Portfolio

Design in Programs and Models

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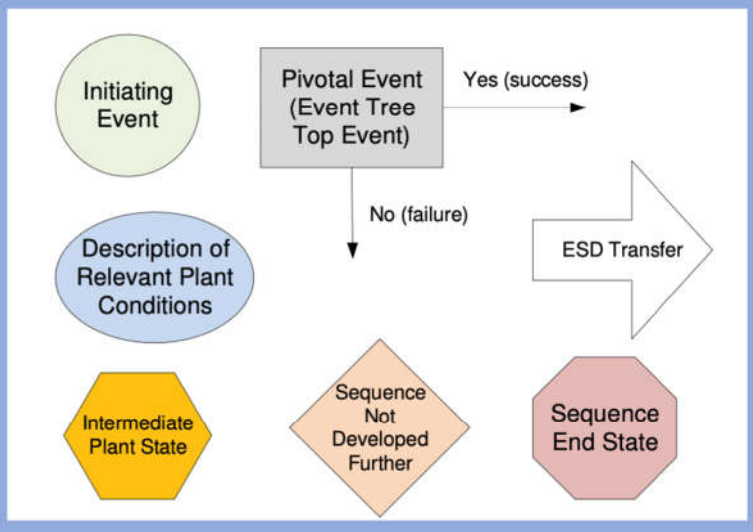

https://github.com/lemcee/NCSU-GEARS

Methods and Software for Probabilistic Assessment Applications
Event Sequence Diagram Visualization

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Program Advisor: Prof. Mihai A. Diaconeasa & Arjun Earthperson

Introduction

Probabilistic risk assessment (PRA) is a systematic and comprehensive approach that conducts a risk assessment of a variety of potential outcomes.
The **OpenPRA** program aims to provide a unique platform that integrates multiple PRA methods and tools into a holistic, easy-to-use, and highly customizable framework.
In this project, we are supposed to solve the issues in the development of the software OpenPRA **Web-Editor.** My job focus more on the frontend development, and center on the **event sequence diagram visualization**.

OpenPRA Web Editor
build v0.7.70

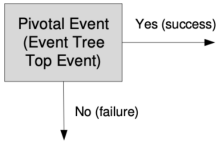
Methods

The **Event-sequences diagram(ESD)** is an analytical method intends to illustrate all possible success paths from a particular **accident-initiating event to a safe-shutdown condition.**

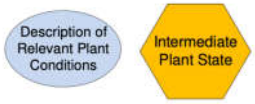
The start of ESD, typically something happens.

Turn to another page when ESD is to big too show on one page.

The end of ESD branch, all kinds of end conditions and expressions for not developed sequence.



Specific judgment conditions, used to form two divided branches of the ESD.



The comments in ESD, when it comes to nuclear engineering, talks about the plant state and condition.

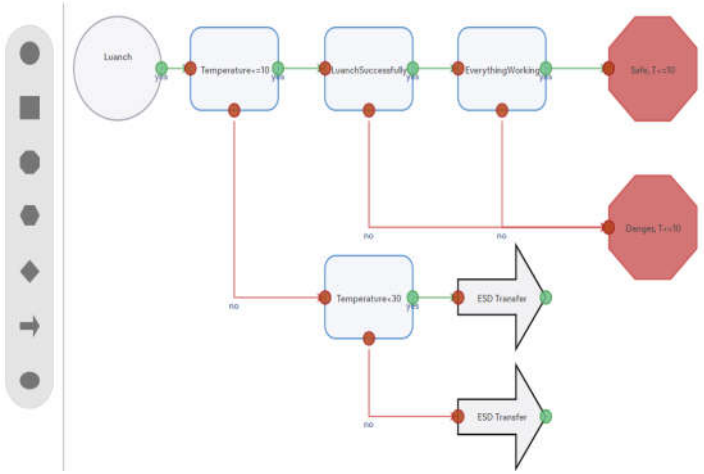
Tasks

Task 1: Event sequence diagram symbols
In the Event Sequences interface, only Initiating Event, Functional Event and End State were implemented more **specific symbols** need to be added in order to draw a more detailed event sequence diagram for PRA of nuclear plants.

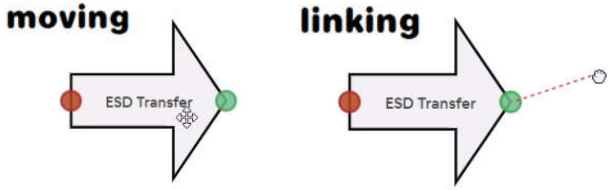
Task 2: Enable **arrow key** control and shortcuts
If we are allowed to use an arrow key to make control on the vertices, then the operation will be much more convenient. We will develop this in our project.

Results

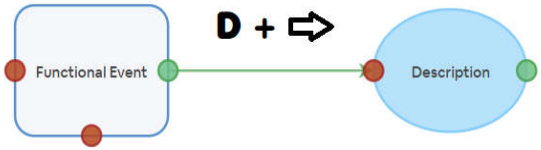
1. Many **Typescript classes** related to the symbol are modified in order to add new symbols, including the style, the shape, the vertex value and the geometry. Applying **vector math**, the generic shape of the symbols are redrew into more specific ones with significant colors.



