Surveillance of dairy animals using a smartphone-based system

DESIGN DOCUMENT

DEC1616
Client
MENG LU
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Xin Tong: App development (Skill: X-code)
Di Zhao: Mount design and 3D printing (Skill: Solidworks)
Le Wei: Optical design (Skill: Code V)
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1 Introduction

1.1 PROJECT STATEMENT

We want to use the smart phone to precede the fluorescence polarization assay kit. Fluorescence polarization techniques are particularly useful for inter-molecular interactions. This method is direct and immediate detection of the bound tracer molecules / free rate. Considering smart phone is popular in these years. Our project will make a new device to replace traditional spectroscopic instruments. We want use CCD camera in smart phone to replace the detector (PMT) to assay the result. In order to reach the purpose for our project. We must to design the new equipment. Different software will be used to design the project. For the first part: Xin Tong studies the X-Code to development the APP for the iPhone, which can provide the picture data for the fit. For the second part: Tianqi Luo learns about Fluorescence polarization assay and Lei Wei and Di Zhao design the optical structure.

1.2 PURPOSE

Fluorescence polarization plays an increasingly important role in many areas of life science. Most hospital use FP assay C-reactive protein to discover disease and follow up the disease. Fluorescence polarization is more safe and reliable, which does not pose a threat to the researchers, it does not produce radioactive waste is difficult to handle. In addition, FP required less sample, high sensitivity, good reproducibility and easy operation. In our project we want use advantage of fluorescence polarization without the inconvenient traditional spectroscopic instruments. Considering a lot of factors. We want to use the smart phone to replace detector (PMT). Because smart phone is popular today and CCD camera can achieve the same function as photomultiplier. Our project uses the advantage of fluorescence polarization and convenience of smart phone, which will be more easily to make medicine assay, blood assay and many areas. So our project will make a big effect in many areas of life science.

1.3 GOALS

For this senior design project has different parts. For the final goal we want to design a device and application for iPhone. Our new device can use iPhone to make a fluorescence polarization assay. So our project will be more easily to make medicine assay, blood assay and many areas than traditional spectroscopic instruments. As a list for our parts' goals:

(1) Designing the correct optical model to allow the laser attach the destination by polarization and reflection.

(2) Using Solidwork to design the structure to hold the optical units and smartphones.

(3) Developing an application for iPhone and use iPhone's camera to read the data.

(4) Using the achieved data to analyze by fluorescence polarization assay.

2 Deliverables

The advantage of our project is that uses CCD camera to replace the traditional detector (PMT). In order to finish our project we must make a new device. There is our to-do list:

(1) Using the Code V to design the optical simulation in the computer. If the optical simulation can success.

(2) We will use the Solidwork to design the structure to hold the optical component and iPhone. Then we will send our Solidwork file to 3D print and get real structure.

(3) Developing app for iPhone will provide necessary data from sample for people to assay.

(4) Assaying data by fluorescence polarization way.

So the optical design, app development, Solidwork design and fluorescence polarization assay are all the most important parts for our project. Just because every part is important and independent. So every goals is necessary for our project. We only finish every goals step by step, which will accomplish the final goals to make a perfect device and app for medicine assay, blood assay and other life sciences.

3 Design

Include any/all possible methods of approach to solving the problem. Discuss what you have done so far. What have you tried/implemented/tested etc. We want to know what you have done.

3.1 SYSTEM SPECIFICATIONS

3.1.1 Non-functional

a. We need to adjust the lens and mirrors to get the images. We not only need to know how the camera which in the smart phone worked, but also need to know how to operate which is the exact same way for changing the attributes of an image.

b. We need to know what polarization is, and make sure that we can let others know what it is. We have three EE students, and one of us will explain to others clearly about what the polarization is so clients would know what effect such analysis can create.

c. People need to provide their email addresses, and then we can send the analysis information of the image to them. The analysis data could only be collected by sending emails; otherwise, when starting the analysis, the previous one will be deleted.

