

LS-ACTS 1.0

USER MANUAL

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1 Introduction

1.1 Product Specification

LS-ACTS: Large-Scale Automatic Camera Tracking System is a structure-from-motion software, which is able to robustly and efficiently recover camera parameters from one or multiple image/video sequences. The recovered 3D data are useful for many applications, such as augmented reality, video composition, 3D modeling and animation. Compared to our previous SfM system ACTS (<http://www.zjucvg.net/acts/acts.html>), LS-ACTS is much faster (near real-time) and can handle very long sequences (over 100K frames) and even multiple image sequences.

1.2 Feature Functionalities

There are three main modules contained in the system, listed as follows:

- **Feature tracking module:** automatically extracts the feature points and track them. It contains two stages: 1) Consecutive point tracking: only track feature points among neighboring frames. 2) Non-consecutive track matching: efficiently recognize the common features among different subsequences and match them. It is very important for drift-free SfM estimation.
- **Single sequence tracking module:** can automatically track a long image sequence with loop closing.
- **Multiple sequences tracking module:** can automatically track multiple long sequences and accurately align them into a common 3D coordinate system.

1.3 Feature Functionalities

- **Input:** one or multiple image/video sequences
- **Output:** camera parameters, feature tracks and their corresponding 2D/3D positions.
- **Supported export formats:**
 - ✓ ACTS tracking format (.act). You can use ACTS to load the saved act file and export txt file, 3D Studio Max file (.ms) and Maya file (.ma).

1.3.1 Automatic Tracking

Our system supports to track freely moving camera. The whole process is very simple, only requiring several clicks on the buttons. Some interactive and visualization tools are also provided, allowing the user to conveniently examine the tracking quality.

1.3.2 Support for Camera Tracking Under Varying Focal Length

LS-ACTS can efficiently and robustly handle very long sequences with varying focal length, without requiring any prior knowledge.

1.3.3 Support for Loop Closure Detection and Multiple Sequences Tracking

LS-ACTS can efficiently and robustly track multiple sequences with known intrinsic matrices, and align them into a common 3D coordinate system. It also can automatically and efficiently detect loop closures and close the loops with global optimization to eliminate reconstruction drift.

1.3.4 Recommended System Requirements

- Microsoft Windows 7, 8 and 10.
- Intel i5/i7 CPU Processor.
- Nvidia GTX 650 with 1GB video memory or above.
- OpenGL and Cuda compatibility.
- 8GB memory or above.
 - For speed, current version keeps all tracking data in memory, so the required memory space may be large for very long sequences. In the near future, we will provide an option to save temporary tracking data into hard disk and load them into memory when needed, so the required memory space could be much smaller for long sequences.
- 2GB of free disk space.

2 Overview

2.1 Image Sequences

The input should be one or multiple image/video sequences. The system does not directly support a video format file. The user should decompress the video clips into image sequences beforehand. Most image formats are supported, such as BMP, JPEG, PNG etc.

2.2 Feature Tracks

2.2.1 Feature Points

Feature points refer to the interesting points in the image. The system can automatically detect the feature points and match them among consecutive frames.

2.2.2 Track Lifetime

The matched feature points constitute the feature tracks. It corresponds to a 3D point in the scene. A key characteristic of feature tracks is the track lifetime—the number of frames over which a point is visible. Long tracks are more useful than short tracks.

2.3 Camera Tracking

2.3.1 The Camera

Each image frame has intrinsic and external camera parameters. The external camera parameters contain camera rotation and translation. The intrinsic parameters include:

- **Principal point:** the center of the lens. Its default value is the center of the image.
- **Focal length:** the distance between the optical center and the focus plane, which can be divided to the focal lengths in X and Y directions, respectively.
- **Radial distortion:** current version assumes there is no radial distortion.

It should be noted that the current version of LS-ACTS assumes the principal point is at the image center and the pixel aspect is 1.0 at default, and there is no radial distortion. If the intrinsic matrix is known and constant, you can directly input it. The focal length can be unknown and varied. LS-ACTS will support **automatic radial distortion estimation** in the near future.

2.3.2 Camera Constraints

The camera can freely move. Currently, LS-ACTS does not support pure rotation constraint.

2.3.3 Camera Tracking

The camera tracking step solves for the camera motion as well as the 3D positions of the

sparse feature tracks.

2.3.4 The 3D Environment

After camera estimation, the user can immediately review the tracking results. The provided 3D view mode allows the user to inspect the recovered 3D trajectory and 3D positions of the tracked feature points. The user can insert a 3D object into the 3D scene. The interactive 3D tool allows the user to freely change the position, orientation and scale of the inserted object.

3 A Simple Example

3.1 Startup

Figure 3-1 shows the initial user interface by starting up LS-ACTS.

