

APPLICATION OF THE SIMPLIFIED SPATIAL DATA ACQUISITION SYSTEM K-SCOPE TO EDUCATION AND RESEARCH

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ABSTRACT:

The needs for spatial information acquisition tools using digital stereo images have been increasing in the popularization of digital sensors. Accordingly, spatial information becomes more popular in the field of application research, more researchers are becoming eager to acquire spatial information by themselves. On the other hand, most spatial information acquisition tools are designed for professional use, and there are few training tools for beginners. There are another problems in educational institutions in Japan. Since a professional tool is too expensive, it is difficult to arrange enough tools for students. Moreover, there are few trained instructors necessary for training 3-D measurement using a professional tool in educational institutions in Japan. In order to train engineers and part-time employees in-house, Kokusai Kogyo Co., Ltd. has developed a simplified spatial information acquisition system (K-Scope) under the concepts of anyone, easily, exactly and simple, small, compact. Although K-Scope was designed originally for business use, we believe that K-Scope has potential to be a good training system for beginners. In this paper, we introduce the outline of K-Scope and demonstrate the experimental results of K-Scope for the university level education.

1. INTRODUCTION

1.1 Needs for Photogrammetry Education

In recent years, the needs for 3-D measurement and spatial information acquisition tools using digital stereo images have been increasing in response to the current of digitization of aerial photographs and the trend to higher resolution of satellite images. Accordingly, it is urgent to train many engineers capable to execute 3-D measurement. Moreover, as spatial information becomes more popular in the field of application research, more researchers are becoming eager to acquire spatial information by themselves.

On the other hand, Japanese photogrammetry industries are worried about lack of talent resources. Most photogrammetrists never had a chance to receive any photogrammetry education when they were university students in Japan. Accordingly, not a few employees have to get on-the-job training (OJT) at their companies to become a photogrammetrist. These situations are imposing a burden on Japanese aerial photogrammetry companies. Therefore, it is important to conduct photogrammetry education in Japanese university.

1.2 Problems of Current Photogrammetry Education

Almost all spatial information acquisition tools in the current market are designed for professional use, and there are few training tools for beginners. Functions of a professional tool such as a digital stereo plotter are too excessive for education or application research. Furthermore, it is too complicated and difficult for beginners to operate a professional tool, and a long-term training is necessary to master 3-D measurement techniques using a professional tool.

In the practice of photogrammetry education, the abundant verification data is necessary to understand the behavior of stereo plotter correctly. However, it is difficult for the students to gather the abundant verification data by themselves.

If the students only use stereo plotter, they never know its principle and workflow. In this case, it is difficult to keep their motivations. It is quite important to use good manual books along with practical machines to understand the basic theory.

1.3 Action Plan for Photogrammetry Education

Kokusai Kogyo Co., Ltd. (KKC for short from now on) has developed a simplified spatial information acquisition system (K-Scope) for training in house engineers. In order to solve the above problems of photogrammetry education, we have made action plans to evaluate effectiveness of K-Scope as a training tool in an educational institution. The experiments are conducted under the collaboration with Tokai University (TU for short from now on). Our action plans are as follows:

- (1) KKC will provide K-Scope as a simple and low cost stereo plotter system to TU for student education.
- (2) KKC will provide stereo photo datasets around the university. It is important to use the datasets of well-known place for students. Since the dataset are familiar to the students, they can verify the accuracy of their products by comparing with field surveying data.
- (3) We will determine the fascinating curriculum to teach photogrammetry skill efficiently to students with keeping their motivations and easy understanding.

2. OUTLINE OF K-SCOPE

2.1 Features of K-Scope

KKC developed K-Scope as an easy and useful stereo plotter that was designed originally for business use. However, we believe that K-Scope has a potential to be a good training tool for beginners at universities. Major features of K-Scope are as follows:

- (1) Easy operation: The major advantage of K-Scope is that it is easy for beginners to operate. Short-term training allows beginners to execute digital stereo measurement.
- (2) Small scale and low cost hardware: The second advantage of K-Scope is that necessary hardware is compact and not expensive. The hardware system components are mainly a personal computer, a stereo viewing device such as 3-D LCD glasses and a 3-D pointing device.
- (3) Provision of products of the requested quality: K-Scope can provide highly precise spatial information. Precision of spatial information acquired by K-Scope depends on the skill of an operator.
- (4) Cooperation with Stereo-Set-Manager: K-Scope cooperates with the image-database management system Stereo-Set-Manager (SSM for short from now on) which manages stereo pairs of digitized aerial photographs. K-Scope is able to display a pair of stereo images around the specified point immediately with the assistance of SSM.
- (5) Points cloud processing function: K-Scope can process points cloud data acquired by a laser scanner.
- (6) No orientation function: K-Scope has no orientation function for easy operation and system simplification. Orientation parameters will be provided with stereo image datasets by KKC.

