MonoVo

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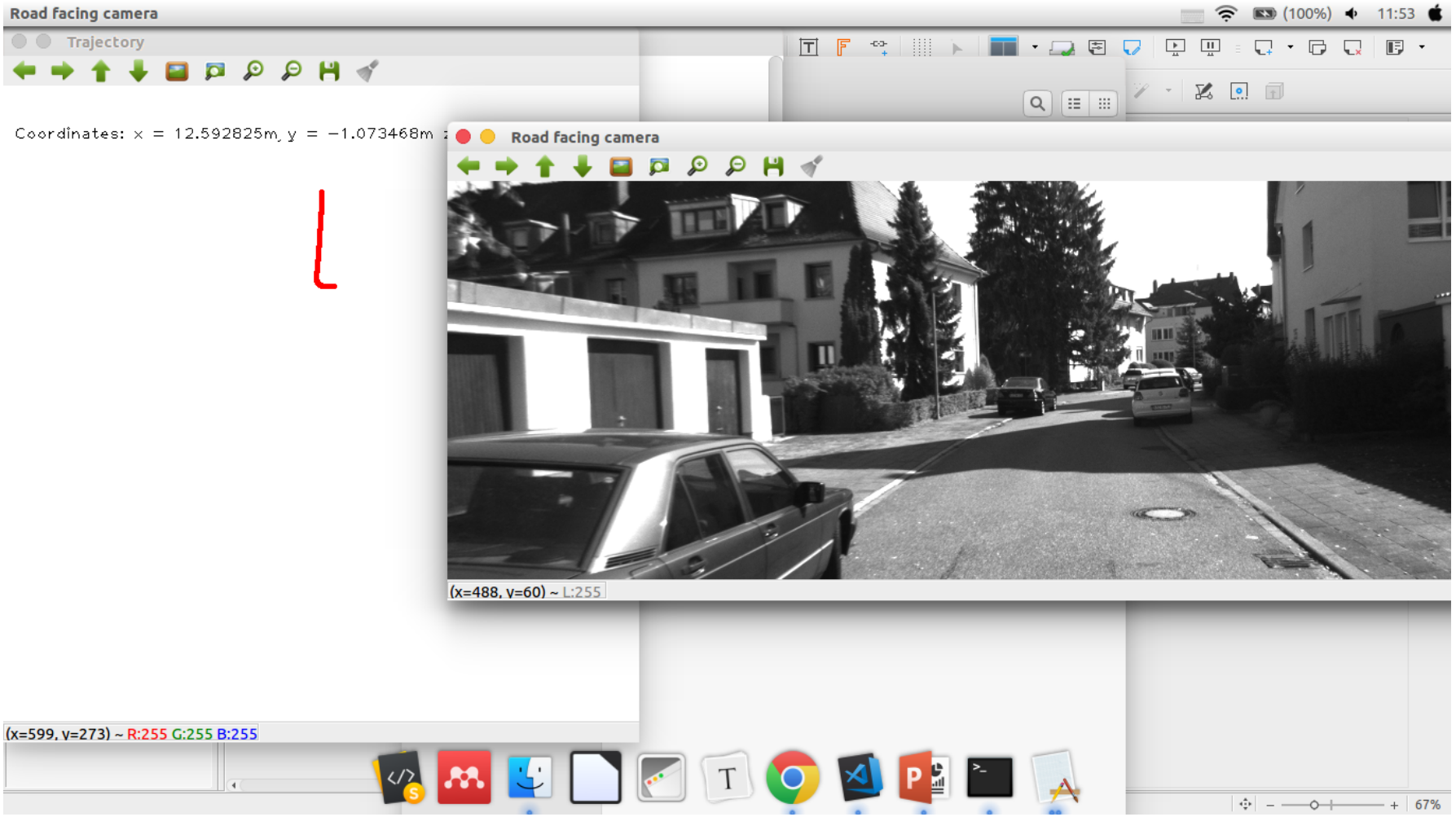
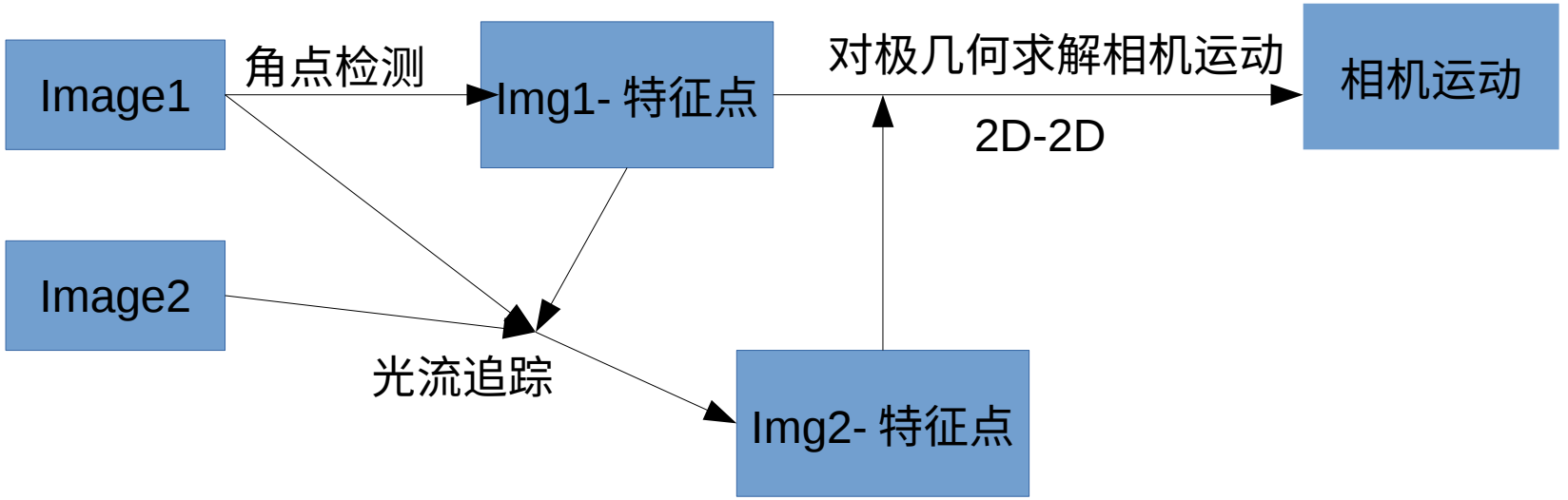
工作比例：李 6：冯 4