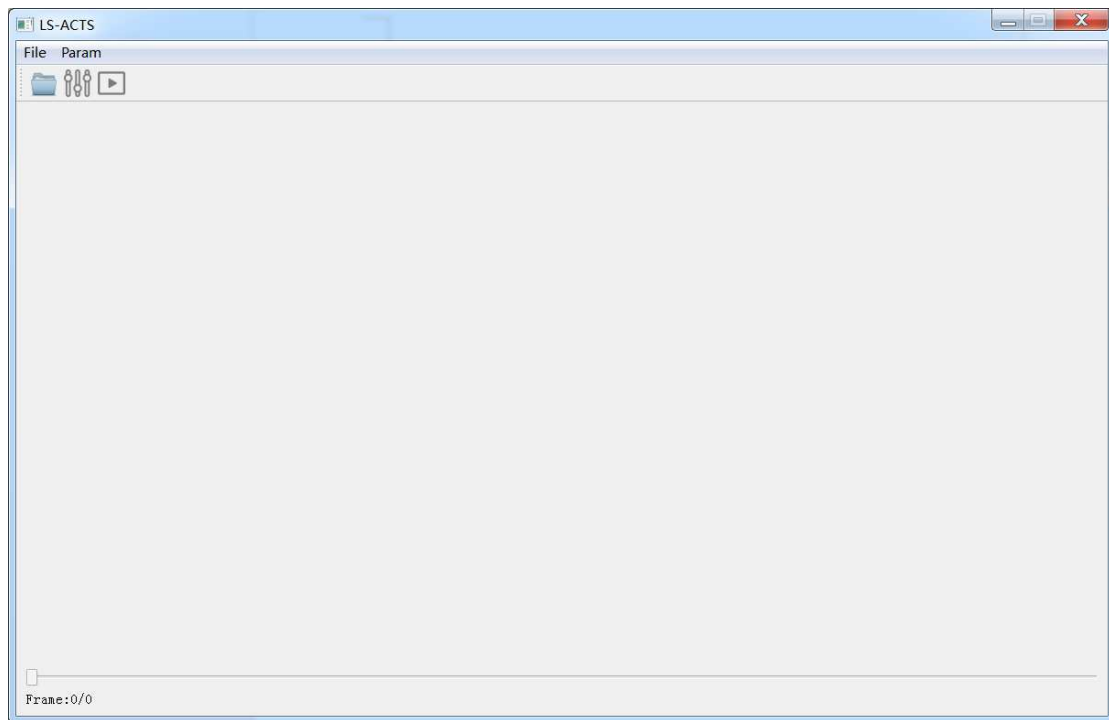


Figure 3-1. The main user interface before importing an image sequence.



: open a dialog to begin import image sequence.



: set the Parameters of system.




: start running.

Meanwhile the slider at the bottom is used to control frame switches.

The main area is used to show frames.

3.2 Importing an Image Sequence



Click , or click **File -> Open** in the menu bar, a dialog is opened to import image sequence and a task mode has to be chosen, as in Figure 3-2.

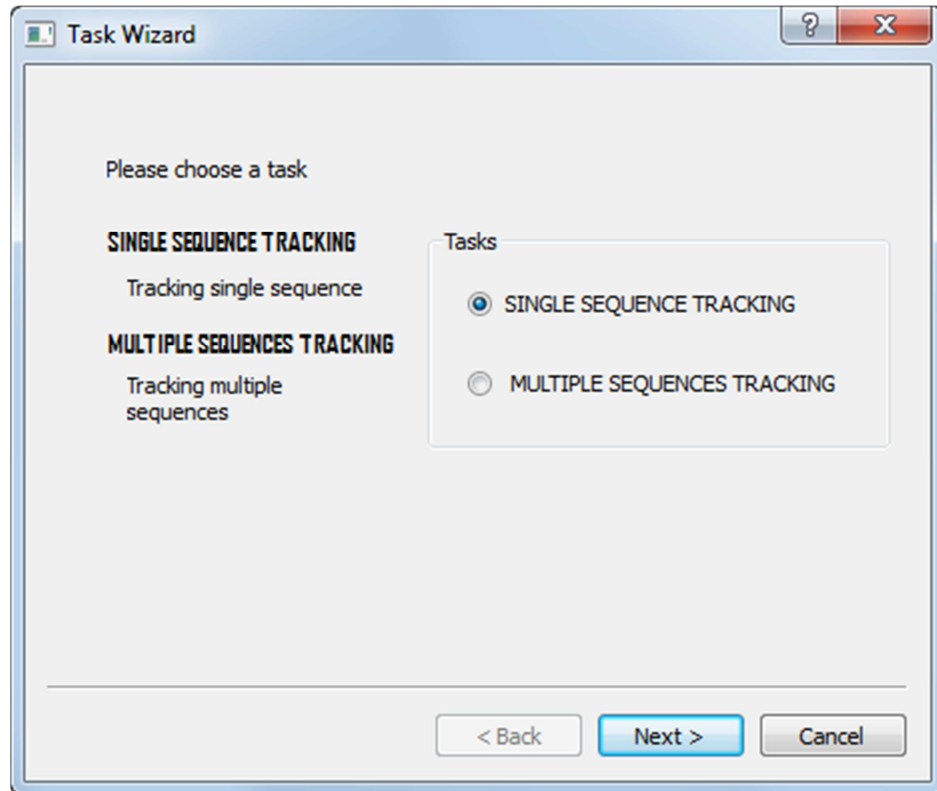


Figure 3-2. Task mode selection.

There are two choices for user.

- a) **SINGLE SEQUENCE TRACKING**: tracking single sequence.
- b) **MULTIPLE SEQUENCES TRACKING**: tracking multiple sequences.

Here two different modes will be introduced respectively.

3.2.1 The **SINGLE SEQUENCE TRACKING** mode

Choose the **SINGLE SEQUENCE TRACKING** and click **Next**, a dialog will be shown to import an image sequence, as in Figure 3-3.

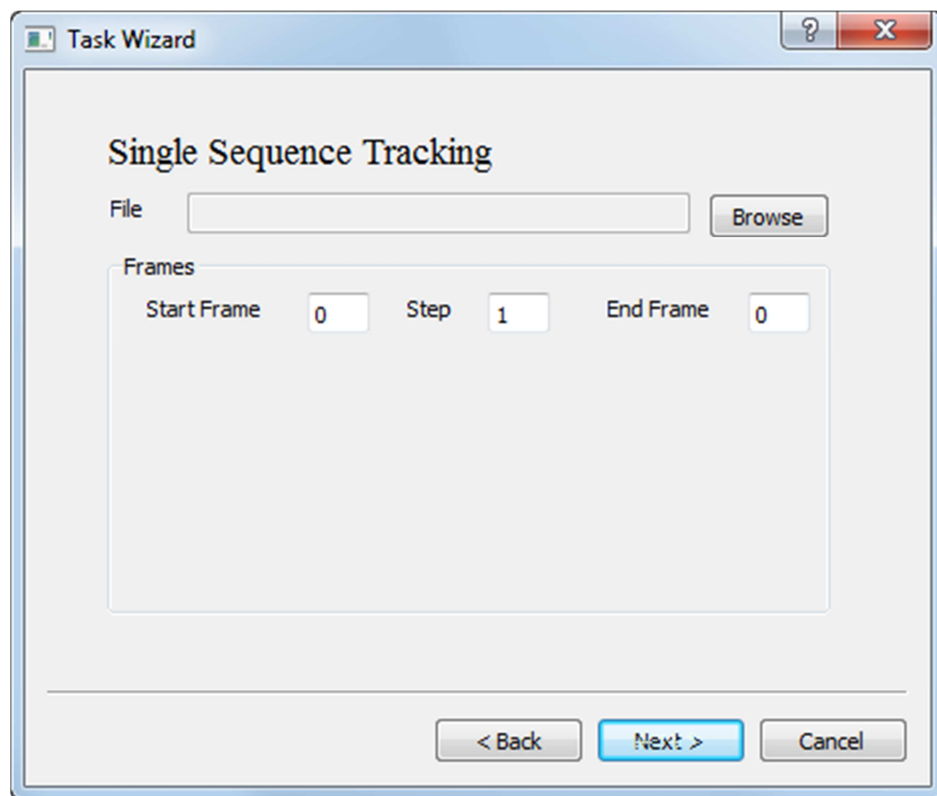


Figure 3-3. Importing image sequence in **SINGLE SEQUENCE TRACKING** mode

Click **Browse**, and select the first image of the image sequence, as in Figure 3-4.