2.2 Hardware Configuration of K-Scope

The hardware configuration of K-Scope is shown in Figure 1.

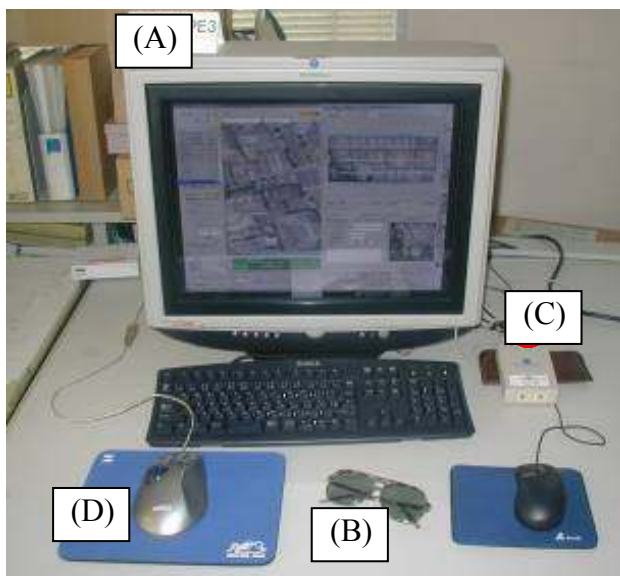


Figure 1. Hardware Configuration of K-Scope

2.2.1 Personal Computer: K-Scope works on a personal computer with a keyboard, a pointing device such as a mouse, OpenGL graphics card and CRT display. The graphics card and CRT display are required to be able to display with vertical refresh rate of 120Hz.

2.2.2 Stereo Viewing Equipment: K-Scope will provide stereo viewing equipment for operators. We have two types of crystal stereo shutter for stereo viewing. One is the monitor type as shown in Figure 1 (A). It attaches a crystal shutter filter to the front of the CRT display and it can provide stereo viewing for several persons wearing polarizing glasses (Figure 1(B)). Another one is the glasses type (stereo3d.com, Shutter-glasses Comparison Chart, 2005) as shown in Figure 2. It can use for only two persons at the same time.



Figure 2. Glasses Type of Stereo Shutter

A crystal shutter controller (Figure 1(C)) should be used to provide stereo viewing. It serves to make a synchronized signal for a stereo liquid crystal shutter. Some vendors provide stereo projectors as shown in Figure 3 (Cyviz, viz3D, 2005). If it can be used in a university classroom, quite a few students can take a lesson efficiently.



Figure 3. Stereo Projector

2.2.3 3D Pointing Device: K-Scope can utilize 3D pointing devices such as a 3D handle, a normal 2D mouse or a 3D mouse (Figure 1(D)). A 3D handle is used by most photogrammetrists. It is a very efficient device for professional. However, it is difficult to master operating it for beginners. Normal 2D mouse can be used as a 3D pointing device. However, it is not useful for all operators. We recommend using a 3D mouse as a 3D pointing device on K-Scope.

2.3 Software Configuration of K-Scope

The software configuration of K-Scope is shown in Figure 4.