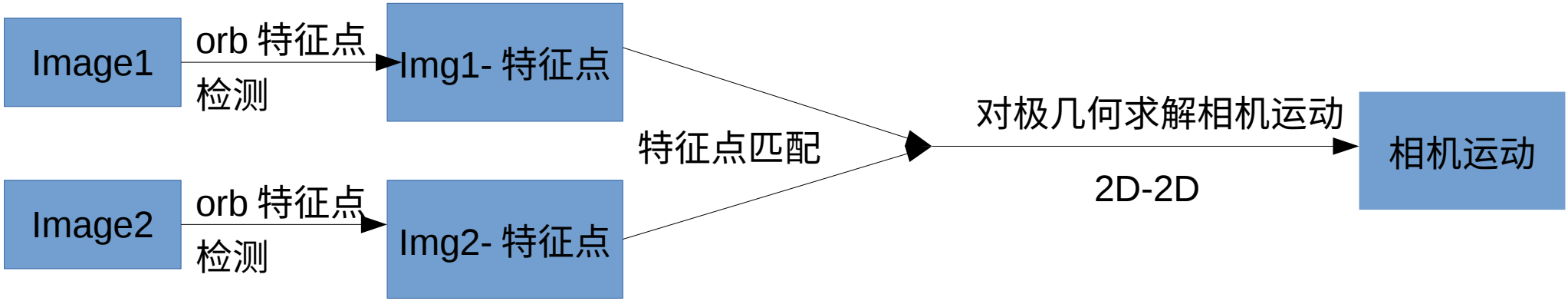
效果展示


Road facing camera
Trajectory
Coordinates: x = 12.592825m, y = -1.073468m
Road facing camera
(x=488, y=60) ~ L:255
(x=599, y=273) ~ R:255 G:255 B:255
67%