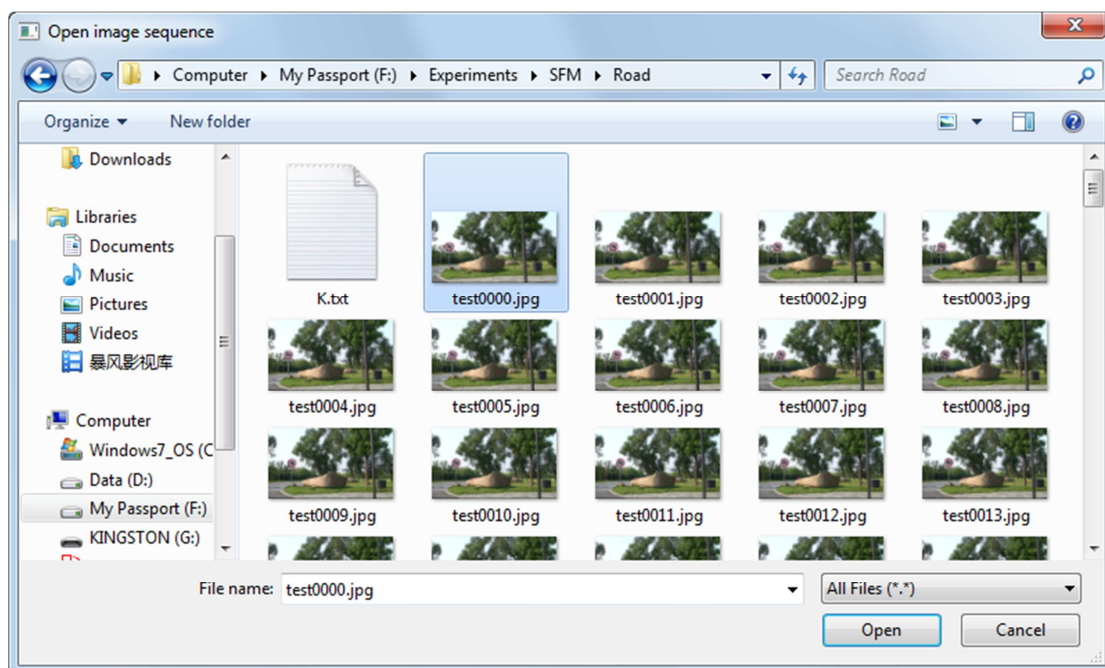


Figure 3-4. Selecting the first image of the sequence.

Click **ok**, importing the whole “Road” sequence (141 frames), as in

Figure 3-5.

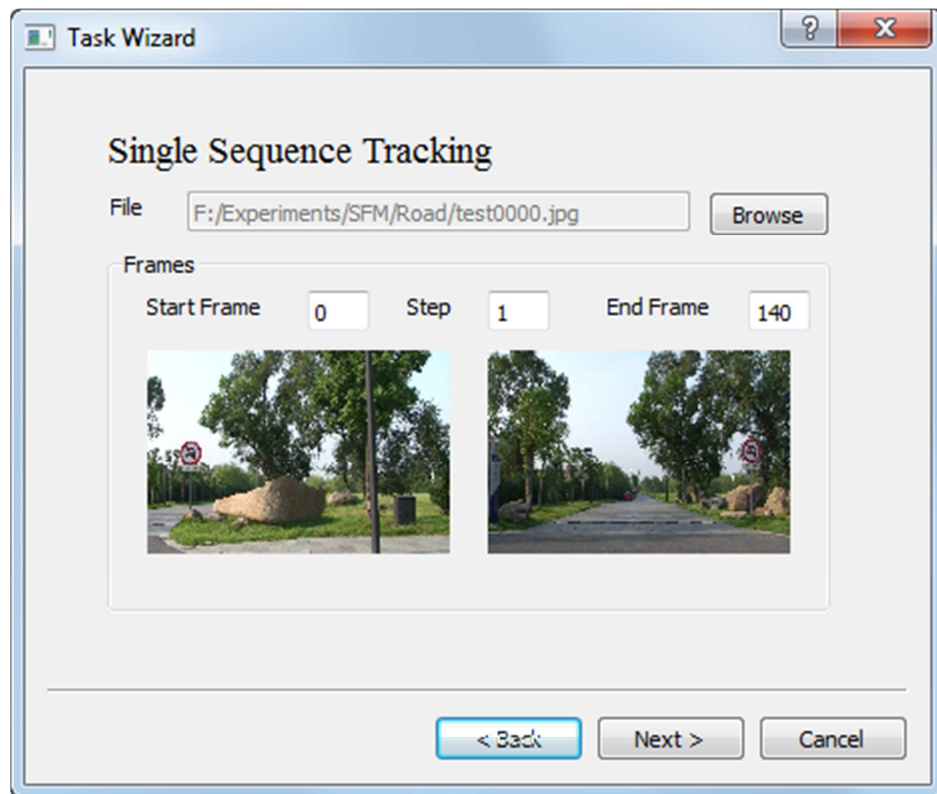


Figure 3-5. import image sequence

The dialog above shows the start frame, end frame, the step which is default set to be 1.

Click **Next**, a dialog is shown to set the parameters of the camera, as in Figure 3-6.