2. **Ports** were added to each vertex so that it is easier to make links between vertex and separate the **linking** function and the **moving** function.



3. Two functions were implemented with arrow keys: **Navigation** and **Keyboard Shortcus.** We use “hotkey.js” library to bind keys with actions.



Conclusion

1. To implement a software, we need both frontend and backend support. Applying Typescript, React and MxGraph library, I have a deeper understanding in frontend develop and visualization.
2. ESD is a method of great significance in PRA. Using specific symbols, an ESD can show us the path of risk. Through the implementation, I learned much about ESD model.

References

1. PRA Procedures Guide
https://www.nrc.gov/docs/ML0635/ML063560439.pdf

Global Education, Academics and Research Skills Program (GEARS)

Global Training Initiative
Office of Global Engagement
gti.ncsu.edu/gears/

GEARS Student Evaluation Summer 2022

Program Overview: Administered by the NC State University Global Training Initiative (GTI), GEARS is a 4 to 8 week long academic, research and cultural exchange program that enables domestic and international students to experience campus life and academic research at universities across North Carolina. Participants in this non-degree and non-credit program have a rich on-campus experience, participate in a variety of cultural and social programs, explore research relevant to programs at their home institution and present their work via a judged poster presentation exhibit. GEARS is a competitive program whereby students submit their Transcripts and CVs and apply for particular projects of interest mentored by university faculty. Student acceptance and placement decisions are made after consultation between GTI staff and mentoring professors.
***Due to the COVID-19 pandemic, the Summer 2022 GEARS program took place in a virtual format. The six week program ran from July 11 - August 19th, 2022. Students and professors communicated by video conference and email, and projects were worked on remotely. All students turned in an electronic version of an academic poster with an accompanying video or audio presentation.**

Mentoring Professor Name and Title

Mihai A. Diaconeasa, Assistant Professor

Mentoring Professor University and Department

North Carolina State University, Nuclear Engineering

Mentoring Professor Email Address

madiacon@ncsu.edu

Student Name

Mochuan Liu

Student Home University

Shandong University Weihai

Project Title

Methods and Software for Probabilistic Assessment Applications

Project Overview: Please give a brief description of the research project, the tasks assigned and accomplished by the student and how closely you worked with the student.

In this project we explored the Probabilistic Risk Assessment (PRA) models and its software the OpenPRA Web Application, which can be used in many industries to identify and manage risks. A scenario-based risk assessment involves multiple steps. Firstly, the analysts define objectives, familiarize themselves with the system, and identify initiating events. Secondly, the analysts develop models including scenario models through event trees and failure models through fault trees. Finally, by applying embedded quantification methods, which are followed by uncertainty analysis, sensitivity analysis ranking, importance ranking and data analysis, the PRA methodology helps decision makers gain insight on the weaknesses or vulnerabilities in system processes and operations.

Overall, Mochuan's task was to implement the code and configuration to the frontend and backend for developing event sequence diagrams for the OpenPRA Web Application. More specifically, this task included learning the event sequence diagram methodology and implementing the necessary symbols and layouts in OpenPRA. During the program, Mochuan met almost daily with my graduate student, Arjun Earthperson, and I.
To conclude, Mochuan created a poster showcasing the acquired knowledge and skills during the program.

Numeric Evaluation: Please rank the student from 1-5 on each statement below.
1 = Strongly Agree
2 = Agree
3 = Neither Agree nor Disagree
4 = Disagree
5 = Strongly Disagree
N/A = Non-Applicable

Student had, or acquired during the program, the theoretical knowledge necessary to properly carry out assignments	1 = Strongly Agree
Student had the analytical and critical thinking skills needed to complete assigned tasks	1 = Strongly Agree
Student understood tasks and assignments once instructions were provided without requiring much additional support	1 = Strongly Agree
Student was dependable and could be trusted to deliver results	1 = Strongly Agree
Student worked well independently	1 = Strongly Agree
Student worked well with others and was a team player	2 = Agree
Student communicated clearly, effectively and in a professional manner	1 = Strongly Agree
Student was punctual, able to respect a timetable and provided valid excuses when late or absent	1 = Strongly Agree
Student was able to accomplish their research tasks by the end of the program	1 = Strongly Agree

Overall, the student was pleasant to work with	1 = Strongly Agree
Overall, your interaction with the student during the program was positive	1 = Strongly Agree

Overall Impressions: Please provide any additional information regarding the student's capacities, as shown during their participation in the GEARS Program.

What were the student's most notable strengths?

Arjun and I appreciated Mochuan's ability to investigate independently and ask valuable questions.

In what areas could the student improve?

We encourage Mochuan to continue learning the web stack used in our project and become familiar with the other PRA modeling techniques.

What additional skills or knowledge areas would you recommend for the student to be better prepared for graduate research or professional activity in their field of study?

We recommend Mochuan maintain his commitment to engineering that will eventually give him the skills to identify research questions and succeed in his future professional activities.

