DESIGN EXPO

2015 WINTER

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JOINT INSTITUTE
交大密西根学院

PROJECT LIST of UM-SJTU JI DESIGN EXPO

Wireless Stethophone

Sponsor: Li Weng, ***General Electric***
Team Members: Shucheng Liang, Ningyu Ma, Chengxi Yu, Yifan Chi, Sihao Yao
Instructor: Prof. Yunlong Guo

Problem Statement

A common approach to diagnose lung or heart diseases is by using a stethophone. However, a patient has to go to hospital himself to let the doctor do such diagnose, which can be inconvenient or even harmful to one who has serious heart diseases. In that case, the application of a wireless stethophone, which makes advantage of the internet, the cloud share technology, and the smart phone systems, is essential. By this equipment, one can stay at home and transmit his chest voice to the doctor.

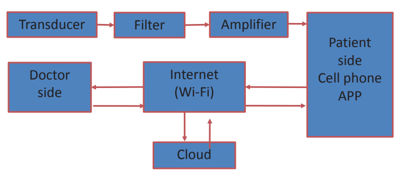


Fig. 1 The expected working process of the wireless stethophone

Concept Generation

A microphone is involved in the system to collect sound signals from the patient's chest. The sound will then be converted into electrical signals and sent to the patient's phone by Bluetooth. The patient will be able to use the bundled phone APP to send the sound to his doctor, or share it on Cloud, or directly talk with his doctor. To realize this, a hardware part of a signal filtering and amplifying circuit, a Bluetooth transporting circuit, and a USB charge circuit, as well as a software part of bundled Android application, is required.

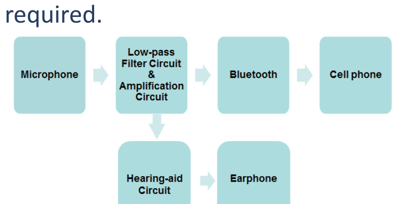


Fig.2 Layout drawing of hardware part

Design Description

The amplification circuit with LM741 (Fig. 3) can amplify the heart beat signal for us to hear the heart beat and is at the same time within the voltage range of Bluetooth module. To get a frequency range of below 2000 Hz, we designed two stages of low-pass filter circuit with cut-off frequency of 2000Hz to reduce high frequency noise.

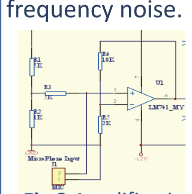


Fig.3 Amplification circuit

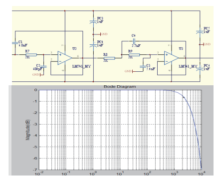


Fig.4 Low-pass filter circuit and frequency response

We used WM-61A electret condenser microphone with frequency range of 20-16000 Hz and S/N ratio of more than 70dB, which fits our specification. Fig.5 shows the circuit diagram and appearance of the microphone. 2V for "+U" and 2.2kΩ for pull up resistor R give us a desired signal in terms of our goals.

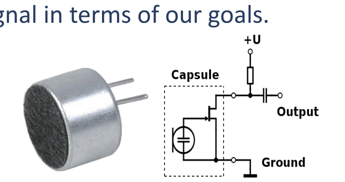
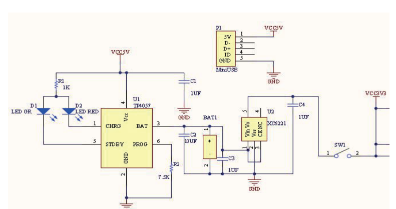


Fig. 5 WM-61A microphone [1]

we designed an USB charging Circuit (Fig.6) and chose a 3.7V, 200mAh lithium battery which can be recharged to realize this goal.



The unpacked hardware part is shown in Fig.7. The components, from left to right, are the electret microphone in a chest piece, the amplification and filtering circuit, the Bluetooth module, and the lithium battery.

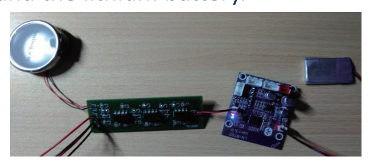


Fig.7 The whole hardware part (unpacked)

In software part, we finally choose a third party server "云信NetEase" and use its relative module to complete our application. The application realized functions of sending sound record from patients to doctors and real-time video call between doctor and patient.

Validation

Validation Process:
Whether the specifications are met can be verified by real tests. Some of the specifications are simply verified by the existing parameters of corresponding components.
Validation Results:

- ✓ Transmission speed=24Mbps
- ✓ Signal-noise ratio>=70dB
- ✓ Replaceable components>=50%
- ✓ Battery endurance>=6h
- ✓ Sample frequency>=32kHz

√ means having been verified.

Conclusion

Currently the prototype is able to collect heart beat sound from patients and transmit the sound via Bluetooth. With the help of servo and app, doctors can easily hear this heart beat.

Acknowledgement

Jizhou Zhang from UM-SJTU Joint Institute

Reference

[1] http://www.yinwang.org/blog-cn/2012/05/18/user-friendliness/

JOINT INSTITUTE 交大密西根学院
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3D Motion Measurement for Rotational Steerable System Directional Drilling

Sponsor: Zhiguo Ren, ***General Electric***
Team Members: Ardo Hintoso, Hanwen Yao, Lingfan Liang, Yi Dong, Yuzhang Liu
Instructor: Prof. Yunlong Guo

Problem Statement

Rotational steerable system (RSS) is an increasingly popular technology as it greatly ameliorates vertical and horizontal directional drilling in harsh drilling conditions. At the initial stage of a large scale R&D industrial project, our task is to develop a robust algorithm that accurately locates the drill bit attitude and position.

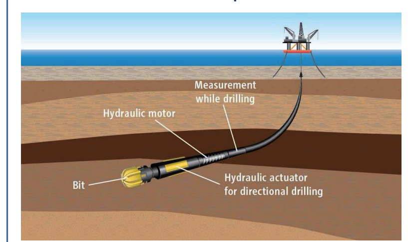


Fig. 1 Schematic of an example of RSS [1]

Concept Generation

Through metamorphological analysis, core functions and sub-functions were generated, and the optimum solution was chosen. Our design incorporates sensors that include a gyroscope and accelerometers; an Arduino and Bluetooth module is utilized for data transmission, which is later processed and displayed in the demo system UI through MATLAB.

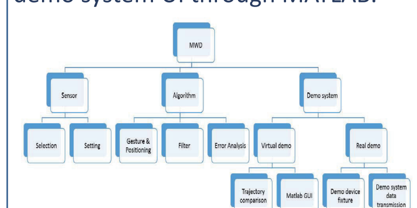


Fig. 2 Detailed structure function

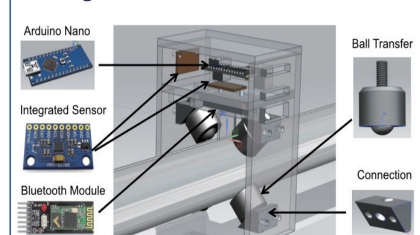


Fig. 3 Concept design of MWD device

Design Description

The readings from the sensors (accelerometers, gyroscope, and encoder) can be used to calculate the attitude and drill bit position. The accelerometers are installed in three mutually orthogonal directions. The angular increment in inertia form can be determined from the sensors, and the quaternion and frame transfer matrix is updated to obtain the attitude. Sensor readings also can be transformed into inertia frame and integrated twice to obtain the displacement of the drill bit. An encoder is used in a minimum curvature method to improve the accuracy of the integration results.

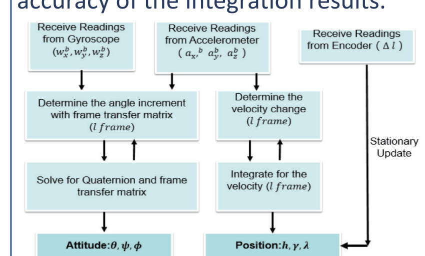


Fig.4 Algorithm locating drill bit & attitude

Modeling and Analysis

In the testing phase, the iterative process of calibration, error measurement, and refinement of the algorithm is pivotal in building an accurate model for later stages of the project. The Kalman filter is implemented for data analysis because vibration is a constant act of disturbance/noise while drilling.

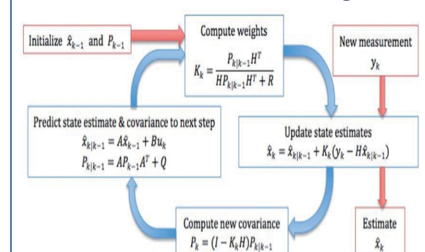


Fig. 5 Process Map of Kalman Filter

Validation

Validation of the algorithm can be done through actual track and virtual simulation. An arbitrary, predefined trajectory can be designed and tested with MATLAB. Simple trajectories such as a straight line and 90 degrees rotating curve can be employed. An alternative solution is to use an actual track for a fixed trajectory with scaled linear dimension. As shown in the image below, the second validation method is present in the demo.

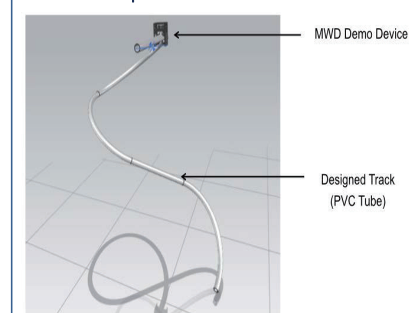


Fig.6 Prototype for demo with designed track for simulation

Conclusion

In the future, our designed MWD algorithm can be transferred to a larger scale platform that takes into consideration certain requirements such as enduring high temperature and pressure while remaining shock resistant and waterproof. This can be done simply by replacing the sensors with appropriate functions. Those sensors were not in the scope of this project because the specifications were not considered as inputs or constraints to the algorithm.

Acknowledgement

Sponsor: Zhiguo Ren from GE
Kai Xu, Yunlong Guo from UM-SJTU Joint Institute

Reference

[1]http://youngpetro.org/wp-content/uploads/2013/10/image.jpg

Indoor Positioning and Navigation System

Sponsor: Fengcheng Sun, ***Ph.D, GE***
Team Members: Guangyu Zhang, Sheng Zhu, Zeming Wang, Xi Deng, Shuhui Ding
Instructor: Prof. Yunlong Guo

Problem Statement

The rapid development and maturation of global positioning system (GPS) has already brought great convenience and benefits to people around the world in the previous decades. However, high-precision indoor positioning is still a problem waiting to be solved. We are expected to design a high-precision and low-cost indoor positioning system for industrial use, especially warehouse management, etc.

Concept Generation

The communication technology concerned with all top features. After studying six types of technology and their pros and cons comparison in the below table, we decided to use Ultra-Wide Band communication technology to

Design criterion	Weight factor	Unit	ZigBee	Blue-tooth	Ultra-sound	Wi-Fi	UWB		
			Score	Score	Score	Score	Value	Score	Rating
Cost	0.18	¥/100 m²	9(1.62)	9(1.62)	8(1.44)	8(1.44)	1,500	7	1.26
Coverage area	0.15	m²	9(1.35)	6(0.90)	7(1.05)	7(1.05)	2,000	8	1.20
Industry temperature range	0.07	℃	8(0.56)	6(0.42)	9(0.63)	9(0.63)	-40 to +85	9	0.72
Battery duration	0.07	month	9(0.63)	9(0.63)	8(0.56)	6(0.42)	2	8	0.56
Lifetime	0.07	year	9(0.63)	9(0.63)	8(0.56)	8(0.56)	5	9	0.63
Multi-tag capacity	0.10	#	9(0.90)	9(0.90)	5(0.50)	9(0.90)	1,100	9	0.90
Position precision	0.28	cm	6(1.68)	6(1.68)	9(2.52)	5(1.40)	10	9	2.52
Time delay	0.08	ms	3(0.24)	5(0.40)	6(0.48)	9(0.72)	60	8	0.72
			6.98	7.18	7.74	7.12			8.51

Fig. 1 Communication Technology Comparison

For ranging algorithm, we decided to use the Time difference of arrival (TDOA) algorithm, which is an algorithm improved from TOA.
For the system topology, we decided to use the mesh topology, which is the most flexible but complex one. Considering the high accuracy, large coverage and high efficiency, mesh topology was selected as our system topology.

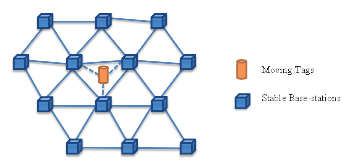


Fig. 2 Mesh Topology

Design Description

Our design implemented the chip on a microprocessor, Arduino pro mini which can transmit UWB signal among base stations and tags, and communicate with microprocessor through SPI. The distance between two objects could be obtained from TDOA (Time Difference Of Arrival) data and send to the computer for further calculation and visualization.
The micro-controller, Arduino boards input UWB communication signals, and feedback the relative length values to Matlab functions.

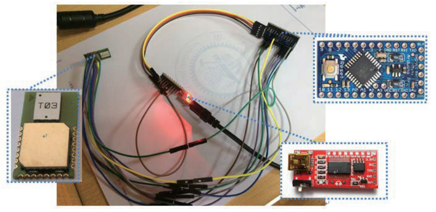


Fig. 3 signal transmitter unit

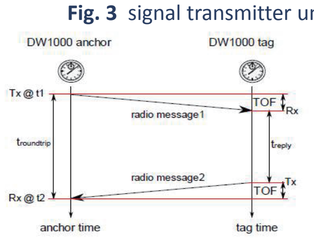


Fig.4 Two Ways' Ranging Concept

Modeling and Analysis

The programming and visualization of the positioning algorithm are implemented in Matlab R2015b with its functional programming language. 3 lengths among the three base stations will input to generate the absolute coordinate system. Every two of the three path lengths can formulate a system of equations. Hence, we can get three different but very close absolute coordinates of the tag. the final positioning absolute coordinate is the approximation among the three solutions.

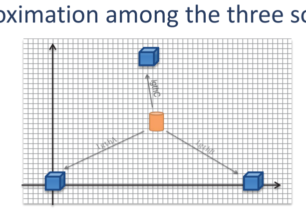


Fig. 5 Coordinate Diagram

Validation

The main equipment we used for testing is 2 Lego cars with NXT programmable controller and a laser rangefinder (80 m,±1.5mm).

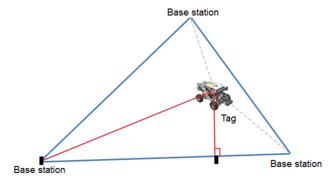


Fig. 6 Schematic Diagram of Testing

By using the laser rangefinder, we can get the distance from a stationary tag to each of the base stations and the perpendicular distance to the line of every two base stations.
For moving object, we compare the difference of the trace forming by the points given by our design and the actual route which is settled in advance.
Based on the validation testing, most specifications can be met as desired.

- ✓ Position precision <=10 cm
- ✓ Time delay<=200ms
- • Multi-tag capacity>=100
- ✓ Correct rate >=95%
- ✓Cost<=6000RMB/100m2
- • Lifetime >= 5 years

√ means having been verified and means to be determined.

Conclusion

Our UWB-based indoor positioning system used mesh topology as the system structure and the Time Difference of Arrival Algorithm as our positioning algorithm. Based on the validation testing, our design can reach a position precision within 10cm, which is the primary specification of our design. Besides, our design met the requirement of low-cost and high-capacity for industrial use.

Acknowledgement

Sponsor: Fengcheng Sun from GE
Yunlong Guo, Kai XU from UM-SJTU Joint Institute

Industrial Internet: Power Plant Monitoring

Sponsor: Mr. Ming Su, ***GE***
Team Members: Peihao Ding, Haitian He, Yingda Dong, Hanyang Liu, Yuxuan Guo
Instructor: Prof. Yunlong Guo

Problem Statement

Monitoring power plant can improve the efficiency and save the energy. Nowadays, power plant monitoring software can only monitor one local power plant, but unable to monitor several power plants at the same time. This project is an application of the concept "Industrial Internet" to the monitoring of power plants. The KPIs and other data shown on the website indicate the working condition of heat exchangers. With the help of our product, you can know the performance of your power plants at anytime and anywhere.

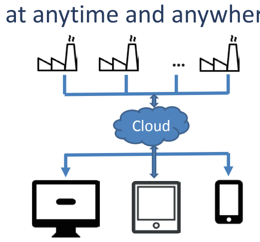


Fig. 1 Schematic illustration of our product

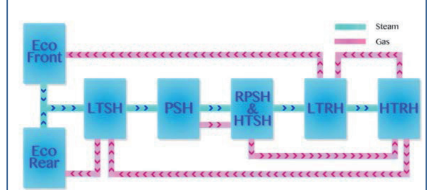


Fig. 2 Flow of steam and gas between heat exchangers

Concept Generation

The most crucial part is data acquisition and storage, and MySQL is qualified to establish a stable database. Moreover, php and html languages are suitable for fetching data and building GUIs on website.

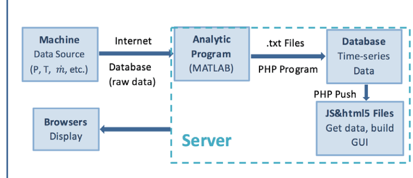


Fig. 3 Concept diagram

Design Description

This design is to show the performance of the power plants in the Website GUI. Firstly, analyze the raw data from the machine by the analytic program in matlab. Then, store the data from matlab into the database, MySQL. At last, show the data in the database on the Website GUI. For website, there are line charts and bar charts to show the performance intuitively and also other functions such as relevant information of the power plants, search and warning function.

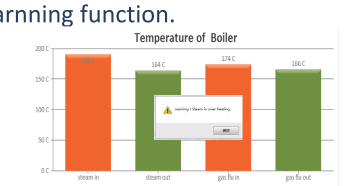


Fig. 4 Sample bar chart of temperature on webpage and warning function.

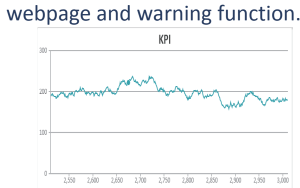


Fig. 5 Sample line chart of KPI on webpage.

Modeling and Analysis

We analyze every sub-system in order to verify the feasibility of our concept. Firstly, we tested time needed for operations of Analytic Program to confirm that we can conduct real-time monitoring with update frequency of once per second. Secondly, we realized that data would be missing if machine goes wrong, so we assign time to data in each second to record this possible error. Thirdly, we calculated for capacity of database needed for one-year data from the power plant and found that we can store more than ten years of data from ten similar power plants. Finally, we tested the dynamic charts on website to assure real-time monitoring.

Validation

First, we will run the Virtue Machine and generate data including normal ones and delayed ones. Then we will run MATLAB function to generate txt files which contain time and KPI. After that, PHP functions will load txt files into MySQL and generate figures on web pages. If any process goes wrong, warning messages should appear on the webpage to tell users which part goes wrong.
Some other specifications can also be verified using easy experiments.
Validation Results:
According to validation part, most specifications can be met.

- ✓ Mathematic errors of analytics results [%]: less than 1.23%
- ✓ Availability of web app for most browsers
- ✓ Cloud storage capacity: capable for 1-year historical data
- ✓ GUI data update frequency [s/time]: coordinate with update frequency of data source.
- • Fancy and Concise GUI

√ means having been verified and · means to be determined.

Conclusion

Users of our website will gain benefits from both engineering and business aspects. With real-time monitoring online, engineers can timely solve the fouling problem whilst companies can simplify monitoring department to save money. With historical data, managers can make efficient plans for operations of a power plant to increase profits.

Acknowledgement

Sponsor: Ming Su from General Electric
Prof. Y. Guo, K. Xu, C. Ma, M. Li from UM-SJTU Joint Institute

Reference

[1]http://labs.seas.wustl.edu/bme/Wang/index.html

UAV Autopilot and Ground Monitoring System

Sponsor: Xu Fu, ***General Electric***
Team Members: Peng Yuan, Heng Zhang, Bo Li, Tianyu Wang, Robert Li
Instructor: Prof. Chengbin Ma

Problem Statement

UAV stands for Unmanned Aerial Vehicle which is aircraft without pilot. GE is assembling their own fixed-wing UAV. This project is to build a base autopilot control system and ground monitoring system with GE's own patent to help control the UAV. This system will be able to display real-time data of the UAV, such as its position and velocity, and send commands to the control board of UAV to implement simple tasks.

Fig. 1 Fixed-Wing Unmanned Aerial Vehicle[1]

Concept Generation

In our project, we will design the UAV ground monitoring system, which contains functions to analyze input data and send control signals. The ground monitoring system should have user-friendly interface which can show aircraft's status to users and send commands to control UAV.

We will also design the base control system for DSP board on the UAV. In order to generate the whole status of UAV and finish simple control tasks, we need different kind of sensors to detect real-time data.

Besides, we need to use 3D model to visualize the current UAV status in the ground monitoring system.

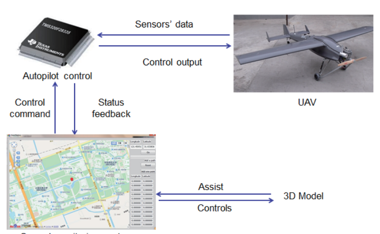


Fig. 2 Concept Diagram

Design Description

Our project can be decomposed into three major parts: autopilot control, Grounding monitoring system, and Unity modeling.