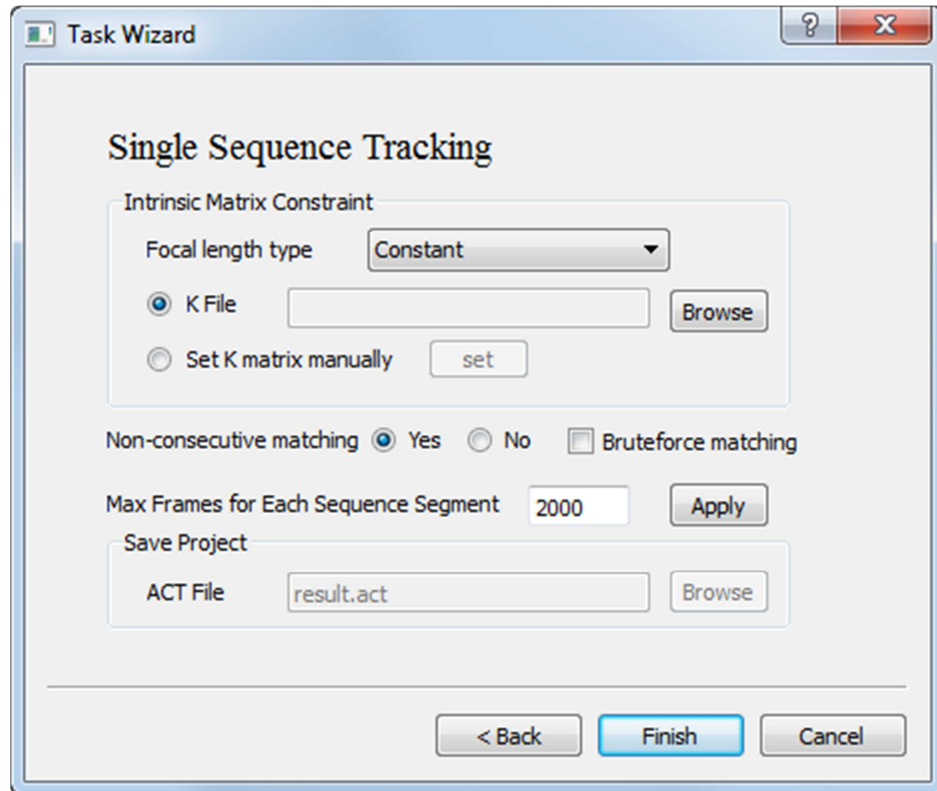


Figure 3-6. Setting camera tracking parameters

As shown in Figure 3-6. There are 2 parameters need to be set.

Focal length type: used to determine the type of focal length. 2 choices are available. **Constant:** fixed focal length, **Variable:** Variable focal length.

K Matrix: used to set the internal camera parameters. One can load from a file by choosing **K File**, or set it manually. The manually set parameters will be saved in the image sequence folder. How to manually set parameters will be introduced later.

To be noticed, the setting of **K Matrix** is Optional, you can leave it unset in this mode. If you choose a **K File** or manually set the **K Matrix**, then our system will use the specified K matrix directly and not further optimize it.

Non-consecutive matching: perform non-consecutive track matching or not.

Bruteforce Matching: perform brute force matching or not.

Max Frames for Each Sequence Segment: Our system will split a long

sequence into multiple sequence segments if necessary. Here you can set a value for specifying the max frames for each sequence segment. For example if you set it as 1000, and the original sequence contains 10,000 frames in total. Our system will split the sequence into 10 sequence segments, each segment contains 1000 frames.

Save Project: Our system will save the project as “result.act” in the image sequence folder. Current version does not allow the user to modify the project file name.

Click **Finish** to complete the import, as in Figure 3-7.

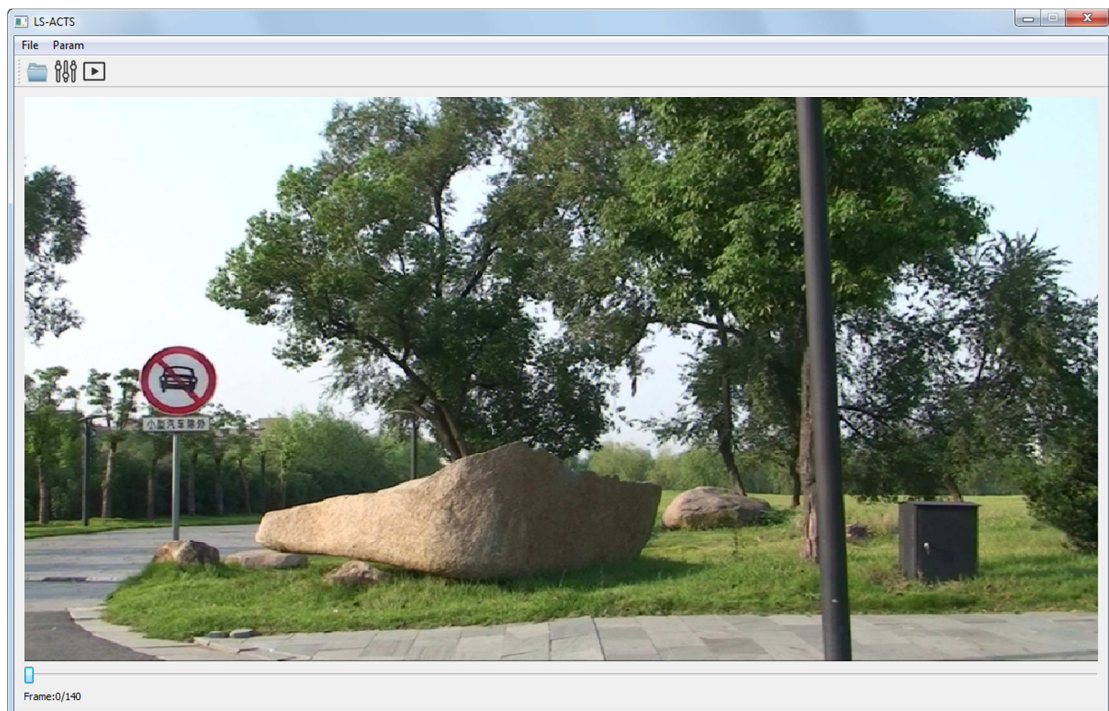


Figure 3-7. The user interface after importing “Road” sequence

By now the importing task is finished.

3.2.2 The MULTIPLE SEQUENCES TRACKING Mode

Choosing the **MULTIPLE SEQUENCE TRACKING** and click **Next** in Figure 3-2, a dialog will be shown to load multiple image sequences, as in Figure 3-8.