Signature

Date

Thursday, August 18, 2022

Python Chatbot and MINST

------Software Training Bootcamp Project

Chatbot

I joined the Software Training Bootcamp”Python and AI” held by my school in January 2020, which aimed to develop a simple AI program in Python. Under the teacher’s guidance, I developed my first program: an AI Chatbot, Peppa. The first program of mine was able to conduct simple conversations, drawing pictures, open web pages and crawl for photos. To conduct conversation, I firstly created a chat list. By comparing the input content with the list content using a function, Peppa can give the preset answer. If the content does not match with the list, the user can teach Peppa how to answer by inputting the answer, which was actually adding to the list. By applying Turtle and library requests_html, Peppa can draw pictures and web crawl. I also use Image to process the download photos and create a photo wall.

```
print('Peppa: ', 'Hello!')
while True:
    a = input('Michael: ')
    # Exit command
    if a == 'Exit':
        break
    # Compare a with strings in chat_list and choose the most similar one
    # print('Peppa:', chat_list[chat_list.index(a) + 1])
    cur_index_chat, cur_rate_chat = cf.get_chat_str_index(a, chat_list)
    cur_index_cmd, cur_rate_cmd = cf.get_chat_str_index(a, cmd_list)
    # Check which one is the most similar and cmd chat
    if cur_rate_cmd > cur_rate_chat:
        cur_rate = cur_rate_cmd
        cur_index = cur_index_cmd
        if cmd_list[cur_index] == 'Tell me the time':
            import clock
            clock.draw_time()
            print('Peppa: ', 'I have drawn you a clock')
        elif cmd_list[cur_index] == 'Draw a Peppa Pig':
            import peiqi
            peiqi.my_draw_peiqi()
            print('Peppa: ', 'I have drawn you a Peppa')
        elif cmd_list[cur_index] == 'Open Google':
            import webbrowser
            webbrowser.open('www.google.com')
            print('Peppa: ', 'I have opened Google')
        elif cmd_list[cur_index] == 'Download or Search':
            # Download"word"
            word = a[a.index('"')+1:a.index('"')]
            page_num = 2
            img_list = bd_dwn.my_download(word, page_num)
```

```
D:\chatbot\venv\Scripts\python.exe D:/chatbot/my_chat.py
Peppa:  Hello!
Michael: hi
Peppa:  Hello, how can I help you?
Michael: what is the weather like
Peppa:  Rainy today
Michael: why
Peppa:  I do not have this question in my storge. Could you please teach me?1: Yes, 2: No
Michael: 1
Peppa:  I am ready to receive, please type
Michael: because it's in British
Michael:  I have received, thanks
Peppa:  why
Michael: why
Peppa:  because it's in British
Michael:
```

MINST

Apart from Chatbot, I learned about TenserFlow and Minst. After data normalization, I can create the model by stacking layers. The model can be trained and can predict the object.

```
import tensorflow as tf
import numpy as np
# load minst data
mnist = tf.keras.datasets.mnist

(xtrain, ytrain), (xtest, ytest) = mnist.load_data()
print(xtrain.shape, ytrain.shape, xtest.shape,ytest.shape)
# The data is normalized and the values are scaled to [0,1]
xtrain, xtest = xtrain/255.0, xtest/255.0

# build the model by stacking layer
model = tf.keras.Sequential([
    tf.keras.layers.Flatten(input_shape=(28,28)),
    tf.keras.layers.Dense(128,activation='relu'),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(10,activation='softmax')
])
#
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
# tf.losses.loss
# save the model
check_path = 'my_mnist_checkpoint/ckpt/cp-{epoch:04d}.ckpt'
save_mode_cp = tf.keras.callbacks.ModelCheckpoint(check_path, verbose=1, save_weights_only=True, period=2)

# train
model.fit(xtest,ytest,epochs=5,callbacks=[save_mode_cp])
```

https://github.com/lemcee/chatbot

https://github.com/lemcee/Tensorflow

8051 Microcontroller Programming

-------Applying C language

In course Design of MCU Application System, I finished nine experiments on 8051 microcontroller.

1. Phone number display
2. High and low level duration detection
3. LED flashing at certain Frequency
4. Long or short press detection for control
5. A pre-set timer with an alert tone
6. Send digital package to computer and display
7. Send detected message and display
8. A timer with alert tone set by another PC

The code below is the experiment “A pre-set timer with an alert tone”

