DeMaMech Exchange Student Report

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University of Tokyo

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2 Executive Summary (max 1 page)

I spent 4 months in Belgium and 1 month in Denmark. I made a research in Belgium and took intensive lecture in Denmark.

From September to December, I belonged to the Katholike Universiteit Leuven. I was involved in a project which is a part of a field of micro fluidic actuator. My project is to polish small tubes which are utilized in the micro fluidic actuator. I designed and fabricated a wire polishing setup for these small tubes and made some experiments to evaluate the polishing effect.
It is quite comfortable to live in Leuven as a student. The Katholike Universiteit Leuven is a main facility of the city of Leuven, so most restaurants and barber shops have student discount.

After staying in Leuven, I went to Denmark and belonged to the Technical University of Denmark. I took 3 weeks intensive course in the university. I chose “Image analysis and optimization” and this lecture requires the specialistic knowledge of some analysis software, so keeping up with this lecture is quite hard for me.

People in both Belgium and Denmark can speak English fluently. I surprised the level of their linguistic skill. There are no troubles to spend ordinal daily life if you can only speak English.

I traveled a lot of countries in Europe and received much impression from many historical monuments, cultures and arts. I reconfirmed that Europe is the centre of the art.

This exchange program is a wonderful opportunity to touch not only the research in Europe but the culture of Europe. I appreciate very much to give me such a good opportunity and every people who support me during my exchange life.

3 Travel Schedule

1st/Sep/2005 – 23rd/Dec/2005 Katholieke Universiteit Leuven (Leuven, Belgium)

2nd/Jan/2006 – 21st/Jan/2006 Technical University of Denmark (Lyngby, Denmark)

4 (1)Research in Leuven

“Polishing a Small Tube”

4 - 1 Introduction

4 - 1 - 1 Micro actuator with small tubes

There are some actuators which comprise small tubes, as for instance the hydraulic micro actuator shown in Figure 1. Strong demand to improve work density of this sort of actuator is existed. A simple way to improve this actuator is to reduce the friction force which occurs on the inner wall of the tube. To reduce the friction, it is necessary to polish the inner wall of the tube, but it is not possible to use ordinal polishing techniques such as buff polishing or barrel polishing. The size of those tubes whose inner diameter range from 1mm to 0.3mm is too small to polish with these techniques, so we have decided to use another technique of polishing, a wire polishing. The wire polishing is suitable for inner wall of a small tube. Figure 2 shows a commercial wire polishing machine for small ruby bearing used in watches. However, this machine is expensive and limited in polishing diameter. Therefore, we have to design and fabricate a simple setup to polish the inner wall of the small tubes.

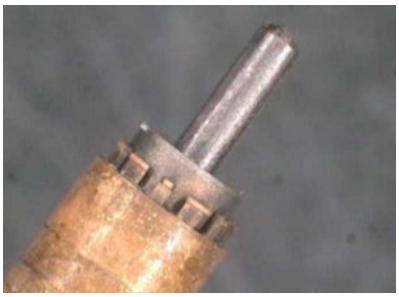


Fig 1: Micro fluidic actuator from M. De Volder et al.

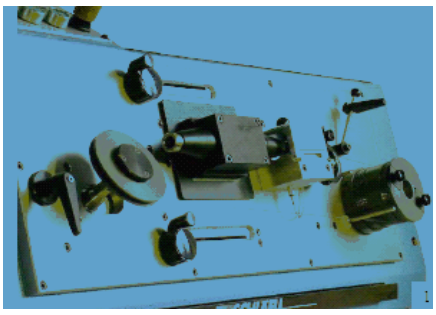


Fig 2: Commercial wire polishing machine from Schlafli

4 - 1 - 2 Objective

The goal of this research is to design and fabricate a wire polishing setup for a small tube and make some experiments to evaluate the polishing effect.

4 - 2 Material and Method

4 - 2 - 1 Mechanism of wire polishing

Figure 3 depicts the cross-section of a cylinder through which a polishing wire is pulled. We will exert some force on the tube to push it against the wire. The tube turns and the wire moves back and forth, so that the wire can polish the inner wall of the tube. We have to decide the way how we fix and rotate a tube, the type of work piece holder, a wire type and the abrasive.