3.1.2 Functional

a. First part is the mechanical part. We want to use the camera and lens, which are in our smartphone. The phone's camera can collect the image accurately, which the essence is to hold the position of the phone well.

b. Second part is embedded optical part; we can see the reflection dimension of the object clearly from the smartphone camera. The dimension of the object is reflected by two general glasses mirror, and we need to add some lens to collect the lights.

c. Another part is application part, during scanning. We can analyze the polarization intensity from the line-chart by clicking on any two spot of the image. Polarization is calculated by the special formula, we programmed it into the app.

d. When analyzing the image, we can see the object's horizontal and side image, as the original object is 3-dimensional. Since the screen is a 2-dimensional, we need to decompose the 3-dimensional real object into 2-dimensional

3.2 PROPOSED DESIGN/METHOD

We hope that we can analyze the data by using our mobile phone. We can analyze their wavelength and bands. Through repeated comparison and testing, we can collect the accurate data. We believe that our people can use their phones to test their blood samples in the future. Humans can detect their blood samples by using any mobile device.

The whole design is divided into four parts. The first part is the theory, we studied many papers to determine use which kind of method to excite fluorescent molecules in our sample. The second part is the optical design, with the guidance of our professor, we try a variety of optical design. We try to make the model as small as possible. After we finished optical design, we began the third part the 3D printer. We can make our model can match our smart phone or other device. The last part is the development of APP. It allows mobile devices to detect a variety of samples.

3.3 DESIGN ANALYSIS

We have made a preliminary model, when we set other components into our model. We can see two clear spot on the sensor. This is consistent with our optical design. But our APP cannot analyze samples. And we hope that the model can be made smaller. Thus, we decided to change our optical design portion. At the same time we can enough time to improve our APP. And also we can find more paper to improve our theoretical basis.

4 Testing/Development

4.1 INTERFACE SPECIFICATIONS

The software we are currently working on is the app on IPhone. Since our goal is to collect the samples from CCD and displays them through an application, this interface is going to be an app called 'Cylambda'. This part is all done by Xin Tong, so he will handle all of this part of discussion.

4.2 HARDWARE/SOFTWARE

From Xin Tong's experience: The previous senior designers have taken turns to fix and complete more of the code, and then as I am taking this turn, however, our instructor found that the rectangle capture tool could not precisely capture the polarization from the sample, so my job is to create code that modify capture tool from rectangle shape to circular shape.

From Tianqi Luo and Le Wei's experience: During the meeting with instructor, the most important thing that instructor Lu always emphasizes is to test whether the image refracted is precisely going through the small spot. The laser beam shines through the object, and the image will be reflected from two angled mirrors, and then refracted thought the lens to get an real image.

4.2 PROCESS

Xin:

1. Being as an apple developer and setup my device as the developing reference.
2. Run the code on my device, and take a browse on this app, and indicate the polarization capture function.
3. Go through the code and find the function that processes the polarization capture tool.
4. Write a brief plan that describes how I am going to change the shape of this tool into circular one.

Tianqi Luo and Le Wei:

1. Measure the reflection angle, and the distance between object and lens in theory.
2. Calculate where the two mirrors need to be set, including their distance.
3. These data need to be given to Di Zhao for structure design.

5 Results

Since we haven't combined our work together, we are still onto individual testing.

Xin has successfully run the code onto his device, but the modification task is just starting. Based on the speed of development. APP for our project may test kits and give some sample data.

Di Zhao has made her structure on Solidworks well, but since we haven't got the actual object printed from 3D printer. Only we combine the optical model in Code V with Solidworks structure model and make some size change. Di Zhao will send Solidworks file to some companies to print the real structure.

Le Wei is designing the whole optical model. Le Wei uses the Code V to design the model and have already to make the four different versions.

Tianqi Luo is finding the fluorescence polarization kits in Internet and buys some kits. Then Tianqi Luo will take the kits to Bio-center to collect data and compare with our data from our device.

6 Conclusions

Our project is more challenge for us, as we told before we learned more about the knowledge that we never toughed, so we should send much time to study and totally understand every detail about the software that we learned. For our team we separate four parts for four team members. Each week we have our own tasks to do. If we met some problems that during the process, we will send the email to our group mentor: Zijian Zhao or our instructor: Meng Lu. The meeting time with advisor holds on Tuesday 11: 00 every week, our team meeting holds on three times each week. After finished the meeting we should write the TO-DO list and send the advisor to check. The beneficial of this project in the future that is the APP will be appear on the market, it should be make contribution to the field of medicine and life science because through the APP it can easily to get the data to analyze, small molecules substances such as drugs content in the sample.