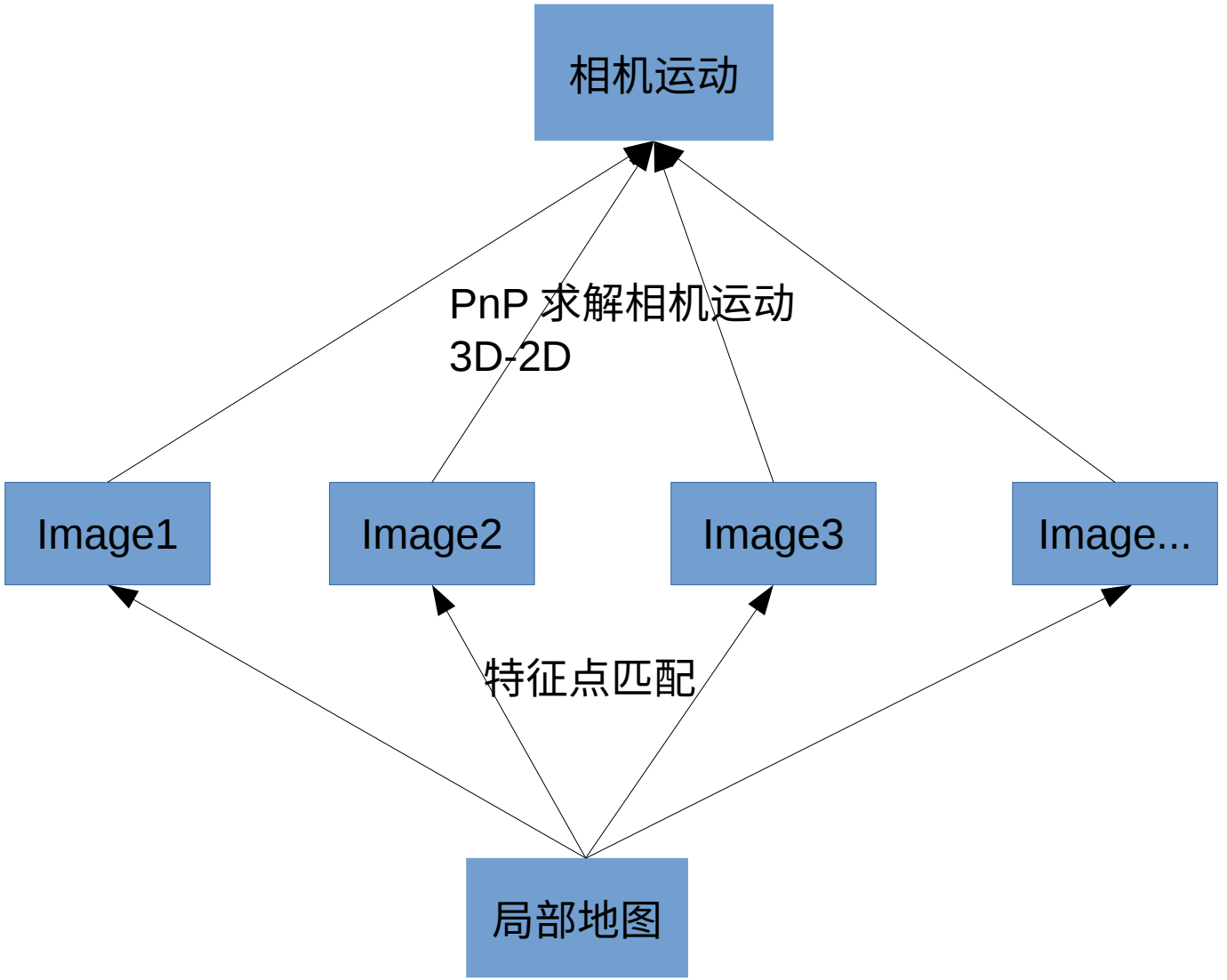
基于光流追踪的视觉里程计



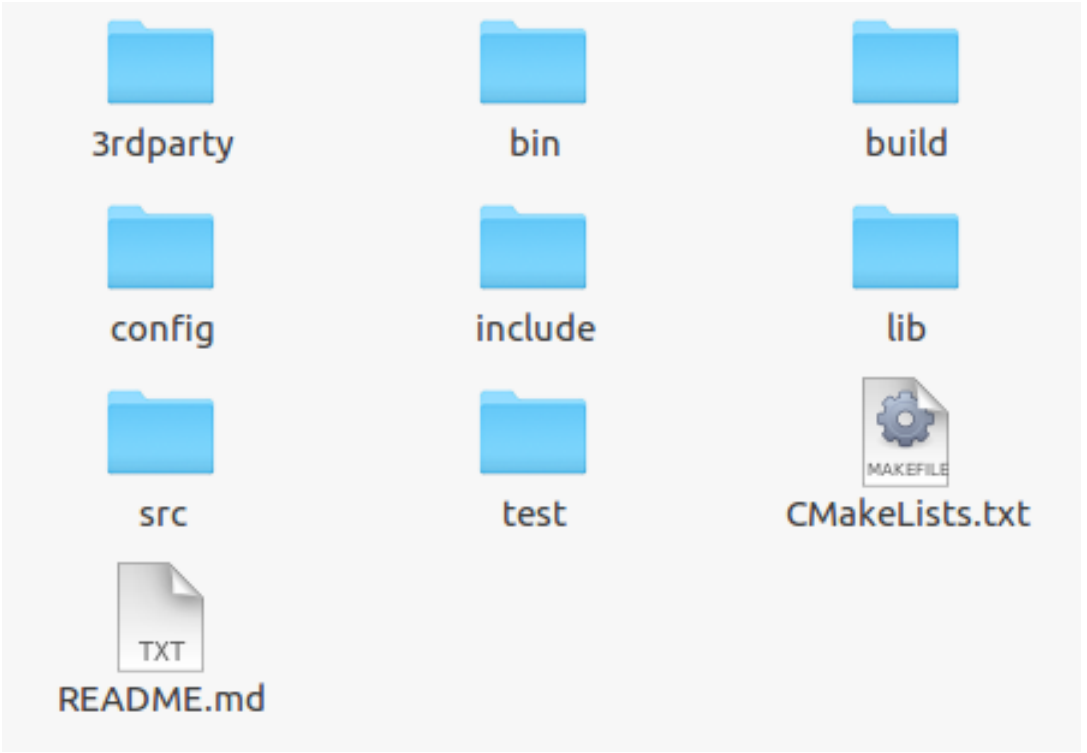
基于特征点匹配的视觉里程计



基于匹配附加局部地图的视觉里程计



代码实现



include
- camera.h
- common_include.h
- config.h
- frame.h
- localmap.h
- map.h
- mappoint.h
- simplevo.h
- vo_track.h
- vo.h

