

THE CONCEPT OF A PHOTOGRAMMETRIC WORKSTATION OUTLINED BY THE EXAMPLE OF THE LEICA SD2000

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Abstract

The paper will explain the general concept of a photogrammetric workstation. It will describe the tasks required to fulfill the needs of such a workstation. The underlying concept of the workstation is applicable through the whole line of photogrammetric restitution instruments. It is independent of the machine starting with analogue machines, carried through analytical machines up to totally digital workstations, based on digital images. The latest development of analytical instruments by LEICA SD2000 is based on this concept.

1. INTRODUCTION

The development of Leica SD2000 started with the evaluation of the current situation of the photogrammetric hard- and software. The aim of the new development was defined to improve the existing solution for a photogrammetric working environment with respect to productivity and easy interfacing of new soft- and hardware components.

Hard- and software should be developed in a modular fashion which allows for easy extension and exchange of components. The software especially should not be limited to be used in combination with one instrument only. It should have generic interfaces to various input and output devices.

2. EXISTING ENVIRONMENT

The existing solution at the time of development of the SD2000 was the DSR-line of instruments with its distributed processor concept (Chapuis, 1980). The solution uses basically three dedicated processors termed P1, P2 and P3 which are linked together by some hardware interfaces.

In this arrangement the tasks are distributed in the following manner. The P2 processor, also called plate processor, which is a certain DEC PDP-11 LSI 11xx performs the real-time loop operations to drive the instrument (DSR). The P1 processor which may be either a VAX or a PC type of computer runs application software namely orientation programs, all kinds of data collection programs and mapping software. The third processor P3 controls a special keyboard the operator control panel and the footpedals of the instrument.

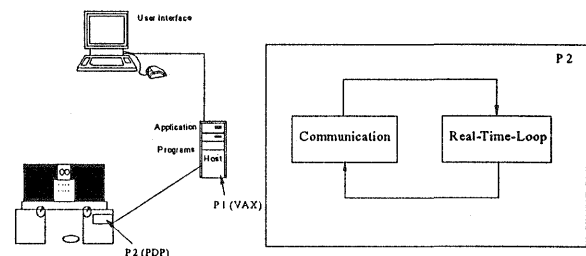


Figure 1: Former concept with DSR-series and PDP P2

A disadvantage of this solution is that several photogrammetric tasks like e.g. orientations (inner, relative, absolute) need to be available on every hardware platform of P1. Furthermore photogrammetric tasks like interchange of input encoder axes or functions like building squaring had to be repeated in every application software.

3. NEW CONCEPT

The new concept is to move as much photogrammetric tasks as possible to the processor P2 to take away redundancies from the application software. Advantages of moving as many photogrammetric tasks as possible to the P2 processor will be the following:

- interfacing of application software like CAD, GIS or mapping becomes easier
- range of application software to be interfaced will increase, because they don't need to know about photogrammetry, they use the interface as a 3D digitizer
- the interface protocol will be simplified, only transmission of a code and coordinates is required

- the integration of options like image superimposition is simplified, because it will be guided by software on P2
- the environment becomes more user friendly and productive with ability to build macros on P2 which can be send to application software on P1
- the integration of specialized photogrammetric tasks like digital image processing with additional hardware becomes easier
- with integration of a user interface on P2 with point and click philosophy the use of the instrument is simplified
- by use of a generic machine interface on P2 the integration of various photogrammetric machines is possible
- extended software on P2 to correct for systematic machine errors allows for cheaper production costs on the instrument (analytical instruments only)
- managing of multiple models on the photo stages in close range applications with small size photographs can be handled directly on P2

4. PHOTOGRAMMETRIC TASKS

4.1. Software concept

To achieve the required aim a suitable software concept for the P2 controller software must be used. The requirements are: handling of multiple tasks together with real time capabilities. Therefore a multitasking software concept with the ability for real time interceptions is a suitable solution.