For the ground monitoring system, we selected MFC in VC++ to develop it. We choose to use Baidu Map API for the positioning and map illustration. For the major data structures we use linked list. And for the HUDs in the user interface, we use VC++ to implement it. The ground monitoring system can show the real-time data of the UAV on the map, data chart and HUD. Besides, it can also send command to the control Board on the UAV.

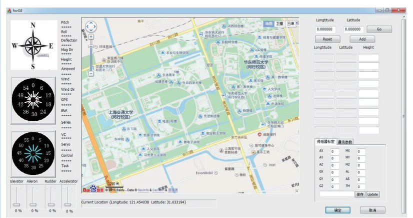


Fig.3 The User Interface of Ground Monitoring system

For the base control system on the UAV, we use DSP f28335 board as the microcontroller. To acquire the 3D position and 3D attitude, we choose to use the Mti-G-700 sensor. For the air speed sensor we choose SM9541. The base control system can acquire data form the sensors and send it back to the ground monitoring system. It can also receive commands from the ground monitoring system and control the servos on the UAV.

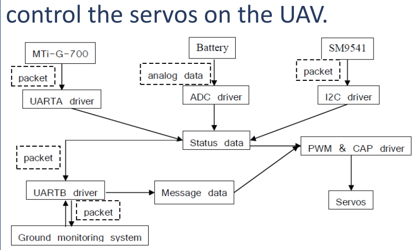


Fig. 4 Software Structure for Base Control System

We use unity to visualize the current status of the UAV.

Fig.5 Unity Modeling Result

Validation

Validation Process:

In software part, we checked the validation of software by researching the description files of corresponding computer and chips. In autopilot part, we ran the all the driver functions in the DSP board.

Validation Results:

According to validation part, most specifications can be met.

✓Memory used <= 530 KB
✓Context Switch Speed <= 3500 ns
✓Cost <= 1000 CNY
✓3D position accuracy <= 2m/s
✓Velocity accuracy <= 0.5 m/s
✓Acceleration accuracy <= 0.3 m/s^2
✓Attitude accuracy <= 1 degree

√ means having been verified and · means to be determined.

Conclusion

In conclusion, we successfully developed one UAV ground monitoring system with high reliability and one UAV autopilot base system prepared for future autopilot developing. Our project met most engineering specifications with reasonable compromises.

Acknowledgement

Sponsor: Xu Fu from General Electric
Faculty Advisor: Chengbin Ma
Course Instructor: Kai Xu, Yunlong Guo and Mingjian Li from UM-SJTU Joint Institute

Reference

[1]北京数维翔图高新技术有限公司. fixed.jpeg. http://www.uav-competitive.com/photo/html/199.html.

JOINT INSTITUTE 交大密西根学院
VM450 • Design and Manufacturing III & VE450 • Major Design Experience

Data Visualization in 3D Modelling

Sponsor: Yukai Ji, Zeng Don, Marco Cao
Team Members: Zhang Boqun, Zhu Junjie, Lin Zhen, Yan Minkuan and Shubham Ashok Agarwal
Instructor: Prof. Guo Yunlong

Problem Statement

Control Valves are used to regulate the change of pressure in the production line of a factory. They often need to be repaired and thus the repair log is accumulated in several folders which makes it inconvenient to search repair information. The purpose of this project is to design a website and display the repair data of the relevant parts of the valve. Designing a 3D model of the valve makes it easier for the user to visualize the repaired components.

Fig. 1 3D Image of a Control Valve

Concept Generation

The 3D model is built using 3Ds Max. Three.js is then used to transfer the 3D model into a web interface created using Java Script. The components of the valve are highlighted on the webpage using Grunt Server Setting and Grunt Package. The repair log is shown on the website using codes in JavaScript.

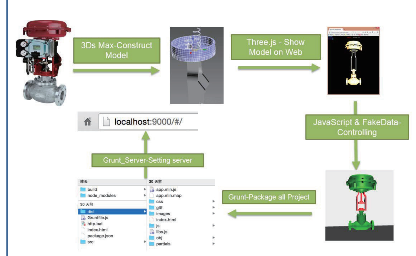


Fig. 2 Detailed Concept Diagram

Design Description

The design is accomplished by using 3dsmax to build the 3D model of the valve, and then using three.js to display 3D model on the webpage. In designing the model, we first build the exterior part and then cut the model into two halves to draw the internal components. In the design of the webpage, options to select components are divided into 6 parts. Checkboxes are used for selection of the components. On selection, the color of the component changes and the relevant repair log is displayed. A photo link for a display of the sample broken valve is also added.

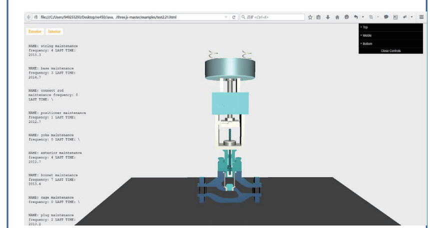


Fig.3 Web Interface of the Valve

Modeling and Analysis

A 3D Model of the original valve is constructed using 3ds Max software, based on real photos and 2D pictures of the valve. Each component of the model is separately built and can be displayed individually on the webpage so that details are visible.

Fig. 4 3D model of the Valve

Validation

Validation Process:

For webpage access time, the Network elements in Devtools (embedded in Chrome explorer) could be viewed to gain the access time of each element on the webpage. Then, the webpage access time was gained by summing them up.

For 3D model load time, we used the same way of webpage access time.

For rotation degree, we tested it by rotating the model on webpage in orientations of up, down, left, and right. If it didn't lose configuration and clarity, it meets the requirement.

We can perform similar experiments to verify the other specifications too.

Validation Results:

✓ Webpage access time < 1.5s
✓ 3D model load time < 0.5s
✓Response time to mouse < 0.2s
✓ Rotation degree = 360º
✓ Cost <= 1150RMB
• Similarity of 3D model > 90%

Where: √ have been verified and
· to be verified

Conclusion

The website is able to display a 3D model, and the convenient user interface makes data visualization possible. Key features of this design include highlighting the repaired components and displaying the repair log, thus satisfying the requirements of the project with accurate results.

Acknowledgement

Sponsor: Yukai Ji, Zeng Don, Marco Cao from GE
Instructor: Prof. Guo Yunlong from UM-SJTU Joint Institute

Budget Solution for Media Type Detection

Sponsor: David Chen, ***HP***
Team Members: Yidong Zhang, Xiangxuan Ge, Zimu Zhai, Yuqing Xie, Wenjie Xu
Instructor: Dr. Mingjian Li

Problem Statement

Most printers have the function of media type selection, but none of them can determine which type the media is by the printer itself. People have to choose the media type on computer screen manually before papers are printed. With our ideal capstone project, people do not need to choose the media type before printing anymore.

Fig. 1 An ordinary printer [1]

Concept Generation

After literature survey, we decided to differentiate different types of printing media by the following physical characteristics: light penetrating intensity, light reflection intensity, weight, elasticity, and capacitance. We build prototypes of these sensors and integrated them together to get the result we want. Here is the different concepts we get from brainstorming.

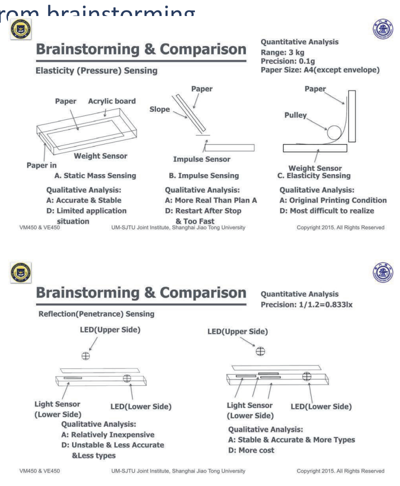


Fig. 3 Design for reflection sensing

Design Description

The figure below show our final detailed design. A black box made by acrylic contains all our sub-systems. There are also hollows for LCD output and paper to feed in. The weight sensor and the platform are fixed. We place a parallel capacitor inside the box and let the media to go through it. We also placed LEDs and light intensity sensors at the upper and lower side of the media to detect the penetration and reflection of light. A weight sensor is placed as the platform to measure the weight and elasticity of the media.

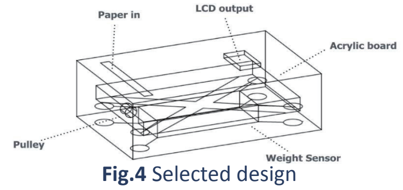


Fig.4 Selected design

Modeling and Analysis

Our design is expected to create a device that includes paper feeding system and testing mechanisms to detect both physical properties and electrical properties of printing media. We use a main controller to process the data transmitted from sensors. We perform a technique called "Sensor Fusion" to combine all these data together to get the exact type of the media based on the data stored in controller and the data sent by sensors.

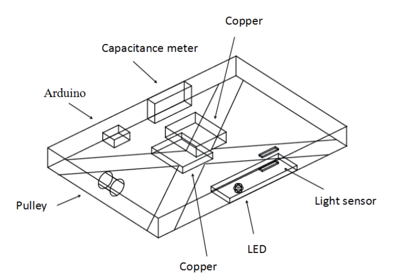


Fig. 5 Concept diagram

Validation

For the types of media supported, we can use our different types of sensor to test it in the following way. We can differentiate glossy media, transparent film, plain paper, and recycled paper using light sensor. Using elasticity sensor, we can differentiate different weights within one category of media. Capacitance sensor is used to differentiate with envelope and plastic paper. For the detection time, since our sensors have relative high sampling speed and high accuracy, the detection time should be guaranteed within 3 seconds.

Validation Results:
√ 11 types of media supported
√ Cost within 7000 RMB
√ 3s detection time
√ 2s operation time
√ 80% detection accuracy
• 5 years' lifetime
• Weight within 2.3 kg
• Size within 15000 cm3
√ means having been verified and • means to be determined.

Conclusion

The types of printing media can be determined by comparing the light, elasticity, and capacitance of the material. Sensor fusion technique is used to process the data from different sensors to provide the accurate result. The cost and size of this project should be carefully considered, too.

Acknowledgement

Sponsor: David Chen from HP
Kai Xu and Mingjian Li from UM-SJTU Joint Institute
Chengbin Ma and Yunlong Guo from UM-SJTU Joint Institute

Reference

[1]http://pic4.nipic.com/20090903/2639940_111237001973_2.jpg

Distributed Printing Service (Software Solution)

Sponsor: Chenghu Wang, ***HP***
Team Members: Xiang Li, Ji'an Zhu, Xinzhao Ma, Jiajing Luo
Instructor: Dr. Mingjian Li

Problem Statement

In many small or medium companies, HP printers are scattering in the office shared by several people. Sometimes they need to print hundreds or thousands of pages, which cause huge waiting time, for single normal printers. However, either buying a professional printer or going outside for professional printing service costs too much. Instead, HP is expected to help them fully utilizing existing printers in the office network to do large jobs together, so as to minimize the waiting time and the huge expense.

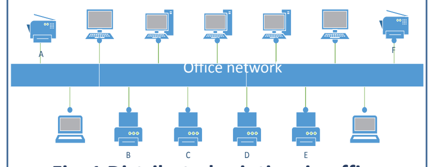


Fig. 1 Distributed printing in office network

Concept Generation

We divide the project into four sub-functions. First, the printing task is separated to parts for different selected printers. Then print job is generated for each printer, and transmitted to corresponding printers. Finally remaining printing time is estimated. For each part, we generate several concepts based on brainstorming.

Solution #3 is our selected selection.

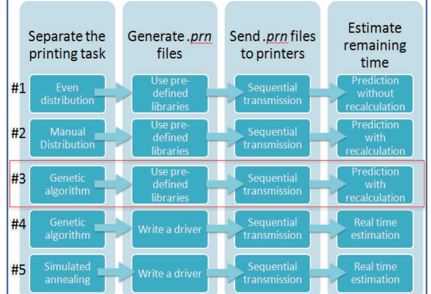
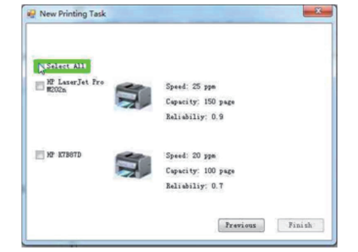


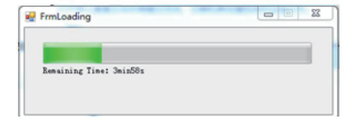
Fig. 2 Concept decomposition with selected solution

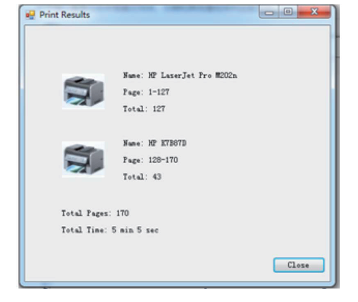
Design Description

To accomplish the distributed printing goal, six basic steps are needed to be done. First, users needed to select the file they want to print. Second, the software would gather the information about available printers in the network. Third, based on returned information, users select the printing group. Fourth, the software allocates the print job to small ones. Fifth, print jobs are sent to printers sequentially. Sixth, the software would calculate the printing time and show the remaining time to users.

For the distribution algorithm part, genetic algorithm is used [1]. For the computer-printer interaction part, several Windows APIs (EnumPrinters() and *printDocument* class) are called to read printer information and send print jobs. For UI parts, *C#* provides many programming facilities.







Validation

Experiment setting: printing 70 pages with two printers, HP LaserJet Pro M201- M202 PCL6 and HP DeskJet 1110 series. We perform three printing methods: first is the original one with single printer; second using even distribution as allocation algorithm; third using genetic allocation algorithm, as our software.

Validation Results:

For Method One, it printed as a speed of 2.4 seconds per page. For Method Two, two evenly-distributed printers took a speed of 1.5 seconds per page. For our solution, the faster printer printed 127 pages and the slower one did 43 pages, with an average speed of 1.34 seconds per page.

	Use a single printer	Two printers with even distribution	Our solution
Printer 1	150+20	85	127
Printer 2	N/A	85	43
Total time	6 min 48 s	4 min 15 s	3 min 48 s
Overall Speed	2.4 s/page	1.5 s/page	1.34 s/page
Overall Reliability	153	136	137.8

Fig.4 Comparison result

Conclusion

The Distributed Printing Service (Software Solution) provides a user-friendly software, which helps companies to deal with large print jobs using multiple printers concurrently, and significantly saves the total printing time. Moreover, the software supports multiple printers, both .doc and .pdf files, and recently-used printing-group option.

Acknowledgement

Sponsor: Chenghu Wang from HP
Instructor: Mingjian Li from UM-SJTU JI
Review Panel: Kai Xu, Chengbin Ma, and Yunlong Guo from UM-SJTU Joint Institute

Reference

[1] K. Deb, et al. "*A fast and elitist multiobjective genetic algorithm: NSGA-II.*" IEEE Transactions on Evolutionary Computation, 6.2 (2002): 182-197.

Face Detection Using Deep Convolutional Neural Networks

Sponsor: Kevin Que, ***Intel***
Team Members: Jie Zhu, Wenxin Zhang, Yichen Yao, Yue Sun, Zui Tao
Instructor: Prof. Kai Xu

Problem Statement

Face detection system is broadly used in biological verification and unmanned security system with surveillance cameras. Every years, thousands papers will be published in this field. The main challenge is improving accuracy of detecting with low delay and detecting faces in extreme environment. The purpose of our project is to detect all the faces occurred in the real-time video, including frontal, partial and prole faces.

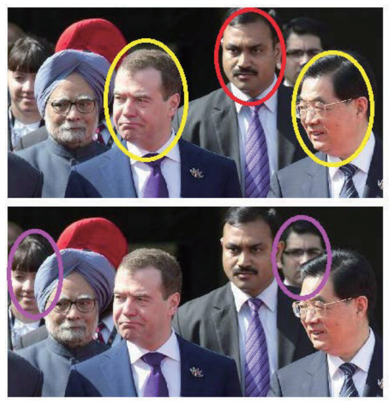


Fig.1 Face Detection[1]

Design Concept

Our project mainly contains three parts: image extraction, face positioning and face detection. Firstly, capture images from webcam by OpenCV for real-time detection with fast response time and stability. Then we use Image Pyramid and Sliding Window to locate the place where there is a face. Finally, a convolutional neural network(CNN) derived from AlexNet determines the final face location.

Implement Description

In image extraction, firstly we input real-time video by webcam connected to the computer. Then the program captures images from video. The capture rate can be changed regarding the speed of the next two parts. After capturing, the program will save images in a specific folder. In face positioning, Image Pyramid works to decrease the height and width of the image by 1.5 times each time. Since we assume the standard input video sequence is 640×480, the size of the sequences of one image is 640×480 → 427×320 → 284×213 → 189×142 → 126×94.

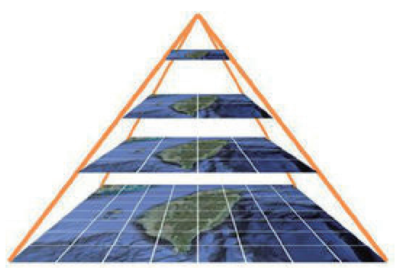


Fig.2 Image Pyramid[2]

Then we use Sliding Window to cut out the part of image surrounded by each window. The size and the location of the window containing a face in the original image can be computed. We will locate places which contains faces with next part. In face detection We build a convolutional neural network(CNN) derived from AlexNet. The system contains 3 convolutional layers, 3 pooling layers, 3 rectifiers and 2 fully connected layers. The number of layers are determined by testing. To improve its accuracy, we use 25,000 positive samples and 15,000 negative samples for training. Using the CNN mode determine whether there is a face in the rectangle window. Then we can record the location of windows which have faces and determine the size and location of the rectangles which indicate there is a face. Finally we combine rectangles with similar size and similar locations.

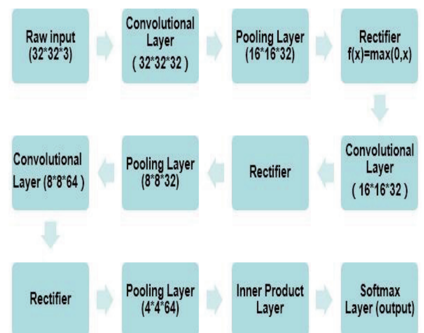


Fig.3 CNN Model

Validation

We tested our system in dormitory circumstance. The detection result was satisfactory. We can detect frontal, partial and profile faces correctly. The system also worked when there are two faces.

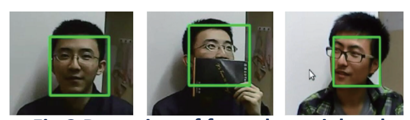


Fig.3 Detection of frontal, partial and profile face

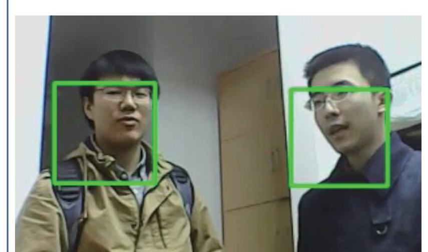


Fig.2 Detection of two faces

According to test results, we have 98% accuracy for a image, and we can deal with a 640×480 video in 80ms each image.[1]

Reference

[1]http://img0.imgtn.bdimg.com/it/u=3039187172,929904544&fm=21&gp=0.jpg
[2]http://h.hiphotos.baidu.com/baike/w%3D268/sign=56e37a0556fbb2fb342b5f14774a2043/5ab5c9ea15ce36d3da34f16839f33a87e950b1b1.jpg

Pedestrian Detection Using Deep Convolutional Neural Networks

Sponsor: Michael Fu, Evelyn Yan and Fleming Feng , ***Intel***
Team Members: Yuan Gao, Shuai Qin, Yifei Li, Chenlai Zhang, Danbing Zhu
Mentor: Kevin Que, ***Intel***
Instructor: Prof. Kai Xu

Problem Statement

Pedestrian detection is a very hot topic nowadays, which has many promising practical applications in our daily life. For example, it can be used in surveillance in video system. It can also be used in automotive industry to improve safety. Although very attractive, the performance of extant implementations of pedestrian detection is not satisfactory. Deep Convolutional Neural Networks (CNN) provides a possible solution.

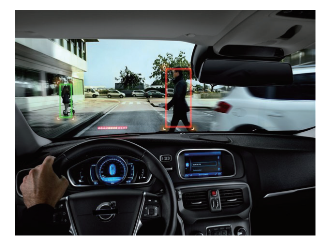


Fig. 1 Pedestrian detection used in automotive industry[1]

CNN & Sliding Window Algorithm

Neural network itself is a classical machine learning topic, and CNN is one of the most powerful training method for neural network. A basic idea of CNN is that it will first divide images into some partitions in iterations. Then it will generate a linear combination of image bases. Finally the classier layer will do classification and return result whether or not the detection is passed.