代码实现—类的组织与功能

```
namespace slam
{
class Camera
{
private:
    /* data */
public:
    typedef std::shared_ptr<Camera> Ptr;
    float fx_, fy_, cx_, cy_, s_, depth_scale_;

    Camera();
    Camera(float fx, float fy, float cx, float cy, float s = 0, float depth_scale = 1):
    fx_(fx), fy_(fy), cx_(cx), cy_(cy), s_(s), depth_scale_(depth_scale)
    {}
    ~Camera();

    cv::Point2f pixel2cam_cv( const cv::Point2d& p, const cv::Mat& K );

    Vector3d world2cam(const SE3& T_c_w, const Vector3d& point_world);
    Vector2d cam2pixel(const Vector3d& point_camera);
    Vector3d pixel2cam(const Vector2d& point_image, double depth = 1);
    Vector3d cam2world(const SE3& T_c_w, const Vector3d& point_camera);

    Vector2d world2pixel(const SE3& T_c_w, const Vector3d& point_world);
    Vector3d pixel2world(const SE3& T_c_w, const Vector2d& point_image, double depth =1 );

};

}
```

```cpp
namespace slam
{

class MapPoint;
class Frame
{
private:
    /* data */
public:
    typedef std::shared_ptr<Frame> Ptr;
    long id_;
    cv::Mat rgb_, depth_;
    cv::Mat R_,t_;
    Camera::Ptr cam_;
    SE3 T_c_w_;
    cv::Mat Tcw;
    double time_stamp_;

public:
    Frame();
    Frame(long id, double time_stamp=0, SE3 T_c_w=SE3(),
     Camera::Ptr cam=nullptr, Mat color=Mat(), Mat depth=Mat());
    ~Frame();
    static Frame::Ptr createFrame();
    double findDepth(const cv::KeyPoint& kp);
    Vector3d getCameraCenter() const;
    bool isInFrame(const Vector3d& pt_world);
    void se3ToT34();
};

}
```

```cpp
namespace slam
{
class Mappoint
{
private:
    /* data */
public:
    typedef std::shared_ptr<Mappoint> Ptr;
    unsigned long id_;
    long _frame_id;
    Vector3d point_pos_;
    Vector3d view_direction_;
    int observed_times_;
    int correct_times_;
    Mat descriptor_;
public:
    Mappoint();
    Mappoint(long id, Vector3d point_pos, Vector3d view_direction);
    Mappoint(long id, long frame_id, Vector3d point_pos, Vector3d view_direction);
    inline cv::Point3f getPositionCV() const {
        return cv::Point3f( point_pos_(0,0), point_pos_(1,0), point_pos_(2,0) );
    }
    ~Mappoint();

    static Mappoint::Ptr createPoint();
    static Mappoint::Ptr createPoint( Vector3d point_poss);
    static Mappoint::Ptr createPoint( Vector3d point_poss, long frame_id);

};

} // myslam
```

```cpp
namespace slam
{

class Localmap
{
public:
    int _max_key_frames;
    std::vector<Frame::Ptr> key_frames_;
    std::vector<Mappoint::Ptr> map_points_;
public:
    typedef std::shared_ptr<Localmap> Ptr;
    Localmap() {}
    ~Localmap() {}
    Localmap(int max_key_frames)
    :_max_key_frames(max_key_frames)
    {

    }
    void addKeyFrame(Frame::Ptr frame);
    void addMapPoint(Mappoint::Ptr point);
};
} // namespace slam
```

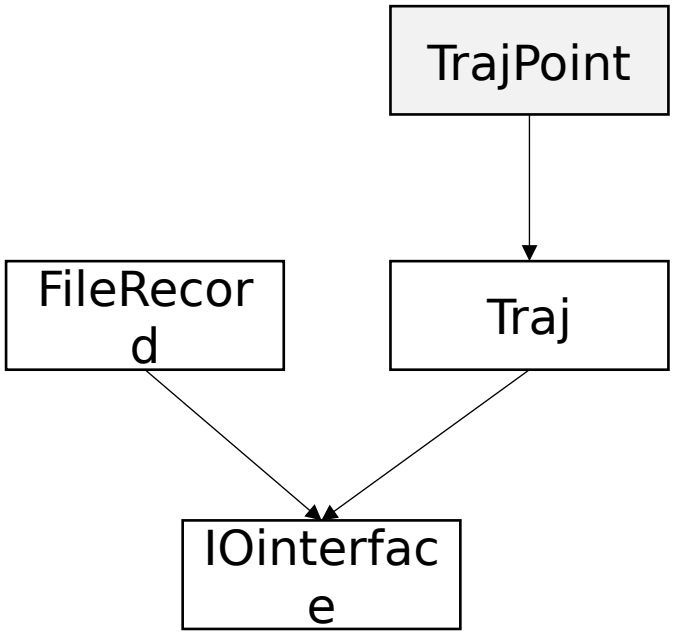
```
class Trackvo
{
public:
typedef std::shared_ptr<Trackvo> Ptr;
typedef cv::Size2i Size;
enum VoState {
    INITIALIZING=-1,
    LOST=0,
    NORMAL=1
};
VoState vo_state_;
Frame::Ptr ref_frame_;
Frame::Ptr cur_frame_;

std::vector<cv::Point2f> key_point_curr_;
std::vector<cv::Point2f> key_point_ref_;

cv::Mat relative_R_;
cv::Mat relative_t_;

double absolute_scale_;

public:
    Trackvo(/* args */);
    ~Trackvo();

    bool addFrame(Frame::Ptr frame);

public:
    void epipolorSolve();
    void getAbsoluteScale(long frame_id);

    void featureDetection();
    void featureTracking();
};
```

```
public:
    Vo(/* args */);
    ~Vo();

    bool addFrame(Frame::Ptr frame);

public:
    void extractKeyPoints();
    void computeDescriptors();
    void featureMatch();
    void featureMatchFromMap();
    void poseEstimatePnP();
    void setRefPoint3d();
    void addKeyFrame();
    void updateMap();
    void epipolorSolve();

    bool checkEstimatedPose();
    bool checkKeyFrame();


    int hanmingDistance(Mat str1, Mat str2);
```