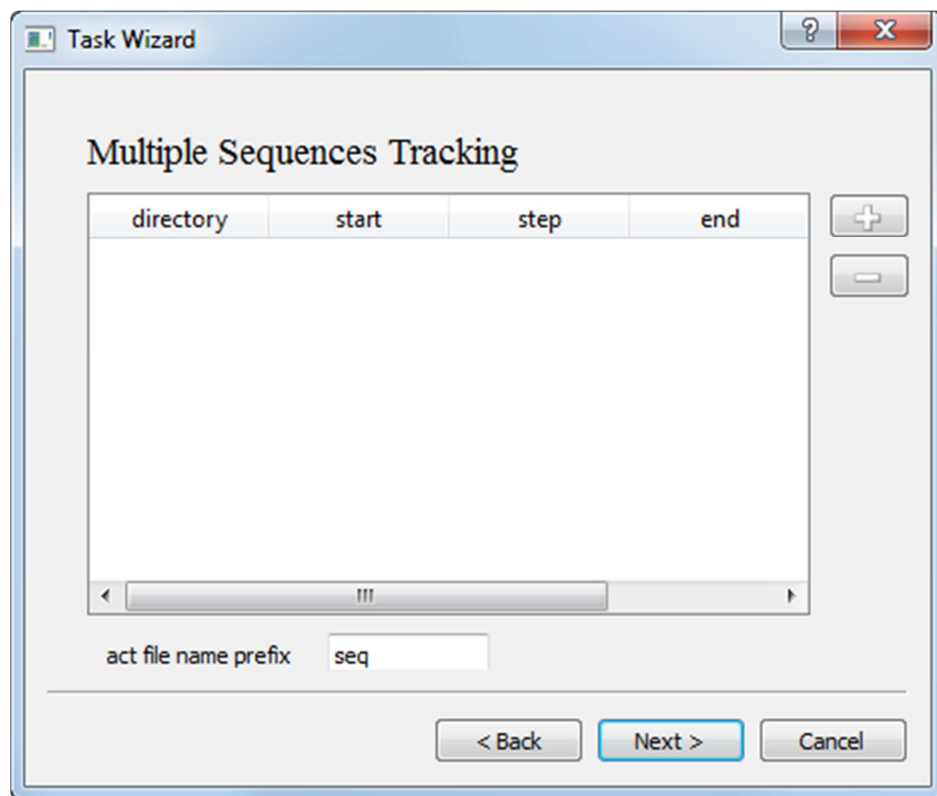



Figure 3-8 import image sequence in **MULTIPLE SEQUENCES TRACKING** mode

Click  to import image sequence. Similar with the **SINGLE SEQUENCE TRACKING** mode, choosing the first image of a sequence, and the table in the dialog will show the information of the imported sequence. As in Figure 3-9.

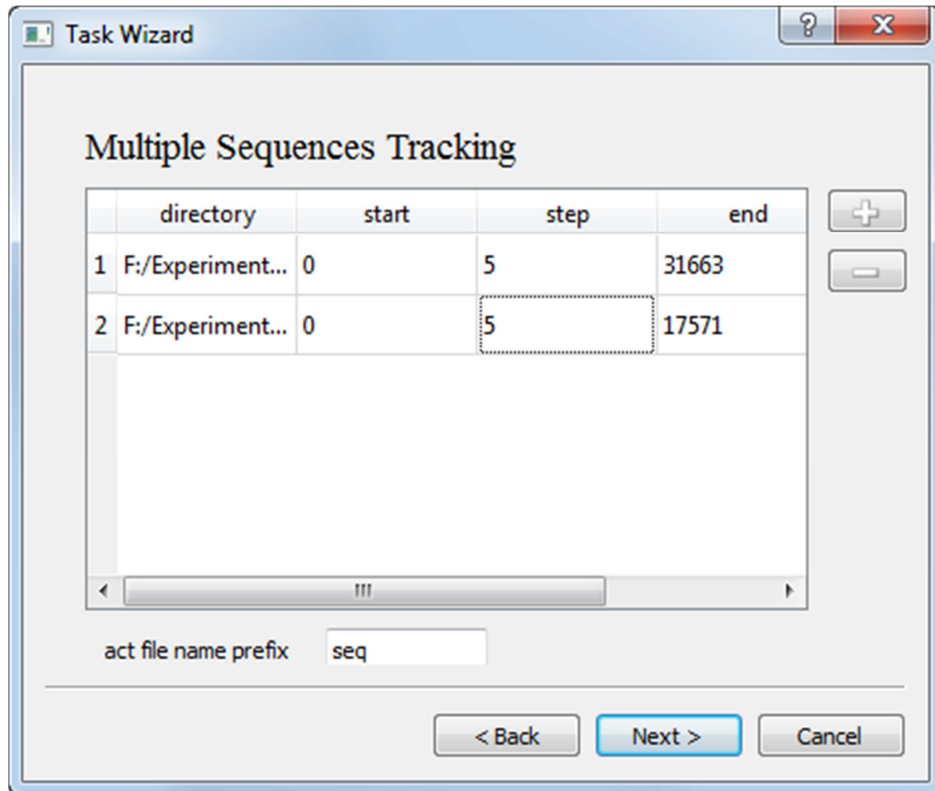



Figure 3-9 The information of the chosen sequences

The content in the input box of **act file name prefix** is used to form the prefix of the output file: act file, along with the sequence number shown in the table. For example: with “seq” in the input box, you will get seq_0.act , seq_1.act and so on.

The  is used to remove the chosen sequence that one does not need any more.

Click **Next**, a dialog is shown to set the parameters of the camera, as in Figure 3-10.