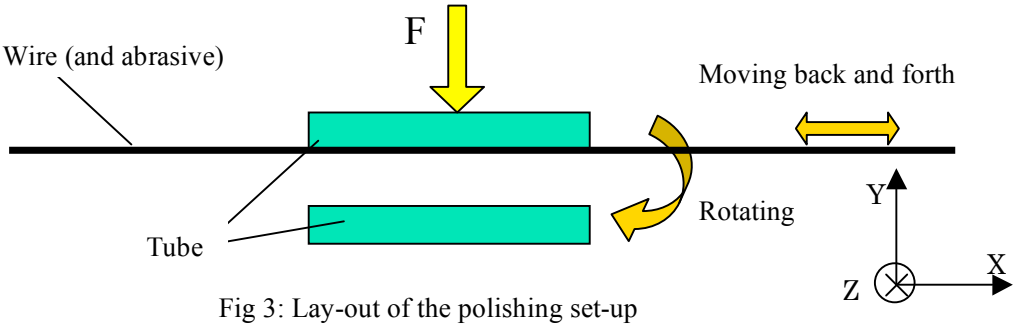


Fig 3: Lay-out of the polishing set-up

4 - 2 - 2 Work piece drive

Work piece drive is a structure which turns and grips a tube. Several features are required to the work piece drive. The work piece drive should fix a translation of the tube along X-axis which is parallel to the polishing wire in order to avoid changing the tube position by a friction force between wire and inner wall of the tube. On the other hand, we should not disturb a free translation in Y-Z plane in order to keep the symmetrical property in Y-Z plane, otherwise it is quite difficult to polish the tube parallel to the hole. The other properties that we require are rotation freedom around the Y and the Z axis, operation stability, design simplicity and abrasive compatibility.

Considering these factors, we designed the work piece drive. Figure 4 shows an image of the work piece drive. We can see hinges holding a shaft in this figure. These hinges will limit the movement along X-axis and allow moving in the Y-Z plane. The grooved pulley which is in the middle of 2 hinges will attach to the work piece (or work piece holder) and rotate it. Figure 5 is a picture of the hinge and grooved pulley structure.

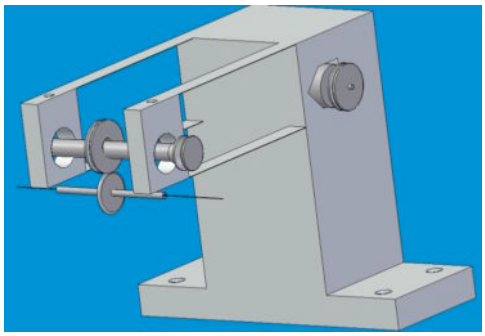


Fig 4: Work piece drive

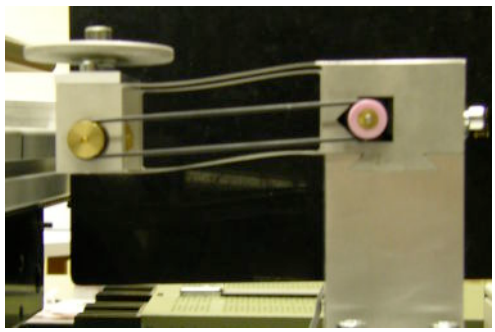


Fig 5: A picture of the work piece drive

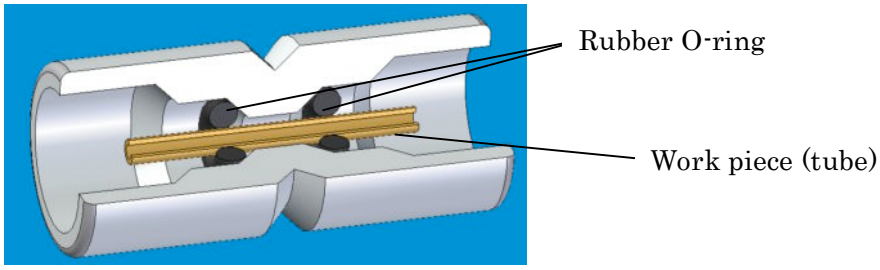
4 - 2 - 3 Work piece holder

We require that a work piece holder which allows using various kinds of tube regardless of its diameter and the centre of the work piece holder should coincide with the centre of the polished tube precisely because we want to polish the tube with keeping its symmetrical property.

