同濟大學
TONGJI UNIVERSITY

IPMV-Experiment-5

Lab Camera geometry with eigen

课程名称：图像处理与机器视觉

实验地点：嘉定校区智信馆 131

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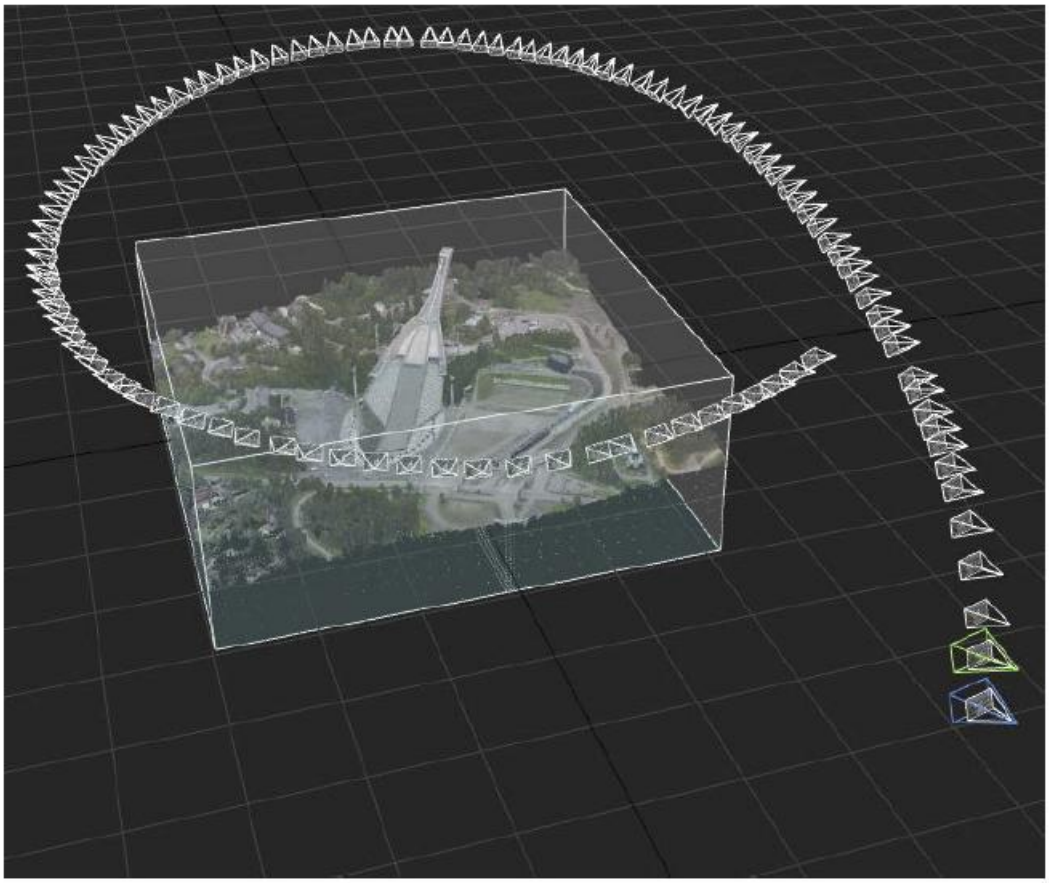
Task

Background

In this experiment, we need to project world points into the images.



We are going to use Holmenkollen dataset.

110 images taken from helicopter.

For each image, consists:

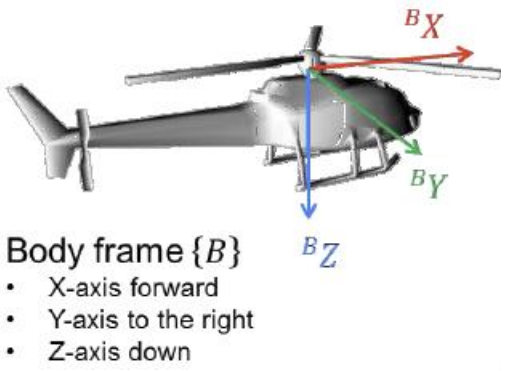
Intrinisc calibration

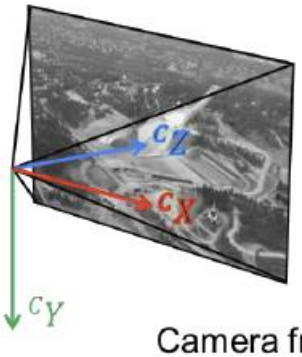
Helicopter pose in geographical coordinates

Camera pose relative to helicopter

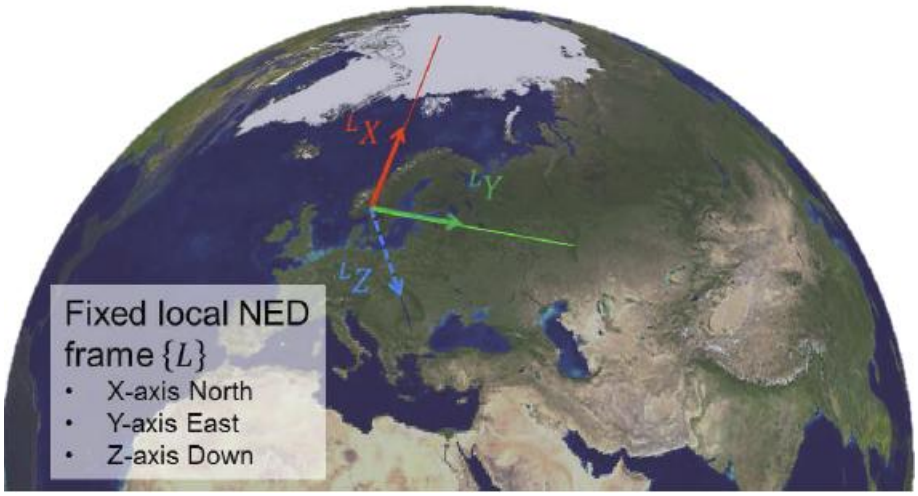
The coordinate systems are shown as below:

