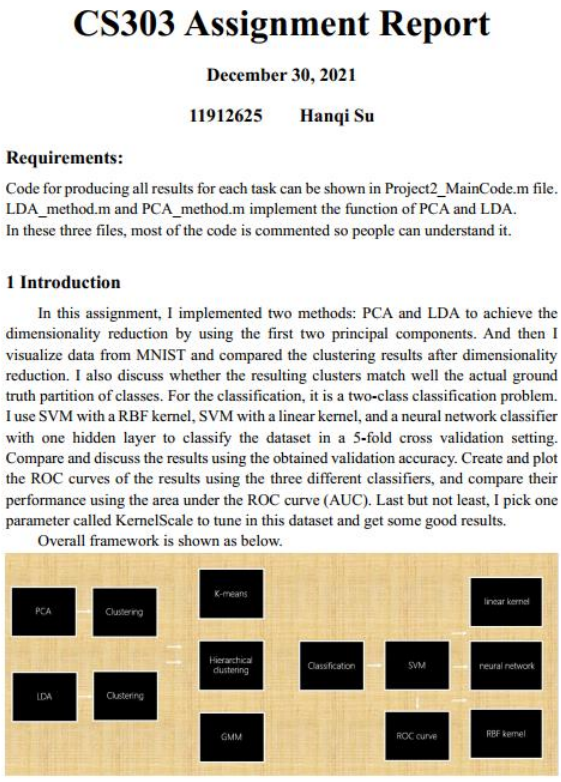
Project 2: Classification and Clustering (individual project)
Nov 2021 – Dec 2021

Project Description:
Content:

- Implemented two methods: PCA and LDA to achieve the dimensionality reduction by using the first two principal components.
- Visualized data from MNIST and compared the clustering results after dimensionality reduction.
- Used SVM with an RBF kernel, SVM with a linear kernel, and a neural network classifier with one hidden layer to classify the dataset in a 5-fold cross-validation setting.
- Create and plot the ROC curves of the results using the three different classifiers, and compare their performance using the area under the ROC curve (AUC).

PPT

Report



CS303 Assignment Report

December 30, 2021

11912625 Hanqi Su

Requirements:

Code for producing all results for each task can be shown in Project2_MainCode.m file. LDA_method.m and PCA_method.m implement the function of PCA and LDA. In these three files, most of the code is commented so people can understand it.

1 Introduction

In this assignment, I implemented two methods: PCA and LDA to achieve the dimensionality reduction by using the first two principal components. And then I visualize data from MNIST and compared the clustering results after dimensionality reduction. I also discuss whether the resulting clusters match well the actual ground truth partition of classes. For the classification, it is a two-class classification problem. I use SVM with a RBF kernel, SVM with a linear kernel, and a neural network classifier with one hidden layer to classify the dataset in a 5-fold cross validation setting. Compare and discuss the results using the obtained validation accuracy. Create and plot the ROC curves of the results using the three different classifiers, and compare their performance using the area under the ROC curve (AUC). Last but not least, I pick one parameter called KernelScale to tune in this dataset and get some good results.

Overall framework is shown as below.

For more details, please refer to the 10_AI_B project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/10_AI_B)

11 Awareness Practice of Manufacturing Engineering (Instructor: Dong Lu)
Revolving restaurant
Apr 2022 - Jun 2022 SUSTech

- Designed the conceptual model of the new revolving restaurant with aesthetic and economic value, and carried out the layout and planning with multidisciplinary knowledge of economics, mechanics, aesthetics, etc.
- Designed the parts with Solidworks, processed the parts through additive manufacturing and reduced material manufacturing, and finally assembled and tested the real effect.

Model photo

PPT

For more details, please refer to the 11_RR project on Github (https://github.com/hope-redemption/Portfolio_HS/tree/main/11_RR)