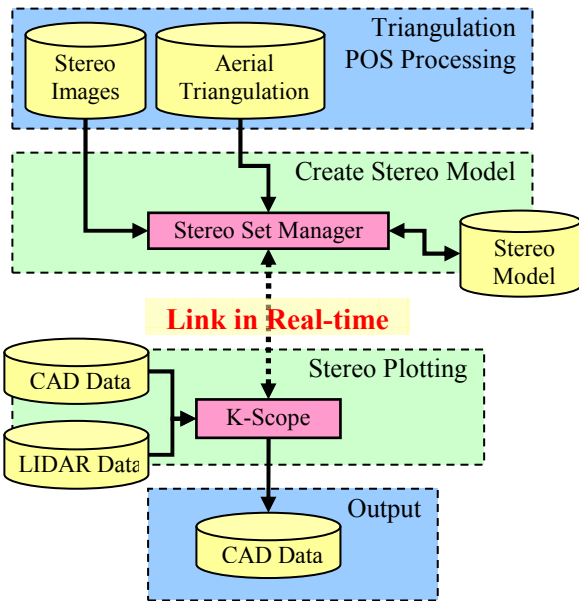


Figure 4. Software Configuration of K-Scope

2.3.1 Stereo set manager (SSM): SSM can manage stereo data sets. SSM shows thumbnail images as an index map by using digitized photographs and results of POS (Position and Orientation System) processing or aerial triangulation. K-Scope will be launched from SSM directly and immediately provide a stereo viewing. SSM can avoid annoying procedures to create stereo datasets.

2.3.2 K-Scope: K-Scope shown in Figure 5 provides stereo viewing for spatial data acquisition. We developed K-Scope that can start from SSM directly by clicking a stereo pair of images. Therefore, we can adjust the function design of K-Scope to fit the purpose. K-Scope's basic functions are the layer management function, the display graphics function and the spatial data input and edit function.

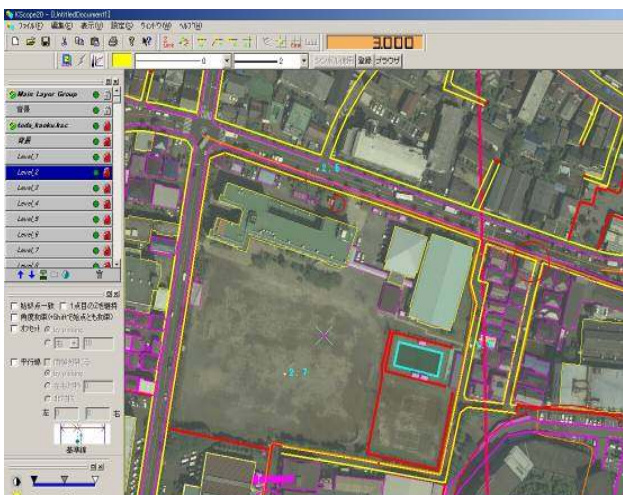


Figure 5. Screen of K-Scope

2.4 Workflow of Spatial Information Acquisition

Workflow of spatial information acquisition is as shown in Figure 6. The workflow divides into three steps such as the pre-processing step, the SSM and K-Scope step, and the post-processing step.