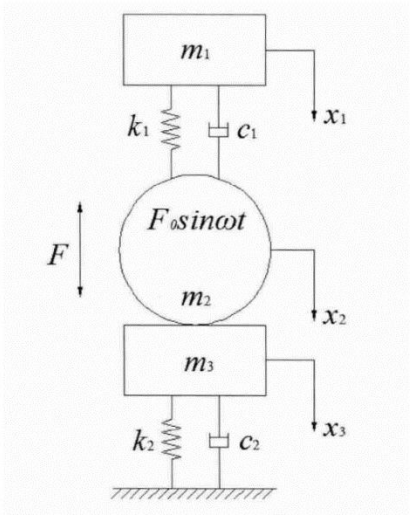
```
#include<reg51.h>

#define uchar unsigned char
#define uint unsigned int

sbit k2=P3^2;
sbit k3=P3^3;
sbit P21=P2^1;
sbit P22=P2^2;
sbit P23=P2^3;
sbit P24=P2^4;
sbit P00=P0^0;
sbit buzz=P3^7;

uchar number[]={0xc0,0xf9,0xa4,0xb0,0x99,0x92,0x82,0xf8,0x80,0x90};
uchar j=0;uchar tmp=0;uchar cnt=0;uchar i=5000;

void delay(uint k)
{
    while(k--);
}

main()
{
    TMOD=0x01;
    TH0=0x3c;
    TL0=0xb0;
    ET0=1;
    IT0=1;
    IT1=1;
    EA=1;
    EX0=1;
    EX1=1;
    while(1)
    {
        switch(j)
        {
            case 0:P21=1;P22=1;P23=1;P24=0;P0=number[tmp%10];delay(1000);j++;break;
            case 1:P21=1;P22=1;P23=0;P24=1;P0=number[tmp/10%10];delay(1000);j++;break;
            case 2:P21=1;P22=0;P23=1;P24=1;P0=number[tmp/100%10];delay(1000);j++;break;


            case 3:P21=0;P22=1;P23=1;P24=1;P0=number[tmp/1000%10];delay(1000);j=0;break;
            default:break;
        }
    }
}

void In0() interrupt 0
{
        delay(4000);
        if(k2==0)
            tmp++;
}

void In1() interrupt 2
{
    TR0=1;
}

void Timer0() interrupt 1
{
    TH0=0x3c;
    TL0=0xb0;
    cnt++;
    if(cnt==20)
    {
        cnt=0;
        if(tmp!=0)
        {
        tmp--;
        }
        if(tmp==0)
        {
            buzz=0;
            delay(1000);
            buzz=1;
            ET0=0;
        }

    }
}
```

https://github.com/lemcee/8051-MCU

Simulation on Dynamic Performance of Vertical Vibratory Roller

-------Applying Matlab Simulink

Mathematical modeling



The figure above shows the mathematical model of a vertical vibratory roller under its main working condition (compaction). The mathematical model is based on the following assumptions:

(1) The vibration wheel, frame and related parts of a vertical vibratory roller are regarded as concentrated mass blocks with certain mass, and all of them are set as rigid bodies

(2) It is assumed that the motion path of the vibrating wheel only exists in a plane perpendicular to the ground. The upper part of the above mathematical model represents the characteristics of the vertical vibrating roller, and the lower part represents the characteristics of the pressed material.

(3) The vibration reduction system of the vibratory roller and the compressed material along with the vibration are considered to be spring - damping units without mass.

The dynamic equation of the above vibration system:

$$\begin{cases} m_1\ddot{x}_1 + c_1\dot{x}_1 + k_1x_1 - c_1\dot{x}_2 - k_1x_2 = 0 \\ (m_2 + m_3)\ddot{x}_2 + (c_1 + c_2)\dot{x}_2 + (k_1+k_2)x_2 - c_1\dot{x}_1 - k_1x_1 = F_0 sin\omega t \end{cases}$$

m_1- frame mass; m_2- the mass of the vibrating wheel; m-the mass of soil with vibration; k_1-stiffness of shock absorber; c_1-damping of shock absorber; k_2-the stiffness of soil; c_2-the dumping of soil; F_0 −excitation force; ω-excitation angular frequency。

Rewrite the original system into matrix form：

$$M\ddot{X} + C\dot{X} + KX = F(t)$$

Mass matrix $M = \begin{bmatrix} m_1 & 0 \\ 0 & m_2 + m_3 \end{bmatrix}$

Damping matrix $C = \begin{bmatrix} c_1 & -c_1 \\ -c_1 & c_1 + c_2 \end{bmatrix}$

stiffness matrix $K = \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1+k_2 \end{bmatrix}$

Matlab/Simulink emulation

The original equation is transformed into a state-space equation in which the four matrices do not change with time：

$$\begin{cases} \dot{X} = AX + Bu \\ Y = CX + Du \end{cases}$$

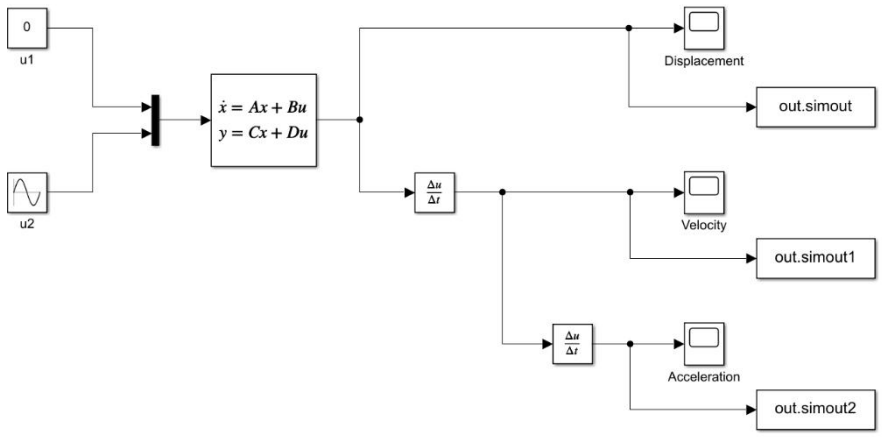
State matrix $A = \begin{bmatrix} O_{2\times2} & I_{2\times2} \\ -M^{-1}G & -M^{-1}C \end{bmatrix}$

