机器视觉作业8

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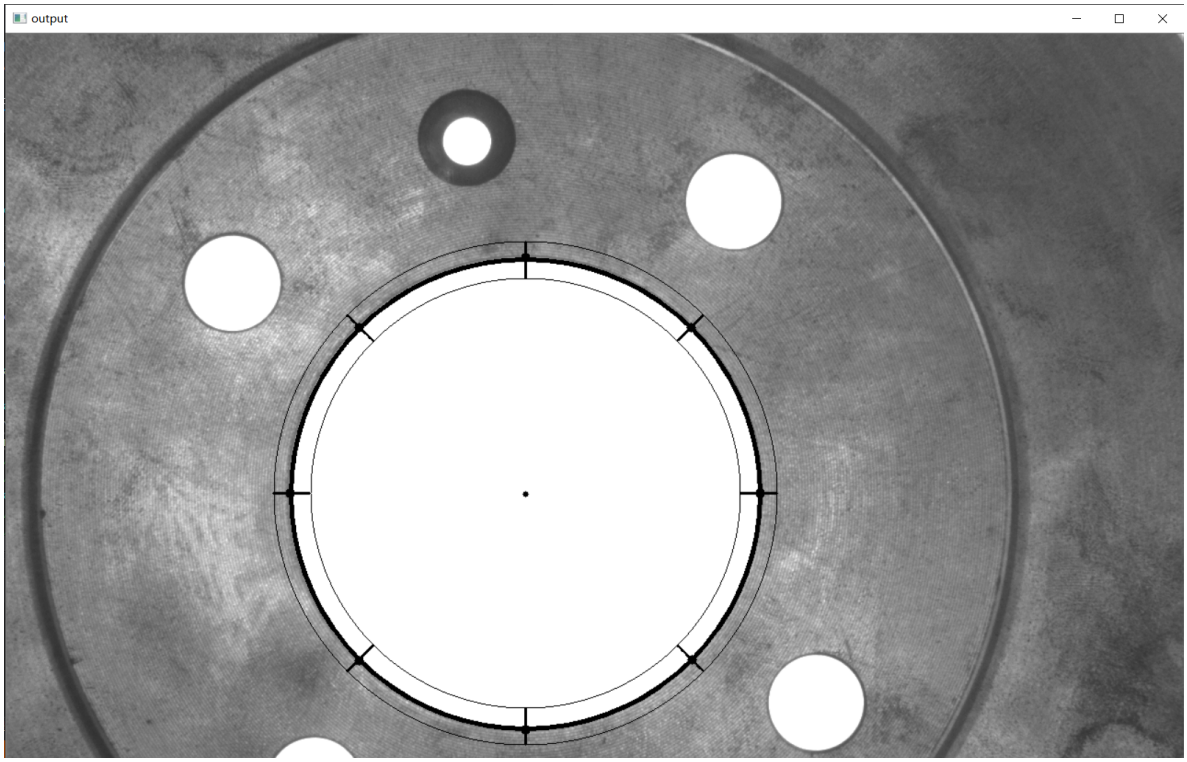
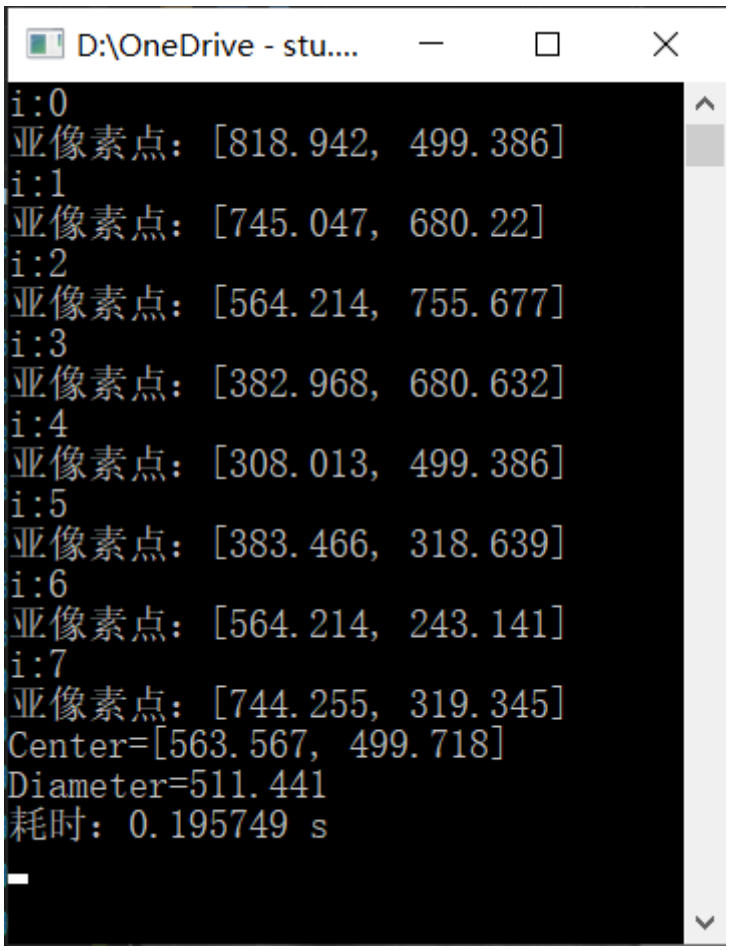
0.结果





1.代码

```
//
// Created by chrisliu on 2020/4/9.