The tasks belonging to a photogrammetric workstation can be identified as follows:

- Real-Time-Loop
- task scheduler (kernel)
- communication to P1
- instrument control interface
- user interface
- photogrammetric applications
 - calibration of instrument
 - orientation
 - data collection support (building squaring etc.)
 - digital image processing
 - image superimposition

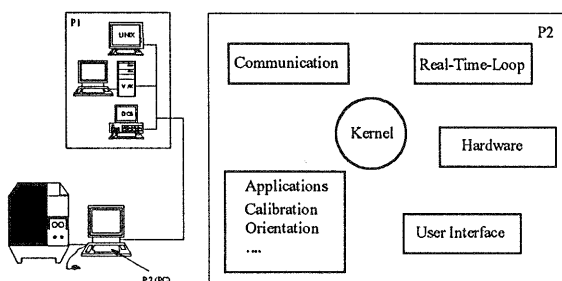


Figure 2: Tasks required on P2 computer

4.1.1. Real-Time-Loop

The Real-Time-Loop task performs the reading of encoder input, mathematical transformations and moving of images accordingly on a regular frequency basis. This task has the highest priority in the system.

4.1.2. Task scheduler (Kernel)

For this type of applications a preemptive multitasking is required. The task scheduler is responsible for distribution of CPU resources among the tasks. It is based on a time slicing concept. The task scheduler will switch among tasks on a predefined model thus giving the impression that tasks are working concurrently.

4.1.3. Communication to P1

This task is responsible for the communication to P1. It handles requests from application software on P1. In event mode it will notify software on P1 of the event type that happened on P2. Typically events are:

- footpedal signals
- keyboard signals
- movement of images

Typical for multitasking software is asynchronous communication where buffers are implemented on both sides. This ensures high performance without loss of data.

4.1.4. Instrument control interface

This task is connected with the user interface and the instrument. On instruments (like e.g. on the SD2000) with software control features for image illumination, floating mark size and illumination, zoom etc., this task is dedicated to perform the requested service. The advantage of having software control is that it might be used manually by the operator by use of the user interface or by software controlled from application programs. This might be any application like calibration, orientation or digital image processing.

4.1.5. User interface

The user interface interacts with the operator by means of the keyboard and mouse. It displays its feedback on the attached monitor. It fulfills various needs:

- coordinates displays
 - ground system
 - machine system (coarse display)
- change parameters of the instrument
 - encoder resolution
 - assignment of encoder axes
 - image illumination
 - zoom
 - floating mark size and illumination
- build macros for various tasks
- send information to P1
- handle multiple models
- start photogrammetric application programs

- display information of photogrammetric application programs

Due to the amount of functionality the user interface is configurable by the user to fulfill his needs. He can arrange the display in the form he wants and iconize information seldom used.

4.1.6. Photogrammetric applications

This is actually a group of tasks. Individual programs are launched by the operator through the user interface.

4.1.6.1. Calibration

This task is used to measure a known grid plate. The grid plate serves as reference system. The machine is calibrated against the grid plate. Discrepancies between the grid values and the machine readings are interpreted as machine errors. They lead to a correction matrix which is stored on P2. During normal operation of the Real-Time program corrections from the correction matrix are applied for every position.

4.1.6.2. Orientation

This group of programs performs tasks like inner, relative and absolute orientations. The photogrammetric know how for measuring and adjustment is therefore located in this tasks.

4.1.6.3. Data collection support

Putting this task onto P2 leads to a further simplification of the software on P1. With functions like building squaring on P2 the coordinates belonging to one building first will be transformed to produce a building with orthogonal sides and afterwards will be transmitted to the application software. With such features the use of standard software without special photogrammetric extensions on P1 becomes possible.

4.1.6.4. Digital image processing

In this context digital image processing means measurements of objects (houses) and e.g. topography (heights). With appropriate hard- and software for this task photogrammetric data collection can be improved. As long as digital image processing methods cannot work fully automatically they can already help to support the operator. With this approach a smooth transition from a hybrid system to a totally digital fully automatic photogrammetric workstation can be realized.