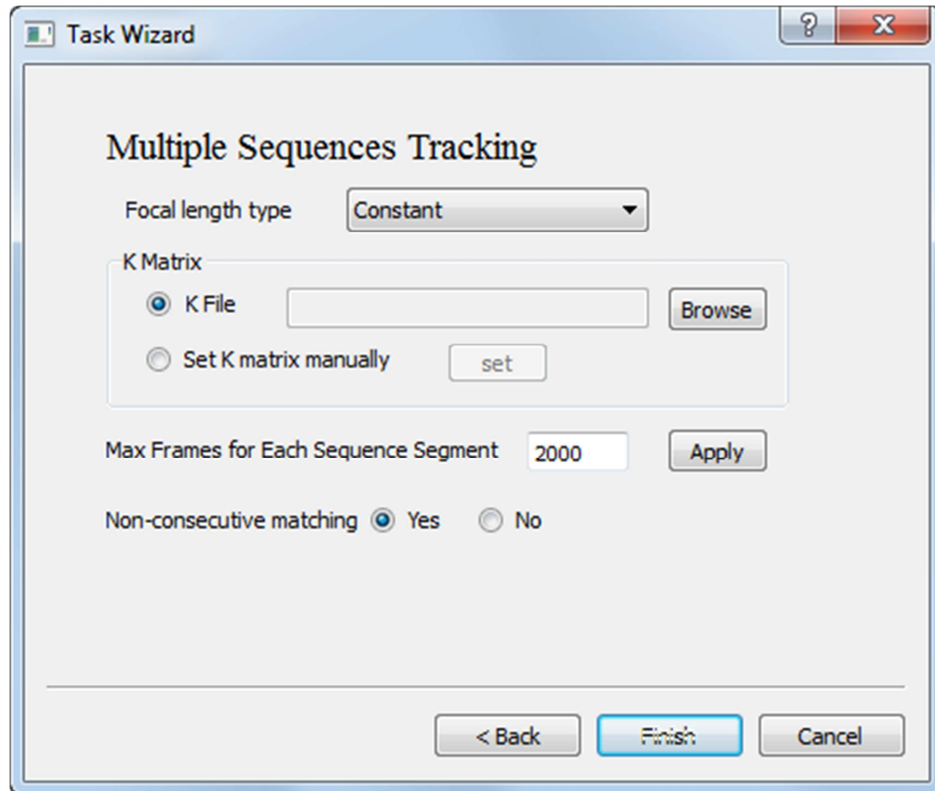


Figure 3-10 Setting camera tracking parameters

The setting here is almost same with mode **SINGLE SEQUENCE TRACKING** except that the setting of **K Matrix** is necessary an only constant focal length type is supported.

Click **Finish** to end the import.

3.3 Other Interfaces

There are some other interface should be introduced.

- 1) Parameter setting interface, as shown in Figure 3-11.

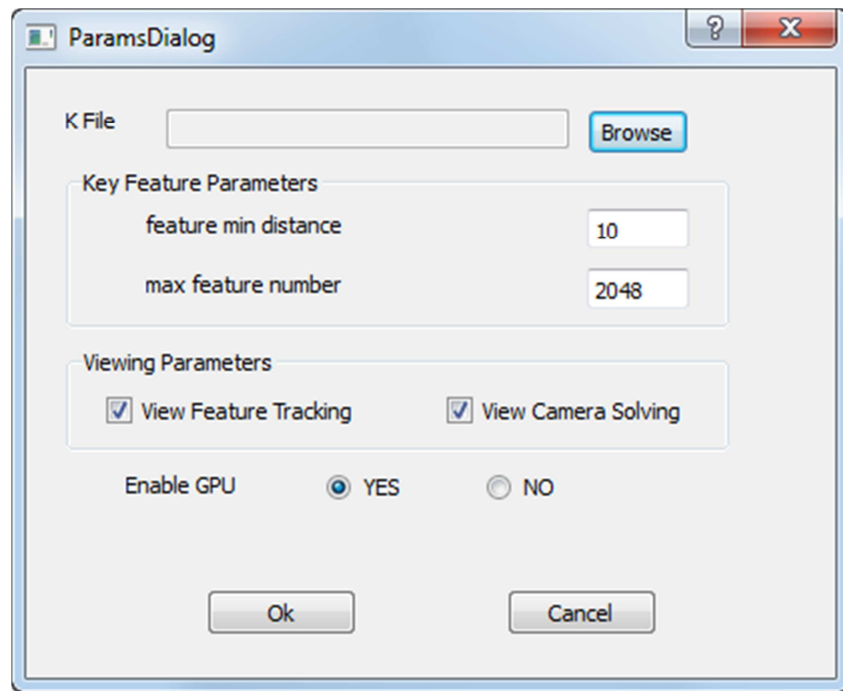



Figure 3-11 Parameter Configuration

You can get this dialog by clicking the  or clicking the **param -> set params**.

K File: import the K File from disk to initialize the internal camera parameters.

Two key feature parameters may need to be modified usually for different image resolution:

Feature min distance: set the minimum spatial distance of the features.

Max feature number: set the feature numbers.

Viewing Parameters: you can set these two parameters to watch the visual procedure of feature tracking and camera solving. Turn off these two options will may make the tracking faster.

Enable GPU: enable GPU acceleration for Feature Tracking.

2) K matrix setting interface, as shown in Figure 3-12.

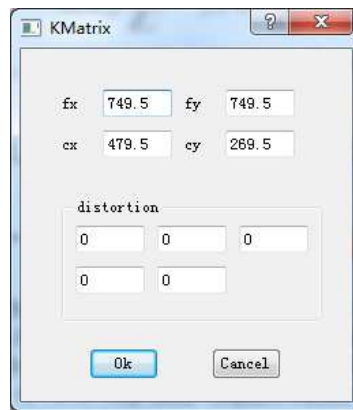


Figure 3-12 K matrix setting

This dialog is used to manually set the internal camera parameters. You can get this dialog by clicking **param** -> **set k matrix**, or choosing "**set k matrix manually**" as in figure 3-6.

fx, fy: the focal length in x and y directions respectively.

cx, cy: optical center positions.

distortion: distortion parameters.

3.4 Start Running


Once the image sequence has been imported, click  to start running. A tracking window will pop up during running, as shown in figure 3-13.



Figure 3-13. Tracking window

The result act file will be saved in the image sequence folder.

Press **ESC** to exit.

3.5 Watching the Result

After tracking, the tracking window provides an intuitive way for the user to watch the tracking result. The user can press **Space** key to switch between 2D view mode and 3D view mode. 2D viewing mode is shown as in Figure 3-14. 3D view mode is shown as in Figure 3-15. For “Multiple Sequences Tracking” mode, you can press key “q” to switch showing the recovered 3D points and camera trajectories among three kinds of modes: 1) only showing the active sequence; 2) showing the active sequence and other inactive sequences with grey color; 3) showing all sequences encoded with different colors. By pressing key “p”, the system will show or hide the 3D points.