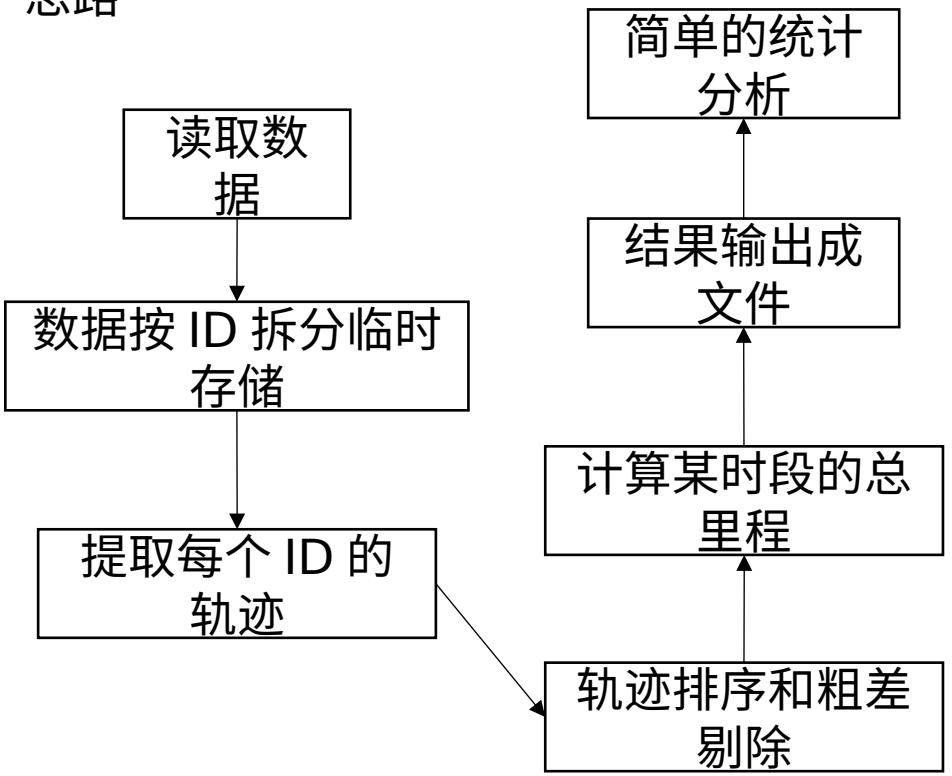
课程作业

- 项目名称：TrajectoryExtraction
- 环境：ubuntu 14.04 cmake 工程
- 数据：20161001.txt

项目结构



思路



- FileRecord 类：存储数据的每一条记录；
- TrajPoint 结构体：存储每个位置点的时空属性；
- Traj 类：存储每辆车的轨迹，并对轨迹进行排序、去粗差、计算累计距离等操作；
- Iointerface 类：用于文件的输入输出。

FileRecord 类

成员变量

```
bool            isGood = false;
time_t          time;
string          company;
int             id;
double          longitude;
double          latitude;
double          speed;
double          azimuth;
int             status;
int             flag;
string          reserved_field;
time_t          unloading_time;
```

构造函数

```
FileRecord();
FileRecord(string _str);
```

Traj 类

TrajPoint 结构体

```
struct TrajPoint{
    time_t time;
    double longitude;
    double latitude;
    double speed;
    double azimuth;
    int status;
};
```

成员变量

```
int id;
string company;
list<TrajPoint> trajPoints;
```

构造函数

```
Traj();

Traj(vector<Trajectory::FileRecord> frs);
```

方法

```
void BL2xy(double lon, double lat, double &x, double &y);
double calDist(TrajPoint tp1, TrajPoint tp2);
double calVel(TrajPoint tp1, TrajPoint tp2);
int eraseError();
void sortTrajPoints();
double calTotalDist(time_t tstart, time_t tend);
```

IOinterface 类

方法

```
static void readFile(string path, vector<Trajectory::FileRecord> &records);

static int splitFilewithID(string path,  bool IDflag[], int &recordnum);

static void deleteFilewithID(bool IDflag[]);

static void getFileNames(string path, vector<string>& filenames);

static time_t inputTime(int year,int month,int day,int hour,int minute,int
second);

static void outTrajLenth(string dataPath, string outPath, time_t tstart, time_t
tend);

static void outTrajLenthUsingThread(string dataPath, string outPath, time_t
tstart, time_t tend);
```

IOinterface 类

多线程

```
static void outTrajLenthUsingThread(string dataPath, string outPath, time_t tstart, time_t tend);
void *mythread(void *data)
{
    ioPath *iopath=(ioPath*)data;
    vector<Trajectory::FileRecord> frs;
    Trajectory::IOinterface::readFile(iopath->inPath,frs);
    Trajectory::Traj traj = Trajectory::Traj(frs);
    traj.sortTrajPoints();
    int errornum=traj.eraseError();
    double trajdist = traj.calTotalDist(iopath->t_start,iopath->t_end);

    pthread_mutex_lock(&mutex);
    ofstream outfile;
    outfile.open(iopath->outPath, ios::out |ios::app);
    if(outfile.is_open()){
        stringstream ss1,ss2;
        ss1<<traj.id ;
        ss2<<trajdist;
        string str =ss1.str() +","+ ss2.str();
        outfile <<str <<endl;
    }
    outfile.close();
    pthread_mutex_unlock(&mutex);

}
```