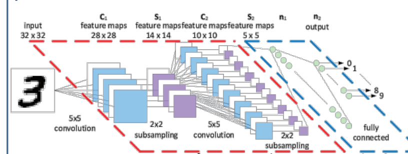


Fig. 2 A typical convolutional neural network structure[2]

CNN is just like a baby, we have to train it in order to get a good performance. We will use Caltech pedestrian detection dataset[3] to train our model.

Sliding window is an effective image processing routine that has been widely-accepted. We employ sliding window algorithm in our project to preprocess the image sequence. As shown in Fig.3, the window will scan the image with certain step width. At each step, the portion enclosed by the window will be used as the input of the CNN. Once the whole image is scanned, it will be scaled down by a certain factor and then repeat until the image can not be scaled down anymore.

Fig. 3 Sliding window algorithm

Design Description

An overview of our design is illustrated in Fig.4. Our program will take a video clip and transfer it to a sequence of images. Each image will then be scanned by the sliding window. The portion extracted by sliding window will be judged by our trained CNN model to see if it contains pedestrian. After all the images are detected, the program will transfer the labeled images back into a video clip.

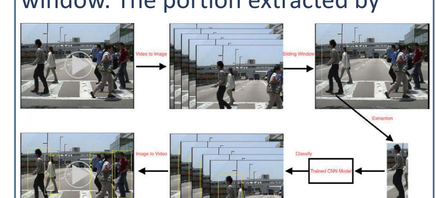


Fig. 4 Design overview

Validation

To verify the functionality of our model, we carried out many tests. Here is one of examples.

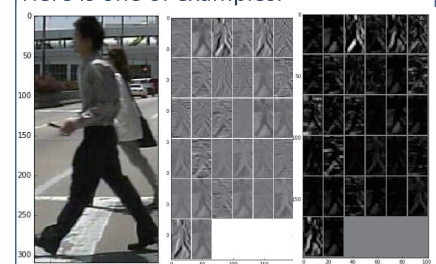


Fig. 5 Origin(left), 1st conv. layer(mid), 1st max pooling layer(right)

Fig. 6 Result

The judgment given by our model is 1 with a very high probability, which means our model is very sure that the image contains a pedestrian.

Conclusion

In this project, we build the model based on Cifar-10 and refine Caltech Pedestrian Dataset to train our model. We design advanced sliding window algorithm to label pedestrian. The accuracy demonstrates the success of our project.

Acknowledgement

Our sponsors Michael Fu, Evelyn Yan and Fleming Feng from ***Intel***
Our mentor Kevin Que from ***Intel***
Our instructor Prof. Kai Xu from ***UM-SJTU JI***

Reference

[1] http://www.eurocarnews.com
[2]http://parse.ele.tue.nl/education/cluster
[3] P. Dollár, C. Wojek, B. Schiele and P. Perona Pedestrian Detection: An Evaluation of the State of the Art PAMI, 2012

OpenCL – Based 3D Surface Reconstruction (Moving Least Squares Acceleration)

Sponsor: Intel Software Service Group and Yan Wang, ***Intel***
Team Members: Junxiong Mao, Jinmeng Li, Yixiang Ma, Han Song, Yi Wei
Instructor: Prof. Kai Xu

Problem Statement

In recent years, 3D model has become a hot topic. Intel also released its own 3D scanner, the RealSense Technology. However, the process of reconstructing surfaces of point cloud data is complex and slow. In that case, we came up with a solution to accelerate the main procedure of 3D surface reconstruction, the Moving Least Squares Algorithm, based on OpenCL framework.

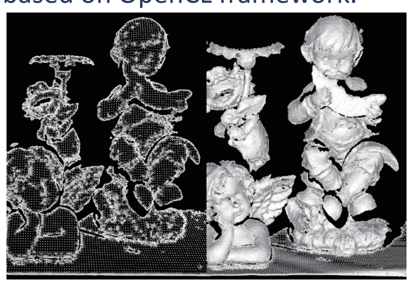


Fig. 1 (a) Original Point Cloud (b) Our 3D Surface Reconstruction Model

Concept Generation

Sub-process concepts are resampling the original point cloud data and constructing the surfaces based on resampled data. We use Moving Least Squares to perform resampling, and Greedy Projection Triangulation to construct the surfaces.

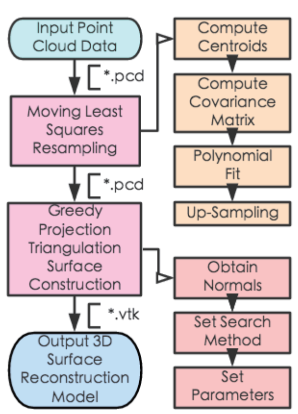


Fig. 2 Detailed structure function

Design Description

The core implementation focuses on Moving Least Squares Algorithm acceleration. To deal with huge amount of points, we utilize the parallel programming, with OpenCL. The data will pass through with one-dimensional array, and then be allocated into the work-items inside GPU, working simultaneously.

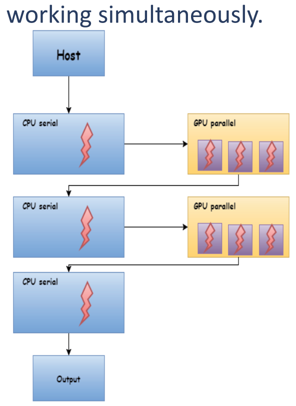


Fig.3 OpenCL Execution in Hardware Level

Analysis

The "for" loop in normal framework will be broken, working synchronously using kernels. C++ functions are useless for OpenCL. We implement each functions, including computing centroids, computing covariance matrix, polynomial fitting and up sampling. Inside each "big" functions, there are also a bunch of small functions need to be rewrote. Data types and the way of visiting data are also different from general object oriented programming.

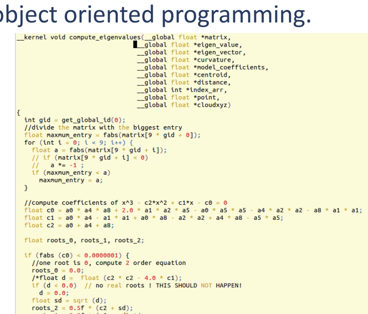


Fig.4 Example of Kernel Implementation

Validation

Validation Process:

We will run test cases to meet the engineering specifications. The test cases include the runtime comparison between our program and the original serial implementation of Point Cloud Library. We run Googletest to check if the results we produce are equal to the pre-stored model answers. Point Cloud Data with large amount of points will also be applied.

Validation Results:

According to validation part, most specifications can be met.

- Moving Least Squares Time Consuming <= 70% serial
- Coordinate Tolerance with Googletest < 0.001 unit
- Consecutive Working Time > 5 h
- Input Data Size < 500,000 points
- ✓ Memory Usage < 1,024 MB
- ✓ GPU Compatibility = Intel GPU
- ✓ Cost < 1,500 RMB

√ means having been verified and · means to be determined.

Conclusion

It is the first time, for all of us to get in touch with the field of 3D image processing, especially the OpenCL framework, and we implement the Moving Least Squares Algorithm using OpenCL all by ourselves. Apparently, parallelism is a faster way to handle huge amount of data than serialism.

Acknowledgement

Yan Wang and Xiuli Pan from Intel Software Service Group from Intel Kai Xu, Chengbin Ma, Yunlong Guo and Mingjian Li from UM-SJTU Joint Institute

Reference

Alexa, Marc, et al. "Computing and rendering point set surfaces." Visualization and Computer Graphics, IEEE Transactions on 9.1 (2003): 3-15.

ActiveFitConference – Fitness (iWatch App)

Sponsor: Welly Feng, ***Logic Solutions***
Team Members: Yujiang Duan, Xinli Jia, Zihao Liu, Chengkai Xu, Ti Zhou
Instructor: Prof. Chengbin Ma

Problem Statement

Most full-time workers are required to sit all day. Therefore they have little time to do exercise. And the lack of exercise leads to some health problems such as overweight.
Most of them want to do exercise and long for an appropriate way to do exercise while not affect their working efficiency.

Fig. 1 A man with overweight healthy problem[1]

Concept Generation

We basically convert the concept to two parts: to help organize workers' conferences' time and to encourage the workers to exercise during the conference. A further approach is to design an App for iOS which is widely used among white-collar workers. This App also contains a branch App for Apple Watch. The Apple Watch App will help the worker organize their plan more efficiently and conveniently.

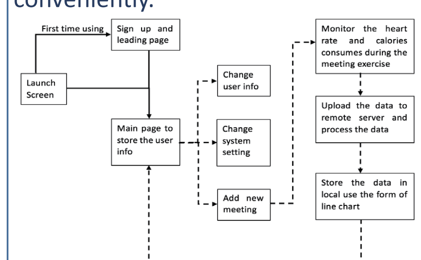


Fig. 2 Detailed flow function

Design Description

The design includes the App for IPhone iOS, an auxiliary Apple Watch App to serve part of the function by Apple Watch and a with all the data uploaded by users and developers.
The iOS App dealing with most of the information. It helps the users set their fundamental data and their need for the exercise methods and conference time scheduling. The users can also upload their evaluation for the exercise or conference efficiency.
The Apple Watch App is sub-App based on the iOS App. It provides the user with more convenience and efficiency.
The server serves as a prediction method to help users improve their exercise efficiency.

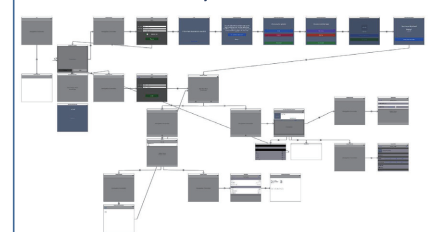


Fig. 3 The storyboard of iPhone App

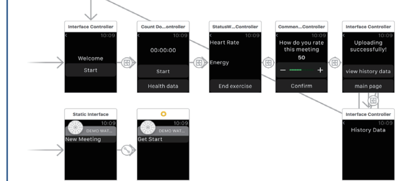


Fig. 4 The Storyboard of iWatch App

Implementation and Building

We build both iPhone App and iWatch App in real iPhone and iWatch with bundle identifier: com.team12, com.team12watch- kitapp, and com.team12watchkit-appextensionapp. The UDID of the iPhone is 135B95A4E4C66A7-2B9D1E879BE812715063710C4 and the UDID of iWatch is 39951-ca56a590afc2df651fc8c57bdb9adc29fc8.

Validation

Validation Process: Install and uninstall the App in different system environment. Check the language and words in the App. Test the functions of the buttons and basic function of the App and consider different situations when using the App. Test the interference of the App. Check the user-interface of App. The UI should allow the users use the App without any problem

Validation Results:

According to validation part, most specifications can be met.

- ✓ The App can be installed or uninstalled for times without any problem
- ✓ All the words in the App are suitable
- ✓ Buttons and basic function work well
- ✓ Graphs and icons are complete
- ✓ No interference with most general App
- ✓ Data can be uploaded and downloaded from remote and local server

Conclusion

The App can perform well for the requirements. It can help the workers exercise while having a conference. The combination of the Apple Watch and iPhone also improve the efficiency of the App. In addition, the server can help deal with further requirements. More functions such as social network and big data collection can be explored in the future to complete the App.

Acknowledgement

Sponsor: Welly Feng, ***Logic Solutions***
Ma Chengbin and Kai Xu from UM-SJTU Joint Institute

Reference

[1]http://img1.imgtn.bdimg.com/it/u=907008421,702616860&fm=21&gp=0.jpg

ActiveFitConference-(Integration)

Sponsor: Welly Feng, ***Logic***
Team Members: Haochen Sun, Hanyang Zhou, Li Rodriguez, Patricia Espinosa
Instructor: Prof. Chengbin Ma

Problem Statement

Nowadays, many people want to stay active and fit, but only a small percentage of those can find time to do exercise. Working too long and being stuck in meetings all day is a common excuse. This project allows people stay active and healthy while working in the office. This way they will not only be fitter, but they may also have the ability to think better and come up with creative solutions and new ideas.

Fig. 1 effect picture for conference fit system [1]

Concept Generation

For conference room, users need convenient and adjustable system to improve efficiency. On the other hand, our team needs to find simple control method to keep safe and improve productivity when they are meeting.

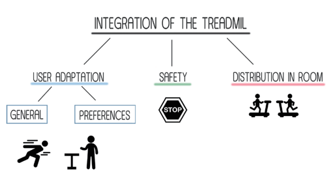


Fig. 2 Detailed generation process

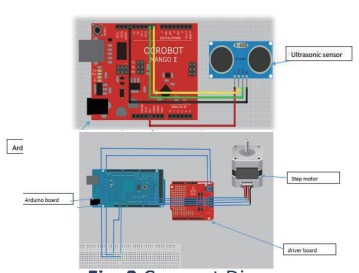


Fig. 3 Concept Diagram

Design Description

In this project, our detailed design can be divided into two main parts, electrical system and mechanical system. The electrical system have such components: ultrasonic sensor, Arduino board, driver board and step motor. For data collection system, when Arduino board get signal, our team design algorithm to translate it to distance statistics. We design other algorithm to get data for driver system from this statistics to control it. For driver system, the driver board gets signal and send signal to step motor. The step motor moves and change the height of desk.

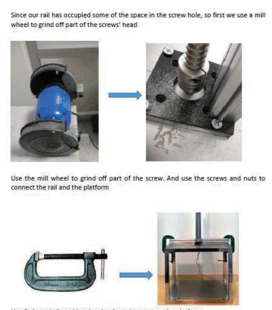


Fig.4 The whole set-up system

Modeling and Analysis

It's our 3D modeling. We use the platform, the walls on the sides and the rail. what lifts is an acrylic board base fixed to the rail. This stabilizing base will have four supports that go directly connected to the table. Apart from this, we will also use 4 metal drawer structures that will connect the platform with the acrylic base.

Fig. 5 3D modeling

Validation

Validation Process:
Most items listed in specifications are easy to verify. We just need a ruler to measure the length or distance and a scale to measure the weight. For other specifications listed, we need special test. Since we already have the final desk and treadmill, we know both fulfill the requirements. Also, we've fulfill the adaptable height range that can be easily controlled by the driver plate and motor.
Validation Results:
The total volume of treadmill and desk [1.5-3m^3]
The distance between members [1-2m]
Table area [0.3-0.5m^2]
The adaptable height range [20-60cm]
The total weight of the machine [35-50kg]
Maximum velocity of the treadmill [10km/h]
Average life expectancy [>20 years]
Sound of the step motor [<65dB]
Cost [<8000 RMB]

Conclusion

In modern society, people need more time to do exercise without broad space. Our team want to design a treadmill-desk system to meet the need of conference room better business and better health. Hence, our project has important meaning. Ultrasonic sensor can be used for detect distance and gesture control.

Acknowledgement

Sponsor: Welly Feng from Logic
Chengbin Ma, Kai Xu, Yunlong Guo and Mingjian Li from UM-SJTU Joint Institute

Reference

[1]http://www.lifespanfitness.com/workplace/treadmill-desks/tr5000-dt5-treadmill-desk

Real-Time Tip-Clearance Measurement System

Sponsor: Libing Jia, ***SIEMENS***
Team Members: Chuan Zhang, Tianyi Zhang, Hongxi Jin, Jingyi Deng, Jiadong Chen
Instructor: Dr. MingJian Li

Problem Statement

The efficiency of compressor and turbine are very important in electric power generation area. They are highly relative to the tip-clearance which is the distance between blades' tip and outer shell. The air flowing through this space only decrease the efficiency. This project is to set up a real-time tip-clearance measurement system in order to increase the turbine's efficiency.

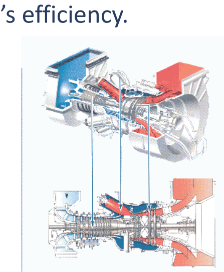


Fig. 1 Gas Turbine Structure [1]

Concept Generation

Sub-system concepts are converting the electrical energy caused by motor into kinematic energy for the blades' rotating speed. Then the tip-clearance position signal can be transfered by sensors into electrical signal. The data acquired can be used to analysis.

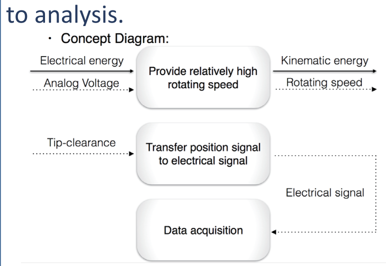


Fig. 2 Detailed structure function

Design Description

The final design is determined to be the solution group of mid speed servo motor, CVT, inductive sensor and PC. The shelf is made with aluminum section bars and the internal stucture formed in the middle can support the motor. The motor and CVT are able to sustain peak rotating speed of at least 3,600rpm. In order to work in the 450℃ enviroment of , the sensor is chosen to be the inductive sensor which has a 0.20 mm precision and a 0.50~20.00 mm range respectively and fixed in the hole of the casing. Varying dimensions small metal cubes onto the blades are used to adjust the tip-clearance. The whole set-up system are assembled as Fig.3 shown.

Fig.3 The front side (left) and the reverse side (right) of the whole set-up system

Modeling and Analysis

Using labview,the tip-clearance voltage data collected by the inductive sensor can be transformed into data in Matlab as Fig.4 shown. By dealing with these voltage data, the real-time tip-clearance measurement can be shown on the laptop screen.

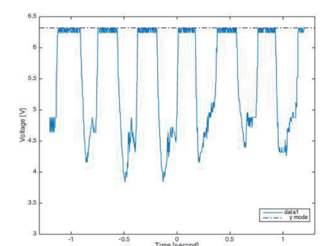


Fig.4 Skecth of voltage-time

Validation

Validation Tasks:
In calibration section, real precision and range measurement will be determined. The curve of U-TC_0 can be constructed as shown in Fig.5 TC can be calculated by Eq.1

$$TC=(U=0.228)/0.498 - t_{casing} \quad \text{(Eq.1)}$$

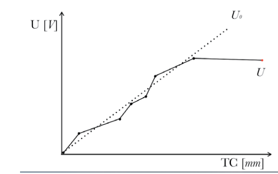


Fig.5 Sketch of U-TC

In measurement section, real-time tip-clearance with high rotating speed will be measured and the precision and range will also be calculated.
Validation Results:
According to validation part, most specifications can be met.
✓Measurement Range: 0~20 mm
✓Measurement Precision: 0.2 mm
✓Rotating Speed: 3,600 RPM
✓Thermal Stability: 450 ℃
✓Size: 580x500x580 mm^3
✓ Cost<=6000RMB
√ means having been verified and · means to be determined.

Conclusion

Realtime tip-clearance measurement is essential for increasing turbines' efficiently by controlling tip-clearance. The final design of this project is the solution group of mid-speed servo motor, CVT, inductive sensor and PC. The measurement range is expected to be 0.50~10.50 mm with precision of 0.06 mm. Actual measurement range and precision and the realtime measure value will be found according to the validation results.

Acknowledgement

Sponsor: Libing Jia from Simens
Mingjian Li, Kai Xu, Yunlong Guo and Chengbin Ma from UM-SJTU Joint Institute
Yuheng Du and Chuantang Xiong from UM-SJTU Joint Institute

Reference

[1]http://a2.att.hudong.com/07/73/01300000201800122820739237833.gif

An Autostereoscopic Display Based on Spinning Mirror System

SIEMENS

Sponsor: Xiang Yu, ***Siemens*** & Prof. Wenjie Wan, ***UM-SJTU Joint Institute***
Team Members: Manna Yang, Yinfan Chen, Liang Liu, Lisa Trinh, Guanzhong Wang
Instructor: Dr. Mingjian Li

Problem Statement

3D display is always a very hot topic. Nowadays, 3D display is becoming increasingly important in our daily life. However, most of the existing 3D display technologies rely on special glasses. These special glasses are inconvenient for those people who already wear glasses. Furthermore, wearing glasses for a long time will cause dizziness. This project aims to construct a true 3D display device without glasses, which allows multiple viewers to see the 3D display from multiple angles.

Fig. 1 Traditional 3D Display with Glasses [1]

Concept Generation

Morphological analysis is used here to generate concepts. Our device should convert mechanical energy to luminous energy and transfer 2D pictures to 3D display. To be specific, our device should first generate multi-angle pictures through digital processing. Then, our device should project pictures onto the pattern receiver. Finally, with the help of motor, our device can provide volumetric display.

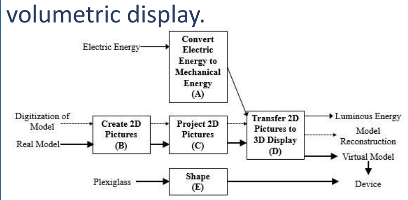


Fig. 2 Detailed Function Structure

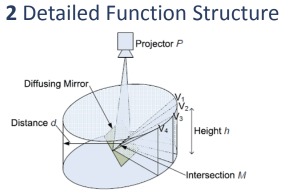


Fig. 3 Concept Diagram

Design Description

Our final prototype includes a holder, a DLP light crafter, a step motor with generator and controller, a mirror with diffuser, a power supply, a laptop and entire plexiglass box.