Figure 6-1 is an image of the holder. Two rubber O-rings are put inside a work piece holder and these rubber O-rings grip the polished tube. If we use rubber rings which have different inner

diameters, we can clamp various tubes. Figure 6-2 is a picture of the work piece holder. After putting rubber O-ring in the work piece holder, different metal tubes and plastic screws are put from the both ends of the work piece holder to fix the rubber O-ring at the right position. Figure 6-3 is a work piece holder with all these components.

1



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3

Fig 6: Pictures of the work piece holder with rubber rings

4-2-4 Wire

Some coiled wire, such as piano string or guitar string is well-suited to the polishing wire. It is slender but quite tough. It has a spiral structure and its groove can catch and pull the abrasive slurry through the tube that needs to be polished. In this research, we used this type of coiled wire (see Figure 7). For using abrasive, we prepared an abrasive collector under the wire. We will also design an abrasive supplying machine in the future.

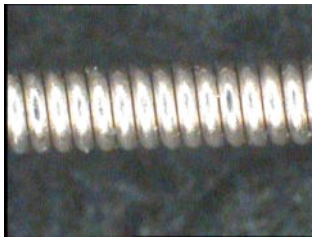


Fig 7: Enlarged view of a guitar wire

4-2-5 Abrasive

It is important to find the most suitable abrasive for this small tube polishing.

At first, we have to choose a particle size of abrasive. If the diameter of abrasive powder is too big, the abrasive will scratch the surface and leave scars. If the diameter is too small, the abrasive will be

no help for polishing. Secondly, we have to decide the material of abrasive. There are some materials for the abrasive; **$CaCO_3$, SiO_2, CeO_2, Al_2O_3** and **Diamond**. Each material has its property. The table 1 shows the hardness and usual usage of these abrasives.

We will use a brass tube as a polished tube in the first test and the brass is soft metal. Therefore, Al_2O_3 will be suitable. WC (Tungsten Carbide) will be tested next. WC is relatively hard metal, so diamond will be suitable.

Table 1: Comparison of abrasive

Hardness	**Material**	**Abrasive for**
Soft ↕ Hard	$CaCO_3$	Tooth paste
	SiO_2	Silicon wafer polishing
	CeO_2	Glass lens polishing
	Al_2O_3	Metal polishing
	Diamond	Hard metal polishing

4 - 3 Experiment

4 - 3 - 1 Setup

We have fabricated a work piece drive, a work piece holder and an abrasive collector and prepared several types of wire, which are diamond coated wire, coiled wire, guitar wire and piano wire. Then all these components are assembled. Figure 8 shows a setup of wire polishing machine. The wire moves along horizontal axis, switching by the optical sensor.

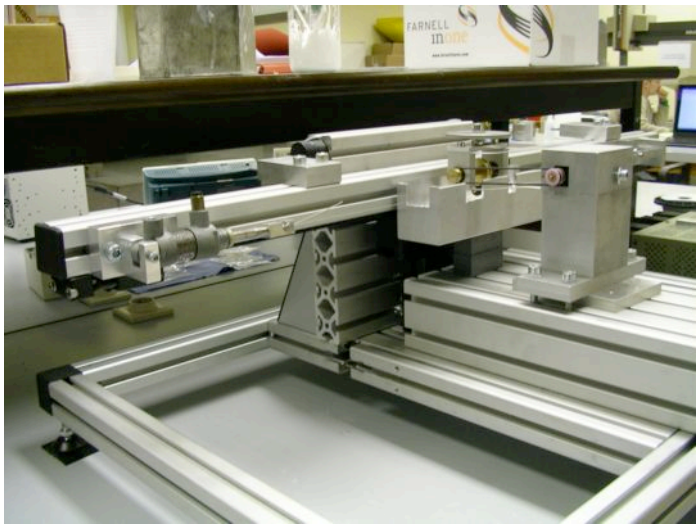


Fig 8: A wire polishing machine

4 - 3 - 2 Abrasive

We tested the polishing effect of abrasive. Experimental conditions are showed below.

<Work piece>

Inner Diameter: 0.8mm

Outer Diameter: 1.5mm

Length: 15mm

Material: Brass

<Polishing>

Rotation speed of the tube: 2.5 rotation/s

The wire length of one stroke: 53.5cm

Total polishing: 200stroke (10 minutes)

We polished a brass tube with three different abrasive. By way of comparison, no polished tube is included.