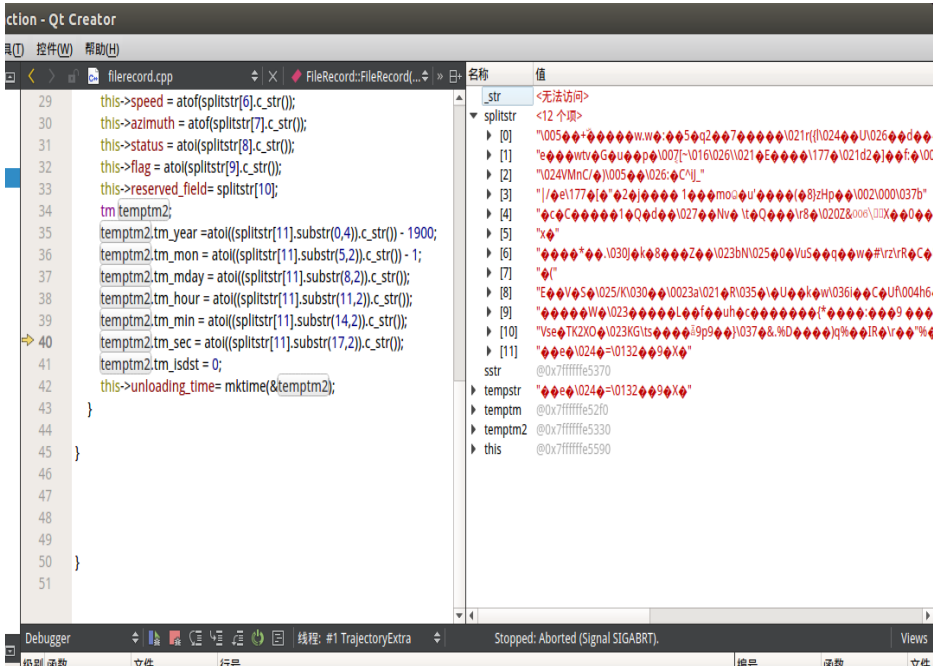
思路：

用 5 个线程读约 5800 个文件，处理后写入同一个输出文件。

互斥锁

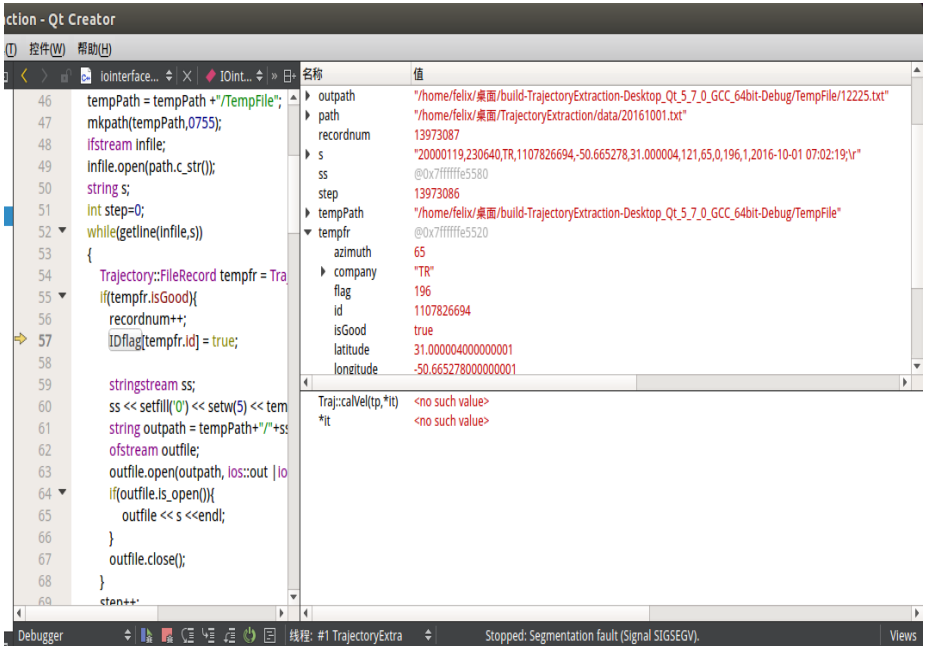
过程与结果

数据读取存在乱码：

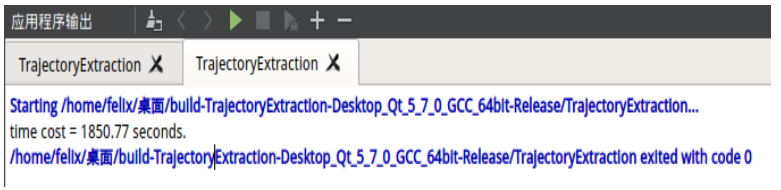



```
Starting /home/felix/桌面/build-TrajectoryExtraction-Desktop_Qt_5_7_0_GCC_64bit-Release/TrajectoryExtraction...
record number =  17936963
good number =  10855832
time cost = 169.857 seconds.
/home/felix/桌面/build-TrajectoryExtraction-Desktop_Qt_5_7_0_GCC_64bit-Release/TrajectoryExtraction exited with code 0
```