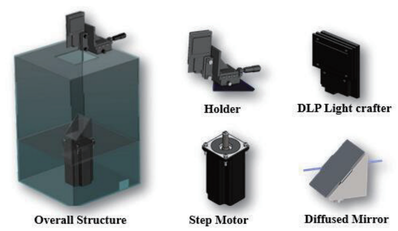


Fig.4 The Whole Set-up System

Optical part:
The projecting process relies on the spinning mirror system. We project pictures onto the spinning mirror and the rotating system will split those pictures into space domain. Then, when we watch horizontally, we can see a 3D object. We use plexiglass to reflect light. Also, in order to increase scattering, we add a piece of adhesive tape as diffuser.

Mechanical part:
The Majority of device is made of plexiglass. The bottom part controls the rotation of motor and the upper part controls the projection. Also, we add a connector between mirror and motor to increase the stability.

Algorithm part:
We first construct 3D model in UG, then we use Matlab to read 3Dmodel and convert it to multi-angle 2D pictures.

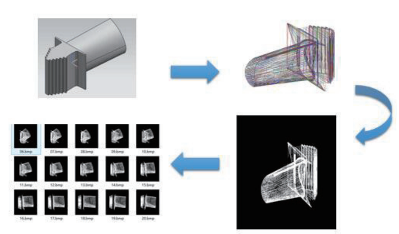


Fig.5 Encoding Algorithm

Validation

Validation Process:
We set up the equipment to test whether our engineering specifications can be met or not. We use rulers to measure dimensions and we use weighing machine to obtain weight. For resolution, we take pictures and calculate resolution under the help of Matlab.

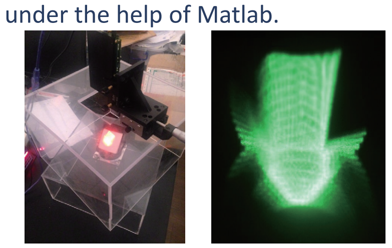


Fig.6 Validation

Validation Results:
According to validation part, most specifications can be met.

- ✓ Pattern frequency=1440Hz
- ✓ Frequency of step motor=20Hz
- ✓ Power supply<=48V*4A
- ✓ Viewing angle=360°
- ✓ Dimension=10kg
- ✓ Weight<=8kg
- ✓ Cost<=5000RMB
- • Resolution>=300*400pixels

√ means having been verified and · means to be determined.

Conclusion

Our spinning mirror system allows 360° autostereoscopic display. This kind of technology provides a brand new thought on 3D displaying.

Acknowledgement

Sponsor: Xiang Yu from Siemens and Prof. Wenjie Wan from UM-SJTU Joint Institute
Instructor: Prof. Kai Xu, Prof. Chengbin Ma, Prof. Yunlong Guo and Dr. Mingjian Li from UM-SJTU Joint Institute
Helper: Jianfan Yang and Tian Qin from UM-SJTU Joint Institute

Reference

[1]http://tech.xinmin.cn/2013/01/09/18050975.html

Emulator of Networked Energy System

JOINT INSTITUTE
交大密西根学院

Sponsor/Instructor: Prof. Chengbin Ma
Team Members: Puyu Wang, You Li, Yangyang Tang, Bei Chu, Jaime Manero

Problem Statement

Due to the limitations in energy and power densities, reliability, and cycle-life, a single energy storage device often cannot meet load requirements efficiently and continuously. A hybrid energy system, formed by combining multiple energy storage devices and generators has proved to be a feasible solution to meet the energy/power requirements.This project is to investigate the configuration and build up an emulator for the merging networked energy systems.

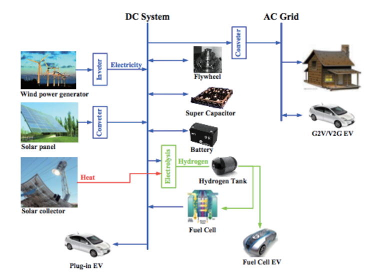


Fig. 1 An example of networked energy system[1]

Concept Generation

This project focuses on the DC part of the networked energy system. Use electric wire as the main bus and connect solar panel,wind turbine, battery, ultra-capacitor and electric loads to the main bus.

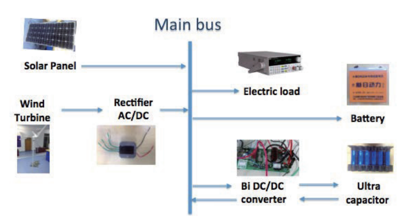


Fig. 2 Detailed Concept diagram

Design Description

The design connects the power generating devices to the DC bus directly. The batteries are also connected to the DC bus to stabilize the voltage of the bus. A buck-boost DC-DC converter is implemented to control the charging/discharging process. It is realized by controlling the duty cycle of the NMOS of the converter. High frequency components and the ripple waves on the main bus can be absorbed by the ultra-capacitor, so the charging cycle is prolonged. Also, the risk of running out of energy of the ultra-capacitors has been reduced. Carefully designed control strategy can ensure stable charging/discharging process of the batteries. Programmable electric load is used to simulate the dynamics of homes and electric vehicles. Combined all those above, this project developed a set of dispatch strategies for the system.

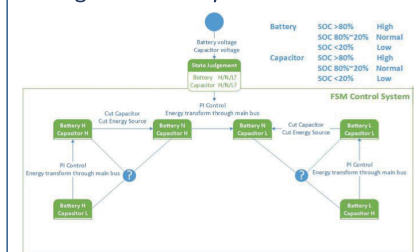


Fig.3 Control strategy[2]

Modeling and Analysis

Hall components, sampling resistors are used to monitor the currents to each devices. With the help of NI Compact Rio, the behaviors and monitor the dynamics of each devices could be emulated. The graph below show the ripples come from the inverter of the wind turbine.

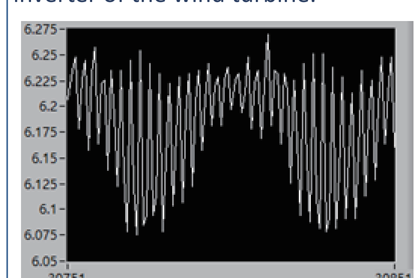


Fig.4 Voltage waveform

Validation

Validation Process:
For voltage measurement, connect the signal wire to Compact Rio and use Labview to show the fluctuation of the voltage. For current measurement, use sampling resistors and measure the voltage across the resistors to calculate the current. The value of power could be calculated by multiplying the current and voltage.

Validation Results:
According to validation part, most specifications can be met.

- ✓ Monitor the voltage & power of wind turbine,solar panel, battery, ultra-capacitor and dynamic simulation of various DC loads under various conditions

√ means having been verified and · means to be determined.

Conclusion

This project could emulate the DC part of a networked energy system under various conditions and monitor the power and voltage of each component by using Compact Rio and Labview through a computer screen.

Acknowledgement

Sponsor: Prof. Chengbin Ma from UM-SJTU Joint Institute
He Yin,Chen Zhao from UM-SJTU Joint Institute

Reference

[1] H. Yin, C. Zhao, M. Li, C. Ma: "Utility Function-Based Real-Time Control of A Battery-Ultracapacitor Hybrid Energy System", IEEE Transactions on Industrial Informatics, Vol. 11. No. 1, pp. 220-231, February 2015.
[2] Dong, B., Li, Y., & Zheng, Z. (2011). Composite converter of hybrid storage in distributed renewable energy generation system. Electrical Machines and Systems (ICEMS), 2011 International Conference on(pp.1-4). IEEE.

JOINT INSTITUTE 交大密西根学院

Monitoring and Parking Assistant System for Electric Vehicles

Sponsor/Instructor: Prof. Chengbin Ma
Team Members: Cheng Cheng, Chen Zhemin, Diego Garcia, Li Daimeng, Yang Jian

Problem Introduction

To reduce the operational burden of drivers during parking process, a variety of parking assistant systems have been developed by automotive manufacturers. In recent years, electric vehicles emerged and have taken a share of the market. Electric vehicles have different powertrain configuration from fuel driven cars, and parking assistant systems have to be developed specifically for them. The aim of this project is to develop a monitoring and parking assistant system for electric vehicles.

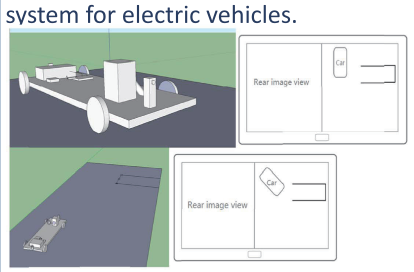


Fig. 1 Project Concept Diagram

Design Description

The whole system consists of several sub-functions. To detect the relative position of the vehicle with respect to surrounding obstacles, ultrasonic distance sensors are employed. The microcontroller, Arduino Mega could process data collected from ultrasonic sensors and camera, and send control signals to the vehicle. A DC servo motor is controlled to realize steering via mechanical structures. Acceleration or braking is also automated by electronic signals.

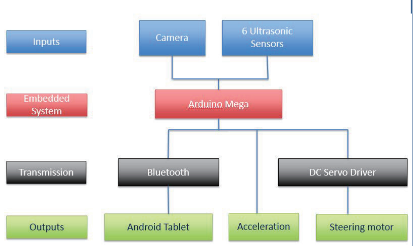


Fig. 2 Concept Diagram

Electric power steering (EPS) system is employed to assist with the steering of the vehicle. Based on information of surrounding environment, motion instructions of steering and accelerating or barking are given by signals generated by the embedded system. The whole system is based on Android OS, which is an open-source platform that can be integrated into vehicles.

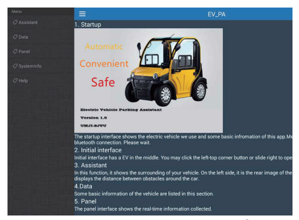


Fig. 3 Android App Interface

Sensors embedded in the car are able to collect information of the vehicle, such as current, speed, and temperature of the motor, and battery conditions, etc. These information could be displayed on an Android tablet along with rear-view image captured by a camera at the back of the car.

Modeling and Analysis

The path planning algorithm is simulated by MATLAB. Based on the input signals from ultrasonic sensors around the vehicle, the algorithm could generate a legitimate path for the parking process.

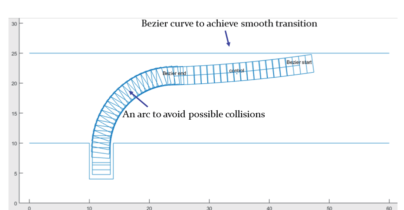


Fig. 4 MATLAB Simulation

The path consists of three parts. First, a Bézier curve is followed to achieve smooth transition to start point of the arc. The radius of the arc is properly set to avoid possible collisions with the barriers in front of the vehicle and the car next to it. Finally, the vehicle moves backwards in a straight line.

Validation

The whole mechanical structure is integrated with the electronic part. It could assist with the steering operations of the vehicle.

Our system will be implemented and validated on a commercially available electric vehicle.

All the customer requirements are fulfilled:

Parking time < 1 min
Parking speed < 5km/h
Size < 200mm*200mm*200mm
Response time < 0.5 s
Cost <= 3000RMB

Fig. 5 Dayang Chok Model [1]

Conclusion

We have developed the whole system that is able to be installed on an electric vehicle. It has realized automatic parking function. The Android App could display vehicle information on an Android tablet, and make the driver aware of the vehicle condition. The system was also tested on a real electric vehicle.

For future improvements, image processing techniques could be applied to detect available parking spaces.

Acknowledgements

Project supervisor: Professor Ma Chengbin, DSC Lab, UM-SJTU Joint Institute
TA: Mr. Xiong Chuantang, DSC Lab, UM-SJTU Joint Institute

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Wearable Assistive Exoskeleton for the Shoulder Joint Using Continuum Mechanisms

Sponsor/Instructor: Prof. Kai Xu
Team Members: Hantian Liu, Han Li, Haicang Wu, Dingyuan Shen

Problem Statement

This project focused on the shoulder joint rehabilitation for patients with stroke, paraplegia or neuromuscular defects. Through a combination of rigid links and continuum structure, it provides anatomy adaptive assistance for them to fulfill most of the normal mobility of shoulder and upper arm, including the arm's abduction or adduction, flexion or extension and corresponding scapular motions. This project is adequate for clinical use, with relatively light weight, low fabrication cost, large load capacity, and large motion range at the same time.

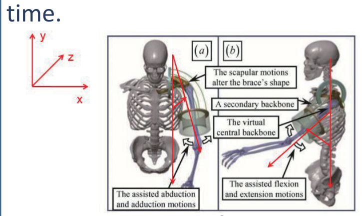


Fig. 1 Motion range for exoskeleton [1]

Concept Generation

Morphological analysis is used to develop the concepts. With the transmission of the mechanical energy, the brace guides the motion of the shoulder joints. Three sub-functions are to transmit the energy, to undertake loads and to guide the motion. By function synthesis and analysis, physical solutions are combined into some sets of concept variants. Thus the most appropriate design concepts could be further narrowed down, as shown in Figure 2.

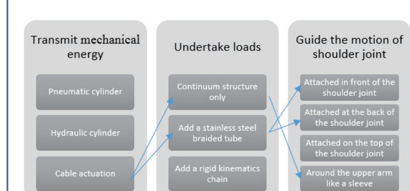


Fig. 2 Concept variants

Design Description

The exoskeleton includes a body vest, which enables different patients to put on it more easily, an actuation unit with two AC servo motors, and a continuum brace attached at the front with a rigid sleeve.

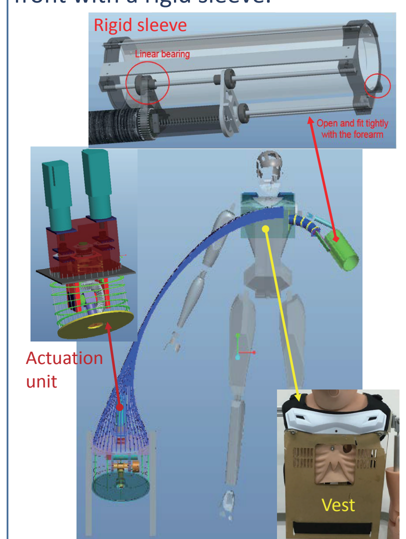


Fig.3 Final design overview

The base disk of the brace has a radius of 25 mm. 36 NiTi backbones with 1.3 mm in radius are evenly distributed around the disks. Two rigid links are made of stainless tubes and can ensure that the bending section of the NiTi backbone inside is 150 mm. Springs are used to guide the automatic linear motion of rigid links for patients with different shoulder widths, and they are fixed by hooks on the disk.

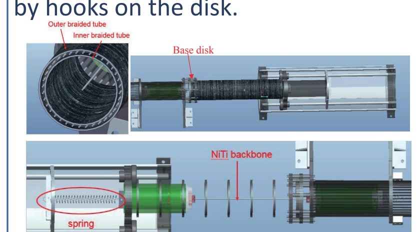


Fig.4 The CAD cross-section, overview and inside vision of the brace

The spacers inside will prevent the backbone from buckling. There are two layers of braided tubes in order to fix the position of backbones and increase the payload capacity of the brace.

Validation

A 3D force sensor is used for measurements to ensure that the total force on the joint will not exceed 20N. Additional weight is added onto the manikin arm to ensure a 4kg of payload capacity. For motion range, both Matlab simulation and testing are utilized.

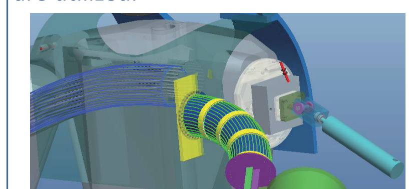


Fig.5 3D modeling for the 3D force sensor

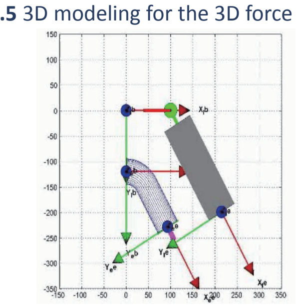


Fig.6 Matlab simulation of motion range

Conclusion

This wearable exoskeleton for the shoulder joint would be able to passively adapt to a group of patients without mechanical adjustments. In terms of mass production, it would be convenient for the target costumer such as hospitals and patients.

Acknowledgement

Sponsor & Instructor: Kai Xu from from UM-SJTU Joint Institute

Reference

[1] Xu, K., Zhao, J., Qiu, D., & Wang, Y. (2014). A Pilot Study of a Continuum Shoulder Exoskeleton for Anatomy Adaptive Assistances. Journal of Mechanisms & Robotics, 6(4), 1491-1503.

Dexterous Laparascopic Electrosurgical Tool

Sponsor/Instructor: Prof. Kai Xu
Team Members: Tianlai Dong, Yifeng Jiang, Ziyue Xia, Zhaoyun Xiong

Problem Statement

Single-Port Laparoscopic (SPL) Surgery belongs to the Minimally Invasive Surgery (MIS). Compared with traditional open approaches, it greatly reduces incision size and thus patients' pain. The operation of manual SPL tools is difficult, so robot assistance is introduced to reduce surgeons' workload and make surgeries faster and safer. In this project, it is required to design and manufacture a new surgical tool base on the SURS [1] from our sponsor.

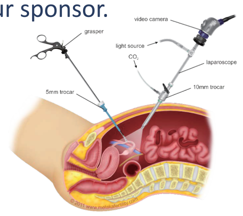


Fig. 1 Minimally Invasive Surgery [2].

Design Overview

The final design is shown in Fig.2. The DENSO system is added to achieve overall linear and rotational motion among all six DoF. Particularly, the structure of the tool is shown in Fig.3.

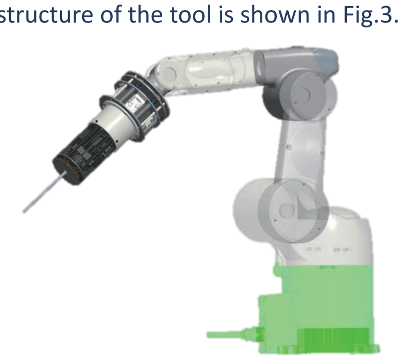


Fig. 2 Final Design.

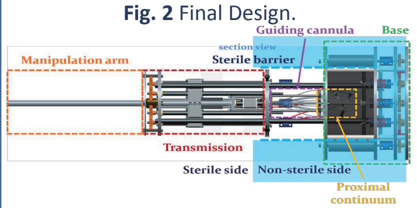


Fig. 3 Structure of the surgical tool.

Design Description

The design includes the following parts:

- **The base & sterile barrier:** Motors and electronics surround the bucket-shaped sterile barrier. Motion is transmitted through the barrier via three-segment couplers to facilitate change of surgical tools.

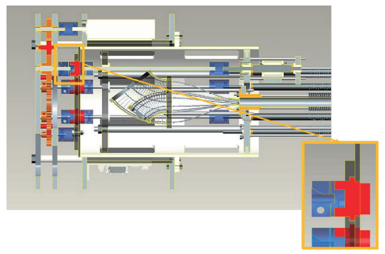


Fig. 4 Sterile barrier (white), electronics, and couplers (red).

- **The dual-continuum arm:** the bending of our flexible arm is driven by 16 Ni-Ti backbones. Bending at the proximal segments transmits motion to distal segments inside patient's abdomen.

Fig.5 The dual-continuum arm.

- **The transmission unit:** it transforms motors' rotation to linear motion by pulling/pushing backbones. Anti-buckling structures are also involved. The Spatial arrangement is optimized.

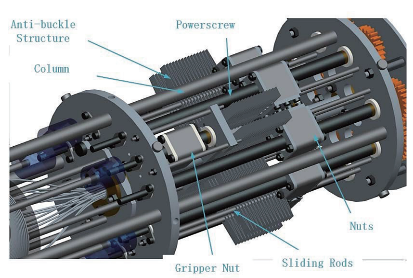


Fig.6 The transmission unit.

Modeling and Analysis

To obtain a smooth trajectory leading our surgical arm to its targeted coordinate/orientation, we need to "solve" systems of non-linear equations with iterative methods. Algorithm flow and Matlab simulation are illustrated below.

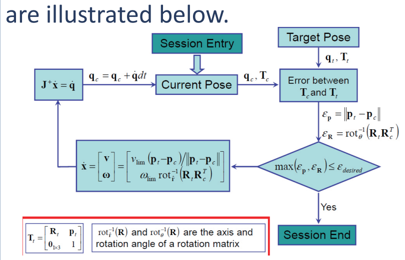


Fig. 7 The Resolved Rates Algorithm [3].

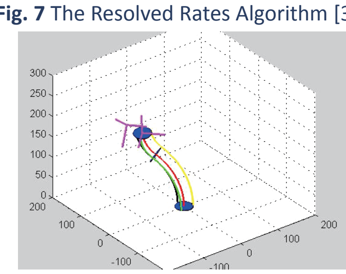


Fig. 8 Control Algorithm Simulation.

Validation

✓ Payload ≥ 5 N
✓ Workspace $\geq 100\times100\times100$ mm^3

Conclusion

A stronger, more dexterous surgical arm was designed. Modularized sterile barrier and compact spatial arrangement highlights our design.

Acknowledgement

Sponsor & faculty adviosor: Prof. Kai Xu, UM-SJTU Joint Institute;
The RII Lab, UM-SJTU Joint Institute.