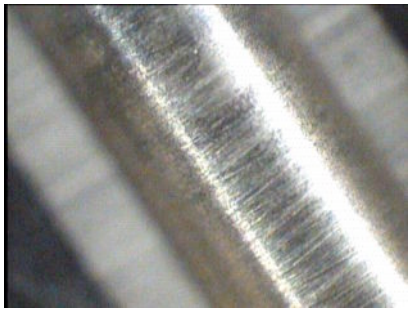
1 No polished tube

2 Polished without abrasive

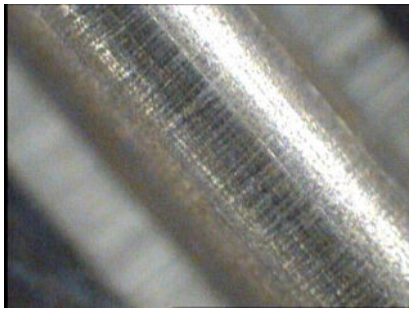
3 Polished with Diamond paste (1μm)

4 Polished with Diamond paste (1μm) and Al_2O_3 (200 stroke with each abrasive)

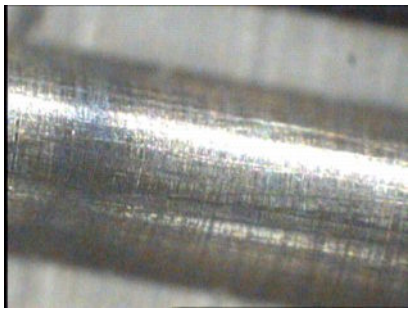
Unfortunately, a surface roughness measuring machine was out of order, so we could not evaluate them only by their optical images. Figure 9 shows each polished surface of the tube. In the Figure 9-1, 2 and 3, we can see many scratches vertical to the cylindrical axis. This may be a scratch made by a drill to make a hole. In the Figure 9-4, there seems to be no scratch, so it proved that Al_2O_3 is suitable for the brass polishing.



1: No polished tube



2: Polished without abrasive



3: Polished with diamond paste

4: Polished with diamond paste and Al_2O_3

Fig 9: Polished surfaces

4-3-3 Straightness Accuracy

We cut the polished tube and measure the inner diameter of each part so that we checked whether the tube was polished parallel to the hole of the tube (see Figure 10). We measured the length of inner diameter and circularity of the both ends of the cut tube. Figure 11 is a graph of this measurement. The graph shows that there is relatively big irregularity between the end and the centre of the tube. It is strange that the inner diameter of the end part is smaller than that of the centre part.

It may indicate that the work piece holder did not grip the tube well in this case, so it is necessary to test again.