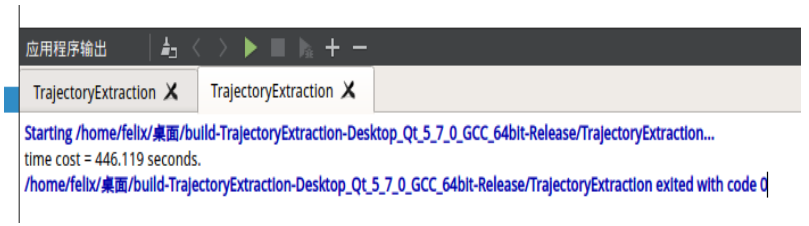
数据异常：



3.8G 数据读取用时

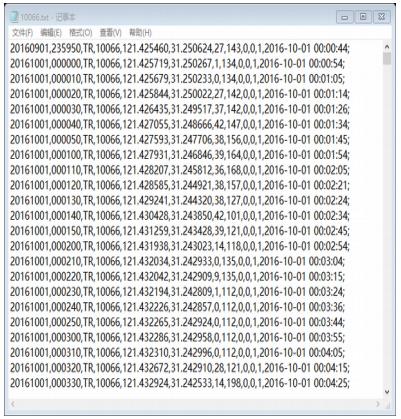


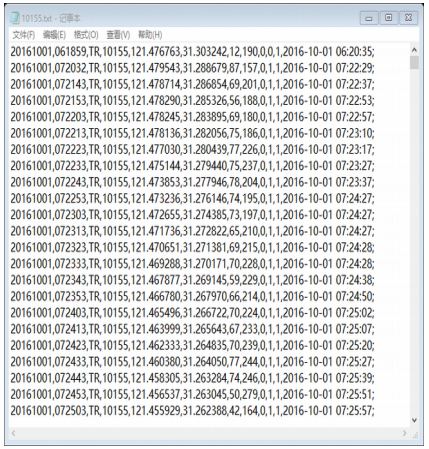
3.8G 数据处理输出用时



过程与结果

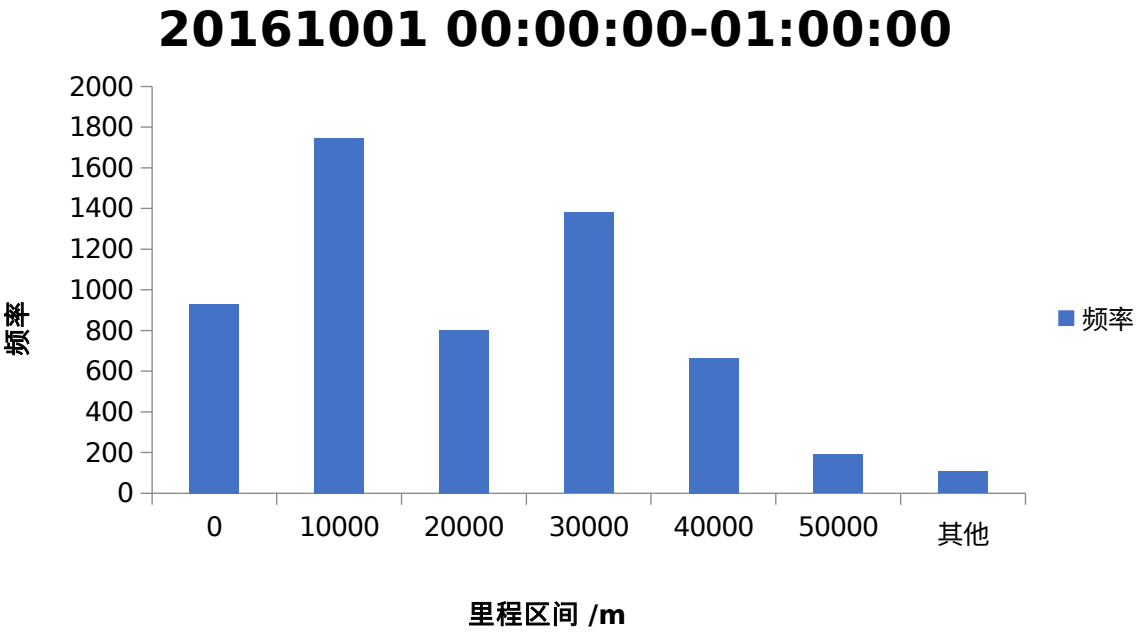
按 ID 拆分的临时文件中的两个个：





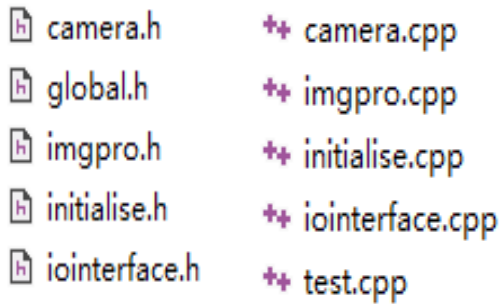
输出结果：

```
10066,27059.2
10068,19148
10073,7955.76
10074,48181.8
10081,20162.9
10082,350.232
10091,36596.6
10093,18672.9
10096,22399.5
10100,42828.7
```



大作业

- 项目名称： MonoVO
- 环境： ubuntu 14.04 cmake 工程



- Camera 类：记录 K 矩阵和畸变矫正系数；
- ImgPro 类：关于图像处理的静态方法；
- IOinterface 类：文件读取输出静态方法；
- Initialise 类：计算两帧影像 R， t 以及特征点深度。