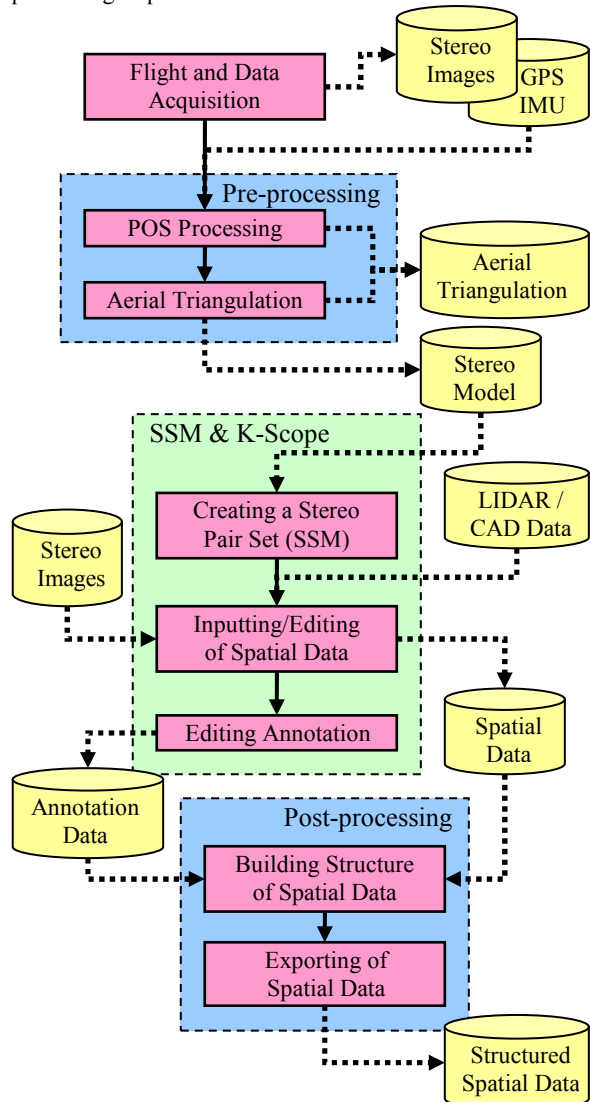


Figure 6. Workflow of Spatial Data Acquisition

2.4.1 Pre-processing Step: The main task at the pre-processing step is preparation of image data and annotation data of digitized aerial photographs.

- (1) Flight and data acquisition: First, we should obtain stereo pairs of aerial photographs and GPS and IMU data. The analog aerial photographs should be digitized.
- (2) POS processing: In this process, the position and attitude of each image will be obtained from GPS and IMU data with POS-Pac of Applanix Inc.
- (3) Aerial triangulation: In the case of lack of GPS and IMU data, or inaccurate POS processing results, we should conduct an aerial triangulation by using ground control points with ImageStation of Intergraph Inc.

2.4.2 SSM and K-Scope Step: This section shows the main step of spatial information acquisition.

- (1) Loading of stereo model data: SSM can load stereo model project files that are created with ImageStation. SSM can load many stereo images at a time. After loading the stereo model project file, SSM can show the index map of all stereo images. Then SSM shows the annotation information such as project name, area name, course number, photo number, flight date and remarks.
- (2) Creating a stereo pair set: A stereo pair set is created by manually. One can set a pair of link between two images by using drag and drop from index map of SSM. This operation is necessary once. KKC will provide stereo pair datasets to a university without a fee or at a marginal cost.
- (3) Layer and window management: Layer Manager can manage the layer of raster and vector datasets. Then the changing layer order is conducted with drag and drop. It has the function of show and hide, or lock and unlock for each layer. Window Manager can save the status of working window into a file and restore from the stored file. It is easy to restart working from the last status of the window placement.
- (4) Graphics displaying: Figure 7 shows some screens of K-Scope. K-Scope has three graphics modes such as the ortho view mode, the perspective view mode and the stereo view mode. The ortho view mode (Figure 7(A)) is fixed vertical viewing that is not stereoscopy to see 2D map images. The perspective view mode (Figure 7(B)) can see from any viewpoint. The stereo view mode (Figure 7 (C)) can see from any viewpoint with stereoscopy. Stereo view mode can help to check the 3D object of spatial data.