4.1.6.5. Image superimposition

By adding this task which controls image superimposition the photogrammetric part of the work is taken away from the implementation. All mathematical transformations including corrections for instrument errors are provided as service from the controller software. This means that superimposition software is primarily responsible for movement of the superimposed image and updating the superimposed information according to events. The superimposition task is triggered from the controller software each time a relevant event takes place. Relevant events for image superimposition are

image movements and point measurements. With all mathematical transformations performed only at one place, this allows for easy implementation of various image geometries also for use by image superimposition without any changes in the software.

4.1.7. Intertask communication

Within a multitasking software package communication between tasks needs to be established. This is realized in form of a message system with predefined protocol among the various tasks. Each task is assigned a mail box from where it receives messages from remaining tasks. By use of the predefined protocol the implementation of additional tasks becomes quite simple.

4.2. Hardware controls

The hardware components of a photogrammetric workstation controlled by the multitasking controller software are best explained by use of Figure 3. An example of photogrammetric workstation hardware is shown in Figure 4.

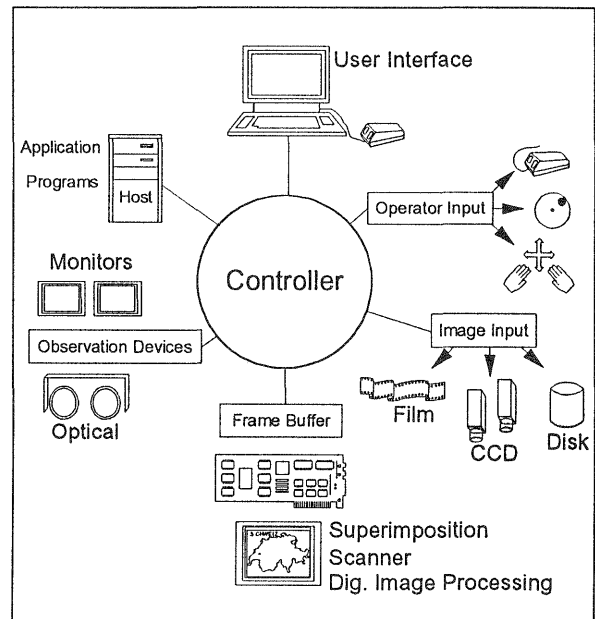


Figure 3: Hardware components of Photogrammetric Workstation

4.2.1. Controller

The controller is a computer which is suitable to perform the required tasks. Preferably is a machine with an extension bus for plug in boards. Furthermore it should deliver sufficient computation power to perform the numerical computations in real time.

4.2.2. Operator Input

To drive the floating mark about the stereo model the operator needs appropriate 3D input devices. As a cheap solution a standard mouse or trackball together with a Z-handwheel may be considered. However a professional operator will tend to use traditional handwheels or free hand motion along with a footdisk.