Reference

[1]Kai Xu, "Development of the SJTU Unfoldable Robotic System (SURS) for Single Port Laparoscopy", IEEE Transactions on Biomedical Engineering, vol. 20, No.5, pp. 2133-2145, October 2015.
[2]http://dxline.info/img/new_ail/laparoscopic-surgery.png
[3]Kai Xu, "Motion Planning-VM567-Introduction to Robotics", UM-SJTU Joint Institute, 2014.

The Black-and-White Go Pieces Separating Machine

Team Members: Chen Yuyang, Zhao Tianyi, Wang Shihui, Yang Xiaoyu, Ma Jing
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

A formal set of go chess contains 181 black pieces and 180 white pieces. After a game, two kinds of pieces are always mixed together on the chessboard. Most go chess pieces are made of pottery in the shape of semi-elliptical spheres, so they are small and slippery. Thus, separating go pieces with bare hands can be tedious and error-prone. Players need to review a game on the chessboard instantly after playing. Improper position of go pieces may hamper the this process or disturb the players in the next game. Our project aims to design a machine that can separate the go pieces automatically, correctly and efficiently.

Figure 1. Problems of separating pieces[1]

Concept Generation

To distinguish between white and black pieces, we use a color sensor. Then a electrical air pump will work when a white piece is detected by the color sensor. As a result, white pieces will be pushed into a drawer beside the conveyor, while black pieces will drop into another drawer at the end of the conveyor.

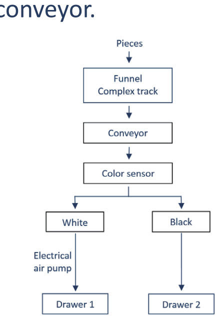


Figure 2. Concept flowchart

Design Description

Use a funnel to collect the pieces. Then the pieces will go through a complex track to make sure they will not be blocked and finally go through the exit of the track one by one. A conveyor is used to move the pieces after the track. The color sensor is fixed above the conveyor to distinguish the color of pieces. After the sensor detects what color the pieces are, an air pump is used to push the white pieces out of the track and leave the black ones on the conveyor. The different pieces will then fall into two different drawers.

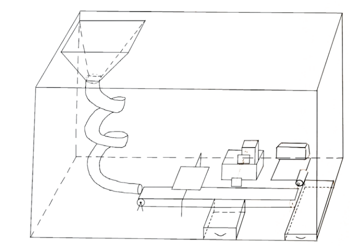


Figure 3. Concept diagram of the structure

Modeling and Analysis

A solid model is built to transport the pieces and separate them into two piles. We use Acrylic board to build the funnel and the box containing the whole system so that we can see the whole process of separating. Then we assemble all the components into the box according to their functions.
We choose to use Arduino UNO to control the whole system. In Arduino programming, RGB is used as a standard to determine a certain color provided by the color sensor. We use RGB to distinguish black and white.

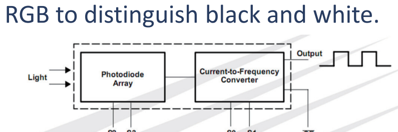


Figure 4. Functional block diagram of the color sensor[2]

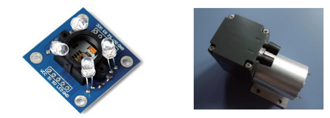


Figure 5. The color sensor and electrical air pump[3]

Validation

A set of go including 361 pieces was poured into the funnel. Pieces are not overlapping each other at the end of the track. We use a timer to record the time needed to separate all the pieces. Through tests, the system can reach a separating speed of 80 pieces per minute. In a room with no light disturbances, the percent accuracy of separating reaches 98 percent. Under sunlight and varying light condition, the system achieves 95 percent accuracy. The need of portability is met on the total weight and volume of the system.

Conclusion

We have created a simple mechanical structure to separate black-and-white go pieces automatically. Such a system can provide convenience for chess player.
Nowadays, separating and recycling are becoming more and more popular. We think our idea can be developed to separate many other different objects and can be widely applied.

Reference

[1]http://www.nipic.com/show/4/113/9418266.html
http://www.gucn.com/Service_CurioStall_Show.asp?Id=9881605
[2]http://wenku.baidu.com/view/7961e4ec71fe910ef12df87d.html
[3]http://www.baaqii.com/promanage/productimage/Ewhole/A/A1089-3.jpg

PAPERMAN
Automatic Paper-Classification Machine

Team Members: Haozhen Chen, Dingyu Wang, Yuxuan Liang, Shiyu Wu, Zhengyang Lyu
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

The problem of paper waste has long existed, but most methods, such as manual paper-classification process, have failed to solve the problem for lack of feasibility and efficiency. This project is to build an automatic paper-classification machine so that used paper can be reused so both sides can be utilized to reduce waste with high accuracy, high efficiency and relatively low cost.

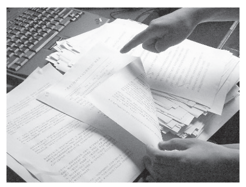


Fig. 1 Paper being used on both sides [1]

Concept Generation

The system's concept is to distinguish reusable paper from completely used paper by improved IR sensors and classify paper into three different levels of usage into four pools by motors and servos.

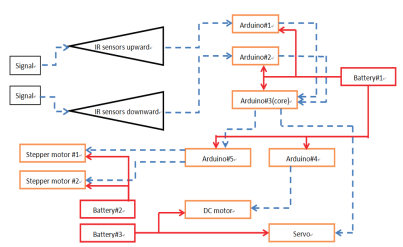


Fig. 2 working process

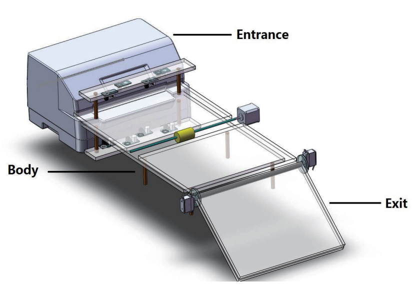


Fig. 3 Concept Diagram

Design Description

Entrance

The useless part of the original structure of a printer is cut out, such as the ink box and ink hoses, with rubber roller and gearbox remaining. A stepper motor is attached to the gearbox.

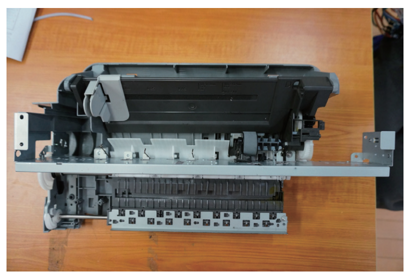


Fig.4 The Entrance

Body

It is formed by five acrylic boards. Sixteen improved IR sensors are attached to two boards to detect the paper sheets. The biggest board is the base which sustains paper sheets, and above the base are two smaller boards. There is a gap between them, and a rubber roller is attached to the gap.

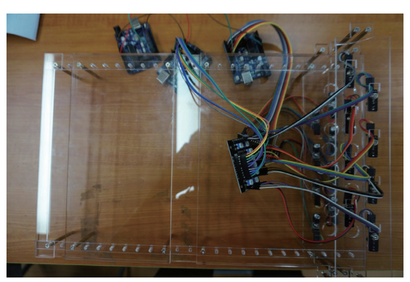


Fig. 5 The Body

Exit

It is the classification system formed by a servo and four paper pools. Servo is controlled by Arduino and has four angles to rotate to. Each angle leads to a paper pool.

Modeling and Analysis

Several diagrams of different parts' structures are drawn and the dimension is calculated. The control system is built from general to specific. Then the electrical supply system is designed.

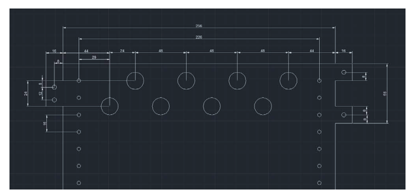


Fig.6 CAD of The Acrylic Board

Validation

Validation Process:

A convex lens and an ordinary IR sensor are combined as a set. The set was pasted over a drawer, and a piece of paper with several black lines with different width went under the sensor. Then the resolution of the sensor was measured. Then a similar validation as the primary process is run. Resolution>=15 ppi (pixels per inch)

Conclusion

The automatic paper-classification machine is easy to operate and functions properly. The total cost is relatively low. However, the accuracy, efficiency and external design of the machine need improving. To some extent, the machine helps to reuse paper and thus saves non-renewable energy resources to save our planet.

Acknowledgement

Instructor: Prof. Mian Li & Dr. Irene Wei from UM-SJTU Joint Institute.
Yukai Lin, Yuheng Liu, Yaoziye Mu, Zhijing Li from UM-SJTU Joint Institute.

Reference

[1]http://news.sina.com.cn/c/2009-06-18/074215809229s.shtml

Leg Assistance Trainer for Rehabilitation for Paralyzed People

Team Members: Jiankun Lou, Yining Ni, Yunzhen Fan, Jianshu Li, Huanian Song
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Most patients suffering from the stroke, after the medical treatment, still need 6 months and lots of effort to recover from the paralysis. The present rehabilitation equipments for patients with leg paralysis are large, heavy and inconvenient. On the other hand, the expense for professional therapists is really high. This project aims at reducing the discomfort and making it easier and simpler to train legs with the purpose of meeting the requirements of patients.

Fig. 1 Image of therapists' helping a patient to strengthen legs [1]

Concept Generation

We detect the position of the patients' legs through the readings of the ultrasonic sensors.

We provide different torques for the patients' knee joints by adjusting the output power of the motor in order to help patients bend their legs and then strengthen their leg muscles.

We use Bluetooth to control the motors' output power so that patients can adjust the device by themselves regarding to self-condition.

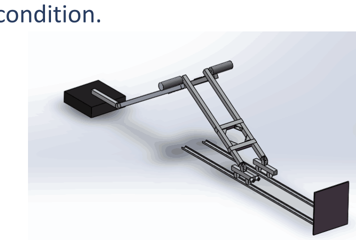


Fig.2 The whole design of the Leg Assistance Trainer

Design Description

1. We use aluminum sticks so that they are strong and light enough for patients. Also, aluminum is affordable for patients of average income.
2. We design a length-adjustable frame by changing the position of motors on the frame so that it can adapt to different patients.
3. We organize a slide which can move straightly, smoothly and freely to make the frame of legs.
4. We use ultrasonic sensors to detect the position of the patients' legs and use the Arduino board to transfer the signals to control the motors.
5. We provide appropriate torques by adjusting the output power of the motors to help the patients to move or bend their legs.
6. We use Bluetooth to control the output power of the motors for the patients' convenience of adjustment.

Modeling and Analysis

The weight of an adult male's leg is about 14 kilograms. Assume that the thigh and calf are both 7kg in weight and 45cm in length. Let Θ be the angle between the leg and the bed board. According to the formula

$$M = \frac{(m_1L_1 + m_2L_2)g\cos\theta}{4},$$

we can get the relationship between the torque needed and Θ.

Θ(°)	10	20	30	40
M(N·m)	15.51	14.80	13.64	12.07

Fig. 3 data table of torque and Θ

By analyzing the data listed above, we can get that, theoretically, the motor should provide the torque of at least 16N·m. So we choose a motor which provides the torque of 25N·m.

Validation

Validation Process:

For our device, we do following tests: We choose 4 patients with different recovery levels from Renji Hospital as samples, and test the effects after using this device and doing exercise without others' help.

Three patients who have received a 2-month recovery training and regained partial leg strength test the device under the lowest power level.

The rest who hasn't received any recovery training tests under the highest power level.

Validation Results:

Three patients under the same situation complete the action of bending legs more than 5 times. The rest completes the action twice.

The height of their knees is 30cm, which means they can complete the whole action.

According to validation part, it can be seen that our device can assist all patients with different recovery levels to move or bend legs in the process of rehabilitation.

Conclusion

Our device can help to provide part of torque needed to bend the legs.

In the next decades, the aging problem in China will become worse and worse. We believe that this project will contribute a lot to the recovery of patients. They will have the opportunity to recover from the disease and live an ordinary life like all of us.

Acknowledgement

Prof. Mian Li, Dr. Irene Wei from UM-SJTU Joint Institute

Reference

[1]http://image.baidu.com/search/detail?ct=503316480&z=undefined&tn=baiduimagedetail&ipn=d&word

Motion Sensing Wireless Gloves-like Mouse

DESTINATION

Team Members: Yangtao Zhang, Hao Guo, Yichen Zhou, Hui Xu, Yuqi Jin
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Due to the wild use of computer, meeting presenters or teachers always use power points to illustrate ideas. Though today there is laser pointer with remote control, but it can only turn pages and point specific areas while sometimes we need to click buttons to open websites or videos. This project is to combine other functions such as clicking and the existing functions.

Fig. 1 Laser Pointer with Remote Control

Concept Generation

Sub-system concepts are sensing the changes such as clicking on micro switches, the rotating on mouse wheel, and processing, transmitting the signal to the computer to control the cursor.

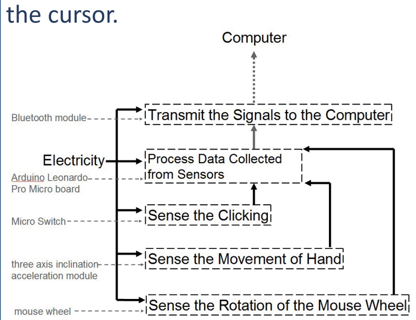


Fig. 2 Detailed Structure Function

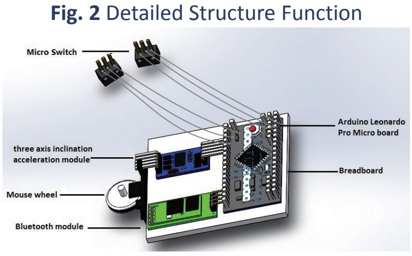


Fig. 3 Concept Diagram

Design Description

The design uses micro switches to sense the clicking, a three axis inclination acceleration module to sense the movement of the hand and one mouse wheel to sense the rotation. The data were input to an Arduino Leonardo Pro Micro board by electrical current and use Arduino programming software to program the progress to process these data. After that, the information will be output to the Bluetooth module and transmitted to the computer wirelessly. Then, by moving or clicking the items on the hand, we can successfully control the cursor on the computer screen.

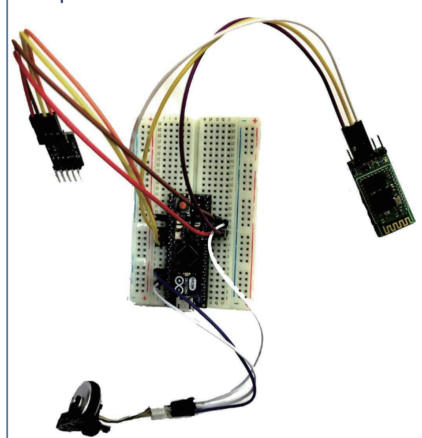


Fig.4 The Whole Set-up System

Challenge

The components we use in the product have special functions in the programming software which are not familiar with us. Meanwhile, because we bought them in Taobao, their qualities couldn't be guaranteed, and we have a lot of problems debugging them. Moreover, the most difficult task is to properly sense the movement of the hand, neither too sensitively nor too slowly.

Validation

Validation Process:

For information transmission rate,the software Mouse Rate Checker can be used. The average moving rate, the mean value of all the rates measured when the mouse moves, can be shown by the software. The higher the value is, the faster the mouse transmits information.

For stability, the software Mouse Rate can also be used. The moving rates' difference to each other shows the mouse's stability. The smaller the difference is, the more stable the mouse is.

For Dots Per Inch, the software and a ruler can be used to measure the distance of the cursor's movement on the screen and the distance of user's hand's movement.

Other validations can also be verified by taking simple measurements.

Validation Results:

According to validation part, most specifications can be met.

✓Information Transmission Rate>=125HZ
✓Volume<=20cm*15cm*5cm
✓Weight<=300g
✓ Cost<=200RMB
•Dots Per Inch>=800dpi

√ means having been verified and · means to be determined.

Conclusion

The Arduino Leonardo Pro Micro Board can be used to apply the motor sensing technology, and the Bluetooth module is used to transmit information wirelessly. Also, the stability and DPI are important factors weighing the performance of our mouse.

Reference

[1] Blum, Jeremy. Exploring Arduino. Indianapolis: John Wiley & Sons, 2013. Print.

Automatic Road Condition Detector

Team Members: Jiazhen Ji, Yuying Li, Hao Wu, Songyuan Guan, Chapwit Na Muangtoun
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

When people drive on the road, the biggest thing they are concerned with is safety. An uneven road is very likely to do damage to vehicles and cause many traffic accidents. In order to improve this situation, too many resources are devoted to fix the uneven road each year and much waste has been caused during this process

Therefore, there exist two problems in daily life now:

Uneven roads cause too many traffic accidents.

Too many resources are devoted to road maintaining and too much unnecessary waste is caused.

Need

So what we need are:

A low-cost measuring device that is efficient to operate.

A portable and delicate integrated system that is easy to be attached to cars.

An APP installed to the phone to receive instant statistics and send them to the terminal of relevant departments.

Design Description

Several sensors and equipment are used to measure and transmit instant statistics to the administration terminal. The main parts are triaxial acceleration sensor, the Bluetooth module, and GPS.A triaxial acceleration sensor is a device that measures acceleration. When a sudden acceleration change happens, the triaxial acceleration sensor starts to work. When a vehicle is on a rough track, we can obtain data from the sensors and calculate the specific data of the concavity of the pavement.

Additionally, relating it with the GPS enables us to know exactly where there exists a hole or pavement imperfection. GPS stands for Global Positioning System which can use ancillary positioning satellites to orientate and timing. We use it to locate where the car is and when a sudden acceleration change, then we read according data received in cellphone via Bluetooth. The Bluetooth module in the system is to establish a connection between our designed system and the phone. When a sudden acceleration change happens, the Arduino board can send the degree of depression and location of the parameters to the phone. Then the phone can immediately receive and transmit it to relevant administration departments.

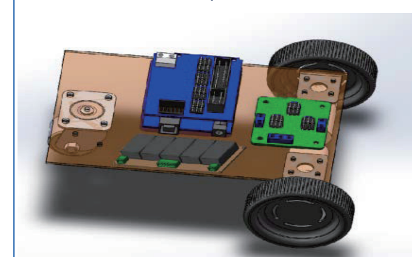


Fig.1 3D plot of the whole system

Modeling and Analysis

The data from triaxial acceleration sensor is transmitted by the Bluetooth onto a mobile application we have created. The data is then transformed into a graph that displays the x-axis that shows the length and the z-axis that shows the height of the road.

Validation

Our system is constructed onto a car which is run by Arduino. For testing, the car is set on a straight motion along a bumpy ground. Each bump on the ground is measured in size. For validation, the data that appears on the application must be relative in terms of the sizes of the bumps.

Below is a list of tasks that our project accomplishes:

The product is in a compact and efficient size

The triaxial acceleration sensor is able to communicate with the Bluetooth

The Bluetooth connection is able to correctly send data to our mobile application

The data of the unevenness of the road is correct in terms of relative magnitude

Conclusion

Our group was able to successfully create a automatic pavement condition detector with the use of traxial acceleration sensor and Bluetooth sensor. The size of the product is perfectly compatible with installing it on a car. The mobile application makes the product very simple and convenient. If installed on many cars on the street, the result gathered would be sufficient for relevant departments to fix parts of the road.

Acknowledgement

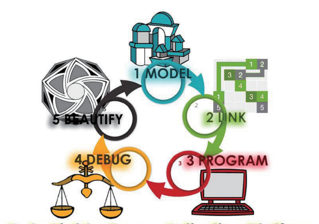
Prof. Mian Li, from UM-SJTU Joint Institute
Dr. Irene Wei, from UM-SJTU Joint Institute

Auto Light-Area Adjusting Platform

Team Members: Sifan Jiang,Shangquan Sun, Yan Zhang, Yuhao Chen, Zhifan Ma
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

When someone needs appropriate light for work, there are problems of energy waste, disturbance on people around, lack of enough light and inflexibility of lighting manner. This project is to provide light that can automatically change its lighted area with appropriate light.



Auto Light - Area - Adjusting Platform
Prototype Design

Concept Generation

Light sensors are converting the luminous energy caused by light which is not obstructed by books into digital signals. And an acrylic plate should be designed to simulate the table, since acrylic plate can transmit light and sensors can be fixed easily on it.

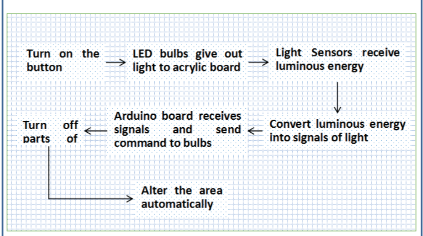


Fig. 2 Detailed structure function

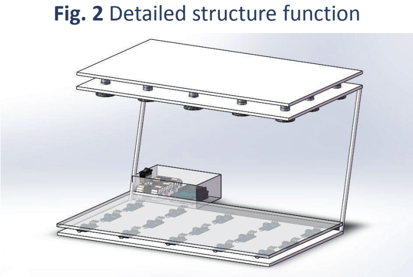


Fig. 3 Concept Diagram

Design Description

The design uses little lampshades to focus the light from the corresponding LED bulb on the distributive area of the whole platform. The transducer receives the luminous signals given out by bulbs and passing through the acrylic plate. The signals of light can be processed by the Arduino board. After processing the signals, Arduino board sends out command signals to LED bulbs and turns off parts of bulbs in order to modify the area lighted up and provide appropriate light.