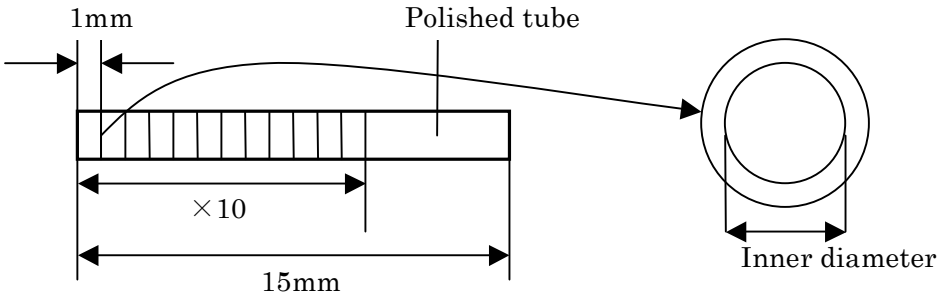


Fig 10: Cut a polished tube and measure the inner diameter

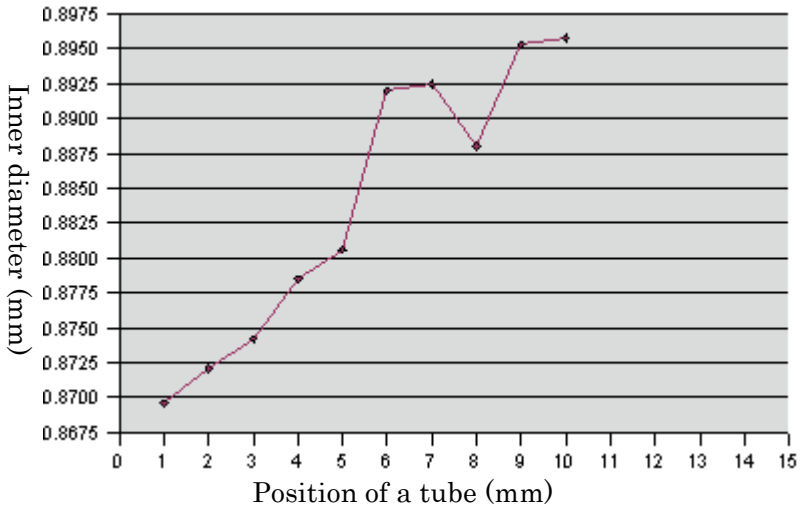


Fig 11: Graph of position of the tube and inner diameter

4 - 4 Conclusion

4 - 4 - 1 Problem

The tube was not polished parallel to the hole of the tube as shown in the result of 3-4. We have to improve this miss alignment somehow.

We have not found the most suitable abrasive yet. The result of this research suggested that Al_2O_3 is better choice, but we should test the diamond paste with smaller particles or other softer abrasive.

4 - 4 - 2 Conclusion

When we compare a tube polished by diamond paste and Al_2O_3 with no polished tube, we can see a clear difference that the polished tube has better surface quality. It means that this wire polishing machine is useful to polish inside wall of a small tube. The machine also leaves a lot of room for improvement, so more experiments are required.

4 (2) Lecture in Denmark

"Plug-in a Visualization to WINAMP"

4 - 1 Abstract

There is a music classification soft. To combine the soft with some graphical contents, we can achieve the visualization of the music genre. In this project, I wrote the graphical content with OpenGL and plug-in to WINAMP.

4 - 2 What I have done

1. Learning what the OpenGL is and how to operate it

I learned OpenGL by reading the tutorial. It was difficult to understand every parts of the source code within this very short period, but at least I understood the way of writing several 3D objects which are pyramid or rectangular, texture binding to the surfaces of objects and simple transfer and rotation. Then I wrote a cube which each plane is bond with texture of some music genres (see Figure 1). I called this cube "texture cube".

Fig 1: 3D cube with texture (written by OpenGL)

2. Plug-in the graphical contents to WINAMP

For the next step, I attached this 3D image (texture cube) to WINAMP.

3. Combining graphics with music classification soft

I combined the 3D image, cube texture, with music classification soft and made a system to show the image suitable to the music category. I will explain the structure of this system.

There are 21 categories of music and the music classification soft calculates the strength of each parameter. Figure 2 shows the process of calculating. Then, it also calculates which element of category is the strongest and returns the number of the strongest category. According to this number, the cube texture shows certain plane. The result of display is showed in Figure 3. In this project, I categorize these 21 music categories into 6 categories to make the source code simpler.