背景：

1、特征点法初始化过程，一般利用本质矩阵进行初始位姿的估计，这个过程可以利用 opencv 实现。这个过程一般没有考虑约束条件。

2、可以使用摄影测量的相对定向过程求解，但由于这个过程元素进行展开求解，并使用行列式等复杂形式，公式不够简洁。

我的工作：

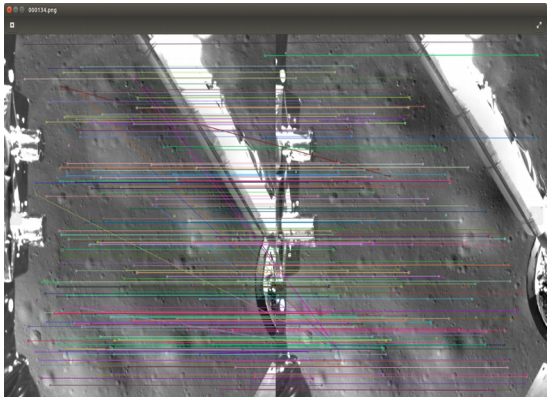
1、利用李代数左乘扰动进行优化，加入基线长约束，对特征点法的初始化过程求解。

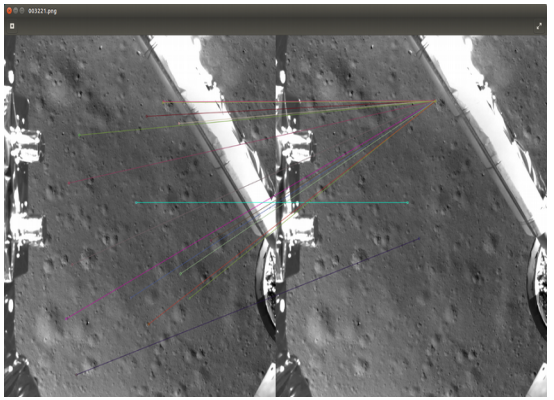
大作业

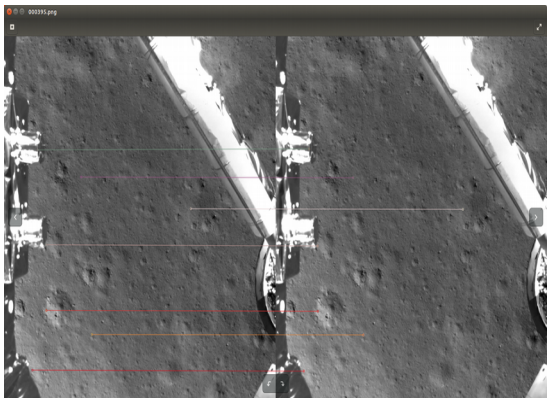
特征匹配

问题:
1、特征点多时，大部分正确，小部分出错;
2、条件苛刻时，点数太少难以计算;
3、利用单应矩阵进行 RANSAC，会出现多对一的情况。

解决思路:
1、首先使用 ORB 特征匹配;
2、利用单应矩阵进行 RANSAC，分析匹配结果;
3、结果不满足要求就用 sift 特征匹配，并进行 RANSAC







大作业

视频

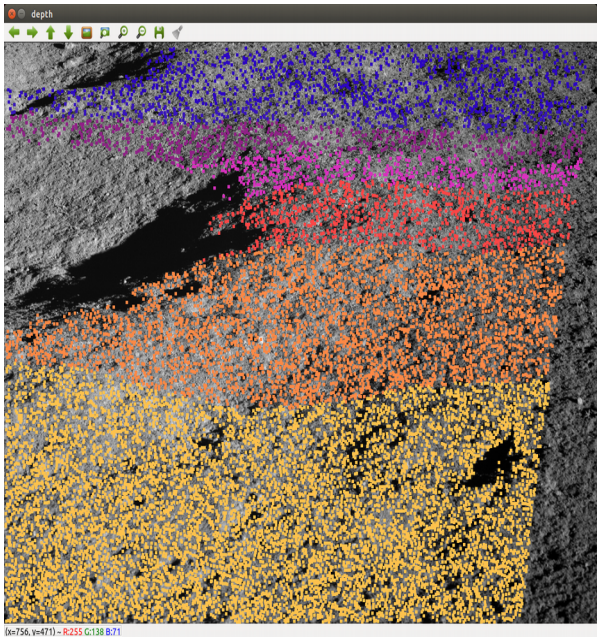
大作业

数据：

左右相机的影像

序列

特征点深度可视化



结果

```
Debugging starts
&"warning: GDB: Failed to set controlling terminal: \345
 fai = 0.00324311 , -0.0135707 , -0.00762696
theta = 0.911078
 euler = 0.00329503 , -0.0135582 , -0.00764942
 t = 199.93 , -4.66564 , -2.47558
good result !
```

```
Debugging starts
&"warning: GDB: Failed to set controlling terminal: \34
 fai = 0.00319594 , -0.00773234 , -0.0029868
theta = 0.509011
 euler = 0.00320755 , -0.00772754 , -0.00299921
 t = 199.91 , -5.4348 , -2.51216
good result !
```

```
Debugging starts
&"warning: GDB: Failed to set controlling terminal: \34
 fai = 0.00332873 , -0.01064 , -0.00530976
theta = 0.707515
 euler = 0.00335709 , -0.0106311 , -0.00532766
 t = 199.936 , -4.66846 , -1.96573
good result !
init done
opengl support available
Debugging has finished
```