Input matrix $B = \begin{bmatrix} O_{2\times2} \\ M^{-1}G \end{bmatrix}$

Output matrix $C = [I_{2\times2} \quad O_{2\times2}]$

Direct matrix $D = O_{2\times2}$

(1) Build Simulink simulation model

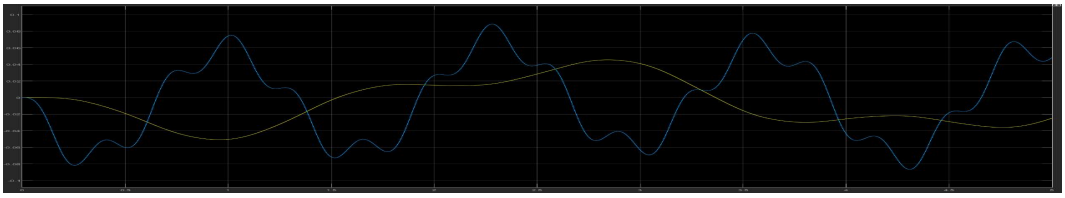


As shown in the figure above, the model is built based on State-Space module. According to the differential equation, the input external force is zero force and sine force. Three Scopes and Derivative devices are used to read the displacement of frame and vibration wheel and the corresponding output of speed and acceleration, and output to the workspace via simout. Complete the line as shown in the figure, and set its amplitude, angular frequency in the sine input (sine). Complete the input of each matrix in the State-Space module and set the initial value (default value is 0).

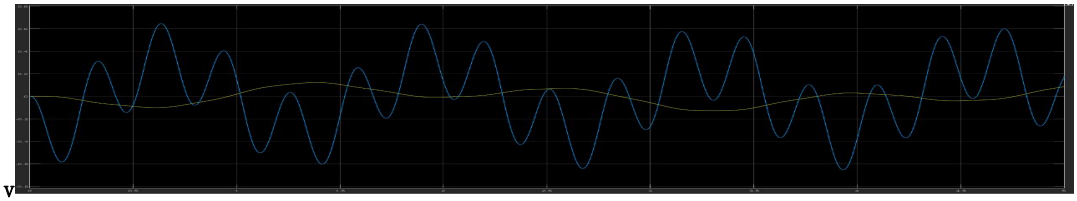
Parameter	Name	Unit	Value
Frame mass	m_1	kg	290
the mass of the vibrating wheel	m_2	kg	310
the mass of soil with vibration	m_3	kg	6
stiffness of shock absorber	k_1	N/mm	1200
stiffness of soil	k_2	N/mm	5800
damping of shock absorber	c_1	N · s/mm	2.3
damping of soil	c_2	N · s/mm	2.0
excitation angular frequency	ω	rad/s	20

(2) Simulation result

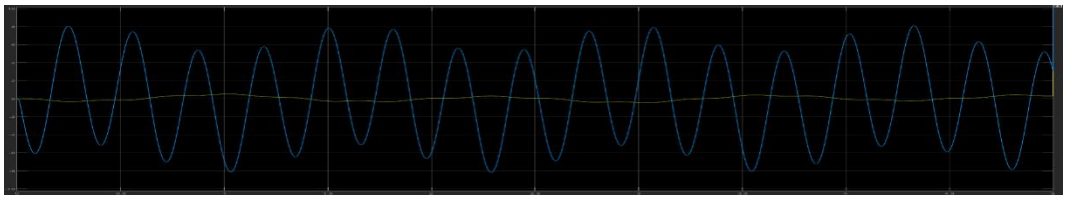
The simulation results are as follows, where the yellow line represents the frame curve and the blue line represents the vibration wheel curve:



Displacement/Time curve



Speed/Time curve



Acceleration/Time curve

Analysis of experimental results

The curve performance of displacement, velocity and acceleration of the frame over time is relatively regular. This is because the frame shock absorber reduces the mechanical vibration of the system by self-damping. In the process of working, the frame shock absorber converts part of the energy into heat energy, while the other part is stored in the form of potential energy, which improves the dynamic stability of the system. The motion of the vibrating wheel is not a simple harmonic motion of a single frequency, but a superposition of harmonic motion of a variety of different frequencies. This is because when the roller starts to work, the frequency is gradually increasing, and finally the stable frequency is reached, that is, the vibration frequency.