Fig.4 The whole set-up system

Modeling and Analysis

To validate the eye protection function of the device, Formula. 1 and Formula. 2 are quoted.
Formula. 1 is listed:

$$\text{Luminous Flux} = \text{Luminescent Efficiency} \bullet \text{Power of LED Bulb}$$

Formula. 2 is listed:

$$\text{Intensity of illumination} = \frac{\text{Luminous Flux}}{\text{Illumination Area}}$$

Combine two formulas into Eq. 1. And intensity of illumination can be figured out, provided that power of LED and luminescent efficiency are known. Eq. 1:

$$\text{Intensity of illumination} = \frac{\text{Luminescent Efficiency} \bullet \text{Power of LED}}{\text{Illumination Area}}$$

{Eq. 1}

Validation

Validation Process:
For diameter of light area, a ruler was set along the diameter of a single light spot. If the value is greater than 6 cm, it can meet this specification. For light intensity, a book was set on the acrylic board and then run the system. If the word in the book can be comfortably read, it can meet this specification. For loading-bearing, a 5kg object was put on the acrylic board. If the board doesn't deform a lot, then run the system. And if the system work normally, it can meet this specification. Some other specifications can also be verified using easy experiments.
Validation Results:
According to validation part, most specifications can be met.

- ✓ Load-bearing>=5kg
- ✓ Diameter of light area>=6cm
- ✓ Light intensity is exact for reading
- ✓ Weight<=10kg
- ✓ Cost<=800RMB
- • Time for data processing<= 30ms

√ means having been verified and · means to be determined.

Conclusion

Auto Light-Area Adjusting Platform can detect the area of a book and then determine the area of the light. The key to achieve this goal is to use an array of lightsensors. And also, the sensitivity of sensors and the use of spotligts is very important to area adjusting.

Acknowledgement

Yukai Lin, Ziye Muyao and Yuheng Liu from UM-SJTU Joint Institute

Reference

[1] http://www.gog.com.cn/zonghe/system/2014/04/25/013438826.shtml?--xppyc.uz.taobao.com--facai.html

Smart Water-Saving Squatting Pot

Team Members: Wang Hanqin, Cheng Junkai, Huang Zanhua, Li Lewei, Dai Yifan
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

The squatting pots, or Asian toilets, are widely accepted in China. However, people find it awful to flush out the excreta without enough water pressure. This project aims at flushing it out in the most efficient way and thus achieving our goal of saving water and energy. Also, compared with the traditional ones, the less time for flushing eliminates the audience's awful feelings.

Fig. 1 Solutions Before

Concept Generation

The Smart Water-Saving Squatting Pot System consists of two essential systems: Information Gathering System (IGS) and Information Addressing System (IAS).
IGS is mainly made up of a camera module. It can gather the basic shape and positional information of excreta. After that, the information will be converted to digital signals and then be received and addressed by IAS, which is mainly composed by a Raspberry Pi 2B. After data analysis, the system will properly control the water flows.

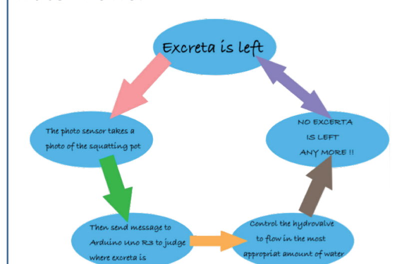


Fig.2 Flow Diagram

Modeling and Analysis

The main idea of this project is to make use of Bernoulli's Principle, which is:

$$P + \frac{1}{2}\rho v^2 + \rho g h = C$$

According to this equation, the pressure of the fluid (P) increases as the speed of it (v) decreases and vice versa.

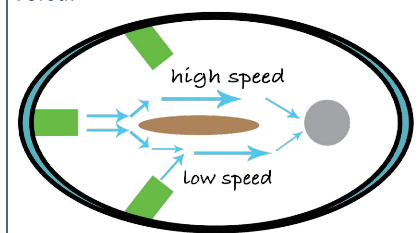


Fig.3 Schematic Diagram

If excreta is left as Fig.3, which is the most frequently confronted situation, we open one side hydro-valve, thus making one side flow much slower than the other side. According to Bernoulli's Principle, such flows result in different pressures. Thus it gives a force, pointing to the high speed side, to the excreta. Such force can make excreta slip towards the high speed side, changing the friction force of the excreta from static friction force to kinetic friction force. As kinetic friction force is always relatively smaller than static friction force in magnitude, it is much easier to flush out the excreta.

Design Description

In this project, we basically need three hydro-valves, one Raspberry Pi 2B, one camera module, one model toilet , driving boards and DuPont lines. First, we use DuPont lines and USB lines to connect hydro-valves and camera modules with Raspberry Pi 2B, to which programming has already been uploaded. Second, the camera module takes a photo of the excreta, transfers it to digital signals and then send it to Raspberry Pi 2B. Then Raspberry Pi 2B addresses the digital signals to get the information of excreta's location and shape. According to the method illustrated in 'Modeling and Analysis', Raspberry Pi 2B controls the water flows using hydro-valves. After the excreta is flushed, Raspberry Pi 2B will close the hydro-valves.

Fig.4 Components

Validation

Validation Process:
When a process of flushing the toilet is finished, how much water it used can be measured. Then compare it with using a traditional method of flushing the toilet, we can judge whether our project succeeds or not.
Validation Results:

- ✓ None excreta is left in the pot.
- ✓ Water is saved by up to 15%.

More accurate data is to be measured.

Conclusion

Smart Water-Saving Squatting Pots can be used to save more water and energy. The key to achieve this goal is to make use of Bernoulli's Principle and to perfect the program used in camera modules.

Acknowledgement

Instructor: Prof. Mian Li, Dr. Irene Wei

Reference

[1]http://www.zhihu.com/question/28641163

Intelligent Suitcase

Team Members: Zhixian Ma, Chenxin Zhou, Yunguo Cai, Romijn Enninful, Tongan Cai
Faculty Advisor: Prof. Mian Li, Prof. Irene Wei
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

We always go on a flight trip with a drawbar suitcase box, but before departure, we have to check the weight of the box. This is a tedious and troublesome job. Other perplexing problems, like the zipper design box, can be really difficult to close. It always gets stuck or worse, broken. On your trip, if your mobile phone is running out of battery, and your power bank was inside your suitcase, it is very tedious to empty out the contents of the suitcase just to get that power bank out and the consequence of messing up your clothes comes with this tedious action.

Fig. 1 Troublesome Traditional drawbar box [1]

Concept Generation

The intelligent suitcase is composed of the security part, the controlling part and the other-function part. The main components of the intelligent suitcase include electromagnetic locks, fingerprint identification module, mass sensors, portable power source, the controlling single chip and two motors. The process is shown in Fig.2

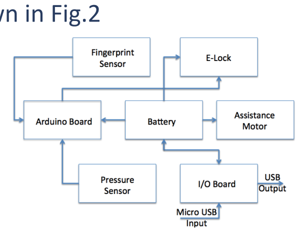


Fig. 2 Process Diagram

Design Description

The fingerprint system can detect a matching finger and send signals to the control board, which will let the relay release current instantly to unlock the suitcase. The assistance system will let motors rotate when it's power on. The weighing system can measure the suttle by the pressure sensors inside the box and add it to the initial weight of the suitcase. The result will be shown on a LCD screen. The charging system connects an input-output control board with batteries, which enables an output USB port and an input micro-USB. Batteries placed inside the suitcase can provide power for electronic locks, motors and Arduino board. They also serve as a charge pal for other electrical components.

Fig. 3 Prototype

Modeling and Analysis

In the analysis of fingerprints, an open source system is used to analyze the validity of a fingerprint. The basic processing system is shown in Fig.4

Fig. 4 Fingerprint Analysis

Validation

Validation Process:

For fingerprint identification module, 5 distinguishable kinds of fingerprints were set up as initial data, and the experimental frequency was over 50 times. A timer was used to measure the unlocking response time.

For loading bearing, several 2kg lead bricks were added to the intelligent suitcase, and the experimental frequency was also over 50 times to determine the weighing accumulative error.

Some other specifications could also be verified by simple experiments.

Validation Results:

According to validation part, most specifications can be met.

- ✓ Unlocking success rate>=98%
- ✓ Unlocking response time<=0.8s
- ✓ Load bearing<=20kg
- ✓ Standby power<=1w
- ✓ Output current<=2.1A
- ✓ Motor speed<=350rpm
- • Weighing accumulative error<=5%

√ means having been verified and · means to be determined.

Conclusion

"Intelligent Suitcase" is a promising traveling companion with multiple functions. It caters to the exact needs of travelers for intelligence and combinatorial optimization rather than material and external issues. The addition of a carrying assistance is aimed at being optimized so that the suitcase can be more intelligent as it is coupled with fingerprint scanning, weighing and acting as a charging system to bring more convenience to people.

Reference

[1]http://www.meiermeichina.com/xinwenzhongxin/190/

Auxiliary Door Controller

Team Members: Jiecheng Shi, Duli She, Yangzhen Zhang, Zijian Sui, Pengbo He
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Opening and closing a door repeatedly in some public places such as offices, classrooms and dormitories is troublesome and forgettable sometimes. Although some kinds of doors like swing doors have been made to work out the problem, the high cost and the complexity of replacing an ordinary door are still unsolved. What's more, they may occasionally clamp people's fingers.

This project is to create a mechatronic equipment that can be attached to ordinary doors to control the doors, which can also be safer, cheaper and more user-friendly than existing ones.

Fig. 1 The picture of a swing door [1]

Concept Generation

Controller concepts are converting m echatronics charged by Human–Machine Interaction. Namely, through collecting data by sensors together w ith acquiring users' request by switch, Human—Machine Interaction summarizes, processes and feedbacks information to mechatronics platfor m, which in final achieves controlling i ntelligent and convenient.

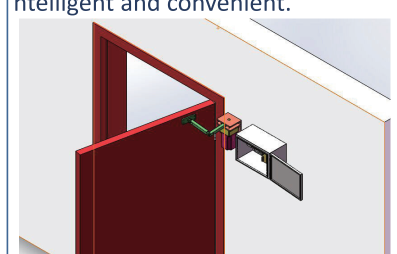


Fig. 2 3D image of the door

Design Description

The design has two main parts: mechanical drive system and electrical control system.

In the mechanical drive system, sensors detect whether there are people at the door and whether people's fingers might be clamped by the door. A stepping motor actuates the spindle by driving the pushrod, making the door reset to a certain angle.

In the electrical control system, an Arduino Board receives information from these sensors and in respond control the motor by a program. The program controls the reset angle and when to reset the door.

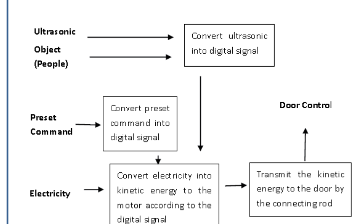


Fig. 3 Detailed structure function

Modeling and Analysis

In order to prevent the door from clamping people's fingers, an analysis about the height of people's fingers should be made so that most cases can be covered in only two ultrasonic sensors. The following graph shows the statistics in the analysis.

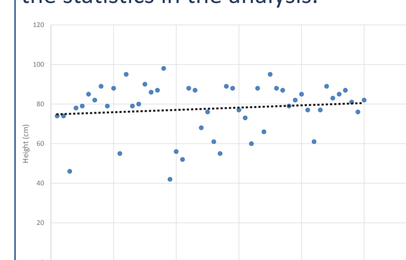


Fig. 4 Height Distribution of People's Fingers

Validation

Validation Process:

To verify the mass of the door our product can handle, we can easily weigh the door plank we use by an electronic scale.

For whether the angle that the door was opened to is up to users' preset, we can measure it by a protractor.

To measure whether the duration before the door is reset is up to users' preset, a timer can be used.

To test its safety, we can keep walking through the door to see whether it may clamp us or our fingers.

Some other specifications can also be verified using easy experiments.

Validation Results:

According to validation part, most specifications can be met.

The error of the angle the door is opened to<=1'.

The error of how long it will be before the door is reset<=1".

The mass of the door that our device can handle<=50kg.

Cost<=100yuan.

Safety: safe and sound.

Conclusion

The equipment can be easily adhered to a door to control it according to th e owner's commands. And the additio nal requirements are also met that pe ople who follow the first person need n't bother to open the door again as well as prevent their fingers from bein g clamped. The key to achieve this go al is to set up the mechanical drive sys tem and electronic control system.

Acknowledgement

Sponsor: Mian Li and Irene Wei from UM-SJTU Joint Institute
Yukai Lin, Yaoziye Mu, Yuheng Liu and Zhijing Li from UM-SJTU Joint Institute

Reference

http://detail.net114.com/chanpin/1026775630.html

Bike Turning Assistant System

Team Members: Yipeng Chen, Kaiwei Tu, Xuanyu Wang, Jeremy Putra Wijanto, Jing Cao
Faculty Advisor: Dr. Irene Wei **Instructor:** Prof. Mian Li

Problem Statement

The deficiency of bicycle safety has become a serious problem. With high death rate and injury, the potential danger of bicycle is increasing as more people choosing bicycle as a traffic transport. Many bicycle accidents occur because of being unaware of other bicycle's turning. Meanwhile, most bicycles lack an effective turning system which is practical and useful. This project aimed at providing bicycle riders with a turning system which is both accurate and portable.

Fig. 1 Photograph of a bicycle accident scene

Concept Generation

Bike assistant will have a Bluetooth controller placed on the steer of the bike. Sensors, generator, and lights will be connected to this controller. Then the controller will send signal to the turning displayer. Depending on the different signal, it will light differently. When the bike turns left (or right), the screen will show a arrow pointing to left (or right.) When the bike brakes, the screen will show all red to alert the riders behind.

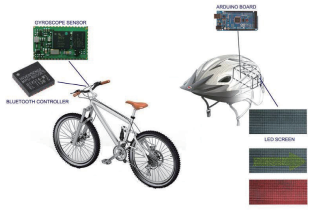


Fig. 2 Concept Diagram

Design Description

The project uses the Gyroscope sensor on the steer to monitor the turning of the bicycle. It then will send a signal about the turning from the Bluetooth controller to the Arduino board. The Arduino board will then control the LED screen on the tail light based on the different signals it received to show different signs. The electricity will be provided by a device on the rear wheel which can transfer the energy generates from the rolling of the wheels into electricity. The device makes use of the electromagnetic induction theory which will produce induced current when the magnetic flux changes in the closed loop. Then a manostat will be used to store the current and then make it stable in voltage, so that it can supply energy to the LED screen.

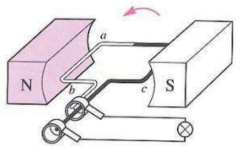


Fig. 3 Electromagnetic induction

Modeling and Analysis

A matlab model is built to give the data for the instant voltage of the generating set. It considers the consumption of energy and the rage of wheel's rotate speed. The model is also built to give the data of the gyroscope sensor, to give a feedback of the relationship between gyroscope sensor and accelerated speed.

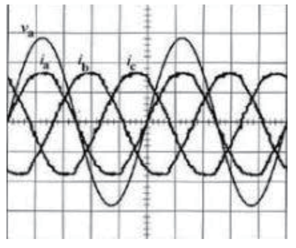


Fig. 4 Voltage tracing diagram

Validation

Validation Process:

For the blinker, we test it indoor using a bike stand. We then start cycling and pretending to turn using the bike, to see if the gyroscope works, and the bluetooth transmitter can send the signal to the blinker.

For the dynamo, we also test it indoor using a bike stand.

To check if our product is waterproof, we spray water all over it, and the device is still working perfectly.

Validation Results:

According to our test, most requirement for our project can be meet, such as:

- The blinker work well as we turn
- Both bluetooth transmitter and receiver can work without having any connection problem
- Waterproof device

Conclusion

Gyroscope sensors can be used effectively to detect the turning of the bicycle and thus the bike assistant system might be powerful. The key to achieve this goal is to make a electricity- generating system and modify the program by doing repeating experiments so as to make it sensitive enough.

Acknowledgement

Sponsor: Mian Li and Irene Wei from UM-SJTU Joint Institute
Yuheng Liu, Yukai Lin, Yaoziye Mu from UM-SJTU Joint Institute

Reference

[1]http://www.sensorwiki.org/doku.php/sensors/gyroscope
[2]http://wapbaike.baidu.com/view/1500370.htm?adapt=1&
[3]http://sm.baike.com/item/3df8a98aa7d08c75eb9c9877ea7067f6.html?from=smsc&uc_param_str=dnntnwvepffrgibijbpr

Dimengie
SJTU-UMJI-VG100

Secret Rhythm Detecting Lock

Team Members: Changxu Luo, Jinhao Zeng, Jiadi Zhang, Xinyu Zhang, Xinyi Zhang
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Nowadays, many people prefer to leave their doors open or the cabinets unlocked when they are away for a while out of convenience. However, the hidden danger can't be neglected, we need a better way to combine the security with the convenience. So the project is to use rhythm or any secret lock instead of keys to guarantee both the safety and convenience.

Fig. 1 The Insecurity and Inconvenience of the Key [1]

Concept Generation

The main concept is that the lock can record the pauses of knocking and transfer them into digital signals. And then the motors are started to unlock the doors or cabinets automatically without any keys.

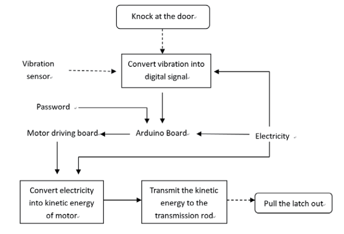


Fig. 2 Detailed structure function [2]

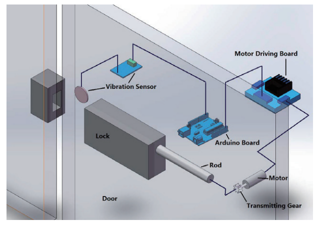


Fig. 3 Concept Diagram [3]

Design Description

The design contains a simple feedback system. A vibration sensor is attached to the doors or cabinets so that the knocking process can be recognized and recorded clearly. When knocking process takes place, the sensor will send signals to Arduino board to analyse the signals. Arduino board will recognize the correct knocking code and then send signals to motor driving board to start a motor. The motor is connected to the axle of the lock's striking plate and hence the lock is opened successfully.

Fig.4 The whole set-up system [4]

Modeling and Analysis

The Arduino programming is used to record the time spot for each of the knock. This process depends on the vibration sensor's function of transforming the vibration signal into the digital signal. Then the Arduino board can analyze the transformed digital data and do some reaction.

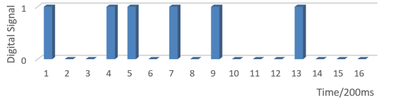


Fig. 5 Digital Signal Diagram [5]

Validation

Validation Process:

For loading bearing, a 1N object is connected to the motor through drive gears. If the motor can operate normally and smoothly, it can meet this specification.

For data acquisition, the sensibility of the sensor should be properly. The sensor will be attached to a door. If the sensor only react to the knock, not the other disturbance, it can meet this specification.

For programming, the time span should be set properly. If the equipment can clearly record and identify the rhythm, it can meet this specification.

Some other specifications can be verified using easy experiments

Validation Results:

According to the validation part, most specifications can be met.

Transducer frequency >= 100Hz

· Weight <= 200g

· Proper sensibility

· Motor moment >= 2kg·cm

· Cost <= 500yuan

Conclusion

The rhythm of locking at the door can be a special kind of "key" to open the door. And the rhythm can be changed to any passwords or even Morse codes. The key to achieving this goal is to apply mechanical and electrical integration to our system. On the other hand, the accuracy and simplification are also essential.

Acknowledgement

Lin Yukai, Liu Yuheng and Mu yaoziye from UM-SJTU Joint Institute
Instructor: Prof. Mian Li

Reference

[1] http://www.arduino.cn/

Smart Nursing Bottle

Team Members: Fernando Boaro, Su Wenhao, Hua Yang, Zhou Qixuan, Li Yuanjue
Instructor: Prof. Mian Li , Dr. Irene Wei

OVERLOAD

Problem Statement

Nowadays, parents find the task of taking care of their babies to be increasingly difficult. It seems easy, but there are many possible problems. Babies may feel hungry when Parents are going crazy in order to mix the powder in the bottle, heating it up, cooling it down, which could lead to their carelessness; as a consequence, the baby could get hurt. To solve the problem, our project is to create a multi functional nursing bottle by using a security system and a temperature control system.