Figure 3-14. 2D view mode

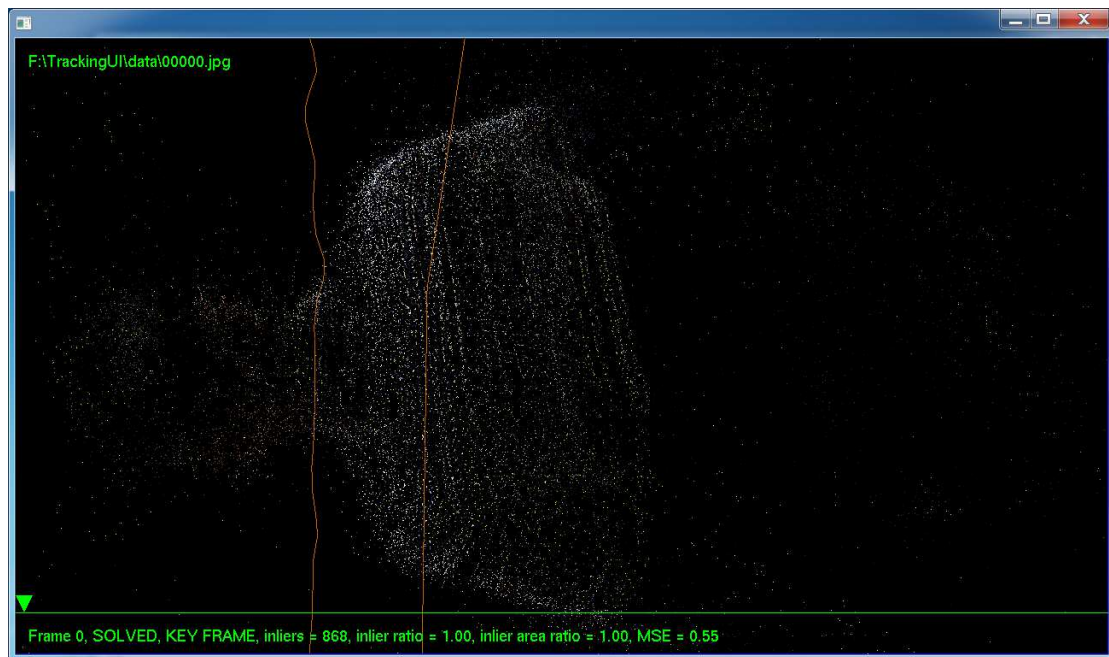


Figure 3-15. 3D view mode.

In 3D mode, user can do different operations to better watch the result, including rotation, translation, moving near/farther.

Pressing the key “r”, then the scene can be rotated by **mouse** with any mouse button held down. Scene after rotated as in Figure 3-15.

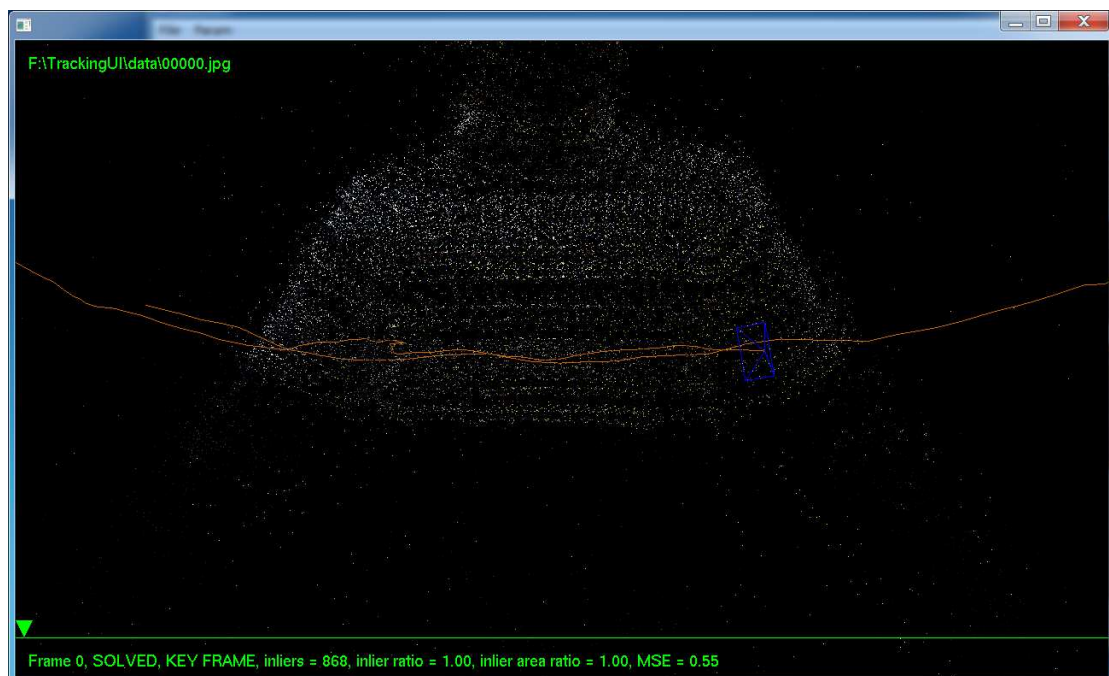


Figure 3-16. Rotating the scene.

Pressing the key “x” and hold down any mouse button, you can move the scene with up/down/left/right directions, as shown in Figure 3-16.