https://github.com/lemcee/roller-matlabsimulink

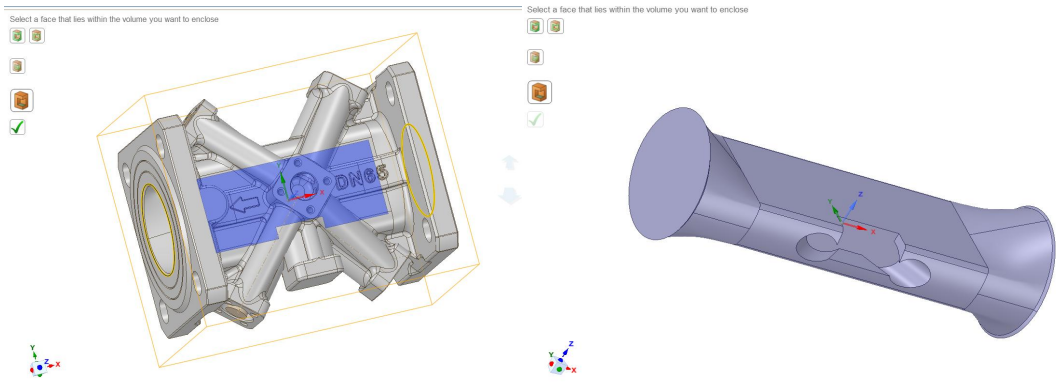
Fluid Simulation and Reed Vibration Simulation

------Applying Ansys and Abaqus

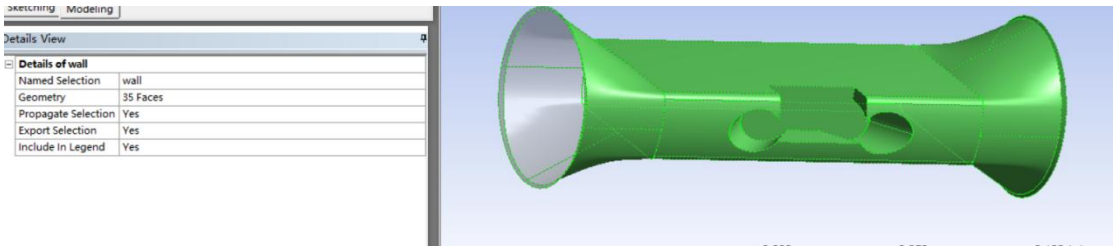
Fluid simulation

During the process of Industrial Practice in Weihai Ploumeter Co., I implemented simulation analysis of the fluid situation in the water meter. Through simulation calculation of the flow rate in the water meter under different working conditions, I obtained the influence of pressure loss and temperature on the flow rate of the water meter. By calculating the flow rate under different working conditions, the relationship between pressure loss, temperature and flow rate is obtained.

(1) Extract the fluid domain. Use Spaceclaim to extract volume from inside the water meter to form a fluid domain for subsequent analysis

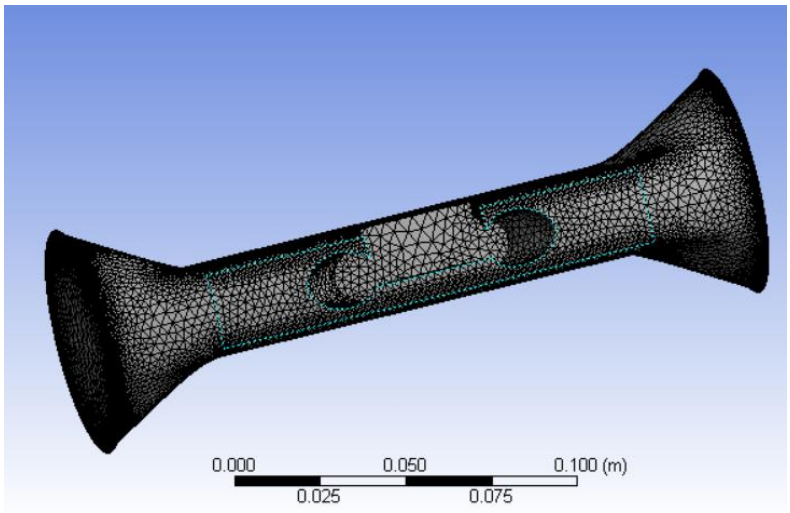


The Wall has no slip boundary conditions, and the inlet and outlet boundary conditions can be flow velocity pressure, etc., which is set as pressure during simulation.



(2) Meshing

Special meshing requirements are applied to the entrance boundary and the complex plane protruding from the surface body. Further adjustments are made according to the meshing Quality.



(3) Fluent simulation

Repeat Fluent simulation under different working conditions, each working condition corresponds to a different inlet timing pressure and fluid temperature.

(4) Simulation experiment result

		Density(kg/m^3)	Viscosity(kg/m*s)	massFlow on Plane 1 (kg/s)
	10 c	999.7	0.001306	20.5724
1bar	100 c	958.4	0.0002818	20.2401
	200c	0.9316	0.00001615	0.632128
	10 c	999.8	0.001306	35.7407
3bar	100 c	958.5	0.0002818	35.2201
	200 c	1.878	0.00001608	1.56095
	10 c	1000.2	0.001305	65.3321
10bar	100 c	958.8	0.0002821	64.4435
	200 c	5.383	0.00001586	4.83061

Conclusion： At the same temperature, the larger the pressure difference is, the larger the mass flow rate is. When the pressure difference is the same, the higher the temperature is, the lower the flow rate is. When the temperature is too high for water vapor, the mass flow rate decreases significantly.

Reed vibration simulation

By using Abaqus software, the finite element analysis of the vibration mode of the cantilever reed is carried out, and the vibration frequency and mode change within ten orders of the reed are obtained. The influence of the change of length, width and thickness on the reed mode is further investigated.