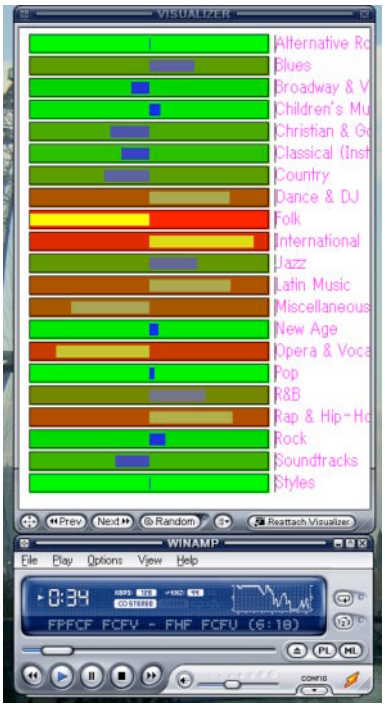


Fig 2: Process of calculating the music parameter

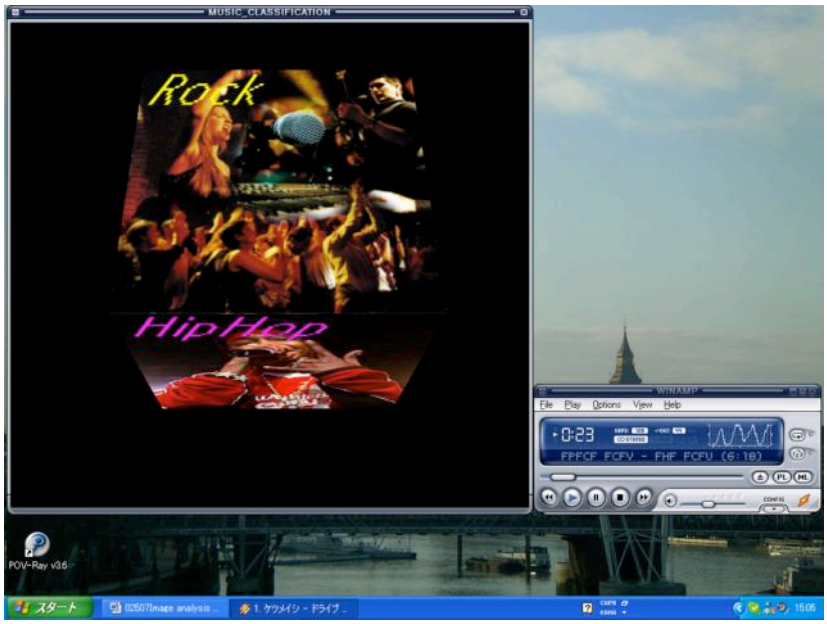


Fig 3: Texture cube combined with result of music classification

4 - 3 Result and Discussion

I succeeded that I combined the music classification soft with graphical contents but there is still large room for improving this system. I will count three points to change.

First, only the maximum element is displayed and all other elements are neglected in this project. We should show the medieval elements somehow.

Secondly, some music categories always have high point regardless of what kinds of music play. For example, when WINAMP played typical classical music, the elements of Jazz or Folk still have higher point than that of classical.

The last point is the texture is too simple to make viewer enjoy. We should replace the texture by the animation, otherwise the display must be boring.

5 Exchange student life (max 2 pages)

The Life in Belgium

Research style in Katholieke Universiteit Leuven is a little different from that of Japan. Japanese laboratory has strong solidarity. On the contrary, students in Leuven work independently. They have more responsibility to the research one by one. The buildings of our mechanical department are apart from the centre of Leuven, so I have little opportunity to contact with students in other department. I hope that I could communicate with many students.

It takes whole two week for me to find an accommodation in Leuven. I hope the University prepared our place to live before I go there. It takes a lot of trouble to find an accommodation and I can not feel ease during this period of time. I always go around the city by bike in the daily life. Most of the stores in Leuven are close at 6pm and even the supermarket is close at 8pm. Almost every store is close on Sundays. I think it is inconvenient because we have to buy large amount before every Sundays.

Katholieke Universiteit Leuven is the main facility in Leuven and there lives so many students, so many restaurant and barber shops have students discount. Buses in Leuven are free for students and sports centre is also free.

Beers are very popular in Belgium, so there are many bars in Leuven. I tasted nearly 100 kinds of beers when I was in Leuven. Actually beer is my best pleasure in the daily life.

Most buildings in Belgium are old fashion and people try to keep those style. They have several common languages, such as Flemish which is similar to Dutch, French and German. Most of people can speak English fluently, so we may not feel any stress if you can use English.

The Life in Denmark

I expected that Denmark is a very cold country but it is not so cold compared to other European countries. It is from 0 to -7 degrees C, so we can bear the cold by wearing the certain outfits. However, it is stressful that snowy and cloudy days continued for many days and we can rarely see the sunlight.

I lived in a dormitory for exchange students and I could meet many exchange students from all over the world. It was quite fun and comfortable to stay in the dormitory.

Travel around the Europe

Belgium is placed at the centre of Europe, so I could travel easily to other European countries. Actually, I traveled around 13 countries during this exchange life. I visited many famous and big cities such as Paris, London, Rome, Brussels and Berlin. Each country has their own traditional

cultures and they impressed me very much. I also feel the power of Christ. I can find several huge churches in every country.

6 Summary

There are no doubt that this exchange program gives us a significant experience. I could feel the style of Europe researches and cultures. Personally speaking, to go to Europe is one of my biggest dream, so I was moved very much when I met the monuments of Rome and Barcelona, the paintings of Renoir, Vermeer and Gogh, and the opera in Vienna. I have never spent such wonderful and amazing five months ever before.