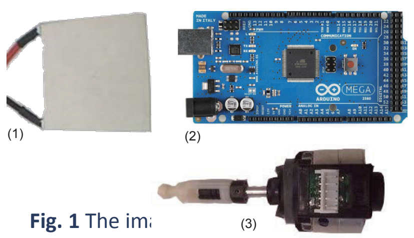


Fig. 1 The im... cooling/heating plate(1), the arduino mega(2) and the piston servo(3)[1]

Concept Generation

The smart nursing bottle is composed of three main sections: temperature system, safety locking mechanism and a stirring system. The Temperature system connects the semiconductor cooling/heating plate with the digital screen. The arduino board works as a main control system to translate analog signals into processible information. The digital screen shows the temperature of the liquid. The arduino board uses this information to decide whether the cooling or heating plates will be turned on. The safety locking mechanism also uses this information to decide whether to stay locked or to release the bottle. In addition, the stirring system eases parents' lives by mixing the milk or powder and water.

Design Description

When the bottle is inserted into the system, the magnet located at the bottom of the milk bottle will start to spin due to the attraction force with the motor's magnet. Thus realize the function of stirring.

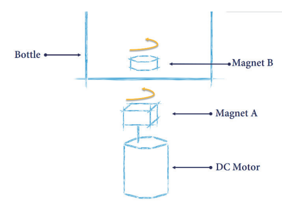


Fig. 2 Stirring System

Then, the screen and the LED indicator lights located on the outer shell of the system will receive the data sent by the Arduino board. The screen will show the temperature of the milk in degrees centigrade while the small lights will turn on or off depending on this data. The red LED indicator light will reamain on if the temperature is higher than the recommended 37℃ and the green LED will turn on when that temperature is reached.

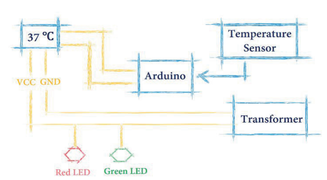


Fig. 3 Temperature Controlling and Indication System

The main component of the safety system is a piston servo. Which is located on the lid of the outer shell, and expands in order to lock the bottle inside. If the red LED is on, the servo expands it's piston into the bottles neck, thus locking the milk bottle.

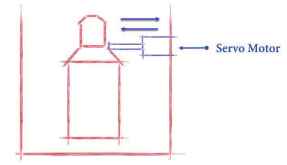


Fig. 4 Servo piston safety locking mechanism

Modeling and Analysis

To determine the shape, we form the SW picture as follows.

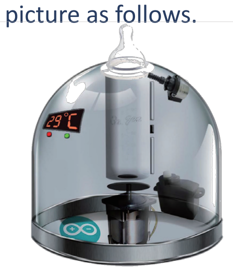


Fig. 5 Image of the 3D SN bottle

Validation

The magnet mounted on the motor spins fast and efficiently mixes the milk powder in the water.

The temperature shown on the screen is sensitive due to the temperature sensors fast response. Despite a little inaccuracy in the readings, it's fast response time allows for an increase cooling/heating process.

The main safety module works well with one servo.

Conclusion

The smart nursing bottle serves as a multifunctional product that can be used by all families. The system can prepare a 37℃ bottle in less time, being it heated up or cooled down to said temperature. If the smart nursing bottle can be put into the market, then there will be no more troubles with carelessness.

Acknowledgement

Prof. Mian Li , Dr. Irene Wei from UM-SJTU Joint Institue

Reference

[1]https://en.wikipedia.org/wiki/Semiconductor

JOINT INSTITUTE
交大密西根学院
VG100 • Introduction to Engineering

Self-cooling and Massage Cushion

ΛLΓΗα

Team Members: Ruowen Tu, Zhe Li, Zixuan Li, Ying Luo, Sheng Shen
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Nowadays, an increasing number of people are fond of doing physical exercise, after which they may feel quite hot and tired. However, most people find it hard to easily find fans or massagers because few of them will take these things at hand. Hence, this project aims to develop an effective way to quickly remove the annoying heat and tiredness instantly.

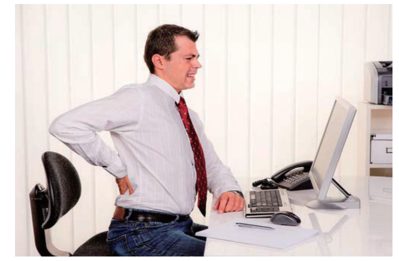


Fig.1 A man suffers from working in front of a desktop for a long time[1]

Concept Generation

The equipment consists of two parts, self-cooling system and massage system. Self-cooling system concepts convert signals from the mobile phone through bluetooth and the temperature sensor into digital signals and give orders to fans. Massage system concepts transform signals from the mobile phone through bluetooth into commands that generate mechanical motion.

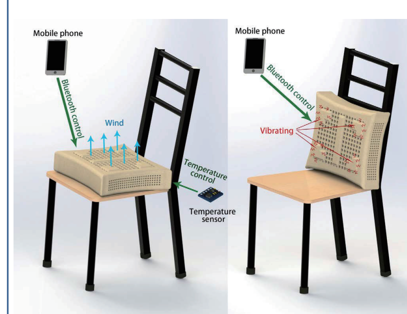


Fig.2 Concept diagram

Design Description

A light and handy modeling is used to ensure the wide application in different places. The massage is done by the vibration of mechanical devices. Sponge, the external packing material, is to make users more comfortable. Temperature sensors and pressoreceptor are utilized so that the equipment will work when the pressoreceptor receive pressure and the environment temperature is high enough. Also, users can use mobile phones to control the cushion.

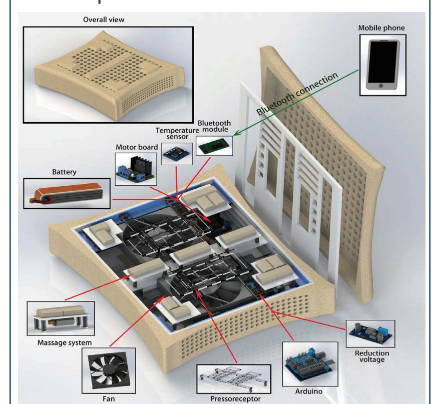


Fig.3 Equipment structure

Modeling and Analysis

CAD drawing is used to determine the 2D fundamental structure of the equipment. Solidworks 3D drawing is used to check and analyze the mechanical strength and improve the CAD structure. Laser cutting is used to make the complex shape of the main mechanical structure and each little part.

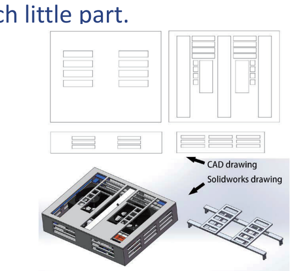


Fig.4 CAD and solidworks drawings

Validation

Validation Process:

For internal spacing, a ruler is placed between the top and the bottom board and the distance between them can be measured and modified. For loading bearing, an 80kg object is placed to test the repeatablity of the system. For noise, a decibel meter can be used to measure. Some other specifications can be measured through simple experiments.

Validation Results:

- ✓ Distance between fans and the bottom>=35mm
- ✓ Size<=370*310*110mm
- ✓ Motor's voltage<=4.5V
- ✓ Load bearing>=80kg
- ✓ Weight<=1.5kg
- ✓ Noise<=50dB
- ✓ Cost<=500RMB

Fig.5 Prototype

Conclusion

Our final product is capable to relieve tiredness and heat instantly. Additionally, it has a considerable market and prospect since nowadays people are more likely to pursue convenience and comfort in daily life. However, due to the time limit, more functions of the cushion are still waiting to be developed.

Reference

[1]http://www.17life.com/ppon/default.aspx?bid=f15f9059-0c33-466e-b3f3-54da8875f9be&rsrc=Youth_we

External Wireless Entrance Control System

ISOTOPE
Team Members: Yang Yichen, Liu Yuzhang, Hu Yichen, Jia Yueyang, Chen Yichen
Instructor : Prof. Mian Li, Dr. Irene Wei

Problem Statement

There are some embarrassing situations where people, especially students, forget their keys and cannot enter the room or they have to let their friends wait outside since they are not in the room. To solve this problem, Kwikset Company has invented the Bluetooth Intelligent Door Lock. However, it is too expensive and cannot be used on other common locks. Therefore, we try to make a cheaper and more convenient door-open device. This project is to build a external wireless entrance control system through which people can open the door just using their phones from a long distance away.

Fig. 1 Using a phone to open the door[1]

Concept Generation

The core of this mechatronic system is the Arduino UNO R3 microcontroller. The Bluetooth sensor receives the Bluetooth signal from the cell phone and sends a message to the microcontroller. The microcontroller then gives the servo a directive to rotate. The servo is attached to the knob of the door by a mechanic device, thus the rotation of the servo can drive the knob to rotate, and then the lock will be opened.

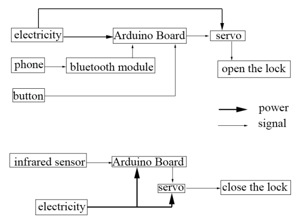


Fig. 2 Running flow chart of system

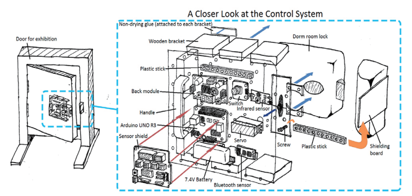


Fig3. Concept diagram

Design Description

The design uses servo, arduino board, Bluetooth Module to open the door. The button will give a signal to the arduino board when it is pushed. The Bluetooth Module is connected with the phone. When receiving the signal from the sell phone, it will send a signal to the arduino board which is used to deal with the signals from the Bluetooth Module and the button. The arduino board controls the servo to open the lock.
To close the door, the design uses the infrared sensor and door closer. The door closer will push the door to the door frame. Then when the infrared sensor receives a stable signal more than 5 seconds, it will give the arduino board a signal and the arduino board will control the servo to lock the door.

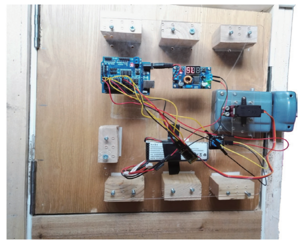


Fig.4 Our product

Modeling and Analysis

First, draw a 2D figure which shows the main structure of the control system. Second, analyze the details and find deficiencies. Then correct the deficiencies and improve the performance. Finally, change the 2D figure into 3D and make the product.

Validation

Validation Process:
To test the effectiveness of the system, we used it to open the door for 20 times and recorded the time it cost. Then we computed the average.
To test the stability of mechanical structure, we opened and closed the door for 20 times without stop and counted the times we succeeded. Then we calculated the percentage.
To test the stability of signal connection and connection time, we have connected the Bluetooth and cell phone starting from disconnecting for 20 times. The distance between the phone and Bluetooth is 1 meter. we counted how many times we have successfully connected them and calculated the percentage. We also recorded the time needed to build the connection and calculated the average value.
Here are the results:
1).opening time <= 1s
2).connection successful rate 100%
3).opening successful rate 100%
4).connection time <= 5s

Conclusion

Wireless technology can be used to send a signal from a long distance away. An external mechanical device can be put on any door lock and operate to open the lock. Be sure that signals can be successfully accepted by the mechanical device and the strength of device is enough, then we can use our phone to open the door conveniently.

Acknowledgement

Prof. Mian Li , Dr. Irene Wei from UM-SJTU Joint Institute
Lin Yukai, Liu Yuheng, Mu Yaoziye, Li Zhijing from UM-SJTU Joint Institute

Reference

[1]http://www.takefoto.cn/viewnews-414783.html

Medical Waste Handling System

BLIZZARD
Team Members: Feng Junhao, Wang Yimin ,Yan Yijun, Geng Zichen, Wu Qiucheng
Instructors: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Nowadays, most hospitals apply disposable medical device to guarantee the safety of patients. Using such convenient stuff is reasonable. However, to properly handle medical waste, we need:

- Professional and skillful dustmen
- Pre-arranged plans when contact medical waste in the dustbin
- Long time to deal with a dustbin when it is already full

Fig. 1 Professional cleaners are disposing of medical waste[1]

Concept Generation

Our system mainly has three functional parts. First, our system can detect the amount of rubbish in the bin. When the rubbish bin is nearly full or the amount of rubbish reaches a certain value, our rubbish bin will pack the rubbish bag automatically. Also, the rubbish bin will seal the bag up and release the rubbish bag. So the system disposes medical waste and avoids touching medical waste by hands, which protects the cleaners to some extent.

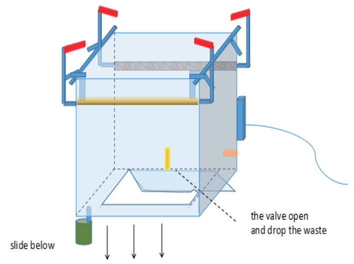


Fig. 2 Concept Diagram

Design Description

To fulfill our expected targets, we decided to divide our project into three parts: Detecting, packing, releasing. We use Arduino Board to control the whole system.

- Detecting: We assume that the distribution of rubbish is proportional,which generally fits the real situation. So we decide to use infrared sensors to detect the height of rubbish. The infrared sensor will be put above the rubbish bin, braced by brackets.
- Packing: The Arduino board will control orbits and heating rods to pack the rubbish bag after receiving messages from infrared sensors. Then The rods will slide on the orbits and carry the rubbish bag from one side to another. When the edges of rubbish bag are heated together, it is sealed up.
- Releasing: After packing rubbish bag, the bottom of the rubbish bin will open, and the rubbish bag will be released automatically because of the gravity. So we use some brackets to raise the system, remaining space for the packed rubbish bag.

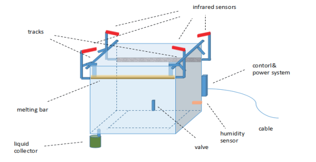


Fig. 3 The whole system

Modeling and Analysis

To make full use of the space in the rubbish bin and protect the dustmen, our system should pack the rubbish bag at a proper time. Besides, we adjust the position of heating rods so that rods can pack the bag without touching the rubbish. Moreover, we apply Auto CAD to help us determine the position of other items.

Validation

We design the test for our system. For the reason that the medical waste are difficult to get, we use some papers and boxes to simulate the real situation. The test result is as follow:

- ✓ Waste in rubbish bin can be sensed
- ✓ Sensors send message to Arduino
- ✓ Heating rods work automatically
- ✓ Waste bag is sealed up
- ✓ Waste bag is released
- ✓ The whole system go back to the original states automatically

To refine our project, we adjust the position of rubbish bag,and make sure it can be carried by the heating rods easily.

Conclusion

The Medical Waste Handling System can detect the amount of rubbish in the rubbish bin, pack the rubbish bag automatically and release the rubbish bag. The dustmen do not need to have much specific knowledge of wrestling with medical waste and the system reduce the possibility of touching medical waste directly. Thus we protect the dustmen and reduce the consumption of manpower.
Moreover, the whole system can be further developed by being connected with a waste disposal unit. Using a transport device, the system can dispose medical waste without any manual work.

Acknowledgement

Prof. Mian Li, Dr. Irene Wei from UM-SJTU Joint Institute Teaching assistants of VG100 course
UM-SJTU Joint Institute

Reference

[1]http://www.wsn-rfid.com/Show_solution.asp?Page=1&ID=103

Automatic Recognition Palette

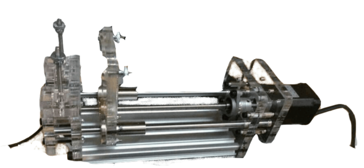
Team Members: Yi Gu, Long Shen, Ruitao Zhang, Guangzheng Wu
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

Some people, like painters, students majoring in drawing, or dying workers, have difficulty in selecting the accurate color to mix. When someone needs to mix colors to draw or dye, they sometimes just mix the needed colors together by feeling or looking, which is much inaccurate. Besides, slight differences exist between the actual object and the painting pigment, which cannot be eliminated through manpower. In some situation such as heritage restoration, high accuracy is required. Therefore, using the plastic (Fig.1 left) or wooden(Fig.1 right) palette is not enough.

Fig. 1 Plastic(left) and Wooden(right) Palette

Concept Generation



Toning manually has several disadvantages: low accuracy that caused by the pigment properties and the conditions of environment and high demanding and time-wasting job that few people can do. As a result, automatic recognition palette is needed to solve all the above problems since there is no similar palette being put into the market. The following picture (Fig.2) about color table will reveal the limitation of toning manually.

Fig.2 Color Table

Design Description

The design uses the single chip as the central controller, the color sensor to collect data and the stepping motor to squeeze certain amount of pigment. Through establishing the numerical relation between the RGB data and the amount of each original color (red, yellow and blue), the user only need to input the sensor at the object and the amount of pigment needed, because we utilize the stepping motor to connect the helical pitch and the volume of pigment. Our controlling part is presented in the Fig.3.

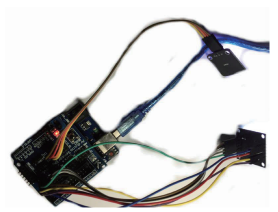


Fig.3 Controlling Part

We need to connect a color sensor, an Arduino UNO R3 board, stepping motors and syringers together to start this project.

Modeling and Analysis

Our color sensor can identify the color clearly (Fig.4).

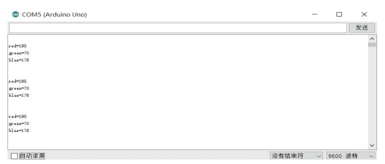


Fig.4 Color Sensor Analysis

Validation

We have found some Automatic Recognition Palettes on the Internet, like the one shown in the following picture (Fig.5). However, despite the little poorer precision, we indeed have some advantage over them, making our product a better one. Firstly, our product is much cheaper, only cost 1/20 of the opponents. Secondly, ours is in a smaller size, which is easier to carry. Moreover, we also added a color sensor to our machine, providing our customers a new way to identify the color.

Fig.5 Our Opponent

Conclusion

Our product is designed to provide the art students with a more accurate method to make the very pigment they want automatically. The user can get any color they want by pointing at the picture and the machine can identify the color automatically and dispense the pigment in the color.

Acknowledgement

Yukai Lin, Yaoziye Mu, Yuheng Liu, teaching assistant from UM-SJTU Joint Institute

Reference

[1]Yuyi, Zhou. "Velocity". Longman Dictionary of Contemporary English (4th). 2004. Print
[2]http://image.baidu.com/search/index?tn=baiduimage&ipn=r&ct=201326592&cl=2&lm=-1&st=-1&fm=result&fr=&sf=1&fmq=1447227146491_R&pv=&ic=0&nc=1&z=&se=1&showtab=0&fb=0&width=&height=&face=0&istype=2&ie=utf-8&word=%E8%B0%83%E8%89%B2

JOINT INSTITUTE 交大密西根学院
VG100 • Introduction to Engineering

Smart Window

Team Members: Ting Zhang, Jianyi Zhang, Haiyang Jiang, Jie Gong, Yujia Xie
Instructor: Prof. Mian Li, Dr. Irene Wei

Problem Statement

It happens frequently that someone goes out with his window open, and then suddenly it begins to rain heavily. The sudden rain almost destroy his room, for it makes the document wet and dirty, make the floor full of water. What's more, there are lots of tragedy due to the toxic gas. In the kitchen, the gas leakage happens regularly. The aim of this project is to keep people safe and keep room clean and tidy, just as in the Fig.1.

Fig. 1 The window is closed when it is rainy

Concept Generation

The project is a machine which can close and open the window automatically. As shown in Fig.2 and Fig.3, it can feel the change of environment and react according to the information. When the weather is rainy, it can help you to close the window. When the weather is sunny, it can help you to open the window. When there is toxic gas in the room, our machine can open the window.

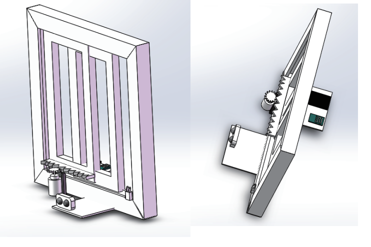


Fig. 2 and Fig. 3 The concept diagram of the window

Design Description

The configuration of the product can be divided into three parts. First, the sensor system. Sensor system includes ultraviolet ray sensor sensor, smoke sensor, sensor of rain and wind. Second, the energy system. With the feedback of the sensor, this system control the vehicles to move. Finally, the connection system. The connections between sensors and vehicles play a crucial role. The whole system can be seen in the Fig.4.

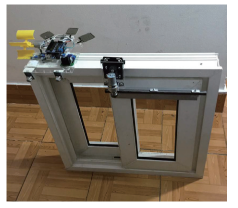


Fig.4 The real project

Modeling and Analysis

We need to write the program to send the data of the sensors to the energy system and make the whole system achieve its functions. Then, we can use Arduino board to receive signals sent by sensors and give corresponding order to the motor. We need to do various experiments to test the whole product. We are supposed to simulate the different conditions like rainy days, windy days, sunny days, poisonous smoke staying in the room and the condition that people are inconvenient to close the windows when in the room. By testing we can get to know how to adjust the system. With the data collected from the testing, we can properly adjust the product to make it perfect and be able to overcome the unexpected difficulties.