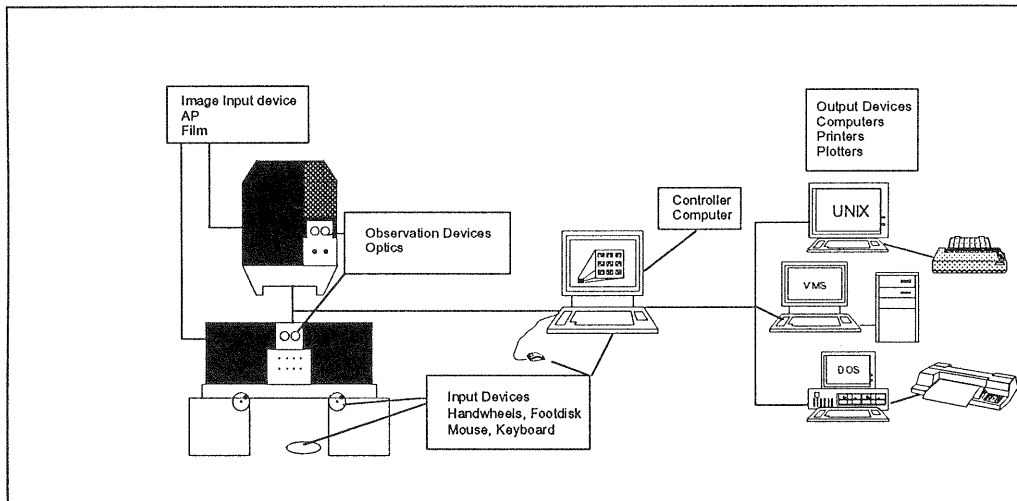


Figure 4: Example for Photogrammetric Workstation hardware

4.2.3. Image Input

The image input varies depending on the type of photogrammetric workstation. With the analytical plotter film is used as image input. The film is placed on motorized stages which are controlled by closed loop servo systems. Additionally the analytical instrument can be equipped with CCD cameras looking at the film. This leads to a hybrid system. The CCD cameras may be used just to display the field of view on monitors and therefore serve as instruction tool. Furthermore the information gathered by the CCD cameras can be used to apply digital image algorithms to it to support the operator during the measuring process.

In case of a digital photogrammetric workstation images would reside on peripheral storage usually harddisks. They will be loaded into the photogrammetric workstation for any type of further processing.

4.2.4. Frame Buffer

A frame buffer is a special type of computer memory used to hold digital image information. This type of memory can be used for image superimposition or as well for digital image processing on digital images. It may be accompanied by a dedicated processor to speed up the related operations.

4.2.5. Observation Devices

Observation devices are necessary to look at the images. In analytical instruments high quality optics are used. In digital workstations monitors serve the purpose to display the images.

4.2.6. Host Computer

A second computer is required to run standard application software. This are packages for data collection, CAD, GIS, DTM and specific photogrammetric software like bundle adjustment programs.

4.2.7. User Interface

The user interface hardware consists of standard computer components like keyboard, mouse and monitor.

5. SD2000

The SD2000 development is based on the previously outlined concept. The SD2000 is an analytical photogrammetric workstation. It uses film as image input and high resolution optics as observation devices. In normal operation mode it is guided by a human operator by use of traditional handwheels or for fast motion by use of a trackball with a special software joystick function. Furthermore, the operator interacts with the SD2000 by use of a graphical user interface which is displayed on the attached monitor of the photogrammetric workstation. During calibration the SD2000 is attached with two CCD cameras and a frame grabber. Together with special software for automatic measurement and calibration, by means of image processing technology, the SD2000 is then totally guided by software without human interaction (Müller, Chapuis, 1992).

The software which drives the whole photogrammetric workstation SD2000 is structured as described before. It is totally event driven. Because of the high demands of a very regular timer event for the real-time-loop, a special programmable timer chip is placed on the electronic interface board, which is located inside of the system computer. This timer is needed to generate interrupts at a pre-defined frequency. This regularity is essential to achieve an acceptable movement of the images. The software is MS-DOS based and runs on a standard Intel 386/387 processor arrangement. To achieve the required functionality of the software a multi-tasking model is implemented along with real time capabilities. It was possible to reach this result by use of a high level structured computer language. It was not necessary to use assembly language. This allows reuse of the software on different hardware platforms.

Currently two photogrammetric instrument lines from Leica are interfaced to the software package.

Namely the SD-line and the DSR-line of analytical workstations. The newly designed electronic interface for the DSR retrofit would also allow for an interface of analogue instruments to the software package.

The image superimposition which is optionally provided for the SD2000 is based on the software interface concept outlined before. The frame buffer is realized in form of a plug in board inside of the P2 computer to drive the superimposed images. It utilizes its own graphics processor to speed up the drawing functions. The software which runs on the add in card is guided by the real time software of P2. The two processes communicate via a predefined software interface. Some memory on P2 is shared to exchange data between the two processes.

On the application computer besides Leicas in house software product line all major independent application software vendors are interfaced. The application software runs on a variety of hardware platforms with various operating systems, e.g. MS-DOS, VMS and UNIX.

6. LITERATURE

Chapuis, A., 1980. The Kern System DSR1-GP1 Digital Stereo Restitution Instrument and Graphic Peripheral. ISPRS Congress, Com. II, Hamburg.

Müller, W.; Chapuis, A., 1992. A new method of calibration for analytical photogrammetric workstations. ISPRS Congress Com. II, Washington D.C.