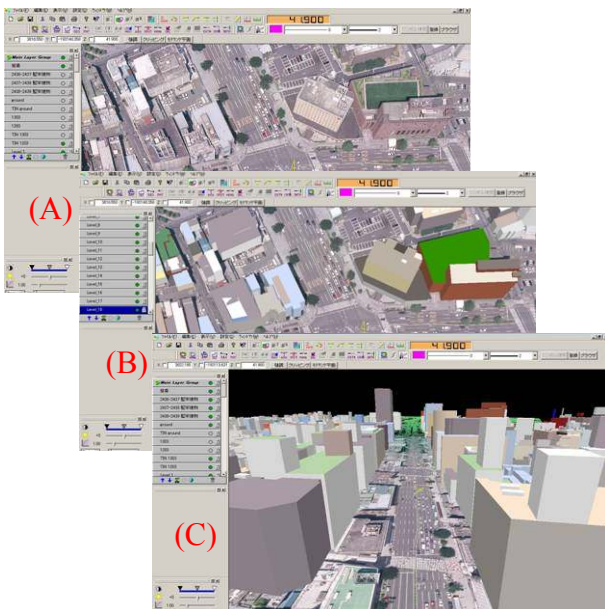


Figure 7. Screens of View Mode

- (5) Inputting and editing of spatial data and annotation data: K-Scope can input and edit the various types of spatial data. K-Scope processes three types of objects such as primitive objects, parametric objects and informative objects. Primitive objects include the types of point, points cloud, vectors and poly-lines / polygons. Parametric objects include the types of circle, arcs and sectors. Informative objects equal to the text objects that can add to some explanation on the layer as an annotation.
- (6) Snapping to existing vector data: It is necessary to join the editing vector data to existing vector data or grid points. It can snap to a line, a vertex, an end point of a poly-line, an intersection point and so on. The grid parameter setting is defined the grid interval from original coordinates is available.
- (7) Symbol manager: Symbol Manager can design the original symbol marker by oneself. It includes a fishing port, a police station, a ruin of castle, a temple, a hospital and a city office and so on. Symbol Manager will provide management function that is selection of symbol and adjustment scale.
- (8) Editing of LIDAR points: Figure 8 shows a editing screen of LIDAR points. Editing function of LIDAR can be conducted to remove and clustering by using stereo view mode. LIDAR points and 3D objects can be seen as digital mapping data or DEM date.

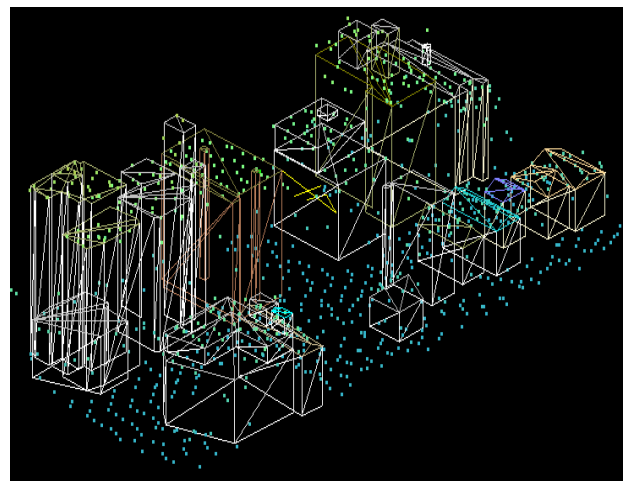


Figure 8. Editing of LIDAR Points

2.4.3 Post-processing Step: After acquisition of spatial data by using K-Scope, it is necessary to build a structure of acquired spatial data and convert structured spatial data into the desired file format depending on the application software.

- (1) Building a structure of acquired spatial data: We should build a topologic structure of spatial data acquired by using K-Scope. This process can be conducted continually using geographical script language such as ArcGIS.
- (2) Exporting of structured spatial data: Finally, we should convert the structured spatial data into the desired file format in order to use it in the application software. Most geographical script languages have many data conversion functions.

2.5 Processing Result of K-Scope

A processing result is shown in Figure 9.

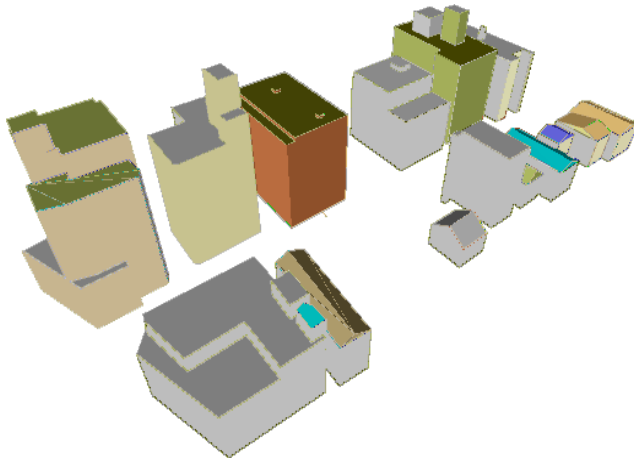


Figure 9. Processing Result of K-Scope

3. PHOTOGRAMMETRY EDUCATION PROGRAM

3.1 Planning of Educational Program

3.1.1 Exercise Experiment: TU and KKC are discussing the contents of exercise experiment for photogrammetry. The discussing points are as follows:

- (1) The current K-scope is too complicated to use at classrooms or for private study. Therefore, the function of K-Scope should be limited for easy operation by the beginners.
- (2) As the first step for introducing K-Scope for education at the university, some master course students will be assigned for learning K-Scope. Both teachers and students are going to have experience to use K-Scope.
- (3) KKC plans to provide stereo images around the campus of TU. The students are going to use them to plot the buildings of university of which they known very well. It is important that the student can keep motivations to compare the plotted results with existing building design data.
- (4) The original curriculum is planed to be applied to the students of Department of Network and Computer Engineering (DNCE) at which department students' interests are more on image processing, remote sensing and GIS. However, the curriculum is planed to be expanded in the future to be applied also to the students of department of architecture at which department students' interests are more on architecture and CAD.