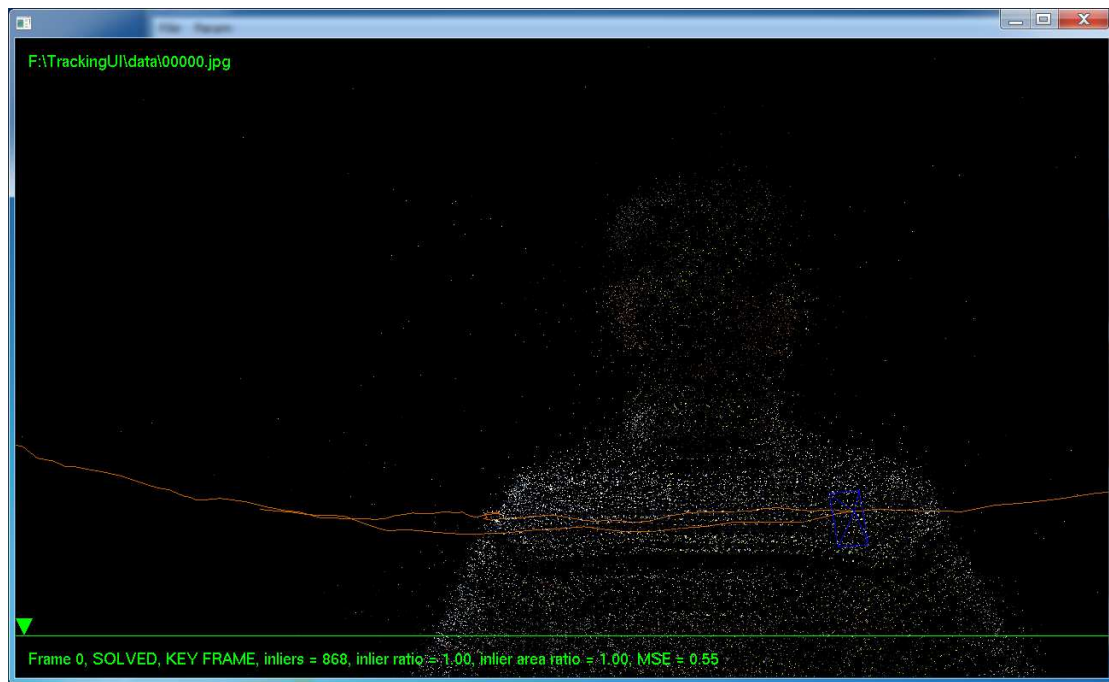


Figure 3-17. Translating the 3D scene

Pressing the key “z”, again with the mouse left/right button down, you can move the scene near or farther, as shown in Figures 3-17 and 3-18.

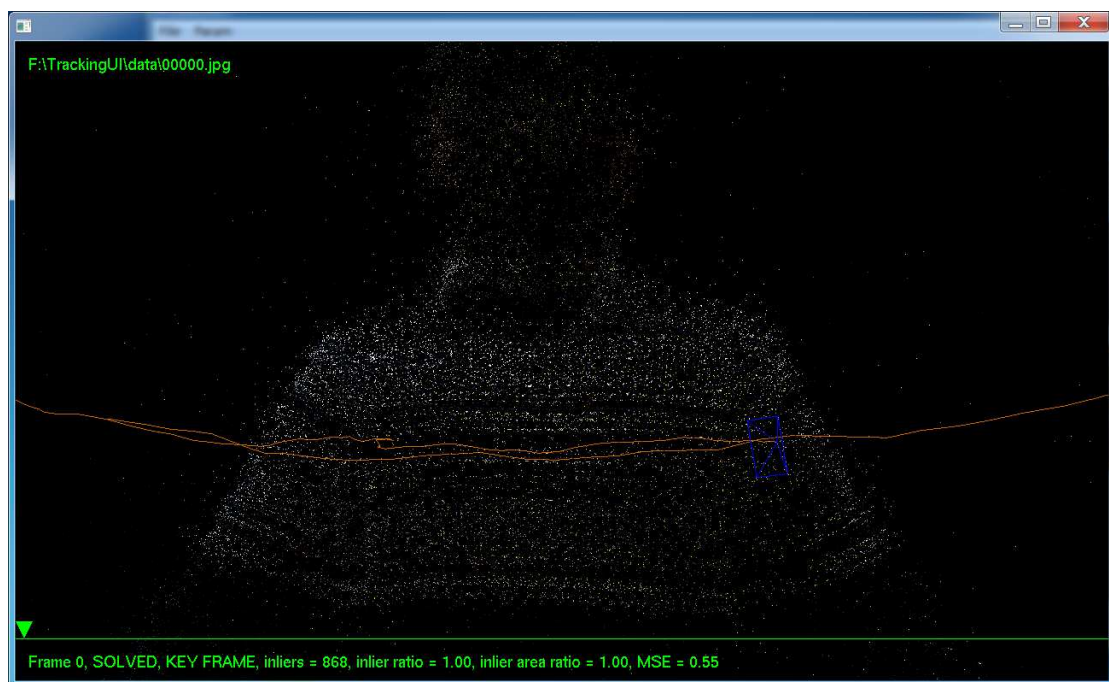


Figure 3-18. Moving the 3D scene near.

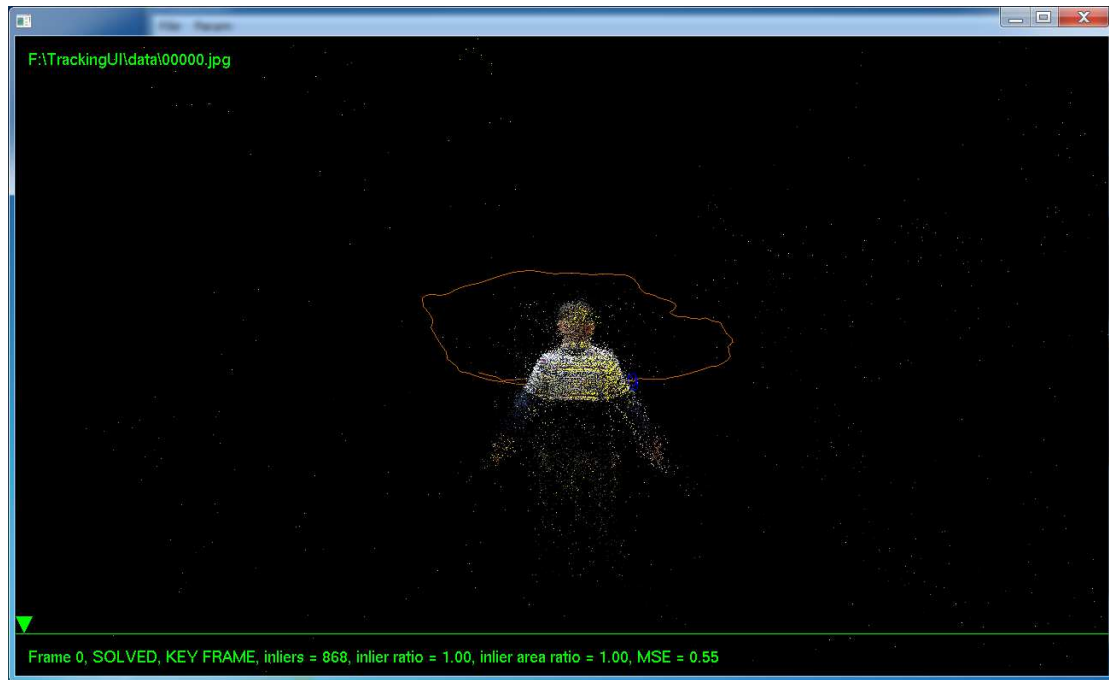


Figure 3-19. Moving the 3D scene farther.

By pressing key “t”, the system will set the viewing angle and position to the camera pose of the current frame.