So far, we have made great progress. We go over and over to change our optical design. Now we succeeded. We can see two different spots in the sensor. This is exactly as our previously thought. The current issue is that, we hope can make this model as small as possible. And we also need time to improve our APP. Thus, We will pay more attention on the developing of APP for next week. We believe that, at the end of this semester, we can use our smart phone to analysis simple samples.

7 References

List any references used in the document.

Reference for paper:

1>. (*Smartphone Fluorescence Spectroscopy*)

2>. (*Pierce® Fluorescent Protease Assay Kit*)

3>. (*Fluorescence Polarization in Life Science*)

References for videos (YouTube)

4>. *SolidWorks Tutorials*

http://www.youtube.com/watch?v=cy3ExIAcI2Y (part 1/3)

https://www.youtube.com/watch?v=ll_9D6J2yTo (part 2/3)

https://www.youtube.com/watch?v=0fYL-lCrEv4 (part 3/3)

5> **Code V Study:**

Code V Optical Design Software:

https://www.youtube.com/watch?v=6-wIkoiwvXo

https://optics.synopsys.com/codev/?gclid=CICXjtu6hMsCFQgxaQodo1ILJg

https://optics.synopsys.com/learn/learn-student-license.html

6> **optical design**

https://lightmachinery.com/optical-design-center/

http://www.zemax.com/

http://www.atmos-software.it/Atmos.html

7> **Fluorescence Polarization assay kit**

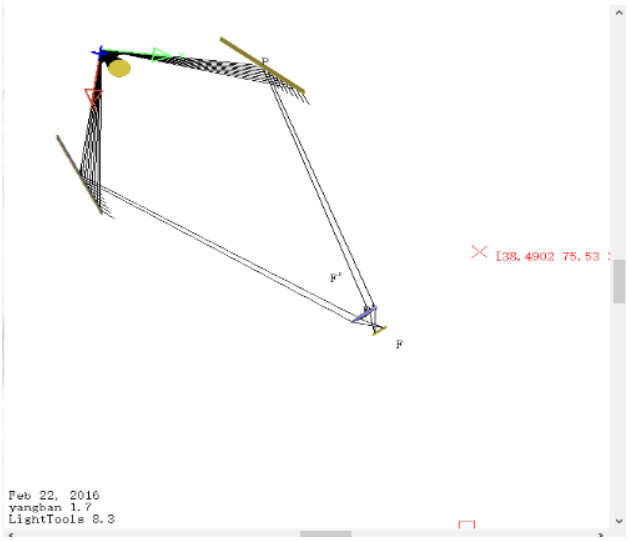
https://www.youtube.com/watch?v=HiG6KWkkrV4