3.1.2 Lecture Class: It is not easy to use a tool without understanding the basic theory. TU and KKC are also discussing about the curriculum of photogrammetry for the lecture class. The discussing points are as follows:

- (1) A textbook will be used to explain the principle of photogrammetry.
- (2) In this lecture, the students will create simulated images as simple models. Through this process, they may understand the principle of stereo viewing method.

- (3) Step by step, the students will learn the principle of photogrammetry including stereo model, lens distortion, triangulation, etc.
- (4) Finally, the teacher will set the problems on the report and check the achievements of learning.

3.1.3 Practice and Evaluation: After the exercise experiment and the lecture class, it is important to give the students chance to use the learned skill in the actual situation. Then the teacher could rightly evaluate the student's outcome. The practice and evaluation plans are as follows:

- (1) KKC will order jobs related to acquisition of spatial data to TU. The students of TU will be able to try their skill and/or to skill up through the part time jobs. At the same time, this will allow KKC to be able to solve lack of operators.
- (2) KKC will check the student's outcome and will report the result to the teachers of TU.
- (3) The teacher will evaluate the achievement of students due to the record of spatial data quality from KKC.

3.2 Step of Lecture Implementation

The lecture implementation steps are shown in Figure 10.

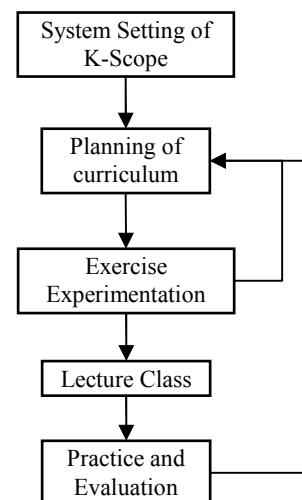


Figure 10. Step of Lecture Implementation

3.2.1 System Setting: The Department of Network and Computer Engineering at TU equips two sets of K-Scope in the laboratory for initial investigation. TU prepares two sets of PC hardware that has components (see in 2.2) for K-Scope. KKC provide software of K-Scope and its USB key for license. In addition, KKC installs the software onto the PC by using installer software.

3.2.2 Planning of curriculum: More discussion should be performed to finalize the plan of curriculum for the exercise experimentation.

3.2.3 Exercise Experiment: Several trial of exercise experiment will be performed using master course students. By evaluating the results, we will feed back to improve the curriculum.

3.2.4 Lecture Class: The curriculum of the lecture class will be finalized according to the results of exercise experiment.

3.2.5 Practice and Evaluation: By performing the practice of part time jobs of KKC after the exercise experiment and the lecture class, the achieved skills of students will be clear. We plan to evaluate the results, and will feed back them to improve the curriculum.

4. CONCLUSION

4.1 Development of Simplified Stereo Plotter

KKC have developed a simplified stereo plotter K-Scope. K-Scope has good features as training system for beginners such as easy operation, small scale and low cost hardware, provision of products of the requested quality, etc. Accordingly, SSM can avoid annoying procedures to create stereo datasets. Moreover, Stereo view mode of graphics displaying can help to check the 3D object of spatial data.

4.2 Apply to the University Education

K-Scope was originally designed for business use. However, we think that we can apply K-Scope to the university level education. We have made experiment plans to evaluate effectiveness of K-Scope as a training tool in an educational institution. Experiments are conducted under the collaboration with TU.

4.3 Future Works

In this paper, we have made a plan for learning photogrammetry technique by using K-Scope. More consideration is needed for creating efficient curriculum. Especially, it is difficult to teach the principle of functions such as lens distortion correction, triangulation and bundle adjustment and so on. Additional software development is necessary.

Moreover, in order to strictly evaluate the spatial data sets created by the students, we should establish the method of QA/QC (Quality Assurance and Quality Control) with sampling inspection. Evaluation of both quality of results and working time are important for grasping their achievements of skills as engineers.

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