Equation and model

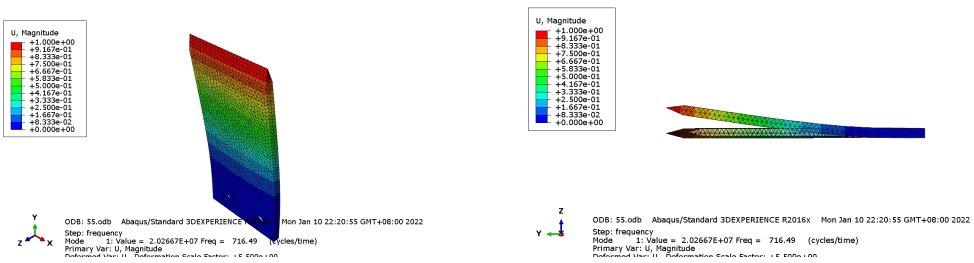
In the modal analysis of the reed, the reed can be regarded as a vibration system with multiple degrees of freedom and multiple natural frequencies. For a linear structure system of N degrees of freedom, the differential equation of motion is:

$$[M]\left\{\ddot{\delta}\right\} + [C]\left\{\dot{\delta}\right\} + [K]\{\delta\} = \{F(t)\}$$

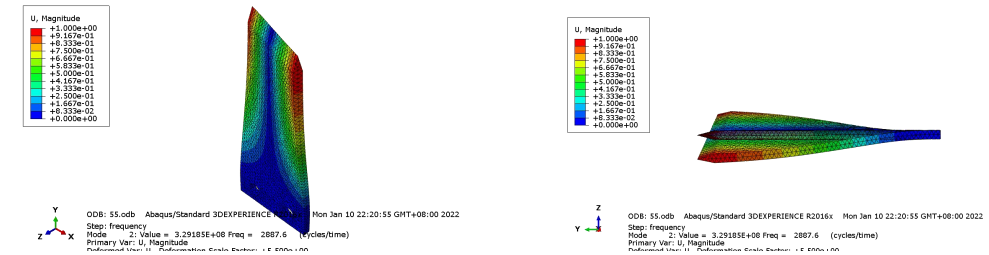
The actual cantilever reed with L (length) ×W (width) ×H (thickness) =55×25×2mm was taken as the calculation model, the angle of the reed wedge was 30° , the two holes on the reed were fixed bolts, the radius of the two holes was 2mm, the distance between the hole center and the tail end was 4mm, and the distance between the side was 6mm. The effective vibration length of the reed was 49mm.

Modal analysis

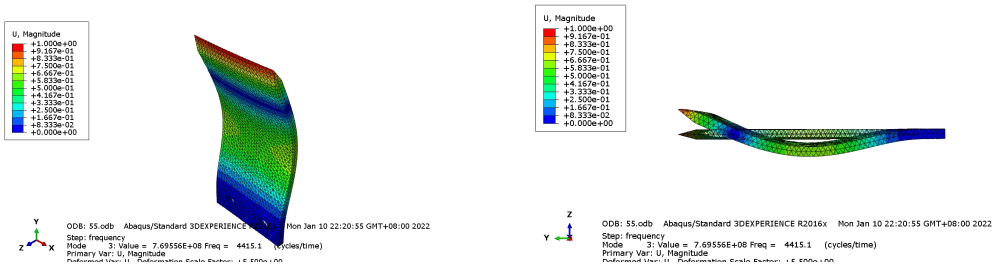
The frequency extraction analysis of the structure was carried out using Abaqus/standard, and the corresponding analysis step types were liner perturbation of new factors.