https://www.youtube.com/watch?v=OdBNVrPvJMY

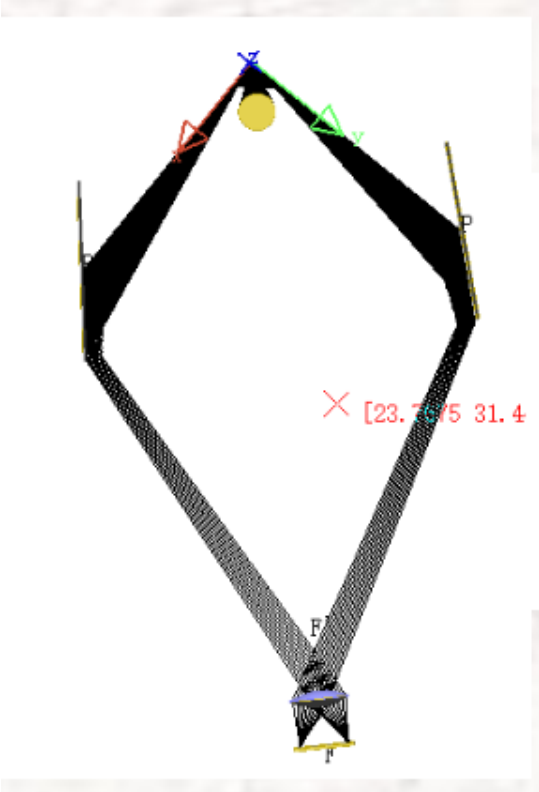
8 Appendices

```
//changing shape, TODO:
- (void)drawRect:(CGRect)rect {
    CGContextRef context = UIGraphicsGetCurrentContext();
    CGContextSaveGState(context);

    // (1) Draw the bounding box.
    CGContextSetLineWidth(context, 1.0);
    CGContextSetStrokeColorWithColor(context, [UIColor blueColor].CGColor);
    CGContextAddRect(context, CGRectInset(self.bounds, kSPUserResizableViewInteractiveBorderSize/2,
        kSPUserResizableViewInteractiveBorderSize/2));
    CGContextStrokePath(context);

    // (2) Calculate the bounding boxes for each of the anchor points.
    CGRect upperLeft = CGRectMake(0.0, 0.0, kSPUserResizableViewInteractiveBorderSize,
        kSPUserResizableViewInteractiveBorderSize);
    CGRect upperRight = CGRectMake(self.bounds.size.width - kSPUserResizableViewInteractiveBorderSize, 0.0,
        kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize);
    CGRect lowerRight = CGRectMake(self.bounds.size.width - kSPUserResizableViewInteractiveBorderSize, self.bounds.size.
        height - kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize,
        kSPUserResizableViewInteractiveBorderSize);
    CGRect lowerLeft = CGRectMake(0.0, self.bounds.size.height - kSPUserResizableViewInteractiveBorderSize,
        kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize);
    CGRect upperMiddle = CGRectMake((self.bounds.size.width - kSPUserResizableViewInteractiveBorderSize)/2, 0.0,
        kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize);
    CGRect lowerMiddle = CGRectMake((self.bounds.size.width - kSPUserResizableViewInteractiveBorderSize)/2, self.bounds.
        size.height - kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize,
        kSPUserResizableViewInteractiveBorderSize);
    CGRect middleLeft = CGRectMake(0.0, (self.bounds.size.height - kSPUserResizableViewInteractiveBorderSize)/2,
        kSPUserResizableViewInteractiveBorderSize, kSPUserResizableViewInteractiveBorderSize);
    CGRect middleRight = CGRectMake(self.bounds.size.width - kSPUserResizableViewInteractiveBorderSize, (self.bounds.size.
        height - kSPUserResizableViewInteractiveBorderSize)/2, kSPUserResizableViewInteractiveBorderSize,
        kSPUserResizableViewInteractiveBorderSize);

    // (3) Create the gradient to paint the anchor points.
    CGFloat colors [] = {
```

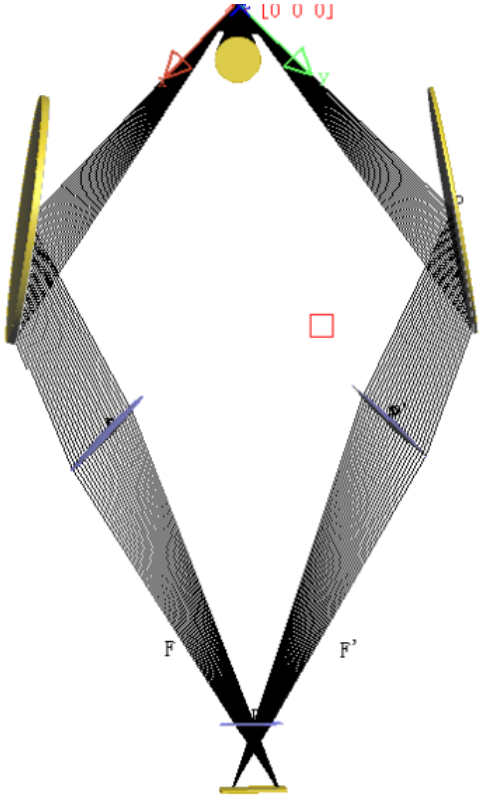
Optical 1.0



2.0



3.0



Final 4.0