helicopter





Camera frame $\{C\}$
- X-axis to the right
- Y-axis down
- Z-axis forward




```
#include "camera_pose_solution.h"

#include "dataset.h"
#include "local_coordinate_system.h"
#include "viewer_3d.h"
#include "opencv2/highgui.hpp"
#include "opencv2/imgproc.hpp"

CameraPoseSolution::CameraPoseSolution(const std::string& data_path)
    : data_path_{data_path}
    , window_name_{"World point in camera"}
{}

void CameraPoseSolution::run()
{
    // Set up dataset.
    Dataset dataset{data_path_};

    // Define local coordinate system based on the position of a light pole.
    const GeodeticPosition light_pole_position{59.963516, 10.667307, 321.0};
```

```
    const LocalCoordinateSystem local_system(light_pole_position);

    // Construct viewers.
    cv::namedWindow(window_name_);
    Viewer3D viewer;

    // Process each image in the dataset.
    for (DataElement element{}; dataset >> element;)
    {
      // Compute the pose of the body in the local coordinate system.
      const Sophus::SE3d pose_local_body =
local_system.toLocalPose(element.body_position_in_geo,

element.body_attitude_in_geo.toSO3());

      // Add body coordinate axes to the 3D viewer.
      viewer.addBodyAxes(pose_local_body, element.img_num);

      // Compute the pose of the camera relative to the body.
      const Sophus::SE3d pose_body_camera(element.camera_attitude_in_body.toSO3(),
                                          element.camera_position_in_body.toVector());

      // Compute the pose of the camera relative to the local coordinate system.
      const Sophus::SE3d pose_local_camera(pose_local_body * pose_body_camera);

      // Add camera coordinate axes to the 3D viewer.
      viewer.addCameraAxes(pose_local_camera, element.img_num);

      // Construct a camera model based on the intrinsic calibration and camera pose.
      const PerspectiveCameraModel camera_model{element.intrinsics.toCalibrationMatrix(),
                                                pose_local_camera,

element.intrinsics.toDistortionCoefficientVector()};

      // Undistort image.
      cv::Mat undistorted_img = camera_model.undistortImage(element.image);

      // Project world point (the origin) into the image.
      const Eigen::Vector2d pix_pos = camera_model.projectWorldPoint(Eigen::Vector3d::Zero());

      // Draw a marker in the image at the projected position.
      const Eigen::Vector2i pix_pos_int = (pix_pos.array().round()).cast<int>();
      cv::drawMarker(undistorted_img, {pix_pos_int.x(), pix_pos_int.y()}, {0.,0.,255.},
cv::MARKER_CROSS, 40, 3);
```

```
      // Add the camera frustum with the image to the 3D viewer.
      viewer.addCameraFrustum(camera_model, undistorted_img, element.img_num);

      // Show the image.
      cv::imshow(window_name_, undistorted_img);

      // Update the windows.
      viewer.spinOnce();
      cv::waitKey(100);
   }

   // Remove image viewer.
   cv::destroyWindow(window_name_);

   // Run 3D viewer until stopped.
   viewer.spin();
}
```

```
#include "perspective_camera_model.h"
#include "opencv2/core/eigen.hpp"
#include "opencv2/imgproc.hpp"
#include "opencv2/calib3d.hpp"

PerspectiveCameraModel::PerspectiveCameraModel(const Eigen::Matrix3d& K,
                                               const Sophus::SE3d&
pose_world_camera,
                                               const Vector5d& distortion_coeffs)
   : K_{K}
   , pose_world_camera_{pose_world_camera}
   , distortion_coeffs_{distortion_coeffs}
{
   camera_projection_matrix_ = computeCameraProjectionMatrix();
}

Sophus::SE3d PerspectiveCameraModel::getPose() const
{
   return pose_world_camera_;
}

Eigen::Matrix3d PerspectiveCameraModel::getCalibrationMatrix() const
```

```
{
  return K_;
}

PerspectiveCameraModel::Matrix34d PerspectiveCameraModel::getCameraProjectionMatrix()
const
{
  return camera_projection_matrix_;
}

PerspectiveCameraModel::Matrix34d
PerspectiveCameraModel::computeCameraProjectionMatrix()
{
  return K_ * pose_world_camera_.inverse().matrix3x4();
}

Eigen::Vector2d PerspectiveCameraModel::projectWorldPoint(Eigen::Vector3d world_point)
const
{
  return (camera_projection_matrix_ * world_point.homogeneous()).hnormalized();
}

Eigen::Matrix2Xd PerspectiveCameraModel::projectWorldPoints(Eigen::Matrix3Xd world_points)
const
{
  return (camera_projection_matrix_ *
world_points.colwise().homogeneous()).colwise().hnormalized();
}

cv::Mat PerspectiveCameraModel::undistortImage(cv::Mat distorted_image) const
{
  // Convert to cv::Mats
  cv::Mat K_cv;
  cv::eigen2cv(K_, K_cv);
  cv::Mat dist_coeffs_cv;
  cv::eigen2cv(distortion_coeffs_, dist_coeffs_cv);

  // Undistort image.
  cv::Mat undistorted_image;
  cv::undistort(distorted_image, undistorted_image, K_cv, dist_coeffs_cv);

  return undistorted_image;
}
```