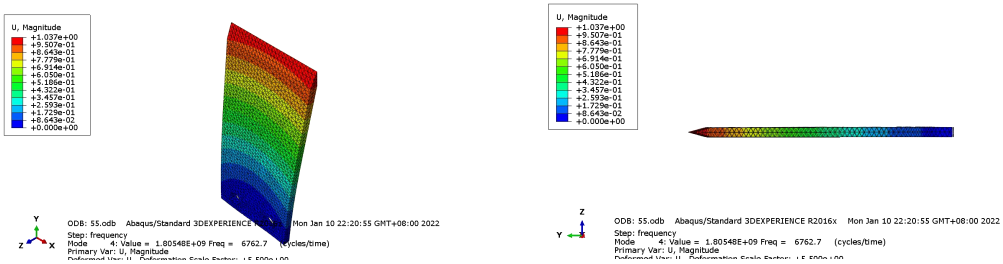
One order



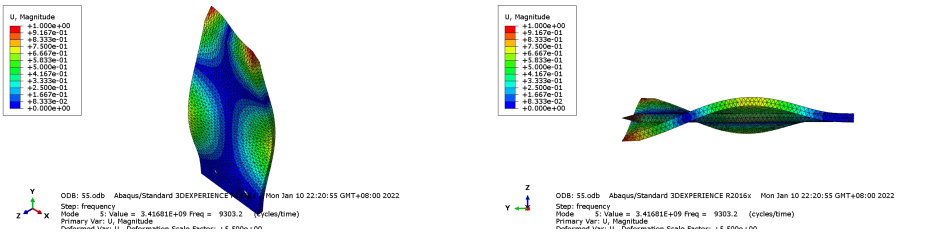
Two order



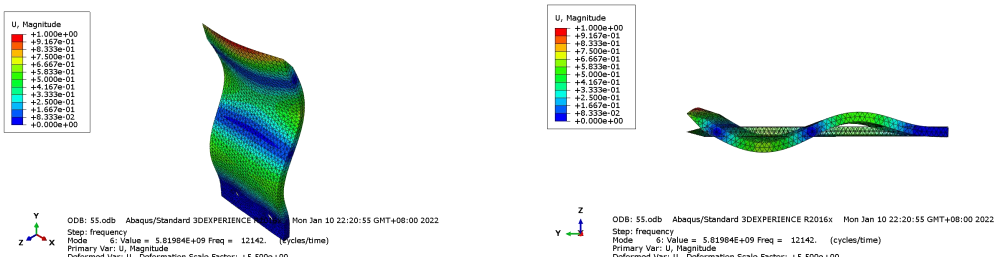
Three order



Four order

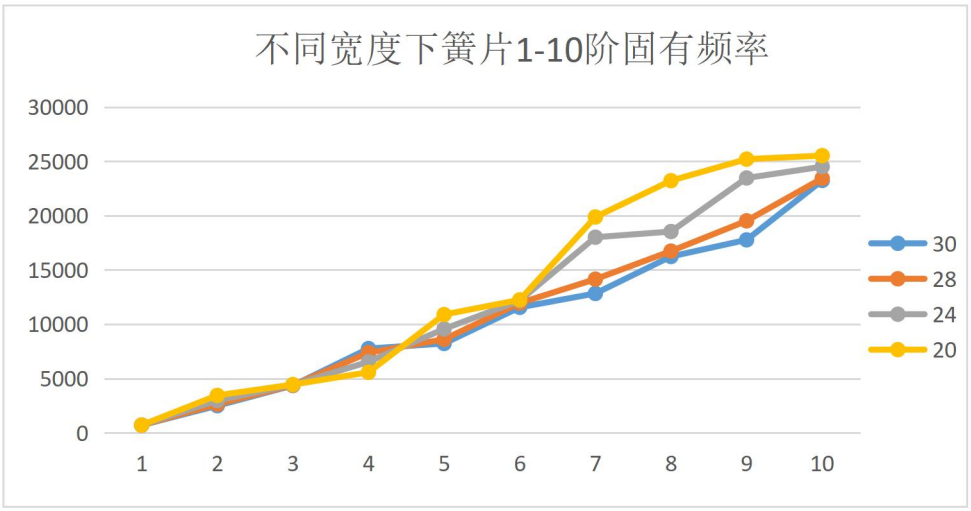


Five order

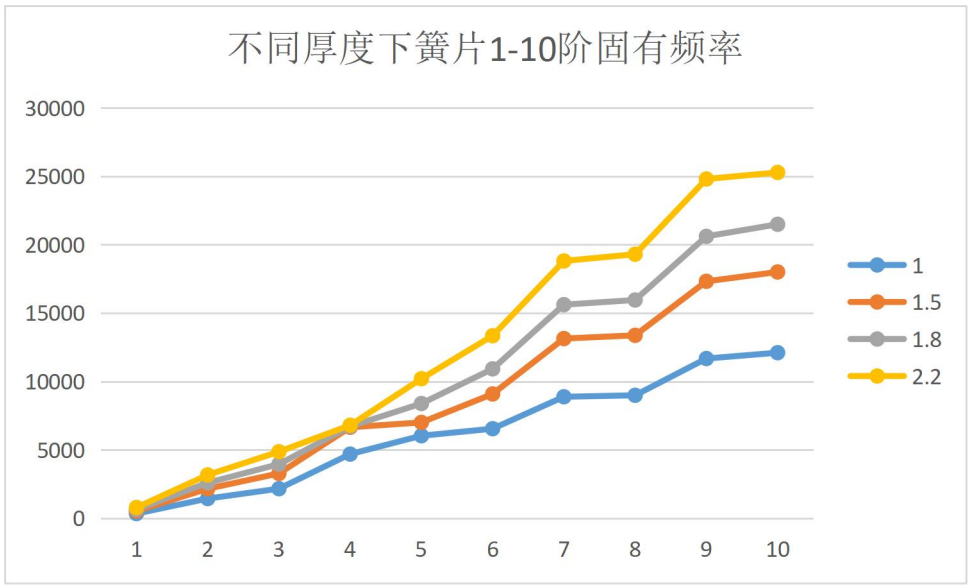


Six order

Results and analyze



When the length and thickness are constant, the change of reed width has little influence on the first 6 orders of vibration frequency. Between 7 and 10 orders of vibration, the corresponding vibration frequency decreases with the increase of the width of the reed. Therefore, it can be considered that the change of width mainly affects the high-order vibration of the reed, but has little influence on the low-order vibration of the reed



When the thickness increases, the vibration frequency of the first order mode changes little, while the higher order frequency increases obviously. When the length and width are fixed, the relationship between the vibration frequency and the order of the spring is a nonlinear changing process under different thicknesses