//

#include <iostream>
#include <opencv2/opencv.hpp>
#include <opencv2/core/core.hpp>
#include <opencv2/imgproc/imgproc.hpp>
#include <opencv2/highgui/highgui.hpp>

using namespace std;
using namespace cv;

#define PI 3.1415926535

//拟合圆
Point3f LeastSquareFittingCircle(vector<Point2f> temp_coordinates)//高斯消元法直接求解方程组
{
    float x1 = 0;
    float x2 = 0;
    float x3 = 0;
    float y1 = 0;
    float y2 = 0;
    float y3 = 0;
    float x1y1 = 0;
    float x1y2 = 0;
```

```
    float x2y1 = 0;
    int num;
    vector<Point2f>::iterator k;
    Point3f tempcircle;
    for (k = temp_coordinates.begin(); k != temp_coordinates.end(); k++)
    {

        x1 = x1 + (*k).x;
        x2 = x2 + (*k).x * (*k).x;
        x3 = x3 + (*k).x * (*k).x * (*k).x;
        y1 = y1 + (*k).y;
        y2 = y2 + (*k).y * (*k).y;
        y3 = y3 + (*k).y * (*k).y * (*k).y;
        x1y1 = x1y1 + (*k).x * (*k).y;
        x1y2 = x1y2 + (*k).x * (*k).y * (*k).y;
        x2y1 = x2y1 + (*k).x * (*k).x * (*k).y;
    }
    float C, D, E, G, H, a, b, c;
    num = temp_coordinates.size();
    C = num * x2 - x1 * x1;
    D = num * x1y1 - x1 * y1;
    E = num * x3 + num * x1y2 - x1 * (x2 + y2);
    G = num * y2 - y1 * y1;
    H = num * x2y1 + num * y3 - y1 * (x2 + y2);
    a = (H * D - E * G) / (C * G - D * D);
    b = (H * C - E * D) / (D * D - G * C);
    c = -(x2 + y2 + a * x1 + b * y1) / num;
    tempcircle.x = -a / 2; //圆心x坐标
    tempcircle.y = -b / 2;//圆心y坐标
    tempcircle.z = sqrt(a * a + b * b - 4 * c) / 2;//圆心半径
    return tempcircle;
}

//拟合曲线
bool polynomial_curve_fit(std::vector<cv::Point2f>& key_point, int n, cv::Mat&
A)
{
    //Number of key points
    int N = key_point.size();

    //构造矩阵X
    cv::Mat X = cv::Mat::zeros(n + 1, n + 1, CV_32FC1);
    for (int i = 0; i < n + 1; i++)
    {
        for (int j = 0; j < n + 1; j++)
        {
            for (int k = 0; k < N; k++)
            {
                X.at<float>(i, j) = X.at<float>(i, j) +
                    std::pow(key_point[k].x, i + j);
            }
        }
    }

    //构造矩阵Y
    cv::Mat Y = cv::Mat::zeros(n + 1, 1, CV_32FC1);
    for (int i = 0; i < n + 1; i++)
    {
```

```
        for (int k = 0; k < N; k++)
        {
            Y.at<float>(i, 0) = Y.at<float>(i, 0) +
                std::pow(key_point[k].x, i) * key_point[k].y;
        }
    }

    A = cv::Mat::zeros(n + 1, 1, CV_32FC1);
    //求解矩阵A
    cv::solve(X, Y, A, cv::DECOMP_LU);
    return true;
}

Mat Circle_Detection(Mat input)
{
    int rows = input.rows;
    int cols = input.cols;

    Mat output = Mat::zeros(rows, cols, CV_8UC1);
    int temp = 0;
    for (int i = 0; i < rows; ++i)
    {
        temp = abs(input.at<uchar>(i, 1) - 0) / 2;
        if (temp > 50)
            output.at<uchar>(i, 0) = 255;
        for (int j = 1; j < cols - 1; ++j)
        {
            temp = abs(input.at<uchar>(i, j + 1) - input.at<uchar>(i, j - 1)) /
2;
            if (temp > 50)
                output.at<uchar>(i, j) = 255;
        }
        temp = abs(0 - input.at<uchar>(i, cols - 2)) / 2;
        if (temp > 50)
            output.at<uchar>(i, cols - 1) = 255;
    }
    vector<vector<Point> > contours;
    vector<Vec4i> hierarchy;
    findContours(output, contours, hierarchy, RETR_TREE, CHAIN_APPROX_SIMPLE,
Point(0, 0));
    vector<Point3f> mems_circle;
    for (int i = 0; i < contours.size(); ++i)
    {
        int increment = contours[i].size() / 8;
        if (increment > 10)
        {
            vector<Point2f> circle_coordinate;
            for (int j = 0; j < 8; ++j)
            {
                circle_coordinate.push_back(contours[i][j * increment]);
            }
            mems_circle.push_back(LeastSquareFittingCircle(circle_coordinate));

        }
    }

    Point3f circle_temp = mems_circle.back();
    float x = circle_temp.x;
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```
    float y = circle_temp.y;
    float r = circle_temp.z;

    Mat output_GRAY = input.clone();
    int radius_param = 20;