Validation

Validation Process:

For raining part, we need to pouring some water on the sensor of rain and wind. Then we can check whether it can feel the rains and whether it can close the window properly. If the machine can finish this two parts normally, it meets our first requirement. For the sunshine part, we need to make the light shining on the ultraviolet ray sensor, and see whether it can detect the light and open the window automatically. If our machine can feel the change of the light and open the window normally, it meets our second requirement. For the toxic gas part, we need some cigarettes to produce some smoke. If the smoke sensor can detect the smoke and open the window, it meets our third requirement.

Validation Results:

According to validation part, most requirements can be met.

✓The sensor of rain and wind works
✓The machine can close the window
✓The sensor IR sensor works
✓ The machine can open the window
✓ The smoke sensor works
✓ means having been verified and means to be determined

Conclusion

Our machine can automaticly close or open the window according to the change of the environment. This project is mainly aimed at promote the quality of life.

Acknowledgement

Sponsor: Prof. Mian Li and Dr. Irene Wei form UM-SJTU Joint Institute
Liu Yuheng, Lin Yukai, Mu Yaoziye and Li Zhijing from UM-SJTU Joint Institute

In VM495, students gain valuable hands-on experience in proposing, planning, and executing an extended experimental program in a mechanical engineering-related topic of their own choosing.

The course involves key areas of engineering investigation and experimentation, including reviewng literature, writing technical proposal, designing and setting up experiments, developing experimental techniques, analyzing test results, and writing laboratory reports.

The technical communication component of the course trains students to be more proficient in communicating technical ideas and results in different formats, including (a) orally — through a series of project presentations, and (b) in writing — via the sequence of written proposal, progress report (memo), poster, and final lab report.

The course also emphasizes team-building skills, necessary for each group of students to work effectively towards a common project goal.

Acknowledgement Licenses for the LabVIEW data acquisition software and additional DAQ modules used in VM495 are kindly donated by National Instruments (NI).

Laboratory assignment

Choose Your Own Experiment —
Analyze, **B**uild, **C**onduct, and **D**esign

Project duration and budget

Seven weeks, 1000 RMB budget per team

Deliverables

- Project proposal (written and oral presentation)
- Team progress memorandum and presentation
- Project poster (in conjunction with the JI Design Expo)
- Team final presentation and final laboratory report

Instructors Prof. David L.S. Hung and Dr. Kwee-Yan Teh

ME Labs Teaching Assistant Team
DONG Yi, HE Qinyue, JIANG Weifu, LIU Yuzhang, WEI Shupeng (VM395 only), TIAN Runfeng

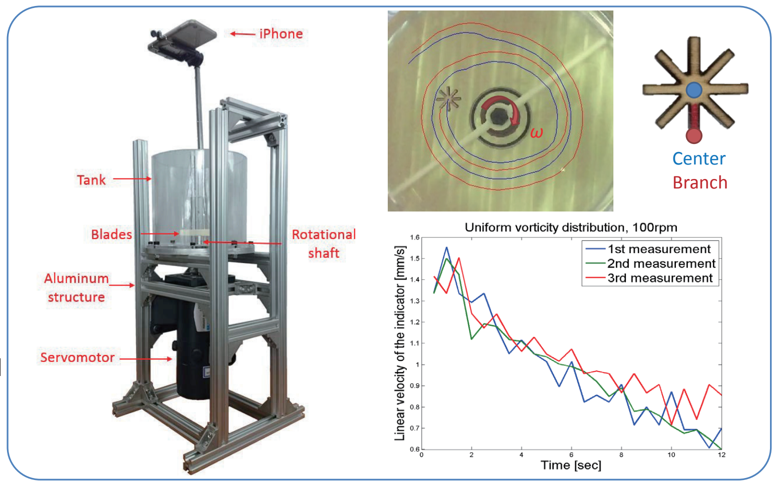
List of projects

- Particle motion in liquid vortex
- Drag and spring vibration induced by a falling object
- Bicycle tire friction and slipping
- Lift of a propeller
- Oscillation of balanced vs. unbalanced rotating masses
- Elastic membrane vibration
- Motion analysis of a spinning top

Trajectory of a Particle Moving on a Liquid Vortex

Jiahao JIANG, Shuqun JIN, Yunfei LU, Zhaohong YANG

The local rotational velocity and vorticity of a fluid vary under different boundary conditions and fluid viscosities. This study considers the influence of these two factors on the motion of the fluid. We selected two canonical cases: uniform vorticity distribution and perfect concentration of plane-normal vorticity. A wooden marker was used to indicate the local fluid motion. The effects of the liquid height and the motor rotational speed on the trajectory of the wooden marker were evaluated. A framework was built to fix the servomotor vertically and to support the liquid tank. The rotational speed of the servomotor was maintained around a preset value using PID control. The tank consisted of a cylindrical acrylic pipe, an acrylic base and an aluminum base. In addition, O-ring and oil seal were used between the acrylic base and the aluminum base to prevent oil leakage. A long shaft connected to the motor was used to generate uniform vorticity, while a short shaft with large blades was used to generate near-perfect concentration of plane-normal vorticity. Our preliminary test yields a trajectory of the wooden marker under the condition of near-perfect plane-normal vorticity concentration. The linear velocity variation of the indicator under the condition of uniform vorticity distribution is also shown (motor speed set at 100 RPM). Further experiments are being conducted at different liquid heights as well as different motor speeds.



JOINT INSTITUTE 交大密西根学院 VM495 • Mechanical Engineering Lab II

Stoke's Drag on a Falling Cylinder and Cubsequent Bouncing of the Cylinder on a Spring

Ya GONG, Jiaqi ZHAI, Chenyang LIU, Baoyu ZHOU

Drag force of an object which moves in a fluid medium is affected by the fluid viscosity and the Stoke's radius of the object, which is related to the shape of the object. This study examines the effects by recording and analyzing the motions of five objects of different shapes in three different fluid media, and the subsequent bouncing of the objects on different springs. Aluminum cylinders of different conical angles were used (90°, 135°, 180°, 225°, and 270°; Fig. 1). Air, water and oil were chosen as the fluid media, and three types of springs were used. The experimental setup is shown in Fig. 2. An aluminum cylinder is dropped into the acrylic tube filled with a fluid. It hits the spring mounted at the bottom of the tube, and causes the spring to vibrate. We use three photo-electric switches to measure the falling velocity of the cylinder at three different locations in order to calculate the coefficient of Stokes drag force. We also use a digital camera to record the vibration of the spring after the cylinder bounces off it. We find that drag force changes with fluid viscosity (Fig. 3). The Stoke's radius, which is related to the conical angle of the aluminum cylinder, also influences drag force but the effect is not obvious. The effect of conical angle on the maximum amplitude of spring vibration in the same medium is also small (Fig. 4), but the effect of the fluid medium is large, and the maximum amplitude is inversely proportional to the coefficient of Stokes drag force. Our experiment created a vivid and comprehensive record for people to understand the effects of Stoke's radius and fluid viscosity on drag force.

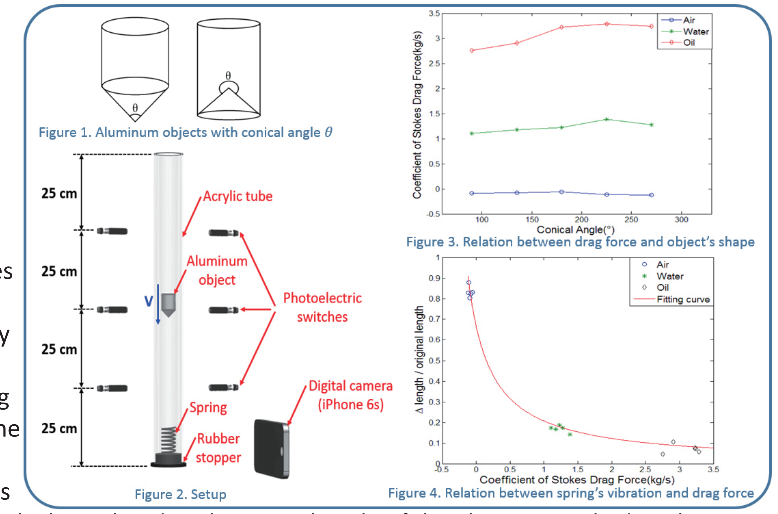


Figure 1. Aluminum objects with conical angle θ

Figure 2. Setup

Figure 3. Relation between drag force and object's shape

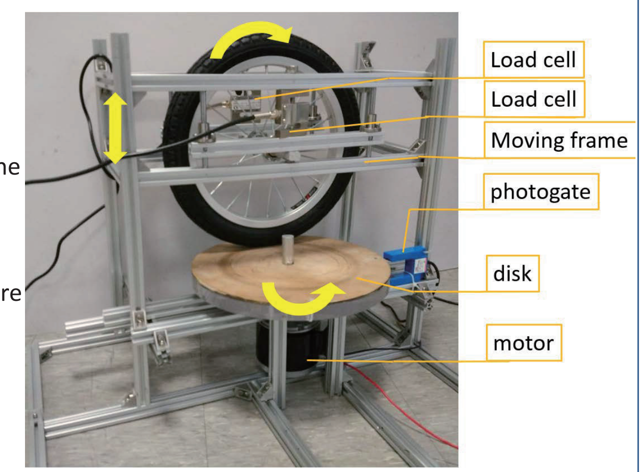
Figure 4. Relation between spring's vibration and drag force

Analysis of Slipping Behavior & Friction Coefficient of Bike Tire

Kevin RATANAWIRA, Mengcheng WANG, Shupeng WEI, Xuanyu ZHOU,

As a bicycle wheel spins faster, it reaches a rotation speed such that the friction force between it and the ground is no longer sufficient to continue propelling the wheel, i.e., slipping occurs. The normal contact force and the contact surface determine the maximum friction force. The bike tire pressure, which affects the contact area between the wheel and the ground, is also a factor. Thus, the objectives of our project are to determine the influence of normal force, ground surface, and tire pressure, on the critical speed at which slipping occurs, and to determine the friction coefficient between the wheel and the ground.

Before every trial, we use a pressure gauge to measure the tire pressure. Disks with different surface finishes (representing the ground) can be rotated by a motor. The vertical position of a moving frame can be changed to alter the normal force applied on the disk. Load cells installed in the structure are used to measure this normal force. Separate photo gates are used to measure the rotation speeds of the wheel and the disk. Slipping occurs when these two speeds are different. We can also determine the maximum static friction force by increasing the torque of the motor gradually until the wheel just begin rotating.

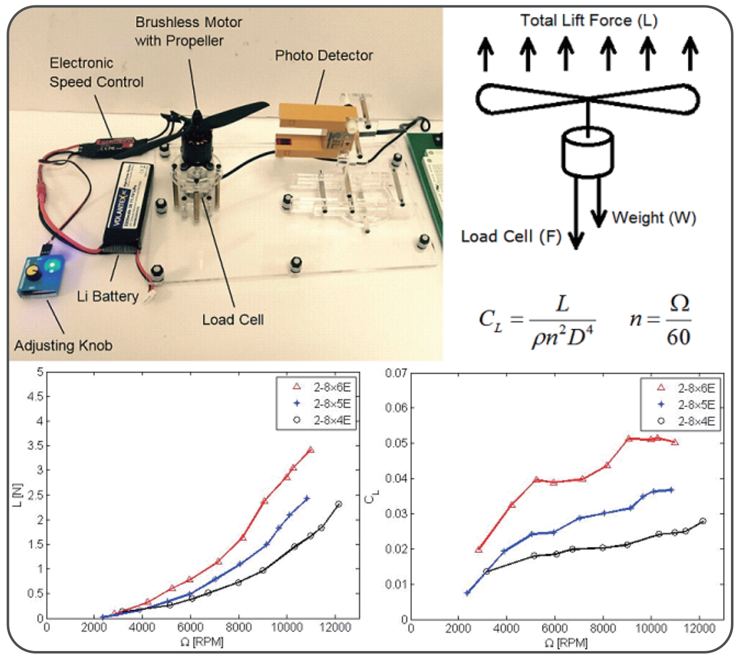


We expect to find that the larger the normal force, the larger the critical speed. The critical speed should also increase when the contact surface becomes rougher. On the other hand, we anticipate that the lower the tire pressure, the higher the critical speed. The value of the maximum static friction and the friction coefficient would also be calculated based on physical principles.

Measurement of Propeller Lift Force

Junjie SHEN, Chennan LI, Mo CHEN, Yang SHEN

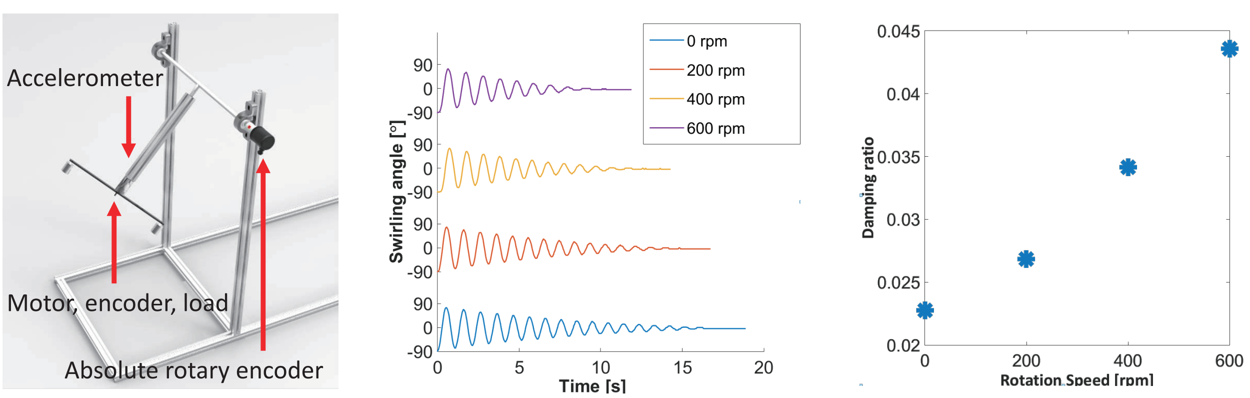
Small Unmanned Aerial Vehicle (SUAV) has excellent motion performance, which triggers our interest in analyzing the performance of the motor(s) mounted with the propeller(s) that power such a vehicle. The objective of this experiment is to measure the lift force of a single propeller as a function of the rotating speed of the propeller. A fixture that combines a propeller, mounted on a brushless motor, which is in turn attached to a force sensor (to measure the propeller lift force), and a photo detector (to measure the propeller rotating speed), is designed and fabricated. The raw data from the two sensors are acquired through a DAQ system. A MATLAB algorithm is then used to analyze the data. The experimental results showed that when the propeller was rotating under static condition (zero flight speed), it generated a lift force that was proportional to the square of its rotating speed. Furthermore, at the same rotating speed, the propeller with a larger size, a larger pitch angle, and/or more blades, would generate a larger lift force. The data collected in this experiment, and the custom-made measuring device can be used to verify whether the SUAV is able to accomplish a proposed mission with the target motor(s) and propeller(s).



Gyroscope Stability and Vibrations of Rotating Unbalance

Lide RODRÍGUEZ INSAUST, TENG Qifeng, WANG Yuxi, YAN Yifei

The objective of this project is to carry out two experiments to discover the vibration effect of a rotating mass mounted on a pendulum. The first experiment is inspired by the fact that a balanced rotational load resists change in its rotation axis orientation due to gyroscopic stability. The pendulum swing is measured while the balanced load rotates at a constant speed (achieved via PID control). A homogeneous second-order response model was used to fit the decaying pendulum swing data. We found that a higher rotating speed induces a larger damping effect in the pendulum motion. The relation between damping ratio and rotating speed is shown.



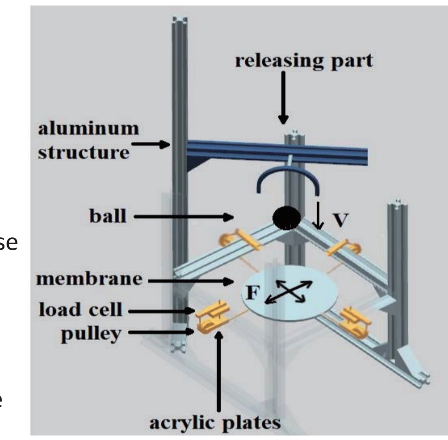
Our goal in the second experiment is to determine how the pendulum motion is affected by an unbalanced rotational load. One additional weight will be attached to one end of the rotational rod. We will record the load on the pendulum rod using an accelerometer, and measure the pendulum motion using an absolute rotary encoder, while the unbalanced load rotates at different speeds.

JOINT INSTITUTE 交大密西根学院 VM495 • Mechanical Engineering Lab II

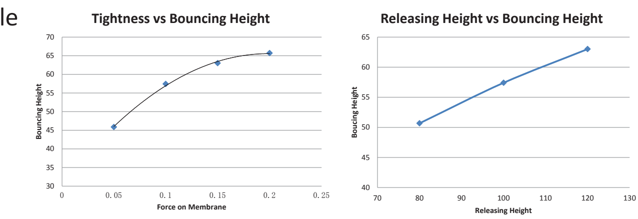
Dynamic Performance of Elastic Membrane and Movement of the Bouncing Object

Qian Shiyi, Hu Qiaoqian, Shen Haishangyang, Jaime Jose Manero Usandizaga

In this experiment, we want to study the dynamic performance of an elastic membrane, and the movement of a ball bouncing on the membrane. This study reports the force in the membrane and the bouncing height of the ball under different initial conditions, including various initial releasing height of the ball, number of clips attached to the edge of membrane, initial force in membrane, and membrane tilt angle. A set of load cells are used to record the force in the membrane, and a high-speed camera is used to record the movement of the ball to find the bouncing height. When a ball is dropped onto the center of the membrane, the force change in the membrane will be sensed by the load cells.



We find that the bouncing height of the ball will increase with the increase of initial tensile force on the membrane, which means that when the membrane is tighter, the energy loss of ball is smaller. We also find that when the initial releasing height of the ball is higher, the energy loss of ball is larger as the membrane will vibrate more substantially. Moreover, if the initial tensile forces stretching the membrane are not balanced, the ball will bounce off the membrane at an angle, rather than vertically. When the tension is more unbalanced, the angle of bounce will be larger. Similarly, when the membrane is tilted more, the bouncing angle will be larger.



Analysis of a Spinning Top

Jianchi HUANG, Patricia ESPINOSA, Xutong ZHANG, Yixuan SONG

Our lab project is to analyze the motion of a spinning top. We focus on three aspects of the motion: the trajectory of the spinning top, its rotating speed, and its tilt angle. We built a fixture that incorporates two digital cameras, Camera 1 pointing downward to measure the angular velocity of the spinning top, and Camera 2 pointing upward to record the overall trajectory of the spinning top. We also designed an electric start-up system that combines a high-speed motor with an electromagnet that can be activated remotely. We use a photo-electric gate to measure the initial angular velocity of the electromagnet, which is also the initial velocity of the spinning top. A track with an adjustable angle is used to offer the spinning top a linear velocity.

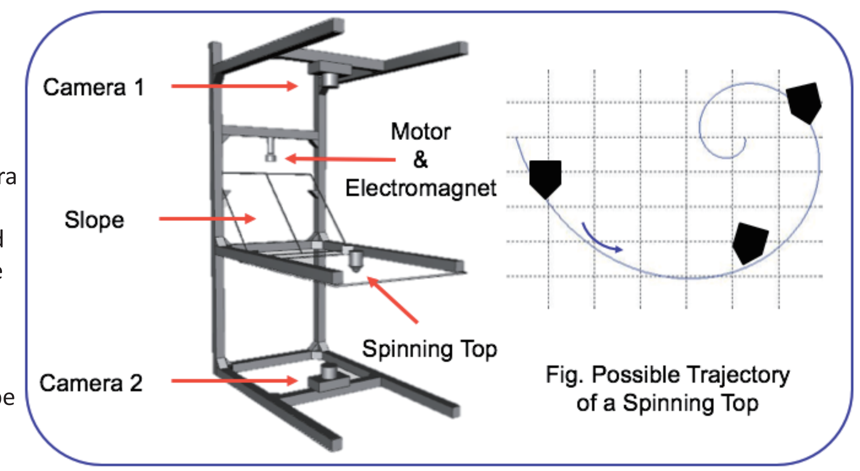


Fig. Possible Trajectory of a Spinning Top

In summary,

a) We expect to record an overall trajectory for the spinning top similar to that shown above. We will determine the factors that affect this trajectory.
b) As the spinning top follows its trajectory, we will also determine how its angular velocity decays.
c) We also expect the tilt angle of the spinning top to increase as the trajectory is followed.

COURSE INSTRUCTORS TEAM

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Instructors:
Kai Xu, Chengbin Ma,
Mingjian Li, Yunlong Guo
VG 100: Introduction to Engineering
Instructors: Mian Li, Irene Wei
VM 495:
Mechanical Engineering Laboratory II
Instructors: David Hung, Kwee-Yah Teh
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Design Expo Coordinator: He Yin

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Oral Defense Classroom: Mike Liu
Library Layout: Huan Liu
Miscellaneous: Leilei Xu & Huan Liu

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Assistant Leads:
Songyang Han, Yandong Wang
Corporate Guest Reception:
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Expo Award Certificate:
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