    circle(output_GRAY, Point2f(x, y), r + radius_param, Scalar(0));
    circle(output_GRAY, Point2f(x, y), r - radius_param, Scalar(0));

    float increment_degree = 2 * PI / 8;
    //cout << increment_degree << endl;
    vector<Point2f> fitting_points;
    for (int i = 0; i < 8; ++i)
    {
        cout << "i:" << i << endl;

        //扫描线采样
        vector<Point3f> edge;
        for (int j = 0; j < 2 * radius_param; ++j)
        {
            float temp_r = r - radius_param + j;
            float temp_x = x + temp_r * cos(increment_degree * i);
            float temp_y = y + temp_r * sin(increment_degree * i);
            Point3f edge_temp;
            //采样点坐标（相对于初始圆点）
            edge_temp.x = temp_x - x;
            edge_temp.y = temp_y - y;
            //采样点灰度值
            edge_temp.z = input.at<uchar>(temp_y, temp_x);
            circle(output_GRAY, Point(temp_x, temp_y), 1, Scalar(0), -1);
            //cout << edge_temp << endl;
            edge.push_back(edge_temp);
        }

        //扫描线一阶导
        //cout << "derivate" << endl;
        vector<Point3f> edge_derivate = edge;
        float derivate_max = 0;
        int derivate_maxIndex = 0;

        edge_derivate[0].z = abs(edge[1].z - 0) / 2;
        for (int k = 1; k < edge.size() - 1; ++k)
        {
            float derivate = abs(edge[k + 1].z - edge[k - 1].z) / 2;
            if (derivate > derivate_max)
            {
                derivate_max = derivate;
                derivate_maxIndex = k;
            }
            edge_derivate[k].z = derivate;
            //cout << derivate << endl;
        }
        edge_derivate[edge.size() - 1].z = abs(0 - edge[edge.size() - 2].z) / 2;
        //cout << "derivate_maxIndex=" << derivate_maxIndex << endl;

        //进行抛物线的拟合
        vector<Point2f> fitting_data;
        float init_x = edge_derivate[derivate_maxIndex - 2].x;
        float init_y = edge_derivate[derivate_maxIndex - 2].y;
```

```
        for (int k = 0; k < 5; ++k)
        {
            int temp_index = derivate_maxIndex - 2 + k;
            //cout << "temp_index"<<temp_index << endl;
            Point2f temp_data;
            temp_data.x = sqrt(pow(edge_derivate[temp_index].x - init_x, 2) +
pow(edge_derivate[temp_index].y - init_y, 2));
            temp_data.y = edge_derivate[temp_index].z;
            fitting_data.push_back(temp_data);
        }
        Mat A;
        polynomial_curve_fit(fitting_data, 2, A);
        float a0 = A.at<float>(0, 0);
        float a1 = A.at<float>(1, 0);
        float a2 = A.at<float>(2, 0);
        /*cout << "a0=" << a0 << endl;
        cout << "a1=" << a1 << endl;
        cout << "a2=" << a2 << endl;
        cout << "xmax=" << -a1 / (2 * a2) << endl;*/
        float fitting_r = -a1 / (2 * a2);
        Point2f fitting_p(x + init_x + fitting_r * cos(increment_degree * i), y
+ init_y + fitting_r * sin(increment_degree * i));
        circle(output_GRAY, fitting_p, 5, Scalar(0), -1);
        cout << "亚像素点：" << fitting_p << endl;
        fitting_points.push_back(fitting_p);

    }

    Point3f fitting_round = LeastSquareFittingCircle(fitting_points);
    circle(output_GRAY, Point2f(fitting_round.x, fitting_round.y),
fitting_round.z, Scalar(0), 3);
    circle(output_GRAY, Point2f(fitting_round.x, fitting_round.y), 3, Scalar(0),
-1);
    cout << "Center=" << Point2f(fitting_round.x, fitting_round.y) << endl;
    cout << "Diameter=" << 2 * fitting_round.z << endl;

    return output_GRAY;
}

int main(int argc, char** argv)
{
    Mat inputImg = imread("D:/OneDrive -
stu.hit.edu.cn/Lessons/Machine_Vision/Homeworks/9/brake_disk_part_06.png");
    cvtColor(inputImg, inputImg, COLOR_RGB2GRAY);
    imshow("inputImg", inputImg);
    //计时
    double time_consumed = cv::getTickCount();
    Mat output = Circle_Detection(inputImg);
    time_consumed = (cv::getTickCount() - time_consumed) /
cv::getTickFrequency();
    cout << "耗时：" << time_consumed << " s" << endl;
    imshow("output", output);
    waitKey(0);
    return 0;
}
```